# The Economics of Green Retrofits

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**Abstract** This is the first study focused on the economics of green renovations. Our findings are focused on Leadership in Energy and Environmental Design (LEED) buildings certified under the Existing Building: Operations and Maintenance (EBOM) certification scheme during the 2005–2010 period. We compare rents and occupancy rates, and investigate the types of improvements undertaken, as well as the amount of investments required. We survey building owners on the typical improvements and their attitudes towards the benefits and costs of upgrades. The findings indicate that investments in ‘‘green’’ retrofits are incorporated by the market, which is consistent with past studies that mostly focused on new construction. The findings indicate that, on average, investments in the sustainability of commercial buildings are economically viable.

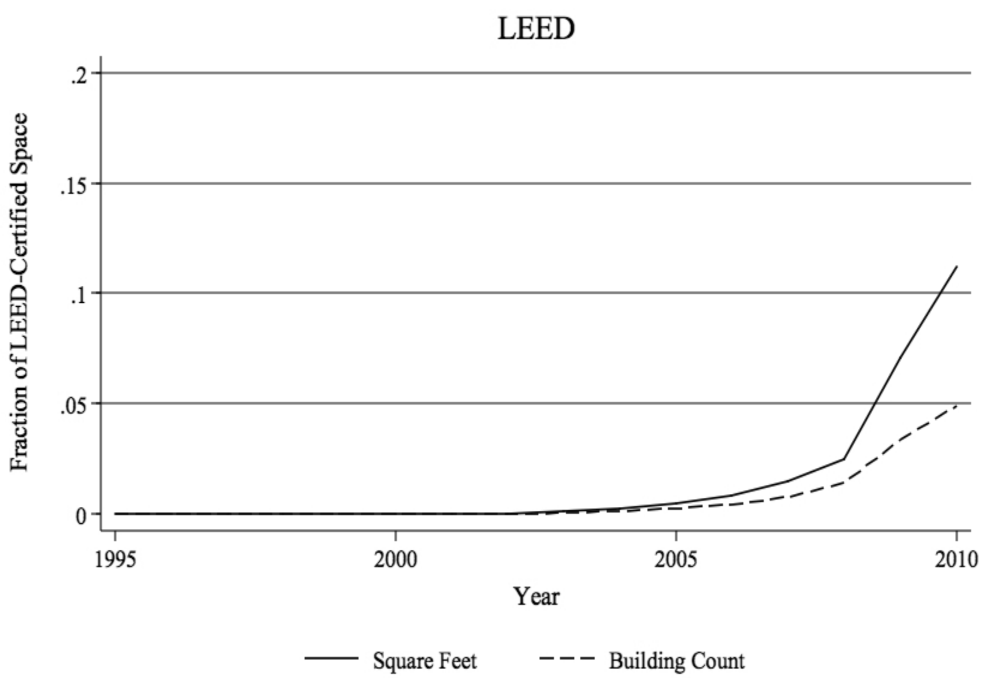
During the past several decades, the average new annual construction within the office market has been about 2.1% of the existing stock (Eichholtz, Kok, and Quigley, 2010). If all of this new construction were to be ‘‘green,’’ and if no renovation took place, it would thus take several decades to improve the energy efficiency and sustainability performance of the existing building stock.

There have been several studies focused on the sustainability of new office construction, as measured by the Leadership in Energy and Environmental Design (LEED) scheme, developed by the U.S. Green Building Council. The certification scheme for Existing Building: Operations and Maintenance (EBOM) is of more recent vintage and with the dearth of new construction in the post-2007 commercial market downturn, certification of existing building renovations is now surpassing new construction certification rates. Exhibit 1 provides some evidence of the growth of LEED-certified space in the marketplace and the role of existing buildings. There has been an explosive growth in LEED certification (Panel A), with about 10% of the U.S. commercial office market certified at the end of 2010 (by square footage). Panel B shows that since 2009, LEED certification for existing buildings outpaces LEED certification for new construction.

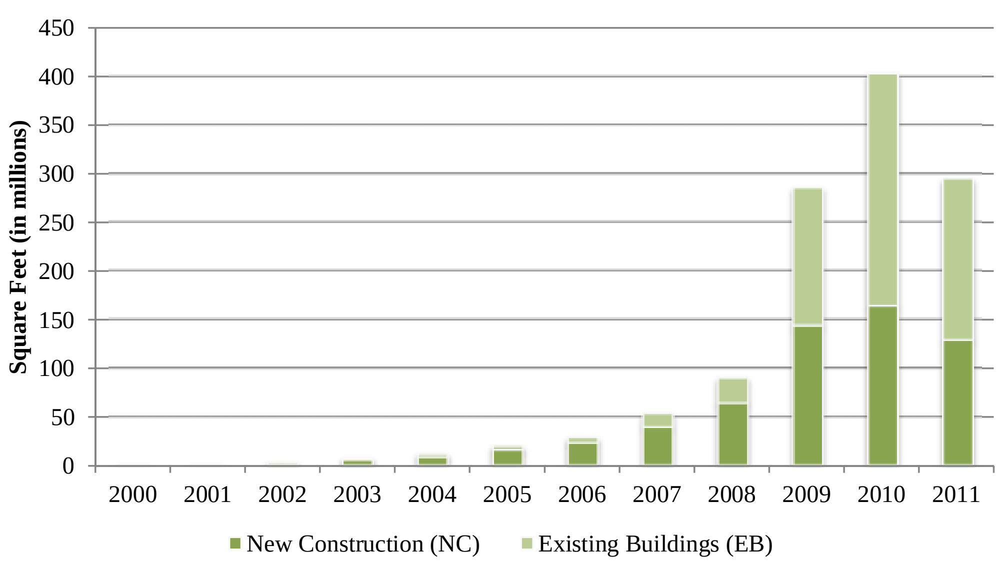
This is the first study to address the economic implications of LEED certification (following a retrofit), extending the rapidly growing literature on the effects of ‘‘green’’ building in the marketplace. The data in this study are from CoStar and includes 374 LEED-certified properties (EBOM) and nearly 600 control properties for comparative purposes and empirical analysis. We also include some results from a survey on the benefits and costs of retrofits. Many of the buildings in our

**Exhibit 1** | Growth in Green Buildings

**Panel A: LEED-Certified Space as a Fraction of Total Office Space (Kok et al., 2011)**




**Panel B: Composition of LEED-Certified Commercial Space**



sample were in the process of renovating to become more sustainable at the time the EBOM system was published. We identify the renovation period as generally starting in 2005–2009, with certification received from 2008 to 2011.

The results show that the average rents on the EBOM-certified buildings were below those of the control buildings prior to 2006, but have exceeded the average rents of the control buildings since 2006. Vacancy rates within EBOM-certified buildings were 7% higher than the control group in 2005. Since 2005, the EBOM group has gained occupancy relative to the control buildings, but still lags slightly behind, primarily due to the soft real estate market since 2007. Using a regression analysis to control for class, age, location, size, and distance to transit, we find a 7.1% rental premium for LEED-certified buildings versus non-LEED buildings. When the ENERGY STAR label is included, we continue to find a significant premium for both ENERGY STAR and LEED certification. The quantitative results, in combination with the survey evidence, provide important information for building owners and investors. There seems to be a tangible financial effect from LEED certification, which outweighs the costs of a retrofit.

## Literature Review

Prior published literature on the financial implications of green certification mostly focuses on new construction within the U.S., and results generally indicate a positive relationship between environmental certification and financial outcomes in the marketplace. Eichholtz, Kok, and Quigley (2010) document large and positive effects on market rents and selling prices following environmental certification of office buildings. Relative to a control sample of conventional office buildings, LEED or ENERGY STAR-labeled office buildings' rents per square foot are about 2% higher, effective rents are about 6% higher, and premiums to selling prices per square foot are as high as 16%. Other studies (Miller, Spivey, and Florance, 2008; Fuerst and McAllister, 2011) confirm these findings.

Importantly, these results appear robust over the course of the financial crisis, as Eichholtz, Kok, and Quigley (2011) document for a recent dataset of 3,000 green buildings that both energy efficiency and ''greenness'' of buildings are capitalized into rents and sales prices. Moreover, this effect is not dented by the recent downturn in property markets. Other studies suggest positive economic benefits from faster absorption, higher occupancy rates, lower operating expenses, higher residual values, as well as greater occupant productivity (Fuerst and McAllister, 2009; Miller, Pogue, Gough, and Davis, 2009; Chau, Tse, and Chung, 2010).

To date, there are no academic studies investigating the market performance of green renovations. There are numerous case studies of single buildings that have been retrofitted for the owner-occupant, but less so in the private rental market.[1]

Anecdotal evidence suggests that the move of tenants towards green real estate is due to enhanced reputation benefits, corporate social responsibility mandates, and employee productivity (Nelson and Rakau, 2010). Such a shift in tenant preferences suggests that tenants are using the buildings that they occupy to communicate their corporate vision to shareholders and employees. The literature on corporate social responsibility (CSR) has generally investigated this link between corporate social performance, reputation benefits, and employer attractiveness (Turban and Greening, 1997; Margolis and Walsh, 2003). In a recent broader study, Pivo and Fisher (2010) suggest higher rents and returns for those engaged in CSR.

Another frequently invoked rationale for occupying green office space is tenant productivity. Miller, Pogue, Gough, and Davis (2009) document using a survey that over half of the occupants of environmentally-certified buildings found their employees to be more productive. Interpretation of these results is problematic, though, as these responses cannot control for management style and individual employee characteristics. However, surveys of tenants in London indicate that there is indeed a shift in corporate preferences. A 2008 research report documents that 58% of tenants find energy efficiency ''essential'' and 50% find green attributes ''essential.''[2] A 2012 survey of Corenet members suggests that tenants want natural light, and better ventilation and temperature control.[3] These features are consistent with more sustainable and greener space.

Improving the bottom line through energy efficiency in buildings is often reported as one of the direct economic benefits for real estate investment companies when considering energy efficiency and sustainability in their portfolios. Jones Lang LaSalle reports that of 115 office properties in its portfolio for which the energy efficiency was improved in 2006, the average realized savings for 2007 and 2008 were $2.24 million and $3 million, respectively.[4] British Land reports that across its portfolio, there is a reported 12% decrease in energy use, amounting to $1.12 million in annual savings in energy, and a decrease of 11.1 million kWh of energy used in 2009.[5]

Another stimulus for demand of sustainable space is government regulation. In many markets such as New York City, San Francisco or Washington, D.C., we see increased government pressure both on the regulatory side (through mandatory disclosure) and from direct government office demand of the government services offices (the federal GSA as well as the California GSA) that require ENERGY STAR or LEED-labeled space for most new leases.

## Data

We collect data from CoStar on those markets where we observe the largest number of EBOM-certified office buildings, as of the first quarter of 2011. We apply the following filters: built prior to 1990; at least 15,000 square feet; multi-tenant; multiple floors; and Class A or B. This resulted in 374 certified office buildings, distributed over 14 markets, where there were at least 12 or more observations in any one market. The 14 markets are: New York City, Washington, D.C., San Francisco, Houston, Los Angeles, Chicago, Seattle/Puget Sound, Boston, Orange County, East Bay/Oakland, Denver, Atlanta, Dallas/Fort Worth, and Minneapolis/St. Paul.

**Exhibit 2** | Descriptive Statistics
(374 LEED Certified Buildings and 582 Conventional Buildings)

| | LEED Certified | Control Sample |
|---|---|---|
| Rent ($ / sq. ft.) | 28.15 | 29.23 |
| Occupancy Rate (percent) | 83.73 | 87.38 |
| Effective Rent ($ / sq. ft.) | 23.83 | 25.05 |
| ENERGY STAR (1 = yes) | 86.88 | 37.35 |
| Building Class | | |
| Class A (percent) | 83.09 | 66.34 |
| Class B (percent) | 16.91 | 33.66 |
| Building Size (1000s sq. ft.) | 522.40 | 495.10 |
| Typical Floor Area (1000s sq. ft.) | 27.10 | 45.60 |
| Age (years) | 22.33 | 26.93 |
| Renovated (percent) | 41.40 | 31.90 |
| Distance to Transit (miles) | 0.30 | 0.43 |

The 374 buildings are managed by 317 property managers (with some managers overseeing more than one building). Structured surveys were sent to these managers, inquiring into the types of improvements that were made to achieve LEED certification.

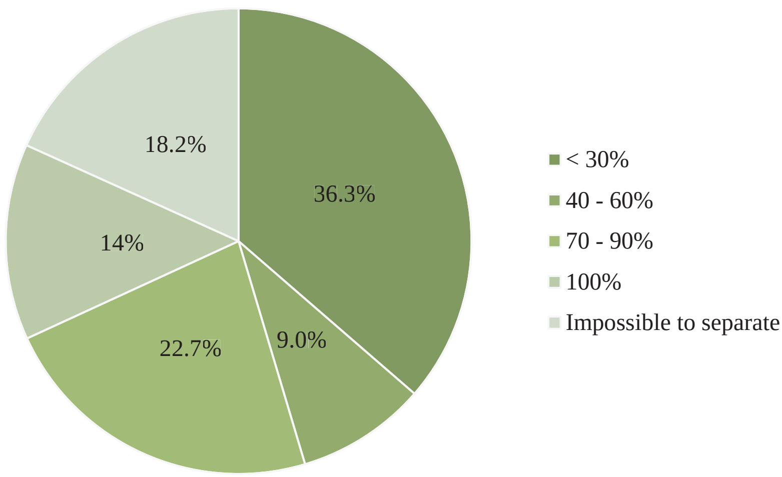
CoStar data on property details are used in the empirical analysis and to select a control sample group. The control group is matched in terms of the above-mentioned filters, but we also adjust the selection such that the ages and sizes of the treated and untreated samples are as similar as possible. The control sample includes some 600 properties, after applying the filters on location, age, and size.

Exhibit 2 summarizes the information available on the samples and reports the means and standard deviations for a number of hedonic characteristics of the green and control buildings, including their size, quality, and number of stories, as well as indexes for building renovation and proximity to public transport. Compared to earlier studies on the economics of green building, the sample characteristics are quite similar. Green buildings are slightly younger and have a higher renovation propensity, but the differences are clearly limited through the data selection procedure.

## Survey Results

The survey resulted in a response of 13%, or 41 respondents, all of which registered buildings for and achieved LEED certification. We analyzed the survey responses to understand better the real-life challenges and perceptions of commercial building retrofits. Of course, retrofits also take place to simply

**Exhibit 3** | Survey Results
Percentage of Improvements Related to Sustainability




improve the quality of a building, so we first ascertained what percentage of the improvements were related to sustainability and which were simply necessary to update otherwise obsolete buildings. We asked the following question: ''Of the improvements made when you retrofit this building, what percentage was sustainable-related, as opposed to merely updating the building to remain competitive?'' Exhibit 3 provides a breakdown of the answers. Just 14% of the respondents indicate that all the improvements were related to sustainability, and over 18% indicate that this is impossible to separate. But for a significant fraction of the respondents, the improvements were related to sustainability, and the most common improvements are provided in Exhibit 4. Not surprisingly, most respondents have implemented what many in the industry refer to as ''the low hanging fruit''—for lighting, paybacks are generally very fast. Other popular improvements relate to HVAC, followed by water flow systems (low-flush toilets, etc.) and recycling containers. Motion detectors, automatically switching systems on/off, were also implemented by the majority of respondents. More expensive improvements, like replacing roofs, installing PV solar cells, and changing floors, insulation, and operable windows and better glazing also took place.

The renovation investments ranged in size from just over $400,000 to more than $2 million, with the average LEED building being just over one half million square feet. Expected paybacks are provided in Exhibit 5. This simple measure of financial performance is quite common among the engineers and contractors engaged in building renovations. The most typical payback period is fairly quick, at less than five years. This reflects the preference of commercial building owners for ''quick wins,'' rather than most aggressive, deep retrofits. About one-third of the respondents expect a payback period of 5–10 years, whereas the financial implications of the investments are unclear for some 13% of the respondents.

**Exhibit 4** | Survey Results
Major Improvements During Retrofit

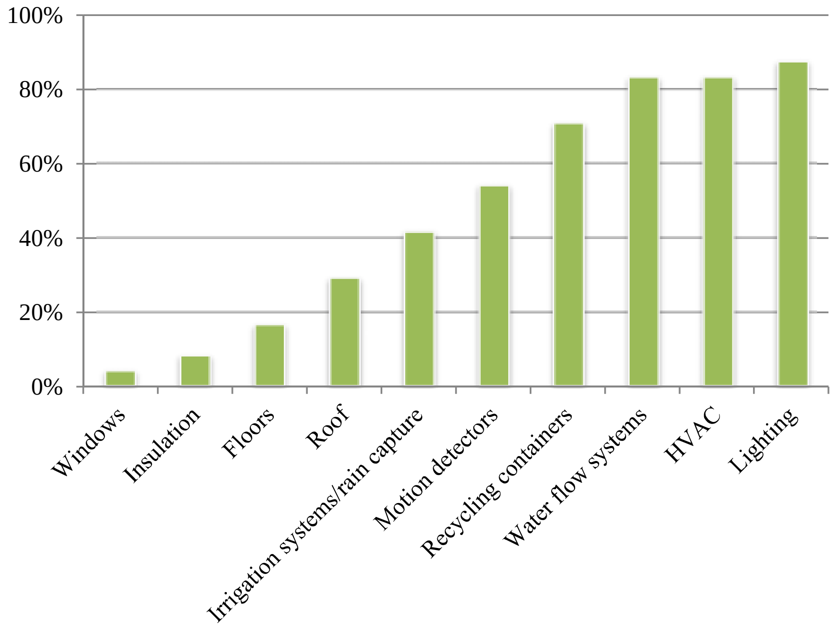



**Exhibit 5** | Survey Results
Expected Payback in Years on Sustainability-related Improvements

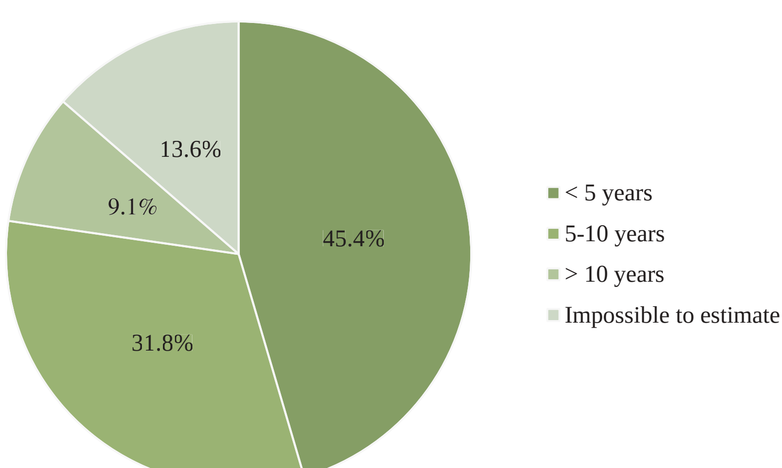
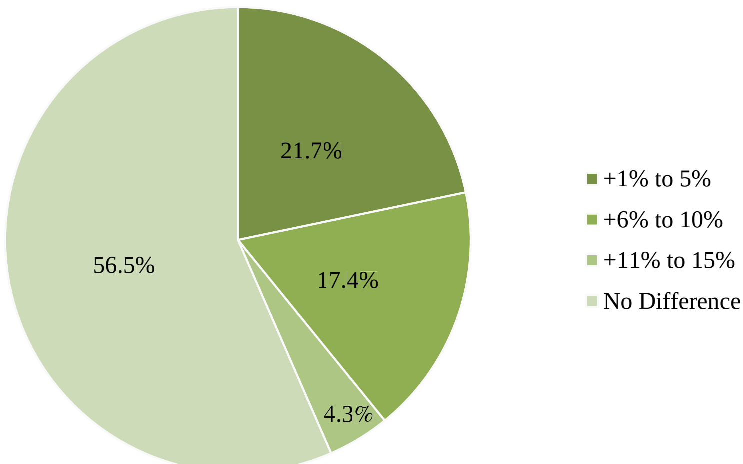


**Exhibit 6** | Survey Results
Current Rent Level Compared to Average Rent for Similar But Non-LEED Buildings




We asked respondents to compare the current rental level in their LEED-certified building, as compared to the rental level prior to the renovation. The results in Exhibit 6 show that 56% perceived no change. (Given that the survey was executed during a period of declining rents, ''no change'' is not necessarily bad news). Twenty-one percent of the respondents estimated the change in rents to be 1%–5%. And a small number of respondents noticed rent increases of more than 10%.

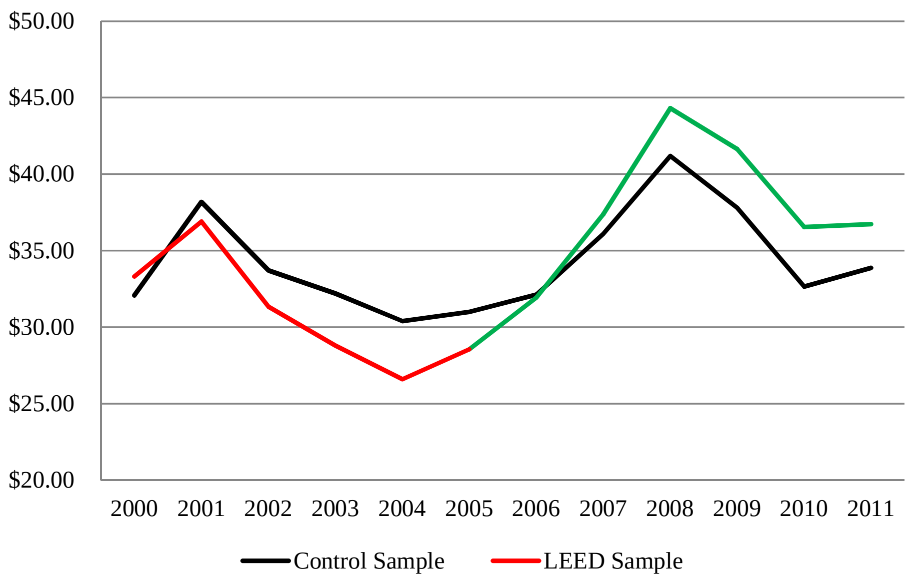
## Digging Deeper: Analytical Results

### *Aggregate Trends in Rents and Occupancy Rates*

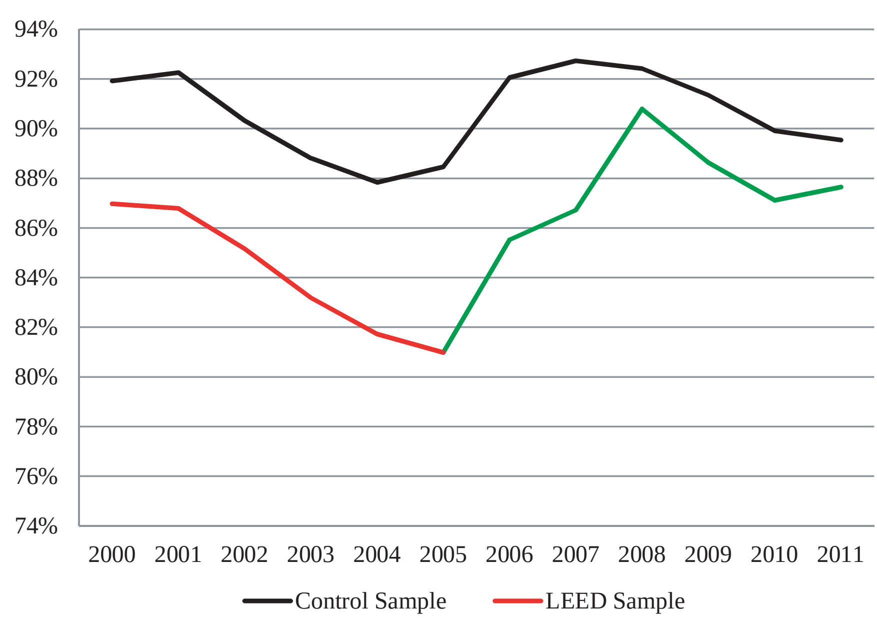
Of course, we can also measure changes in rents and occupancy rates directly. Aggregate rental indices are provided in Panel A of Exhibit 7 and average occupancy rates are provided in Panel B of Exhibit 7 for both the EBOM and control samples. The period prior to renovation is before 2005 and depicted in red. Most improvements were completed after 2005 (although some improvements continued throughout the time period after that) and this period is depicted in green. Note that the rents on the renovated property were lower as compared to rents in the control sample prior to the renovation. Similarly the occupancy rates prior to the renovations were lower than for the control sample. Of significance is the fact that average rents increased faster than for the control group through 2008. While premiums were maintained for the buildings certified by LEED for existing buildings, the rents declined after 2008 at about the same rates as for the control sample. This result is similar to finding by Eichholtz, Kok, and Quigley (forthcoming). We document that the occupancy gap narrowed after the improvements but never completely dissipated during the rather soft rental period from 2007 through 2010.

**Exhibit 7** | Rents and Vacancy Rates of LEED Sample and Control Sample (2000:Q1–2011:Q1)

**Panel A: Rental Levels Prior to and After Renovation**




**Panel B: Occupancy Rates Prior to and After Renovation**



Of course, rental and occupancy rates vary by market, and we provide more details on individual markets in Exhibit 8, for the 14 markets studied here. Significant rental premiums are observed in the major markets of Washington, D.C., New York City, and Boston. Occupancy rates strongly depend on when the LEED buildings came ''on line;'' with many of the LEED buildings being renovated during a period of decline, we continue to observe lower occupancy rates for green buildings in quite a few markets.

## *Regression Analysis*

To more formally investigate how EBOM certification influences the rent and occupancy of commercial office buildings, we start with the standard valuation framework for commercial real estate. The sample of rated office buildings and the control sample consisting of nearby nonrated office buildings in the same city are used to estimate a semi-log equation relating office rents (or effective rents) per square foot to the hedonic characteristics of the buildings (e.g., age, building quality, amenities provided, etc.) and the location of each building:

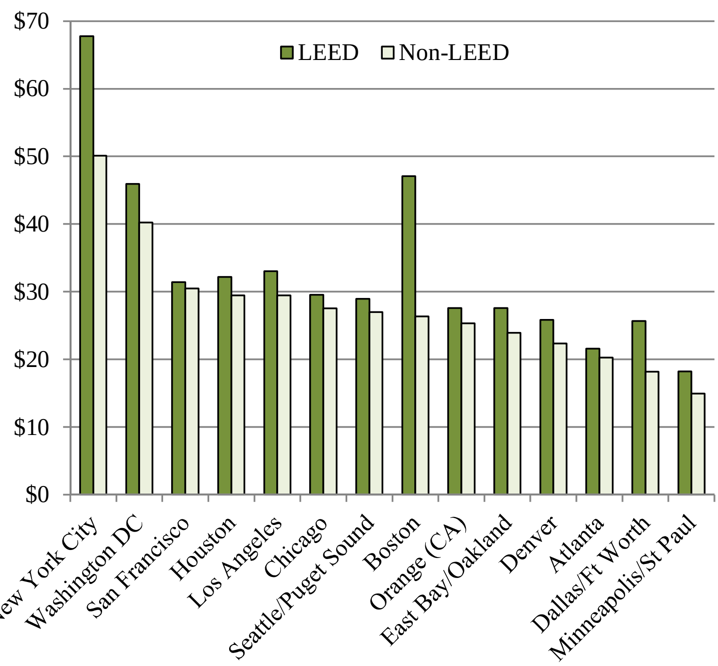
$$\log R_{in} = \alpha + \beta_i X_i + \sum_{n=1}^{N} \gamma_n c_n + \delta g_i + \varepsilon_{in}. \qquad (1)$$

In this formulation, $R_{in}$ is the contract rent (or effective rent) per square foot commanded by building $i$ in city $n$; $X_i$ is the set of hedonic characteristics of building $i$, and $\varepsilon_{in}$ is an error term. To control more precisely for locational effects, we include a set of dummy variables, one for each of the $N$ cities. $c_n$ has a value of one if building $i$ is located in city $n$ and zero otherwise. $g_i$ is a dummy variable with a value of one if building $i$ is rated by USGBC and zero otherwise. $\alpha$, $\beta_i$, $\gamma_n$ and $\delta$ are estimated coefficients. $\delta$ is thus the average premium, in percent, estimated for a labeled building relative to those buildings in its geographic cluster.

Exhibit 9 presents the basic results for the sample, relating the logarithm of rent per square foot in commercial office buildings to a set of hedonic and other characteristics of the buildings. Results are presented for ordinary least squares regression models corrected for heteroscedasticity (White, 1980). Column (1) reports a basic model relating rent to building quality, measured by class designation, size, age, and distance to public transportation. The regression, based upon 956 observations on buildings, explains some 63% of log rent, which is comparable to similar studies in this field. Higher quality buildings, as measured by building class, command a substantial premium. Rent in a Class A building is about 12% higher than in a Class B building. Rent is not significantly higher in larger buildings, as measured by the logarithm of building size. Distance to public transport, which represents an important element of sustainability, is negatively and significantly related to the rent commanded by an office building: For each mile increase to public transport, location rents decrease by about 11%. This corroborates evidence from other studies on sustainability in the property market

**Exhibit 8** | Aggregate Rents and Vacancy Rates of LEED Sample and Control Sample (By Market, 2011:Q1)

**Panel A: Rental Levels**




**Panel B: Occupancy Rates**

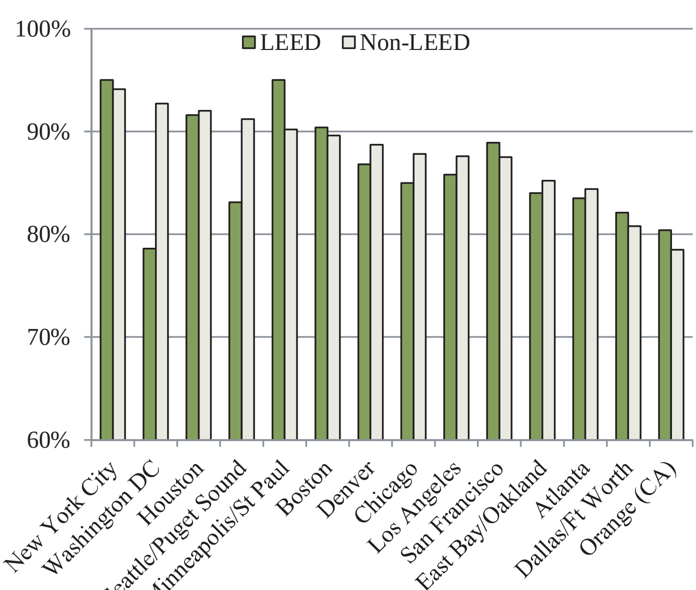


**Exhibit 9** | Regression Results

LEED Ratings and Rents

| | (1) | (2) | (3) |
|---|---|---|---|
| LEED Certified (1 = yes) | | 0.071*** | 0.052** |
| | | (0.023) | (0.023) |
| ENERGY STAR (1 = yes) | | | 0.056*** |
| | | | (0.020) |
| Building Class | | | |
| Class A (1 = yes) | 0.115*** | 0.110*** | 0.101*** |
| | (0.022) | (0.022) | (0.022) |
| Building Size (log) | −0.022 | −0.024 | −0.032 |
| | (0.020) | (0.020) | (0.020) |
| Typical Floor Area (log) | 0.030 | 0.034* | 0.037* |
| | (0.020) | (0.019) | (0.019) |
| Age (years) | 0.002 | 0.002 | 0.002 |
| | (0.001) | (0.001) | (0.001) |
| $Age^2$ (years) | −0.000* | −0.000** | −0.000** |
| | (0.000) | (0.000) | (0.000) |
| Distance to Transit (miles) | −0.112*** | −0.110*** | −0.106*** |
| | (0.015) | (0.015) | (0.015) |
| City-Fixed Effects | Y | Y | Y |
| Constant | 2.941*** | 2.887*** | 2.932*** |
| | (0.279) | (0.278) | (0.277) |
| $R^2$ | 0.636 | 0.640 | 0.643 |
| Adj. $R^2$ | 0.629 | 0.632 | 0.635 |

*Note:* Standard errors in parentheses. There are 970 observations.
*$p < 0.1$
**$p < 0.05$
***$p < 0.01$

that measured the impact of green aspects on building performance using density tools, like the Google ''Walkability'' Index. For the Dutch office market, Kok and Jennen (2012) document that a one-kilometer increase to a train station decreases rents by 13%. For the U.S. office market, Pivo and Fisher (2011) use an index to calculate distances from commercial facilities to prominent and important neighborhood amenities. Results indicate that for every 10-point increase in walkability, property values increase by about 9%, providing evidence that sustainability matters beyond the physical attributes of a building.

In column (2) of Exhibit 9, green certification is indicated by a dummy for LEED-certified buildings. Importantly, holding all other hedonic characteristics of the buildings constant, an office building with a LEED EBOM certification rents for a 7% premium, on average. Measured attributes of sustainability and energy efficiency are incorporated in property rents, and this seems to have persisted through periods of volatility in the property market.

In column (3) of Exhibit 9, the green rating is disaggregated into two components: an ENERGY STAR label and a LEED certification. The coefficients of the other variables are unaffected when the green rating is disaggregated into these component categories. Importantly, the relationship between LEED and the rental premium remains significant when an ENERGY STAR rating is taken into account as well. These results imply that energy efficiency and other indicia of sustainability are complementary. The estimated premium for buildings registered with the EPA is not significantly higher than the premium for LEED-certified office buildings. A recent analysis of the thermal properties of a small sample of LEED-certified buildings indeed concluded that these buildings do consume less energy, on average, than their conventional counterparts. However, 18%–30% of LEED-certified buildings used more energy than their counterparts (Newsham, Mancici, and Birt, 2009). In our LEED sample, there are 299 buildings (87% of those with LEED certification at any level) with both LEED certification and an ENERGY STAR rating.

Exhibit 10 presents the results when the dependent variable is measured by the logarithm of effective rent. When endogenous rent-setting policies are taken into account (we may expect property owners to adopt differing asking rent strategies, ceteris paribus, landlords who charge higher rents will experience higher vacancy rates), the results suggest that the effect of a green rating is even larger. In column (2), the statistical results suggest that a green rating is associated with a 9% increase in effective rent. In the regression reported in column (2), which is exactly similar to results documented by Eichholtz, Kok, and Quigley (forthcoming) for a large sample of LEED-certified office buildings in 2009. Taken together, the results reported in Exhibits 9 and 10 suggest that the occupancy rate of green buildings is about 2% higher than in otherwise comparable non-green buildings.

## Incremental Costs and Benefits of Energy Savings Related Improvements

On average, our empirical results suggest a rental premium of $2 per square foot a year for buildings certified by LEED for existing buildings (i.e., 7% times an average rent of some 29 dollars per square foot), which at a capitalization rate of 8% (Eichholtz, Kok, and Quigley, forthcoming) results in a value impact of $25 dollars per square foot.

We also note that more energy-efficient buildings may have significant energy savings, but do not count these as they may accrue to the benefit of the tenant, depending on the kind of lease and pass-through terms. This well-known issue is referred to as the ‘‘split incentive’’ problem, where landlords making investments in energy savings that primarily benefits the tenants who may or may not be willing to pay as much in additional rent as the suggested energy savings. Green lease provisions may be helpful in this regard, where a third-party auditor assists in determining how much the utility costs would be in the absence of specific

**Exhibit 10** | Regression Results

Green Ratings and Effective Rents

| | (1) | (2) | (3) |
|---|---|---|---|
| LEED Certified (1 = yes) | | 0.091*** | 0.058 |
| | | (0.035) | (0.037) |
| ENERGY STAR (1 = yes) | | | 0.098*** |
| | | | (0.031) |
| Building Class | | | |
| Class A (1 = yes) | 0.155*** | 0.147*** | 0.132*** |
| | (0.034) | (0.034) | (0.034) |
| Building Size (log) | 0.035 | 0.033 | 0.019 |
| | (0.032) | (0.032) | (0.032) |
| Typical Floor Area (log) | 0.033 | 0.038 | 0.044 |
| | (0.031) | (0.031) | (0.030) |
| Age (years) | 0.007*** | 0.007*** | 0.007*** |
| | (0.002) | (0.002) | (0.002) |
| $Age^2$ (years) | −0.000** | −0.000*** | −0.000*** |
| | (0.000) | (0.000) | (0.000) |
| Distance to Transit (miles) | −0.135*** | −0.132*** | −0.126*** |
| | (0.023) | (0.023) | (0.023) |
| Constant | 1.907*** | 1.839*** | 1.915*** |
| | (0.436) | (0.435) | (0.434) |
| City-Fixed Effects | Yes | Yes | Yes |
| $R^2$ | 0.487 | 0.491 | 0.496 |
| Adj. $R^2$ | 0.477 | 0.480 | 0.485 |

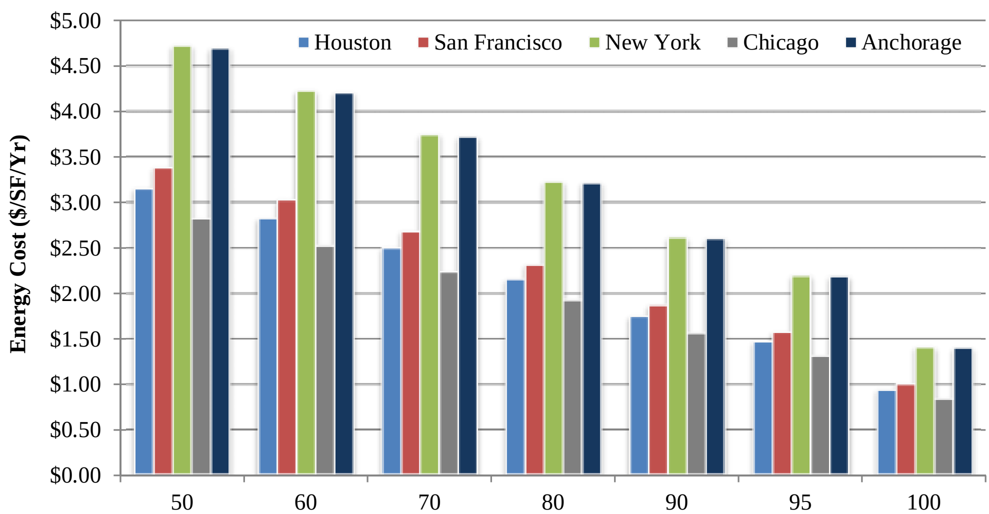
*Note:* Standard errors in parentheses. There are 952 observations.
*$p < 0.1$
**$p < 0.05$
***$p < 0.01$

improvements, and a portion of this is paid in additional rent. But we do not have sufficient detail to match up the energy savings with the rental changes to be able to draw any detailed conclusions beyond those provided by Eichholtz, Kok, and Quigley (forthcoming).

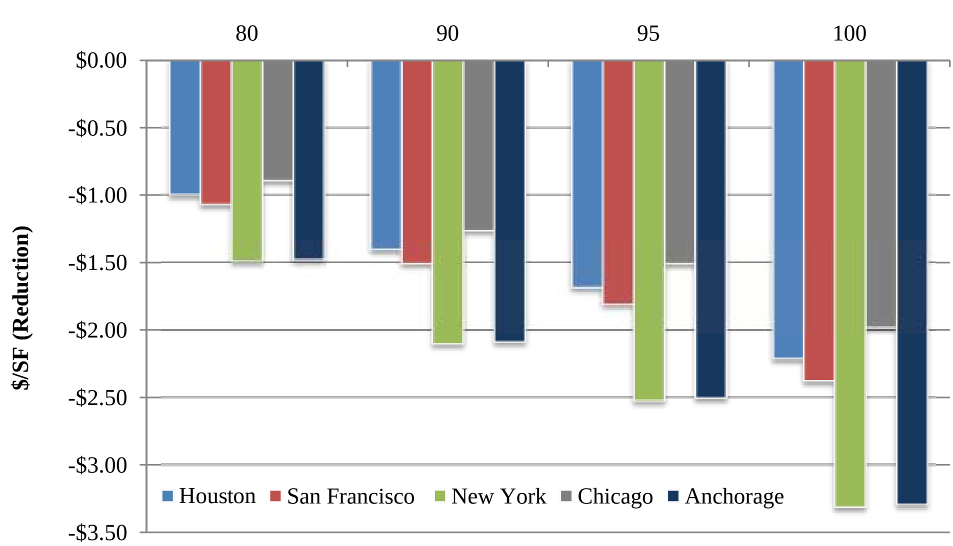
We can, however, estimate the energy-related savings and the strategies based on the work of Davis Langdon Global Construction Managers (see Exhibit 11 for an overview of commercial building energy cost and potential cost savings for five regions).[6] There are several easy strategies to conserve on energy, and we note that even non-green buildings can be well managed and green buildings can be poorly managed. Among the easiest strategies discovered in studies by Miller, Pogue, Saville, and Tu (2010) are daytime cleaning and sub-metering where

**Exhibit 11** | Energy Reduction Strategies and Costs
(www.DavisLangdon.com: see research reports)

**Panel A. Energy Costs and ENERGY STAR Scores**




**Panel B. Cost Reduction from Meeting ENERGY STAR Target (From 50)**




permitted. Davis Langdon lists the most common renovated related strategies, and each of these reduction strategies is discussed below.

**Plug Loads:** The typical office property consumes about 10 to 20 KBtus per square foot per year for plug load, but that can easily be improved to 4–10 KBtus, by replacing outdated appliances and equipment (printers, faxes, computer screens) and adding occupancy sensors that shutoff power when no there are no occupants (after an appropriate delay). ''Vampire kill switches'' also shut down the entire suite or floor power when the last person leaves the premises. Importantly, the cost for these strategies is negligible.

**Lighting:** The typical office property consumes 10–15 KBtus per square foot per year for lighting, with the best practices at 4 to 7 KBtus. Simply replacing the lights with more modern T5/T8s and motion sensors, adding task lighting and day lighting controls, and moving to daytime cleaning will accomplish this energy reduction for a cost of $3–$5 per square foot. LED lighting is even more efficient and prices are rapidly dropping. LEDs are twice as efficient as most fluorescent fixtures, so even greater efficiency will soon be possible. Day lighting can be brought in by a variety of new skylights, some with reflectors and sun tracking, as well as light diffusers.

**Ventilation:** The ideal situation for indoor air quality and energy use reduction is operable windows, but that is considered a deeper retrofit. The typical office property requires 6–10 KBtus per square foot per year and can reduce that to 3–6 KBtus for a cost of $2–$5 per square foot. The work required includes sealing air ducts, optimizing air handlers and terminal units, and better balancing heating and cooling with integration, if possible, with shade controls and windows. In some cases, large fans are brought in and the maximum comfortable temperature can be raised prior to any cooling.

**Cooling:** Typical office buildings require 15–40 KBtus per square foot per year for cooling, except for those in cooler climate zones. The current best practices are 10–20 KBtus; it costs about $3–$7 dollars per square foot to reach these with a retrofit. The typical strategies include replacing primary equipment, drying the air prior to cooling, adding large fans, and better ventilation, so that the equipment capacity can be decreased. Shading windows also helps control heat gain or adding glazing, although this is considered a deeper retrofit.

**Heating:** The typical office property requires 5–15 KBtus per square foot per year for heat, while the best practices are at 2–8 KBtus. This can be accomplished for just $1–$2 dollars per square foot by replacing primary equipment, improving controls, optimizing terminal units, and balancing heating and cooling with more localized controls.

**Water Conservation:** Water flow equipment investments are economically justified when fixtures must be replaced, but there is no reasonable economic payoff at present as water prices are often too low for any kind of significant return on investment or reasonable payback.

**Deeper Retrofits:** For $10–$75 per square foot, deeper retrofits can be accomplished, including envelope sealing, improved glazing, additional insulation, chilled beams or some form of radiant cooling. Computer-controlled window shades may be considered, along with solar photovoltaic cells or wind turbines. Energy recapture systems can also be employed on elevators. Such strategies typically reduce the energy consumed by 10–25 KBtus and can add energy generation equal to that consumed in some cases.

The summary table below provides an overview of the renovation strategies, their costs, and estimated savings. Quite clearly, the capitalized benefits of a light retrofit (some $25 per square foot) outweigh the costs, ceteris paribus.

| Strategy | KBtu / SF / Yr (Reduction) | Cost / SF |
|---|---|---|
| Plug Load | 6–15 | Minor |
| Lighting | 6–8 | $3–$5 |
| Ventilation | 4–5 | $2–$5 |
| Cooling | 10–15 | $3–$7 |
| Heating | 3–10 | $1–$2 |
| Total | 30–50 | $10–$20 |

## Summary and Conclusions

Existing building retrofits have accelerated over the past several years. Since 2008, achieving LEED certification for existing buildings has become an attainable goal and it now outpaces LEED certification for new construction. This paper is the first to address the financial implications of LEED EBOM certification in the U.S. commercial property market. Using a survey among the managers of 374 buildings, an empirical analysis of data on rents and occupancy, and anecdotal information on retrofit costs, we document that investments in sustainability features and strategies seem to result in value impacts likely to exceed costs. Our LEED EBOM sample, which included most of the renovated buildings in major cities from 2005 through 2010, exhibits significant rental premiums compared to a large, matched control sample. In addition, there are other operational cost factors that favor green buildings over conventional buildings. For example, some insurance firms now charge lower premiums once buildings have attained LEED certification.[7]

Our results are consistent with those findings observed on new construction of LEED-certified buildings. Most salient is the fact that the types of office space renovations observed here for improved productivity and energy efficiency apply to a much larger pool of candidate properties. These market developments will continue to affect the existing stock of non-certified office buildings, especially as regulatory trends are forcing greater energy consumption transparency upon the commercial real estate market and as tenants report on actions to achieve corporate social responsibility goals via portfolio sustainability reporting tools such as the Global Reporting Initiative and the Global Real Estate Sustainability Benchmark,[8] and the plethora of building-level benchmarks now available for assessing the sustainability of commercial real estate.[9]

## Endnotes

1 For example, one study on Australia, by Miller and Buys (2008), examined the benefits of retrofits from the perspective of tenants in a large office property. They found positive

sentiments that green retrofits would continue and were well received by tenants. No study we are aware of has examined the economics of retrofits based on a broadly selected sample.

[2] CBRE. 2010. Locational Preferences of Central London Occupiers. CBRE Research.

[3] See Corporate Occupier Sustainability Perspectives–2012 by Corenet Global, CBRE, and the University of San Diego.

[4] Jones Lang LaSalle. 2009. The Performance Measurement Challenge.

[5] British Land. 2010. Achieving More Together: Corporate Responsibility Summary Report 2010.

[6] See http://www.davislangdon.com/Global/.

[7] For example, Fireman's Fund charges about 5% lower insurance premiums for such buildings.

[8] See https://www.globalreporting.org/ and http://www.gresb.com.

[9] For example, LEED (global), BREEAM (global), ENERGY STAR (U.S.), CASBEE (Japan), HK BEAM (Hong Kong), Green Star (Australia), HQE (France), and DGNB (Germany).

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