

The Green Revolution in Building: Private Interests and Public Purposes

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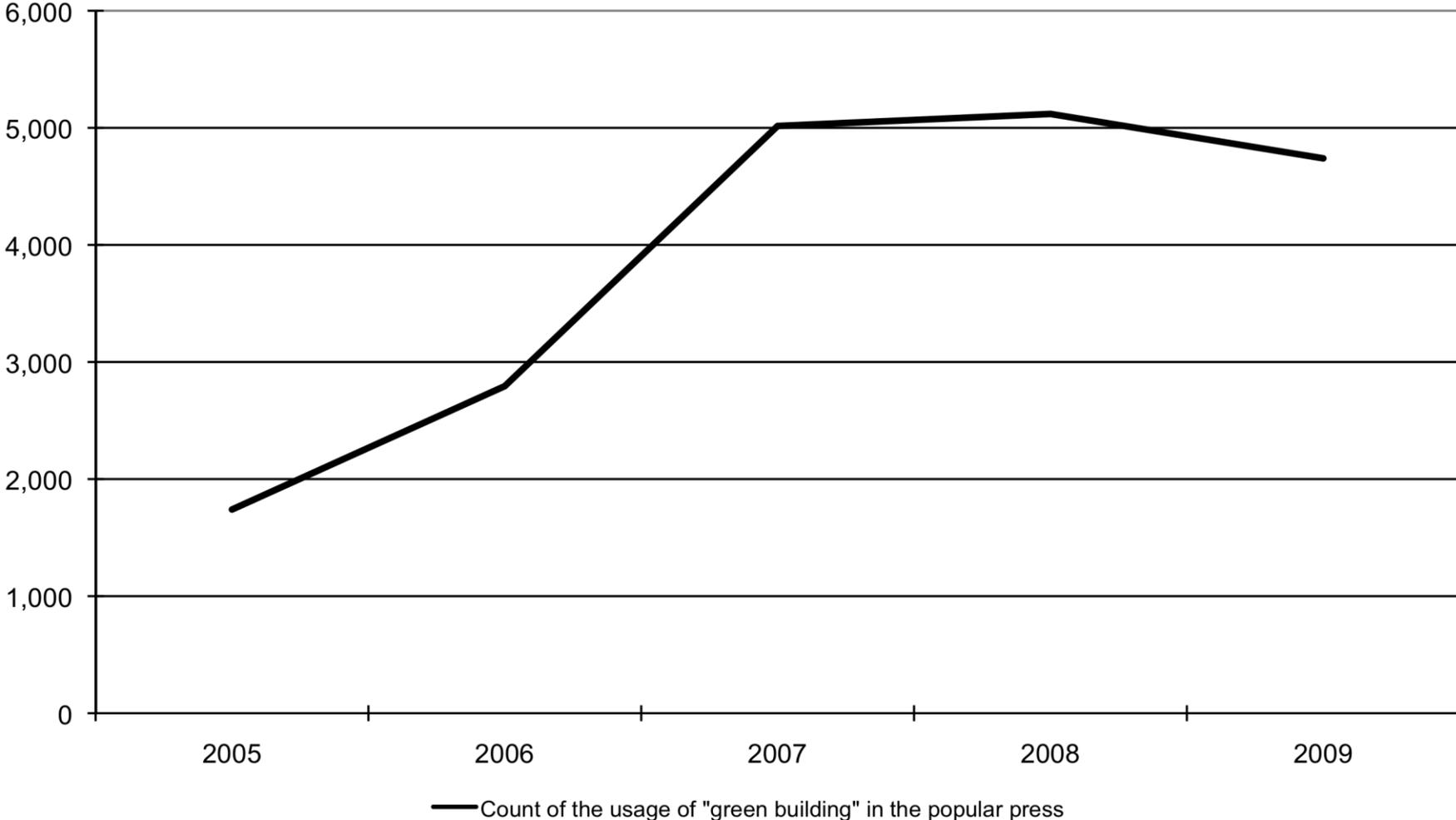
Energy and Buildings

- Buildings Account for 40 Percent of Consumption of Raw Materials and Energy
- 55 Percent of Wood Not Used as Fuel is Consumed in Building
- 30 Percent of Greenhouse Gas Emissions
- Energy Represents 7-9 Percent of Total Occupancy Costs for Buildings.

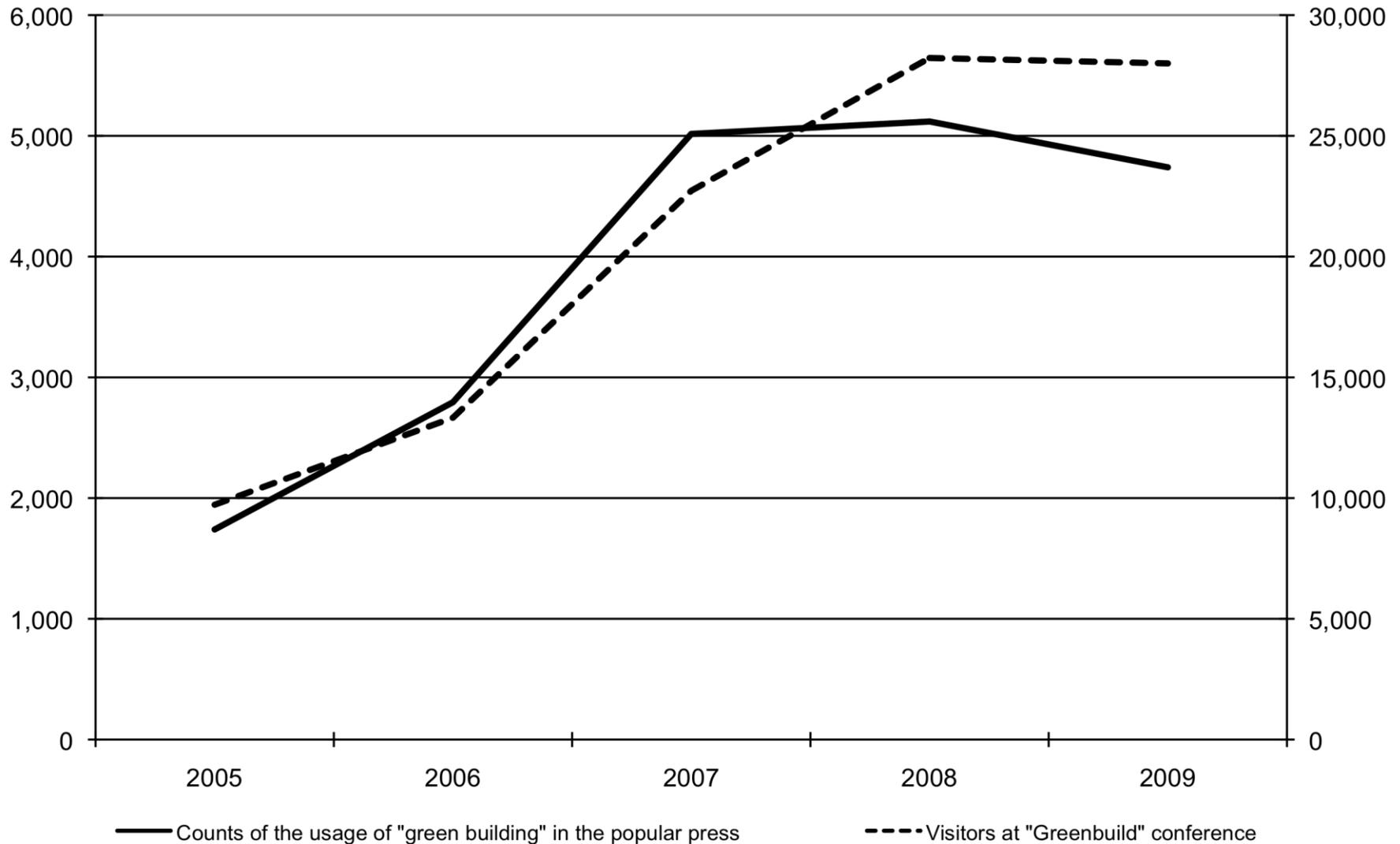
Awareness is Growing

- Increases in voluntary “green” labeling standards
- Corporate real estate and CSR
- “Sustainable” property investment funds and increased Public Sector Involvement
- Waxman-Markey Bill in US House
- EPBD in the EU

Usage of “green building” in the popular press...



...and visitors at the "Greenbuild" conference



“Eco Efficiency” and Capital Budgeting

Costs versus revenues in ‘green’ buildings

Investments in buildings may result in:

1. Energy savings and emission reduction

- Save on current resources
- Insure against future price increases

2. Higher rents

- Increase productivity
 - Improved indoor air quality
- Improve corporate image of tenants
 - Reputation effects

3. Increased economic lives, reduced depreciation, lower risk (e.g. less variation in occupancy)

“Green” Ratings for Office Buildings

Measuring Energy Efficiency and Sustainability

- **EnergyStar**

- ~ EPA and Department of Energy
- ~ Engineering estimates – benchmarked
- ~ Energy consumption and emissions

- **LEED**

- ~ US Green Buildings Council
- ~ Private non-profit initiative
- ~ In-house estimates
- ~ Includes Energy Star-like measure, but also:
 - Bike sheds
 - ‘Green’ cleaning, location, purchasing, etc.

- **BREEAM, GreenStar, CASBEE, ...**

Property Sector Offers a Laboratory

**“Laboratory Studies” with Piet Eichholtz,
Nils Kok, and Studies Underway with
Matthew Kahn and Erin Mansur**

Investment dynamics and the source of “green” increments

Research Design

I. Sample of 8,000 office buildings (2007 – 2009 panel), 694 of which are certified by EPA's Energy Star or the U.S. Green Building Council

1. Short-run price dynamics of green office buildings
 - Returns during turbulent 2007 – 2009 period

II. Sample of 28,000 office buildings (2009 cross section), 3,000 of which are certified by EPA or USGBC

1. New evidence on the economic premium for green office buildings
 - Rigorous control for quality differences (PSM)
 - Label vintage
2. Identify the sources of rent and value increments
 - Explicit link to
 - USGBC measures of “sustainability”
 - EPA's measures of energy efficiency

Control Sample

GIS methods used to select comparables

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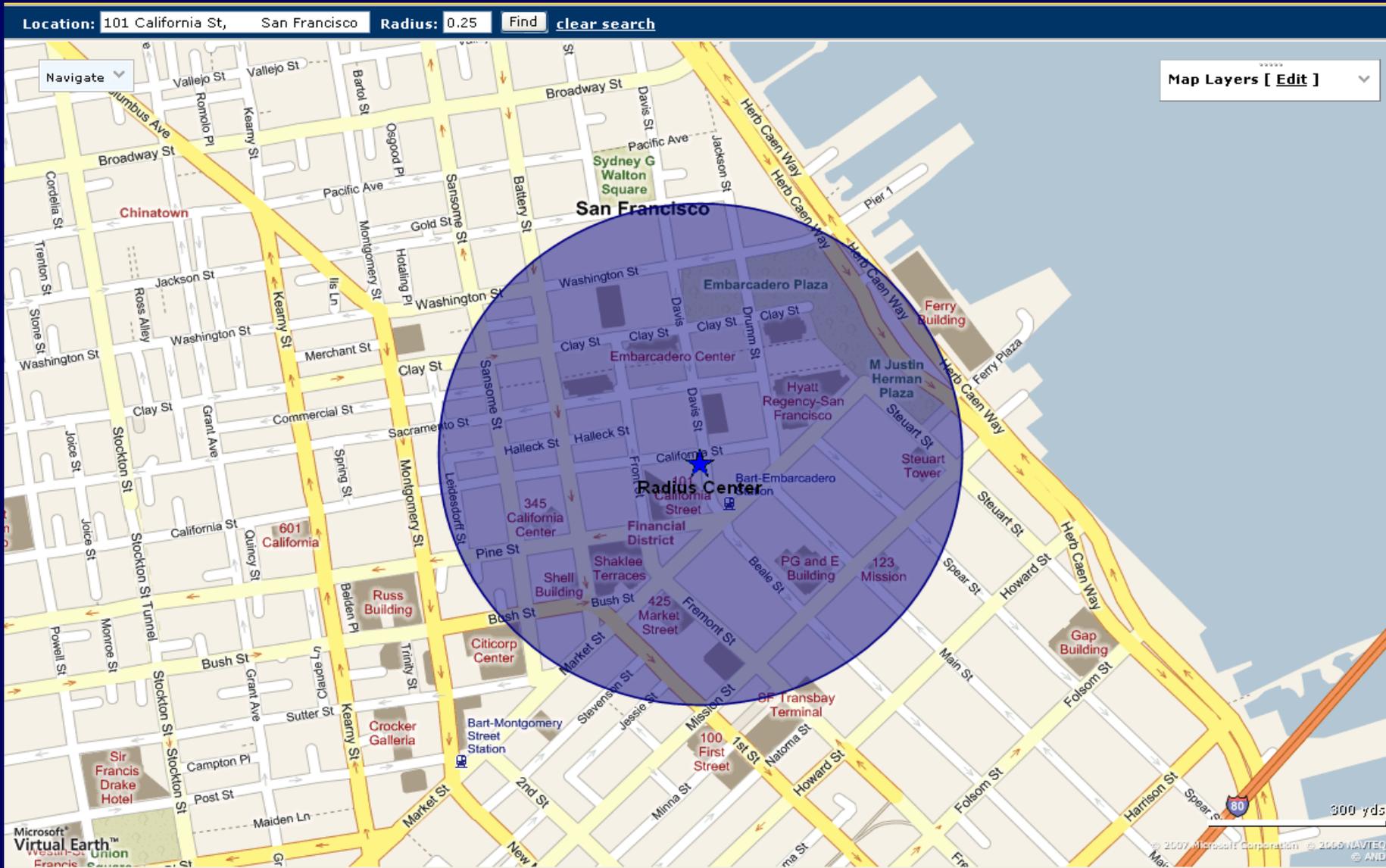
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Alternate Dusk Shot

Control Sample

GIS methods used to select comparables



Clusters of Green and Control Buildings

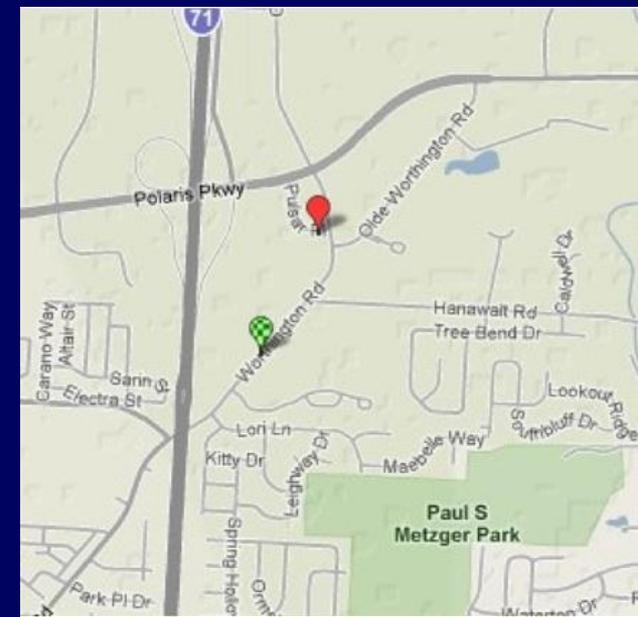
Chicago, IL



Houston, TX



Columbus, OH



Our Formulation Generalizes the Treatment of Spatial Variation

- Methodology: standard valuation framework

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

$$(2) \quad \log R_{in} = \alpha + \beta_i X_i + \sum_{n=1}^N \gamma_n c_n + \sum_{n=1}^N \delta_n [c_n \cdot g_i] + \varepsilon_{in}$$

R = rent or “effective rent”

X = vector of hedonic characteristics (e.g. age, size, quality, etc.)

g = dummy variable if building has green label

c = dummy variable for location each n

Green buildings and conventional comparables

Propensity score weighting substantially reduces differences

	Rental Sample			Sales Sample		
	Rated Buildings	Control Buildings	PSM Controls	Rated Buildings	Control Buildings	PSM Controls
Sample Size	1,943	19,452	19,452	744	5,321	5,321
Size (thousands sq. ft.)	299.83 (292.40)	155.65 (245.73)	282.88 (176.74)	326.39 (336.85)	139.92 (275.21)	311.86 (270.99)
Building Class (percent)						
A	75.75 (42.87)	26.9 (44.34)	71.94 (37.53)	75.66 (42.95)	21.50 (41.09)	69.53 (44.23)
B	23.21 (42.23)	52.73 (49.93)	26.90 (12.57)	23.47 (42.41)	51.16 (49.99)	29.24 (15.16)
C	1.04 (10.15)	20.37 (40.27)	1.16 (1.31)	0.87 (9.32)	27.34 (44.58)	1.23 (1.01)
Age (years)	24.65 (17.36)	53.22 (34.33)	25.93 (7.56)	26.31 (19.47)	60.48 (37.29)	28.37 (9.84)
Rental Contract (percent)						
Triple Net	22.11 (41.51)	14.74 (35.45)	22.94 (23.04)			
Plus Electric	7.99 (27.12)	8.16 (27.38)	9.22 (13.22)			
Modified Gross	1.31 (11.39)	7.94 (27.04)	2.58 (5.79)			
Plus All Utilities	0.82 (9.03)	1.34 (11.51)	0.64 (2.89)			
Gross	67.76 (46.75)	67.81 (46.72)	64.62 (30.07)			

Propensity-weighted regression results

Market implications of Energy Star and LEED

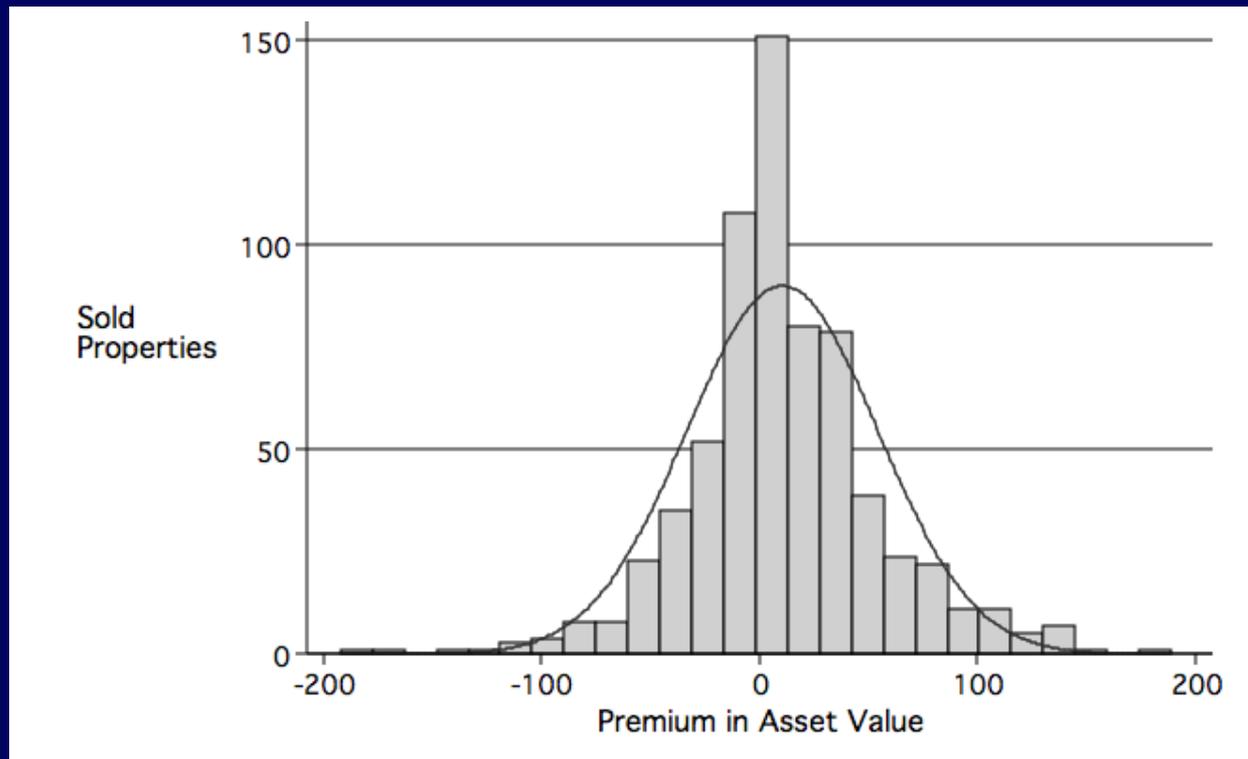
Dependent Variable	Rent (per sq. ft.)	
	(1)	(2)
Green Rating (1 = yes)	0.018*** [0.003]	
Energy Star (1 = yes)		0.0212*** [0.005]
Label Vintage (years)		-0.004** [0.002]
LEED (1 = yes)		0.058*** [0.010]
Building Class:		
Class A (1 = yes)	0.155*** [0.013]	0.156*** [0.013]
Class B (1 = yes)	0.094*** [0.013]	0.094*** [0.013]
Rental Contract:		
Triple Net (1 = yes)	-0.196*** [0.004]	-0.195*** [0.004]
Plus Electric (1 = yes)	0.022*** [0.008]	0.022*** [0.008]
Modified Gross (1 = yes)	0.042*** [0.009]	0.042*** [0.009]
Plus All Utilities (1 = yes)	-0.044** [0.022]	-0.045** [0.022]
Constant	0.995 [0.646]	1.177* [0.646]
Hedonic Variables	Yes	Yes
Location Clusters	Yes	Yes
Sample Size	20,801	20,801
R ²	0.833	0.834
Adj R ²	0.817	0.817

Generalization of the Model

Estimate the premium for each “green” building

- The increment in rent or market value for the green building in cluster n , relative to the prices of other buildings in that cluster (i.e., controlling for location, climate, and quality):

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



The sources of economic premiums for “green”
Detailed information on certification process

- Relate increments in rent and market value to the characteristics of LEED and Energy Star-rated buildings:

$$\hat{\delta}_i = \omega Z_i + \eta_i$$

The rental increment for LEED rated buildings

	A. Effective Rent Increment					
	(1)	(2)	(3)	(4)	(5)	(6)
Certified (1 = yes)	0.039 [0.049]	0.057 [0.050]	0.417** [0.207]	0.483** [0.208]	0.435** [0.208]	0.496** [0.210]
LEED Score			-0.026*** [0.010]	-0.027*** [0.010]	-0.048 [0.032]	-0.046 [0.032]
LEED ²			3.48e-04*** [1.34e-04]	3.51e-04*** [1.33e-04]	0.001 [0.001]	0.001 [0.001]
LEED ³					-7.53e-06 [1.01e-05]	-6.25e-06 [1.01e-05]
Energy Star (1 = yes)		0.087* [0.049]		0.094* [0.049]		0.092* [0.049]
Constant	0.079*** [0.030]	0.020 [0.045]	0.0793*** [0.029]	0.015 [0.044]	0.079*** [0.030]	0.017 [0.044]
Observations	209	209	209	209	209	209
R ²	0.003	0.018	0.036	0.053	0.039	0.055
Adj R ²	0.000	0.009	0.022	0.035	0.020	0.032

- LEED-certified, score 40: effective rent of 2 percent higher than otherwise identical, registered building
- LEED-certified, score 60: effective rent of 20 percent higher

The transactions increment for LEED rated buildings

	B. Transactions Increment					
	(1)	(2)	(3)	(4)	(5)	(6)
Certified (1 = yes)	0.192 [0.119]	0.223* [0.119]	0.786*** [0.213]	0.804*** [0.211]	0.804*** [0.212]	0.814*** [0.211]
LEED Score			-0.037** [0.015]	-0.038** [0.014]	-0.123** [0.060]	-0.102 [0.062]
LEED ²			4.43e-04* [2.41e-04]	4.52e-04* [2.39e-04]	0.004* [0.002]	0.003 [0.002]
LEED ³					-3.13e-05 [2.12e-05]	-2.38e-05 [2.21e-05]
Energy Star (1 = yes)		0.195 [0.127]		0.184 [0.121]		0.144 [0.127]
Constant	0.110 [0.078]	-0.035 [0.122]	0.110 [0.0747]	-0.027 [0.117]	0.110 [0.074]	0.003 [0.120]
Observations	102	102	102	102	102	102
R ²	0.026	0.049	0.127	0.148	0.147	0.158
Adj R ²	0.016	0.029	0.101	0.113	0.111	0.114

- Energy Star certification is complimentary to LEED certification

The rental increment for Energy Star rated buildings

	Panel A. Effective Rent Increment					
	(1)	(2)	(3)	(4)	(5)	(6)
Site Energy Consumption (kbtu/total degree days)	-3.294** [1.345]	-3.202** [1.349]				
Source Energy Consumption (kbtu/total degree days)			-1.396*** [0.453]	-1.365*** [0.455]		
Utility Bill (dollars per sq. ft./total degree days)					-0.126*** [0.043]	-0.124*** [0.043]
LEED Certified (1 = yes)		0.063 [0.070]		0.059 [0.070]		0.096 [0.072]
Constant	0.103*** [0.026]	0.099*** [0.026]	0.120*** [0.027]	0.117*** [0.027]	0.102*** [0.025]	0.099*** [0.025]
Observations	774	774	774	774	730	730
R ²	0.008	0.009	0.012	0.013	0.012	0.014
Adj R ²	0.006	0.006	0.011	0.011	0.011	0.012

- LEED certification complements Energy Star certification

Energy Efficiency and Market Value

- One dollar of site energy savings yields \$18.32 in increased value – a cap rate of 5.5%.
 - ~ If cap rate is 6.0%, then the other desirable attributes of a rated building contribute 8% to increased valuation
- One dollar of source energy savings yields \$20.73 in increased value
 - ~ Why would landlords pay for source energy savings?
- And...systematic variation in industry occupancy
 - ~ Who rents green?

Implications

*Eco-investment real estate sector
is not merely “doing good”*

- *Ceteris Paribus*, Green Buildings
 1. Have Higher Rents by 2-3%
 2. Have Higher Effective Rents by 6-9%
 3. Have Higher Selling Prices by 16-17%
- The average non-green building in the rental sample would be worth \$5.5 M more if it were converted to green.
- The average non-green building sold in 2004-2007 would have been worth \$5.7 M more if it had been converted to green.

More Implications

“Green” label effectively reflects energy efficiency

- Among green buildings, a 10 percent more energy-efficient building rents for 1.1 percent more.
- One dollar of site energy savings yields \$18 of increased value
 - ~ Assuming cap rate of 6 percent, other desirable attributes contribute about 8 percent to increased valuation
 - ~ One dollar of source energy savings contributes \$21 of increased value
- The increment to green building is not merely a labeling effect
- Private market incorporates signal of energy efficiency