Spatial penetration and performance of LEED ratings & certification levels among office buildings

Dr. Sofia Dermisi
Professor of Real Estate
W. E. Heller College of Business Administration
Roosevelt University,
Chicago, IL, 60605
Phone: 312-281-3355
Email: sdermisi@roosevelt.edu

Abstract

Leadership in Energy and Environmental Design (LEED) is increasingly pursued by office buildings. This paper focuses for the first time on property distributions among the various versions of LEED from USGBC's inception until today while distinguishing between ratings and certification levels. The paper focuses on spatial penetration and autocorrelation of LEED - Existing Buildings: Operations Management (EBOM), New Construction (NC) and Core & Shell (CS) followed by an in depth analysis of the LEED-EB building performance (vacancy rate and gross rent levels) before and after their certification. The results of the study indicate that the overall market penetration of LEED among class A & B office buildings ≥50,000 square feet across the US is currently about 9% (based on sf). LEED EBOM is the most popular rating among all ratings (60% based on sf) followed by CS (18% based on sf) and NC (17% based on sf). Properties are pursuing more aggressively the Gold (overall - 46% based on sf) and Silver (overall - 33% based on sf) certification level under the recent LEED versions versus the initial ones. The spatial modeling does not provide evidence of spatial autocorrelation with the exception of LEED-NC. Shifting the focus to LEED-EBOM, the recent recession increased vacancy levels by 11% for properties after their LEED certification - a significant number of them received it during the recession. Overall gross rental premiums of properties certified and to be certified increased by more than 25% during the same period when comparing the before and after trends of certified properties. A series of state, utility and local incentives were tested for their impact on vacancy and rents of LEED-EBOM properties and green building incentives seem to have a more than 23% positive effect on rent levels.

Introduction

The U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design – (LEED) designation is increasingly pursued among new and existing office buildings throughout the US and abroad. USGBC launched LEED in 1998 and in April of 2009 released version 3 in a continuous effort to improve the green standards of building facilities. The four most relevant ratings for office buildings are: LEED – New Construction (NC), LEED- Commercial Interiors (CI), LEED- Core & Shell (CS) and LEED- Existing Buildings: Operations & Maintenance (EBOM) (USGBC website).

This paper focuses only on class A and B office buildings across the US with 50,000 square feet (sf) or more and has a threefold goal: i) provide an overview of the office building distribution among the various ratings (differentiation among the different LEED versions) & certification levels from the

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inception of the USGBC until today; ii) examine the spatial penetration of the various ratings & certification levels across the mainland US states and iii) examine closely the rent and vacancy performance of LEED-EB before and after their designation while controlling for the latest financial crisis.

Green trends

Professional and currently academic cycles are increasingly focused in identifying the extent of green strategies' adoption among building management and construction in an effort to improve building performance by saving in operating costs at the same time. Some key driving forces behind LEED construction are (Van Schaack, 2009): i) lower interest rates for construction & permanent loans; ii) increased likelihood of financing by certain banks; iii) pension funds investment interest; and iv) policies of the vast majority of fortune 500 companies, which show an increasing preference towards LEED over non-LEED buildings. An increasing number of senior executives are embracing sustainability as one of their priorities even for leasing space - something lacking 3 - 5years ago (Carreira, 2009).

The adoption of green strategies and LEED for office buildings has also some financial challenges for both new and existing facilities: i) although a high quality LEED certified project can be developed with nominal cost it won't save money in the long-run operation of the facility (Lothan, 2010).[1] Only the adoption of base building systems controls (such as heat-exchangers, displacement air systems, double wall systems, active shading systems, motion sensors for lighting etc.) can save money in the long-run but they come with an upfront premium (Lothan, 2010)[2]; ii) in cases where structures need to be demolished/rehabbed and/or the site needs to be mitigated, disposing the various material in an environmentally friendly way can also be costly[3] (Lothan, 2010); iii) from an operating budget standpoint the upfront capital required for the LEED certification, might take more than 3 years to recapture, which can possibly exceed the developer's holding period and create a dilemma (Rolander, 2009); iv) the cost savings cannot be determined yet because of the lack of (Carreira, 2009): a) significant number of LEED buildings with historical information and documentation; b) documentation on the cost savings received separately by the tenants and the building; and c) documentation on the changes of employee sickness

[1] For example, certain LEED points can be achieved very inexpensively, by putting bicycle racks, showers and being close to transportation (Reisner, 2010).

[2] For example, by adopting multi-layered energy system the building can: circulate air more effectively and efficiently based on different situations (e.g. seasons, occupancy etc.) and synchronize lighting with day-light using lighting controls, which can reduce the power consumption (Lothan, 2010)

[3] In Chicago for example, virtually every site is assumed to be contaminated (old tanks, asbestos etc.) and certain materials which are disposed need to be sent to landfills approved for special handling (e.g. sorting and containing dangerous material etc). Unfortunately there aren't many landfills accommodating this type of debris and those which exist are feeling up quickly and are not in close proximity to the city, therefore adding to the disposal cost. (Lothan, 2010)

patterns in LEED compared to non-LEED buildings; v) the disparity between who pays for most of the LEED certification and who reaps the benefits is a major influence on decisions (Harder , 2009). While tenant attitudes increasingly recognize the benefits, business decisions to participate in the costs are lagging (Harder, 2009).

In the last few years multiple surveys were conducted among industry executives on their attitude towards green buildings (World Business Council for Sustainable Development, 2007; Jones Lang LaSalle, 2008; IBT, 2008; Turner 2008) with the most recent surveys focusing on attitude changes due to the recession: i) Allen Matkins/Constructive Technologies Group (CTG) and the Green Building Insider conducted their 4th Annual Green Building Survey in 2009 and reported a strong support for green building (92%) and LEED certification (62%), although both of them decreased by 4.5% and 4.7%, respectively, compared to 2007. LEED Gold projects seem to experience mixed results in cost premiums with more than 51% experiencing a premium of more than 4%, while 30% reported a premium of less than 3%. Their survey offers three reasons for this contradictory result (e.g. building type, local codes, incentives etc.); ii) the National Real Estate Investor (Sibley Fleming, 2009) and USGBC conducted a survey among developers, tenant executives and city/county level government officials in 2009. The vast majority of them (more than 86%) consider green design more important now than before the recession, with developers indicating with an 89% their expectation to own, manage or lease at least some green properties five years from now – a significant increase since 2007. Some of the other developer related findings were, that: a) 73% retrofitted or were inclined to retrofit their properties for greater energy efficiency; b) they estimated their recovery cost to be 3% to 4%; c) they expect to charge tenants an additional 2% on average for LEED vs. non-LEED properties and d) few took advantage of tax incentives, rebates/discounts on environmental products and grants.

Beyond the surveys conducted by various organizations, research on the effect of sustainability on real estate is starting to expand among academic cycles. A number of studies focus on the effect of green on rents/sf and sale prices. Dermisi (2009) examined the effect of the different LEED ratings and certification levels on Assessed (AV) and Market Values (MV), while controlling for a property's characteristics and its location. A series of other recent studies focused on controlled experiments with a "green" group of LEED and Energy star buildings and a controlled group of buildings with similar but "non-green" characteristics in the US. Eichholtz et al. (2010a) results indicated that rents/sf and sales prices were roughly 3% and 16%, respectively, higher for the "green" group, while earlier studies by Miller et al. (2008) and Fuerst and McAllister (2008, 2010) indicated larger differences between the two groups. In their latest study Eichholtz et al. (2010c) analyze a panel of office buildings and determine the lack of a significant difference in their rents or values during these volatile times. They also found significant premiums in their rents and values.

Another set of recent studies looks at tenants and occupancy levels; Eichholtz et al. (2010b) provided the first comprehensive evidence of tenant shift towards green over non-green facilities especially among the mining, oil and banking industries, as well as non-profit organizations. Fuerst and McAllister (2009) analysis of LEED & Energy star office buildings indicated that occupancy rates are 3% and 8% respectively higher for these types of buildings versus non-green comparable buildings. Kok et al. (2010) developed an environmental score card - Environmental Real Estate Index for corporate space with the results becoming a benchmark for the future.

Data

The overall dataset includes data feeds from USGBC, CoStar Group and the Database of State Incentives for Renewable Energy (DSIRE). Initially, all U.S. office buildings with 50,000 sf or more were extracted from the US Green Building Council (USGBC) database at the end of September 2010 with all their accompanying information (address, project name, city, state, rating type, certification level – date, gross square feet etc.). From the overall USGBC dataset 1,287 LEED properties were office within the square foot requirement of the study and they were certified from October 2000 through September 2010 with various ratings & certification levels. The LEED-EBs (1.0 Pilots, 1.0, 2.0, O&M and O&M:2009) became a subset with 465 LEED-EB properties (Figure 1, 2). The addresses/project name of this LEED-EB subset was then matched with the CoStar Group property information (building class, Rentable Building Area (RBA), year built, vacancies and gross rent levels on a quarterly basis before and after their LEED certification). Out of the 465 properties CoStar had information on at least one building characteristic (e.g. RBA) for 433 properties, with more complete records fluctuating from 238 properties (gross rental rates) to 419 (vacancy rate). Both vacancy and rent values were then averaged based on the certification quarter, while data were gathered from the first quarter of 1997 through the third quarter of 2010. The after designation was given to the average properties' performance from the following quarter of certification and until the third quarter of 2010. The before designation was given to average properties' performance form the quarter a property received certification going back to the first quarter of 1997.

Finally the LEED-EB & CoStar subset benefited by the extraction of all the financial incentives for energy efficiency offered at a state-by-state basis from each state, utility agency and local government (DSIRE database). The DSIRE data were cleaned to include incentives focused only on commercial facilities and integrated to the LEEED-EB subset.

Methodology

As described in the introduction, the purpose of this paper is threefold, requiring different types of approaches in the examination of the underlying trends for the overall dataset and the LEED-EB subset: i) the distribution patterns among the ratings and certification levels was examined through descriptive statistics; ii) the spatial market penetration was examined visually with the use of GIS mapping and estimation of Moran's I (Eq. 1, 2) for the identification of any spatial autocorrelation among the number of LEED properties per state as well as the property square footage; and iii) the vacancy & rent performance of LEED-EB buildings before & after their certification is examined by: a) a fixed effect regression controlling for the different states but not controlling for the financial incentives for energy efficiency (Eq. 3) and b) an OLS regression controlling for the energy efficiency financial incentives by state (Eq. 4).

Moran's I is estimated for both the number of properties and the square footage based on the GIS maps with (ESRI 2010; Griffith, 1987):

$$I = \frac{n}{S_0}\frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{i,j} z_i z_j}{\sum_{i=1}^{n} z_i^2} \qquad \text{Eq. 1}$$

where: z_i is the deviation of an the number of properties (or sf) of state I from its mean ($x_i - \bar{x}$)
w_{ij} is the spatial weight between i and j
n equals the total number of features
S_0 is the aggregate of all the spatial weights: $S_{0=} \sum_{i=1}^{n}\sum_{j=1}^{n} w_{i,j}$
and z_I –score is computed as: $z_I = \frac{I - E[I]}{\sqrt{V[I]}}$ Eq. 2
where $E[I] = \frac{-1}{(n-1)}$ and $V[I] = E[I^2] - E[I]^2$

The fixed effect regression takes the form:

$$PC_{it} = a + \beta_i r_{it} + \sum_{i=1}^{5} \gamma_{it}\, c_{it} + \delta_{it} X_{it} + \eta_{it} + \varepsilon_{it} \qquad \text{Eq. 3}$$

where: PC represents either a building's vacancy rate or the average gross rent (logged) for property i at time t (after) or t-1 (before the certification)
r represents a recessionary dummy variable which takes the value 1 for properties certified from 2008 through 2010 and zero otherwise. The decision to extend the recession to 2010 was made because of the continuous high unemployment rate in 2010 – directly affecting office space – regardless of the National Bureau of Economic Research determination that the recession ended in the summer of 2009
c is the property's certification year (values from 2006 – 2010)
X represents property characteristics such as RBA, year built and building class
η are the state fixed effects for property I at time t or t-1
ε is the error term

The final equation controls for the various financial incentives offered in each state by the state, utility companies and local government (Eq. 4):

$$PC_{it} = a + \beta_i r_{it} + \sum_{i=1}^{5} \gamma_{it}\, c_{it} + \delta_{it} X_{it} + \sum_{i=1}^{2} \kappa_i T_{it} + \sum_{i=1}^{3} \varrho_i L_{it} + \sigma_i g_{it} + \varepsilon_{it} \qquad \text{Eq.4}$$

where: variables r, c and X are the same as above

T represents two separate dummy variables; corporate and property tax incentives. The variables take the value 1 if property i is located in a state which offers either incentives and zero otherwise.

L represents three dummy variables: i) commercial loans offered by the state; ii) commercial loans offered by utility companies and iii) commercial loans offered the local government. These three variables take the value 1 if property i is located in a state which offers either incentives and zero otherwise

g is a dummy variable which takes the value 1 if the state offers green building incentives and zero otherwise

Results

The descriptive statistics provide a first insight on the distribution patterns across the various ratings by differentiating for the first time between the current and previous versions offered by USGBC. In Figure 1, LEED-CI seems to be the less pursued rating although the latest version seems to be attracting more office buildings. LEED-CI properties in the earlier levels mainly achieved the lowest certification level (certified) in contrast to the current version which they seem to be achieving Gold and Silver. In contrast LEED-CS and EB[4] are steadily achieving Silver & Gold certification in the previous and current version. LEED-NC properties are achieving Gold and Silver status in the two latest versions in contrast to the NC 2.0. The platinum level which is the highest certification level continues to be really difficult to achieve especially for new construction. Comparing the percentage distribution among the four certification levels, for both number of properties and square footage, it is clearly evident that there is a 40% or more aggregation at the Gold level.

Figure 1 also shows that the total number of LEED certified class A & B office buildings with 50,000 sf or more in the US are currently 1,287 with 427.2 million square feet (overall data). Assuming that the office market size with the above classification and sf characteristics is 4.59 billion sf (CoStar Group) then LEED certified properties represent currently a 9.3%[5] of the office stock, which will continue to increase. This percentage indicates a substantial penetration/adoption of LEED across the office market within a 10-year span.

Figure 2 (overall dataset) groups the four LEED ratings regardless of version and compares the number of properties and square feet trends. The results indicate that even though the most popular ratings based on number of properties are the LEED-EBOM (36%) and NC (27%), EBOM (60%) is followed by CS (18%) instead of NC (17%) based on square footage. Shifting the focus to certification level Gold and Silver are the most popular for both number of properties (43% & 35%, respectively) and square footage (46% & 33%, respectively). There are two reasons which make LEED-EB properties lead

[4] LEED EB 1.0 Pilots Only included only one property.

[5] In reality this percentage should be lower because CoStar Group does not include all office properties across the US, although it is considered among the most reliable data sources.

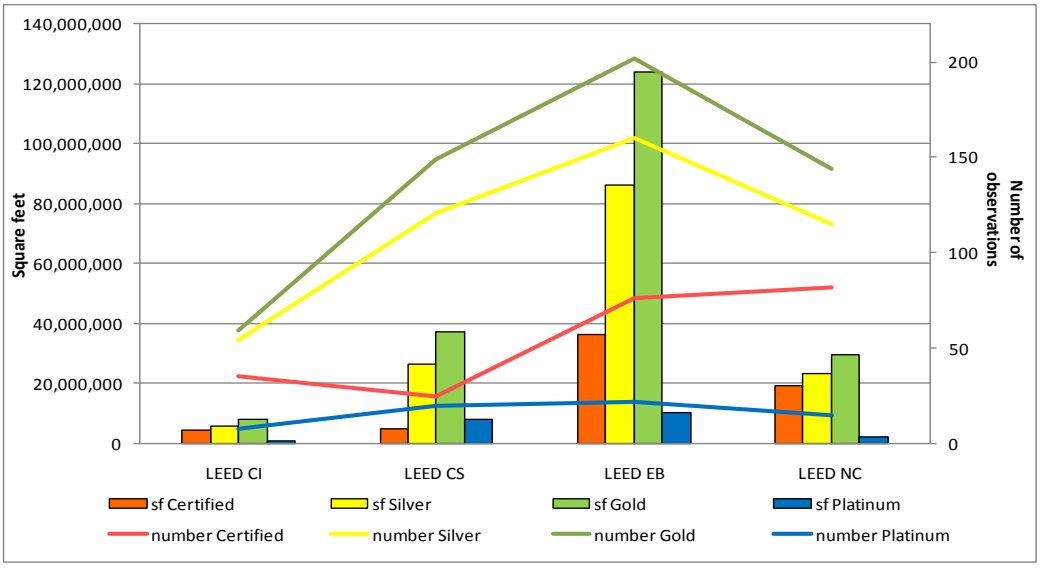
in terms of number of properties and square footage: i) although existing buildings have a more substantial upfront retrofitting cost compared to a new facility they can both save money in the long-run and improve their competitive advantage over other comparable non-green properties; ii) older buildings are usually larger in size compared to the newer/smaller and more efficient office construction taking place.

Figure 1. Distribution table

Ratings	# Certified	# Silver	# Gold	# Platinum	sf Certified	sf Silver	sf Gold	sf Platinum
LEED CI 1.0 Pilots Only	83.33%	16.67%	0.00%	0.00%	95.27%	4.73%	0.00%	0.00%
LEED CI 1.0 (accepted after 2004)	66.67%	33.33%	0.00%	0.00%	47.75%	52.25%	0.00%	0.00%
LEED CI 2.0	19.05%	35.37%	40.14%	5.44%	18.66%	30.58%	45.29%	5.48%
LEED CS 1.0	10.77%	41.54%	40.00%	7.69%	5.01%	29.56%	51.32%	14.11%
LEED CS 2.0	7.20%	37.60%	49.20%	6.00%	6.74%	36.17%	47.53%	9.56%
LEED EB 1.0 Pilots Only	100.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%
LEED EB 1.0	16.67%	25.00%	50.00%	8.33%	33.80%	20.79%	28.20%	17.21%
LEED EB 2.0	21.00%	29.00%	39.00%	11.00%	17.73%	27.93%	48.49%	5.85%
LEED EB O&M	13.93%	36.53%	47.37%	2.17%	12.37%	34.63%	51.08%	1.92%
LEED EB O&M v:2009	41.38%	34.48%	13.79%	10.34%	6.95%	54.07%	21.64%	17.33%
LEED NC 2.0	61.64%	16.44%	20.55%	1.37%	32.35%	31.69%	33.08%	2.87%
LEED NC 2.1	20.66%	33.88%	41.32%	4.13%	38.12%	21.55%	37.52%	2.81%
LEED NC 2.2	4.46%	39.49%	50.32%	5.73%	15.22%	38.47%	43.18%	3.13%
Totals	**218**	**450**	**554**	**65**	**65,088,056**	**141,659,939**	**198,793,172**	**21,654,065**

In yellow - aggregation of 40% or more

Figure 2. Rating & certification trends by number of properties and square footage



Figures 3 through 5 outline the spatial distribution of the three most popular LEED ratings for office properties. The comparison of the three maps indicates that LEED-EB was not achieved yet by any office property of 50,000sf or more among 17 states while CS rating was not awarded to any property among 12 states. There are certain states (e.g. California, Washington, Colorado, Texas, Illinois and

Florida) where all LEED ratings have substantial presence and others (Montana, North Dakota and Wyoming) with a complete lack of any LEED certified properties.

Figure 3. LEED-CS distribution by number of properties

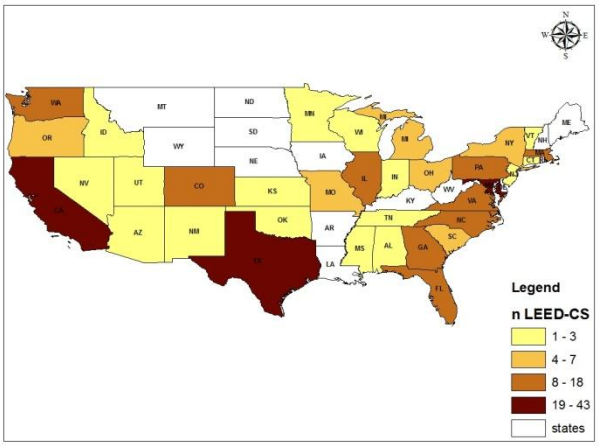


Figure 4. LEED-EB distribution by number of properties

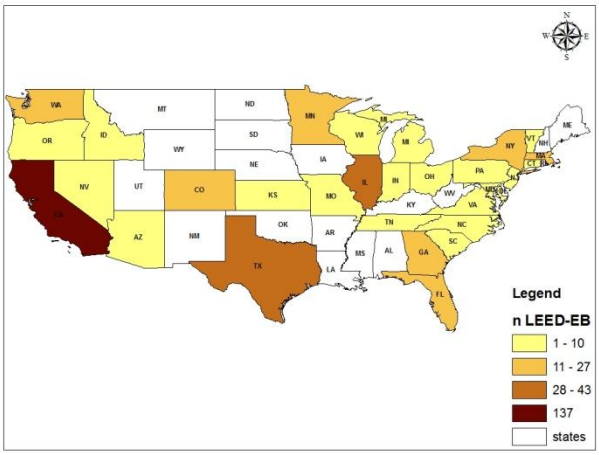
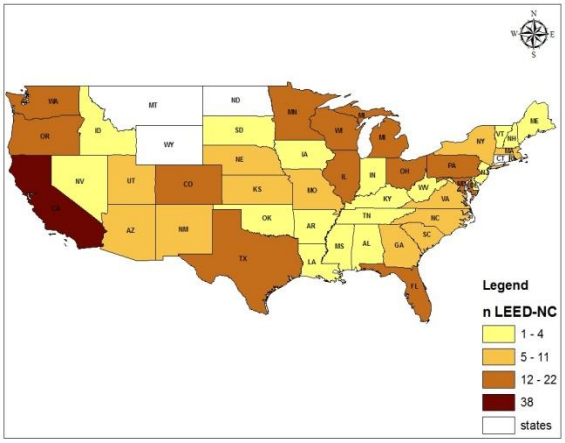


Figure 5. LEED-NC distribution by number of properties



Figures 6 through 9 outline the spatial distribution of all the certification levels offered by LEED. Figure 6 shows the difficulty in achieving Platinum rating, which is mainly concentrated in 6 states across the US while 24 other states lack even one property at that level. In contrast, Gold and Silver properties are found across the US. Certified properties seem to be less represented in the middle of the US. The comparison across the four figures continues to show the strength of California, Texas and Illinois among all certification levels.

Figure 6. Platinum distribution by number of properties

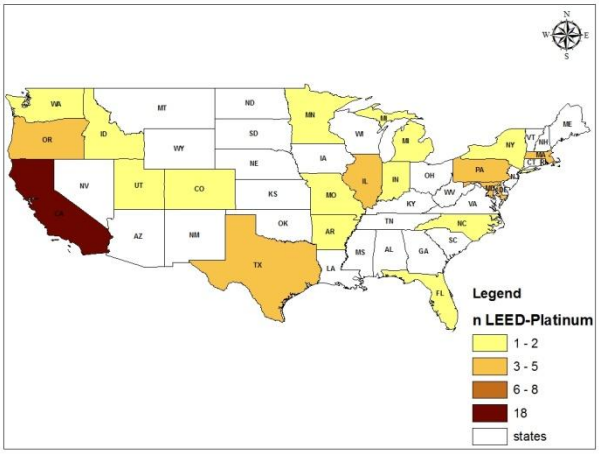


Figure 7. Gold distribution by number of properties

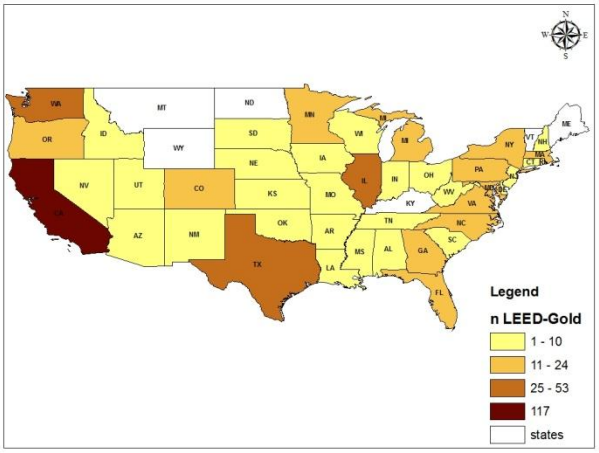


Figure 8. Silver distribution by number of properties

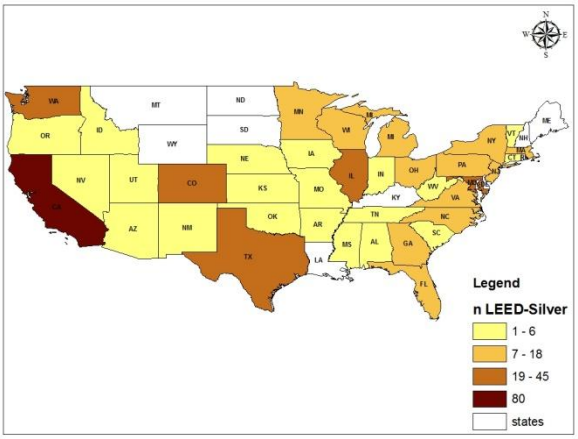
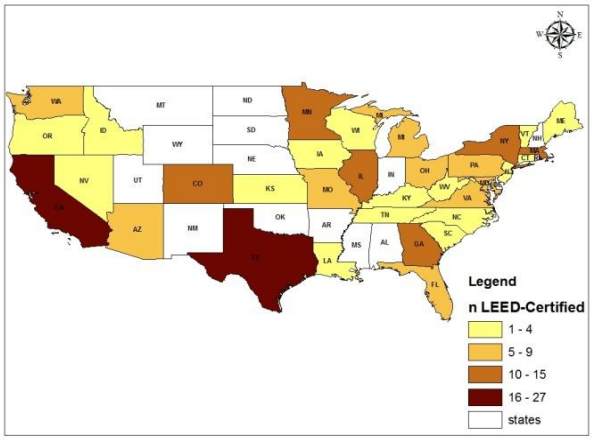


Figure 9. Certified distribution by number of properties



Beyond the spatial distribution of the three most popular ratings and the four certification levels, the next step was to determine the existence of any spatial autocorrelation. Figure 10 Moran's I results indicate that with the exception of LEED-NC, where there is clustering, no clustering is evident on any other case.

Figure 10. Moran's I results

	number			sf		
	Moran's I	z-score (sd)	pattern	Moran's I	z-score (sd)	pattern
LEED-CS	-0.4	-1.33	random	-0.04	-1.04	random
LEED-EB	-0.03	0.32	random			
LEED-NC	-0.01	3.17	clustered	-0.02	1.62	random
Platinum	-0.07	-1.46	random	-0.06	-1.04	random
Gold	-0.02	0.7	random	-0.02	1.25	random
Silver	-0.03	-1.22	random	-0.03	-1.10	random
Certified	-0.03	-0.12	random	-0.04	-1.05	random

The period studied in this paper (from 1997 until 2010) includes one of the worst recessions since the great depression of 1927. Beyond the inclusion of the recession variable in the regression modeling an initial t-test was also performed on the LEED-EB properties' subset (figure 11). The t-test results indicate the existence of a significant difference in the after as well as the before vacancy level, before and after the recent recession. This recession caused vacancy levels, in both vacancy cases, to increase substantially compared to their before recession levels. In contrast, gross rents did not see a significant difference due to the recession similar to Eichholtz et al. (2010c) result.

Figure 11 T-test results on LEED-EB properties

	Mean			
	Before recession	After recession	two-tailed t-test	p-value
Vacancy % after certification	1.90%	14.48%	t(380)=-3.11	p=0.002
Vacancy % before certification	5.47%	11.19%	t(431)=-2.61	p= 0.009
Gross rent after certification	21.82	29.50	t(236)=-1.76	p=0.078
Gross rent before certification	27.52	30.02	t(321)=-0.56	p=0.569

Figure 12 examines the average vacancy and rental performance[6] of LEED-EB properties before and after certification on a quarterly basis in more depth. The after bar and line on each quarter encapsulates the average long-term performance of properties which received certification that quarter (after = the average properties' performance from the following quarter and until the third quarter of 2010). The before bar and line on each quarter are calculated with the same logic (before = the quarter a property received certification going back to the first quarter of 1997). Assessing the trends of figure 12 the following observations can be made:

- The earliest LEED-EB certification found in the dataset was 2006 with limited number of properties in the first two years but a substantial increase in 2008 when cross-referencing with the CoStar database. This limited number of certified properties in 2006-07 leads to extreme variations for both vacancies and rent levels. From the first quarter of 2006 through the third quarter of 2008 the number of properties/observations was limited to less than 10 but the number of certified properties increased exponentially after that quarter.
- Vacancy level increases and spikes coincide with the recent recession, while from the third quarter of 2008 through the fourth quarter of 2009 vacancy of LEED-EB properties certified at those quarters are much higher than those certified up to the third quarter of 2010.
- The information on gross rent levels was even more limited compared to vacancy rates, with the first quarter of 2009 being the first reaching 10 properties. The increase in the following quarters was, however, exponential providing a much larger number of properties with both USGBC and CoStar

[6] We need to keep in mind that the observations were very limited in the first two years compared to the latter ones and there are differences among the number of observations with available vacancies and gross rents.

information. In the majority of quarters, gross rents for properties certified until the third quarter of 2010 was higher than those certified before (after the first quarter of 2009).

Figure 12. Vacancy and rent trends for LEED-EB before and after their certification

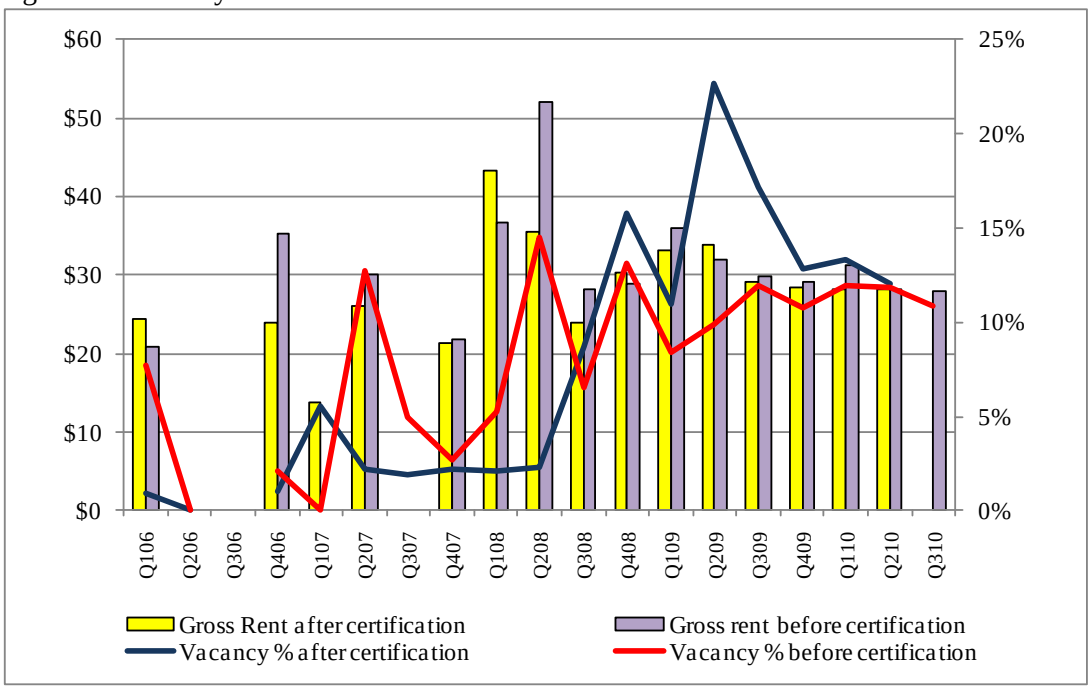


Figure 13 provides the results of the two regression models applied on the LEED-EB subset. Column 1 indicates that the average vacancy rate, for LEED-EB office properties, has increased by 11% after their certification in the current recession – also evident from figure 12. This effect, however, is not shared in column 2. Although the effect the recession had on vacancy levels of certified properties is significant, this result can be attributed to the larger number of properties receiving certification during the recession and the lack of a significant after (long-term) stabilization trend, which can smooth the initial reaction to the external economic conditions. Another interesting observation between columns 1 and 2 is the RBA effect on vacancy levels. In both cases the effect of larger RBAs on average vacancy levels is negative. Considering that LEED-EB properties are older facilities with larger RBAs (as seen in figure 2), this statistically significant effect indicates a higher level of efficiency than other older and larger properties. Another difference between columns 1 and 2 is the building classification, which indicates that class A facilities have a 4% higher vacancy level before they become LEED certified but the classification effect is not statistically significant after the property is classified as LEED.

Columns 3 and 4 (figure 13) indicate that independent variable effect on gross rent levels before and after certification is identical with a slight percentage difference. In contrast to vacancy levels,

properties' gross rents were boosted by 48% after a property became LEED-EB certified and 36% before its certification. This effect should be less and it can be considered skewed due to the limited data input before the recession. The results also indicate that the more recently a property is certified (e.g. 2010 versus 2008 or 2009) the gross rent after certification decreases by 5%, while the decrease in the before rent is 4%. The last variable with a statistically significant effect on rent levels is building class, with the expected positive effect a class A property has over other building classifications.

Columns' 5 and 6 results are identical to columns' 1 and 2 in terms of the statistical significance of the recession, RBA and building class effect. Focusing on the performance of properties based on the various finance incentives, the increase in property tax incentives and local grants seem to be associated with an unexpected increase in vacancy levels after certification by 15% and 14%, respectively (column 5). In contrast, property taxes do not have any effect among LEED-EB properties before their certification (column 6) because properties can mainly benefit from them after certification. Any financial benefits can be passed on to the tenants, therefore decreasing the property's operating expenses. The last variable, with a statistically significant effect on vacancy levels after certification (column 5), is the state loan incentives which are associated with a decrease in vacancy levels after certification by 10%, which is expected. In contrast, state loan incentives do not have any effect on vacancy levels before certification because any savings will probably not be immediately passed on to tenants through lower operating expenses due to retrofit required before certification.

Columns' 7 and 8 results are identical with columns' 3 and 4 in terms of the statistical significance of the recession, RBA and building class, while the certification year does not appear to be statistically significant. Columns 7 and 8 have only two similarities; in both of them an increase in local grants and utility loans has a negative effect on rent levels for both before and after LEED-EB certification, which is unexpected. In contrast, local green-building incentives have an expected positive effect on rent levels (23% after certification and 37% before certification). Focusing on column 8, a number of variables are associated with a rental increase before a property is certified. Corporate tax incentives boost rent levels by 12%, because they are more quickly distributed to corporations in an effort to pursue sustainable facilities. State and utility grants have the similar positive effect (8% and 28% respectively) on rents, because of the retrofitting premium required and the additional funds provided from these grants during the retrofitting stage before certification.

Figure 13. Regression results

	Avrg. Vacancy rate after	Avrg. Vacancy rate before	Avrg. gross rent after (log)	Avrg. gross rent before (log)	Avrg. Vacancy rate after	Avrg. Vacancy rate before	Avrg. gross rent after (log)	Avrg. gross rent before (log)
	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8
Recession	0.11	0.01	0.48	0.36	0.11	0.005	0.39	0.25
	(1.86)**	(0.37)	(3.52)*	(3.05)*	(2.35)*	-0.10	(3.11)*	(1.98)*
Year certified	0.002	0.01	-0.05	-0.04	-0.002	0.01	-0.04	-0.04
	(0.13)	(1.31)	(-1.66)**	(-1.93)**	(-0.13)	(1.50)	(-1.08)	(-1.32)
RBA	-4.95E-08	-3.22E-08	1.70E-07	8.98E-08	-6.42E-08	-3.86E-08	1.48E-07	6.69E-08
	(-1.83)**	(-2.51)*	(3.84)*	(2.86)*	(-3.16)*	(-3.48)*	(3.15)*	(2.01)*
Year built	5.00E-05	-2.59E-04	1.84E-04	-4.13E-04	2.11E-05	-1.26E-04	-1.06E-03	-1.35E-03
	(0.11)	(-0.94)	(0.18)	(-0.59)	(0.05)	(-0.37)	(-0.89)	(-1.28)
Building class	0.03	0.04	0.16	0.18	0.04	0.05	0.23	0.24
	(0.92)	(2.88)*	(2.67)*	(4.01)*	(1.37)	(3.28)*	(3.66)*	(5.03)*
Corporate tax					0.03	0.02	0.03	0.12
					(0.98)	(1.09)	(0.27)	(1.97)*
Property tax for commercial property					0.15	0.02	-0.08	-0.09
					(2.24)*	(0.86)	(-0.98)	(-1.80)**
Grants dummy for commercial property - state					-0.02	-0.02	-0.01	0.08
					(-0.76)	(-0.83)	(-0.12)	(1.78)**
Grants dummy for commercial property - utility					-0.01	-0.02	0.04	0.09
					(-0.30)	(-1.01)	(0.66)	(1.65)**
Grants dummy for commercial property - local					0.14	0.06	-0.17	-0.16
					(3.82)*	(3.43)*	(-3.25)*	(-4.21)*
Loans dummy for commercial property - state					-0.10	-0.02	-0.10	-0.06
					(-3.47)*	(-0.93)	(-1.48)	(-1.28)
Loans dummy for commercial property - utility					0.02	0.03	-0.24	-0.16
					-0.74	(1.77)**	(-3.91)*	(-3.33)*
Loans dummy for commercial property - local					0.01	0.01	0.11	0.28
					-0.23	(0.35)	(1.20)	(3.58)*
Greenbuilding number of initiatives for commercial property - local					0.01	0.01	0.23	0.37
					(0.54)	(0.56)	(2.87)*	(7.37)*
Constant	-4.60	-21.37	100.31	86.94	23.97	-25.24	77.99	75.99
n	368	419	238	323	368	419	238	323
R2	19.76%	18.12%	49.09%	58.30%	14.53%	10.39%	28.78%	38.85%
F	2.221	1.952	5.982	11.67				

t-statistics in parenthesis

* Statistically significant at 5%; ** statistically significant at 10%

Conclusions

The goal of this study was the establishment of a benchmark for LEED office buildings of 50,000 square feet or more across the US. The results indicate a significant penetration of LEED in the overall market at about 9% over a 10-year span (the first property certified in the dataset was in October, 2000). LEED – EBOM is the most popular rating among all ratings both based on square footage (60%) and number of properties (36%) followed by LEED-CS (based on sf - 18%) and LEED-NC (based on sf – 17%); the latter two change places in popularity based on number of properties NC – 27% and CS-24%. Shifting the focus to certification level, Gold (43% by number of properties and 46% by sf) and Silver (35% by number of properties and 33% by sf) are the most popular certifications. In addition to the overall LEED trends the study presents very interesting findings on the before and after performance of LEED-EBOM and the effect of the latest recession. Vacancy rates of LEED-EBOM buildings increased after their certification and due to the recession, but gross rents also increased providing an interesting

dynamic when comparing before and after trends. The application of various financial incentives (by state, utility and local government) on energy efficiency indicates that green building incentives among others increase rent levels both before and after a property becomes certified.

An estimation of the current LEED market penetration will help future researchers determine the growth rate compared to the overall office buildings'. The separate analysis of the different ratings and certification levels can help future researchers in their study of growth patterns among them as well as USGBC in determining areas of possible change in LEED ratings and/or certifications. Finally, the study of LEED-EBOM provides the first research window into the performance of properties before and after their certification. The only challenge faced in the study of this window was that a large number of properties achieved LEED-EBOM designation during the recent recession, which caused a different market reaction in vacancy and gross rent levels compared to a more normal market.

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