

Green on Buildings: The Effects of Municipal Policy on Green Building Designations in America's Central Cities

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Abstract This study quantitatively examines the effect of municipal policies on commercial green office building designations. Many states and cities have adopted green building requirements and incentives as policy instruments. This study conducts an OLS regression analysis using American central cities as a unit of analysis and codes municipal green building regulations and incentives for separate dummy variables. The findings reveal that municipal regulatory policy has been a strong tool to promote green office building designations as expected, but incentive-based policies have not been effective except for administrative incentives.

“Green on Real Property” has emerged as a major tool to increase sustainability in urban areas. It is believed that greening real estate has improved overall energy consumption (Rajgor, 2005; Fellows, 2006; Pan, Yin, and Huang, 2008), indoor air quality (James and Yang, 2005; Matela, 2006; Borrelli, 2007; Richardson and Lynes, 2007; Prasow, 2008), occupants’ satisfaction and office occupancy rate (Paul and Taylor, 2008; Prasow, 2008; Fuerst and McAllister, 2009), and rental and sales revenues (Fuerst and McAllister, 2008; Miller, Spivey, and Florance, 2008; Dermisi, 2009). Under the assumption that these externalities can be generated by being “green,” city and state level decision makers have adopted various green building requirements as policy instruments. In addition, many non-profit sectors have significantly influenced the green building movement. The grass-roots level push for green building was heard by politicians and the response has been an increase in public policies to encourage these types of developments. As a result, the green building movement continues to grow rapidly. According to the U.S. Green Building Council (USGBC), since the 2000 Leadership in Energy and Environment Design (LEED) green building rating system, the U.S. experienced a 50% increase in cumulative LEED-registered projects and nearly a 70% increase in LEED-certified projects in 2006. The USGBC is a non-profit organization dedicated to sustainable building design and construction; it is the developer of the LEED building rating system.

This study tests the impact of both regulatory and incentive-based green building policies at the city level on the increase in green office building designations, particularly for the private sector. Perhaps there is less need to implement green

building policy through the larger units of government, such as the federal and the state levels; however, fear of increased costs and regulation may foster reluctance among local governments to implement any policy that would discourage building in smaller cities or those in weaker economies that compete with each other for businesses.

In this study, a green office building refers to an office building registered in the LEED green building rating system or ENERGY STAR. The USGBC developed LEED standards in 1998. LEED is a green building rating system that considers the design, construction, and operation of buildings in accordance with environmental considerations. LEED was developed from a checklist of recommended construction practices to include development; the LEED rating system is an ongoing collaborative process between architects, builders, and building owners and operators (Simons, Choi, and Simons, 2009). ENERGY STAR is also a “green” measurement, developed in 1992 through the efforts of the United States Environmental Protection Agency (USEPA). The focus of the ENERGY STAR program is to reduce energy consumption, thereby lowering greenhouse emissions. ENERGY STAR measures energy efficiencies for operating buildings, building systems, and equipment used inside buildings and homes. ENERGY STAR is incorporated into LEED standards for the renovation of existing buildings (Simons, Choi, and Simons, 2009). There are other green building rating systems in the U.S., such as Green Globe and Green Seal. Green Globe is a set of international standards initially endorsed by 182 heads of state at the United Nations Rio de Janeiro Earth Summit in 1992. Founded in 1989, Green Seal is a non-profit entity helping to set standards for the service industry and individual products (Simons, Choi, and Simons, 2009). This study does not include office buildings designated under either the Green Globe or Green Seal standards because the number of office buildings registered in these two systems in each central city cannot be obtained.

This study looks at the effects of municipal green building policies obtained from web research as of October 2009. Public policies at the municipal level are divided into two sub-categories: municipal regulatory policy and municipal incentive-based policy. In addition, municipal incentive-based policy can be divided into three sub-categories: administrative incentive, financial incentive, and technology support incentive. For the statistical model, therefore, these four public policies including regulation policy and three sub incentive-based policies are coded as separate dummy variables. An Ordinary Least Squares (OLS) regression analysis is conducted using central cities in the U.S. as the unit of analysis. The market penetration of commercial green office buildings in each central city is the dependent variable while the policy dummy variables serve as independent variables. Eight control variables are used to account for demand and supply side factors of green buildings, as well as to control for environmental factors. Factor analysis is used to reduce the nine control variables into three factors because the sample size ($n=103$) is not large enough to run the regression model with an array of 13 explanatory variables (four policy dummy variables and nine control variables). An additional OLS regression analysis is conducted to test whether a city that has used both regulation policy and incentive-based policy experiences

an effect on market penetration that is different than a city that has used only a regulation policy or an incentive-based policy alone.

Literature Review

Although American cities have experienced a rapid increase in the number of green buildings, there have been few empirical studies that have analyzed the factors that may affect green building development. Several motivators for private sector “greening” have been discussed by previous literature: supply-side factors such as increased property value and rents (Fuerst and McAllister, 2008; Miller, Spivey, and Florance, 2008; Dermisi, 2009), demand-side factors (Clemens and Douglas, 2006; Richardson and Lynes, 2007; Paul and Taylor, 2008; Simons, Choi, and Simons, 2009), environmental condition and public policy (Simons, Choi, and Simons, 2009). How an entity values each of these motivators depends on whether the entity is the operator, tenant, owner, or developer of a building.

Supply-Side Factors

Real estate deals are strongly affected by supply-side factors. Green office building initiatives may also be affected by supply-side factors of the existing office market. These supply-side factors include: availability or vacancy of existing office stock, rents or sales prices of existing or planned office buildings, and current condition of existing office stock (Rosen, 1984; Tse and Webb, 2003). Higher vacancy and availability rates will motivate the developer not to invest in green office building because these two proxies indicate that either the office market is down for new construction (meaning that it is hard to find office building buyers or tenants) or competition with other offices is too tough to warrant added investment costs for new green office building construction. Current building conditions may influence owners or operators of older office buildings to convert their properties to green buildings because the costs for rehabbing and converting their properties to green buildings simultaneously can be less if than if done separately.

Previous studies of rents or sales prices of green buildings are important because the existence of a rent or sales price premium 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 more benefit through green investment. Two papers presented at the American Real Estate Society annual meeting in 2008 investigated the difference between ENERGY STAR or LEED designated buildings (i.e., green buildings) and conventional buildings (Miller, Spivey, and Florance, 2008; Fuerst and McAllister 2008; Dermisi, 2009) in terms of rents and building sales prices. They both found market premiums for green building.

Demand-Side Factors

Who wants to buy or work in green office buildings? Buyers and tenants who think green office buildings are more comfortable than conventional office

buildings generate demand (Paul and Taylor, 2008). Paul and Taylor's study compared occupant comfort and satisfaction between a green building and a conventional building. They collected the comfort and satisfaction perceptions of the occupants of a green university building and two conventional university buildings with a questionnaire that asked occupants to rate their workplace environment in terms of aesthetics, serenity, lighting, acoustics, ventilation, temperature, humidity, and overall satisfaction.

Buyers and tenants who consider public perception or who think "it is the right thing to do" generate demand for green office buildings as well (Simons, Choi, and Simons, 2009). Under this assumption, it is logical that if a city has more educated people, the city is likely to possess more green office buildings. Many times a lack of internal leadership among stakeholders is very important for green office building development because this assumption is not related to tangible benefits. Richardson and Lynes (2007) pointed out the importance of internal leadership and communication between participants of green office building development. They explored the barriers to and motivations for the construction of green buildings at the University of Waterloo. The authors conducted 13 in-depth interviews with key university individuals and found that a lack of internal leadership among stakeholders with decision-making power, a lack of quantifiable sustainability targets, an operational structure that does not reward building designs with lower energy costs, and a lack of communication between professional designers, facilities management, and faculty were all barriers to constructing green buildings at the university.

Environmental Conditions

Simons, Choi, and Simons (2009) pointed out that various climate environments serve as motivators for green building initiatives: cities that experience many days of sunshine are able to utilize solar panels; cities with less water access and higher water costs motivate water conservation; and warmer climates use more electricity for air conditioning, motivating building users to provide shade and green roofs.

Green building developments can be motivated by environmental protection. Green building developments have been used in the context of local commitment to the U.S. Mayors Climate Protection Agreement and other climate change programs (Retzlaff, 2009). Although some environmental benefits are not easily quantified, it is believed that green building generates less pollution and landfill waste. According to the U.S. Department of Energy (2008), buildings in the U.S. contribute 38.1% of the nation's total carbon dioxide emissions, including 20.6% from the residential sector and 17.5% from the commercial sector. For the public side, green buildings can be a good tool to reduce air and water pollution by using eco-friendly building materials, recycling or reusing old materials, and using eco-friendly energy sources such as fuel cells.

Public Policy

Simons, Choi, and Simons (2009) qualitatively investigated the impact of public policies on the market penetration of green commercial office buildings. The

research had limited generalized findings because the results were drawn from case studies. They researched policies at both the state and city level through various methods, such as website research and interviews with public 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 originally established but these programs are no longer funded in California. Moreover, mandates initially were not required for private developers but private developers were encouraged to follow suit. According to their research, Chicago not only encourages LEED design for all new buildings, but since green does not stop at new buildings, Chicago also works with existing building owners and operators to incorporate ENERGY STAR efficiencies into rehab projects. The authors concluded that the most common form of 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. 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.

Retzlaff (2009) divided municipal policies impacting use of the LEED building assessment system into three categories: policies for buildings that are funded or owned by municipalities, private development requirements, and incentives. According to her, the inclusion of LEED in municipal policies is a new trend; prior to 2000, only two cities—Austin, Texas and Scottsdale, Arizona—had adopted green building policies. She found in the private side, which is a focus of this paper, that no jurisdiction enacted a policy that requires all buildings to use LEED; however, some places require multiple types of buildings, all buildings in certain zoning districts, or those that meet minimum size requirements to use LEED.

The National Association of Industrial and Office Properties (NAIOP) Research Foundation retained Yudelson Associates in 2007 to investigate local government incentive programs specifically for green buildings. Yudelson Associates identified and characterized local and state incentives for green building construction by the private sector through several case studies and survey research. From their survey, “incentive payment from a utility energy-efficiency program” and “direct monetary payment from a city or county (grant, rebate or reimbursement)” were two most popular incentives for green building construction by the private sector. Yudelson Associates also listed current government programs at the local level by city or state. They found that local governments have increasingly instituted policies, programs, and incentives in the effort to encourage sustainable buildings (Yudelson Associates, 2007).

Profiles of Municipal Green Building Policies: Web-Based Research

Based in part on information derived from a review of the academic literature, websites for central cities that possess more than one green office building were

reviewed. The intent was to ascertain whether or not city governments apply green building policies. The search phrases used were “green building requirement” and “green building incentives.” The table in the Appendix lists all central cities that have implemented municipal green building policies.

Green policies can be adopted through either executive orders or legislative enactment. Executive orders are a quicker method for implementing policy. Legislation often gets bogged down by politics. Working through different political agendas often results in green legislation going nowhere (Simons, Choi, and Simons, 2009). The general concept for implementing green building techniques through regulatory policies is straightforward: some of newly constructed or renovated buildings or all of buildings in certain zoning (Retzlaff, 2009) must meet LEED or LEED-equivalent requirements. Municipalities have mandated that all or some of their buildings must meet LEED or equivalent requirements (Yudelson Associates, 2007), while state governments have mandated their “public buildings” to utilize some green building techniques (May and Koski, 2007). Regulation is viewed as the most powerful policy tool for promoting specific development activities because a city or a state can conduct disciplinary action for non-compliance.

Central cities also utilize various incentive-based policies to encourage green building. Such policies can be divided into the three main categories previously mentioned: administrative incentives, financial incentives, and technical support (Retzlaff, 2009; Simons, Choi, and Simons, 2009). With administrative incentives, green building projects will pass through the plan review and approval process faster so that developers can save time and money. With financial incentives, green building developers can get various tax credits, funds, and rebates. With technical support, a municipality provides every effort for the developers who want their properties to be green certified; this support is very useful since green building requirements are often new or unfamiliar for private sector initiators.

Public Policy: State or City?

The provisions of state green requirements include incentives for constructing green buildings, mandates for adherence to LEED provisions for new facilities, and requirements for LEED provisions for renovated buildings that meet specified size or value requirements (May and Koski, 2007). As Simons, Choi, and Simons (2009) and May and Koski (2007) point out, most state policies promote the utilization of green building techniques in state buildings, schools, and other public facilities, while municipal policies more often focus on promoting green construction in the private sector. In other words, the state requirements do not affect single-family homes or commercial structures. Therefore, this study assumes that municipal policies may be more effective on the market penetration of green buildings than state policy because municipal policies deal with commercial developers’ investment. In addition, municipalities may be the best place for green policies because they have the organizational structures to adopt and enforce development regulations, they can respond best to local government conditions and issues, and because public sustainability activism is more meaningful and

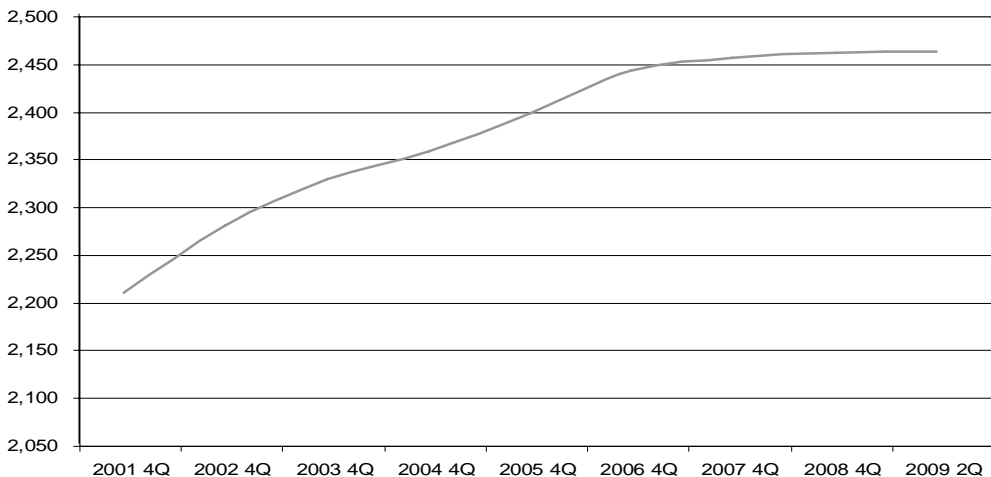
effective at the local level (Theaker and Cole, 2001). Working from this position, this study is primarily concerned as to whether the market penetration of green office buildings has been affected by municipal policies, including both regulatory policies and incentive-based policies, while controlling for other external factors that can affect the green building initiations.

Green Building Profiles in the U.S.

According to the definition of the U.S. Environmental Protection Agency (EPA), green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle, from siting to design, construction, operation, maintenance, renovation, and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort (EPA). Green buildings are also regarded as sustainable high-performance buildings that are designed to reduce waste sent to landfills, conserve energy and water, provide a safe and healthy environment for occupants, reduce greenhouse gas emissions, and reduce operating costs for the building owner, which can then be passed on to tenants through lower rents and utility costs. For example, green buildings may incorporate sustainable materials in their construction (e.g., materials that are reused, recycled-content, or made from renewable resources), create healthy indoor environments with minimal pollutants (e.g., reduced product emissions), and feature landscaping that reduces water usage (e.g., by using native plants that survive without extra watering).

Exhibit 1 depicts the trends of the number of existing green office buildings in the U.S. with ENERGY STAR designations since 2001. In the fourth quarter of

Exhibit 1 | Number of Existing ENERGY STAR Office Buildings since 2001



Data Source: www.costar.com.

2001, 2,215 office buildings were certified as ENERGY STAR, and in the second quarter of 2009, 2,468 office buildings were certified as ENERGY STAR, showing an increase of over 10% during this period. There were 564 green office buildings certified as LEED in 2000 and 1,311,137 green office buildings certified as LEED in 2009.

Exhibit 2 depicts new constructions of green office buildings certified by ENERGY STAR or LEED since 2001 in the U.S. The exhibit shows that approximately 200 green office buildings were constructed around 2000. It appears that after USGBC developed LEED standards in 1998, many efforts in the private sector have been made to meet LEED standards. However, new constructions of office green buildings have experienced a rapid decrease since 2008; the continuing economic crisis may explain this reversal (Exhibit 3).

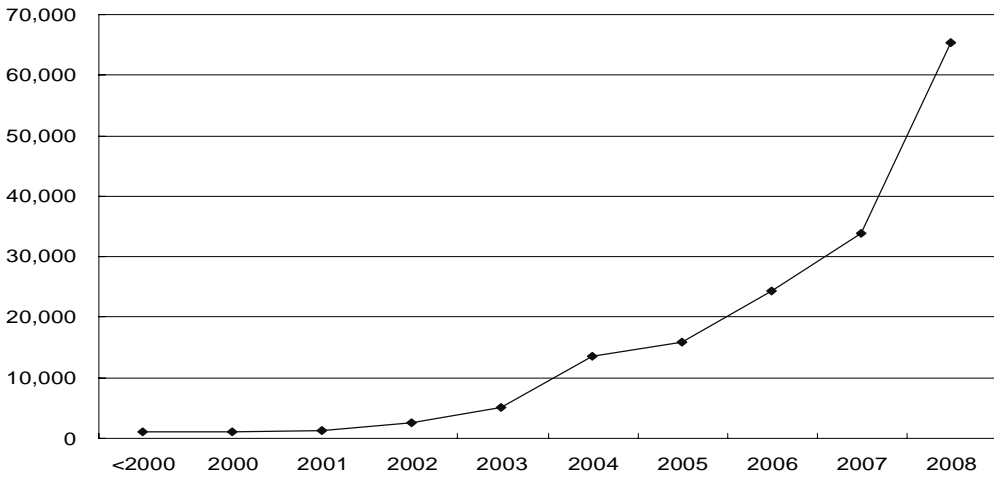
Exhibit 4 lists the top 20 states in terms of the distribution and density of green office buildings. There are 2,801 green office buildings in the CoStar database in the U.S., as of March 26, 2009; each building in the database was listed as having rental vacancy and “green” status. The exhibit indicates state rankings by concentration of buildings on the left side and the availability of green office buildings per million state residents on the right side.

In terms of the number of green office buildings, California was ranked as the top with 691 green office buildings, followed by Texas (285), Colorado (155), Illinois (113), and Massachusetts (96). The top 10 states possess approximately 70% of the green office buildings. For the availability rankings of green office buildings per million people in each state, Colorado was at the top with approximately 31 green office buildings per million people (excepting the District of Columbia), followed by California (19), Oregon (17), Minnesota (16), and Massachusetts (15). The average of green office buildings per million people was approximately 8.26, yet only 13 states exceeded the average green office buildings per million people.

Exhibit 2 | New Constructions of Green Office Buildings: Trend Since 2001



Data Source: www.costar.com.

Exhibit 3 | Number of Existing LEED Office Buildings since 2000

Data Source: USGBC.

Exhibit 5 shows the distribution of green office buildings expressed as the number of buildings per million. Western states such as Texas, Colorado, Washington, Oregon, and California have more than 10 office green buildings per million people. On the other hand, no office green buildings were found in states located in northern states such as Montana, North Dakota, South Dakota, and Wyoming. This result seems to be due to cold weather in these states. In addition, no office green buildings were found in Vermont or New Hampshire. This result seems to be due to small office markets in these states.

Exhibits 4 and 5 show that the green building movement is not a uniform nationwide trend. It has been concentrated in several states, especially in the western states (Simons, Choi, and Simons, 2009).

Exhibit 6 shows the market penetration rates for green office buildings in the top 10 central cities in the U.S. The market penetration rate is calculated by dividing the number of green office buildings in a city by the city's total office buildings. San Francisco has the highest market penetration rate, with approximately 6.23% market penetration, followed by Houston (5.89%), Washington D.C. (4.63%), Denver (4.32%), and Duluth (4.32%).

In San Francisco, both incentive-based and regulatory policies are in place and seem to be working. According to San Francisco's Department of the Environment, projects that commit to LEED Gold certification are eligible for priority permit processing through coordination with the Planning Department, Department of Building Inspection, and Department of Public Works. There are also rebates for installation of photovoltaic systems, water efficiency and energy efficiency measures available from the San Francisco Public Utilities Commission. Coupled with the California Solar Initiative state rebates and federal tax credits, incentives can pay half the cost of a solar power system installed in an office

Exhibit 4 | Top 20 States by the Number of Green Office Buildings

Ranking	Concentration		Availability	
	State	Number of Offices	State	Per Million People
1	California	691	District of Columbia	135.17
2	Texas	285	Colorado	31.38
3	Colorado	155	California	18.80
4	Illinois	113	Oregon	16.89
5	Massachusetts	96	Minnesota	15.52
6	Washington	88	Massachusetts	14.77
6	Florida	88	Hawaii	14.75
8	Minnesota	81	Washington	13.44
9	New York	80	Texas	11.72
9	District of Columbia	80	Virginia	10.04
11	Virginia	78	Arizona	8.77
12	Pennsylvania	73	Illinois	8.76
12	Georgia	73	Connecticut	8.28
14	Oregon	64	Maryland	7.63
15	Michigan	63	Georgia	7.54
16	Arizona	57	Kansas	6.78
17	North Carolina	51	Michigan	6.30
18	New Jersey	50	Pennsylvania	5.86
19	Ohio	48	New Jersey	5.76
20	Maryland	43	Delaware	5.73

Notes: The source is Simons, Choi, and Simons (2009), modified by the author. Data are from www.costar.com. $N = 2,801$. Average number of green buildings per million people = 8.26.

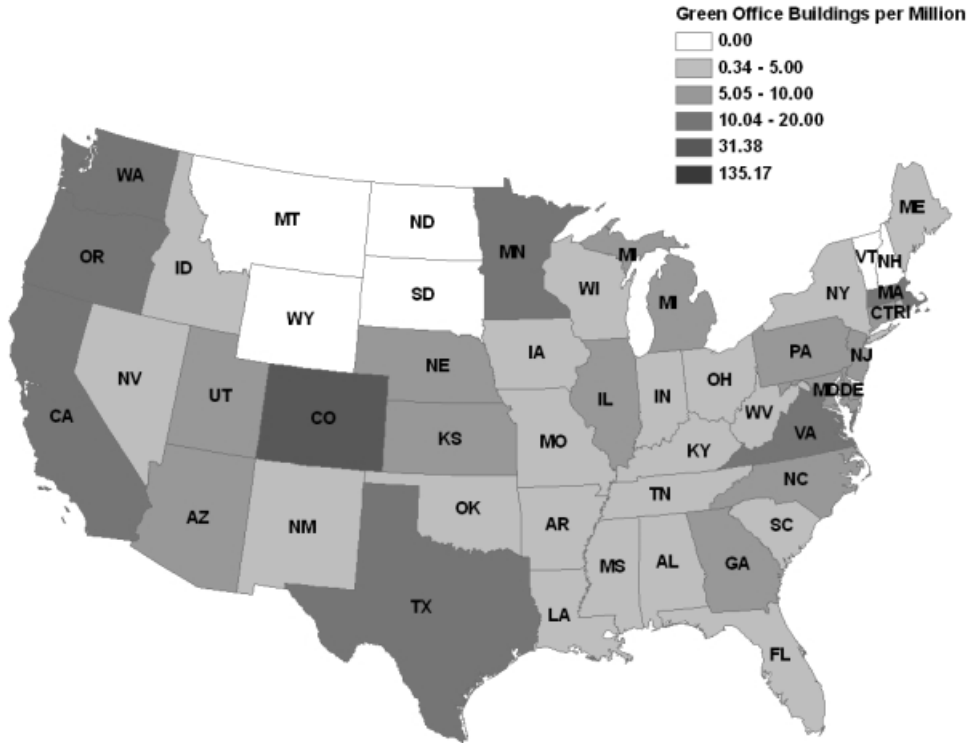
building in San Francisco. In terms of regulations, the city enacted private sector green building requirements that became effective November 2008. Chapter 13C of the San Francisco Building Code will require new buildings constructed in the city to meet green building standards, which were developed by the Green Building Task Force. In addition, all municipal projects, both new construction and major renovations over 5,000 square feet, are required to achieve LEED Silver certification from the USGBC.

Methodology

Study Area

This study uses America's central cities as a unit of analysis. Central cities are defined as core urban areas; they often have higher poverty and crime rates with

Exhibit 5 | Distribution of Green Office Buildings



Source: www.costar.com; map produced by the author.

Exhibit 6 | Market Penetration; Top 10 Central Cities in 2009

Central City	State	Green Office Buildings	Total Office Buildings	Market Penetration
San Francisco	CA	102	1,638	6.23%
Houston	TX	129	2,189	5.89%
Washington D.C.	DC	81	1,750	4.63%
Denver	CO	56	1,296	4.32%
Duluth	MN	5	118	4.24%
Minneapolis	MN	23	593	3.88%
Seattle	WA	47	1,266	3.71%
Honolulu	HI	11	300	3.67%
Burlington	NC	4	112	3.57%
Chicago	IL	62	1,790	3.46%

Note: The data source is CoStar, Inc. (www.costar.com).

lower median household incomes than the surrounding Metropolitan Statistical Area (MSA). It is believed, moreover, that central cities have relatively poor environmental conditions, such as lower air and watershed quality, than suburban cities (Warner, 2001; Harner, Warner, Pierce, and Huber, 2002; Rast, 2006; Chambers, 2007). On the other hand, many job generators including commercial offices are concentrated in the central cities. This study assumes that green building policies are more common in central city areas than suburban areas. The principal cities of each MSA are considered the central cities, but not all central cities in the U.S. have green office buildings. Central cities without green office buildings are not included in the sample, leaving 103 central cities in the study. California has the most central cities (14) where such buildings exist, followed by Florida, North Carolina, and Texas, each with six central cities possessing green office buildings.

Data

The dependent variable is the market penetration rate of green office buildings in each central city (Exhibit 7). The market penetration of green office buildings is measured as the ratio of green office buildings to total office buildings. These data were obtained from CoStar, Inc.'s database (www.costar.com).

Each category of green building policies, including regulatory policy, administrative incentive, financial incentive, and technical support are coded as separate dummy variables. The policy categories are based on the following criteria:

- **Regulatory Policy:** New/rehabbed commercial buildings must Meet LEED or LEED-equivalent;
- **Administrative Incentive:** Priority building permit process, expedited development plan review, and marketing materials;
- **Financial Incentive:** Various tax incentives including tax credits and refunds, as well as various grants and rebates for green building development; and
- **Technical Support Incentive:** Technical support for construction or rehab methods, building preparation, site evaluation, material selection, and training.

This study uses average office rent expressed in dollars per square foot per year and average of office age to control effects of supply-side factors on green building development. The percentage of white population and the median household income are used to control the effects of demand-side factors on green building development. To account for the environmental motivations of green building initiatives, controls for the density of the carbon are integrated into the analysis. Since a significant number of sunny days may affect green building development (Simons, Choi, and Simons, 2009), it is reasonable to include the average temperature in July for last 30 years as a control variable.

Exhibit 8 shows basic statistics for the factors used as dependent variables and used for factor analysis in this study. The mean of market penetration of green

Exhibit 7 | Descriptions of Variables

Variable	Description	Source
<i>MP</i>	The market penetration rate of green office buildings (green office buildings / total office buildings).	www.costar.com
<i>LNOFFICERENT</i>	The natural logarithm of average office rent per year per square foot.	www.costar.com
<i>LNOFFICEAGE</i>	The natural logarithm of average office age.	www.costar.com
<i>LNRB</i>	The natural logarithm of the average rentable building area.	www.costar.com
<i>WHITE</i>	The percentage of white population.	Census 2000
<i>GRADUDEGREEE</i>	The percentage of graduate or professional degree.	Census 2000
<i>LNINCOME</i>	The natural logarithm of median household income.	Census 2000
<i>LNCARBON</i>	The natural logarithm of carbon density.	www.airnow.gov
<i>LNOZONE</i>	The natural logarithm of ozone density.	www.airnow.gov
<i>TEMPERATURE</i>	Average temperature in July since last 30 years.	www.city-data.com
<i>REGULATION</i>	A dummy variable indicating the presence of the regulation policy.	Web Research
<i>ADINCENT</i>	A dummy variable indicating the presence of the administrative incentive.	Web Research
<i>FINAINCENT</i>	A dummy variable indicating the presence of the financial incentive.	Web Research
<i>TECHINCENT</i>	A dummy variable indicating the presence of the tech support incentive.	Web Research

Note: www.costar.com is the website of a commercial real estate information company. www.airnow.gov is a cross-agency government website that provides air quality information for the U.S.

Exhibit 8 | Descriptive Statistics

Variable	Min.	Max.	Mean	Std. Dev.
Market Penetration	0.04%	6.23%	1.38%	1.41%
Office Rent	\$10.19	\$52.82	\$20.33	\$7.01
Office Age	19.50	89.40	43.66	16.02
Rentable Building Area (SF)	809,261.00	494,050,780.00	36,360,186.74	59,707,504.82
White Percentage	7.00%	92.00%	52.91%	21.40%
Graduate Percentage	2.00%	49.00%	10.63%	6.61%
Median Household Income	\$23,234	\$99,102	\$37,496	\$9,852
Carbon Density	1.00	5.10	2.32	.74
Ozone Density	.04	.10	.08	.01
Temperature	62.80	92.80	76.78	5.94

office buildings is 1.38%. The mean of office rent square foot per year was approximately \$20 and the mean of office age was approximately 44 years old. The highest temperature was 93 degrees while the lowest temperature was approximately 63 degrees. On the mean, cities included in this study have 77 degrees.

Exhibit 9 shows a distribution of central cities' green building policies: 30 central cities have regulatory policies, 11 central cities use administrative incentives, 9 central cities have various financial incentives, and 6 central cities use technical support.

The Models

This study runs simple Ordinary Least Squares (OLS) regressions to determine which factors affect the market penetrations of green office buildings including public policies. The baseline OLS model in this study is expressed as in the reduced form:

$$y = \beta_0 + \beta_1 \text{Supply} + \beta_2 \text{Demand} + \beta_3 \text{Env} + \beta_4 \text{Policy} + \varepsilon \quad (1)$$

Where:

- y = Green building market penetration;
- Supply = A vector indicating supply-side variables;
- Demand = A vector indicating demand-side variables;
- Env = A vector indicating environmental variables
- Policy = A vector indicating policy variables; and
- ε = The error term

However there is a crucial issue to run the OLS model with 14 variables in four factors because of the small sample size and possible correlation between independent variables. To minimize this issue in this study the baseline Model (1) is specified into four sub-models. Exhibit 10 presents model specifications in this study. All variables except public policy dummy variables are checked at least twice in the analysis.

Exhibit 9 | Frequencies of Green Building Policies

Policy	Frequency	Percentage
Regulatory Policy	30	29.13%
Administrative Incentive	11	10.68%
Financial Incentive	9	8.74%
Technical Support	6	5.83%

Note: Total central cities in sample is 103.

Exhibit 10 | Model Specifications

Variable	Model 1	Model 2	Model 3	Model 4
<i>LNOFFICERENT</i>	○			○
<i>LNOFFICEAGE</i>		○		○
<i>LNRBA</i>			○	○
<i>WHITE</i>	○			○
<i>GRADUDEGREE</i>			○	○
<i>LNINCOME</i>		○		○
<i>LNCARBON</i>	○			○
<i>LNOZONE</i>		○	○	
<i>TEMPERATURE</i>	○		○	○
<i>REGULATION</i>	○	○	○	
<i>ADINCENT</i>	○	○	○	
<i>FINAINCENT</i>	○	○	○	
<i>TECHINCENT</i>	○	○	○	

Empirical Results

Exhibit 11 presents estimation results of OLS regression analyses. Model 1 includes *LNOFFICERENT*, *WHITE*, *LNCARBON*, and *TEMPERATURE* with policy dummy variables. This model has a 0.636 adjusted R^2 , which means that the variables explain approximately 64% of the total variation. In this model, *WHITE* is statistically significant at the 5% level with a negative sign, and *TEMPERATURE* is statistically significant at the 1% level with a positive sign, which means that cities with higher temperatures are more likely to show higher market penetration rates of green buildings. In this model, *REGULATION* is statistically significant at the 1% level, with a positive sign meaning cities adopted regulation policy are more likely to show higher market penetration rates while other incentive-based policies are not statistically significant.

Model 2 included *LNOFFICEAGE*, *LNINCOME*, and *LNOZONE* with policy dummy variables. This model has a 0.567 adjusted R^2 , which means that variables explain approximately 57% of total variation. *LNOFFICEAGE* is statistically significant at the 1% level, with a positive sign, which means that cities with older office properties are more likely to have higher market penetration rates. In this model, both *REGULATION* and *ADINCENT* are statistically significant at the 1% level with positive signs, which mean that cities that adopted regulation or administrative incentive program are more likely to have higher market penetration rates.

Model 3 included *LNRBA*, *GRADUDEGREE*, and *LNOZONE* with policy dummy variables. This model shows a 0.543 adjusted R^2 , which means that the variables

Exhibit 11 | Estimation Results

Variable	Model 1		Model 2		Model 3		Model 4	
	Beta	<i>t</i> -value	Beta	<i>t</i> -value	Beta	<i>t</i> -value	Beta	<i>t</i> -value
<i>LNOFFICERENT</i>	0.130	0.928					0.137	0.700
<i>LNOFFICEAGE</i>			0.318	3.744***			0.107	0.655
<i>LNRBA</i>					0.320	3.171***	0.054	0.327
<i>WHITE</i>	-0.259	-2.150**					-0.328	-2.081**
<i>GRADUDEGREE</i>					-0.032	-0.326	0.160	1.027
<i>LNINCOME</i>			0.031	0.305			0.359	2.285**
<i>LNCARBON</i>	-0.067	-0.620					-0.059	-0.479
<i>LNOZONE</i>			-0.084	-0.937	-0.171	-1.816*		
<i>TEMPERATURE</i>	0.354	3.229***					0.314	1.971*
<i>REGULATION</i>	0.459	3.713***	0.453	4.885***	0.356	3.504***		
<i>ADINCENT</i>	0.105	0.811	0.248	2.723***	0.212	2.197**		
<i>FINAINCENT</i>	0.024	0.185	0.069	0.673	0.012	0.116		
<i>TECHINCENT</i>	0.146	1.195	0.105	1.098	0.129	1.310		
Adj. R ²	0.636		0.567		0.543		0.529	
F-value	8.072***		12.555***		11.552***		5.198***	

Notes: *N* = 104.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

explain approximately 54% of total variation. In this model, *REGULATION* is statistically significant at the 1% level with a positive sign and *ADINCENT* is statistically significant at the 5% level with the positive sign. Such results confirm the estimation results of Model 2.

Conclusions and Policy Implications

Only recently have local governments started to look at their regional needs, as well as strengths and weaknesses to help develop individualized standards for implementing green building policies (Simons, Choi, and Simons, 2009). Numerous public policies have been implemented in the last ten years to promote green building in the private sector. Focusing on municipal policies, this study divided policies into two main categories: regulatory policy and incentive-based policy. In addition, this study also divided incentive-based policy into three sub-categories: administrative incentive, financial incentive, and technical support. Under regulatory policies, newly constructed or rehabbed buildings must meet LEED or LEED-equivalent requirements. Under administrative incentives, green building projects will pass through the plan review and approval process faster so that developers can save time and money. Using financial incentives, green building developers can get various tax credits, funds, and rebates. Technical support occurs when a municipality provides every effort for the developers to get their properties as green certified.

Using American central cities as the unit of analysis, this study conducted OLS regression analyses. In the regression models, the municipal regulatory policies, the municipal administrative incentive, the municipal financial incentive, and the municipal technical support were coded as four distinct dummy variables. The model controlled for the effects of various external factors driven by the literature review.

Strong effects of the municipal regulatory policy on green building development have been pointed out (Simons, Choi, and Simons, 2009). In fact, many central cities with higher market penetration rates of green buildings have mandated regulatory policies; such policies are found in the top three central cities (San Francisco, Houston, and Washington, DC). Not surprisingly, the effects of regulatory policy on green building developments were found by estimation of this study.

It is interesting that the municipal administrative incentive has a significant impact on green building development. Through “priority building permit process” and “expedited development plan review” developers can save time and money. Green building projects pass through the process faster and will be approved more quickly through the plan review phase (Yudelson Associates, 2007). This result suggests that developers consider permit and approval processes as barriers to building development. Simons, Choi, and Simons (2009) pointed out that difficulties involved with identifying appropriate architects, construction firms, construction materials, legal counsel, and other development necessities can

lengthen the project schedule. Delays often lead to greater risks and higher costs that developers would rather avoid, given tight budgets and time frames. In this context, faster building approvals and permitting processes for green building projects lower the risks for the private sector developers with the added benefit of promoting greener construction.

On the other hand, financial incentives have not worked as a tool for green office building developments. Yudelson Associates (2007) listed municipal financial incentive programs for the private sectors. These programs include tax credits, refunds/abatements, bond funds, loan/loan funds and various fees as mentioned. It is quite interesting that, although many central cities are under these financial incentive programs, monetary supports have not worked for private sector green building developments. This result may imply that financial incentives have been in name only or developers have not shown interest in such incentive programs because they could not offset construction or rehab costs due to greening properties. Simons, Choi, and Simons (2009) found that in many cases, particularly in California, existing financial incentives were rarely disbursed to developers. This does not eliminate the possibility that the monetary incentives provided by central cities cannot offset greening costs.

Future researches will focus on the role of green buildings in urban sustainability in the U.S. These research topics will enumerate positive externalities of green building development in urban areas in terms of suitability.

Appendix

Green Building Policy Profile of America's Central Cities

States	Central City	Regulation	Incentive-Based		
			Administrative	Financial	Tech-Support
AZ	Phoenix	○		○	○
AZ	Tucson	○			
CA	Bakersfield				
CA	Los Angeles	○			
CA	Oakland	○			
CA	Oxnard				
CA	Riverside		○		
CA	Sacramento	○		○	
CA	Salinas				
CA	San Diego		○	○	
CA	San Francisco	○	○	○	
CA	San Jose	○			
CA	San Luis Obispo				

Appendix (continued)

Green Building Policy Profile of America's Central Cities

States	Central City	Regulation	Incentive-Based		
			Administrative	Financial	Tech-Support
CA	Santa Ana				
CA	Santa Rosa				
CA	Stockton				
CO	Boulder				
CO	Colorado Springs				
CO	Denver			○	○
CO	Fort Collins	○			
DC	Washington, DC	○	○		○
FL	Miami		○		
GA	Atlanta	○			
HI	Honolulu	○			
IL	Chicago	○	○		
MA	Boston	○			
MA	Springfield				
MD	Baltimore				
MI	Ann Arbor				
MI	Detroit				
MI	Grand Rapids	○			
NE	Omaha	○			
NJ	Camden				
NJ	Newark				
NM	Albuquerque	○			
NM	Farmington				
NM	Santa Fe				
NV	Las Vegas				
NY	Albany				
NY	Buffalo				
NY	New York	○			
OH	Cincinnati	○			
OR	Bend				
OR	Portland	○		○	
OR	Salem				
PA	Allentown				

Appendix (continued)

Green Building Policy Profile of America's Central Cities

States	Central City	Regulation	Incentive-Based		
			Administrative	Financial	Tech-Support
PA	Harrisburg				
PA	Philadelphia				
PA	Pittsburgh				
TX	Austin	○			
TX	Dallas	○			
TX	Houston	○			
TX	San Antonio		○	○	
WA	Olympia				
WA	Seattle	○	○		○
WA	Spokane				
WI	Madison	○			

Note: Policies obtained from the web-based search done by the author. Some cities may be omitted from the table, therefore, if they implemented green building regulations or incentives since the web-based search was completed in October 2009.

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