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Green Design and the Market for Commercial Office Space

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Abstract This paper considers the relationship between energy-efficient design and the leasing/sales markets for commercial real estate. An economic model is provided that considers lease rates and occupancy in simultaneous equilibrium. The behavior of both is predicted to be influenced by efficient design attributes. Selling price is determined by both rents and occupancy; therefore the impact of efficient design on commercial sales activity should be distributed through the leasing market. The model is tested empirically using a national sample of sales and leasing data for class A office buildings. The evidence indicates that "green" buildings achieve superior rents and sustain significantly higher occupancy. The improved performance in the rental market is reflected in a significant premium for the selling price of Energy Star-labeled and LEED-certified properties.

Keywords Green design · Office · Leasing · Pricing

Introduction

Members of the real estate industry considering new development often question whether the economics of "green" design will result in higher occupancy, rents or selling prices for their project. Clearly the costs associated with sustainable building vary substantially from one property type to the next, as well as within each property type depending on the scale, location, and level of environmental impact desired.

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The decision to build green is routinely examined as an incremental series of expected cash flows. Development of a green building implies higher construction costs early in the project. With income-producing properties, the investor considers whether these costs will be offset by higher rents, improved occupancy, or savings in operating expenses associated with an energy-efficient building. At the end of the holding period, the property is expected to sell at a premium based on higher expected future cash flows.

The difficulty with this approach is that very little market information exists on the premiums associated with green design. This paper presents an economic model to examine the market for commercial office space. We hypothesize that if green buildings demonstrate superior rent and occupancy potential in the leasing market, then these properties must also earn a premium in the sales market for commercial office space. Three economic explanations are provided for how this might happen, including the potential for green office space to command higher rents, the enhanced ability of a green building to attract desirable tenants (i.e., improved occupancy), as well as the direct impact of savings in operating expenses.

This study uses data collected from the CoStar Group® examining class A office leasing activity in 46 markets across the USA. The results provide evidence that green-labeled buildings achieve significantly higher rents—estimated at 7.3 to 8.6% for Energy Star properties and 15.2 to 17.3% for LEED-certified properties. Simultaneously estimated occupancy levels are higher by approximately 10 to 11% for Energy Star properties and 16 to 18% for LEED-certified properties. CoStar® sales data is utilized to examine price differences in the value of energy-efficient buildings. Consistent with findings of superior performance in the rental market, the empirical results provide evidence that both Energy Star-labeled and LEED-certified properties sell at significant premiums to comparable properties; \$30 and \$129/ft^2, respectively.

As an example, in July 2006, the 50-story One Atlantic Center (1201 W Peachtree St.) sold for \$305 million, or \$277/ft^2. One Atlantic Center was the tallest building in Atlanta when it opened in 1987, but was later eclipsed by the 55-story Bank of America Plaza at 600 Peachtree St. In September 2006, Bank of America Plaza sold for a record-setting \$436 million, pushing the upper limit of the highest Atlanta office sale price to \$348 per square foot. In the same month (Sep. 2006), and in the same Midtown Atlanta office submarket, the 41-story 1180 Peachtree building sold for \$273 million, or \$408/ft^2, instantly shattering the record price per square foot for office building sales in Atlanta. Although 1180 Peachtree was not the largest building in Atlanta, it was the first LEED-certified class A office building to sell in that market.

This paper is organized as follows. The next section discusses related research and provides an historical perspective on green building in the market for commercial office space. The model and methodology used in this research are described in section three. The data and variables that impact rents, occupancy and prices are identified and described in section four. In the fifth section, the model is estimated and the empirical findings analyzed. The paper concludes with a summary of the findings of this study.

Background

Green Design and Commercial Office Properties

Green design, or green building, refers generally to using sustainable methods and materials in the design and construction of new properties (or in the renovation of existing properties). The scope of green design is very broad and includes using energy efficient lighting technologies, redeveloping brownfield sites, or using green roofs that allow for runoff water to be recycled, among a host of other possibilities.

Energy use in commercial buildings and manufacturing plants accounts for nearly half of the total US greenhouse gas emissions and energy consumption nationwide.[1] Energy costs are the largest and most manageable operating expense for commercial properties, typically representing about 30% of operating costs.[2] Commercial buildings with the Energy Star label use nearly 40% less energy than average buildings.[3] Beyond the direct impact of higher net operating income (NOI), there is discussion among developers, primary and secondary mortgage market participants, and valuation professionals regarding whether or not green buildings are subject to lower risk and higher demand, and therefore should be valued using lower capitalization rates.[4]

Energy Star is a joint program of the US Environmental Protection Agency (EPA) and the US Department of Energy aimed at the promoting energy-efficient products to reduce greenhouse gas emissions. In 1999, the Energy Star label was made available for commercial buildings. By the end of 2007, nearly 4,100 buildings earned the EPA's Energy Star, including about 1,500 office buildings. The Energy Star ratings are developed by using national data from the Commercial Building Energy Consumption Survey to empirically quantify energy usage for each property type. Energy efficiency is measured by the residual between actual and predicted energy consumption. The Energy Star label requires a score in the top quartile on the EPA's energy performance rating system, along with satisfactory compliance with indoor air quality standards. The main requirement of the application process involves tracking a building's energy performance and making the results available to the EPA.

The LEED designation was developed by the US Green Building Council as a way to encourage the adoption of sustainable building practices. LEED takes a whole-building approach to green design and construction by focusing on five areas of human and environmental well-being, rather than solely on energy conservation.

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[1] EPA press release, Feb. 12, 2008 "Green Choices Grow with Energy Star Qualified Buildings."

[2] In two reports prepared as guidelines for appraisers considering the contribution of energy costs, Chao et al. (1999) and Chao and Parker (2000) use data from *Building Owners and Managers Association 1998 Experience Exchange Report* to illustrate that median energy costs contribute between 23 to 30% of total operating costs in four major downtown California office markets and between 31 to 37% in four major downtown New York office markets.

[3] EPA press release, Feb. 12, 2008 "Green Choices Grow with Energy Star Qualified Buildings."

[4] See, for instance, Evolution Partners press release, Dec. 6, 2005 "Meeting Notes: LEEDÒ and Energy StarÒ Building Finance Summit."

These five areas include sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality. The LEED system is based on points awarded in several different categories. There are four levels of achievement possible: “Certified” requires at least 26 points; “Silver” requiring 33–38 points; “Gold”, 39–51 points; and “Platinum”, for 52–69 points. There are currently 1,255 LEED certified buildings in the US across the four certification levels, while another 8,000 projects have registered their intent to seek LEED certification.

LEED is in the process of developing standards for New Construction (LEED-NC), Existing Buildings (LEED-EB), Commercial Interiors (LEED-CI), Core and Shell (LEED-CS), Schools, Retail, Healthcare, Homes, and Neighborhood Development. Each LEED standard is developed by a committee in close consultation with a large group of experts from the construction industry. The process of gaining LEED certification is costly and time-consuming, requiring documentation to support points in each category of LEED 2.1 standards. Watchman (2007) reports that the certification fee alone can range anywhere from $1,000 to $20,000, ignoring the potential for additional costs of consultation or building commissioning.

Cassidy (2003) reports that 62% of LEED-registered projects were buildings owned by some level of government, either local, state, or federal, or by a non-profit corporation. The relatively low percentage of LEED-registered projects owned by private, for-profit corporations can be traced to continuing concerns that the costs to build to LEED standards are prohibitive. In one popular study of green building, Kats (2003) estimates large net present value benefits to designing and building to attain LEED certification; however, a large portion of the positive benefit is in the form of increased worker health and productivity. Kats (2003) argues that the cost to build green will decline over time as the firms gain more experience designing and building environmentally sustainable structures.

Office Space Valuation, Rents, and Occupancy

Until recently, market data for the office space product was largely difficult for researchers to attain and often limited in scope. As a result, the valuation of office product has received limited attention in the literature. Rosen (1984) appears to be the original exception to this lack of scientific coverage. Specifically, he points out how indirect measures such as absorption rates and normal vacancy rates serve as indirect measures of market conditions in the market for office product. Being unsatisfied with this, Rosen develops a partial equilibrium model of supply and demand for office product. The model reveals variables such as the stock of office space, vacancy rate, and rents as key determinants of value. Most relevant to this study, Rosen demonstrates that vacancy and rents are jointly determined in equilibrium.

The literature on the determinants of rent is considerably better developed. Property characteristics such as age, size, location and vacancy are commonly found to significantly determine market rent levels. Early work by Clapp (1980) identifies property age as a physical characteristic, along with other locational variables, as significant factors that influence the level of office rents. Later research continues to verify the significance of property age, including that of Frew and Judd (1988), Wheaton and Torto (1994), Bollinger et al. (1998), and Slade (2000). Also in the early-1980s, Brennan et al. (1984) examine office rents in Chicago and identify building size and locational characteristics within the CBD as key factors of influence. Glascock et al. (1990) study rents in an unnamed office market over a five-year period. In addition to recognizing the contribution of property size, Glascock et al. (1990) provide empirical evidence for the economic relationship between rents and occupancy. The findings of Hekman (1985), Shilling et al. (1987), Pollakowski et al. (1992), Hendershott (1996), Hendershott et al. (2002) all support this empirical connection between vacancy and rents in office markets.

Economic theory for the potential endogeneity between occupancy and rents is discussed further in the residential leasing literature. Wheaton (1990) provides a generalized model for housing that applies to both leasing and for-sale markets. The model predicts that vacancy will have a significant influence on both prices/rents and expected search duration. Williams (1995) presents a sequential-search model where price and duration are determined in equilibrium. The impact of vacancy is discussed as a liquidity premium, which is sensitive to search inefficiencies, transaction costs, interest rates, and the relative flow of market participants. Wheaton (1999) builds on this discussion by considering the effects of vacancy through real estate market cycles. In response to demand shocks, the speed of occupancy adjustment is distorted due to increased depreciation, supply inelasticity, and delays in new delivery of space.

The price elasticity of demand for office space has been investigated on several occasions. Hekman (1985) examines fourteen office markets in the US, finding no evidence that changes in occupancy are systematically sustained from one year to the next. Consistent with the findings of this study, Hekman (1985) identifies a significant positive correlation between rents and occupancy. Wheaton and Torto (1994) document the persistence of this relationship using office rent indices, and Benjamin et al. (1998) offer analogous evidence for the retail market. These works all serve as background and support for the empirical estimations of office rents and valuation, which are presented in the next section.

The Model

Green Design and Operating Expenses

The value of a real estate asset can be examined by considering the set of attributes possessed by the property. Physical property characteristics include both functional and design attributes. For a property to possess a certain set of functional attributes S_j, there are countless ways to design the property. Design attributes can generally be classified in two categories, with one category consisting of attributes providing aesthetic appeal only. The value of these attributes depends largely on user tastes and preferences. The other category includes a set of efficient design attributes D_j, which are assumed to reduce operating expenses $X(D_j)$, in addition to any possible visual appeal. A property is identified as a "green design" building when it has a necessary level of efficient design attributes D_{Gj} to achieve the set of functional attributes S_j. In other words $X(D_{Gj}) < \overline{X}(D_j)$, where $\overline{X}(D_j)$ is the market average operating expenses for all properties with the set of functional attributes S_j.

The profit-maximizing developer imposes a cost-minimizing constraint for a given level of revenue. If only the set of functional attributes S_j are valued by the market, developers will always take the least-cost approach to design (absent third-party incentives). If instead efficient design attributes are also priced in the market, developers will consider incorporating additional design elements as the expected payoff from each attribute outweighs the opportunity costs.

Market Rents and Occupancy

Market rents vary substantially from one property to the next. Even for properties with an identical set of functional attributes, rents are affected by a number of other factors, including locational attributes, operating expenses, leasing terms and efficient design attributes. In addition, we assume that rents and occupancy levels are determined simultaneously.

$$R = r(S_1, D_1, G_1, X(D_1), L_1, O) \quad (1)$$

Where

- R rent per unit of service
- S_1 vector of functional attributes
- D_1 vector of efficient design attributes
- G_1 vector of locational attributes
- X vector of operating expenses
- L_1 vector of lease terms
- O occupancy level

While a green building may cost more to produce than the average building in the market, the observed rental rate may be impacted in at least two ways. Green buildings typically have a unique visual appeal to potential users. This impact of green design on rents depends heavily on current user tastes and preferences. Some tenants place a high individual value on green space because it enhances some other aspect of their business operations. As McHugh et al. (2002) point out, examples of non-energy benefits to occupants of green buildings include improved marketing to environmentally-conscious clients, increased employee productivity and comfort, reduced maintenance, and risk avoidance/insurance issues (e.g., mold and power outages).

The other impact of green design on the rental rate is transmitted through a reduction in operating expenses. Depending on the lease type, tenants can negotiate a lower base rent in exchange for a commitment to reimburse some or all of the associated operating expenses. In a lease with reimbursements, operating expenses of a green building are assumed to be lower than those of the average building. Hence, the owner of a green building might be able to negotiate higher base rents when reimbursements are expected to be lower.

A natural vacancy rate in rental markets can exist for a number of reasons, including search costs, short-run supply inelasticity, unpredictable changes in demand, and the uniqueness of tenant needs. As a result, the occupancy level for a specific property will depend on market-specific characteristics. In addition, occupancy and rents are not independent variables—a landlord that is too aggressive in rent setting might expect less than competitive occupancy. Occupancy is an indicator for the ability of a property to serve the market needs. For a given rent, occupancy will be determined based on the attributes a property possesses.

$$O = f(S_1, D_1, G_1, X(D_1), L_1, R) \tag{2}$$

If the market is not saturated with green buildings, then available space may rent in a segmented market characterized by excess demand. When this is true, green buildings might be able to both command premium rents and achieve superior occupancy.

Investors consider the value of a property based on discounting expected future cash flows. The expected selling price V of a property is determined by

$$V = v(S_1, D_1, G_1, X(D_1), L_1, R, O). \tag{3}$$

A property with reduced operating expenses should sell at a premium due simply to the expected savings in operating costs. If the same property is also able to achieve higher rents or improved occupancy, the pricing premium will be even larger.

Description of the Data

The data used in this paper is provided by the CoStar Group®. The first set of data is collected from CoStar Property® on January 9, 2008, and includes current leasing information for a national sample of Class A office buildings. This study focuses on Class A office space because the market for Class A space tends to be highly responsive to changes in design technology. We identify 46 office markets across the USA with data available for Energy Star-labeled and LEED-certified properties. The sample is limited within these markets to include only properties with current leasing and occupancy data available, including a specification for the lease type associated with each observed rental rate. This includes a total of 7,308 properties.

The second set of data used in this study includes a sample of class A office building sales data collected from CoStar COMPS®. We identify 25 office markets with sales information available for Energy Star-labeled and LEED-certified properties. The sample is restricted within these markets to include only observations with data on property size, year built, and date of sale, which provides a total of 1,151 observations.

The variables used from the two samples are described in Table 1. Indicator variables recognize properties listed as LEED-certified and Energy Star-labeled. For the leasing data, variables were also created to identify each office market[5] and lease

[5] Leasing markets include Atlanta, Austin, Boise City/Nampa, Boston, Charlotte, Chicago, Cincinnati/Dayton, Cleveland, Colorado Springs, Columbus, Dallas/Ft Worth, Denver, Detroit, East Bay/Oakland, Hampton Roads, Hartford, Hawaii, Houston, Indianapolis, Inland Empire (CA), Jacksonville (FL), Kansas City, Los Angeles, Louisville, Milwaukee/Madison, Minneapolis/St Paul, Nashville, New York City, Northern New Jersey, Orange (CA), Orlando, Philadelphia, Phoenix, Portland, Raleigh/Durham, Sacramento, Salt Lake City, San Diego, San Francisco, Seattle/Puget Sound, South Bay/San Jose, South Florida, St Louis, Tampa/St Petersburg, Toledo, Washington DC.

Table 1 Variable legend

Variable	Description
Age	The age of the property (in years)
Avg_rent	The weighted-average rent
Bldg_SF	The size of the building (in square feet)
D_Double_Net	1 if lease type listed as "Double Net"
D_Modified_Gross	1 if lease type listed as "Modified Gross"
D_Negotiable	1 if lease type listed as "Negotiable"
D_Net	1 if lease type listed as "Net"
D_Plus_All_Utilities	1 if lease type listed as "Plus All Utilities"
D_Plus_Cleaning	1 if lease type listed as "Plus Cleaning"
D_Plus_Elec and Clean	1 if lease type listed as "+Elec and Clean"
D_Plus_Electric	1 if lease type listed as "Plus Electric"
D_Tenant_Electric	1 if lease type listed as "Tenant Electric"
D_Triple_Net	1 if lease type listed as "Triple Net"
D_Utilities_ and _Char	1 if lease type listed as "Utilities and Char"
Energy_Star	1 if the property is Energy Star®-labeled, 0 otherwise
LEED	1 if the property is LEED-certified, 0 otherwise
Max_contiguous	The maximum contiguous space available (in square feet)
Occupancy	The percent of the property leased
Sale_Date	Number of days since property sale (relative to 01/09/08)
Sale_Price	The sale price

type.[6] For the sales data, indicator variables are also used to distinguish each office market.[7] The market and lease type data are described in the Appendix 1. Table 2 provides summary statistics describing other variables of interest. In "Leasing data", it is shown that the LEED-certified and Energy Star-labeled properties rent at significantly higher rates. However, these descriptive statistics do not distinguish for differences across markets and lease types. "Sales data" shows that the green buildings are significantly larger than the average class A building in the sample; accordingly these buildings sell at a significant premium to the market average.

The ability to empirically test the models presented in this research is highly dependent on the nature of data available. Office rents vary substantially across the USA according to geographic location and lease type; therefore, much of the variation explained in the empirical work is a result of including the indicator variables for location and lease types. Beyond this, several other variables are also included in the empirical analysis. In the leasing data, the Max_contiguous variable was selected as a proxy for the ability of a property to satisfy the needs of heterogeneous tenants. We expect property owners with large amounts of contiguous space available to demand higher rents due to the opportunity to attract larger, more established tenants. Low occupancy properties are the most likely to have large amounts of contiguous space available. In both the sales and leasing data, Age was

[6] Lease types include Full Service Gross, Modified Gross, Negotiable, Net, Plus All Utilities, Plus Cleaning, Plus Electric, Tenant Electric, Triple Net, Utilities and Char.

[7] Sales markets include Atlanta, Boston, Charlotte, Chicago, Columbus, Dallas/Ft Worth, Denver, East Bay/Oakland, Houston, Jacksonville (FL), Los Angeles, Milwaukee/Madison, Minneapolis/St Paul, Northern New Jersey, Orange (CA), Philadelphia, Phoenix, Portland, Sacramento, San Diego, San Francisco, Seattle/Puget Sound, South Florida, St Louis, Washington DC.

Table 2 Summary statistics

Variable	Mean	Standard Deviation	Mean (LEED=1)	Mean (Energy_Star=1)
Leasing data (n=7,308)				
LEED	0.004	0.062	–	–
Energy_Star	0.060	0.237	–	–
Age	22.7	17.0	20.9	25.0***
Avg_rent	$26.48	$13.08	$31.90*	$30.10***
Max_contiguous	27,795	66,022	69,514**	24,346*
Occupancy	76.30%	28.06%	80.80%	89.90%***
Sales data (n=1,151)				
LEED	0.010	0.102	–	–
Energy_Star	0.061	0.239	–	–
Age	20.2	20.3	10.2**	22.7*
Bldg_SF	194,925	221,126	387,673**	420,567***
Sale_Date	431	481	436	565
Sale_Price	$45,471,961	$72,533,961	$142,422,790***	$120,409,923***

*p=0.1, significant difference from the mean of the control set
**p=0.05, significant difference from the mean of the control set
***p=0.01, significant difference from the mean of the control set

selected as a control for contemporary design, operating expenses and functional obsolescence.

Empirical Results

Office Space Rental Market

The simultaneous estimation of Eqs. 1 and 2 requires a two-stage least squares (2SLS) approach, using instrumental variables.[8] Table 3 reports the results of both the ordinary least squares (OLS) and 2SLS estimates from the simultaneous modeling of rent and occupancy. The parameter estimates and the model fit are similar for the OLS and 2SLS approach. In each model, the market indicator variables are included with the indicator for the Washington DC market suppressed. In the interest of space, the parameter estimates are not shown for the 45 market indicators included in each model. In addition, indicators for the type of lease are included—measured relative to the suppressed indicator for gross lease. It is worth mentioning here that the inclusion of lease type indicators and the variable transformations of Avg_rent, Age and Max_contiguous greatly improve the models' goodness-of-fit. An R-squared of 63.2% for OLS and 58.4% for 2SLS represents a high degree of explanatory power relative to most models of commercial office market rents.

[8] Model 2 uses the 45 market indicators along with the 11 lease type indicators as instrumental variables in the first-stage estimation to collect predicted values for Occupancy. In the second stage, the market indicator for "Los Angeles" along with the lease type indicator for "Double Net" are omitted so that the model is full rank resulting in second-stage parameter estimates that are unique, consistent and unbiased. Model 4 uses the 45 market indicators as instrumental variables in the first-stage estimation to collect predicted values for ln(Avg_rent). The market indicator for "Kansas City" is omitted in the second stage.

Table 3 Results from simultaneous leasing model estimation (n=7,308)

Variable	Model 1- OLS Dependent variable: ln (Avg_rent)	Model 2- 2SLS Dependent variable: ln (Avg_rent)	Model 3- OLS Dependent variable: Occupancy	Model 4- 2SLS Dependent variable: Occupancy
	Coefficient (*t*-statistic)			
Intercept	3.415***	3.223***	107.8***	107.8***
	(100.68)	(23.03)	(23.15)	(5.34)
D_Double_Net	−0.1658	–	−17.76*	−19.64**
	(−1.63)	–	(−1.90)	(−2.10)
D_Modified_Gross	−0.0426**	−0.0151	−5.471***	−5.965***
	(−2.59)	(−0.71)	(−3.62)	(−3.95)
D_Negotiable	−0.0109	0.0387	−5.550***	−5.726***
	(−0.67)	(1.45)	(−3.73)	(−3.85)
D_Net	−0.2174***	−0.1701***	3.211*	1.062
	(−11.61)	(−6.56)	(1.85)	(0.62)
D_Plus_All_Utilities	−0.0018	0.0252	−3.255	−3.311
	(−0.08)	(0.94)	(−1.60)	(−1.62)
D_Plus_Cleaning	−0.2079***	−0.1522**	−11.864**	−14.097***
	(−3.53)	(−2.18)	(−2.19)	(−2.61)
D_Plus_Elec and Clean	−0.1119**	−0.1160**	−0.105	−1.232
	(−2.40)	(−2.25)	(−0.02)	(−0.29)
D_Plus_Electric	0.0171	0.0351**	0.086	0.259
	(1.27)	(2.18)	(0.07)	(0.21)
D_Tenant_Electric	0.0354*	0.0217	6.128***	6.558***
	(1.83)	(0.96)	(3.44)	(3.68)
D_Triple_Net	−0.2173***	−0.1552***	−1.539*	−3.744***
	(−24.50)	(−6.07)	(−1.82)	(−4.60)
D_Utilities_ and _Char	−0.1184	0.0698	−32.52***	−34.10***
	(−1.64)	(0.61)	(−4.91)	(−5.15)
ln(Age)	−0.0706***	−0.0540***	14.71***	14.17***
	(−15.69)	(−11.88)	(38.41)	(37.41)
ln(Max_contiguous)	0.0196***	0.0067***	−11.03***	−10.96***
	(7.17)	(2.60)	(−51.08)	(−50.77)
ln(Avg_rent)	–	–	9.946***	10.23*
	–	–	(9.27)	(1.75)
Occupancy	0.0012***	0.0046***	–	–
	(9.27)	(2.77)	–	–
LEED	0.1516***	0.1730***	16.20***	17.92***
	(3.47)	(3.60)	(4.04)	(4.47)
Energy_Star	0.0734***	0.0862***	10.18***	11.03***
	(6.34)	(6.81)	(9.61)	(10.45)
Market controls:	Included	Included	Included	Included
R-square	63.2%	58.4%	46.3%	45.9%

*p=0.1
**p=0.05
***p=0.01

The results show that older properties rent for less, but tend to have higher occupancy. As construction costs rise, the feasibility of new properties requires higher rents—even during the lease-up phase. Older properties are more likely to have established tenants with long-term leases and spaces that become available only when a tenant leaves (i.e., frictional vacancy). Max_contiguous has the opposite effect, as expected. Buildings with large amounts of vacant space quote higher lease rates due to their ambition of attracting larger, more successful tenants. Properties with the most contiguous space available have lower occupancy, almost by definition.

Interestingly, Occupancy and Avg_rent are positively related. Hence, not all Class A office space is created equal. A building with high-quality design and preeminent location is expected to be quite popular in the central business district (CBD). Such a property will have an improved ability to minimize vacancy, and should be able to command premium rents at the same time due to the intensity of demand. Less desirable buildings in suboptimal locations will have greater difficulty attracting stable tenants and will be forced to offer lower rent as a result.

Both Energy_Star and LEED are found to have positive and significant impacts on Avg_rent and Occupancy. The coefficient for Energy_Star is 0.0734 in the OLS model and 0.0862 in the 2SLS model for ln(Avg_rent). Due to the data specification in this research, these coefficients have a very straightforward interpretation for the impact of green building on the market for commercial office space. When controlling for differences across regional markets and lease types, Energy Star-labeled properties achieve premium rents of 7.3 to 8.9% relative to comparable properties. For the national sample of class A office space in 46 markets with green-labeled properties, the average rent for properties that are not green-labeled is $\$26.90/ft^2$. The coefficient for LEED in models 1 and 2 indicates a premium of 15.2 to 17.3% above than the sample average. Some of this premium might be attributed to the value of tenant savings in operating expenses from using an energy-efficient space. However, can all of this premium be credited to the savings in operating expenses?

The impact on Occupancy of green-labeled properties is also found to be positive and significant. In models 3 and 4 of Table 3, the coefficients for Energy_Star are 10.18 and 11.03, respectively. Hence, when controlling for differences across markets and lease types, Energy Star-labeled properties sustain approximately 10 to 11% higher occupancy relative to comparable properties. Similarly, LEED-certified properties support 16.2 to 17.9 percent higher occupancy levels. The results from these *Occupancy* estimations speak more directly to attributes of green buildings beyond the impact of savings in operating expenses. With models 3 and 4 controlling for age and rent, significantly higher occupancy for these properties implies a superior ability to attract tenants and quickly lease-up relative to properties that were built in the same year. In other words, green design has a considerable impact on the user marketing of class A office space.

Office Building Sales Market

The results above indicate that green-labeled office buildings rent at a premium and achieve higher occupancy, relative to their competitors. Combined with associated savings in operating expenses, green buildings demonstrate superior income potential in the rental market. Buyers of tenant-occupied office buildings typically care a great deal about the financial performance of an asset, and a considerable amount of work has been done to identify the relationship between income potential and selling prices. Many in industry understand and use the cap rate method. Although there are several criticisms of this method, in many cases the cap rate has become a self-realizing mechanism of the trade. Regardless of which method is appropriate, most would agree that higher income potential is associated with higher selling prices in the market for income-producing real estate. Therefore, the next step of this research is to examine the impact of green design on selling price.

Table 4 provides the results of two estimations. Models 5 and 6 examine the determinants of selling price. Each market examined is assumed to have unique behavior regarding price and size. Indicator variables are included to control for fixed price differences across markets (i.e., market controls estimate individual intercepts). The market indicators are multiplied by Bldg_SF to create market interaction variables that estimate the OLS price per square foot for each market. The indicator and interaction for the Washington DC submarket is suppressed; hence, the Bldg_SF coefficients of $590.64 and $586.40 estimate the price increase per square foot of property size for class A office space in the DC market. It is worth mentioning here that this estimate differs from the traditional interpretation of industry. For example, the average property size in the DC market is 257,543/ft^2 and the average selling price is $125,072,456, so the average price per square foot in the DC market is $485.64. The estimates from the approach used in this research differ because of the constant term included in the regression model. This provides an intercept to the line of predicted values, rather than assuming an intercept of zero. The result is a model with a better fit (i.e., minimizing the sum of squared errors) and parameter estimates that are more accurate.

In models 5 and 6 of Table 4, older properties are found to sell at a discount. This could be attributed to the anticipation of higher capital expenditures. Properties of age might also be more likely to exist in an area that has transitioned and is no longer considered the most desirable part of the CBD; this should be reflected in lower rents. Model 6 introduces variables to measure the impact of green-labeled office buildings on selling price. Compared to model 5, the parameter estimates do not change much. The variables Energy_Star and LEED are insignificantly different from zero, suggesting that the hyperplane of intercepts for the market pricing lines

Table 4 Results from pricing model estimation (Dependent variable=Sale_Price)

Variable	Model 5		Model 6	
	Coefficient	(*t*-statistic)	Coefficient	(*t*-statistic)
Intercept	−37,422,093***	(−10.05)	−37,188,480***	(−10.11)
Age	−141,856***	(−2.84)	−122,272**	(−2.48)
Bldg_SF	590.46***	(29.60)	586.40***	(29.63)
Sale_Date	10,684***	(4.93)	10,582***	(4.95)
LEED	–	–	−7,588,562	(−0.45)
Energy_Star	–	–	−10,546,043	(−1.59)
LEED*Bldg_SF	–	–	129.18***	(3.45)
Energy_Star*Bldg_SF	–	–	29.71**	(2.20)
Market controls:	Included		Included	
Market interactions:	Included		Included	
R-square:	82.4%		83.1%	
Number of observations	1,151		1,151	

*p=0.1
**p=0.05
***p=0.01

are no different for green-labeled office buildings. Instead, the interaction terms Energy_Star*SF and LEED*SF are both positive and significant. The coefficient for Energy_Star*SF is 29.71, with an interpretation that Energy_Star-labeled properties sell at a premium of $29.71/ft^2$ relative to comparable properties. Likewise, LEED-certified properties are found to sell at a premium of $129.18. These results suggest that the significant impact of these green-labeled properties on the rental market is revealed in the sales market through a substantial pricing premium for green design.

Conclusions

This research provides original evidence that EneryStar-labeled and LEED-certified properties maintain superior performance in the leasing markets, which is reflected in a significant sales premium for green-labeled class A office buildings. How much of this premium can be attributed to the obvious savings in operating expenses? The premiums for green design are dramatic. Rents are higher by roughly 7 to 17%; occupancies improve by roughly 10 to 18%. The selling premium is estimated at $30 and $130/ft^2$ for EnergyStar-labeled and LEED-certified properties, respectively.

Green-labeled properties are relatively new in the historic timeline of urban office space and appear to benefit from improved marketability. It is likely that green office space trades in segmented markets that are characterized by local imbalances in supply and demand. As new products are increasingly energy-efficient, the premiums for future deliveries should adjust proportionately. Nonetheless, given the magnitude and significance of these premiums, it seems plausible that additional factors are adding value to green buildings beyond the simple savings in operating expenses. As more data becomes available and interest in the topic mounts, additional research is necessary to better understand the behavior of green office space in national commercial markets.

Appendix 1

Table 5 Description of markets

Market	Leasing data (n=7,308)			Sales data (n=1,151)	
	Percent of sample	Mean: Avg_rent	Mean: Occupancy (%)	Percent of sample	Mean: Sale_price/ Bldg_SF
Atlanta	4.02	$21.57	78.01	4.87	$169.60
Austin	1.43	$19.94	75.34	–	–
Boise City/Nampa	0.49	$18.09	55.14	–	–
Boston	3.13	$26.59	80.77	5.73	$291.70
Charlotte	1.94	$20.39	70.01	3.13	$101.70
Chicago	4.57	$19.87	76.51	6.17	$168.20
Cincinnati/Dayton	1.71	$15.63	66.55	–	–
Cleveland	1.14	$19.89	73.39	–	–
Colorado Springs	0.38	$15.46	66.88	–	–
Columbus	1.35	$14.00	73.21	1.30	$119.10
Dallas/Ft Worth	3.59	$22.47	77.09	4.17	$140.70
Denver	2.59	$21.20	79.83	5.47	$136.00

Table 5 (continued)

Market	Leasing data (n=7,308)			Sales data (n=1,151)	
	Percent of sample	Mean: Avg_rent	Mean: Occupancy (%)	Percent of sample	Mean: Sale_price/ Bldg_SF
Detroit	2.14	$21.53	67.92	–	–
East Bay/Oakland	1.02	$29.25	84.71	0.35	$251.10
Hampton Roads	0.88	$21.00	67.28	–	–
Hartford	0.69	$21.68	81.27	–	–
Hawaii	0.25	$24.82	85.67	–	–
Houston	2.58	$22.11	77.90	1.82	$161.00
Indianapolis	1.44	$19.12	72.75	–	–
Inland Empire (CA)	1.39	$25.67	50.17	–	–
Jacksonville (FL)	0.61	$20.76	75.48	1.04	$180.90
Kansas City	1.01	$21.30	69.85	–	–
Los Angeles	8.14	$35.21	84.76	7.91	$298.40
Louisville	0.53	$17.34	68.23	–	–
Milwaukee/Madison	1.07	$15.96	63.26	1.04	$64.90
Minneapolis/St Paul	1.45	$16.04	72.99	1.56	$142.20
Nashville	1.30	$20.69	72.43	–	–
New York City	2.27	$90.09	93.37	–	–
Northern New Jersey	6.22	$25.03	72.02	6.08	$174.40
Orange (CA)	2.85	$33.04	84.46	1.91	$237.40
Orlando	1.22	$23.56	69.49	–	–
Philadelphia	6.64	$21.62	71.66	6.52	$127.10
Phoenix	2.79	$28.31	66.34	5.39	$197.30
Portland	1.43	$24.05	80.89	0.52	$289.50
Raleigh/Durham	1.93	$21.59	62.70	–	–
Sacramento	1.59	$27.23	72.71	0.61	$219.40
Salt Lake City	0.93	$20.25	67.66	–	–
San Diego	2.08	$34.74	70.75	2.87	$336.20
San Francisco	1.45	$43.02	83.55	2.35	$1,126.00
Seattle/Puget Sound	1.50	$30.28	83.08	1.74	$370.40
South Bay/San Jose	0.80	$36.22	76.37	–	–
South Florida	3.50	$25.66	72.48	6.78	$102.50
St Louis	1.77	$22.41	75.50	0.61	$183.30
Tampa/St Petersburg	1.44	$23.46	64.04	–	–
Toledo	0.20	$16.25	67.27	–	–
Washington DC	8.55	$33.90	76.51	16.33	$236.90

Appendix 2

Table 6 Description of lease types

Lease type	Leasing data (n=7,308)		
	Percent of sample (%)	Mean: Avg_rent	Mean: Occupancy (%)
Double Net	0.07	$27.10	49.30
Full Service Gross	51.07	$27.89	79.91
Modified Gross	3.01	$24.57	70.83
Negotiable	3.22	$32.92	69.84

Table 6 (continued)

Lease type	Leasing data (*n*=7,308)		
	Percent of sample (%)	Mean: Avg_rent	Mean: Occupancy (%)
Net	3.02	$16.82	73.74
Plus All Utilities	2.01	$30.24	71.55
Plus Cleaning	0.22	$19.77	61.68
Plus Elec and Clean	0.33	$22.64	79.57
Plus Electric	11.20	$30.97	78.67
Tenant Electric	5.66	$26.04	77.62
Triple Net	20.05	$20.73	68.05
Utilities and Char	0.14	$20.72	27.62

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