

RESEARCH REPORT

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# RICS RESEARCH

DOING WELL BY DOING GOOD? AN ANALYSIS OF THE FINANCIAL PERFORMANCE OF GREEN OFFICE BUILDINGS IN THE USA

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**This report describes a research project aimed at assessing the financial performance of ‘green’ office buildings in the United States of America, carried out by Piet Eichholtz and Nils Kok of Maastricht University, the Netherlands, and John Quigley of the University of California, Berkeley, United States of America. It is in two parts. First, there is a non-technical summary of the work, which gives the background to the work, an overview of the research and the main results. This is then followed by the researchers’ full technical paper, which gives the detailed specification of the research methodology and the complete results.**

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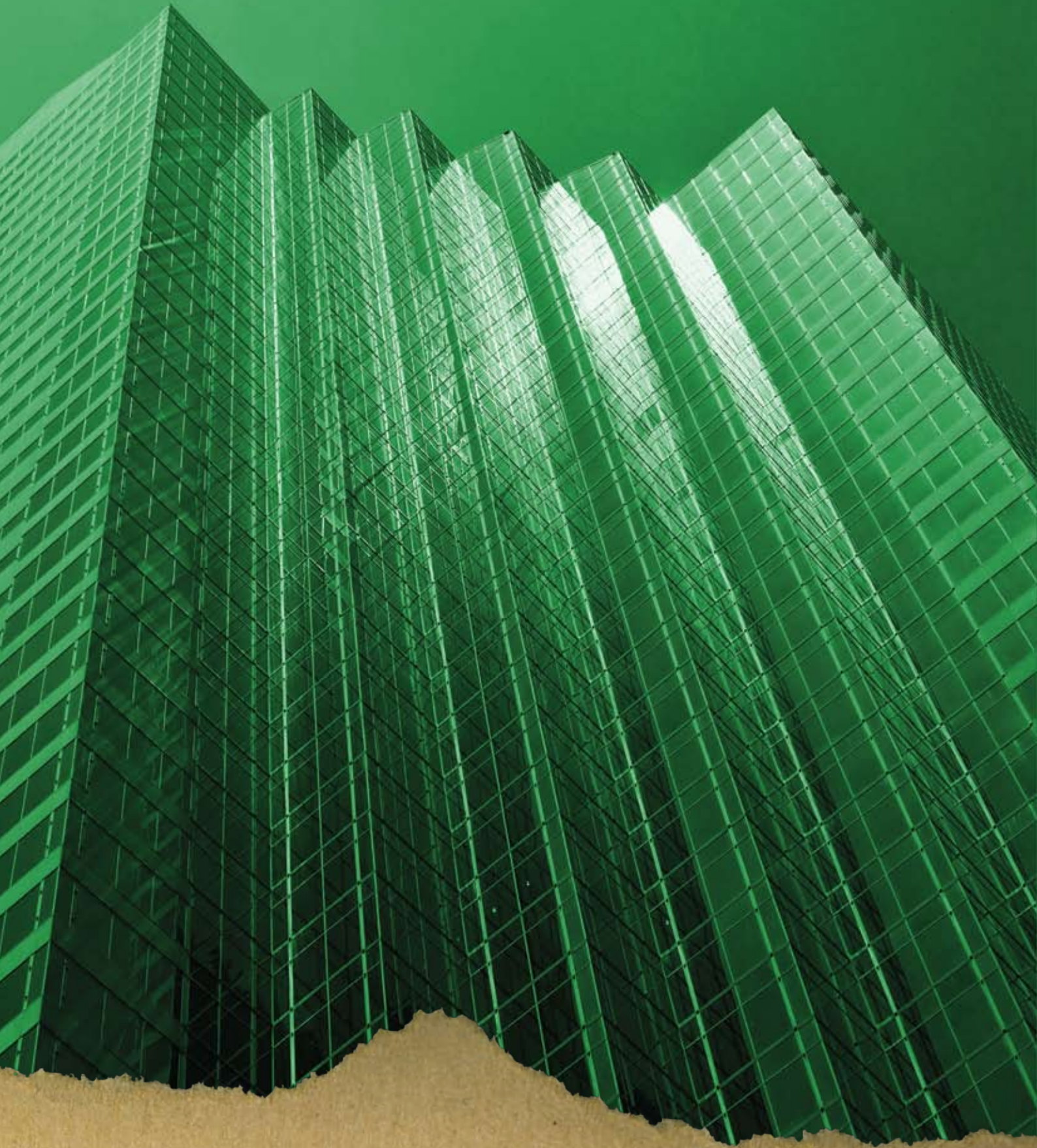
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DOING WELL BY DOING GOOD

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## Part A Summary

**When the opportunity arose in April 2008 for the Royal Institution of Chartered Surveyors (RICS) to help support a global research programme being developed by Piet Eichholtz and Nils Kok of Maastricht University, and John Quigley of the University of California, Berkeley, into the financial performance of 'green' office buildings, it was one that we welcomed and valued. To be able to work with researchers to examine in a rigorous and impartial manner whether there was a financial premium attached to 'green' buildings is central to the aims and aspirations of RICS.**

It has become increasingly clear that the design and operation of the built environment is both a problem and opportunity – a problem to the extent that it is a major source of greenhouse gases, but an opportunity, in that we know that we can take realistic and practical steps to reduce those emissions. Awareness of this fact is growing. The increasing emphasis on “green rating” systems for buildings - initiated by both government and industry - gives witness to this development. In general, these ratings assess the energy footprint of buildings, and they may provide owners and occupants with a solid yardstick for measuring the energy efficiency and sustainability of properties. However, the use of these ratings has so far been limited, and the global diffusion of rating systems is relatively slow. Moreover, both real estate developers and institutional investors are understandably uncertain about how far to go in implementing environmental investments, since the economic rationale for the development of sustainable buildings is based almost entirely on anecdotal evidence.

Alongside this, we have been seeing an increasing trend in the corporate sector to engage with and take on board corporate social responsibility (CSR) as a way of informing business decisions. It has been suggested that companies that embrace CSR may be able to out-perform others for a number of reasons, such as improved corporate reputation, less pressure of regulation, and improved profitability through lower input costs and higher employee productivity. In terms of how this relates to real estate investment, it may have an impact through:

- The impact on the construction process in terms of materials used and processes adopted
- 'Green' buildings having a longer economic life
- Enhanced employee productivity as a result of improved internal environmental quality
- Improved corporate image through occupying 'green' buildings







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## Summary

What we, therefore, wanted to know is whether investors are prepared to pay a premium for 'green' buildings and, if so, what that premium might be. This research programme seemed to give us the opportunity to develop those kinds of insights. For developers to be prepared to commit money and resources to 'green' buildings, they need to be confident that there will be a market for their product. If there is no premium, why go to the trouble and expense of creating a premium product? Up until now, there has been much anecdotal evidence, but none of this has been tested in the marketplace. What, however, is needed is hard evidence and this is what we set out to find.

Here we report on the first study that Piet Eichholtz, Nils Kok and John Quigley have undertaken in this research programme, which explores the financial performance of 'green' office buildings in the United States of America, definitely the largest and probably the most sophisticated real estate market in the world. If we can find evidence there, it would be extremely powerful in supporting the case that investing in 'green' buildings is more than just good for the planet.

### How did they go about this?

The first task that the researchers had to undertake was to draw up the sample. In the USA, there are two major rating systems for 'green' buildings – Energy Star and LEED.

The Energy Star program is jointly sponsored by two Federal agencies: the U.S. Environmental Protection Agency, and the U.S. Department of Energy. It began in 1992 as a voluntary labeling program designed to identify and promote energy-efficient products in order to reduce greenhouse gas emissions, and was extended to non-residential buildings in 1995.

Non-residential buildings can receive an Energy Star certification if the site energy use, the source energy use, and the greenhouse gas emissions of the building achieve certain specified benchmark levels. The benchmark is chosen so that the label is awarded to the top quarter of all comparable buildings, ranked in terms of energy efficiency. The Energy Star label is marketed as a

commitment to conservation and environmental stewardship. But it is also promoted as a vehicle for reducing building costs and for demonstrating superior management skill. Indeed, the Energy Star website draws attention to the relationship between energy conservation in buildings and other indicia of good "corporate governance". As of October 2008, 5,709 buildings in the U.S. had been awarded the Energy Star designation, including 2,230 office buildings.

The U.S. Green Building Council (USGBC), a private non-profit organization, has developed the LEED ("Leadership in Energy and Environmental Design") green building rating system to encourage the "adoption of sustainable green building and development practices." Since adoption in 1999, separate standards have been applied to new buildings and to existing structures. The requirements for certification of LEED buildings are substantially more complex than those for the award of an Energy Star rating, and additional points in the certification process are awarded for such factors as "site selection," "brownfield redevelopment," and the availability of "bicycle storage and changing rooms," as well as energy performance.

It is claimed that LEED-certified buildings have lower operating costs and increased asset values and provide healthier and safer environments for occupants. It is also noted that the award of a LEED designation "demonstrate[s] an owner's commitment to environmental stewardship and social responsibility". As of October 2008, there were 1,703 buildings certified by the LEED Program of the USGBC<sup>1</sup>.

Both Energy Star and LEED provide the addresses of the buildings that they cover, so the next step was to get data on their financial performance. This has been obtained from the CoStar Group, and by matching the three sources, it was possible to identify 1,360 green office buildings which could be identified in CoStar, of which 286 were certified by LEED, 1,045 were certified by Energy Star, and 29 were certified by both LEED and Energy Star<sup>2</sup>.

<sup>1</sup>The USGBC does not release the composition of its LEED-rated buildings, so the exact number of commercial office buildings with USGBC ratings is not available.

<sup>2</sup>In the September 2007 version of the CoStar database, green-rated buildings are separately identified. However, in matching the Energy Star and LEED-certified buildings by street address, we discovered that about a quarter of the buildings certified by Energy Star and LEED had not been recorded in the CoStar database.



Of the total of 1,360 possible buildings that could be analysed, the researchers could find all the required matching data from CoStar on 893, comprising 694 for which the researchers have rental data as of September 2007, and 199 that were sold between 2004 and 2007.

Figure 1 shows where these buildings are located. As can be seen from this, in some states – notably Texas, Washington, and Minnesota – more than 5% of office buildings are ‘green’ rated. The highest proportion is in California, where almost 9% – some 122 million square feet – of office space are labeled. In a large number of states, however, only a small fraction of office space is certified by Energy Star or the USGBC. Apart from California, it seems that states that experience extreme temperatures are more likely to have ‘green’ rated office buildings.

In order to be able to say anything meaningful about the financial performance of these buildings, it is not enough just to explore their own performance – that needs to be compared to buildings in similar markets that are not ‘green’. How did they do this? The approach that they took was to identify every building in the CoStar dataset that was within a radius of a quarter of a mile of the sample of 893 buildings – this resulted in a sample of 9,998 buildings for which financial data could be obtained. Of course, some locations are better-provided than others – as can be seen from figure 2, there are 41 buildings in the cluster around one of the ‘green’ buildings in Chicago, while in Houston, there are six nearby non-‘green’ buildings. In Columbus, there is just one non-‘green’ building in the locality. This is probably not surprising – although one can always hope for more comparables, we can only work with the material that we have available to us. The researchers were then able – taking care to account for inherent differences between the ‘green’ and non-‘green’ in terms of their size, age and quality – to extract the differences in financial performance between the two sets of buildings.

### **What did they find?**

The overall conclusion is that there is, indeed, a premium for the rents that ‘green’ buildings with the Energy Star rating can command, but no premium could be found for LEED-rated buildings. Obviously, it varies according

to a number of factors, but the aggregate premium for the whole sample is in the order of 3% per square foot compared with otherwise identical buildings – controlling for the quality and the specific location of office buildings. When looking at effective rents – rents adjusted for building occupancy levels – the premium is even higher, above 6%. The researchers were also able to look at the impact on the selling prices of green buildings, and here the premium is even higher, in the order of 16%. This really is quite significant – what it implies is that upgrading the average non-‘green’ building to a ‘green’ one would increase its capital value by some \$5.5 million (that, of course, does not take account of the cost of conversion, so this is not pure profit).



**Upgrading the average non-‘green’ building to a ‘green’ one would increase its capital value by some \$5.5 million.**

This research has been able to take the analysis one step further – up until now, the analysis has had to simply assess the value of the ‘label’ – what is the premium for having a LEED or Energy-Star label? What has not been possible until now to unpick is what is actually driving that premium, within the label. For the first time, we have been able to unpick that. For 494 of the Energy-Star-certified buildings in this sample, the researchers were subsequently able to obtain detailed estimates of site and source energy usage from the U.S. Environmental Protection Agency, so they were able to make a precise analysis of the relationship between actual energy use in building and financial performance. Again, they find evidence of out-performance for energy-efficient buildings – for instance, an increase of 10% in the site energy utilization efficiency of a green building is associated with a 0.2% increase in effective rent – and this is over and above the six percent premium for a labeled building. The analysis also shows that a \$1 saving in energy costs from increased thermal efficiency yields a return of roughly \$18 in the increased valuation of an Energy-Star certified building.

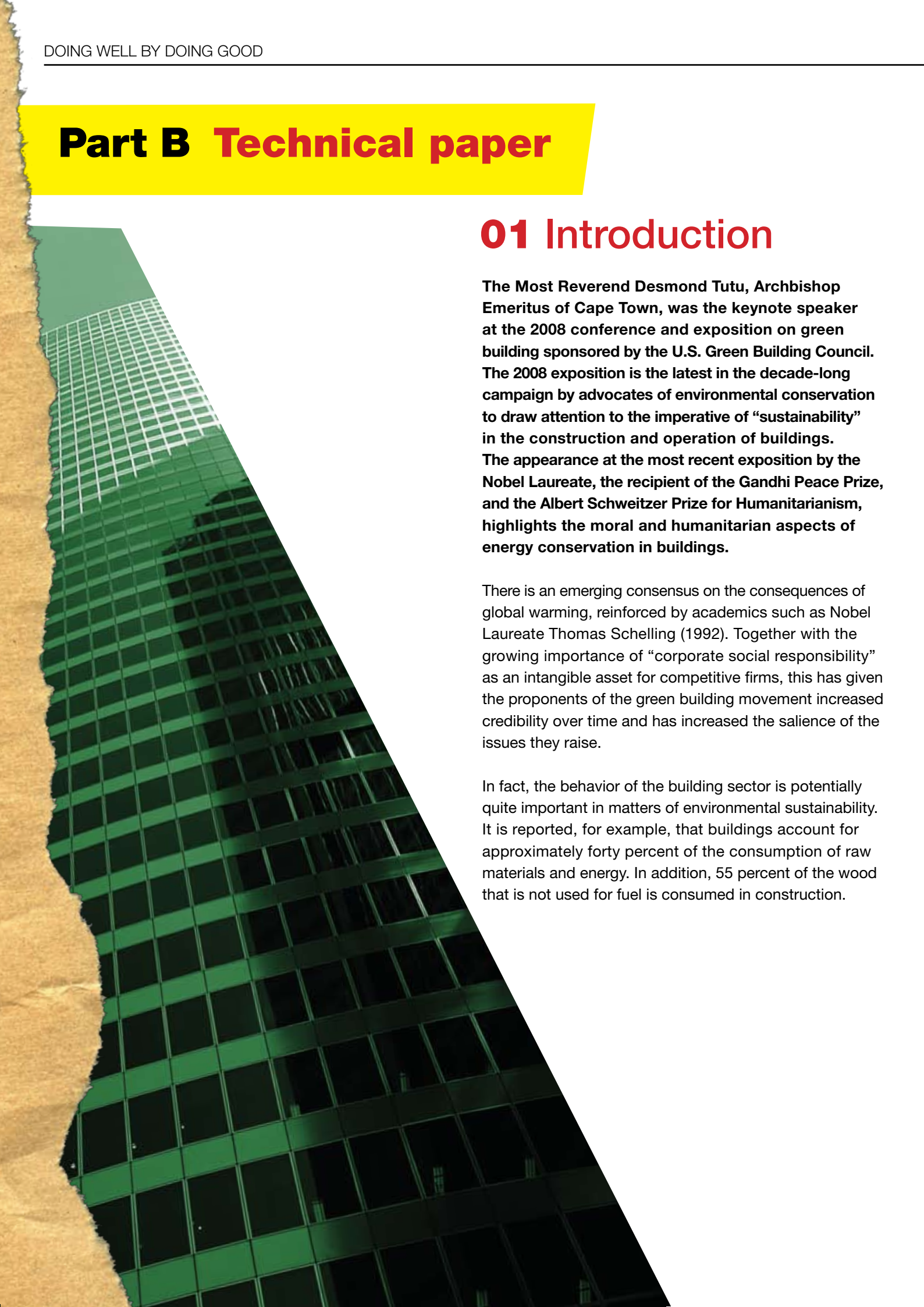
## Part B Technical paper

### 01 Introduction

**The Most Reverend Desmond Tutu, Archbishop Emeritus of Cape Town, was the keynote speaker at the 2008 conference and exposition on green building sponsored by the U.S. Green Building Council. The 2008 exposition is the latest in the decade-long campaign by advocates of environmental conservation to draw attention to the imperative of “sustainability” in the construction and operation of buildings. The appearance at the most recent exposition by the Nobel Laureate, the recipient of the Gandhi Peace Prize, and the Albert Schweitzer Prize for Humanitarianism, highlights the moral and humanitarian aspects of energy conservation in buildings.**

There is an emerging consensus on the consequences of global warming, reinforced by academics such as Nobel Laureate Thomas Schelling (1992). Together with the growing importance of “corporate social responsibility” as an intangible asset for competitive firms, this has given the proponents of the green building movement increased credibility over time and has increased the salience of the issues they raise.

In fact, the behavior of the building sector is potentially quite important in matters of environmental sustainability. It is reported, for example, that buildings account for approximately forty percent of the consumption of raw materials and energy. In addition, 55 percent of the wood that is not used for fuel is consumed in construction.





Overall, buildings and their associated construction activity account for at least thirty percent of world greenhouse gas emissions (RICS, 2005). And once a building is constructed, the energy consumption associated with it continues. The impact of energy costs directly affects the bottom-line of tenants and building owners. Energy represents thirty percent of operating expenses in a typical office building; this is the single largest and most manageable operating expense in the provision of office space.

Thus the design and operation of real estate can play an important role in energy conservation in advanced societies. Awareness of this fact is growing. The increasing emphasis on “green rating” systems for buildings - initiated by both government and industry - gives witness to this development. In general, these ratings assess the energy footprint of buildings, and they may provide owners and occupants with a solid yardstick for measuring the energy efficiency and sustainability of properties. However, the use of these ratings has so far been limited, and the global diffusion of rating systems is relatively slow. Moreover, both real estate developers and institutional investors are understandably uncertain about how far to go in implementing environmental investments, since the economic rationale for the development of sustainable buildings is based almost entirely on anecdotal evidence. This contrasts with a growing body of evidence on the profitability of incorporating eco-efficiency measures in strategic management and investment decision-making (Margolis and Walsh, 2003).

This paper provides the first systematic analysis of the impact of environmentally-sustainable building practices upon economic outcomes measured in the marketplace. We concentrate on commercial property and investigate the relationship between investments in energy efficiency in design and construction and the rents, effective rents, and selling prices commanded by these properties. We analyze a large sample of buildings, some of which have been certified as more energy efficient by independent and impartial rating services.

We assemble a national sample of U.S. office buildings which have been evaluated for energy efficiency by one of two leading agencies. For each building, we identify

a control sample of nearby office buildings. For some 10,000 subject and control buildings, we relate contract rents, effective rents and selling prices to a set of objective hedonic characteristics of buildings, holding constant the locational characters of properties. We find that buildings with a “green rating” command rental rates that are roughly three percent higher per square foot than otherwise identical buildings – controlling for the quality and the specific location of office buildings. Premiums in effective rents, i.e., rents adjusted for building occupancy levels, are even higher – above six percent. Selling prices of green buildings are higher by about 16 percent.

Beyond the average price or rental premium, our methodology also permits us to estimate the increment for each “green building” relative to the control buildings in its immediate geographic neighborhood. We find, for example, that the relative premium for “green buildings” is higher, *ceteris paribus*, in places where the economic premium for location is lower. That is, the percent increase in rent or value for a green building is systematically greater in smaller or lower-cost regions or in less expensive parts of metropolitan areas.

For some 500 buildings which have been certified as energy efficient by the Energy Star program, we obtained the engineering estimates of thermal efficiency which were submitted in the certification process. Within this population of certified “green buildings,” we find that variations in effective rent and market value are systematically related to the energy efficiency of buildings. This suggests that the increment to rent or value attributable to its certification as “green” reflects more than an intangible labeling effect.

Section 2 provides a brief review of the emerging literature on corporate social responsibility and its relationship to environmentally sustainable buildings. In Section 3 we discuss the sources of ratings for the environmental aspects of buildings, and we describe the data used in our analysis, a unique body of micro data on the economic and hedonic characteristics of office buildings. We also discuss the engineering data made available to us by the U.S. Environmental Protection Agency. Section 4 presents our methodology and empirical results. Section 5 is a brief conclusion.

## 02 Social responsibility

“Corporate social responsibility” (CSR, Waddock and Graves, 1997) has become a normative standard that describes firms’ choices about inputs (e.g., the source of raw materials), internal processes (e.g., the treatment of employees), and publicity (e.g., community relations). Judgments about the social responsibility of private firms have become an investment criterion for some investors, and it is estimated that \$2.7 trillion is currently allocated to “socially-screened” portfolios in the United States alone (Social Investment Forum, 2007). However, the economic rationale for investing in companies or investment funds that rank high in corporate social performance is a matter of debate, and there is no consensus about the financial performance of these investments (Margolis and Walsh, 2003).

Companies with well-defined and aggressive CSR policies might be able to outperform others for several reasons: improved corporate reputation (Turban and Greening, 1997), less intrusion from activists and governmental organizations (Baron, 2001, Lyon and Maxwell, 2006), reduced threat of regulation (Maxwell et al., 2000), and improved profitability through lower input costs and higher employee productivity. The latter two represent the most tangible elements of corporate social responsibility.

In the real estate sector, these issues of eco-efficiency are confounded with straightforward capital budgeting decisions involving choices between the levels and types of initial investment and consequent operating inputs chosen to maximize investor returns. In this context, the investment in green buildings could lead to economic benefits in several distinct ways.

First, investments at the time of construction or renovation may: save current resources expended on energy, water and waste disposal; decrease other operating costs; insure against future energy price increases; and simultaneously decrease greenhouse gas emissions. The financial benefits of energy savings and waste reduction are measurable, but existing empirical studies focus on environmental consequences rather than financial performance. For example, Khanna and Damon (1999) study how reductions in releases of chemicals influence financial performance in the chemical industry; they find that firms that reduce the release of toxic chemicals suffer losses in the short run, but gain in the long run. For real estate, the evidence on

energy savings in green buildings is typically based upon engineering studies of energy usage. There seems to be a consensus that a variety of capital expenditures improving energy efficiency in property are cost-effective at reasonable interest rates, given current and projected energy costs.

Second, an improved indoor environmental quality in green buildings might result in higher employee productivity. But while energy and waste savings can be measured fairly precisely, the relation between employee productivity and building design or operation is far more complicated. The financial impact of healthier and more comfortable green buildings is hard to assess, in part because the cost of poor indoor environmental quality (for example, lower productivity and higher absenteeism) may simply be hidden. However, there is popular discussion of the putative health and productivity costs that are imposed by poor indoor environmental quality in commercial buildings (<http://www.epa.gov/iaq>). In reliance upon this, tenants may be willing to pay a higher rent for buildings in which indoor environmental quality is better.

Third, locating corporate activities in a green building can positively affect the corporate image of tenants. Leasing space in a green building may send a concrete signal of social awareness, and of the superior social responsibility of tenants. This may be important for some firms, and it may be a determinant of corporate reputation (Frombrun and Shanley, 1990). Favorable reputations may enable firms to charge premium prices (Klein and Leffler, 1981), to attract a better workforce (Turban and Greening, 1997), and to attract investors (Milgrom and Roberts, 1986). As a result, tenants may be willing to pay higher rents for green buildings.



Fourth, sustainable buildings might have longer economic lives – due to less depreciation – and lower volatility in market value – due to less environmental and marketability risk – leading to reduced risk premiums and higher valuations of the properties. Orlitzky and Benjamin (2001) address the relation between corporate social performance and risk, and argue that the better a firm's social reputation, the lower its total market risk. If this relationship holds for the real estate sector, building green may result in a lower cost of capital and higher building valuation. So, even if green buildings did not command higher spot rents, they could still be valued higher.

Economists are quick to point out that many of these advantages could be obtained if energy inputs were appropriately priced (to reflect their social and environmental costs). Appropriate investments in energy efficiency would minimize life-cycle costs discounted at market rates, maximize developer returns, and correctly economize on energy costs (Quigley, 1985, 1991). But to the extent that productivity, corporate image, and intangible or hard-to-measure returns are important, simple adjustments of input prices are just that – too simple.

If the economic benefits of green building for commercial property are indeed reflected in tenants' willingness to pay premiums on net rent for green spaces or in lower risk premiums for green buildings, this would enable investors to offset the higher initial investment required for sustainable buildings, or even to command higher risk-adjusted returns. However, for real estate investors, hard evidence on the financial performance of green buildings is limited and consists mainly of industry-initiated case studies. An example is the report for California's Sustainable Building Task Force (2003) on the costs and financial benefits of green buildings. For a sample of 33 California buildings with green ratings, it was concluded that the financial benefits of green design were ten times as large as the incremental outlays to finance those green investments. However, the sources of the financial benefits identified in this case study are diverse, hard to quantify, and they were not verified by market transactions. To persuade real estate developers and investors in the global marketplace of the benefits of "eco-investment," the payoff from investment in green buildings needs to be identified in that same marketplace.

## 03 Data on commercial buildings

In the USA, there are two major programs that encourage the development of energy-efficient and sustainable buildings through systems of ratings to designate and publicize exemplary buildings. The Energy Star program is jointly sponsored by two Federal agencies, the U.S. Environmental Protection Agency, and the U.S. Department of Energy. Energy Star began in 1992 as a voluntary labeling program designed to identify and promote energy-efficient products in order to reduce greenhouse gas emissions. Energy Star labels were first applied to computers and computer equipment and were later extended to office equipment, to residential heating and cooling equipment, and to major appliances. The Energy Star label was extended to new homes in 1993 and has been promoted as an efficient way for consumers to identify builders as well as buildings constructed using energy-efficient methods. The Energy Star label is marketed as an indication of lower ownership costs, better energy performance, and higher home resale values. The label is also marketed as an indication of better environmental protection, and the Energy Star website for new homes stresses that “your home can be a greater source of pollution than your car.” The Energy Star label was extended to non-residential buildings in 1995.

Non-residential buildings can receive an Energy Star certification if the site energy use, the source energy use, and the greenhouse gas emissions of the building, as certified by a professional engineer, achieve certain specified benchmark levels. The benchmark is chosen so that the label is awarded to the top quarter of all comparable buildings, ranked in terms of energy efficiency. The Energy Star label is marketed as a commitment to conservation and environmental stewardship. But it is also touted as a vehicle for reducing building costs and for demonstrating superior management skill. Indeed, the Energy Star website draws attention to the relationship between energy conservation in buildings and other indicia of good “corporate governance.”

As of October 2008, 5,709 buildings in the U.S. had been awarded the Energy Star designation, including 2,230 office buildings.

The U.S. Green Building Council (USGBC), a private non-profit organization, has developed the LEED (“Leadership in Energy and Environmental Design”) green building rating system to encourage the “adoption of sustainable green building and development practices.” Since adoption in 1999, separate standards have been applied to new buildings and to existing structures. The requirements for certification of LEED buildings are substantially more complex than those for the award of an Energy Star rating, and additional points in the certification process are awarded for such factors as “site selection,” “brownfield redevelopment,” and the availability of “bicycle storage and changing rooms,” as well as energy performance.

It is claimed that LEED-certified buildings have lower operating costs and increased asset values and provide healthier and safer environments for occupants. It is also noted that the award of a LEED designation “demonstrate[s] an owner’s commitment to environmental stewardship and social responsibility.”







## Data on commercial buildings



As of October 2008, there were 1,703 buildings certified by the LEED Program of the USGBC<sup>3</sup>. Energy-Star-rated buildings and LEED-rated buildings are identified by street address on the websites of Energy Star and the USGBC respectively. We matched the addresses of the rated buildings in these two programs as of September 2007 to the office buildings identified in the archives maintained by the CoStar Group. The CoStar service and the data files maintained by CoStar are advertised as “the most complete source of commercial real estate information in the U.S.” The CoStar Group maintains an extensive micro database of approximately 332,000 U.S. commercial buildings, their locations, and hedonic characteristics, as well as the current tenancy and rental terms for the buildings. A separate file is maintained of the recent sales of commercial buildings. Our match yielded 1,360 green office buildings which could be identified in CoStar, of which 286 were certified by LEED, 1,045 were certified by Energy Star, and 29 were certified by both LEED and Energy Star<sup>4</sup>.

Figure 1 provides a geographic summary of our match between the Energy Star-certified commercial office buildings, the LEED-certified buildings, and the universe of commercial buildings identified in CoStar. The figure reports the number of certified commercial office buildings in each state, as well as an estimate of the fraction of office space in each state which has been rated for environmental sustainability<sup>5</sup>. About four percent of U.S. office building space is green-labeled. As the map indicates, in some states – notably Texas, Washington, and Minnesota – more than five percent of office buildings are rated. The incidence of green office space is almost nine percent in California – 122 million square feet of office space are labeled. In a large number of states, however, only a small fraction of office space is certified by Energy Star or the USGBC. Apart from California, states with extreme temperatures are apparently more likely to have rated office buildings.

### 3.1 The analysis sample

Of the 1,360 rated buildings identified in the CoStar database, current information about building characteristics and monthly rents were available for 694 buildings. In addition, 199 of these buildings were sold between 2004 and 2007<sup>6</sup>. To investigate the effect of energy efficiency on the rents and values of commercial buildings, we matched each of the rated buildings in this sample to nearby commercial buildings in the same market. Based upon the latitude and longitude of each rated building, we used GIS techniques to identify all other office buildings in the CoStar database within a radius of one quarter mile. In this way, we created 893 (i.e., 694 plus 199) clusters of nearby office buildings. Each small cluster – 0.2 square miles – contains one rated building and at least one non-rated nearby building. On average, each cluster contains about 12 buildings. There are 8,182 commercial office buildings in the sample of green buildings and control buildings with rental data, and there are 1,816 buildings in the sample of buildings which have been sold.

Figure 2 illustrates the research design - designated clusters of nearby properties. For the green building pictured in Chicago, the map indicates that there are 41 non-green office buildings within the surrounding 0.2 square miles. For the green building in Houston, there are six nearby non-green buildings, while for the green building in Columbus, there is only one non-green building within a quarter of a mile.

<sup>3</sup>The USGBC does not release the composition of its LEED-rated buildings, so the exact number of commercial office buildings with USGBC ratings is not available.

<sup>4</sup>In the September 2007 version of the CoStar database, green-rated buildings are separately identified. However, in matching the Energy Star and LEED-certified buildings by street address, we discovered that about a quarter of the buildings certified by Energy Star and LEED had not been recorded in the CoStar database.

<sup>5</sup>Ratios based upon the CoStar data probably overstate the fraction of green office space in the U.S. inventory, since CoStar's coverage of smaller and older office buildings is less complete.

<sup>6</sup>We choose this interval, 2004 – 2007, in part, because the formula for rating office buildings was unchanged throughout the period.

## Data on commercial buildings

Table 1 compares the average characteristics of the green buildings with the nearby buildings selected for comparison. For the rental sample, the green buildings are substantially larger, on average, than the nearby control buildings. They have slightly higher occupancy rates, and the cross-sectional variability in occupancy is lower for green buildings than for the control buildings. Green buildings are also more likely to have a net rent contract, in which the tenants pay directly for utilities. On average, the green buildings are slightly taller, by about two stories. The green buildings are much newer, averaging about 24 years in age while buildings in the control sample are about 49 years old, on average. Because they are older, the control buildings are much more likely to have been renovated than are the green buildings.

The overall quality of the green buildings is substantially higher. 79 percent are rated as “class A,” while only 35 percent of the control buildings have that rating. Only about one percent of the green buildings are rated as class C, while over 16 percent of the control buildings have this rating. A larger fraction of green buildings have on-site amenities such as retail shops, mail rooms, and exercise facilities.

The sample of sold buildings exhibits the same qualitative features, but the differences between the green and the non-green buildings are larger. Certified green buildings are twice as large, and about six stories taller. They are of much higher quality, and they are much newer. Eighty percent of the green buildings are considered class A buildings, while only 22 percent of the non-green buildings have this rating. Thirty-seven percent of the green buildings are less than twenty years old; only eleven percent of the non-green buildings are less than twenty years old.

The figures in Appendices A and B further illustrate the differences in the distributions of characteristics between the green buildings and the control sample. As reported in panel A in each appendix, the age distribution of the control sample is bimodal, with a substantial fraction above 50 years of age. Panel B illustrates the differences in effective rents and selling prices between the green samples and the control samples, while panel C illustrates the differences in the size distributions between the green and non-green buildings in the two samples.









## 04 Empirical analysis

### 4.1 The premium for labeled buildings

To investigate how the certification of energy efficiency influences the rent and value of commercial office buildings, we use the standard valuation framework for commercial real estate. The sample of energy-rated office buildings and the control sample consisting of one-or-more nearby nonrated office buildings are used to estimate a semi-log equation relating office rentals (or selling prices) per square foot to the hedonic characteristics of the buildings (e.g., age, building quality, amenities provided, etc.) and the location of each building:

(1a)

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

(1b)

$$\log R_{in} = \alpha + \beta_i X_i + \sum_{n=1}^N \gamma_n c_n + \sum_{n=1}^N \delta_n [c_n \cdot g_i] + \varepsilon_{in}^{**}$$

In the formulation represented by equation (1a), the dependent variable is the logarithm of the rent per square foot  $R_{in}$  in commercial office building  $i$  in cluster  $n$ . In other results presented, the dependent variable is the logarithm of effective rent per square foot<sup>7</sup> or the selling price per square foot.  $X_i$  is a vector of the hedonic characteristics of building  $i$ . To control for regional differences in demand for office space,  $X_i$  also includes the percentage increase in employment in the service sector for the Core Based Statistical Area (CBSA) containing a cluster of a green building and its nearby controls<sup>8</sup>.  $c_n$  is a dummy variable with a value of 1 if building  $i$  is located in cluster  $n$  and zero otherwise.  $g_i$  is a dummy variable with a value of 1 if building  $i$  is rated by Energy Star or USGBC and zero otherwise.  $\alpha$ ,  $\beta_i$ ,  $\gamma_n$  and  $\delta$  are estimated coefficients, and  $\varepsilon_{in}$  is an error term. For the sample of rental properties in expression (1a), there are 694 location coefficients which may affect office rents, one for each of the  $N$  distinct 0.2-square-mile clusters<sup>9</sup>. The increment to rent associated with a rated building is

$\exp[\delta]$ . For the sample of sold buildings, there are 199 location coefficients, one for each cluster, as well as dummy variables for the year of sale<sup>10</sup>.

In equation (1b), the locational measure is further generalized. In this formulation, the effect on commercial rents or selling prices of a green rating may vary separately for green buildings in each of the 694 clusters in the rental sample and for green buildings in each of the 199 clusters in the sample of sold buildings. The increment to rent or market value for the green building in cluster  $n$ , relative to the rents of the other buildings in cluster  $n$ , is  $\exp[\delta n]$ .

Table 2 presents the basic results for the rental 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 heteroskedasticity (White, 1980). Column (1) reports a basic model relating rent to building quality, measured by class designation, size, and occupancy rate. The regression, based upon 8,182 observations on buildings (694 rated buildings and 7,488 control buildings, each located within 1,300 feet of a rated building), explains some 71 percent of log rent. When rents are quoted gross, they are about five percent higher than when they are quoted net of utilities. Higher quality buildings, as measured by building class, command a substantial premium. Rent in a class A building is about twenty-three percent higher than in a class C building, and about thirteen percent higher than in a class B building. Rent is significantly higher in larger buildings, as measured by square footage, but the magnitude is quite small, about one percent for an additional 100,000 square feet. Employment growth in the service sector has a strong effect on rents; one percent increase in employment in the service sector leads to an increase of 0.6 percent in rent. The coefficients for the 694 dummy variables for location are highly significant, with an F-ratio of 23.49. Importantly, holding other factors constant, the estimated rent premium for a green building is about 3.5 percent.

<sup>7</sup>That is, the rent per square foot multiplied by the occupancy rate.

<sup>8</sup>For the rental sample, we use the employment growth in 2006; for the transaction sample, we use the employment growth in the year before the transaction date. These data are available from the National Bureau of Labor Statistics ([www.bls.gov](http://www.bls.gov)).

<sup>9</sup>In this way, the specification recognizes the old adage about the three most important determinants of property valuation: "location, location, location."

<sup>10</sup>Our formulation thus generalizes the treatment of spatial variation in the real estate asset pricing literature where spatial variation is commonly analyzed in one of three ways: first, by including location dummies for submarkets (Glasscock et al., 1990, Wheaton and Torto, 1994); second, by studying a specific MSA or small region to isolate the influence of spatial variation (Gunnellin and Söderberg, 2003, Rosen, 1984, Webb and Fisher, 1996); or else by using Geographic Information System methods to specify the distance of a property to specific locations, for example the CBD, airport, highway or railway station (Bollinger et al., 1998, Öven and Pekdemir, 2006, Sivitanidou, 1995, Sivitanidou, 1996). Our analysis generalizes these methods by treating each of the small geographic clusters as distinct.



In column (2), the green certification is distinguished by its Energy Star or its LEED rating. The results suggest that the LEED rating has no statistically significant effect upon commercial rents, but the Energy Star rating is associated with rents higher by 3.3 percent.

In column (3), a set of variables measuring building age in four categories is added to the model. The coefficients of the other variables are quite stable. The results indicate that there is a substantial premium associated with newer buildings. *Ceteris paribus*, rents in a commercial office building less than ten years old are twelve percent higher than those in a building more than forty years old.

Column (4) adjusts for differences in the number of stories and for the presence of on-site amenities. There is evidence that rents in very tall buildings, greater than twenty stories, are slightly lower. On-site amenities are associated with higher office rents.

Importantly, when the specification of the hedonic variables is changed in various ways, the magnitude and the statistical significance of the green rating is unchanged. *Ceteris paribus*, the rent in a green building is significantly higher by 2.8 to 3.5 percent than in an unrated building.

Column (5) presents the results from estimation of equation (1b). In this formulation, the specification includes 1,388 dummy variables (not reported in the table) – one for each of the 694 clusters, and one for the specific green building identified in each cluster. When the model is expanded in this way, the coefficients of the other variables are unchanged, and the explained variance is slightly larger. Of course, in this more general specification, the rent premium for a green building varies in magnitude for each separate cluster. In Section 4.2, we provide further analysis of the rent increments estimated for individual green buildings.

Table 3 presents the results when the dependent variable is measured by the logarithm of effective rent. In this formulation, we multiply the rent per square foot of leased space by the fraction of the building which is leased. When endogeneous rent-setting policies are taken into account<sup>11</sup>, the results suggest that the effect of a green rating is even larger. In the simplest model, column (1), the statistical results suggest that a green rating is associated with a ten percent increase in effective rent. In the regression reported in column (2), the dummy variable representing a LEED-rated building indicates a premium of nine percent, but the estimate is not significant at conventional levels. When the other hedonic characteristics and amenities of buildings are accounted for in column (4) – as far as possible – the results still indicate an effective premium of more than six percent for Energy-Star-rated buildings.

Table 4 presents analogous results based upon the smaller sample of 199 green office buildings sold in the 2004-2007 period and the control sample of 1,617 non-green buildings sold within a quarter mile of those green buildings<sup>12</sup>. These models explain only about a third of the variation in the dependent variable, the logarithm of selling price per square foot, but the qualitative results are similar. For each of the specifications reported, the variable reflecting certification of a green building is highly significant. When the certification is reported separately for the Energy Star and the LEED systems, there is no evidence that the latter certification is associated with higher selling prices. There is some evidence that selling prices per square foot are higher when buildings are larger, and when they are of higher quality (as measured by class rating). It appears that buildings with fewer stories sell for higher prices per square foot. Buildings sold in 2004 were lower in price by 17-20 percent compared to buildings sold in 2007.

The results reported in Tables 2, 3, and 4 are robust to other variations in the hedonic characteristics included on the right-hand side in the vector  $x$ . They are not robust to the exclusion of the dummy variables identifying the neighborhoods in which the sample and control variables are located.

<sup>11</sup>We may expect property owners to adopt differing asking rent strategies. *Ceteris paribus*, landlords who quote higher rents will experience higher vacancy rates.

<sup>12</sup>The data source does not permit a match of sales observations on green buildings to sales observations on control buildings in the same year, so we include year of sale dummies in the regression to control for the time variation in market prices. Furthermore, the regressions for sales price do not include the occupancy level and the rental contract type, since we do not have data on these variables for all years during the 2004 – 2007 period.





# Empirical analysis

The distribution of green-rated buildings is not random within urban areas in the U.S. and if this is not taken into account explicitly, statistical analyses can be highly misleading<sup>13</sup>. Figure 3 illustrates this point. It presents the joint frequency distribution of the dummy variables estimated for each cluster and the dummy variables estimated for the premium for the green building in that cluster. (These are the coefficients estimated in equation 1b.) This relationship is presented separately for the premium in effective rents and in market values.

An inverse relationship between any cluster premium and its associated green premium is clearly apparent. The correlation coefficient between cluster and green increments is significantly different from zero at the one percent level. This suggests that the premium for a green building, relative to nearby buildings, tends to be larger in smaller markets and regions and in the more peripheral parts of larger metropolitan areas, where location rents are lower. Apparently, a green label for a building adds less in value at a prime location, but it serves as an important signal in an otherwise lower-quality location.

Figure 4 reports the joint frequency distribution of the rent and value increments for green buildings and a measure of demand for energy – the number of “degree days” in the locations in which these green buildings are placed<sup>14</sup>. The figure reports a positive but weak relationship between the estimated rent and value increments for green building and a measure of the climatic conditions surrounding each of the buildings. This suggests that an energy-efficient building is more valuable in regions with more extreme climates, where heating and cooling is likely to be a larger part of total cost of occupancy. This is explored below.

## 4.2 The premium for energy efficiency

As demonstrated in the previous section, there is a statistically significant and rather large premium in rent and market value for green labeled buildings. The statistical analysis does not identify the source of this premium, or the extent to which the signal about energy efficiency is important relative to the other potential

signals provided by a building of sufficient quality to earn a label. But the estimated premiums do vary within the stock of Energy-Star labeled buildings – most of which are certified to be in the top quarter of comparable buildings in terms of energy efficiency.

Figure 5 presents the distribution of the rent and value premiums for each of the 694 green buildings in the rental sample and the 199 green buildings which were sold between 2004 and 2007. Figures 5A, B, and C report the distribution of the premium in rent per square foot, effective rent per square foot, and in selling price. These figures are based upon the regressions reported in column (5) of Tables 3, 4 and 5 respectively. The figure indicates that the values of the estimated premiums vary across buildings, and in at least a few cases, the estimated effects are negative. However, a simple t-test indicates that the probability that the mean rent or value premium is negative for this sample of buildings is miniscule<sup>15</sup>. Appendix C reports the distribution of the t-ratios for the increments to rent and value (from the regression in columns (5) in Tables 2, 3 and 4). Each t-ratio is a test of the hypothesis that the estimated regression coefficient is different from the coefficient reported for rated buildings as a group (reported in column (4) in Tables 2, 3 or 4). As the figures show, a substantial fraction of the estimated individual premiums are indeed significantly different from the mean premium<sup>16</sup>.

The rent premium associated with the label on any building represents the joint effects of the engineering efficiency of the building together with other unmeasured, but presumably important, attributes of the building. The fact that the estimated premiums are different from each other suggests that systematic variations in the thermal properties of buildings – even among certified green buildings – may be reflected in economic performance.

<sup>13</sup>Results from additional specifications and specifications that do not identify specific clusters are available on request (or online at <http://urbanpolicy.berkeley.edu>).

<sup>14</sup>Degree days measure the deviation from a temperature of 65 degrees during a year. For each day with an average temperature lower or higher than 65 degrees, the degree day is the difference between that average temperature and 65 degrees. Data are available by CBSA ([www.ncdc.noaa.gov](http://www.ncdc.noaa.gov)).

<sup>15</sup>For rents, the probability is 0.0007. For effective rents, it is 0.0000, and for selling prices the probability that the mean value premium for green buildings is smaller than zero is 0.0000.

<sup>16</sup>For rent, 52 percent of the estimated increments are significantly different from 0.028, for effective rent, 45 percent of the estimated increments are significantly different from 0.064, and for transaction values, 38 percent of the estimated increments are significantly different from 0.167.

## Empirical analysis

For 494 buildings that have been certified as energy efficient by the Energy Star program, we obtained detailed data on energy efficiency as reported by a licensed engineer in the application for certification in the program. More specifically, we have the underlying raw data on energy use as submitted and verified by building owners in the Statement of Energy Performance (SEP) submitted to the EPA as a part of the certification process.

The energy use of a building is measured in two ways: site energy use and source energy use. Site energy use is the amount of heat and electricity consumed by a building as reflected in utility bills, converted into the standard energy measure, British Thermal Units (BTU) per square foot. This represents the most salient cost of energy use for building owners and occupiers. The site energy use may include a combination of purchases of primary energy (e.g., fuel oil) and secondary forms of energy (e.g., heat from a district steam system). The source energy of a building incorporates all transmission, delivery, and production losses for both primary and secondary energy used in the building. This facilitates a more complete comparison of gross energy use associated with buildings<sup>17</sup>.

To account for the influence of climatic conditions on energy use, we standardize the energy consumption of each Energy-Star-rated building by the total number of degree days in the CBSA in which it is located. Presumably, more energy is needed for the heating of buildings in metropolitan areas with more heating degree days, and more energy is needed for the cooling of buildings in cities with more cooling degree days.

In this part of the analysis, we seek to distinguish the effects of the energy-saving aspect of the rating from the intangible effects of the label itself. These latter effects may arise from the reputational or marketing benefits of the labeled building or from other unmeasured aspects of quality in rated buildings.

Our statistical models utilize data on the thermal properties of the subsample of rated buildings and the climate conditions of the clusters in which they are located. The most straightforward of these takes the form:

(2a)

$$\hat{\delta}_n = \alpha + \Theta_j Z_{jn} + \eta_n^*$$

The dependent variable  $\hat{\delta}_n$ , is the estimate from equation (1b) of the increment to rent commanded by the green building in cluster  $n$ , relative to the control buildings in that cluster, holding constant the hedonic characteristics of the buildings.  $Z_{jn}$  is a vector of the thermal and climatic attributes  $j$  of the building  $n$ . As before, the Greek letters  $\alpha$  and  $\Theta_j$  denote estimated coefficients, and  $\eta_n$  is an error term. Note that the dependent variable is a regression estimate obtained from equation (1b), often with considerable error. Thus equation (2a) is appropriately estimated by generalized least-squares, incorporating the variance-covariance matrix of the parameters estimated in equation (1b). See Hanushek (1974).

As an alternative, we also report estimates of the following form:

(2b)

$$\hat{\epsilon}_{in}^* = \alpha + \Theta_j Z_{jn} + \eta_{in}^{**}$$

In this formulation the dependent variable,  $\hat{\epsilon}_{in}^*$ , is the residual from equation (1a). It is the increment to rent commanded by the specific green building  $i$  that is not attributable to its hedonic characteristics, or to the average premium estimated for a green building, or to its location in a specific cluster. Presumably, this increment reflects energy efficiency as well as random error.

Finally, we report estimates of the following form:

(2c)

$$\log R_{in} - \hat{\gamma}_n = \alpha + \beta X_i + \Theta_j Z_{jn} + \eta_{in}^{***}$$

<sup>17</sup>For details, see [www.energystar.gov/index.cfm?c=evaluate\\_performance.bus\\_benchmark\\_comm\\_bldgs](http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_benchmark_comm_bldgs)





## Empirical analysis

In this formulation, we rely upon the location rent increment estimated for each cluster in equation (1a) using the entire sample of green buildings and control buildings. The dependent variable is the natural logarithm of the rent commanded by green building  $i$  in cluster  $n$  minus the estimated location rent increment for other buildings in cluster  $n$  as estimated in equation 1a.

Table 5 presents estimates of models explaining the variation in the increment in rent and market values as a function of the site energy consumption of an office building. Recall, “site energy” measures energy usage as reflected in the utility bills of the building owners or tenants. We estimate models (2a), (2b), and (2c) in several variants. We report energy usage in BTUs per square foot of gross space per degree day. More energy efficient buildings are those that use fewer BTUs per square foot per degree day. We also distinguish between BTU usage per cooling degree day and BTU usage per heating degree day, reflecting the usage of air conditioning and heating systems.

Panel A reports the increment to market value associated with energy efficiency for the 120 buildings which were sold and for which we were able to match SEP records and CoStar data. There is a clear inverse relationship between market value and energy usage. Within the sample of certified buildings which have been sold, a ten percent decrease in site energy use per degree day leads to an increase in market value of approximately two percent, over and above the average label premium of sixteen percent. These results are statistically significant using models 2a and 2b.

As noted in Table 1, for 39 of the buildings in the sample of 694 green buildings, leases require the tenants to pay separately for utilities. (These are called “net rent contracts.”) For 27 of these buildings, we were able to obtain the SEP and the site energy use of the office building. In panel B of Table 5, we report models relating the increment in rents paid by tenants in these buildings as a function of the same measures of energy efficiency. The table reports estimates of the importance of variables measuring energy usage for these buildings in models which also include the energy usage in other rental buildings. The results indicate that tenants with net rental contracts are willing to pay higher rents for more energy efficient buildings, especially office buildings that use less energy per square foot to heat buildings in cold weather. A ten percent decrease in the energy consumption in a building is associated with an increase in the rent increment of approximately twenty basis points, over and above the six percent premium for a labeled building<sup>18</sup>. The sample sizes are quite small, and the precision of some of these estimates is questionable. Nevertheless, it certainly appears that: when tenants in office buildings pay their own utilities, and when they have chosen to pay a premium for tenancy in rated green buildings, they are nevertheless still willing to pay higher rents for more energy efficient buildings<sup>19</sup>.

<sup>18</sup>This calculation is based on the average site energy use, which is 64 BTU per sq.ft., with a standard deviation of 15 BTUs per sq.ft., the average number of heating degree days, which is 2737 per annum and the average number of cooling degree days, which is 1415 per annum.

<sup>19</sup>As noted in Appendix D, when source energy is used in the analysis (reflecting total energy use, rather than energy reflected in utility bills), the results are consistent.

<sup>20</sup>Not the least because more than forty percent of the sample is from California, and thus the same energy costs are reported.

<sup>21</sup>But for completeness, we report that the analogous calculations for rental buildings yields a capitalization rate of 6.3 percent (based on 27 net rental buildings).



Finally, some rough comparisons can be made between the monetary value of energy savings and the consequent increment to market values. For each rated building, the SEP reports site energy use in BTUs separately for electricity and natural gas. Using the heating and cooling degree days associated with each building and the state average price of electricity and natural gas (from [www.eia.doe.gov](http://www.eia.doe.gov)), we compute the monetary savings associated with a ten percent reduction in site energy use for each building. From the results in Table 5, we can estimate the increment to value associated with this increase in thermal efficiency.

Figure 5 reports the distribution of the estimates of increased market value per dollar of annual energy savings. These estimates, based on model 2b in Table 5, are obviously rather crude<sup>20</sup>, and they suggest considerable variation in increments to value. On average, a dollar of energy savings yields eighteen dollars in increased market value – a capitalization rate of about 5.5 percent. Alternatively, if the capitalization rate is known to be, say, six percent, then the other desirable attributes of a more energy-efficient building (better engineering, design, etc.) contribute about eight percent to the increased valuation.

These specific numerical results are – needless to say – highly uncertain<sup>21</sup>.

## 05 Conclusions

This paper reports the only systematic evidence on the economic value of certification of green buildings to the U.S. economy. In contrast to the anecdotal evidence on the economic effects of investments in environmentally sustainable building, the research reported here is based upon impersonal market comparisons.

For each commercial building in the country which has obtained a LEED and or Energy Star label, we identified a control group consisting of all commercial properties located within about 1,300 feet. For this sample – about 10,000 buildings divided into about 900 clusters, each containing one labeled building and nearby unlabeled buildings – we relate market rents of the properties to the hedonic characteristics of properties, within very small geographical areas of about 0.2 square miles.

The results clearly indicate the importance of a green label in affecting the market rents and values of commercial space. The results suggest that an otherwise equal commercial building with an environmental certification will rent for about three percent more per square foot; the difference in effective rent is estimated to be about six percent per square foot. The increment to the selling price may be as much as 16 percent.

These are large effects. For example, the average effective rent for the 7,488 control buildings in the sample of rental office buildings is \$23.51 per square foot. At the average size of these buildings, the estimated annual rent increment for a green building is approximately \$329,000. At prevailing capitalization rates of six percent, the incremental value of a green building is estimated to be about \$5.5 million more than the value of a comparable unrated building nearby. The average selling price for the 1,617 control buildings in the sample of buildings sold in the 2004-2007 period is \$34.73 million. *Ceteris paribus*, the incremental value of a green building is estimated to be about \$5.7 million more than the value of a comparable unrated building nearby.

Our results also show that the type of label matters. We find consistent and statistically significant effects in the marketplace for the Energy Star labeled buildings. We find no significant market effects associated with the LEED label. Energy Star concentrates on energy use,

while the LEED label is much broader in scope. Our results suggest that tenants and investors are willing to pay more for an energy-efficient building, but not for a building advertised as “sustainable” in a broader sense.

The premium in rents and values associated with an energy label varies considerably across buildings. It is positively related to the intensity of the climate surrounding the rated building: a label appears to add more value when heating and cooling expenses are likely to be a larger part of total occupancy cost. We disentangle the energy savings required to obtain a label from the unobserved effects of the label itself, which could serve as a measure of reputation and marketing gains obtained from occupying a green building. The energy savings are important. A 10 percent decrease in energy consumption leads to an increase in effective rent of about 20 basis points and an increase in value of about two percent, over and above the rent and value premium for a labeled building. Rough comparisons of the monetary value of the link between energy savings and asset values also suggests that the intangible effects of the label itself are important in determining value in the marketplace.







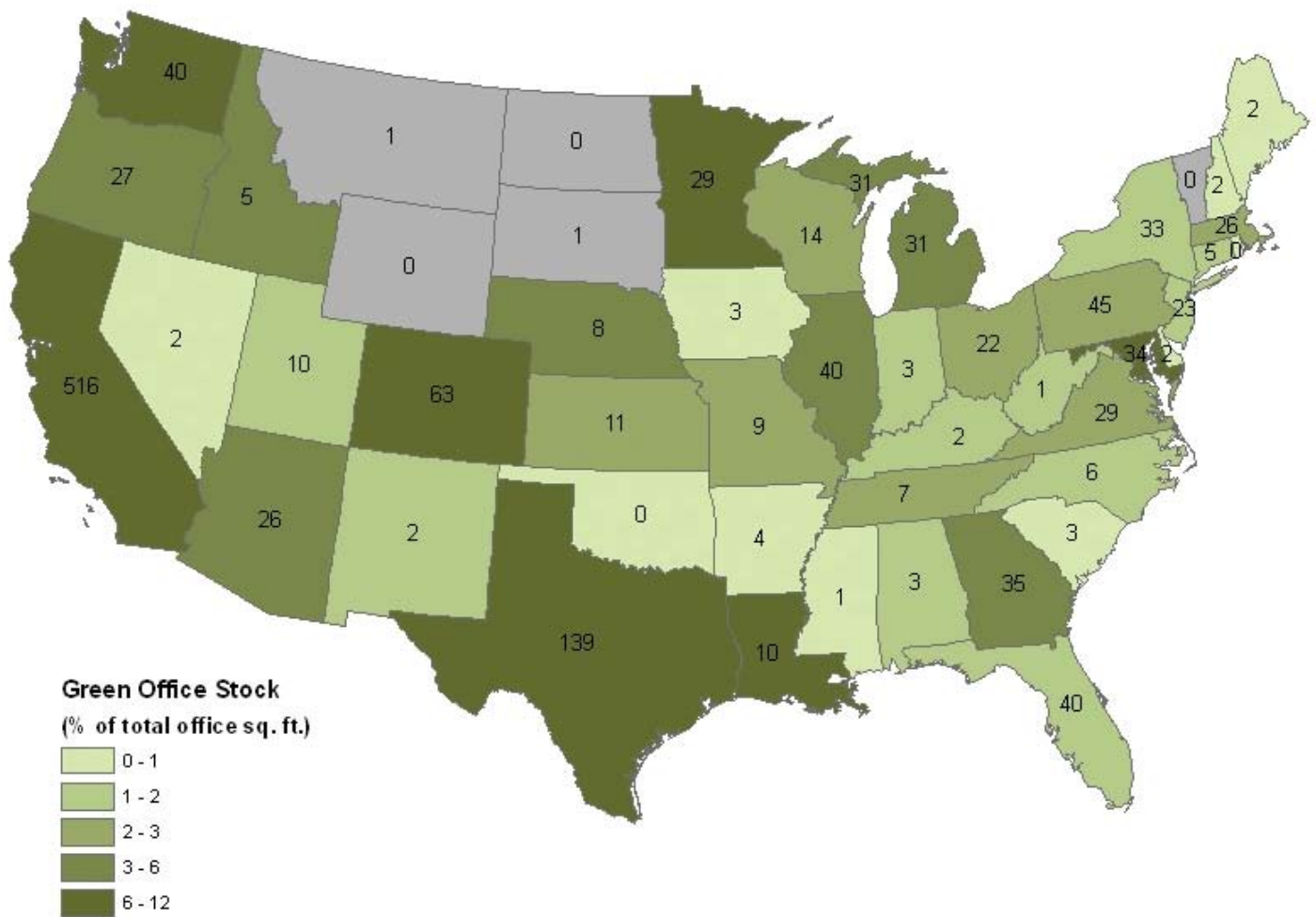
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# Figures

Figure 1 - Distribution of Green Office Buildings by State (percent of the stock of office space) 2007

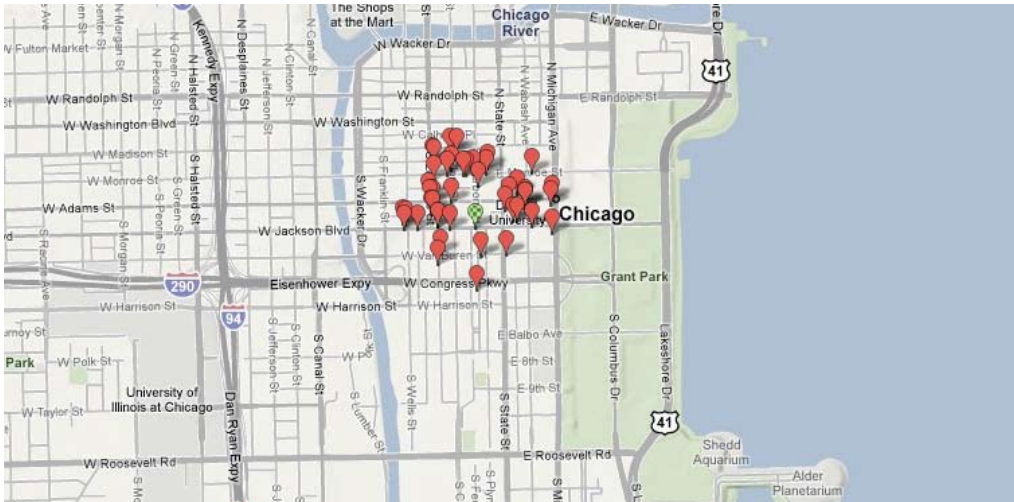


Source: Costar and authors' calculations.

Note: Number in each state represents the number of green buildings in that state.

Figure 2 - Clusters of Green and Control Buildings

A. Chicago, IL



B. Houston, TX



C. Columbus, OH

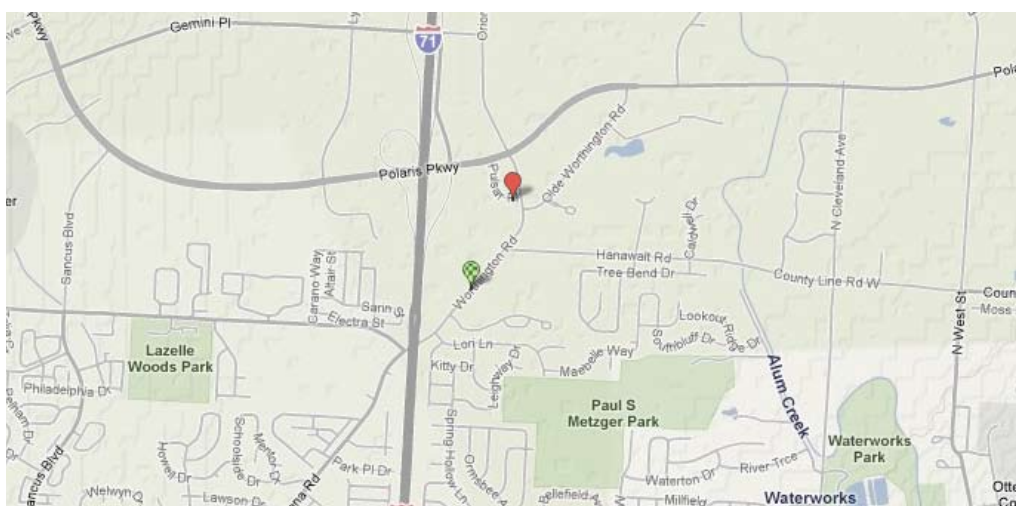




Figure 3 - Location Increments vs Increments for Energy Efficiency

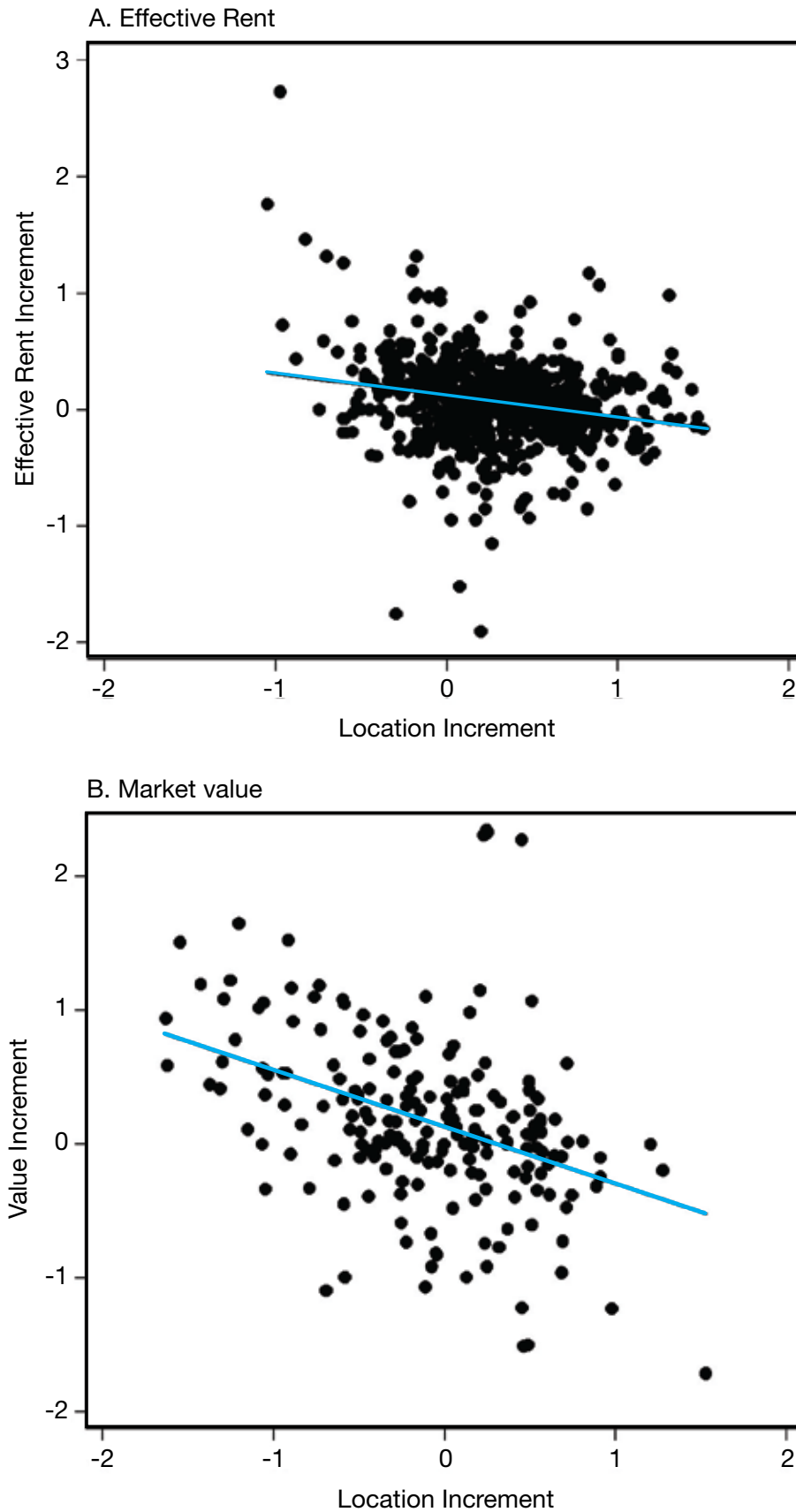
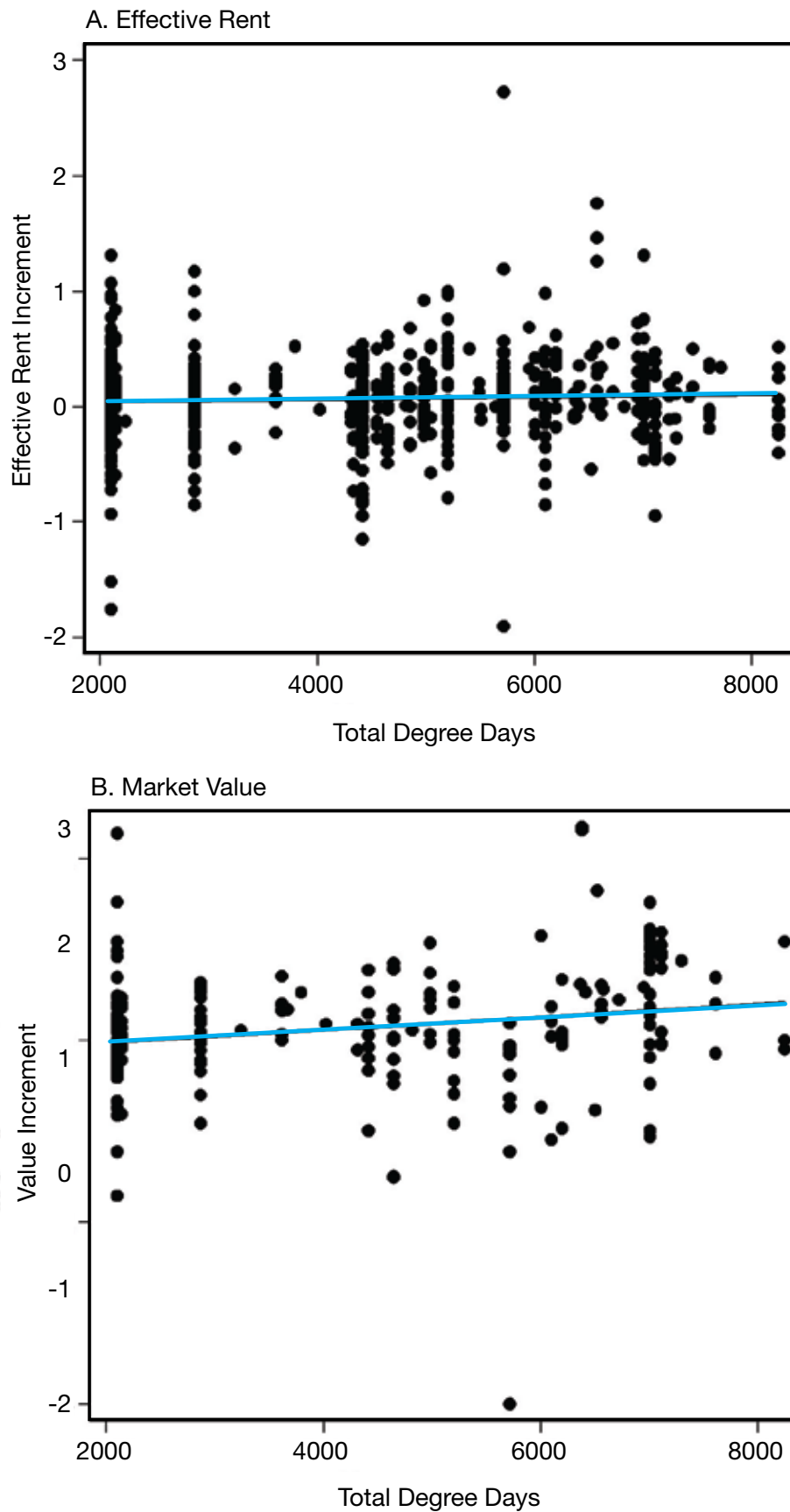
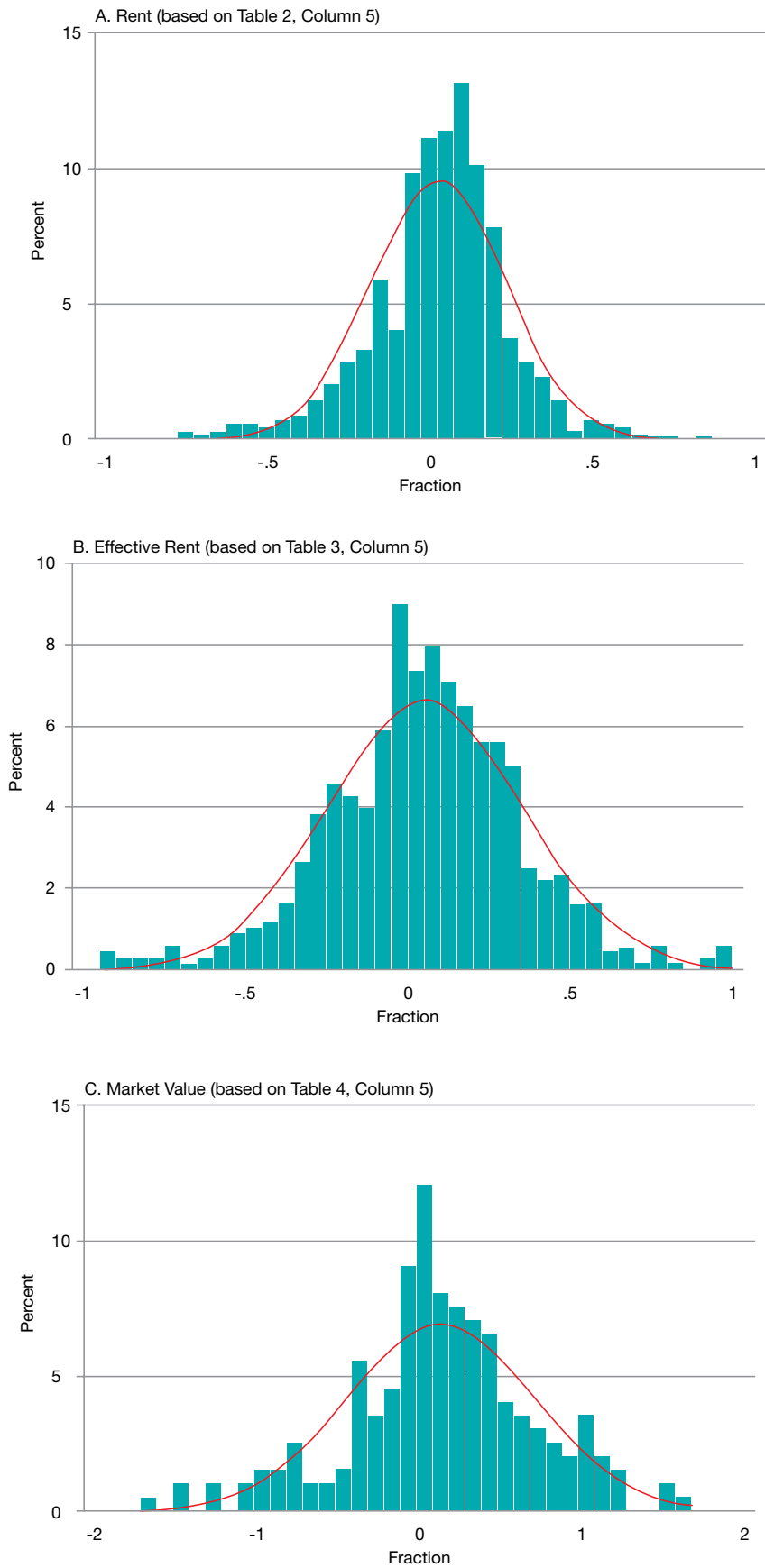


Figure 4 - Degree Days vs Increments for Energy Efficiency

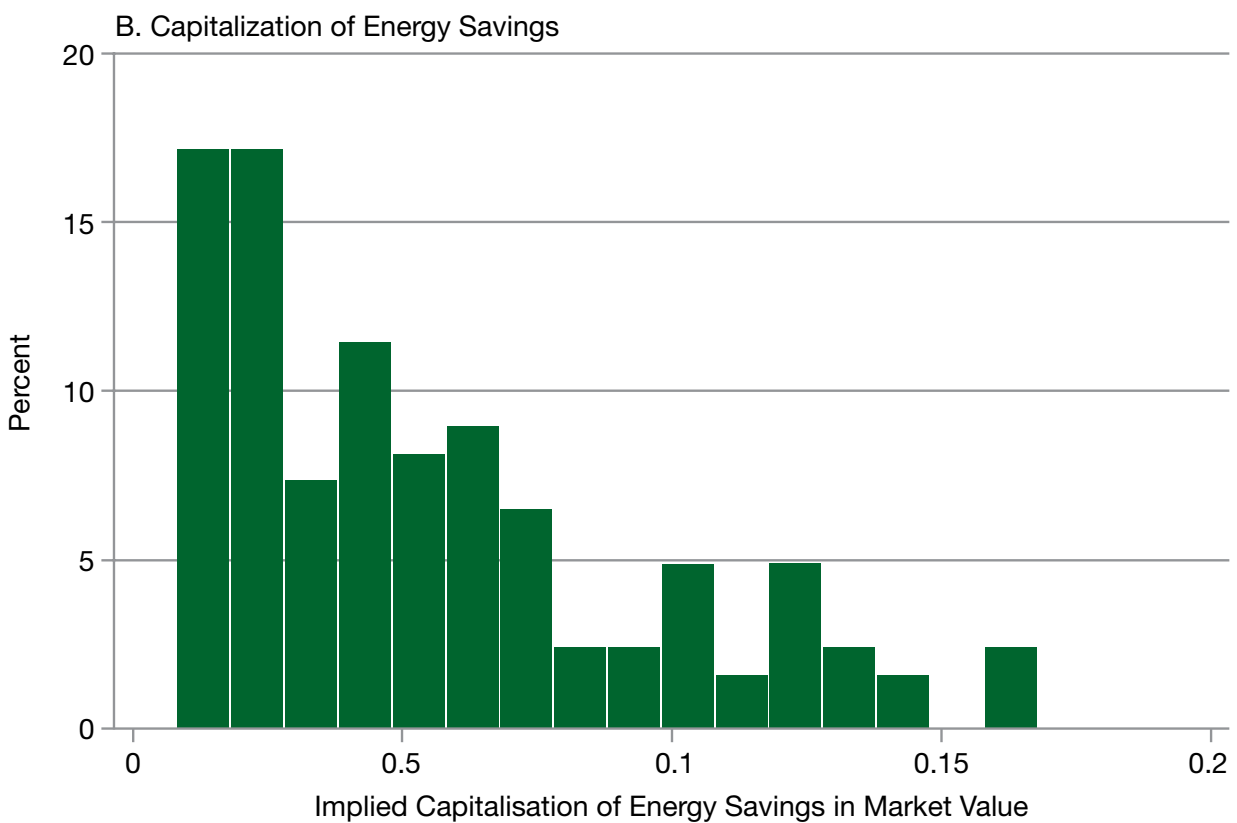
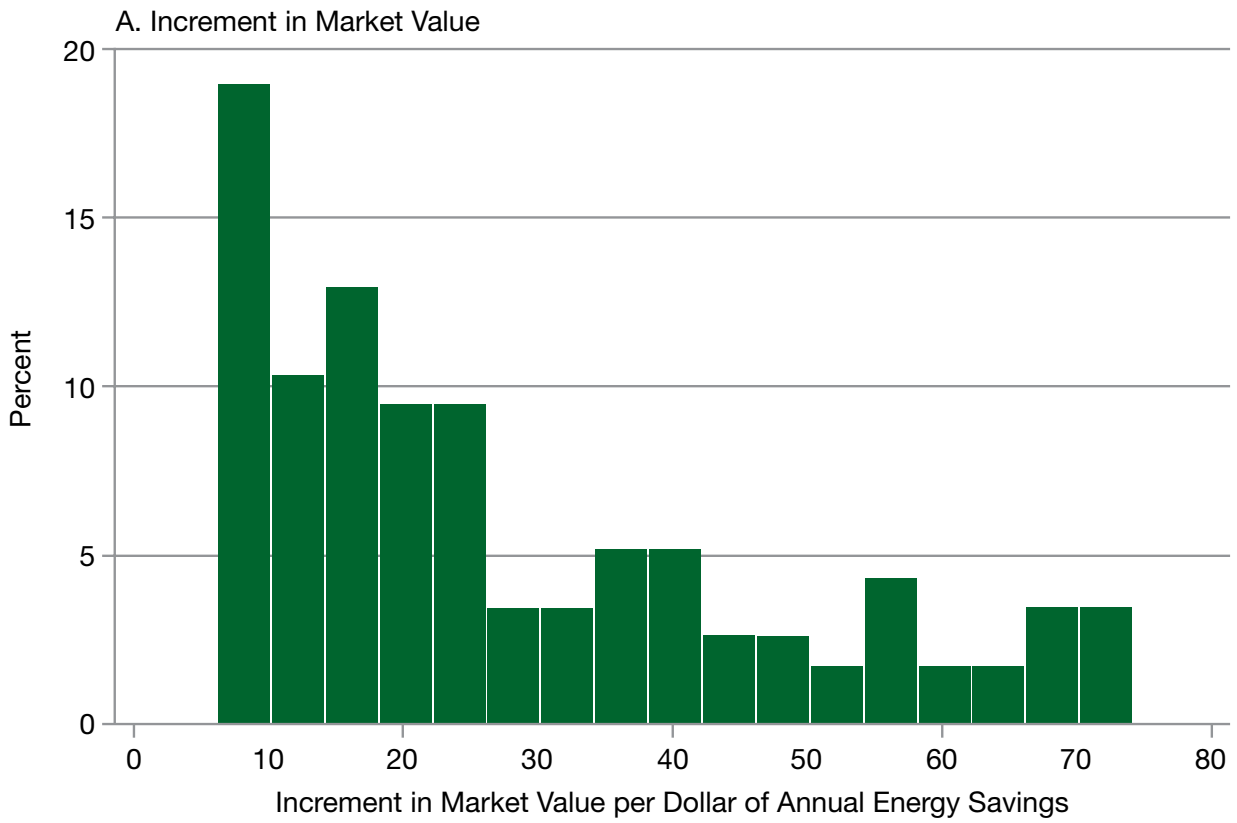




**Figure 5 - Distribution of Regression Estimates of the Increments to Rents or Market Value for Green Buildings**



**Figure 6 - Increase in Market Values following a Ten Percent Increase in Energy Efficiency**





# Tables

**Table 1 Comparison of Green-Rated Buildings and Nearby Control Buildings. Rental Sample and Sales Sample (standard deviations in parentheses)**

Sample Size	Rental Sample		Sales Sample	
	Green Buildings 694	Control Buildings 7,488	Green Buildings 199	Control Buildings 1,617
Asking Rent (dollars/sq. ft.)	29.84 (12.98)	28.14 (15.60)		
Effective Rent* (dollars/sq. ft.)	26.83 (13.00)	23.51 (16.11)		
Sales Price (dollars/sq. ft.)			289.22 (165.70)	248.89 (255.49)
Net Rent Contract** (percent)	5.76 (23.32)	3.15 (17.47)		
Size (thousands sq. ft)	324.08 (288.92)	218.69 (293.67)	358.33 (287.86)	159.12 (257.50)
Occupancy Rate (percent)	89.12 (12.76)	81.53 (22.73)		
Stories (number)	15.31 (13.26)	13.07 (12.11)	16.47 (12.76)	10.35 (10.50)
<b>Stories (percent)</b>				
Low (<10)	46.25 (49.90)	53.49 (49.88)	44.12 (49.77)	63.33 (48.21)
Medium (10-20)	26.66 (44.25)	25.25 (43.45)	23.04 (42.21)	21.34 (40.98)
High (>20)	27.08 (44.47)	21.27 (40.93)	32.84 (47.08)	15.34 (36.05)
Age (years)	23.85 (15.57)	49.45 (32.50)	24.64 (16.40)	60.38 (35.61)
<b>Age (percent)</b>				
Less than 10 years	14.27 (35.00)	4.87 (21.53)	16.18 (36.91)	4.14 (19.94)
10 to 20 years	24.06 (42.78)	9.40 (29.19)	21.08 (40.89)	6.43 (24.54)
21 to 30 years	43.37 (49.59)	25.13 (43.38)	42.16 (49.50)	20.22 (40.18)
31 to 40 years	11.10 (31.43)	13.25 (33.90)	11.76 (32.30)	8.53 (27.95)
Over 40 years	7.20 (25.88)	47.34 (49.93)	8.82 (28.43)	60.67 (48.86)

## Tables

**Table 1 Comparison of Green-Rated Buildings and Nearby Control Buildings.  
Rental Sample and Sales Sample (standard deviations in parentheses) - continued**

Sample Size	Rental Sample		Sales Sample	
	Green Buildings	Control Buildings Control Buildings	Green Buildings 199	Control Buildings 1,617
<b>Building Class</b>				
A	79.39 (40.48)	34.94 (47.68)	80.39 (39.80)	22.26 (41.61)
B	19.45 (39.61)	48.78 (49.99)	19.12 (39.42)	53.12 (49.92)
C	1.15 (10.68)	16.28 (36.92)	0.49 (7.00)	24.55 (43.05)
On-Site Amenities*** (percent)	71.76 (45.05)	49.22 (50.00)	78.43 (41.23)	49.41 (50.01)
Renovated Bldg. (percent)	21.04 (40.79)	38.51 (48.67)	25.49 (43.69)	45.70 (49.83)
Employment Growth (percent)	3.48 (9.52)	3.10 (7.95)	3.40 (3.23)	2.50 (3.63)
<b>Year of Sale (percent)</b>				
2004			15.08 (35.87)	18.99 (39.23)
2005			22.61 (41.94)	26.28 (44.03)
2006			26.63 (44.32)	30.67 (46.13)
2007			35.68 (48.03)	23.87 (42.64)

## Notes:

The control sample consists of all commercial office buildings within a 0.25 mile radius of each rated building for which comparable data are available. All observations are as of September 2007.

\* Effective Rent equals the Asking Rent multiplied by the Occupancy Rate

\*\* Net Rent Contracts require tenants to pay separately for utilities.

\*\*\* One or more of the following amenities are available on-site: banking, convenience store, dry cleaner, exercise facilities, food court, food service, mail room, restaurant, retail shops, vending areas, fitness center.



**Table 2 Regression Results. Commercial Office Rents and Green Ratings**  
(dependent variable: logarithm of rent per square foot)

	(1)	(2)	(3)	(4)	(5)
Green Rating (1 = yes)	0.035 [0.009]***		0.033 [0.009]***	0.028 [0.009]***	
Energy Star (1 = yes)		0.033 [0.009]***			
LEED (1 = yes)		0.052 [0.036]			
Building Size (millions of sq. ft.)	0.113 [0.019]***	0.113 [0.019]***	0.102 [0.019]***	0.111 [0.021]***	0.111 [0.023]***
Fraction Occupied	0.020 [0.016]	0.020 [0.016]	0.020 [0.016]	0.011 [0.016]	0.004 [0.017]
<b>Building Class:</b>					
Class A (1 = yes)	0.231 [0.012]***	0.231 [0.012]***	0.192 [0.014]***	0.173 [0.015]***	0.173 [0.017]***
Class B (1 = yes)	0.101 [0.011]***	0.101 [0.011]***	0.092 [0.011]***	0.083 [0.011]***	0.082 [0.012]***
Net Contract (1 = yes)	-0.047 [0.013]***	-0.047 [0.013]***	-0.050 [0.013]***	-0.051 [0.013]***	-0.057 [0.014]***
Employment Growth (fraction)	0.608 [0.171]***	0.608 [0.171]***	0.613 [0.187]***	0.609 [0.189]***	0.874 [0.054]***
<b>Age:</b>					
< 10 years			0.118 [0.016]***	0.131 [0.017]***	0.132 [0.019]***
10 – 20 years			0.079 [0.014]***	0.085 [0.014]***	0.083 [0.015]***
20 – 30 years			0.047 [0.013]***	0.049 [0.013]***	0.049 [0.014]***
30 – 40 years			0.043 [0.011]***	0.044 [0.011]***	0.044 [0.012]***
Renovated (1 = yes)			-0.008 [0.009]	-0.008 [0.009]	-0.010 [0.010]
<b>Stories:</b>					
Intermediate (1 = yes)				0.009 [0.009]	0.008 [0.010]
High (1 = yes)				-0.029 [0.014]**	-0.032 [0.016]**
Amenities (1=yes)				0.047 [0.007]***	0.054 [0.008]***
Constant	2.741 [0.113]***	2.742 [0.114]***	2.718 [0.126]***	2.725 [0.127]***	2.564 [0.022]***
Sample Size	8182	8182	8182	8182	8182
R <sup>2</sup>	0.71	0.71	0.72	0.72	0.74
Adj R <sup>2</sup>	0.69	0.69	0.69	0.69	0.68

Notes:

Each regression also includes 694 dummy variables, one for each locational cluster. Regression (5) also includes an additional 694 dummy variables, one for each green building in the sample.

Standard errors are in brackets. Significance at the 0.10, 0.05, and 0.01 levels are indicated by \*, \*\*, and \*\*\*, respectively.

## Tables

**Table 3 Regression Results. Commercial Office Rents and Green Ratings**  
(dependent variable: logarithm of effective rent per square foot)

	(1)	(2)	(3)	(4)	(5)
Green Rating (1 = yes)	0.100 [0.016]***		0.082 [0.024]***	0.064 [0.023]***	
Energy Star (1 = yes)		0.100 [0.016]***			
LEED (1 = yes)		0.094 [0.052]*			
Building Size (millions of sq. ft.)	0.261 [0.028]***	0.261 [0.028]***	0.235 [0.027]***	0.189 [0.027]***	0.193 [0.030]***
<b>Building Class:</b>					
Class A (1 = yes)	0.408 [0.028]***	0.408 [0.028]***	0.340 [0.029]***	0.229 [0.030]***	0.226 [0.033]***
Class B (1 = yes)	0.226 [0.027]***	0.226 [0.027]***	0.203 [0.027]***	0.152 [0.026]***	0.149 [0.028]***
Net Contract (1 = yes)	0.015 [0.024]	0.014 [0.024]	0.010 [0.024]	0.009 [0.024]	0.016 [0.028]
Employment Growth (fraction)	0.765 [0.312]**	0.756 [0.322]**	0.773 [0.293]**	0.682 [0.308]**	0.468 [0.421]
<b>Age:</b>					
< 10 years			0.134 [0.045]***	0.177 [0.044]***	0.149 [0.054]***
10 – 20 years			0.141 [0.025]***	0.146 [0.025]***	0.150 [0.028]***
20 – 30 years			0.113 [0.023]***	0.112 [0.023]***	0.128 [0.025]***
30 – 40 years			0.097 [0.018]***	0.090 [0.018]***	0.089 [0.020]***
Renovated (1 = yes)			0.019 [0.018]	0.016 [0.018]	0.022 [0.019]
<b>Stories:</b>					
Intermediate (1 = yes)				0.145 [0.021]***	0.156 [0.024]***
High (1 = yes)				0.086 [0.025]***	0.090 [0.029]***
Amenities (1=yes)				0.118 [0.015]***	0.124 [0.016]***
Constant	2.151 [0.029]***	2.158 [0.059]***	2.093 [0.050]***	2.187 [0.050]***	2.299 [0.060]***
Sample Size	8182	8182	8182	8182	8182
R <sup>2</sup>	0.47	0.47	0.47	0.48	0.51
Adj R <sup>2</sup>	0.42	0.42	0.42	0.43	0.41

## Notes:

Each regression also includes 694 dummy variables, one for each locational cluster. Regression (5) also includes an additional 694 dummy variables, one for each green building in the sample.

Standard errors are in brackets. Significance at the 0.10, 0.05, and 0.01 levels are indicated by \*, \*\*, and \*\*\*, respectively.



**Table 4 Regression Results. Office Sales Prices and Green Ratings  
2004 – 2007 (dependent variable: sales price in dollars/sq. ft.)**

	(1)	(2)	(3)	(4)	(5)
Green Rating (1 = yes)	0.168 [0.051]***		0.158 [0.052]***	0.165 [0.052]***	
Energy Star (1 = yes)		0.191 [0.052]***			
LEED (1 = yes)		0.113 [0.172]			
Building Size (millions of sq. ft.)	0.171 [0.090]*	0.167 [0.089]*	0.104 [0.089]	0.200 [0.108]*	0.192 [0.125]
<b>Building Class:</b>					
Class Aa (1 = yes)	0.164 [0.066]**	0.161 [0.066]**	0.032 [0.078]	0.104 [0.084]	0.143 [0.099]
Class B (1 = yes)	-0.188 [0.051]***	-0.187 [0.051]***	-0.216 [0.057]***	-0.184 [0.058]***	-0.183 [0.064]***
Employment Growth (fraction)	-0.005 [0.004]	-0.005 [0.004]	-0.004 [0.005]	-0.006 [0.005]	-0.006 [0.005]
<b>Age:</b>					
< 10 years			0.201 [0.149]	0.207 [0.147]	0.161 [0.207]
10 – 20 years			0.196 [0.099]**	0.224 [0.100]**	0.226 [0.124]*
20 – 30 years			0.248 [0.070]***	0.276 [0.070]***	0.288 [0.081]***
30 – 40 years			0.226 [0.073]***	0.251 [0.075]***	0.281 [0.090]***
Renovated (1 = yes)			-0.096 [0.046]**	-0.087 [0.046]*	-0.071 [0.053]
<b>Stories:</b>					
High (1 = yes)				-0.185 [0.092]**	-0.232 [0.113]**
Intermediate (1 = yes)				-0.183 [0.057]***	-0.189 [0.067]***
Amenities (1=yes)				-0.043 [0.049]	-0.048 [0.058]
<b>Year of sale:</b>					
2006 (1 = yes)	0.015 [0.060]	0.017 [0.060]	0.021 [0.060]	0.016 [0.060]	0.048 [0.071]
2005 (1 = yes)	-0.040 [0.056]	-0.039 [0.056]	-0.039 [0.056]	-0.048 [0.055]	-0.034 [0.065]
2004 (1 = yes)	-0.177 [0.067]***	-0.175 [0.067]***	-0.173 [0.067]**	-0.200 [0.067]***	-0.174 [0.078]**
Constant	5.314 [0.091]***	5.317 [0.091]***	5.269 [0.151]***	5.406 [0.160]***	5.401 [0.220]***
Sample Size	1816	1816	1816	1816	1816
R <sup>2</sup>	0.43	0.43	0.44	0.44	0.49
Adj R <sup>2</sup>	0.35	0.35	0.36	0.37	0.34

Notes: Each regression also includes 199 dummy variables, one for each locational cluster.

Regression (5) also includes an additional 199 dummy variables, one for each green building in the sample.

Standard errors are in brackets. Significance at the 0.10, 0.05, and 0.01 levels are indicated by \*, \*\*, and \*\*\*, respectively.

## Tables

**Table 5 Regression Results. Increment in Market Value and Effective Rent for More Energy Efficient Buildings Using Site Energy**

Panel A. Value Increments	Model 2a		Model 2b		Model 2c	
<b>Site Energy Consumption</b>						
Per Degree Day	-10.540 [4.859]**		-9.805 [3.922]**		-6.083 [4.397]	
Per Degree Day (heating)		-4.954 [1.906]**		-4.189 [1.952]**		-2.970 [1.969]
Per Degree Day (cooling)		-0.492 [0.303]		-0.442 [0.247]*		-0.504 [0.309]
Constant	0.332 [0.095]***	0.362 [0.088]***	0.302 [0.086]***	0.309 [0.090]***	5.623 [0.295]***	5.637 [0.251]***
Sample Size	120	120	120	120	120	120
R <sup>2</sup>	0.04	0.06	0.05	0.06	0.31	0.33
Adj R <sup>2</sup>	0.03	0.05	0.04	0.04	0.20	0.22
Panel B. Rent Increment	Model 2a		Model 2b		Model 2c	
<b>Site Energy Consumption</b>						
Per Degree Day*Net	0.707 [4.693]		0.539 [3.221]		7.636 [9.255]	
Per Degree Day (heating)*Net	-0.240 [0.282]		-0.197 [0.025]***		-0.238 [0.067]***	
Per Degree Day (cooling)*Net	-0.063 [0.381]		-0.196 [0.238]		-0.395 [0.244]	
Constant	0.028 [0.015]*	0.027 [0.015]*	0.053 [0.013]***	0.053 [0.013]***	2.705 [0.149]***	2.692 [0.154]***
Sample Size	449	449	449	449	449	449
R <sup>2</sup>	0.00	0.00	0.00	0.00	0.23	0.24
Adj R <sup>2</sup>	0.00	0.00	0.00	0.00	0.21	0.21

Notes:

Energy consumption is measured in BTUs per square foot of gross space. See: [www.energystar.gov/index.cfm?c=evaluate\\_performance.bus\\_benchmark\\_comm\\_bldgs](http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_benchmark_comm_bldgs)

In panel B, the specification includes the variables measuring site energy consumption as well as the interaction between site energy consumption and buildings with net rent contracts.

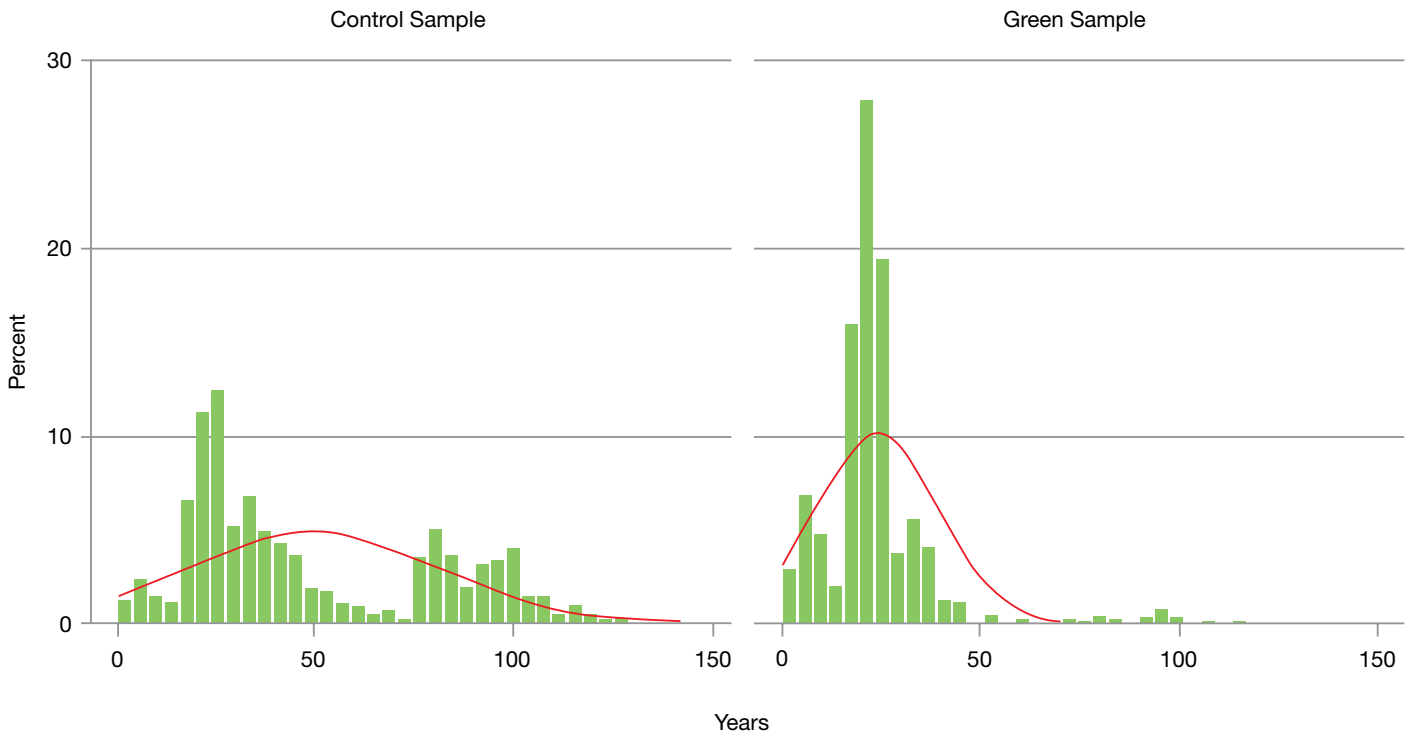
Standard errors are in brackets. Significance at the 0.10, 0.05, and 0.01 levels are indicated by \*, \*\*, and \*\*\*, respectively.



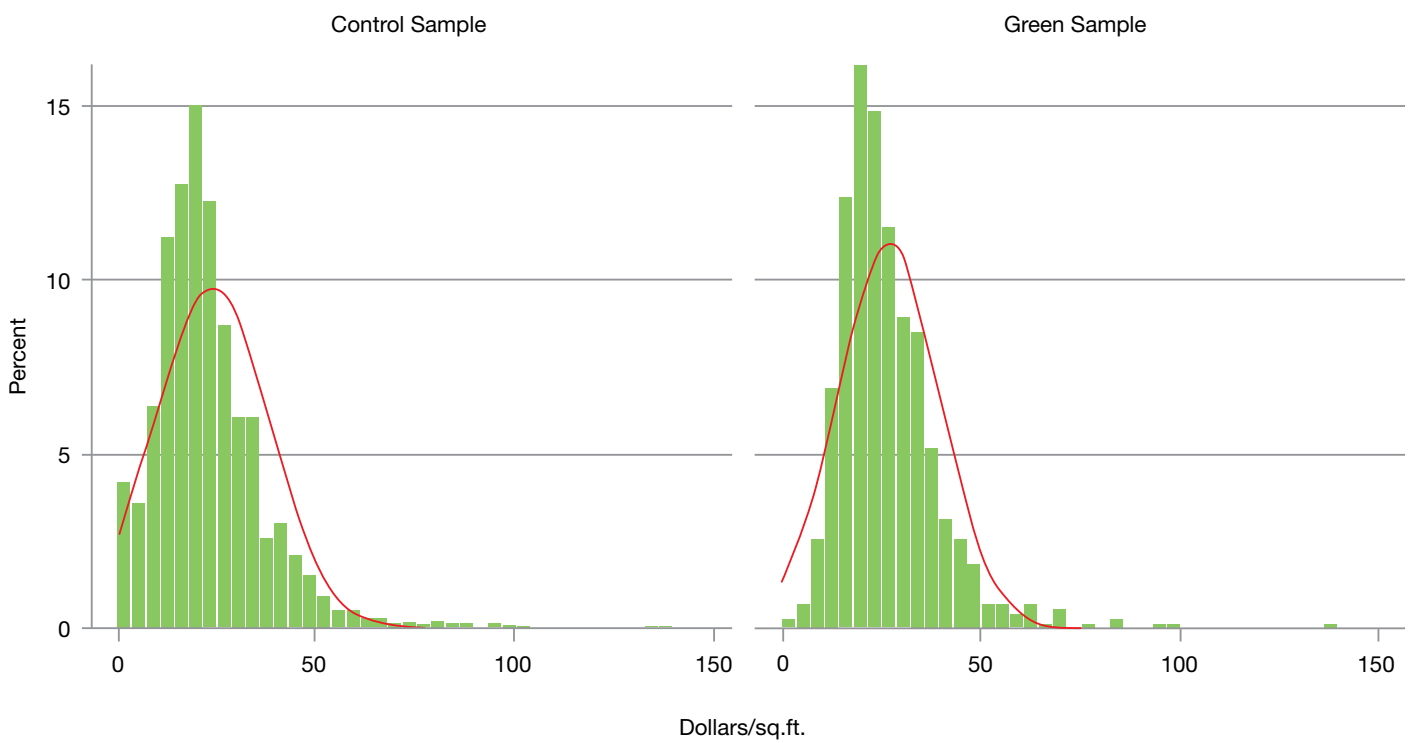
# Appendices

## Appendix A - Age, Effective Rent and Size. Rental Sample: Green Buildings and Control Buildings

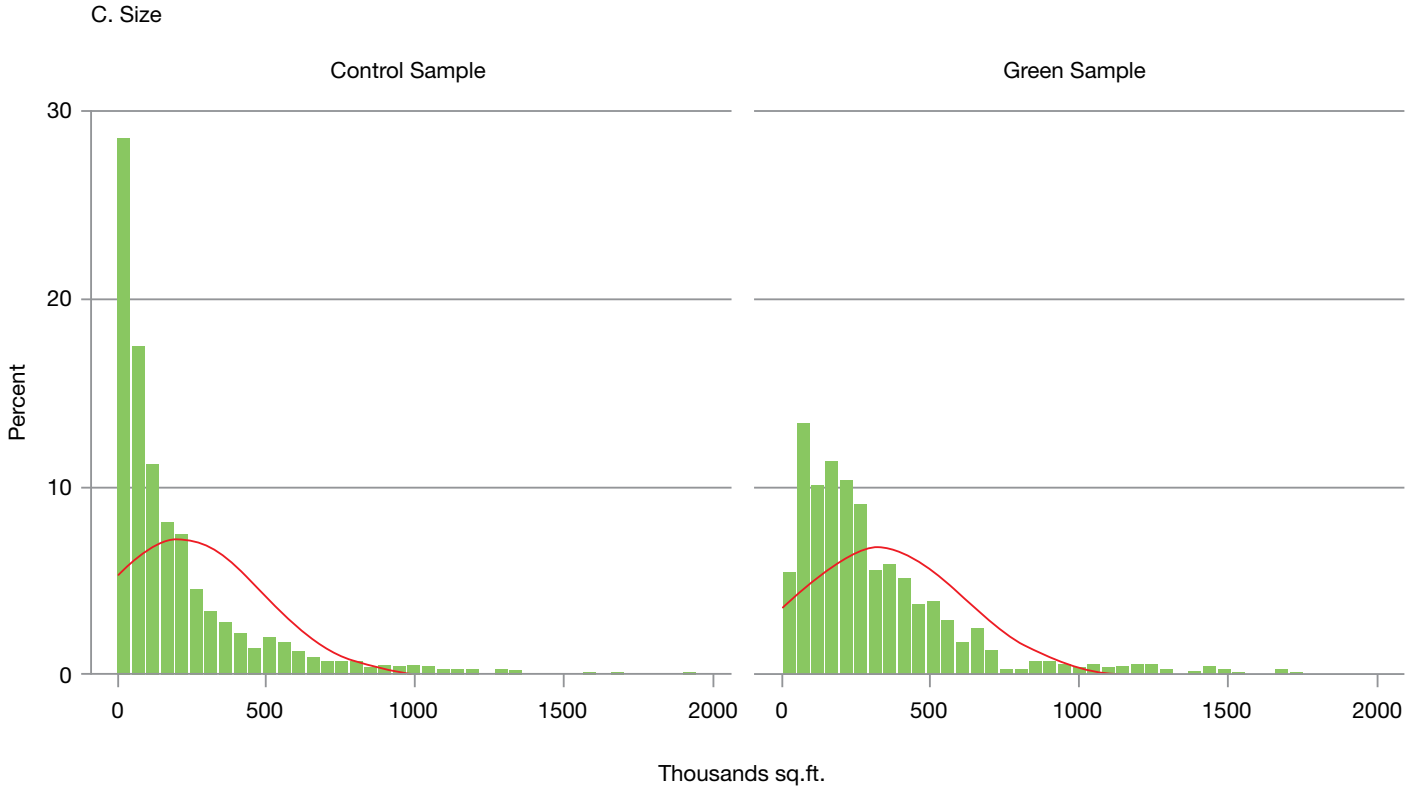
### A. Age



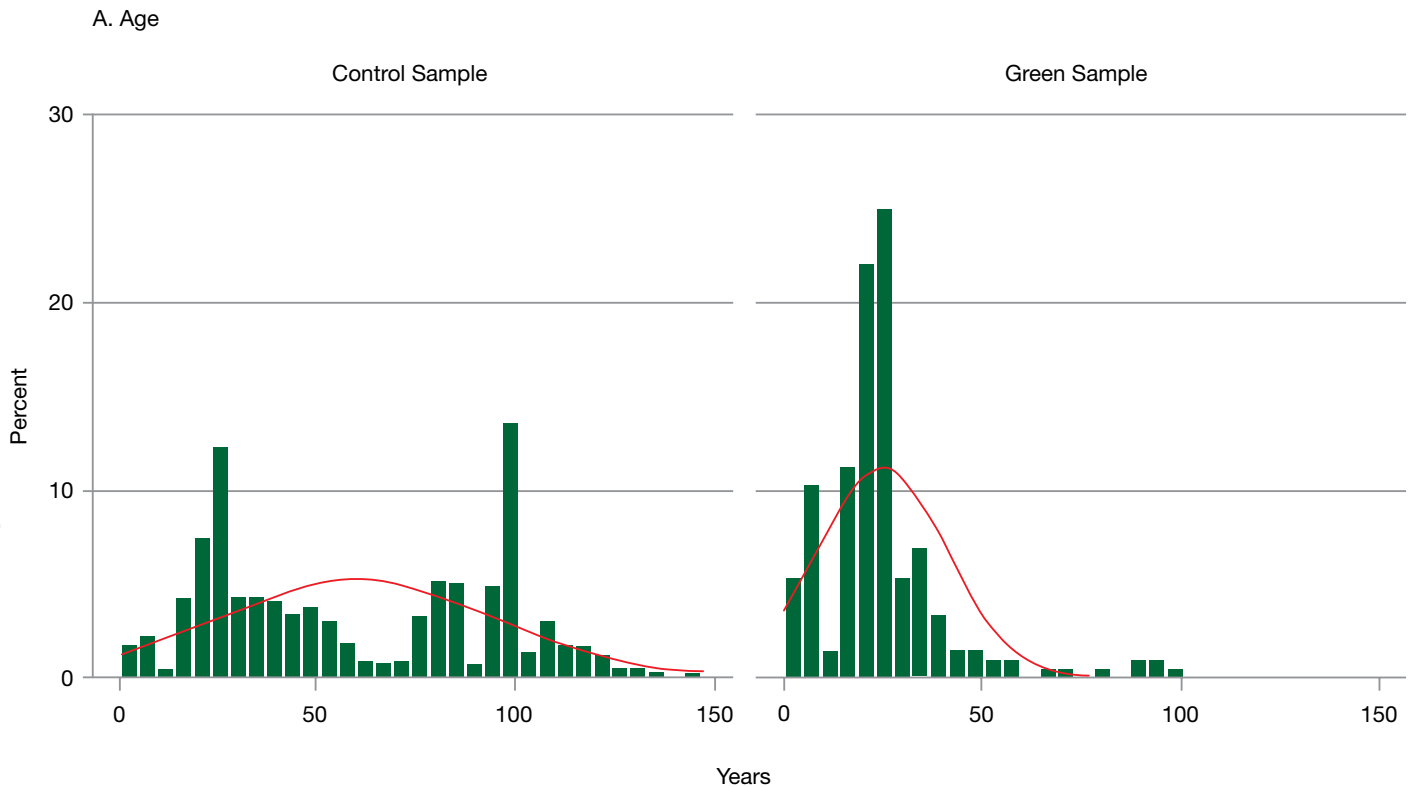
### B. Effective Rent



**Appendix A - Age, Effective Rent and Size. Rental Sample: Green Buildings and Control Buildings**

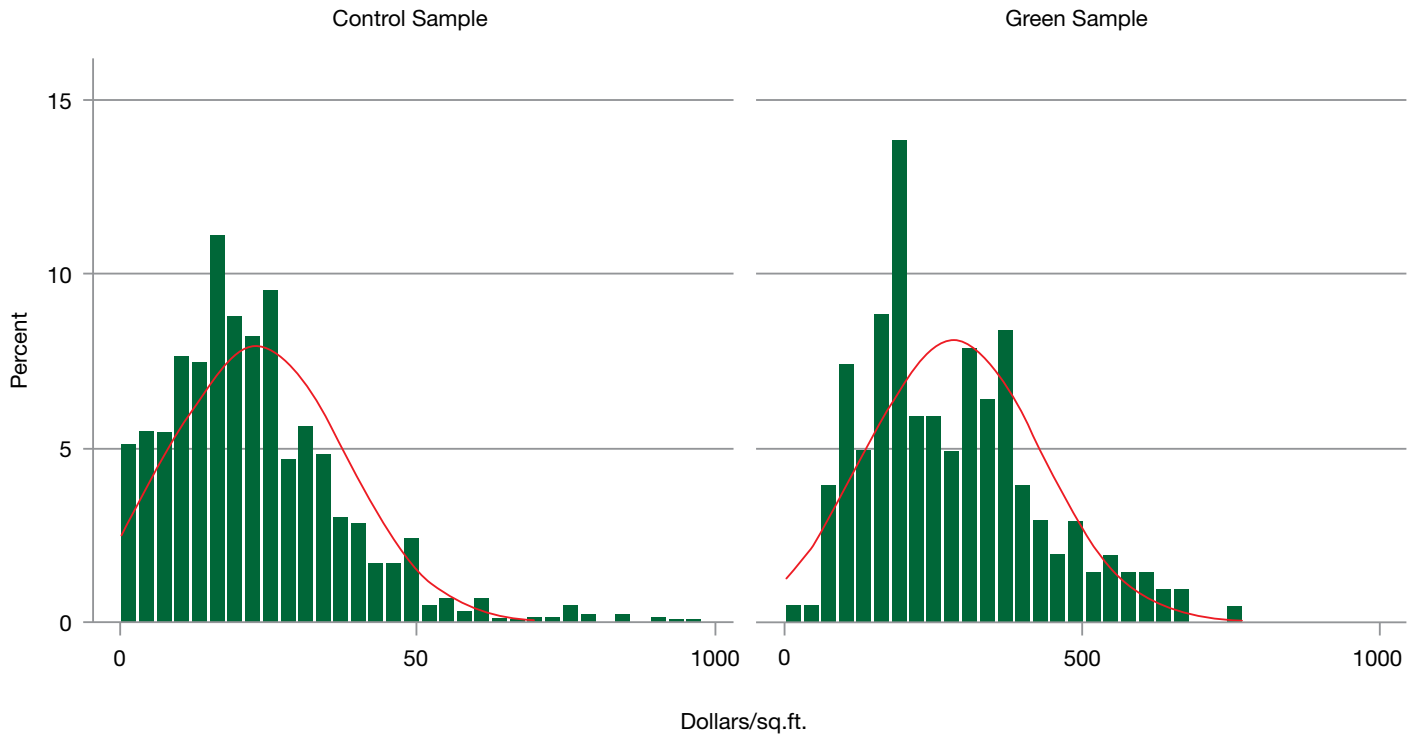


**Appendix B - Age, Sales Price and Size. Sales Sample: Green Buildings and Control Buildings**

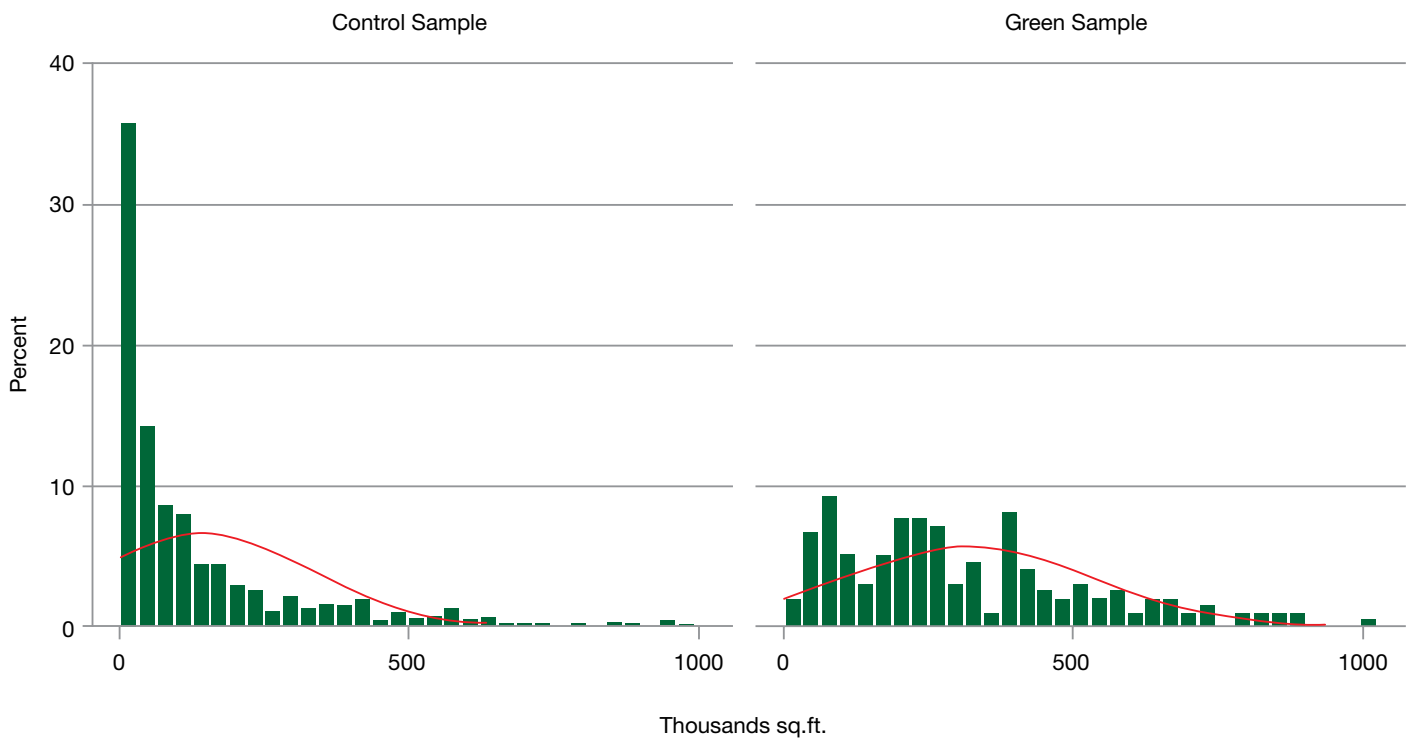




B. Sales Price

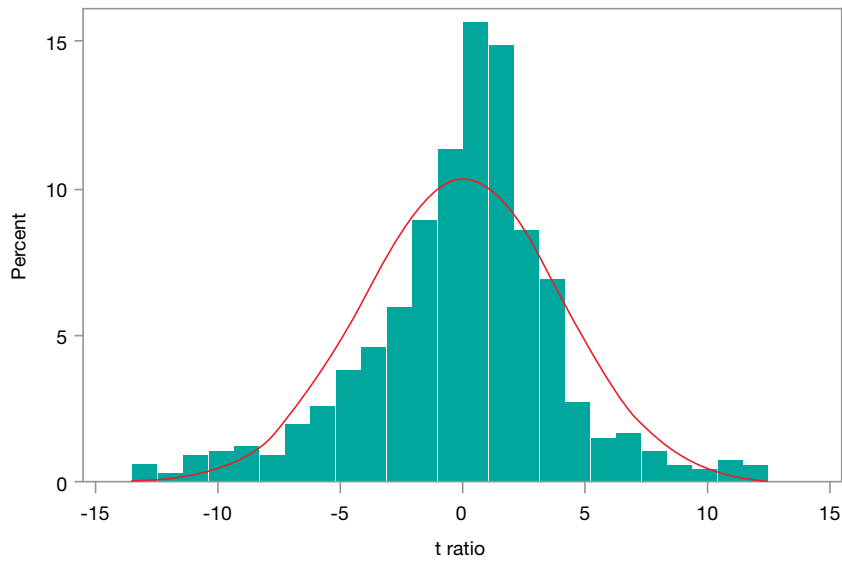


C. Size

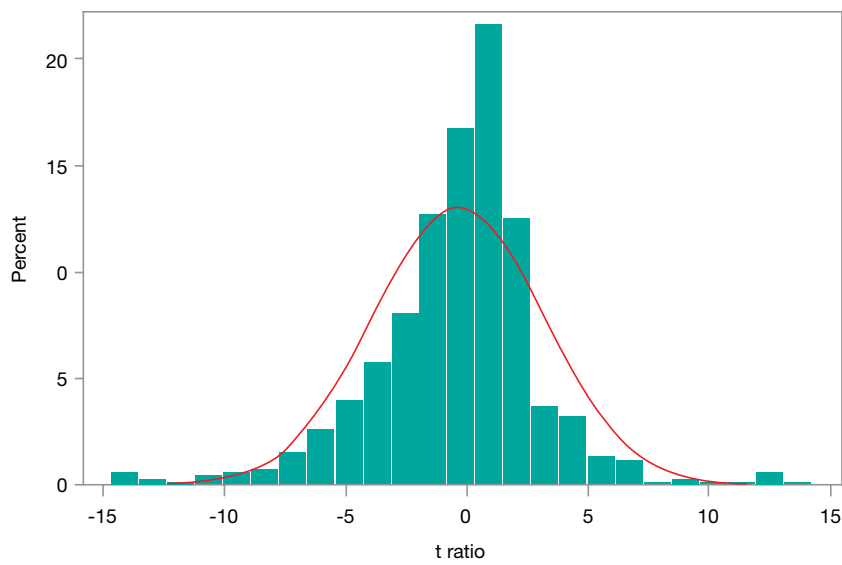


**Appendix C - Distribution of t ratios of the Hypotheses Testing Increments to Rents or Market Value for Green Buildings**

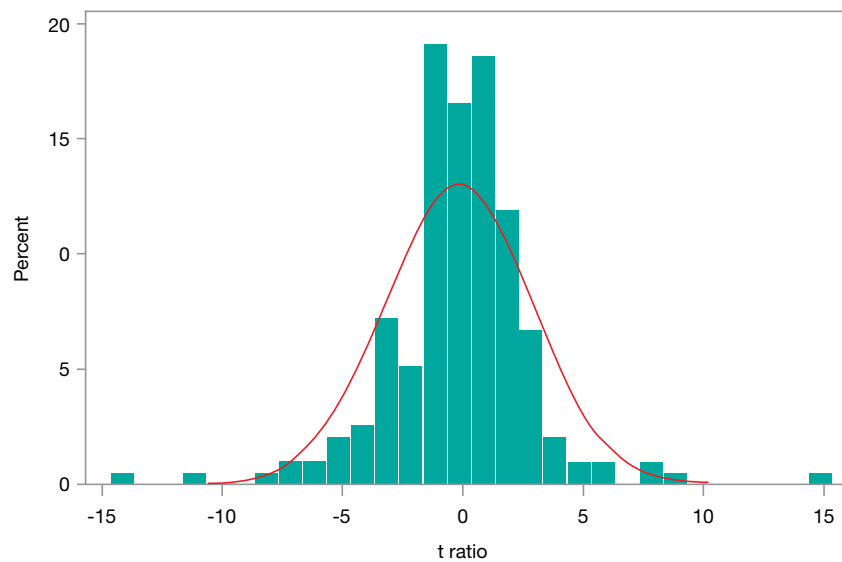
A. Rent (Ho: Rent Increment = 0.028 - based on Table 2, Column 5)



B. Effective Rent (Ho: Rent Increment = 0.064 - based on Table 3, Column 5)



C. Market Value (Ho: Rent Increment = 0.165 - based on Table 4, Column 5)





**Appendix D - Regression Results. Increment in Effective Rent and Value for More Energy Efficient Buildings. Source Energy**

Panel A. Value Increments	Model 2a		Model 2b		Model 2c	
<b>Site Energy Consumption</b>						
Per Degree Day	-4.935 [1.669]***		-4.345 [1.360]**		-3.155 [1.548]**	
Per Degree Day (heating)		-1.667 [0.578]***		-1.447 [0.654]**		-1.133 [0.679]*
Per Degree Day (cooling)		-0.201 [0.104]*		-0.194 [0.085]**		-0.218 [-0.103]**
Constant	0.406 [0.098]***	0.380 [0.086]***	0.359 [0.088]***	0.333 [0.091]***	5.750 [0.284]***	5.666 [0.238]***
Sample Size	120	120	120	120	120	120
R <sup>2</sup>	0.07	0.08	0.04	0.32	0.31	0.34
Adj R <sup>2</sup>	0.06	0.06	0.03	0.21	0.21	0.23
Panel B. Rent Increment	Model 2a		Model 2b		Model 2c	
<b>Site Energy Consumption</b>						
Per Degree Day*Net	0.075 [1.509]		0.067 [1.093]		2.308 [2.913]	
Per Degree Day (heating)*Net		-0.043 [0.134]		-0.089 [0.085]		-0.166 [0.089]*
Per Degree Day (cooling)*Net		-0.072 [0.085]		-0.059 [0.007]***		-0.088 [0.020]***
Constant	0.028 [0.015]*	0.027 [0.015]*	0.053 [0.013]***	0.053 [0.013]***	2.705 [0.149]***	2.946 [0.021]***
Sample Size	449	449	449	449	449	449
R <sup>2</sup>	0.00	0.01	0.01	0.02	0.24	0.24
Adj R <sup>2</sup>	0.00	0.01	0.01	0.02	0.21	0.22

Notes:

Energy consumption is measured in BTUs per square foot of gross space. See: [www.energystar.gov/index.cfm?c=evaluate\\_performance.bus\\_benchmark\\_comm\\_bldgs](http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_benchmark_comm_bldgs)

In panel B, the specification includes the variables measuring site energy consumption as well as the interaction between site energy consumption and buildings with net rent contracts.

Standard errors are in brackets. Significance at the 0.10, 0.05, and 0.01 levels are indicated by \*, \*\*, and \*\*\*, respectively.

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