Green Building and Policy Innovation in Low-Income Housing Developments (LIHTC)

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Abstract

The present article analyzes the integration of green building policy and practice with the largest low-income housing production program in the US and the innovativeness of its housing agencies. Drawing on policy innovation literature, panel data and regression analysis are employed to quantify associations between state-level characteristics and the adoption of green building criteria into the Low-Income Housing Tax Credit (LIHTC) program. Results show that, on average, housing agencies have increasingly adopted green building criteria, and most have identified co-benefits from energy-efficient buildings and smart growth. Despite overall progress, the rate of adoption of green building criteria has decreased, few states have comprehensive criteria, and many have dropped important criteria, such as on-site renewable energy generation. Results are consistent with hypotheses derived from the literature and suggest the integration of green building with LIHTC developments is significantly associated with government motivation, financial resources, and exogenous characteristics that affect the demand for green building. Future research should explore organization-level factors that affect environmental policy innovation. It is recommended that LIHTC housing agencies require compliance with green building rating systems and periodically reconfigure green building criteria based on planned evolutionary change, data-driven strategies, and life-cycle analyses towards zero net energy consumption.

1. Introduction:

While renewable energy is rapidly growing in worldwide adoption, approximately 89% of the energy consumed in the US in 2019 still came from non-renewable sources like coal, gas, and nuclear power [1]. Of that energy produced, the residential sector accounted for about 21% of consumption. Simultaneously, almost half of all renter households are cost-burdened, often due to poverty and, in large metro areas, rapidly rising housing prices [2,3]. The residential sector in the US is clearly in need of comprehensive policymaking reforms that concurrently address affordability and environmental sustainability, reducing uncertainties around the national economy, energy security, declining natural resources, and climate change.

In the spirit of sustainability, Environmental Policy Integration (EPI) has been established as a key strategy to increase organizational effectiveness in policy coordination and achieve equal weighting of sectorial and environmental policies [4,5]. Since the 1980s, many state governments in the US have taken environmental and climate leadership roles following the federal government's dwindling environmental preeminence. For instance, many state governments have integrated green building (i.e., building with higher than basic standards based on a holistic attitude toward the planning, design, construction, operation, and recycling or renewal of buildings) into low-income housing programs to achieve co-benefits like reducing the life-cycle cost of homeownership, increasing energy and water efficiency, increasing indoor environmental quality, providing a healthy, safe, and productive built environment, and furthering environmental stewardship [6,7]. However, the lack of involvement on the part of federal and some state governments combined with obstacles at the local level has created challenges in the ultimate achievement of environmental targets [8].

In 1986, the US Congress enacted the Low-Income Housing Tax Credit (LIHTC) program, which provides state and local LIHTC-allocating agencies with about $8 billion per year to issue tax credits for the acquisition, rehabilitation, or new construction of rental housing for low-income households [9]. With more than 2.4 million active units [10], LIHTC is the principal federal affordable housing production program, which incentivizes the production of a significant portion of below-market-rate multifamily rental units for extremely low-income to low-income households based on an indirect federal subsidy. Residents that qualify to live in a LIHTC unit receive income and quality benefits depending on their certified annual income and the maximum rent set by the project [11]. McClure, 2019, describes the basics of the LIHTC program [12].

Green building is increasingly considered important in LIHTC Qualified Allocation Plans (QAPs), which outline the criteria based on which state housing agencies allocate financial incentives in the form of tax credits to multi-family residential developers. The basic federal criteria included in QAPs do not mandate green building standards, but additional criteria that support state housing policy goals may include specific energy-efficiency or other requirements. Previous studies show QAPs have significant impacts on the location and quality of LIHTC developments [13]. As a result, QAPs could either promote or inhibit the application of innovative designs and technologies in low-income developments. Existing literature on the LIHTC program suggests that, among other co-benefits, green LIHTC properties have generated considerable financial savings for the occupants [14]. Despite its significance as an opportunity to drive innovation in housing, green building in LIHTC has not received much attention in the literature.

The rationale for undertaking this study is twofold. First, there is no systematic study exploring the adoption of green building criteria in LIHTC, and the literature in this area is both nascent and ad-hoc. Second, many states have sometimes reduced or abandoned the adoption of green building criteria despite revealed public health, economic development, and local environmental improvement co-benefits. Drawing from these reasons, this article explores the following questions about the LIHTC program: What components of green building are promoted in state QAPs? Are all states contributing equally to environmental sustainability through the LIHTC program? Why are some LIHTC-allocating agencies more innovative than others in adopting and maintaining green building criteria? The next section sets forth a concise review of the literature on green building and policy innovation. Following descriptive analyses, an empirical framework is then introduced to investigate the extent to which interstate variations in the adoption of green building criteria are associated with certain economic, environmental, political, and societal state characteristics. The article concludes with a discussion on research and policy implications.

2. Literature Review:

2.1. The need for green LIHTC developments

Sustainability thinking has long encouraged integrated, interdisciplinary approaches and policies that holistically address multiple contemporary problems [15]. Sustainable development requires a balanced integration of economic, environmental, and social goals with traditionally siloed policy sectors, such as low-income housing, as a goal of governance [16,17]. Policy integration is deemed necessary because some policy sectors – like environment and climate – alone are not capable of achieving all of the objectives and thus must work with other sectors [18]. Despite the importance of sustainability to the future of the planet, there are inherent economic, environmental, and social justice conflicts involved in reaching sustainable development, and conflict resolution is not easy [19,20].

In light of rapid urbanization and the need for improving the living conditions of low-income households, policy integration has been challenging to implement in the federal political system

[5,21]. Historically, low-income households and racial minorities in the US have lived in proximity to large amounts of pollution and poor environmental conditions and experienced disproportionate costs of energy, transport, healthcare, and safety [22–24]. Even access to green space, recreation, and civic services has been dependent upon income and race and become an environmental justice issue [20]. Affordable housing is often defined solely based on house price to household income ratio, thus, neglecting transportation, healthcare, education, and other trade-offs low-income households should make to survive [25]. Siting and building LIHTC developments under green building standards have the potential to reduce operating costs, promote resident health, and mitigate negative environmental impacts [26].

At the neighborhood level, LIHTC properties built to green building standards can help further revitalize distressed neighborhoods (i.e., the place-based approach) or improve the quality of life of low-income households by moving them to high-opportunity neighborhoods (i.e., the people-based approach) [27]. An increase in the diffusion and clustering of green buildings is associated with positive spillover effects on neighboring buildings, thus reducing the risk of investment in LIHTC developments, improving neighborhood characteristics, and encouraging further sustainability [28]. As social justice advocates increasingly demand the siting of low-income housing beyond central cities, improved building quality could make developments more acceptable to the host suburban communities. Recent studies suggest that LIHTC units are increasingly located in suburban areas with poverty rates of less than 10 percent [29].

At the building level, there is empirical evidence that green building codes and standards bring a range of co-benefits, such as energy and water efficiency, improved health, safety, productivity, and indoor environmental quality, that significantly reduce the total cost of living throughout the building life-cycle [30,31]. Life-cycle thinking is particularly consistent with the finance of LIHTC developments, and empirical evidence suggests green LIHTC units can be more cost-effective than non-green units for stakeholders and the society as a whole in the long term [32,33].

Despite large benefits, affordable housing and green building have positive externalities, meaning multiple factors can lead to underinvestment in these goods in the free market – e.g., split incentives, information asymmetries, risk aversion, skill shortages, and analytical failures – thus government intervention is required for efficient distribution [34–36]. Using hedonic modeling of construction costs, rents, and occupancy rates, previous research on the economic performance of green buildings suggests that building to green standards can increase upfront costs but generate sufficient savings that benefit the owners within an acceptable payback period [37–39]. Although benefits of green building for the society as a whole are often larger than the average cost premium to obtain green building certifications, residential developers demand significant price premiums that are likely to affect affordability [36]. For instance, researchers have often reported up to 10% sales price premiums associated with single-family units with green building certifications in US cities [40,41]. Therefore, LIHTC legislation demanding sustainable construction features like on-site renewable energy generation should include considerations such as higher levels of LIHTC subsidy or other financing mechanisms to preserve affordability. Empirical studies suggest that financing initiatives have as high as 100% impact on the adoption of green building technologies in the residential sector [42]. Therefore, short-term and long-term effects of green building on affordability require careful assessment and several methods to examine such trade-offs are introduced in the literature [25,43]. In practice, motivated LIHTC-allocating agencies have prioritized developers that go beyond the minimum set by building codes to conform to internal or third-party green building standards [44]. For instance, nearly 100% of recently approved LIHTC projects in Virginia have pursued EarthCraft, a local green building rating system.

2.2. *Models of policy innovation*

There is a rich body of scholarship describing mechanisms involved in the adoption and diffusion of innovative state policies as well as complementary structures and characteristics, which can help describe the development of innovative policies like green building in the context of the LIHTC program [45]. State policy innovation is often explained as the acquisition of policies or programs from others that are new to the state adopting them but are not necessarily altogether new ideas. Mohr (1969) broadly defines the policy innovation mechanism as "the function of an interaction among the motivation to innovate, the strength of obstacles against innovation, and the availability of resources for overcoming such obstacles" [46]. Policy innovation researchers argue that as a result of having access to resources and information, public officials should take the initiative to recognize and deploy the utility of innovative policies and programs, whether or not such utilities are expressed wants of the ordinary citizens. This moral standpoint, which describes the significance of policy innovation literature, reflects the idea of market failure in economics – defined as the situation in which goods and services are inefficiently distributed in the free market.

Empirical models developed in the state policy innovation literature can help explain drivers of subnational environmental initiatives, including green building, sustainable development, and climate change [47]. Studies of policy innovation have explored innovation-driving forces to explain why some state or local governments adopt policies or programs while others do not. Major classic models of policy innovation that describe causal processes involved in the adoption of innovative policies include the internal determinants model, the regional diffusion model, and the national interaction model. The first model identifies the internal characteristics of states (e.g., population, income, political orientation) as driving forces of innovation [48]. The second model depicts innovation clusters in which leading-edge states regularly function as regional trendsetters spreading new policies to follower states that are searching for solutions to potentially controversial or complicated issues. The spread of innovation might take place through imitation, emulation, competition, or other mechanisms [49,50]. The third model attributes policy innovation to free interactions between officials from leading-edge and follower states within a national network of communications [51].

These classic models have inspired numerous empirical studies on policymaking. Nonetheless, more recent studies have started to criticize presumptions of single-explanation models, contending that such models do not have the required breadth to independently identify the causes of policy innovation. Some researchers, for instance, argue that government officials' interactions are complex and more selective than what the national interaction model suggests, and causal factors could be understood only if new studies integrate internal and regional diffusion determinants into a single discrete event history analysis [52,53]. Contending the diffusion of innovation does not necessarily depend on geographical proximity, researchers criticize geographic proximity models for failing to account for the role of communication networks, overlapping media, and common attributes of proximate states [45]. Some other researchers question the significance of early adoption – the focal point of the classic policy innovation scholarship - arguing that other considerations like the level of dedication and policy re-invention, could place late adopters in a superior position in solving local problems compared to earlier adopters [54]. There are also studies referring to specification issues and flaws in history analysis models regularly employed in empirical studies [53,55]. Highlighting the role of historical evolution, process innovation, and institutions, more recent theoretical works on innovation follows more comprehensive and interdisciplinary approaches to innovation, thus augmenting earlier diffusion theories in policy studies [56–58]. Despite recent critiques, the early models of innovation remain essential to the literature on environmental policy innovation.

Policy innovation literature does not necessarily expand on complexities involved in decision-making by individuals in organizations, i.e., how decision-making happens within organizations [59]. Organizational economists and theorists help fill this gap by explaining various characteristics of organizations (e.g., birth, functioning, dynamics, progress, and impacts) and variables underlying decision-making (e.g., organizational culture, network structures, framing, and incentives) [60]. Of particular relevance to understanding drivers of policy innovation at the level of organizations are the notions of bounded rationality, optimization versus heuristics (i.e., finding the best solution to the problem versus relying on intuition, habit, or rules of thumb when resources are limited) and human systems properties (e.g., limited certainty, limited predictability, indeterminate causality, and evolutionary change) [61–65]. The next section describes the development of hypotheses of an empirical model informed by a set of internal and regional correlates to explore policy innovation in LIHTC.

3. Methodology:

3.1. Development of hypotheses

This article's hypotheses examine the impact of internal characteristics of states and the horizontal diffusion of policy from neighboring states in the regions on the innovativeness of LIHTC-allocating agencies. The adapted model reflects Mohr's conceptualization of policy innovation as the sum of motivation to innovate, the strength of obstacles against innovation, and the availability of resources for overcoming the obstacles. Motivation has two different dictionary definitions: a) enthusiasm for doing something, and b) the need or reason for doing something [66]. Mohr argues that activism and ideology are both important indicators of the motivation of organizations to innovate. According to Mohr, activism is represented by "the … officer's perception of the extent to which the role of … officer requires interaction with others … to obtain ideas, support, approval, and resources for departmental programs." and ideology is represented by "the … officer's opinion regarding the scope of services that should properly be offered by the local public … agency in non-traditional … program areas." [46]. Resources, according to Mohr, are "not only money and skills to overcome obstacles of expense, but also resources such as a position of authority, a charismatic effect, the support of prestigious individuals and self-confidence to overcome obstacles presented in terms of human forces." [46] Therefore, resources and obstacles that impact innovation can take a variety of forms, e.g., economic, environmental, political, and societal.

Hypothesis (1): There is a positive correlation between the availability of economic resources and the innovativeness of LIHTC-allocating agencies. The successful adoption, maintenance, and development of green building criteria in the long term require financial resources to cover direct and indirect program evaluation and implementation expenses, and states with high rates of debt are less likely to take such initiatives. Obstacles like dependency on traditional construction methods and resistance to change should be surmounted. Where carbon-intensive industries constitute a substantial portion of the state economy, opposition group demand (e.g., lobbying from manufacturing and extractive industries) and general pro-industry sentiments may constrain policy innovation. Therefore, the authors adopt GDP per capita and the rate of state sales tax to represent economic resources and intergovernmental revenue and value-added by manufacturing to represent economic obstacles affecting innovativeness [47].

Hypothesis (2): There is a positive correlation between the availability of environmental resources and the innovativeness of LIHTC-allocating agencies. In geographical areas where the abundance of natural resources facilitate the supply of renewable energy (e.g., wind, solar, geothermal, or biomass) or the high number of degree days increase residential energy demand, stringent energy-efficiency requirements result in more savings in the long term. Urbanizing economies with a high concentration of population often have a high demand for energy use, high concentration of urban pollution, and high density to advance efficient transit services, mixed land-use, smart growth, and transit-oriented development, which all align well with green building requirements [23,67]. On the contrary, in areas where energy generation has historically relied on the presence of ample fossil fuel resources, there could be obstacles to promoting clean energy infrastructure. Also, policymakers are likely to divert resources to immediate- rather than long-term environmental policy solutions in states that experience frequent extreme climatic events and natural disasters. The authors adopt degree days of heating and population density to represent environmental resources and disaster frequency and fossil fuel reliance to represent obstacles affecting innovativeness.

Hypothesis (3): There is a positive correlation between the availability of political resources and the innovativeness of LIHTC-allocating agencies. The presence of environmental attitudes and ideologies among state policymakers could increase motivations to promote green building in LIHTC developments [68]. Besides, supportive environmental and/or climate standards, energy codes, and advanced building regulations and incentives can promote innovation in LIHTC or, at least, increase the baseline LIHTC development requirements [69]. Policy innovation in LIHTC is likely to accelerate in regional policy innovation clusters where state agencies are motivated to remain competitive with their neighbors and receive resources in the form of information, training, and expertise [70,71]. The authors adopt the state government ideology index to represent motivation for innovation, green building in neighboring states to represent regional effects, and the frequency of energy and building incentives and regulations to represent policy resources affecting innovativeness.

Hypothesis (4): There is a positive correlation between the availability of societal resources and the innovativeness of LIHTC-allocating agencies. Since the supply of LIHTC units results from a synthesis of the public sector and private sector actions, market demand – and therefore policymakers' resources – for improved green practices is likely to grow in urbanized states where highly educated citizens with high skills and environmentalist awareness and attitudes reside [72]. Those communities are also more likely to be willing to pay higher upfront costs of building to green codes compared to less educated communities. The authors adopt the percentage of the population living in urban areas, workers holding post-professional degrees in the workforce, and the age of housing stock to represent societal resources affecting innovativeness.

3.2. Dependent and independent variables

Global Green is an organization that "works to create green cities, neighborhoods, affordable housing, and schools to protect environmental health, improve livability, and support our planet's natural systems; to address climate change and create resilient and sustainable communities" [73]. Since 2006, Global Green has published reports and national performance rankings of state LIHTC QAPs on an annual basis (except for 2011) and invited all state housing agencies to review the reports and include any comments or further information before the final scores are released (Table A1). The organization assigns yearly scores to all QAPs based on a 45-point scale composed of the four components of energy efficiency, smart growth, resource conservation, and health protection (Table 1). The final QAP score represents the total number of green building points that states use to help prioritize projects to allocate tax credits.

Table.1. QAP scoring structure and scores achieved by 50 states during the 7-year period (2010, 2012-2017)

Component	Mean	S.D.	Min	Max	Component	Mean	S.D.	Min	Max
Energy Efficiency					*Resource Conservation*				
Energy Codes	1.59	0.79	0	2	Construction & Demolition Recycling	0.47	0.50	0	1
Energy Star Homes	1.77	1.48	0	3	Maintenance Free Standard	0.74	0.44	0	1
Energy Star Appliances	1.77	0.61	0	2	Preserve Existing Flora	0.46	0.50	0	1
HVAC Performance	1.79	0.56	0	2	Recycled Content Materials	0.45	0.50	0	1
Insulation Standards	0.86	0.34	0	1	Renewable Materials	0.32	0.47	0	1
Photovoltaics (PV)	0.47	0.50	0	1	Reused Materials	0.39	0.49	0	1
Specified Efficient Products	0.95	0.22	0	1	Stormwater Protection	0.57	0.50	0	1
Total Energy Efficiency	9.20	2.61	0	12	Water Conservation	3.62	1.73	0	5
					Total Resource Conservation	7.01	3.55	0	12
Smart Growth					*Health Protection*				
Adaptive Reuse	0.85	0.36	0	1	Carpet Quality	0.59	0.49	0	1
Brownfields Redevelopment	0.32	0.47	0	1	Environmental Assessment	0.82	0.38	0	1
Floodplain Preservation	0.69	0.46	0	1	Formaldehyde Free	0.52	0.50	0	1
Habitat Preservation	0.46	0.50	0	1	Hazard Abatement	2.30	1.79	0	5
Proximity to Public Transit	0.85	0.35	0	1	Hazard Proximity	0.66	0.47	0	1
Proximity to Services	0.87	0.33	0	1	Paint Quality	0.65	0.48	0	1
Rehabilitate Existing Housing	1.00	0.05	0	1	Ventilation Quality	0.78	0.42	0	1
Revitalization Plans	0.98	0.14	0	1	Total Health Protection	6.31	2.94	0	11
Urban Infill	0.56	0.50	0	1					
Wetland Preservation	0.62	0.49	0	1					
Total Smart Growth	7.12	2.08	1	10					

The main dependent variable to measure policy innovation among LIHTC-allocating agencies is QAP score, which is the sum of green building criteria. Besides, the authors develop models to explain scores in each of the four green building components. Table 2 describes the independent variables of interest as well as operationalization methods and the sources of the applied database. The authors chose these variables based on their relevance to the hypotheses, a systematic review of the literature on policy adoption [8], and the availability of historic data for the seven-year study period. Since Global Green did not collect QAP data in 2011, the analysis covers the year 2010 plus the 2012-16 timeframe. The regression models include the control variables of income, population, and time.

Table.2. Description of independent variables

Constructs and variables	Type[1]	Definition	Source
Economic characteristics			
GDP per capita	(r)	GDP per capita in 1,000 USD in 2017:Q4 dollars	US BEA
Intergovernmental revenue	(o)	Ratio of revenue from federal government to general revenue in percentage	US Census ACS-1
Manufacturing value added	(o)	Percentage of state GDP that is manufacturing GDP	US BEA
Sales tax	(r)	State general sales tax in percentage	Tax Policy Center
Unemployment rate	(r)	Percentage of unemployed population in the workforce	US Census
Environmental characteristics			
Degree days of heating	(r)	Heating degree days weighted by population in 100 degrees	US NOAA
Density	(r)	Population per square mile state area	US Census ACS-1
Disaster frequency	(o)	Number of federal disaster declarations by state	FEMA
Fossil fuel reliance	(o)	Electricity generated from natural gas in MCF per capita	US DOE
Political characteristics			
Energy code status	(r)	Status of state energy code based on 1-8 ordinal score	US DOE
Government ideology[4]	(m)	State government ideology index. Higher scores are more liberal.	R. Fording
Neighbors' score[2]	(r)	The average QAP score for green building in neighboring states	Global Green
RE incentive policy[3]	(r)	Number of state-wide renewable energy incentives	DSIRE
RE portfolio standard	(r)	Presence of Renewable Energy Portfolio Standard (RPS)	DSIRE
RE regulatory policy	(r)	Number of state-wide renewable energy regulatory policies	DSIRE
Societal characteristics			
Higher education	(r)	Percentage of population holding master's or Ph.D. degrees in the workforce	US Census ACS-1
Housing stock built year	(r)	Median year house was built	US Census ACS-1
Urbanization	(r)	Percentage of urban population	US Census ACS-1
Control variables			
Median household income		Median household income in 1,000 USD	US Census ACS-1
Total population		Total population in 1M persons	US Census ACS-1
Time		Year	

Notes:

1- Motivations (m), obstacles (o), resources (r). For example, gross domestic product is titled as a resource because when its quantity is larger, it implies that more resources are available for policy innovation. Intergovernmental revenue is titled as an obstacle because when its quantity is larger, it implies that the government is largely in debt and faces obstacles.

2- Policy diffusion in a region is often explained by the public choice / economic competition (m) theory or the social learning theory (r) [49].

3- For a concise review and synthesis of the literature on regulatory policies and energy incentives see Ref. [68]

4- Compared to other frequently used measures suitable for cross-sectional single-state studies (e.g., the share of liberal candidate vote in an election) the citizen and government ideology data provided by Robert Fording capture temporal and geographical variations [74].

3.3. Statistical analysis

The authors use multivariate regression analysis with year-specific fixed effects to describe the correlates of policy innovation, assuming that ordinary least-squares regression analysis is an admissible estimate. Based on the maximum number of independent variables (13) included in the current analysis, a priori power analysis using G*Power 3.1.9.4 suggests that a minimum sample size of 218 is required to detect the effect size (f^2) of 0.05 (where 0.15 and 0.02 are f^2 conventions for medium and small effect sizes) with a statistical power of 0.95 at an alpha level of 0.05 [75].

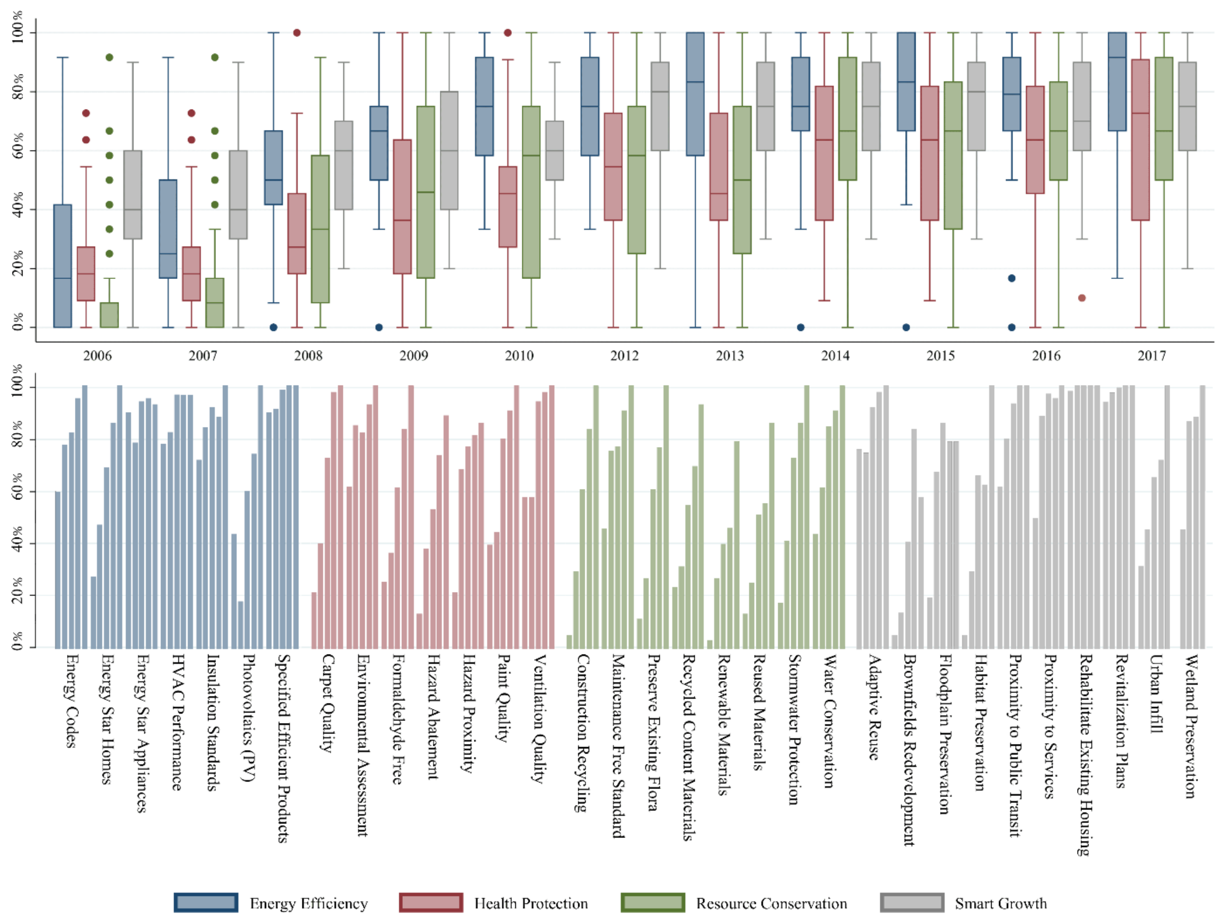
The current analysis – performed in Stata 14.0 of StataCorp LLC – is based on data from all the 50 US states in 7 years. Therefore, the primary sample size is 350, except in the models for which data for the states of Alaska and Hawaii are not applicable, where the sample size is reduced to 336. A Shapiro–Wilk test and standardized normal probability plot is applied to inspect the normal distribution of QAP score and residuals, and Breusch-Pagan / Cook-Weisberg test is used to ensure that heteroskedasticity levels are not significant. To prioritize the independent variables for inclusion in the final regression analysis and to avoid overfitting, the authors rely on the magnitude of Pearson correlation coefficient and statistical significance. To prevent multicollinearity, the use of highly correlated variables in regression models is avoided based on the assumption that the presence of zero-order Pearson coefficients above 0.80 (e.g., between education and income) denotes multicollinearity [76]. The authors use robust standard errors to reduce heteroskedasticity and use Variance Inflation Factors (VIFs) to control multicollinearity in regression models. US Census estimates are at the state level; thus, error margins are negligible when assessed against the coefficient of variation.

4. Results:

4.1.Description of green building criteria in QAPs

Figure 1 (top) presents a box plot of QAP scores achieved by the green building component since the first year in which data collection started. Corresponding to Table 1, the Y-axes represent the scores achieved as the percentage of the maximum score available for each component (top) or construction option (bottom). The level of initiative state housing agencies take toward green building in LIHTC varies considerably, particularly in resource conservation and health protection. The energy efficiency component has the highest total score, followed by smart growth, resource conservation, and health protection. There is also a notable upward trend in the median scores of all four categories. Table A1 ranks the state housing agencies based on mean QAP scores achieved from 2006-17 and categorizes them into role model, strongly committed, committed, moderately committed, and weakly committed (i.e., least innovative) housing agencies [77]. The role model states, namely, Massachusetts and Connecticut, achieved mean scores above two standard errors from the mean of all states. Strongly committed states achieved scores between one and two standard errors above the mean and so on. Figure 1 (bottom) compares mean scores role model, strongly committed, committed, moderately committed, and weakly committed housing agencies achieved within each component as the percentage of the total score available.

Figure.1. Top: box plot of QAP scores achieved by component. Bottom: mean score achieved by the role model, strongly committed, committed, moderately committed, and weakly committed state housing agencies within each component.



4.2. Roles of motivation, resources, and obstacles in innovation

Table 3 introduces the summary of the dataset. The primary dependent variable, QAP score, is reported in the original scoring format, but the secondary dependent variables (component scores) are transformed to the percentage of the maximum score available for each component for consistency. The right-most column contains the uncontrolled Pearson correlation coefficients, suggesting that most dependent variables have statistically significant correlations with QAP score. Among the economic correlates, there is a moderate (± 0.30 and ± 0.49) correlation between GDP per capita (i.e., the per capita total value of produced goods and provided services in a state in a year) and adoption of green building criteria (R=0.317). Among the environmental correlates, QAP score is moderately correlated with degree days and population density. Also, QAP score is significantly correlated with all the political and societal independent variables.

Table.3. Descriptive statistics (n = 350)

	Type	Mean	SD	Minimum	Maximum	Correlation w/ QAP
Green building						
QAP Score	Contin.	29.65	9.18	5.00	45.00	
Energy Efficiency	Contin.	76.64	21.75	0	100	
Health Protection	Contin.	57.35	26.71	0	100	
Resource Conservation	Contin.	58.43	29.61	0	100	
Smart Growth	Contin.	71.23	20.77	10	100	
Economic characteristics						
GDP per capita	Contin.	53.04	10.60	32.49	82.49	0.317***
Intergovernmental revenue	Percent.	33.56	5.71	17.33	50.69	-0.191***
Manufacturing value added	Percent.	11.96	5.65	1.83	29.89	-0.115
Sales tax	Percent.	5.07	1.98	0.00	8.25	0.156***
Unemployment rate	Percent.	7.04	2.31	2.60	15.10	-0.141***
Environmental characteristics						
Degree days of heating (n = 336)	Contin.	49.56	19.97	3.41	98.45	0.302***
Density	Contin.	167.76	205.38	1.07	1032.40	0.412***
Disaster frequency	Contin.	2.00	2.82	0.00	31.00	-0.034
Fossil fuel reliance	Contin.	11.36	11.96	0.01	81.13	-0.100*
Political characteristics						
Energy code status	Contin.	4.44	2.20	1.00	8.00	0.281***
Government ideology	Contin.	42.40	17.53	17.51	73.62	0.355***
Neighbor's score (n = 336)	Contin.	34.57	6.08	17.00	47.33	0.419***
RE incentive policy	Contin.	5.12	4.23	0	24	0.256***
RE portfolio standard	Binary	0.55	0.50	0	1	0.374***
RE regulatory policy	Contin.	4.47	1.89	0	9	0.321***
Societal characteristics						
Higher education	Percent.	9.05	2.26	5.16	16.41	0.476***
Housing stock built year	Contin.	1976.43	8.23	1955	1994	-0.337***
Urbanization	Percent.	73.58	14.44	38.66	94.95	0.178***
Control variables						
Median household income	Contin.	54.58	9.50	36.85	80.78	0.351***
Total population	Contin.	6.35	7.07	0.56	39.54	0.035
Year	Binary	0.1667	0.373	0	1	0.210***

*** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Table 4 presents regression analyses based on the block-wise forward selection method controlling for state population, household income, and time fixed effects. The authors develop four partial- and one full regression models for the primary dependent variable. These models describe the sample after 8 data points are removed as outliers after a visual inspection of the initial regression's residuals. These data points represent states and years in which the greatest radical changes occur to QAPs (including GA 2010, NJ 2013, OH 2013, TX 2014, TX 2015, TX 2016, WI 2016, and WI 2017). Robust standard errors ("vce (robust)" in Stata) are utilized to make the inferences valid despite minor levels of heteroskedasticity. Only independent variables that are statistically significant and describe greater amounts of variance in the dependent variable are included in the full model. All independent variables included in the full model are statistically significant (at $p < 0.05$) and corroborate Mohr's motivation-resource-obstacle hypothesis. The effect sizes (i.e., partial degrees of associations) of independent variables in all models are indicated by the Omega squared statistic ("estat esize, omega" in Stata) in the two right-most columns in Table 4. As expected, the availability of economic resources – represented by sales tax revenue ($\omega^2 = 5.4\%$) and GDP per capita ($\omega^2 = 3.5\%$) – is significantly correlated with the adoption of green building criteria in LIHTC and, to some extent, explain the total variability in QAP score. Each one percent increase in state sales tax (resource) is associated with 0.85 unit (1.89%) increase in QAP score. Environmental characteristics that increase the utility of improved building practices, such as heating degree days ($\omega^2 = 4.3\%$) and density ($\omega^2 = 3.5\%$), appear to create significant resources for policy innovation in LIHTC. Each one hundred degrees increase in heating degree days is associated with 0.12 unit (0.27%) increase in QAP score. There is also significant evidence of the impact of existing legislation, such as renewable portfolio standards ($\omega^2 = 8.1\%$) and horizontal diffusion resulting from communication with innovative neighbors ($\omega^2 = 3.0\%$). Government ideology (i.e., motivation) explains a small percentage ($\omega^2 = 1.9\%$) of the total variability of QAP score among all the variables in the full model. Lastly, the age of housing stock is inversely related to QAP score and explains 1.8 percent of the total variability. The effect sizes of individual dependent variables are small, but together, the full model (Model 5) explains 54.6 percent of the total variability of green building criteria in QAPs.

Table.4. OLS regression and effect size analysis of QAP score

	Model 1		Model 2		Model 3		Model 4		Model 5		
	Economy		Environment		Policy		Society		Full model		
	Coef.	R.S.E.	Coef.	R.S.E.	Coef.	R.S.E.	Coef.	R.S.E.	Coef.	R.S.E.	ω^2
Economic characteristics											
GDP per capita	0.209***	0.074							0.200***	0.048	0.035
Int.gov. revenue	0.088	0.100									
Manufacturing value added	0.046	0.066									
Sales tax	1.205***	0.246							0.853***	0.165	0.054
Unemployment rate	0.289	0.306									
Environmental characteristics											
Degree days of heating			0.144***	0.023					0.119***	0.028	0.043
Density			0.014***	0.002					0.011***	0.003	0.035
Disaster frequency			-0.052	0.142							
Fossil fuel reliance			0.001	0.027							
Political characteristics											
Government ideology									0.066**	0.027	0.019
Energy code status					0.155	0.201					
Neighbor's score					0.327***	0.067			0.220***	0.072	0.030
RE incentive policy					-0.057	0.315					
RE portfolio standard					4.566***	1.004			4.320***	0.873	0.081
RE regulatory policy					0.004	0.249					
Societal characteristics											
Higher education							1.342***	0.333			
Housing stock built year							-0.257***	0.051	0.178***	0.059	0.018
Urbanization							0.027	0.036			
Control variables											
Median household income	0.224***	0.086	0.166**	0.069	0.281***	0.058	-0.017	0.087	-0.098	0.079	0.000
Total population	-0.050**	0.061	0.130**	0.051	-0.057**	0.054	0.016	0.049	-0.001	0.056	0.000
Year	0.625**	0.279	0.911***	0.180	0.582**	0.160	0.819***	0.187	0.944***	0.167	0.072
Constant	-1263.239	563.921	-1823.557	360.469	-1171.302	321.237	-1126.011	359.574	-2251.234	354.819	
Observations	342		328		328		342		328		
R-squared	0.244		0.442		0.458		0.319		0.546		
Root MSE	7.685		6.343		6.258		7.273		5.760		

*** p < 0.01 ** p < 0.05 * p < 0.10

Table 5 is a breakdown of the full model based on three of the four green building components. Since 2010, most housing agencies have received high scores with low variability on the energy efficiency component (Mean = 76.64, SD = 21.75). Therefore, the model does not explain much of the variability of the energy efficiency score data around its mean ($R^2_{EE} = 0.262$) and is removed from this analysis. It appears from Table 5 that resource conservation criteria have been adopted to large extent where liberal governments and environmentally active neighbor states exist. Conversely, resource conservation has gained far less priority than health protection and smart growth components in the presence of manufacturing industries and growing economies. Each one percent growth in manufacturing value-added is associated with 0.54 percent decline in the adoption of resource conservation criteria.

Table.5. OLS regression and effect size analysis of components

	Health Protection			Resource Conservation			Smart Growth		
	Coef.	R.S.E.	ω^2	Coef.	R.S.E.	ω^2	Coef.	R.S.E.	ω^2
Economic characteristics									
GDP per capita	0.543***	0.175	0.022	0.206	0.183	0.000	0.679***	0.122	0.051
Manufacturing value added	-0.349	0.228	0.005	-0.540**	0.236	0.013	0.211	0.177	0.001
Sales tax	2.354***	0.663	0.036	0.719	0.642	0.000	1.297***	0.467	0.014
Unemployment rate	3.943***	0.976	0.042	0.529	1.104	0.000	1.587*	0.845	0.007
Environmental characteristics									
Degree days of heating	0.434***	0.101	0.047	0.410***	0.114	0.036	0.235**	0.091	0.018
Density	0.027***	0.009	0.018	0.020**	0.009	0.007	0.016**	0.008	0.007
Political characteristics									
Government ideology	0.019	0.087	0.000	0.338***	0.093	0.039	0.064	0.079	0.000
Neighbor's score	0.028	0.214	0.000	0.818***	0.259	0.031	0.350*	0.195	0.007
RE portfolio standard	13.057***	2.792	0.064	10.434***	3.366	0.035	9.612***	2.507	0.049
Societal characteristics									
Housing stock built year	0.220	0.205	0.000	0.338	0.213	0.003	0.062	0.205	0.000
Control variables									
Median household income	-0.065	0.275	0.000	-0.221	0.290	0.000	-0.404*	0.214	0.007
Total population	-0.247	0.176	0.001	0.561**	0.231	0.017	-0.424**	0.169	0.015
Year	5.484	0.786	0.110	3.885***	0.891	0.050	2.572***	0.727	0.035
Constant	-11513.330	1584.575		-8505.623	1811.865		-5295.062	1526.580	
Observations	328			328			328		
R-squared	0.467			0.482			0.371		
Root MSE	19.057			20.464			16.127		

*** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

5. Discussion and conclusion

5.1. Main findings and comparison with previous research

From 2006-2010, LIHTC-allocating agencies increasingly incorporated green building criteria into QAPs. Adoption momentum has decreased since 2010 but is still on a slight upward trajectory. Energy efficiency criteria have had the highest rates of adoption, followed by smart growth, resource conservation, and health protection criteria. Even less innovative or weakly-committed agencies, have scored high on the inclusion of energy efficiency criteria (e.g., energy-efficient products, energy star appliances, and energy-efficient HVAC) and some smart growth criteria (e.g., rehabilitation, revitalization, adaptive reuse) which suggests that most decisionmakers have, to some extent, recognized co-benefits associated with these criteria (e.g., immediate financial savings for low-income occupants, air-pollution impacts, technological innovation, reduced fuel cost, and employment possibilities). Even though green building components have become mainstream in the industry, health protection (e.g., carpet quality, paint quality, ventilation quality) and resource conservation (e.g., recycled content materials, stormwater protection, water conservation) have received less attention as project selection criteria. During the last two decades, building product companies have developed and supplied environmentally friendly materials, such as no-VOC paints, recycled content or low-toxic ingredients, waterless urinals, dual-flush toilets, green roofs, etc. The cost of green components has decreased because of an increased availability of green products, technological advances, federal and state subsidies, integrated design-build practices, training of the professional workforce, etc. Nonetheless, the adoption of green building in low-income housing developments is still in its infancy, and there are obstacles to policy innovation besides the ones included in the regression models.

In general, the results are consistent with previous research on green building adoption [78]. As reflected in Table 3 and 4, the results suggest that the role model (i.e., most innovative) LIHTC-allocating agencies have more motivation and resources than weakly-committed states to adopt and commercialize green building policies and technologies. The authors accept the four hypotheses examined since positive and statistically significant relationships exist between policy innovation and the presence of economic resources (represented by sales tax and GDP per capita), environmental resources (represented by heating degree days and population density), political resources (represented by the presence of innovative agencies in the region and supportive environmental standards), and societal resources (represented by the presence of highly educated workforce and newly built housing stock). Based on the uncontrolled Pearson correlation, QAP score is significantly correlated with all the chosen political and societal independent variables. The full model suggests mandates to increase the production of energy from renewable resources, i.e., Renewable Portfolio Standards (RPS), are more important to policy innovation than baseline building codes, incentives, and regulations, which – if adopted alone – may not successfully address such sizeable problems as climate change or dependence on fossil fuel [68]. Besides, the absence of supportive regulation, even in areas where renewable resources of energy like high solar radiation are present, can result in the underutilization of natural endowments [79].

5.2.Limitations, future research, and policy recommendations

The independent variables employed in the regression models collectively explain up to ~ 55 percent of the variance in the dependent variable, which raises the question about what other factors should be included in the model to explain the remaining variance. The adoption of green building criteria has varied significantly across states and, in several cases, changed radically within state over time, whereas the independent variables have not changed as much. Some states have adopted limited criteria to make them more attainable, and some others seem to have adopted them as an efficient instrument for short terms until state-wide standards have evolved [73]. Some states (e.g., Kentucky, Missouri, and Wisconsin) that scored high on green building criteria at the outset relinquished green construction options (Table A1). Anticipating the development of strict state-specific standards, some states dropped third-party certification requirements. In some other states, meeting HERS ratings was mandated as a substitution for certification programs and decreased the QAP score [73]. Texas, Florida, and some other states pursued a different path by abandoning sub-components at the start and re-adopting them in the following years. These organization-level decisions affect the linear trajectory of policy adoption and, thus, reduce the predictability of future outcomes from state-level data. According to previous research on social and psychological barriers to green building, policymaking has not always followed pure rationality in LIHTC too. Rather, individual-, organization-, and industry-level factors seem to be involved in driving sub-optimal outcomes. The literature on organizations and the natural environment broadly identifies and articulates how such factors affect organizations' interaction with complex social and environmental issues [80]. Institutional barriers, such as adherence to rigid building codes and standards, standard operating procedures, and unquestioned biases, that impede rationality, innovativeness, and responses to societal interests regarding complex social and environmental problems are very common in the construction industry and should be accounted for in future research on policy innovation [81].

The current study shows that the change in the environmental performance of LIHTC units has been slow and unsteady in coming, and factors that are external to housing agencies – such as state economy, environment, policy, regional effect, and pressure from the society – provide partial explanations regarding the adoption of green building practices. Future research can follow two lines of research. First, to explore how role model housing agencies like Massachusetts and Connecticut overcome organizational inertia, approach environmental problems, and set strategies for action [82]. Second, to pursue life-cycle cost and benefit analyses of green building components accounting for all measurable co-benefits involved across LIHTC projects' lifespan to maximize the integration of social and environmental concerns into LIHTC developments without foregoing financial viability. Previous research on the role of organizational culture and subculture suggests that the adoption of new practices is easier when framed as a positive and attractive option [83]. This line of research should account for the increased availability of green products, technological advances, federal and state subsidies, integrated design-build practices, and professional workforce, and determine what is needed to close the gap towards net-zero energy. Data-driven analyses showing a long-term reduction in development expenses can motivate LIHTC-allocating agencies to demand higher environmental performance from developers.

The current study shows that supportive state-wide legislation like renewable energy portfolio standards and the presence of innovative agencies in the region can help LIHTC-allocating agencies overcome obstacles to innovation in the LIHTC context. Therefore, it is recommended that LIHTC-allocating agencies cooperate with inter- and intrastate organizations and professional networks to exchange information, training, and expertise in innovative housing policy solutions. It is also recommended that agencies create and maintain effective partnerships with third-party green building rating systems. Meeting long-term environmental and climatic goals in the context of LIHTC requires planned evolutionary change based on data-driven strategies and life-cycle analyses towards zero net energy consumption. Reducing frequent changes to green building requirements would increase transparency, predictability, and the development of long-term contracting and financing solutions. Exercising performance-based rather than prescriptive regulation can help reduce development costs.

5.3.Conclusion

This article explored residential policy innovation in the context of the most significant government-sponsored low-income housing program in the US. Using panel data and information from seven years of collaboration between Global Green and LIHTC-allocating agencies, the authors developed an empirical framework showing interstate variations in green building policy are, to large extent, explained by state-level data of resources, motivations, and obstacles. Significant state-by-state differences in the rate of integration of green building with LIHTC developments persist, which raises the question about how this variation is explained. The results suggest that the determinants influencing the propensity of LIHTC-allocating agencies to require green construction options can include organization-level factors. Using multi-level methods, future policy innovation research should explore factors that impact the utility of policy innovation and barriers the environmental sustainability movement faces at the organization level. QAPs have significant impacts on the location and quality of LIHTC developments and should be used as effective policy tools to drive planned evolutionary change to housing. Buildings represent about 40% of global energy use and 30% of global greenhouse gas emissions, thus provide considerable opportunities for national and subnational governments to promote global environmental sustainability and climate change mitigation [84].

Appendix:

Table.A1. State QAP scores ranked by highest to lowest mean value

	Rank	State	2006	2007	2008	2009	2010	2012	2013	2014	2015	2016	2017	Mean	SD
Role model	1	Massachusetts	33	33	35	38	36	41	45	40	43	41	41	38.73	4.03
	2	Connecticut	6	14	43	45	44	45	45	45	45	45	44	38.27	14.11
Strongly Committed	3	Maryland	25	25	27	38	37	45	45	45	45	39	39	37.27	8.08
	4	Georgia	32	34	33	40	39	34	31	35	35	35	36	34.91	2.70
	5	Pennsylvania	26	26	29	29	27	40	38	40	40	44	43	34.73	7.25
	6	Maine	21	22	32	32	34	33	39	37	37	37	34	32.55	5.92
	7	New Jersey	13	15	32	34	35	38	19	41	41	43	44	32.27	11.38
	8	Minnesota	2	12	19	35	36	36	45	45	45	37	38	31.82	14.41
Committed	9	Washington	3	3	3	39	38	41	44	42	42	42	42	30.82	17.94
	10	New York	5	6	23	35	36	35	34	37	39	40	44	30.36	13.36
	11	Vermont	6	12	26	29	28	39	37	41	39	35	41	30.27	11.82
	12	California	30	28	28	28	30	31	23	30	31	29	40	29.82	4.05
	13	Rhode Island	6	6	11	29	38	36	40	35	36	44	41	29.27	14.44
	14	Nevada	24	23	24	25	27	28	36	34	28	33	35	28.82	4.83
	15	Delaware	6	9	24	26	32	32	33	36	38	40	40	28.73	11.70
	16	Michigan	5	5	27	27	36	34	32	34	35	35	45	28.64	12.63
	17	North Dakota	3	3	28	27	24	27	33	41	39	42	40	27.91	13.87
	18	Arizona	14	16	16	20	22	26	36	35	39	40	33	27.00	9.90
	19	Wyoming	17	17	21	24	18	29	28	37	34	32	38	26.82	7.91
	20	North Carolina	13	13	23	24	24	31	29	34	34	34	33	26.55	7.92
	21	New Hampshire	7	7	19	30	29	31	36	36	29	33	33	26.36	10.61
	22	Illinois	6	6	23	22	30	29	37	32	34	35	35	26.27	11.10
	23	Montana	9	14	29	28	28	29	32	28	29	30	30	26.00	7.35
	24	Iowa	15	15	12	27	31	31	28	33	30	30	33	25.91	7.89
	25	Indiana	17	18	21	27	29	28	28	31	31	26	28	25.82	4.92
	26	Colorado	8	8	8	14	35	33	19	34	34	41	45	25.36	14.16
	27	West Virginia	8	8	14	16	23	18	40	39	37	37	36	25.09	12.90
Moderately Committed	28	Ohio	6	9	13	16	15	35	6	41	44	43	45	24.82	16.56
	29	Alabama	19	20	21	20	21	23	19	25	23	28	32	22.82	4.09
	30	Kentucky	5	7	16	24	24	31	35	26	32	28	23	22.82	9.77
	31	Louisiana	10	15	14	27	26	21	22	23	22	32	34	22.36	7.37
	32	Kansas	13	17	19	21	20	23	26	29	25	24	28	22.27	4.84
	33	South Dakota	11	11	17	19	20	23	23	32	28	30	30	22.18	7.39
	34	New Mexico	8	15	20	23	25	26	27	15	28	29	24	21.82	6.62
	35	Arkansas	14	18	21	21	23	22	23	21	25	28	22	21.64	3.59
	36	Idaho	5	5	6	19	24	24	25	32	33	30	32	21.36	11.14
	37	South Carolina	13	13	16	18	15	23	24	29	23	27	31	21.09	6.44
	38	Utah	12	12	13	14	15	18	19	40	35	21	21	20.00	9.33
	39	Florida	4	4	19	19	20	28	17	25	27	25	28	19.64	8.65
	40	Oregon	7	7	21	6	22	25	14	26	26	31	31	19.64	9.55
	41	Texas	12	12	22	31	29	30	26	9	6	6	31	19.45	10.49
	42	Missouri	15	15	19	21	23	22	25	17	19	16	20	19.27	3.32
	43	Nebraska	2	2	26	14	14	19	29	27	23	26	26	18.91	9.77
Weakly Committed	44	Hawaii			4	19	19	27	28	11	28	11	13	17.78	8.67
	45	Virginia	10	10	12	12	22	21	17	19	22	22	20	17.00	5.02
	46	Mississippi	7	9	15	11	14	17	16	21	20	24	23	16.09	5.61
	47	Tennessee	4	5	7	11	13	15	16	21	20	27	27	15.09	8.09
	48	Wisconsin	5	5	4	14	15	20	22	35	16	5	9	13.64	9.55
	49	Alaska	6	6	10	8	17	12	16	14	16	14	13	12.00	3.97
	50	Oklahoma	6	6	12	12	11	13	13	19	12	12	15	11.91	3.65
		Mean	11.31	12.67	19.54	23.76	25.86	28.36	28.44	31.08	30.84	30.76	32.18		
		SD	7.94	7.70	8.65	8.91	8.13	7.97	9.65	9.16	9.07	9.87	9.23		

References:

1. USDOE Use of energy in the United States Available online: https://www.eia.gov/energyexplained/index.php?page=us_energy_use (accessed on Jul 28, 2019).
2. Glaeser, E.L.; Gyourko, J. The impact of building restrictions on housing affordability. *Econ. Policy Rev.* **2003**, *9*.
3. JCHS *The State of the Nation's Housing 2019*; Harvard University: Harvard Joint Center for Housing Studies, 2019;
4. Adelle, C.; Russel, D. Climate policy integration: a case of déjà vu? *Environ. Policy Gov.* **2013**, *23*, 1–12.
5. Jordan, A.; Lenschow, A. Environmental policy integration: a state of the art review. *Environ. Policy Gov.* **2010**, *20*, 147–158.
6. Pearce, A.R.; DuBose, J.R.; Bosch, S.J. Green Building Policy Options for the Public Sector. *J. Green Build.* **2007**, *2*, 156–174, doi:10.3992/jgb.2.1.156.
7. USGBC What is green building? | U.S. Green Building Council Available online: https://www.usgbc.org/articles/what-green-building (accessed on Jul 28, 2019).
8. Yeganeh, A.J.; McCoy, A.P.; Schenk, T. Determinants of climate change policy adoption: A meta-analysis. *Urban Clim.* **2020**, *31*, 100547, doi:10.1016/j.uclim.2019.100547.
9. HUD Low-Income Housing Tax Credits Available online: https://www.huduser.gov/portal/datasets/lihtc.html (accessed on Sep 4, 2019).
10. HUD LIHTC Database Access Available online: https://lihtc.huduser.gov/ (accessed on Apr 15, 2020).
11. Novogradac About the LIHTC Available online: https://www.novoco.com/resource-centers/affordable-housing-tax-credits/lihtc-basics/about-lihtc (accessed on Apr 13, 2020).
12. McClure, K. What should be the future of the Low-Income Housing Tax Credit program? *Hous. Policy Debate* **2019**, *29*, 65–81.
13. Ellen, I.G.; Horn, K.; Kuai, Y.; Pazuniak, R.; Williams, M.D. *Effect of QAP Incentives on the Location of LIHTC Properties*; Economic Systems Inc.: Falls Church, VA, 2015;
14. Zhao, D.; McCoy, A.P.; Agee, P.; Mo, Y.; Reichard, G.; Paige, F. Time effects of green buildings on energy use for low-income households: A longitudinal study in the United States. *Sustain. Cities Soc.* **2018**, *40*, 559–568.
15. Briassoulis, H. *Policy integration for complex environmental problems: the example of Mediterranean desertification*; Routledge, 2017;
16. Kivimaa, P.; Mickwitz, P. The challenge of greening technologies—Environmental policy integration in Finnish technology policies. *Res. Policy* **2006**, *35*, 729–744.
17. Runhaar, H.; Driessen, P.; Uittenbroek, C. Towards a Systematic Framework for the Analysis of Environmental Policy Integration. *Environ. Policy Gov.* **2014**, *24*, 233–246, doi:10.1002/eet.1647.
18. Lafferty, W.; Hovden, E. Environmental policy integration: towards an analytical framework. *Environ. Polit.* **2003**, *12*, 1–22.
19. Campbell, S. Green cities, growing cities, just cities?: Urban planning and the contradictions of sustainable development. *J. Am. Plann. Assoc.* **1996**, *62*, 296–312.
20. Wolch, J.R.; Byrne, J.; Newell, J.P. Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough.' *Landsc. Urban Plan.* **2014**, *125*, 234–244.
21. Patterson, J.J.; Thaler, T.; Hoffmann, M.; Hughes, S.; Oels, A.; Chu, E.; Mert, A.; Huitema, D.; Burch, S.; Jordan, A. Political feasibility of 1.5°C societal transformations: the role of social justice. *Curr. Opin. Environ. Sustain.* **2018**, *31*, 1–9, doi:10.1016/j.cosust.2017.11.002.

22. Chegut, A.; Eichholtz, P.; Holtermans, R. Energy efficiency and economic value in affordable housing. *Energy Policy* **2016**, *97*, 39–49.
23. Yeganeh, A.J.; Hall, R.P.; Pearce, A.R.; Hankey, S. A social equity analysis of the US public transportation system based on job accessibility. *J. Transp. Land Use* **2018**, *11*, 1039–1056.
24. Bullard, R.D. *Dumping in Dixie: Race, class, and environmental quality*; Routledge, 2018;
25. Mulliner, E.; Malys, N.; Maliene, V. Comparative analysis of MCDM methods for the assessment of sustainable housing affordability. *Omega* **2016**, *59*, 146–156.
26. HUD Green Building in Low-Income Housing Tax Credit Developments Available online: https://www.huduser.gov/portal/pdredge/pdr_edge_featd_article_061614.html (accessed on May 5, 2020).
27. Davidson, N.M. Reconciling people and place in housing and community development policy. *Geo J Poverty Pol* **2009**, *16*, 1.
28. Chegut, A.; Eichholtz, P.; Kok, N. Supply, demand and the value of green buildings. *Urban Stud.* **2014**, *51*, 22–43.
29. McClure, K. The low-income housing tax credit program goes mainstream and moves to the suburbs. **2006**.
30. Breysse, J.; Jacobs, D.E.; Weber, W.; Dixon, S.; Kawecki, C.; Aceti, S.; Lopez, J. Health outcomes and green renovation of affordable housing. *Public Health Rep.* **2011**, *126*, 64–75.
31. Singh, A.; Syal, M.; Grady, S.C.; Korkmaz, S. Effects of green buildings on employee health and productivity. *Am. J. Public Health* **2010**, *100*, 1665–1668, doi:10.2105/AJPH.2009.180687.
32. Bradshaw, W.; Connelly, E.F.; Cook, M.F.; Goldstein, J.; Pauly, J. The costs and benefits of green affordable housing. *Camb. MA New Ecol.* **2005**.
33. Mueller, E.J.; Tighe, J.R. Making the case for affordable housing: Connecting housing with health and education outcomes. *J. Plan. Lit.* **2007**, *21*, 371–385.
34. Deng, Y.; Wu, J. Economic returns to residential green building investment: The developers' perspective. *Reg. Sci. Urban Econ.* **2014**, *47*, 35–44.
35. Matisoff, D.C.; Noonan, D.S.; Flowers, M.E. Policy monitor—Green buildings: Economics and policies. *Rev. Environ. Econ. Policy* **2016**, *10*, 329–346.
36. Yeganeh, A.J.; McCoy, A.P.; Hankey, S. Green affordable housing: Cost-benefit analysis for zoning incentives. *Sustainability* **2019**, *11*, 1–24.
37. Chegut, A.; Eichholtz, P.; Kok, N. The price of innovation: An analysis of the marginal cost of green buildings. *J. Environ. Econ. Manag.* **2019**, doi:https://doi.org/10.1016/j.jeem.2019.07.003.
38. Matthiessen, L.F.; Morris, P. *Costing Green: A Comprehensive Cost Database and Budgeting Methodology*; Davis Landon Adamson, 2004;
39. Matthiessen, L.F.; Morris, P. *Cost of green revisited: Reexamining the feasibility and cost impact of sustainable design in the light of increased market adoption*; Continental Automated Buildings Association, 2007;
40. Walls, M.; Gerarden, T.; Palmer, K.; Bak, X.F. Is energy efficiency capitalized into home prices? Evidence from three US cities. *J. Environ. Econ. Manag.* **2017**, *82*, 104–124.
41. Kahn, M.E.; Kok, N. The capitalization of green labels in the California housing market. *Reg. Sci. Urban Econ.* **2014**, *47*, 25–34.
42. Hughes, J.E.; Podolefsky, M. Getting green with solar subsidies: evidence from the California solar initiative. *J. Assoc. Environ. Resour. Econ.* **2015**, *2*, 235–275.
43. Fulton, L.; Beauvais, B.; Brooks, M.; Kruse, C.S.; Lee, K. A Publicly Available Cost Simulation of Sustainable Construction Options for Residential Houses. *Sustainability* **2020**, *12*, 2873.
44. Prum, D.A.; Aalberts, R.J.; Del Percio, S. In third parties we trust-the growing antitrust impact of third-party green building certification systems for state and local governments. *J Envtl Litig* **2012**, *27*, 191.

45. Karch, A. Emerging Issues and Future Directions in State Policy Diffusion Research. *State Polit. Policy Q.* **2007**, *7*, 54–80, doi:10.1177/153244000700700104.
46. Mohr, L.B. Determinants of innovation in organizations. *Am. Polit. Sci. Rev.* **1969**, *63*, 111–126.
47. Krause, R.M. Policy Innovation, Intergovernmental Relations, and the Adoption of Climate Protection Initiatives by U.S. Cities. *J. Urban Aff.* **2011**, *33*, 45–60, doi:10.1111/j.1467-9906.2010.00510.x.
48. Walker, J.L. The Diffusion of Innovations among the American States*. *Am. Polit. Sci. Rev.* **1969**, *63*, 880–899, doi:10.1017/S0003055400258644.
49. Boehmke, F.J.; Witmer, R. Disentangling Diffusion: The Effects of Social Learning and Economic Competition on State Policy Innovation and Expansion. *Polit. Res. Q.* **2004**, *57*, 39–51, doi:10.1177/106591290405700104.
50. Mooney, C.Z. Modeling regional effects on state policy diffusion. *Polit. Res. Q.* **2001**, *54*, 103–124.
51. Gray, V. Innovation in the states: A diffusion study. *Am. Polit. Sci. Rev.* **1973**, *67*, 1174–1185.
52. Berry, F.S. Sizing up state policy innovation research. *Policy Stud. J.* **1994**, *22*, 442–456.
53. Berry, F.S.; Berry, W.D. State lottery adoptions as policy innovations: An event history analysis. *Am. Polit. Sci. Rev.* **1990**, *84*, 395–415.
54. Glick, H.R.; Hays, S.P. Innovation and reinvention in state policymaking: Theory and the evolution of living will laws. *J. Polit.* **1991**, *53*, 835–850.
55. Buckley, J.; Westerland, C. Duration dependence, functional form, and corrected standard errors: Improving EHA models of state policy diffusion. *State Polit. Policy Q.* **2004**, *4*, 94–113.
56. Freeman, C. *Technology Policy and Economic Performance: Lesson from Japan*; Pinter: London, 1987;
57. Lundvall, B.-A. National Innovation Systems: Towards a Theory of Innovation and Interactive Learning (London: Pinter). *Lundvall B-AA Borrás S1997 Glob. Learn. Econ. Implic. Innov. Policy TSER Programme DG XII Comm. Eur. Union MacKenzie Podsakoff P2012 Common Method Bias Mark. Causes Mech. Proced. Remedies J. Retail.* **1992**, *88*, 542–555.
58. Nelson, R.R. *National systems of innovation: A comparative study*; Oxford: Oxford university press, 1993;
59. March, J.G. *Primer on decision making: How decisions happen*; Simon and Schuster, 1994;
60. Perrow, C. An organizational analysis of organizational theory. *Contemp. Sociol.* **2000**, *29*, 469–476.
61. Gsottbauer, E.; Van den Bergh, J.C. Environmental policy theory given bounded rationality and other-regarding preferences. *Environ. Resour. Econ.* **2011**, *49*, 263–304.
62. Hjorth, P.; Bagheri, A. Navigating towards sustainable development: A system dynamics approach. *Futures* **2006**, *38*, 74–92, doi:10.1016/j.futures.2005.04.005.
63. Marsden, G.; Frick, K.T.; May, A.D.; Deakin, E. Bounded rationality in policy learning amongst cities: lessons from the transport sector. *Environ. Plan. A* **2012**, *44*, 905–920.
64. Nelson, K.L. Municipal choices during a recession: Bounded rationality and innovation. *State Local Gov. Rev.* **2012**, *44*, 44S–63S.
65. Gigerenzer, G.E.; Hertwig, R.E.; Pachur, T.E. *Heuristics: The foundations of adaptive behavior.*; Oxford University Press, 2011;
66. Cambridge English Dictionary Motivation definition in the Cambridge English Dictionary Available online: https://dictionary.cambridge.org/us/dictionary/english/motivation (accessed on Apr 20, 2020).
67. Ewing, R.; Cervero, R. Travel and the built environment: A meta-analysis. *J. Am. Plann. Assoc.* **2010**, *76*, 265–294.
68. Carley, S. The era of state energy policy innovation: A review of policy instruments. *Rev. Policy Res.* **2011**, *28*, 265–294.

69. Shipan, C.R.; Volden, C. Bottom-Up Federalism: The Diffusion of Antismoking Policies from U.S. Cities to States. *Am. J. Polit. Sci.* **2006**, *50*, 825–843, doi:10.1111/j.1540-5907.2006.00218.x.
70. Bushnell, J.; Peterman, C.; Wolfram, C. *Local solutions to global problems: Policy choice and regulatory jurisdiction*; National Bureau of Economic Research, 2007;
71. Kahn, M.E.; Vaughn, R.K. Green market geography: The spatial clustering of hybrid vehicles and LEED registered buildings. *BE J. Econ. Anal. Policy* **2009**, *9*.
72. Kahn, M.E.; Morris, E.A. Walking the Walk: The Association Between Community Environmentalism and Green Travel Behavior. *J. Am. Plann. Assoc.* **2009**, *75*, 389–405, doi:10.1080/01944360903082290.
73. Global Green QAP Reports — Global Green Available online: https://www.globalgreen.org/blog/m8fd4swjex4cj28xp7rxtahjt5zbg4 (accessed on May 13, 2019).
74. Berry, W.D.; Ringquist, E.J.; Fording, R.C.; Hanson, R.L. Measuring citizen and government ideology in the American states, 1960–93. **1998**.
75. Faul, F.; Erdfelder, E.; Buchner, A.; Lang, A.-G. Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behav. Res. Methods* **2009**, *41*, 1149–1160, doi:10.3758/BRM.41.4.1149.
76. Gujarati, D.N. *Basic econometrics*; Tata McGraw-Hill Education, 2009;
77. Rogers, E.M. *Diffusion of innovations*; Simon and Schuster, 2010;
78. Fuerst, F.; Kontokosta, C.; McAllister, P. Determinants of green building adoption. *Environ. Plan. B Plan. Des.* **2014**, *41*, 551–570.
79. Zahran, S.; Brody, S.D.; Vedlitz, A.; Lacy, M.G.; Schelly, C.L. Greening local energy: explaining the geographic distribution of household solar energy use in the United States. *J. Am. Plann. Assoc.* **2008**, *74*, 419–434.
80. Etzion, D. Research on Organizations and the Natural Environment, 1992-Present: A Review. *J. Manag.* **2007**, *33*, 637–664, doi:10.1177/0149206307302553.
81. Hoffman, A.J.; Henn, R. Overcoming the social and psychological barriers to green building. *Organ. Environ.* **2008**, *21*, 390–419.
82. Kaplan, S.; Henderson, R. Inertia and incentives: Bridging organizational economics and organizational theory. *Organ. Sci.* **2005**, *16*, 509–521.
83. Howard-Grenville, J.A. Inside the "Black Box": How Organizational Culture and Subcultures Inform Interpretations and Actions on Environmental Issues. *Organ. Environ.* **2006**, *19*, 46–73, doi:10.1177/1086026605285739.
84. Edenhofer, O. *Climate change 2014: mitigation of climate change*; Cambridge University Press, 2015; Vol. 3;.