Doing Well by Doing Good?
Green Office Buildings

Piet Eichholtz
Maastricht University
Netherlands
p.eichholtz@finance.unimaas.nl

Nils Kok
Maastricht University
Netherlands
n.kok@finance.unimaas.nl

John M. Quigley
University of California
Berkeley, CA
quigley@econ.berkeley.edu

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Abstract

This paper provides the first credible evidence on the economic value of the certification of "green buildings" -- value derived from impersonal market transactions rather than engineering estimates. We match publicly available information on the addresses of Energy Star and LEED-rated office buildings to the characteristics of these buildings, their rental rates and selling prices. 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. *Ceteris paribus*, premiums in effective rents are even higher – above six percent. Selling prices of green buildings are higher by about 16 percent. At prevailing capitalization rates, conversion of the average non-green rental building to an equivalent green building would add about $5.5 million in market value. Conversion of the average non-green office building sold in 2004-2007 to a green building would add $5.7 million in market value. These results are robust to the statistical models employed.

For 494 of the Energy-Star-certified buildings in this sample, we subsequently obtained detailed estimates of site and source energy usage from the U.S. Environmental Protection Agency. Within the sample of rated buildings, our analysis establishes that variations in the premium for green office buildings are systematically related to their energy-saving characteristics. For example, an increase of ten percent in the site energy utilization efficiency of a green building is associated with a twenty basis point increase in effective rent – over and above the six percent premium for a labeled building. Further calculations suggest that a one dollar savings in energy costs from increased thermal efficiency yields roughly eighteen dollars in the increased valuation of an Energy-Star certified building.

I. Introduction

The Most Reverend Desmond Tutu, Archbishop Emeritus of Capetown, 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 other Nobel Laureates such as Thomas Schelling (1992). The growing importance of "corporate social responsibility" as an intangible asset for competitive firms has given the proponents of the green building movement increased credibility, and it 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 (Royal Institute of Chartered Surveyors, RICS, 2005). And once a building is constructed, the energy consumption associated with it continues. The impact of energy costs directly affects the well being 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 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 II below provides a brief review of the emerging literature on corporate social responsibility and its relationship to environmentally sustainable buildings. In

Section III 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 IV presents our methodology and empirical results. Section V is a brief conclusion.

II. 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-

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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.

III. Data on Commercial Buildings

In the U.S., 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

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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."

As of October 2008, there were 1,703 buildings certified by the LEED Program of the USGBC.[1]

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.[2]

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.[3] 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.

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[1] 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.
[2] 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.
[3] 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.

A. 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.[4] 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.

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

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[4] We choose this interval, 2004 – 2007, in part, because the formula for rating office buildings was
(continued at bottom of next page)

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.

IV. Empirical Analysis

A. 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:

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

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

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[5] 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

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unchanged throughout the period.
[5] That is, the rent per square foot multiplied by the occupancy rate.

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.[6] 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. α, β_i, γ_n and δ are estimated coefficients, and ε_{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.[7] 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.[8]

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 $\exp[\delta_n]$.

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[6] 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).

[7] In this way, the specification recognizes the old adage about the three most important determinants of property valuation: "location, location, location."

[8] 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 (Gunnelin 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.

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.

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 IV.B, 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 endogenous rent-

setting policies are taken into account,[9] 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.[10] 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.

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[9] We may expect property owners to adopt differing asking rent strategies. *Ceteris paribus,* landlords who quote higher rents will experience higher vacancy rates.
[10] 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 *(continued at bottom of next page)*

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.

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.[11] 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"

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level and the rental contract type, since we do not have data on these variables for all years during the 2004 – 2007 period.

[11] Results from additional specifications and specifications that do not identify specific clusters are available on request (or online at http://urbanpolicy.berkeley.edu).

in the locations in which these green buildings are placed.[12] 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.

B. 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

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[12] 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).

that the probability that the mean rent or value premium is negative for this sample of buildings is miniscule.[13] 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.[14]

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.

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

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[13] 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.

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.[15]

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:

$$(2a) \qquad \hat{\delta}_n = \alpha + \Theta_j Z_{jn} + \eta_n^*$$

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[14] 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.

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 α and Θ_j denote estimated coefficients, and η_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) $\quad \hat{\varepsilon}_{in}^{*} = \alpha + \Theta_j Z_{jn} + \eta_{in}^{**}$

In this formulation the dependent variable, $\hat{\varepsilon}_{in}^{*}$, 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) $\quad \log R_{in} - \hat{\gamma}_n = \alpha + \beta X_i + \Theta_j Z_{jn} + \eta_{in}^{***}$

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

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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.[16] 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.[17]

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), 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

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[16] 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.

obviously rather crude,[18] 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.[19]

V. 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.

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[17] 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.

[18] Not the least because more than forty percent of the sample is from California, and thus the same energy costs are reported.

[19] 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).

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

Green office stock
(% of total sq. ft.)

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 6
- 6 - 11

Source: Costar and author's calculations
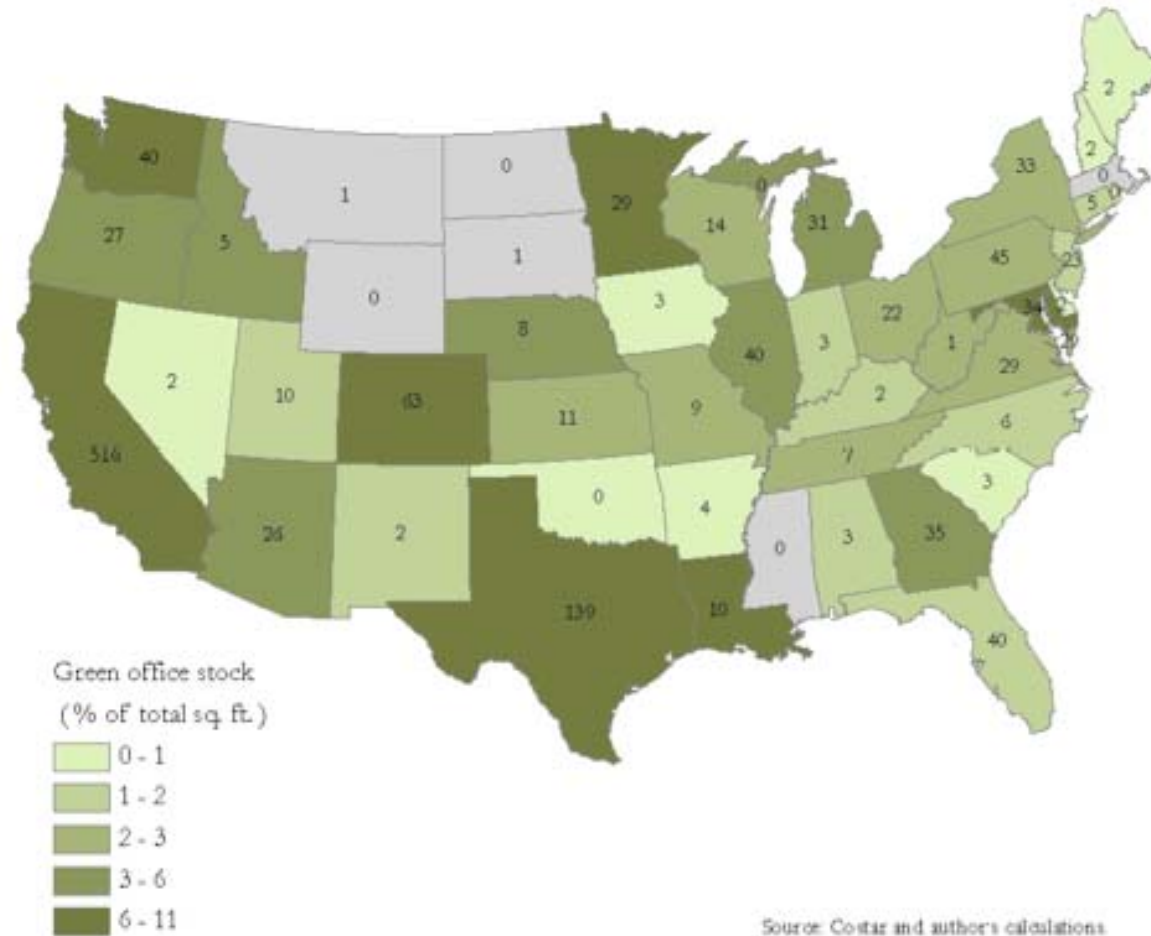
Notes:
    # represents the number of green office buildings in a state

Figure 2
Clusters of Green and Control Buildings

A. Chicago, IL

B. Houston, TX

C. Columbus, OH
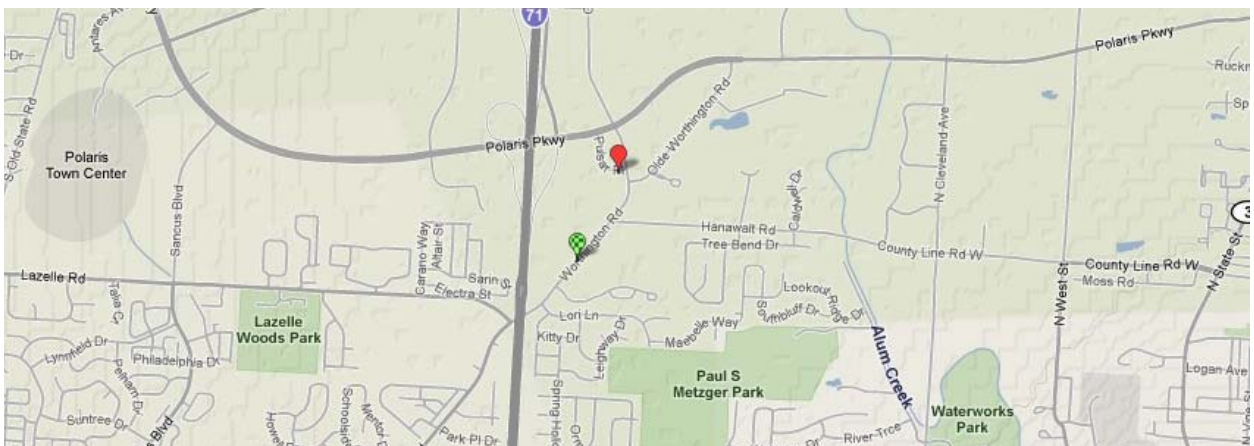
Figure 3
Location Increments vs
Increments for Energy Efficiency
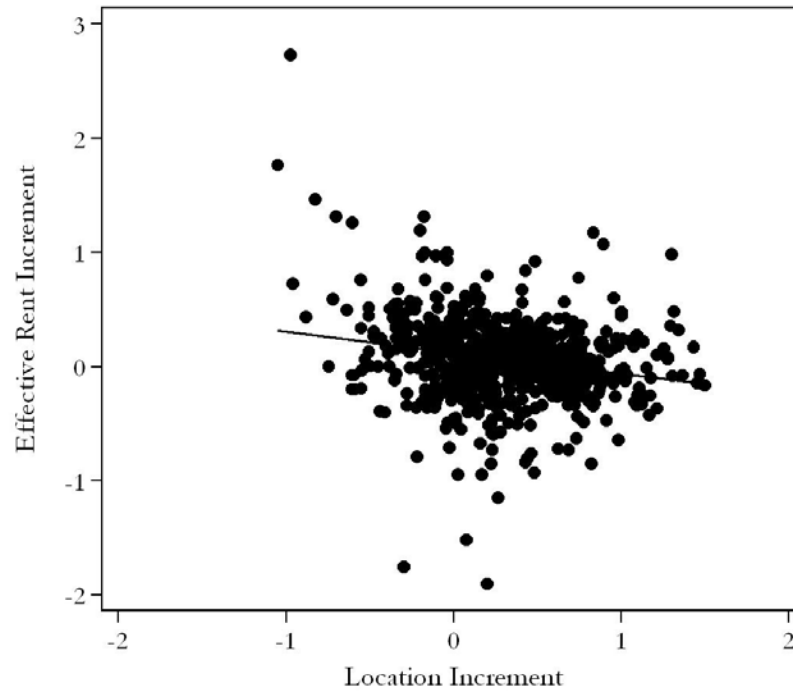
A. Effective Rent
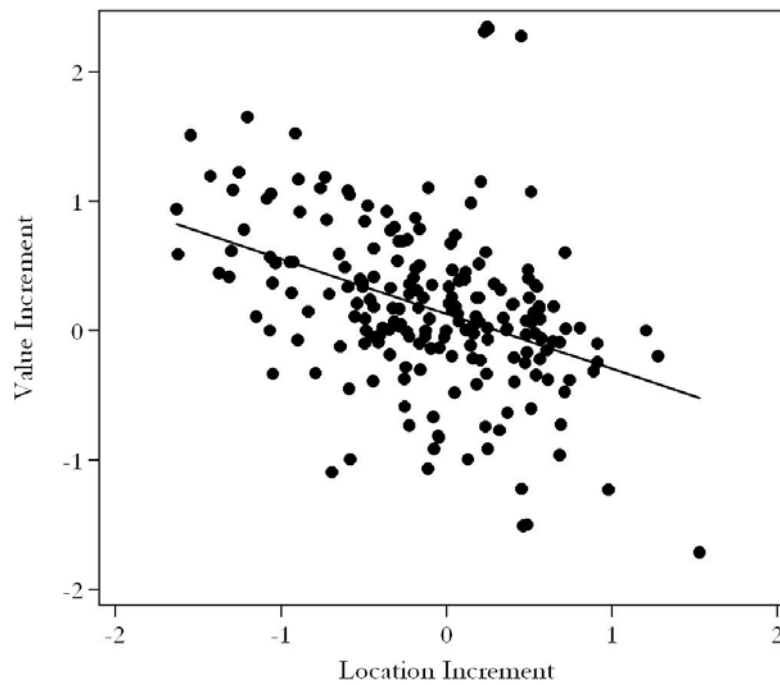
B. Market Value

Figure 4
Degree Days vs
Increments for Energy Efficiency
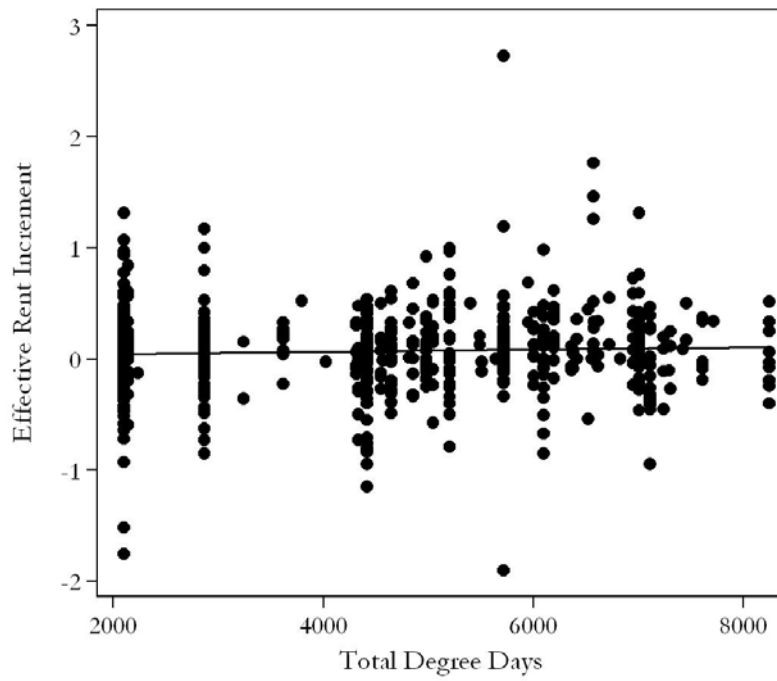
A. Effective Rent
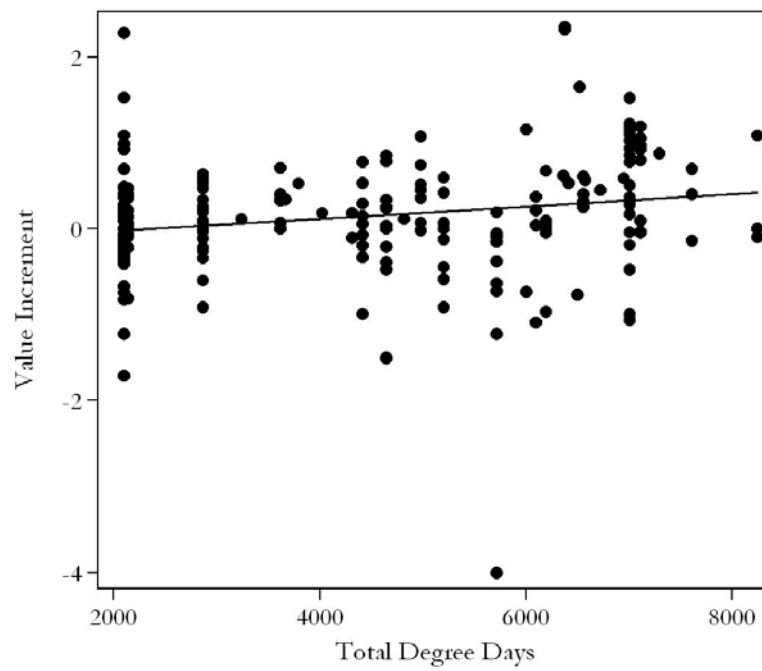
B. Market Value

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

A. Rent (based on Table 2, Column 5)
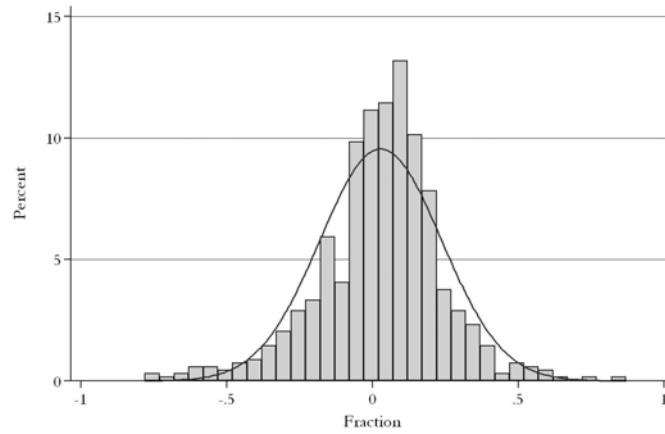
B. Effective Rent (based on Table 3, Column 5)
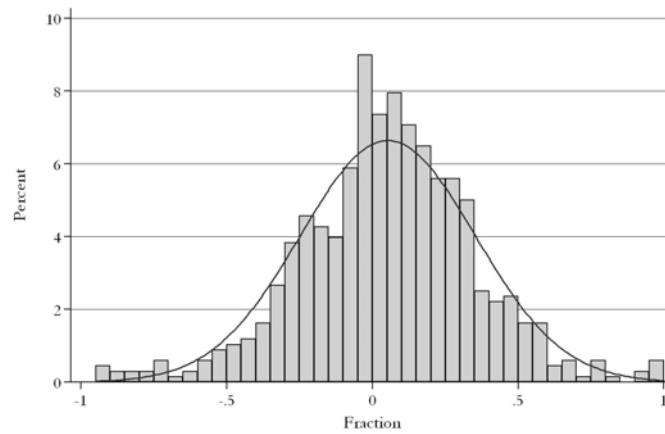
C. Market Value (based on Table 4, Column 5)
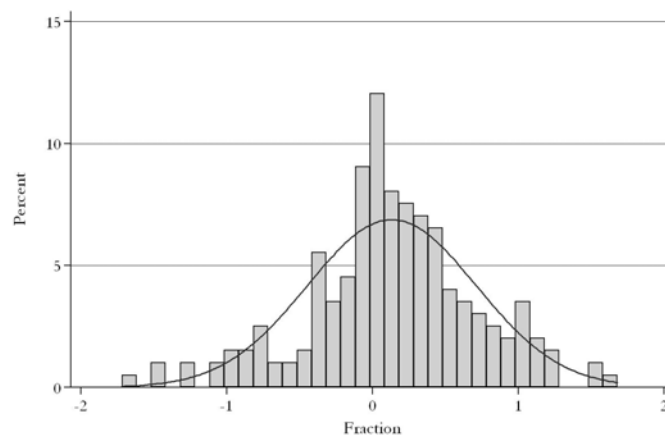
Figure 6
Increase in Market Values
Following a Ten Percent Increase in Energy Efficiency

A. **Increment in Market Value**
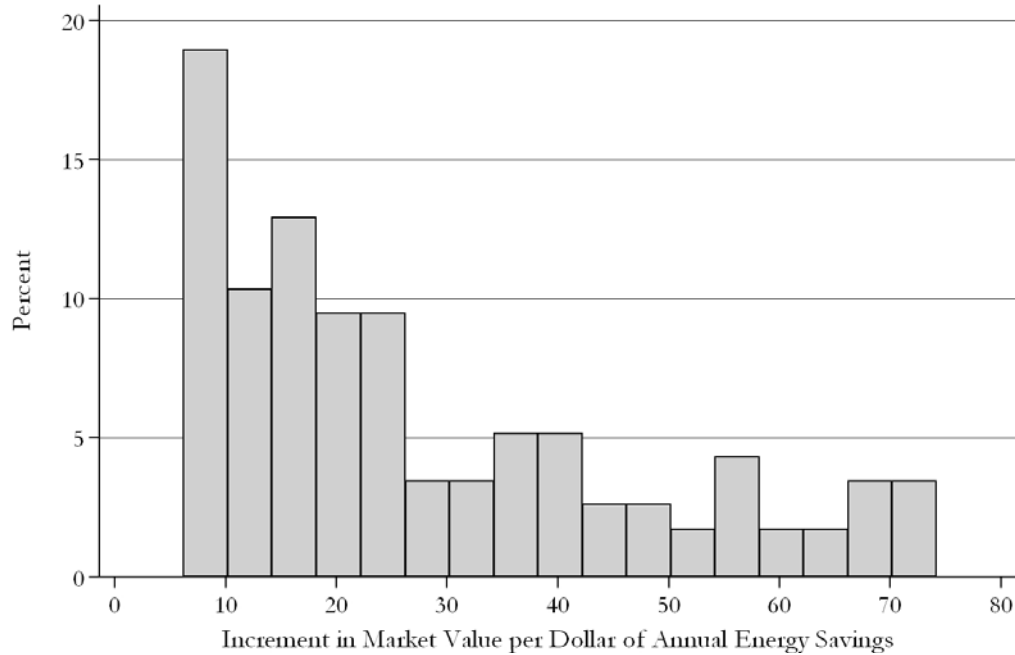
B. **Capitalization of Energy Savings**
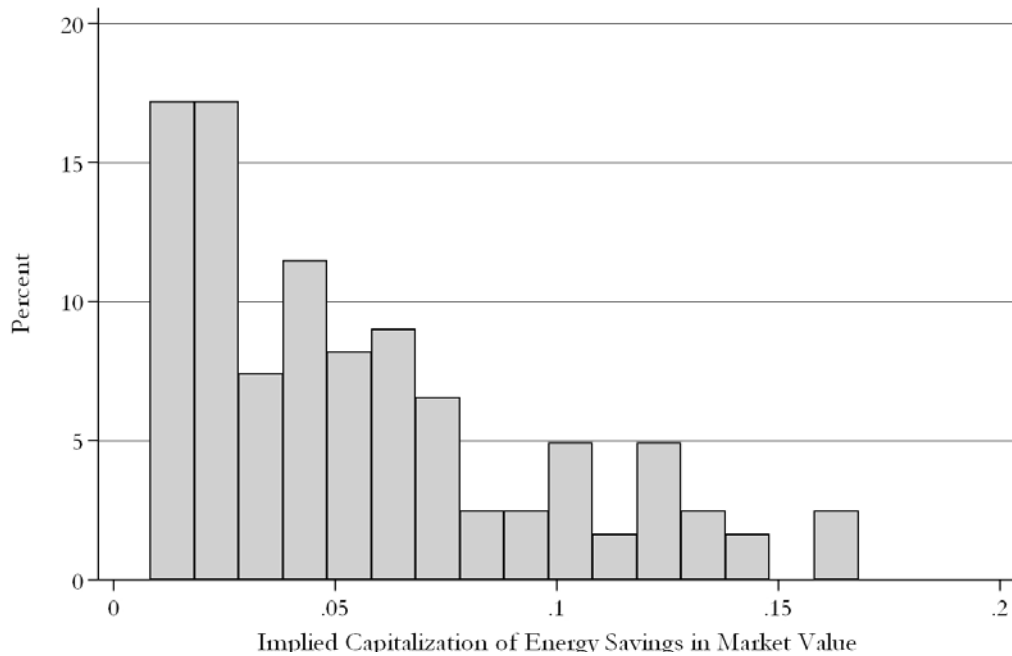
Table 1
Comparison of Green-Rated Buildings and Nearby Control Buildings
Rental Sample and Sales Sample
(standard deviations in parentheses)

	Rental Sample		Sales Sample	
	Green Buildings	Control Buildings	Green Buildings	Control Buildings
Sample Size	694	7,488	199	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)	81.35 (22.73)		
Stories (number)	15.31 (13.26)	13.07 (12.11)	16.47 (12.76)	10.35 (10.50)
Stories (percent)				
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)
Age (percent)				
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)

Table 1
Comparison of Green-Rated Buildings and Nearby Control Buildings
(standard deviations in parentheses)
Continued

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

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		0.082	0.064	
	[0.016]***		[0.024]***	[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	0.261	0.235	0.189	0.193
	[0.028]***	[0.028]***	[0.027]***	[0.027]***	[0.030]***
Building Class:					
Class A (1 = yes)	0.408	0.408	0.340	0.229	0.226
	[0.028]***	[0.028]***	[0.029]***	[0.030]***	[0.033]***
Class B (1 = yes)	0.226	0.226	0.203	0.152	0.149
	[0.027]***	[0.027]***	[0.027]***	[0.026]***	[0.028]***
Net Contract (1 = yes)	0.015	0.014	0.010	0.009	0.016
	[0.024]	[0.024]	[0.024]	[0.024]	[0.028]
Employment Growth (fraction)	0.765	0.756	0.773	0.682	0.468
	[0.312]**	[0.322]**	[0.293]**	[0.308]**	[0.421]
Age:					
< 10 years			0.134	0.177	0.149
			[0.045]***	[0.044]***	[0.054]***
10 – 20 years			0.141	0.146	0.150
			[0.025]***	[0.025]***	[0.028]***
20 – 30 years			0.113	0.112	0.128
			[0.023]***	[0.023]***	[0.025]***
30 – 40 years			0.097	0.090	0.089
			[0.018]***	[0.018]***	[0.020]***
Renovated (1 = yes)			0.019	0.016	0.022
			[0.018]	[0.018]	[0.019]
Stories:					
Intermediate (1 = yes)				0.145	0.156
				[0.021]***	[0.024]***
High (1 = yes)				0.086	0.090
				[0.025]***	[0.029]***
Amenities (1=yes)				0.118	0.124
				[0.015]***	[0.016]***
Constant	2.151	2.158	2.093	2.187	2.299
	[0.029]***	[0.059]***	[0.050]***	[0.050]***	[0.060]***
Sample Size	8182	8182	8182	8182	8182
R^2	0.47	0.47	0.47	0.48	0.51
Adj R^2	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		0.158	0.165	
	[0.051]***		[0.052]***	[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	0.167	0.104	0.200	0.192
	[0.090]*	[0.089]*	[0.089]	[0.108]*	[0.125]
Building Class:					
Class A (1 = yes)	0.164	0.161	0.032	0.104	0.143
	[0.066]**	[0.066]**	[0.078]	[0.084]	[0.099]
Class B (1 = yes)	-0.188	-0.187	-0.216	-0.184	-0.183
	[0.051]***	[0.051]***	[0.057]***	[0.058]***	[0.064]***
Employment Growth (fraction)	-0.005	-0.005	-0.004	-0.006	-0.006
	[0.004]	[0.004]	[0.005]	[0.005]	[0.005]
Age:					
< 10 years			0.201	0.207	0.161
			[0.149]	[0.147]	[0.207]
10 – 20 years			0.196	0.224	0.226
			[0.099]**	[0.100]**	[0.124]*
20 – 30 years			0.248	0.276	0.288
			[0.070]***	[0.070]***	[0.081]***
30 – 40 years			0.226	0.251	0.281
			[0.073]***	[0.075]***	[0.090]***
Renovated (1 = yes)			-0.096	-0.087	-0.071
			[0.046]**	[0.046]*	[0.053]
Stories:					
High (1 = yes)				-0.185	-0.232
				[0.092]**	[0.113]**
Intermediate (1 = yes)				-0.183	-0.189
				[0.057]***	[0.067]***
Amenities (1=yes)				-0.043	-0.048
				[0.049]	[0.058]
Year of Sale:					
2006 (1 = yes)	0.015	0.017	0.021	0.016	0.048
	[0.060]	[0.060]	[0.060]	[0.060]	[0.071]
2005 (1 = yes)	-0.040	-0.039	-0.039	-0.048	-0.034
	[0.056]	[0.056]	[0.056]	[0.055]	[0.065]
2004 (1 = yes)	-0.177	-0.175	-0.173	-0.200	-0.174
	[0.067]***	[0.067]***	[0.067]**	[0.067]***	[0.078]**
Constant	5.314	5.317	5.269	5.406	5.401
	[0.091]***	[0.091]***	[0.151]***	[0.160]***	[0.220]***
Sample Size	1816	1816	1816	1816	1816
R^2	0.43	0.43	0.44	0.44	0.49
Adj R^2	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.

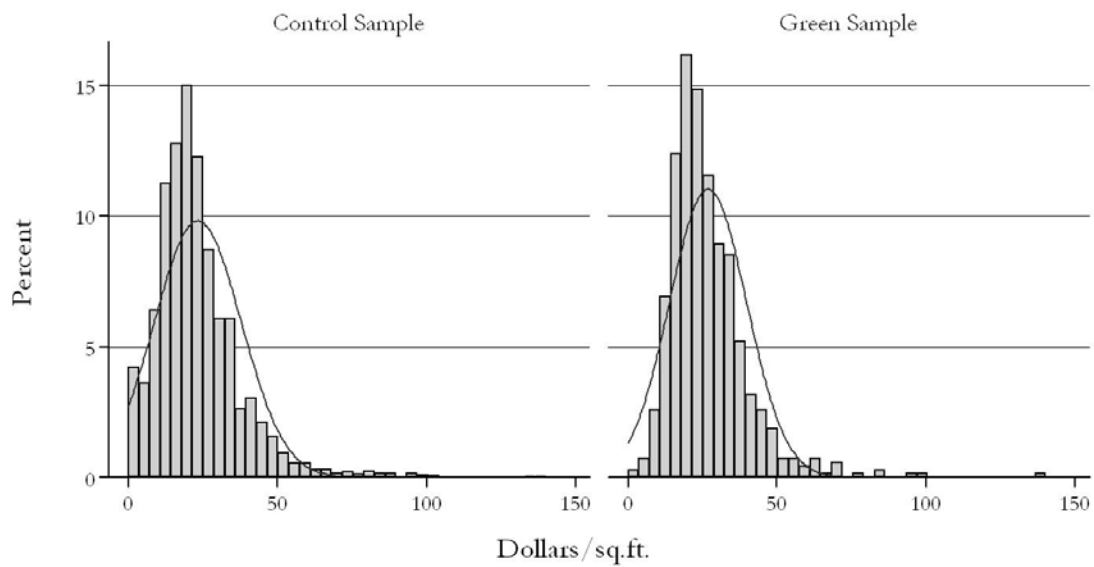Standard errors are in brackets. Significance at the 0.10, 0.05, and 0.01 levels are indicated by *, **, and ***, respectively.

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

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.
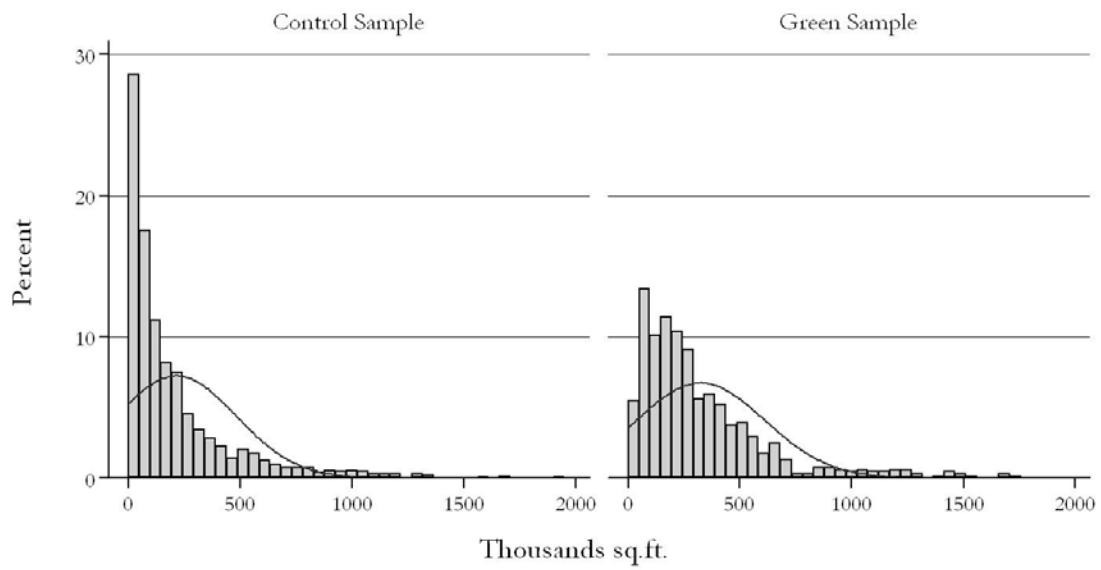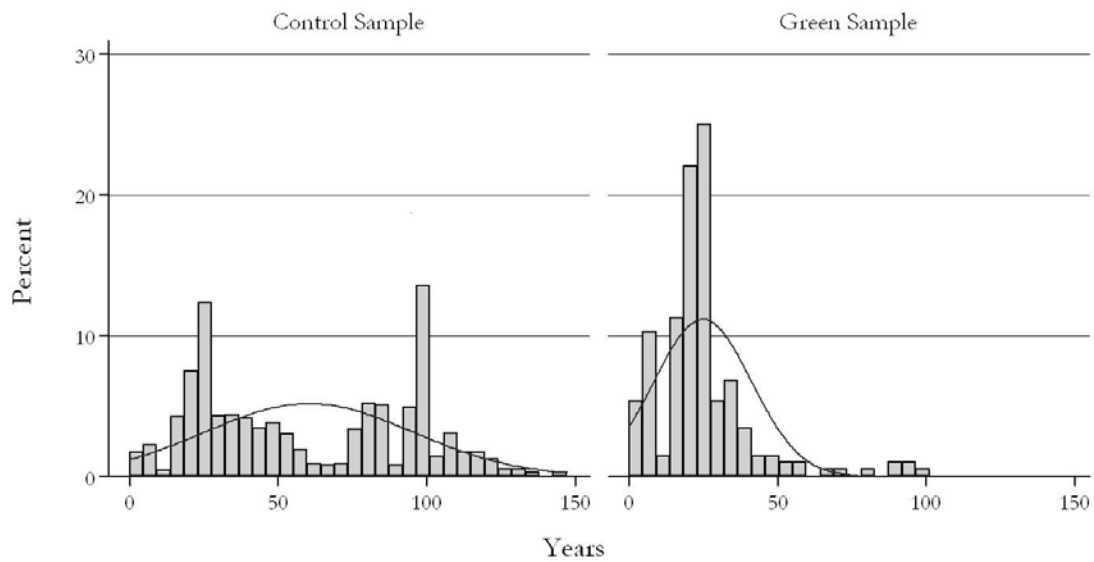
A. Age

B. Effective Rent

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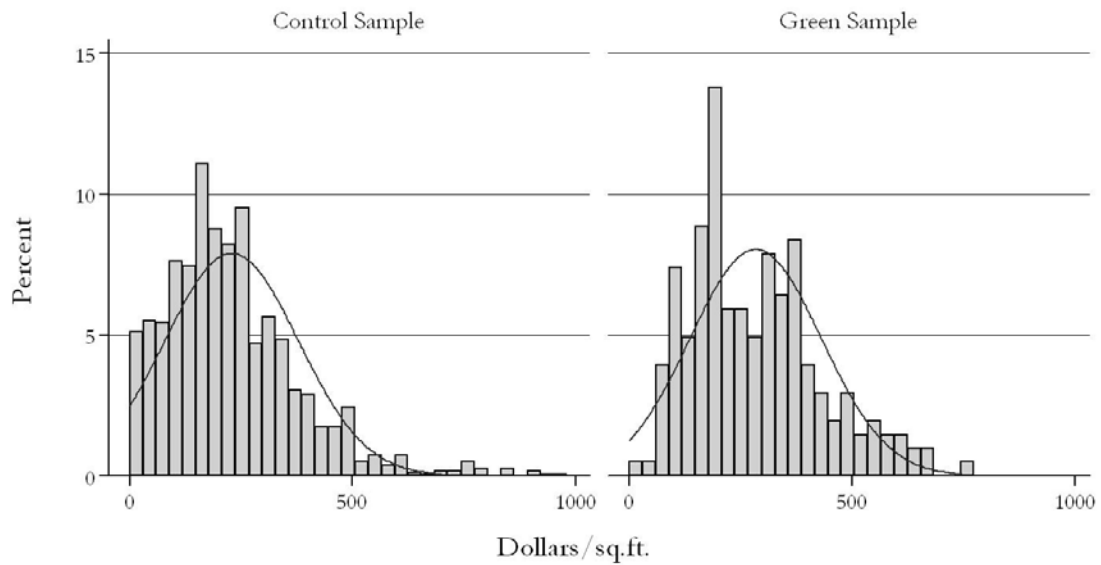**Continued**

C. Size

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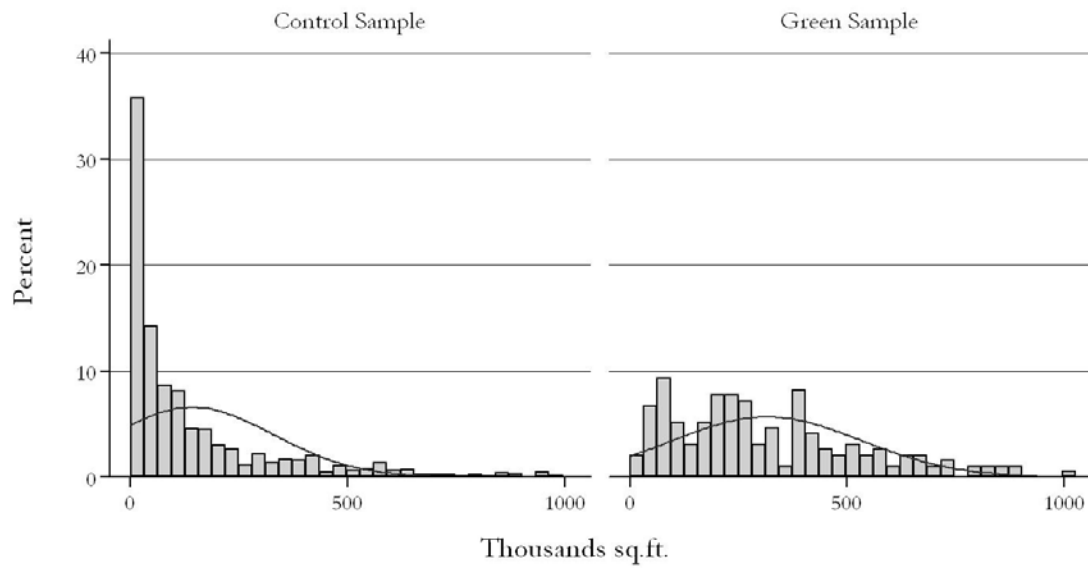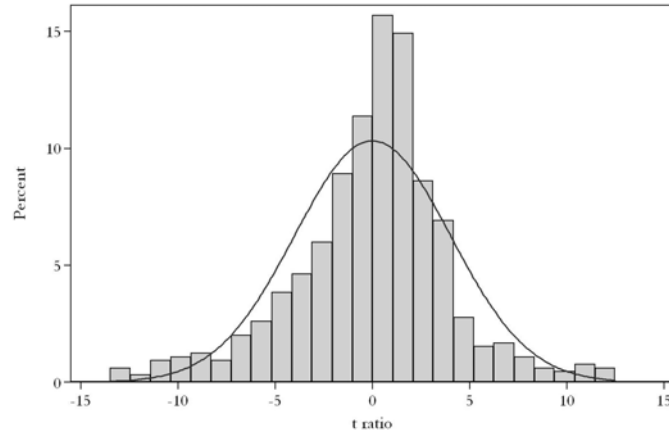
A. Age

B. Sales Price

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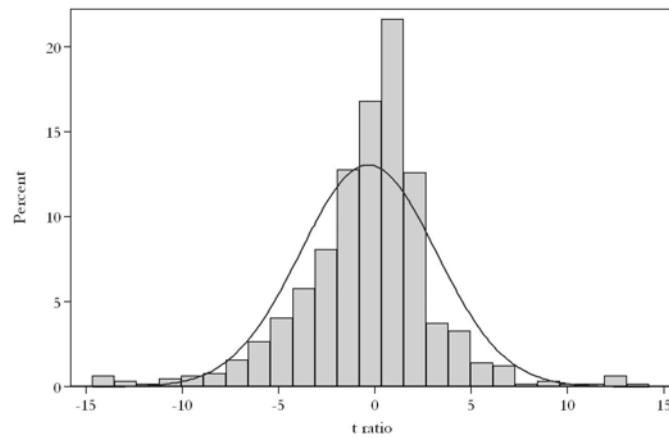**Continued**

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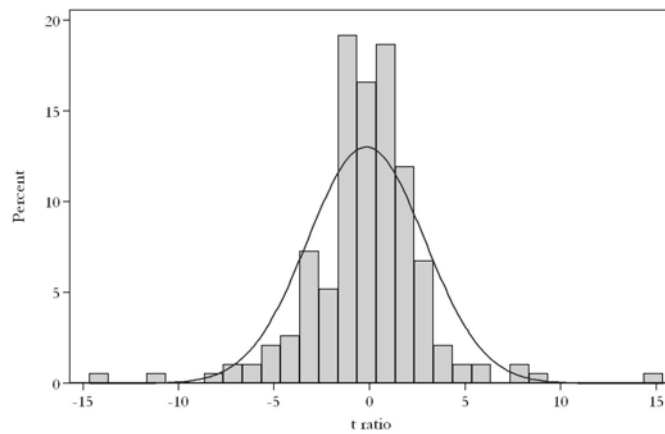
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Panel A. Value Increment	Model 2a		Model 2b		Model 2c	
Source Energy Consumption						
Per Degree Day	-4.935		-4.345		-3.155	
	[1.669]***		[1.360]**		[1.548]**	
Per Degree Day (heating)		-1.667		-1.447		-1.133
		[0.578]***		[0.654]**		[0.679]*
Per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

Notes: Energy efficiency is measured in BTUs per square foot of gross space. See:
www.energystar.gov/index.cfm?c=evaluate_performance.bus_benchmark_comm_bldgs

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