Explaining LEED Concentration:
Effects of Public Policy and Political Party

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Abstract

The United States has experienced a rapid growth in the cumulative number of green buildings since 2000. The purpose of this study is to investigate factors influencing the spatial concentration of LEED (Leadership in Energy and Environmental Design) certified buildings in the United States at the state level. Employing a panel model that accounts for unobserved year and state heterogeneity we hypothesize effects of green building standards at the state level and compare these to the effects of financial incentives supported by the Energy Policy Act of 2005 on the concentration of LEED certified buildings. In the model, we control for other factors such as real estate market conditions, the party of state governors and local office demand that may have effects on the LEED concentration. To measure the LEED concentration we use a Location Quotient function which allows us to know which states have a greater share of LEED certified buildings compared to a reference which is the top 20 US states for cumulative LEED certified buildings. We find that political party has a significant effect on LEED concentration as well as economic growth rates. Federal level economic incentives seem to dominate state level requirements for more sustainable buildings at spurring new LEED certification efforts.

Keywords: green buildings; LEED; environmental policy; panel analysis

1. Introduction

The penetration of sustainable "green buildings" into the market is a trend of great interest. Here we will focus on the penetration success of Leadership in Energy and Environmental Design, hereafter LEED, certified buildings.[1] Green buildings provide two general benefits; (1) more efficiency and productivity for occupants and owners of property and (2) an improved, or at least, less harmed environment for society.

The cost to build to LEED standards has come down to the point that for office properties there is little or no added direct cost to achieve silver certification (from the basic levels of certified, silver, gold and platinum) as of 2010 (Budny 2009, Katz 2009, and Langdon, 2007). For other property types and for office property in less experienced markets[2] some cost premiums may continue and for this reason landlords considering upgrades to LEED EBOM (Existing Building Operations and Maintenance) or considering LEED NC (New Construction) programs may still need convincing that sustainable investments have reasonable payoffs or significant social benefits. With

[1] LEED is facilitated by the United States Green Building Council, USGBC. See www. USGBC.org Energy Star is a label provided by the Environmental Protection Agency, EPA, and is another typical label associated with green buildings. There are also green globes and many other certification systems. See Richard Reed, et al, 2009, Vol. 1, www.josre.org for a comparison.

[2] By "less experienced" we mean where few developers, architects, contractors and vendors are present in the local market. Lack of local experience is highly correlated with higher cost premiums to achieve LEED standards at any level.

respect to increased efficiency or rent and value differentials there is a growing body of evidence suggesting positive economic benefits from higher rents to faster absorption, higher occupancy rates, lower operating expenses, higher residual values as well as greater occupant productivity. See Chau, Tse and Chung, 2010, Eicholtz, Kok, and Quigley, 2011, 2009, Pivo, 2010, Fuerst and McAllister, 2009, Miller and Pogue, 2009, Miller, Florance and Spivey, 2008, Miller, Pogue, Saville and Tu, 2010 as examples.

Some authors have focused on energy and water efficiency (Blengini and Shields, 2010; Chau, Tse and Chung, 2010; Newsham, Mancini and Birt, 2009; Pan, Yin and Huang, 2008), while others have addressed indoor air quality (Chau, Tse and Chung, 2010; Paul and Taylor, 2008) or the reduction in toxic wastes generated from human construction (Blengini and Shields, 2010; Chau, Tse and Chung, 2010; James and Yang, 2005). In the past decades, we have experienced the rapid growth of green buildings in the United States as a percent of new buildings but it will take many years for green buildings to become main stream since we typically build no more than about 2% of the stock in any one year or significantly renovate no more than 3%.[3] The U. S Green Building Council has simulated green building movements in the United States and in many countries around the world. The USGBC continues to allow LEED to

[3] Based on CoStar data we build about 2.1% of the office stock each year but certainly lose some buildings as well to obsolescence. We renovate more but as of 2010 EBOM is just slightly ahead of NC rates of increase based on applications at the USGBC.

evolve based on market feedback and has started to make the rating system more localized.[4] Many scholars have started to document the economics of green buildings looking for investment justification, yet we have found much variation in terms of sustainable investment around the United States. There remains a lack of empirical studies to explain the spatial concentration of LEED certified buildings in some states and cities. Although corporate social responsibility and that it may be the 'Right-things-to-do'[5] from a societal point of view, the growth rate of green efforts is also subject to mandates and incentives by various governments including the federal, state, county and local levels (Retzlaff, 2009; Choi, 2010).

Local regulations are more able to adapt to the unique water and temperature conditions of the region or to address other environmental concerns such as congestion and pollution (Choi, 2010; Simons, Choi and Simons, 2009; Retzlaff, 2009). Public sustainability activism is also more likely to affect local and regional policies (Retzlaff, 2009; Theaker and Cole 2001). To conduct empirical research, however, a small government such as municipality as a unit of analysis is challenging for several reasons. The greatest challenge is the small sample of data as of 2010 by which to do local government research. In addition, it is almost impossible to quantify all the various

[4] The next LEED rollout will be 2012.

[5] It means that green buildings have been voluntarily practiced by building owners, investors and designers (Retzlaff, 2009; Simons, Choi and Simons, 2009).

policy instruments at the municipal levels to enumerate their effects on the growth of green buildings when these policies vary significantly by metro market. Therefore, we concluded that a state-based analysis is the most suitable approach to use for a lengthy panel dataset at this point in time.[6]

This study measures the effect of green building standards (GBS) at the state levels adopted either by executive orders[7] or by legislative proceeding[8] on the spatial concentration of LEED certified buildings. In addition, effects from the Energy Policy Act of 2005 which was the federal law are analyzed in the empirical model of the study since this Act also boosted private investment in green development by providing financial incentives. We have collected analyzable data from CoStar for the top twenty US states based on having the most cumulative LEED certified buildings. Using a 10 year panel approach, we have controlled for a number of demand and supply factors shown to be significant in the literature. We also examine the role of governors' party in the empirical models as we have observed very strong opposition to green development requirements by members of the Republican party. We use the Location

[6] We also recognize that in states like Illinois the Chicago market could dominate the data and in California, LA and San Francisco will represent the highest concentrations. So we do not deny that metros are a major part of the state data shown here and in some cases the state is merely a proxy for the dominant markets or market.
[7] Executive order is an order issued by the state governor in our study.
[8] GBS adopted by legislative proceeding mean a legislation made by the state council.

Quotient (LQ) of LEED certified buildings, defined below, as a proxy for the spatial concentration of LEED.

The remainder of this paper is organized as follows. In Section 2, we present a literature review focusing on factors that stimulate green building designations, and generate hypotheses that will be tested. In Section 3, we provide justifications of our empirical framework, and in Section 4 we describe our dependent and independent variables included in our empirical models. In Section 5, we explain our estimation results and significant findings and in Section 6 finally, we summarize and conclude.

2. Literature review and hypotheses

2.1 Literature review

Governments' policies including regulations and incentives have been pointed out as the main driving force for the spatial concentration of green buildings in the United States by previous studies (see Choi, 2010; Qi et al, 2010; Retzlaff, 2009; Simons, Choi and Simons, 2009).

We examine the impact of the Energy Policy Act of 2005 (hereafter EPA Act 2005) as the federal law signed by President Bush in August 2005. This law contains substantial incentives for the use of renewable energy efficiency for all sectors of

energy demand and supply: Section 1331 of this law enacted Section 179D of the Internal Revenue Code and established incentives for energy-efficiency measures in commercial buildings. The intent of Section 1331 is to encourage energy efficiency in commercial buildings through tax incentives[9]. To qualify for the full tax deductions, the energy-efficient property must produce at least 50% energy and power cost savings (Deru and Crawley, 2007). The significance of this law is that higher green design and development costs for new commercial building construction can be offset by such incentives. The major concern about this law, however, is the limited time availability for tax deductions. The EPA Act 2005 authorized tax deductions for a period of two years starting January 1, 2006 and ending December 31, 2007. However, the Tax Relief and Health Care Act of 2006 extended tax deductions for an additional year (Deru and Crawley, 2007).

At the state level, many state governments have adopted green building standards (GBS) in various forms through executive order or legislation since 2000 as mandates for public facilities. The provisions of state GBS mainly includes mandates for adherence to LEED provisions for new pubic facilities, and for renovation projects for public facilities (May and Koski, 2007). This kind of public policy aims at

[9] The tax incentives are in the form of tax deductions of up to $1.80 per squared feet for energy-efficiency improvements in the interior lighting; HVAC, service hot water; and building envelop.

influencing the private sectors, especially those wishing to secure public sector tenants. Such policies have been called 'Leading by Example' (Simons, Choi and Simons, 2009). California, for example, adopted GBS through both legislative proceeding and executive order in 2004. GBS in California aims at reduction in grid-based energy usage in favor of renewal generation for state buildings to at least 20% of 2003 levels by 2015; and all new and renovated buildings must achieve a minimum equivalent, "Silver" rating on the LEED scale. Ohio, for another example, adopted GBS through executive order in 2007, and it aims at energy use reduction of 15% from fiscal year 2007 as a baseline by fiscal year 2011 in buildings owned or lease by state agencies, boards, and commissions while other requirements vary by building type.[10]

Figure 1 depicts the conceptual model that explains possible effects of public policies on the spatial concentration of green buildings. EPA Act 2005 and GBS in each state have different effects on the green building concentration. EPA Act 2005 had the direct effect on green building constructions in the private sector because it directly provided tax incentives to developers. On the other hand, GBS has had an indirect effect on private commercial buildings. It includes mandates for public buildings or public tenancies, and boosts diffusion from the public sectors to the private sectors.

[10] A brief explanation about the case of California and Ohio was summarized from Database of State Incentives for Renewable & Efficiency (www.DSIRE.org).

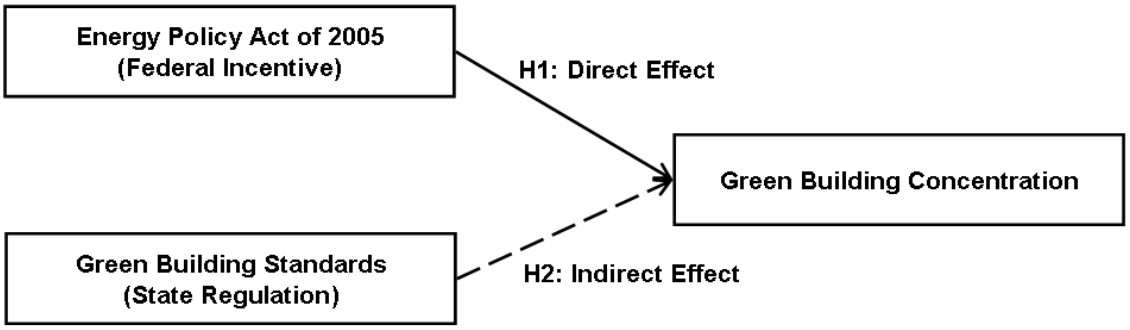

Figure 1. The conceptual model of green building concentration

There has been modest related empirical study to date investigating effects from public policies on the spatial concentration of green buildings. Choi (2010) tested the effects of municipal policies on the number of commercial green buildings including LEED certified buildings and Energy Star-labeled buildings at the central city levels. He classified green buildings policies into regulatory policies[11] and incentive-based policies. Then he divided incentive-based policies into three sub-policies; administrative incentives[12], financial policies and technical supports. His results indicated that at the municipal levels, regulatory policy has been a strong tool to promote green office building developments, as expected, but incentive-based policies have not been very effective. Qi et al (2010) tested the effects of regulations on green building designations. They collected data from a questionnaire sent to the contractors in the

[11] According to Choi (2010), such policies indicate requirements for new and rehabilitated commercial buildings to meet LEED standards or the equivalent.
[12] According to Choi (2010), such policies indicate priority in the building permit process, expedited development plan review, and marketing materials.

Chinese construction industry. From their survey results, they found significant relationships between government regulations and business adoption of green construction practices.

Simons, Choi and Simons (2009) qualitatively explored effects of public policies on the growth of green commercial office buildings. They searched policies at both the state and city level through various methods, such as website research and interviews with pubic officials. They found that many local municipalities in California have adopted green building codes that were mandated for public funding of projects. They also noted that some financial incentives were established but phased out quickly when budget concerns were not as predictable as had been hoped. This is not unlike Las Vegas that initiated enormous property tax breaks for green development and then quickly pulled back from this when it became apparent that the response would be overwhelming. City Center, an 8 million square feet mixed use development responded within the window of opportunity and remains one of the largest LEED Gold developments in the United States as a result of such incentives. Chicago not only encourages LEED design and green roofs for all new public buildings, but also works with existing building owners and operators to incorporate Energy Star efficiencies in rehab projects. Simons, Choi and Simons concluded that the most common form of

local public policy is to require LEED for all public buildings. Several states call this ‘‘Lead by Example’’ and specify that government buildings and/or school buildings be LEED certified, Energy Star rated, or both.[13] They also pointed out that starting with publicly financed new buildings such as schools is the best way to “Lead by Example” and gain knowledge about the green building process.

2.2 Hypotheses

Based on the above understanding and explanation of the potential effects of public policies including GBS which is a regulation for green building mandates and EPA Act 2005 which guarantees financial incentives for commercial developers, the following null hypotheses can be introduced:

Null hypothesis 1: There is no effect of EPA Act 2005 on the spatial concentration of LEED certified buildings. Alternatively, a positive coefficient will suggest an impact on LEED concentration. Null hypothesis 2: There is no effect of states’ green building standard on the spatial concentration of LEED certified buildings. Alternatively a

[13] Similar to this are the new Federal mandates. As of December 19th, 2010 the Government Services Administration or GSA is required to only acquire LEED Gold buildings if new and over 10,000 square feet or lease at least Energy Star labeled buildings which are approximately among the top 25% of the EPA benchmark distribution for energy efficiency. Source: James Nobil, GSA, Dec. 21, 2010.

positive sign will suggest that building code regulations matter in the inducement of LEED certified building.

In addition, as May and Koski (2008) argued, the magnitude of effects of GBS can vary based on whether GBS has been adopted by legislative proceeding or adopted by executive order. Therefore, Null hypothesis 2 is divided into two different null hypotheses:

Null hypothesis 2-1: There is no effect of GBS adopted by legislative proceeding on the spatial concentration of LEED certified buildings. Alternatively, the state level legislative proceedings do have an effect on LEED concentration.

Null hypothesis 2-2: There is no effect of GBS adopted by executive order on the spatial concentration of LEED certified buildings. Alternatively, the state level regulation enacted by executive order (governor's decree) has an effect on LEED concentration.

2.3 Other Drivers

In addition to the effect of public policies on the spatial concentration of green buildings, previous literature pointed out several other drivers influencing green building designations: real estate market conditions, local demand and the role of governors.

Real estate market and investment premiums have affected the decision to go for green building designations. Previous studies on rents or the sales prices of green buildings are important because the existence of rent or sales price premiums for green office buildings indicates that markets can price the benefits of investment in Energy Star and LEED certification (Simons, Choi and Simons 2009). In other words, developers or building owners can derive acceptable returns for green investment.

Dermisi (2009) examined the effect of LEED ratings and certification levels on assessed value and market value, while controlling for other internal and external factors. She found that Energy Star designations increase assessed values and market values substantially while the effect of LEED rating/level on assessed and market values can be differentiated based on the level of geographic aggregation. Wiley, Benefield and Johnson (2010) [14] investigated the relationship between energy-efficient design including both LEED certified buildings and Energy Star-labeled buildings and the leasing/sales markets for commercial real estate. Their model considered lease rates and occupancy in simultaneous equilibrium. In their economic model, selling price is determined by both rents and occupancy: therefore the impact of efficient design on

14 In terms of office occupancy rates, Fuerst and McAllister (2009) found similar results. Using hedonic approach, their results suggested that occupancy rates are approximately 8% higher in LEED certified buildings and 3% higher in Energy Start-labeled properties. They noted, however, that for Energy Star-labeled properties, effects are concentrated in certain market segments.

commercial sales activities should be distributed through the leasing market. Considering "class A" office buildings, they found that "green" buildings achieve superior rents and sustain significantly higher occupancy. Similar results were found by Miller, Spivey and Florance in 2008 and in updates since then[15].

Local economic condition is a used as a proxy of local demand for green buildings, or all buildings for that matter. Healthier economies can afford better quality buildings (Allen and Potiowsky, 2008). Buyers and tenants who consider public perception and those who think "it is the right thing to do" are more likely to act on this social responsibility goal when economies are strong (Simons, Choi and Simons, 2009). Under this assumption, it is logical that if a local economy is growing more buildings tend to be green.

May and Koski (2008) pointed out while the green-building movement has gained considerable momentum in the past decade, the fact remains that by early-2006 only 15 states had adopted requirements that state facilities be constructed to green building standards. For this issue, their theorizing and analyses about state adoption of the requirements point to the actions of governors because governors promote the agenda of their party and the interest groups that support or contribute to the party.

[15] See for example, "Does Green Still Pay Off?" by Miller, Florance and Spivey as posted in 2010 on www.josre.org

Hypothesis Summary

We investigate the impact of the following factors on LEED building concentration with the expected effect:

- The EPA Act of 2005 with tax inducements (positive)
- State level green building code requirements (positive)
- State level legislation enacted via support from the general legislative body (positive)
- State level legislation enacted via an executive order (positive)
- The political party of the governor of the state (positive for Democratic party membership)

3. Empirical framework

The primary objective of this study is to determine the effectiveness of EPA Act 2005 and state level GBS on the spatial concentration of LEED certified buildings in the United States[16]. To enumerate effects of policies on the LEED concentration, we exploit a 10 year panel of data that allows us to control for unobserved state and year heterogeneity. This is akin to a change-in-changes approach with state and year fixed effects we control for existing differences among the states as well as exogenous factors, giving us consistent coefficient estimates. We estimate several models of the form:

$$GREENBLDCONCENT_{it} = \alpha_i + \gamma_t + \xi R_{it} + \vartheta R_{it}^2 + \tau G_{it} + \varpi G_{it}^2 + \eta P_{it} + \beta X_{it} + \varepsilon_{it} \quad (1)$$

[16] We selected top 20 US states in terms of newly built LEED buildings between 2000 and 2009, and we use these states as the unit of analysis. We selected top 20 US states because of the small number of LEED certified office buildings newly built in each year in other excluded states.

where $GREENBLDCONCENT$ is the LEED concentration enumerated in top 20 US states, α_i represents state-specific intercept, γ_t represents year fixed effects, R_{it} is a variable indicating gross rent of newly built offices, R_{it}^2 is to capture a non-linear relationship between the LEED concentration and the office rent, G_{it} is a economic condition which is a proxy for local demand measured by Gross Regional Domestic Products (GRDP) in the model, G_{it}^2 is to capture a non-linear relationship between the LEED concentration and GRDP in each state, and P_{it} represents a dummy variable indicating governors' political party in each year. Finally, X_{it} is a measure of existence of green building policies which are EPA Act 2005 or state level GBS.

4. Data

4.1 A dependent variable: the Location Quotient (LQ) of LEED

In this study, we use the Location Quotient (LQ) of LEED certified office buildings as a measure of the relative concentration of LEED certified buildings[17]. LQ is an economic analysis technique that measures the extent to which an area is specialized, relative to another area, in the production of a particular product. LQ is defined as the ratio of an

[17] The LQ values were used by Cidell and Beata's empirical study (2009) as a proxy for the LEED concentration.

industry's share of the local economy to the industry's share of the national economy (Klosterman, 1990). In this study, therefore, LQ calculates which US states have a greater share of LEED certified office buildings compared to total office buildings in selected US states. The LQ of LEED certified office buildings in each US state in year *t* is obtained from a following function:

$$LEED\_lq_{st} = \frac{LEED_{st} \big/ LEED_{nt}}{OFFICE_{st} \big/ OFFICE_{nt}} \qquad (2)$$

where $LEED\_lq_{st}$ is the LQ of LEED certified office buildings in US states[18] built in year *t*, $LEED_{st}$ is the number of LEED in an US state built in year *t*, $LEED_{nt}$ is the number of LEED in 20 US states built in year *t*, $OFFICE_{st}$ is the number of office buildings in an US state built in year *t* and $OFFICE_{nt}$ is the number of office buildings in 20 US states built in year *t*. The LEED LQ allows us to indentify share of LEED certified buildings as to total office buildings in 20 states. A LQ greater than 1 indicates the total office buildings with a greater share of LEED certified buildings in an US state than is the case in the total 20 US states. This approach is quite similar to a market penetration approach. Thirteen states have LQ's above 1.0 based on this ratio.

[18] LQ of LEED certified office buildings were calculated based on 20 top states in terms of the number of LEED certified buildings constructed between 2000 and 2009.

Figure 2 depicts a trend of the number of LEED certified office buildings constructed between 2000 and 2009. The data were obtained from CoStar, Inc. and include all known LEED buildings. As seen in Figure 2, the number of LEED office construction greatly increased between 2006 and 2007 while LEED NC Growth rates have decreased after 2008. This trend obviously shows a slowing in the construction of LEED certified buildings as affected by macro economic trends. Figure 3 depicts the LEED concentration calculated by the LQ. The overall trend of the LQ has increased since 2000.

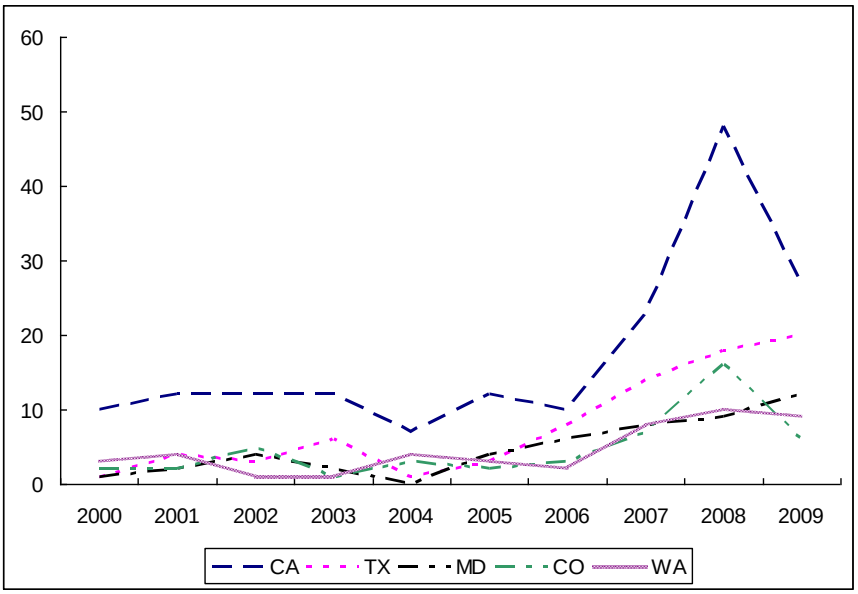

Figure 2. The number of LEED office constructions certified in selected States (Data source: CoStar, Inc)

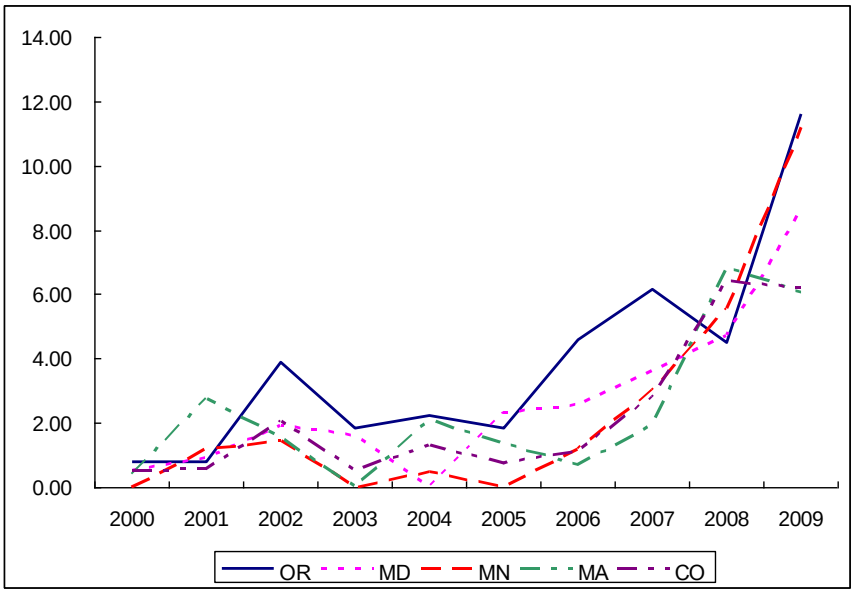

Figure 3. Location Quotients of LEED in selected States
(Data source: CoStar, Inc)

Table 1 lists the top 20 US green states for office buildings. The table contains the number of constructed ~~ions~~units, the market penetration rates[19] and the LQ between 2000 and 2009. This data was also obtained from CoStar's database. In terms of LEED certified office buildings constructed between 2000 and 2009, California was the leading state with 173 LEED buildings followed by Texas (78), Maryland (48) and Colorado (47). In terms of the market penetration rate, however, California was ranked in the 8th place. Oregon was the leading state with approximately 5.85% of the market penetration followed by Maryland (4.12%), Minnesota (3.68%) and Massachusetts

[19] The market penetration rates indicate a ratio of LEED certified buildings as to total office buildings.

(3.63%).[20] In terms of the LQ, the ranking of the LQ was same as the ranking of the market penetration.

In selected US states, on the average, 35 LEED certified office buildings were constructed between 2000 and 2009 per state, and the average market penetration rate was 1.4%. Among 20 states, 13 US states have greater than 1 of the LQ value.

Table 1. Top 20 Green States

Ranking	Construction		Market Penetration		Location Quotient	
	State	Frequency	State	Rate	State	LQ
1	California	173	Oregon	5.847%	Oregon	3.815
2	Texas	78	Maryland	4.108%	Maryland	2.680
3	Maryland	48	Minnesota	3.675%	Minnesota	2.398
4	Colorado	47	Massachusetts	3.631%	Massachusetts	2.370
5	Washington	45	Colorado	3.417%	Colorado	2.230
6	Florida	43	Washington	3.207%	Washington	2.093
7	Oregon	39	Wisconsin	3.075%	Wisconsin	2.007
8	Massachusetts	33	California	2.482%	California	1.619
9	Virginia	33	Michigan	2.320%	Michigan	1.514
10	Michigan	32	Pennsylvania	1.779%	Pennsylvania	1.161
11	Pennsylvania	31	Virginia	1.769%	Virginia	1.155
12	Illinois	30	Illinois	1.762%	Illinois	1.149
13	Georgia	28	New York	1.599%	New York	1.043
14	New York	25	Texas	1.445%	Texas	0.943
15	Minnesota	24	Georgia	1.177%	Georgia	0.768
16	North Carolina	23	North Carolina	1.020%	North Carolina	0.666
17	Arizona	15	Ohio	1.005%	Ohio	0.656
18	Ohio	15	Florida	0.706%	Florida	0.461
19	Wisconsin	15	Arizona	0.543%	Arizona	0.354
20	New Jersey	6	New Jersey	0.405%	New Jersey	0.264

[20] If we included Washington DC it would show the highest LQ.

Average	39.150	2.249%	1.467
S. D.	35.210	1.415%	0.923

Source: CoStar, Inc.

Note: market penetration and LQ values are 10 year averaged values

4.2 Independent Variables

Table 2 lists independent variables used in this study. To control for market conditions in the real estate market, we include the log natural of the gross rent of office buildings per SF per year (LNRENT). This data was obtained from CoStar, Inc. To control for local demand of green buildings, we include the log natural of Gross Regional Domestic Products for all industry (LNGRDP), and this data was obtained from US Bureau of Economic Analysis.

Modeling the role of governors is challenging because their roles and attitudes on green building movements can't be easily enumerated. Thus to control for governors' role in boosting the green building industry, we include a dummy variable indicating the governor's party in each year in each state. In the model, if a governor is Republican in year of *t*, it is coded as "1" while Democrats are coded as "0." Our hypothesis is that there should be less green in Republican dominated states simply because the party has a clear stand on less regulation. On the other hand we have Arnold Schwarzenegger, of California, an unusual Governor who was very pro-environment and still a member

of the Republican Party, so any results supporting our hypothesis would be even stronger without the presence and impact of Governor Schwarzenegger.

As mentioned, EPA Act 2005 was a temporary law terminated at the end of 2008[21]. Therefore years of 2006, 2007 and 2008 for all 20 states were coded by "1" and other years including a year of 2009 were coded by "0." Each state has adopted GBS in different year. Therefore the coding scheme is different for each state. For example, because California adopted GBS in 2004, years between 2000 and 2004 were coded by "0" while years between 2005 and 2009 were coded by "1", and because Ohio adopted GBS in 2007, years between 2000 and 2007 were coded by "0" while fiscal years of 2008 and 2009 were coded by "1." This information was obtained from www.DSIRE.org.

[21] EPAct 2005 authorizes the tax deductions for a period of two years staring Jan. 1, 2006 and ending Dec. 31, 2007 but the Tax Relief and Health Care Act of 2006 extended tax deductions for an additional year (Deru and Crawley, 2007).

Table 2 Variables and Descriptions

Labels	Descriptions	Sources	Mean	Std. Dev.
RENT	The average gross rent of office buildings newly constructed per SF per year	www.costar.com	22.39	4.36
GRDP	Gross Regional Domestic Products for all industry	US Bureau of Economic Analysis (www.bea.gov)	459711.11	349355.12
PARTY	A dummy variable indicating governors' party (if Republican, it is 1)	Official Websites of each state	0.45	0.50
EPA Act 2005	A dummy variable indicating US states under EPA Act 2005 (year 2006, 2007, 2008 are 1)	Environmental Protection Agency	0.40	0.49
GBS	A dummy variables indicating US states under green building standard (if a state has a green building standard, it is 1)	Database of State Incentives for Renewable & Efficiency	0.39	0.49
GBS_E	A dummy variables indicating US states under green building standard adopted by executive order	Database of State Incentives for Renewable & Efficiency	0.16	0.25
GBS_L	A dummy variables indicating US states under green building standard adopted by legislation	Database of State Incentives for Renewable & Efficiency	0.25	0.43

Note: RENT and GRDP were included as log forms in the model

6. Empirical findings

To investigate effects of policies on the LEED market concentration, with the LQ as our dependent variable, we exploit a 10 year panel of data to control for unobserved state and year heterogeneity.

Table 3 shows estimation results of Model 1 and Model 2. Model 1 was to estimate the effects of EPA Act 2005 (EPA Act2005) and state level GBS (GBS) on the LEED concentration and Model 2 was to compare the magnitude of effects of GBS_E and GBS_L.

From the estimation results of a panel Model 1, we found that EPA Act 2005 has significantly affected the LEED concentration in the top 20 US states since the EPA Act of 2005 was statistically significant at the 0.01 level with a positive sign. On the other hand, we did not find any causal relationship between GBS and the LEED concentration from the estimation of Model 1. However, we can not conclude that GBS has not affected the LEED concentration at all because the significant effects of GBS_L can be offset by GBS_E or vice versa. According to estimation results of Model 2, we found that if GBS has been adopted by legislative proceeding it is statistically significant at the 0.1 level with the positive sign, while if GBS has been adopted by executive order it has no impact on the LEED concentration at all.

Table 3 Estimation results 1 (without lag period)

Variables	Model 1			Model 2		
	Coefficient	Std. Err.	t value	Coefficient	Std. Err.	t value
LNRENT	30.00	18.95	1.58	28.52	19.09	1.49
LNRENT^2	-4.10	2.94	-1.39	-3.91	2.96	-1.32
LNGDP	60.65	16.01	3.79***	63.55	15.36	4.14***
LNGDP^2	-2.05	0.58	-3.53***	-2.17	0.56	-3.91***
PARTY	-0.40	0.23	-1.74*	-0.43	0.23	-1.88*
EPA Act 2005	1.26	0.34	3.69***	1.25	0.34	3.69***
GBS	0.34	0.32	1.09			
GBS_E				0.20	0.35	0.78
GBS_L				0.70	0.38	1.84*
R Squared	0.68			0.69		

Note:*, **, *** denote statistical significance at 0.1, 0.05 and 0.01 level, respectively; total sample size is 200 (20 states times 10 years); year and state were fixed in the model. The dependent variable is the change in the concentration index.

Under the assumption that the positive effects of GBS adopted by executive order can not be generated in a very short time period, in model 3, we assumed a 1-year lag for the GBS adopted by executive order. According to estimation from Model 3, it still does not have a significant effect on the LEED concentration. In Model 4, therefore, we assume 2-year lag period for GBS adopted by executive order. According to estimation results of Model 4, GBS adopted by executive order was statistically significant at the 0.1 level with the positive sign meaning it has the greatest effect on the LEED concentration after 2 years passed from effective year of the order. However its magnitude on the effects was smaller than EPA Act 2005 and GBS adopted by legislative proceeding.

Table 4 Estimation results 2 (with lag period)

Variables	Model 3			Model 4		
	Coefficient	Std. Err.	t value	Coefficient	Std. Err.	t value
LNRENT	27.77	18.96	1.46	28.47	18.99	1.50
LNRENT^2	-3.77	2.94	-1.28	-3.90	2.95	-1.32
LNGDP	63.49	15.44	4.11***	63.36	15.43	4.11***
LNGDP^2	-2.16	0.56	-3.85***	-2.16	0.56	-3.86***
PARTY	-0.44	0.24	-1.85*	-0.44	0.24	-1.87*
EPA Act 2005	1.24	0.34	3.64***	1.24	0.34	3.60***
GBS						
GBS_E						
GBS_E_1	0.50	0.39	1.29			
GBS_E_2				0.59	0.45	1.68*
GBS_L	0.63	0.38	1.66*	0.67	0.37	1.81*
R Squared	0.69			0.70		

Note:*, **, *** denote statistical significance at 0.1, 0.05 and 0.01 level, respectively; total sample size is 200 (20 states times 10 years); year and state were fixed in the model. The dependent variable is the change in the concentration index of LEED buildings.

We found several other meaningful results from these estimations. Although Choi (2010) concluded that the incentive-based policies have smaller effects than the regulatory policies on green building designations, our findings instead suggest that the incentive-based policy, EPA Act 2005, had larger effects than state level GBS. This result reflects that EPA Act 2005 provided financial incentives to commercial developers directly while state level GBS does not directly support private investment.

The strongest factor that affects the LEED concentration was the local economy since LNGDP has larger t values in each model based on our estimations. 1% change of GDP accounts for more than 60 of the LQ value of the LEED certified buildings. However we also found a non-linear relationship between the LEED concentration and GDP because the LNGDP^2 was statistically significant at the 0.01 level with the negative sign. This result indicates that the increase rates of the LQ decrease by

approximately 2%.

A governors' party was also a significant factor that affects the LEED concentration. If a governor was a Republican, the state had 0.44 less LQ value than other states governed by Democrats.[22] Interestingly the strongly significant effects of gross office rents on the LEED concentration were not found here, however, it was statistically significant at approximately the 0.15 level.

7. Concluding remarks

The main purpose of this study was to measure the effects of EPA Act 2005 that provided financial incentives to commercial building developers and compare these to the effects of state level GBS which are mandates for public facilities on the LEED concentration in 20 US states. A 10-year of panel data was exploited to control for unobserved year and state effects. We also examined real estate market conditions, local demand and the party of the state governors within several empirical models. We used four different models: Model 1 estimated the effects of EPA Act 2005 (EPA Act2005) and state level GBS (GBS) on the LEED concentration; Model 2 compared the effects of GBS adopted by executive order to the effects of GBS adopted by legislative proceeding; Model 3 assumed 1-year lag period for GBS adopted by executive order; and Model 4 assumed 2-year lag period for GBS adopted by executive order.

In general, we found a strong effect from EPA Act 2005 and GBS adopted by legislative proceeding on the LEED concentration while EPA Act 2005 showed a larger

[22] This result is interesting because we know that California has bucked this finding. The California Republican Party Governor candidate for 2011 stated she would consider placing on hold some of the green mandates should she be elected. A ballot to repeal the measures known as AB32 was rejected in November of 2010.

magnitude than GBS adopted by legislative proceeding. In addition, we have found that if a state had adopted GBS through executive order, its effects were not generated immediately. A 2-year lag period was predicted to have positive effects of GBS adopted by executive order. Based on our empirical findings local demand based on a more vigorous economy was the strongest factor affecting LEED concentration. The party of the Governor also played a role in green building industry penetration.

Several implications can be suggested based on these findings: direct financial incentives for commercial developers are important to boosting investment in green buildings. Green buildings may cost more than traditional buildings in some markets[23] and even the perception of higher construction cost, along with the knowledge barrier of how to go about green building, plays as a powerful role in the decision not to invest in greener buildings. Although the EPA Act 2005 was terminated at the end of 2008, we recommend that various governments including the federal, state and local should not stop providing financial incentives if sustainable building is to remain a priority. State level GBS works and if a state wants to get more efforts in a shorter time period, the state should adopt GBS through the legislative proceeding as opposed to Executive orders. Other incentives, such as quicker permitting may not mean much in early 2011 but they will be important as the market demand for new development comes back. Last, our results found most sustainable real estate efforts as associated green buildings with Democratic governors.

[23] This cost perception is based on surveys by the author at various talks around the United States during 2005 through 2010. When asked of experienced developers and builders who had previously worked on LEED certified projects the direct marginal cost was always negligible to hit certified or silver levels.

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