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Behavioral Responses of Green Builders to Discontinuous Certification Schemes

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Author´s address:

Ayse Tugba Atasoy
Institute for Future Energy Consumer Needs and Behavior (FCN)
School of Business and Economics / E.ON Energy Research Center
RWTH Aachen University
Mathieustrasse 10
52074 Aachen, Germany
E-Mail: TAtasoy@eonerc.rwth-aachen.de

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Chair of Energy Economics and Management
Director, Institute for Future Energy Consumer Needs and Behavior (FCN)
E.ON Energy Research Center (E.ON ERC)
RWTH Aachen University
Mathieustrasse 10, 52074 Aachen, Germany
Phone: +49 (0) 241-80 49820
Fax: +49 (0) 241-80 49829
Web: www.eonerc.rwth-aachen.de/fcn
E-mail: post_fcn@eonerc.rwth-aachen.de

Behavioral Responses of Green Builders to Discontinuous Certification Schemes[*]

Ayse Tugba Atasoy[†]

Institute for Future Energy Consumer Needs and Behavior (FCN), School of Business
and Economics / E.ON Energy Research Center, RWTH Aachen University,
Mathieustrasse 10, 52074 Aachen, Germany

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Comments are very welcome!

Abstract

I study behavioral responses to the green building certification system by the Leadership in Energy and Environmental Design program (LEED). LEED provides four different certification levels ('Certified', 'Silver', 'Gold', and 'Platinum') that are all defined by a threshold. Using micro data on LEED-certified buildings, I document intense bunching of buildings at or slightly above the different cutoffs. This finding is robust to different specifications, observed for different versions of LEED as well as for a comparable building certification system from the UK (the Building Research Establishment Environmental Assessment Method). Using the methods from the public finance literature, which studies bunching responses to 'kinks' and 'notches' in tax systems (e.g., Chetty et al., 2011; Kleven and Waseem, 2013), I quantify the bunching mass at the threshold. Using cross-sectional variation in bunching across different states of the US, I find a significant negative relationship between the bunching estimators and energy prices.

JEL-Classification: H23, Q48, D62
Keywords: Labels, Green Buildings, Energy Efficiency, Notches, Bunching

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[†] Email: TAtasoy@eonerc.rwth-aachen.de.

1 Introduction

The building sector today has a large carbon footprint, being nearly the largest contributor to worldwide greenhouse gas emissions, with approximately one-third of global end-use energy taking place within buildings. Predictions suggest, that the construction and operation of buildings account for about 40% of US energy consumption and almost three-fourth of US electricity consumption in 2014.[1] Governments have started to put a stronger emphasis on climate change mitigation by setting future targets to reduce overall energy demand in the economy via increasing energy efficiency. As the building sector is a significant contributor to greenhouse gas emissions, abatement strategies have to carefully consider the implications of various policy instruments and tools. Governments devote, on the other hand, substantial amount of public resources to research and development to further energy efficient technologies. However, energy efficiency does not only depend on technological advancement, but also considerably on the choice of the user. More inclusive research that brings the behavioral perspective into the discussion[2] is therefore crucial. Analyzing individual responses specifically adapted to different policy attributes is of high importance for the effective policy design, as policy attributes and regulations aimed at correcting externality-related market failures may have unexpected secondary effects.

This paper studies the role of green building certification systems in governing energy efficiency in the building sector. Green building certification systems – such as that provided by the US' Leadership in Energy and Environmental Design (LEED) program or the British Building Research Establishment Environmental Assessment Method (BREEAM) – certify the energy efficiency class of buildings. Hence, similar to labels and product certificates in other domains, these systems are based on given cutoffs that define eligibility for a given discrete classification, as a function of a continuous underlying metric(s) (e.g., energy consumption). The cutoffs imply that marginal changes in the underlying product characteristics – in this case, the energy consumption of a building – may trigger a discrete change in the achieved classification. As long as the demand side values 'higher' certification levels for a given set of underlying characteristics, there exists an incentive to provide buildings that are just above a certification cutoff.

Recent evidence from consumer markets suggests that consumers do indeed value certificates and energy labels (Collins and Curtis, 2016; Houde, 2014a,b; Hyland et al., 2016). Houde (2014a,b) analyzes demand-side responses to the ENERGY STAR certification program, where in the appliance market, producers supply products that bunch just at the certification requirement and charge a price premium for certified models. Influenced by an earlier version of the present paper, Hyland et al. (2016) focus on the energy performance certificates in the Irish property market. By using a hedonic price model, they report a significant effect of Building Energy Rating (BER) labels on property prices, meaning the energy efficient properties transact at a higher price premium. Looking into the case of Irish residential homes, Collins and Curtis (2016) consider responses to thresholds in the BER scheme by exploiting a grant aid scheme program carried out to incentivize residential home retrofits. Homes participated in this in-

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[1] See, EIA World Energy Outlook 2013 and EIA Annual Energy Outlook 2014.

[2] Recently, governments pay closer attention to enclose insights from a behavioral perspective. The UK government for instance, has formed a behavioral insight team that also works in a close manner on energy related issues. Following the 'Social and Behavioral Sciences Team' of the US, also the German Chancellery has formed since 2015 an interdisciplinary team 'Wirksam Regieren' to apply empirical evidence from behavioral economics to public policy making.

centive scheme have been required to assure BER assessments before and after the retrofitting. They find strong evidence of bunching after the retrofitting, however no evidence of it prior to its performance.

In fact, consumers seem to devote significant attention to salient, discrete product classifications rather than the continuous product characteristics. In turn, producers strategically respond by developing products that just pass the cutoffs of a label or a certification system (Comerford et al., 2016; Houde, 2014a; Ito and Sallee, 2014; Matisoff et al., 2016; Sallee, 2014). An instance is the US Gas Guzzler Tax, which levies an excise tax on passenger cars that have fuel economy below a certain threshold (Sallee and Slemrod, 2012). Explicitly, 'car notches' in this framework are the small trigger points in the numerical values of fuel economy (i.e., the difference between 22.5 miles-per-gallon MPG and 22.4 MPG) that lead to large changes in tax liability or the amount of a subsidy. [3] Sallee and Slemrod (2012) provide evidence that the automobile manufacturers respond strategically to these notches and adjust automobile production to be situated at the policy favored side of the threshold.[4] Similarly, Ito and Sallee (2014) argue that the secondary attribute-basing in the case of Japanese fuel-economy regulations, under which the fuel-economy targets are downward-sloping step functions of vehicle weight, wherein the larger or heavier vehicles are allowed to meet lower standards, creates perverse incentives. Comerford et al. (2016) employs a natural experimental approach focusing on the energy performance certificate of residential homes in the UK by investigating responses in bunching before and after a letter-grade building rating scheme is introduced. This approach allows them to isolate the bunching responses potentially attributed to the label. While they find strong evidence of bunching just at the certification cut-off after the introduction of the scheme, they find no evidence of an excess mass at the threshold values prior to its implementation. While most of these studies focus on the European building market, Matisoff et al. (2016) provide evidence, similar to the present study, by the LEED program. Their study points to an opposite trend in the building market, in which while the market is becoming 'greener' the portion of non-performance signal diminishes. They further report spatial clustering of firms, which are just at or above the threshold and suggest evidence of spatial correlation in 'green signaling' behavior for the higher certification tiers. Looking into differences across building types, they propose evidence of higher competitive pressure in government buildings, for which the role of political, regulatory environment could play a stronger role. The present paper contributes to this literature by studying supply-side responses to certificates in the building market.

This study corroborates the existing evidence on strategic responses to notched policies and specifically to the ones in the green building market. In addition to providing bunching evidence, I explore a market that is – in terms of investment scale and 'sophistication' of the demand side – fundamentally different from the consumer markets previously studied in the literature. Further, by exploiting the cross-sectional variation across US states, I distinguish bunching responses to certification system from different margins. In doing so, I find that bunching estimates are higher across states that observe low energy prices and lower across those facing higher energy prices. Finally, this work distinguishes itself from the more prominent economic literature concerning

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[3] With the US Gas Guzzler Tax, a car with a 14.5 MPG rating is subject to a $4,500 tax, whereas a car with a 14.4 MPG (up to as low as 13.5) rating is subject to a $5,400 tax. Here a tax increase of $900 is triggered by a decrease of only 0.1 MPG.

[4] In the case of the US Gas Guzzler Tax, however, as the cutoffs for tax incentives overlap with product labels, it is hard to distinguish between tax- and label-based incentives.

green buildings by providing a novel perspective via focusing on rating systems in detail, rather than real estate or financial aspects of green buildings (Brounen and Kok, 2011; Eichholtz et al., 2010, 2013).

I empirically examine the properties of buildings certified by the LEED program, which evaluates buildings and assigns a score from 40 to 100 with a possibility of receiving an additional 10 bonus points beyond 100 for the 'Platinum' certification. The point scheme captures the buildings energy performance as well as other dimensions of sustainability, wherein the certification process consists of six pillars of sustainability: sustainable sites, water efficiency, material and resources, indoor environmental quality, innovative design, and energy performance.[5] A building that passes a given threshold may obtain one of the four distinct certification levels: 'Classified', 'Silver', 'Gold' and 'Platinum'. Working with micro data on 9,845 buildings certified under the LEED program (version 3), I provide a rich set of evidence on bunching at the cutoffs. The distribution of building scores reveals a pronounced concentration of mass at and slightly above each cutoff. At the same time, there are massive 'density holes' to the left of each cutoff. The evidence therefore suggests that the excess mass at the cutoffs comes from building developers who strategically improve their buildings to 'push' the projects from a point range below the cutoff to the next cutoff to reach the next highest certification level. I document results that indicate highly robust evidence of bunching behavior. This is observed both for different versions of LEED, as well as for an alternative building certification system (BREEAM).

I develop a quantification of the observed bunching masss using methods from the public finance literature (that analyze bunching responses to 'kinks' and 'notches' [6] in tax systems, see e.g., Chetty et al., 2011; Kleven and Waseem, 2013; Saez, 2010). Using this method, I find – relative to an estimated, counterfactual distribution – 47 to 500 percent more buildings with a point score at the program's cutoffs for the 'Silver', 'Gold' and 'Platinum' certificate.

Applying this method, I first discuss differences in bunching estimates between different building and owner types. I observe slightly more bunching for commercial as compared to public building projects as well as for privately owned as compared to publicly owned building projects. Next, I exploit cross-sectional variation in the bunching mass across the United States (US) states. I contrast the bunching estimates for the different states with indicators for corruption levels and energy prices. I look into corruption levels as I hypothesize that the behavior of 'exploiting' and 'manipulating' the point scheme changes notably across states, which have a different legislative and institutional setting shaping the compliance behavior with the certification system. Within the US, I do not find any correlations between corruption scores and bunching. Evidence suggests, however, that there is less bunching in states that face higher energy prices. This finding is consistent with two observations (i) related to attention; that higher prices provide possible investors stronger incentives to compare different product characteristics in detail (i.e., details on a buildings' energy efficiency), which in turn diminishes the building developers' incentive to bunch right at the cutoff, (ii) related to the zero price effect; that the intrinsic value of certification increases as the relative price of labelling decreases in the states

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[5] The information on the distinct metrics is not available under the documentations remained by USGBC registry, thus it is not possible to analyze the variations in assignment and assessment of different metrics throughout the phase of a building's certification.

[6] Kink points imply continuous functions with a changing slope of the associated parameter taking place at a specific point, whereas notches allude to discontinuity in the corresponding function with a discrete jump.

that observe low energy prices.[7]

This study makes several contributions to the literature: first, its focus on green building certification systems explores behavioral responses to a threshold-based classification schedule in a distinct framework from the consumer markets studied previously in the literature. One might argue that consumers are more likely to make 'irrational' choices, by attributing too much attention to labels rather than the fine-grained energy efficiency measures, in a market like refrigerators (Houde, 2014a,b). However, for the demand-side in the building market, one might expect more deliberate and well-informed choices, as this market differs significantly from other end-user markets, for example, in terms of investment scale and market participants. If this is the case, the market should focus on the detailed attributes of each building project, rather than merely focusing on the label. The evidence clearly contradicts this conjecture. Second, I distinguish behavioral responses to the certification system along different margins – thus differentiating intended improvements in building properties from other responses (possibly related to corruption). Third, in terms of methods, I demonstrate the usage of tools from the public finance literature to study 'notches' beyond tax schedules. Finally, this analysis distinguishes itself from the studies concerning green buildings by providing a novel perspective via focusing on rating systems and their policy attributes in detail, using methods from public finance literature, rather than concentrating on the real estate or financial aspects of green buildings (Brounen and Kok, 2011; Eichholtz et al., 2010, 2013).

The rest of the paper is organized as follows: Section 2 provides information on the institutional background. Section 3 describes the data used. Section 4 presents the descriptive analysis. Section 5 introduces the bunching estimation method and presents the findings. Section 6 concludes.

2 Institutional Background

2.1 LEED and Different System Versions

LEED is a non-governmental labelling program promoted by the Green Business Certification Institute (GBCI). Since its acceptance in 1999, distinct standards apply to new buildings and existing structures. The requisitions for LEED-certified buildings are relatively complex. The certification process consists of six pillars of sustainability: sustainable sites, water efficiency, material and resources, indoor environmental quality, innovative design, and energy performance.

The LEED program has separate rating systems for different product categories; namely LEED for 'New Constructions', 'Schools', 'Core & Shell', 'Homes', 'Commercial Interiors', 'Existing Buildings: Operations and Maintenance', 'Neighborhood Development', 'New Construction in Retail', 'Healthcare', and 'New Construction and Major Renovations'. For each of these different rating systems, there are four certification levels: certified (standard), silver (better), then gold, and finally platinum. To obtain certification, projects need to achieve a certain number of points. There are differences in the assessment criteria for each category as well as in their rating schemes.

The reason for various LEED categories is the existence of different attributes for a specific project. The classifications are often related to a distinct project type (e.g., Commercial

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[7] That is, contrary to the standard economic theory, when the products become free, individuals perceive the benefits related with these products much higher than they would otherwise do.

Buildings, Retail, Schools, *etc.*). LEED certification systems and schemes have changed and improved over the time of the sample coverage, and therefore manifold rating systems and corresponding system versions are present for all certification categories in the dataset (such as; LEED for Schools v2009, LEED for Retail v2009, LEED New Construction 2.2, and the LEED for Existing Buildings 2.0). The scope of miscellaneous LEED rating systems is as follows:

- LEED v2: refers to projects and rating systems prior to 2009, which has the following points scheme: 26-32 points: Certified, 33-38 points: Silver, 39-52 points: Gold, 52-69 points: Platinum.
- LEED v3 (or referred to as version 2009): applies to the unique schemes that have been introduced for each project category after 2009.
- LEED v4: indicates the most recent LEED rating system, launched in 2013.[8]

Table 1 gives an overview on both v2 and v3 system versions as well as the corresponding rating scheme observed by distinct project categories.

Table 1: LEED Summary System Versions and Point Rating Systems

	Certified	Silver	Gold	Platinum
LEED 2009 System Versions (v3)	40-49	50-59	60-79	80+
LEED for Schools				
LEED Neighborhood Development Stage 1				
LEED Neighborhood Development Stage 2				
LEED Neighborhood Development Stage 3				
LEED-Commercial Interiors Retail v2009				
LEED-Commercial Interiors v2009				
LEED-Core and Shell v2009				
LEED-Existing Buildings: Operations & Maintenance v2009				
LEED-Healthcare v2009				
LEED-New Construction Retail v2009				
LEED-New Construction v2009				
LEED Pre-2009 System Versions (v2)	26-32	33-38	39-51	52-69
LEED-New Construction 2.0				
LEED-New Construction 2.1				
LEED-New Construction 2.2				
LEED for Retail (New Construction) 2.2				

This analysis mainly derives conclusions from the LEED v3 category, which has the following points scheme: 40-49 points: Certified, 50-59 points: Silver, 60-69 points: Gold, 80+ points: Platinum.[9]

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[8] The number of observations in this category is 15 in the dataset. I have extracted the dataset from the USGBC's website on February 25, 2015.

[9] There are 10 extra achievable bonus points beyond 100 points; however, the number of projects that earn points greater than 100 are limited to four observations in the dataset.

2.2 Building Research Establishment Environmental Assessment Method (BREEAM)

Shortly before the development of rating systems for buildings in the US, similar certification systems were adopted in other countries, including BREEAM in the UK, which was established in the beginning of the 1990s. It is one of the most widely disseminated methods for assessing and certifying sustainable buildings. BREEAM has a separate assessment for its ratings compared to LEED. However, like LEED, it also introduces notches, which differ in thresholds and assessment criteria. To receive a specific BREEAM certification, the building has to meet the minimum standards set by the UK's Building Research Establishment (BRE) in various attributes that are similar to that of LEED, which allows for a possible integration of BREEAM scheme into the analysis. There are five certification levels to be awarded within the BREEAM rating system: 30-44%: Pass, 45-54%: Good, 55-69%: Very Good, 70-84%: Excellent, and +85%: Outstanding.

3 Data

The USGBC registry preserves a list of projects, namely LEED-certified buildings.[10] This repeated cross-sectional dataset covers data concerning the characteristics of the projects plus the certification levels. The data further indicate: the owner types, project types, building floor-size, total property area, corresponding certification levels, and registration including certification dates, zip codes, addresses and points achieved by each project. The former version of the data, available from the USGBC, included information on pre-certification, which is only possible to hold under the LEED Core & Shell system version.[11]

I hypothesize that the variation in bunching response is correlated with differences across-states. Hence, I also gather additional data on a rich set of control variables. I measure income by state and year and consider other variables that could influence the distribution of projects. I quantify bunching for different US states and look into how respective bunching measures correlate with energy prices and corruption indices. Hence, I gather monthly data on energy prices (electricity) for each state and year.[12] Further, I compile state-level data on risk of corruption score from the Center for Public Integrity. I also collect monthly data on climatic conditions by measuring heating and cooling degree-days from the US National Weather Service, and the intensity of LEED-related policies fostering green building and energy efficiency by a simple measure of aggregate policies by state and year. Additionally, I make use of the data provided by the UK's Building Research Establishment (BRE) on the BREEAM assessment system.

The dataset includes projects from seven different rating systems (with different thresholds for each LEED certification level) and eight different system versions. The different system versions are namely: LEED for Schools, LEED for Retail, LEED-Commercial Interior, LEED for Construction in Schools, LEED for Existing Buildings, LEED for Healthcare, LEED for New Construction and LEED for Neighborhood Development, in which the building owner can apply

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[10] The registry keeps the list of buildings that are certified. This prevents us from analyzing and/or comparing the projects that are not certified.

[11] It is also possible to switch from old system versions to more recent ones by making an extra application, therefore I kept the dataset recent for the precision (RE-WRITE!).

[12] Energy prices were created using revenue and sales data provided for each utility by the US Energy Information Administration matched to different states.

for a LEED certification, depending on the characteristics of the building and/or the project type.

Table 2: Summary Statistics

Variable	**Mean**	**Std. Dev.**	**N**
Points Earned	57.659	11.476	9845
Certification Year	2012.667	1.142	9844
Registration Year	2010.93	1.343	9844
Total Property Area (in Log)	12.687	0.659	5935
Gross Square Foot (in Log)	12.688	0.672	9836
Time Lag (Certification-Registration)	1.736	1.083	9843
Pre-certification Year	2011	0.820	515
Energy Prices ($ per kWh)	10.528	2.802	5696
State Income ($ in Log)	20.578	0.982	7449
Received Pre-certification (Yes=1)	0.015	0.121	8737
Certified (Yes=1)	0.229	0.42	9845
Silver-Certified (Yes=1)	0.314	0.464	9845
Gold-Certified (Yes=1)	0.38	0.485	9845
Platinum-Certified (Yes=1)	0.077	0.267	9845
Commercial Buildings (Yes=1)	0.724	0.447	9845
Public Buildings (Yes=1)	0.119	0.323	9845
Educational Buildings (Yes=1)	0.072	0.258	9845
Industrial Buildings (Yes=1)	0.028	0.164	9845
Residential Buildings (Yes=1)	0.048	0.214	9845
Privately Owned (Yes=1)	0.504	0.5	7908
Publicly Owned (Yes=1)	0.489	0.5	7908
Profit Organization (Yes=1)	0.501	0.5	7855
Non-Profit Organization (Yes=1)	0.499	0.5	7855
LEED Incentivizing Policies (Count)	4.878	5.568	7485

Rather than focusing on all distinct LEED rating systems, I concentrate mainly on LEED version 3 for two main reasons. First, the number of building projects certified under this LEED category are the most represented in the dataset. Second, the underlying scheme of version 3 facilitates the method I employ for quantifying bunching. That is, after collapsing the data into point bins I still have a substantial number of points between different certification brackets, which allows us to employ the method I use in Section 5.1 for estimating the counterfactual distribution by excluding the ranges around the thresholds. However, I also run the basic bunching estimations for the LEED version 2 projects.

The LEED version 2009 rating system is the most frequently used rating scheme, as previous point schemes have been transformed into this recent rating system v3 and the second rating system has been used specifically for the 'New Construction' projects. The reported data from the USGBC has asymmetries[13] for some of the variables.[14]

Additionally, I use data on building projects certified under the BREEAM program. The

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[13] Some of the minor abnormalities found in the dataset, specifically concerning the points achieved, have been set to missing values. Some points did not belong to the correct rating system of their stated system version; however, the number of such observations is significantly small.

[14] In the dataset, the most recent rating system (v2009) has 9,845 certified projects, for which I observe both the certification level as well as the specific points achieved (See Table 2).

UK Green Building Council retains a record of projects that have been certified. The BREEAM dataset contains little information on the characteristics of the certified buildings. Therefore, I use the BREEAM data only for a descriptive comparison providing evidence as the prominent European counterpart certification system. The dataset keeps a record of nearly 3,500 certified buildings in Europe.

4 Descriptive Analysis

Figure 1 gives the histogram of certified buildings for the most frequently represented rating system LEED v3. The black lines represent the certification cutoffs for different certification brackets. The figure suggests strong descriptive evidence of bunching at each cutoff. For every threshold specified in the scheme, there is a strongly noticeable asymmetry at the vicinity of every cutoff point. The US Green Building Council maintains only a list of projects that are 'certified', consequently it is not possible to observe the projects that fall short of the bottom LEED certification notch.

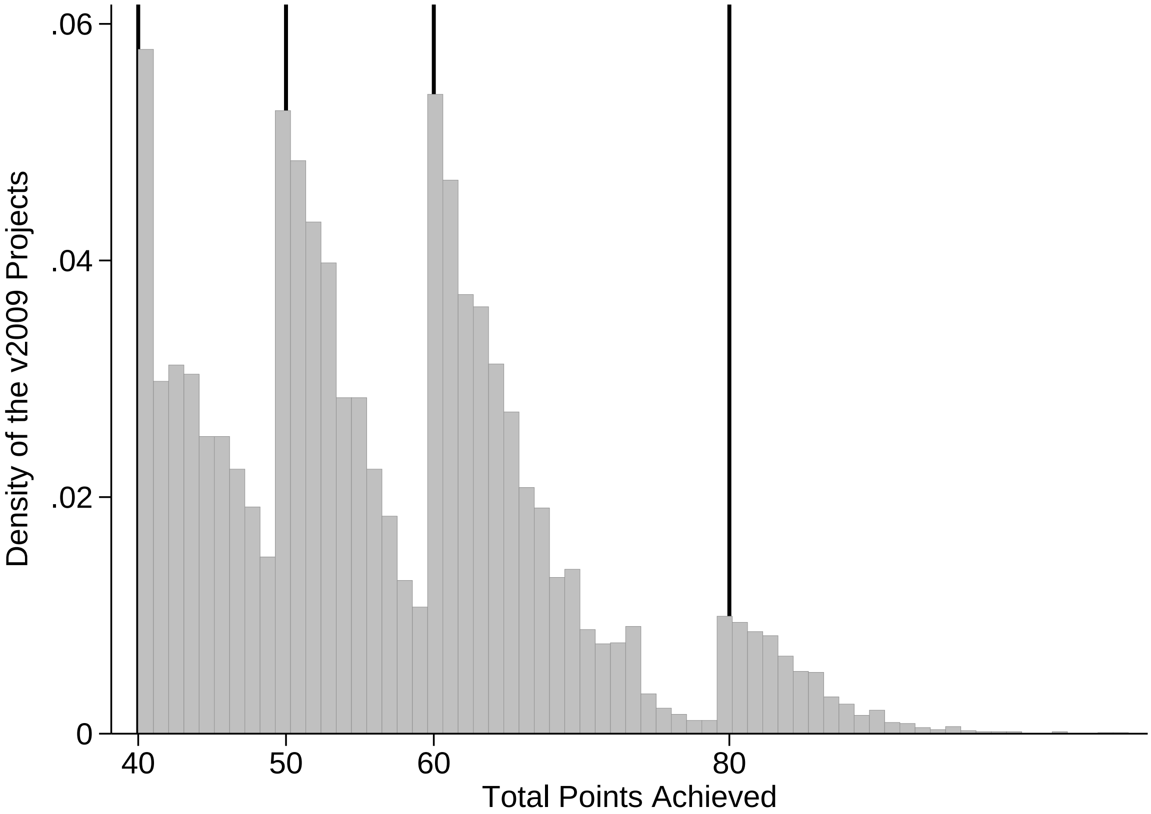
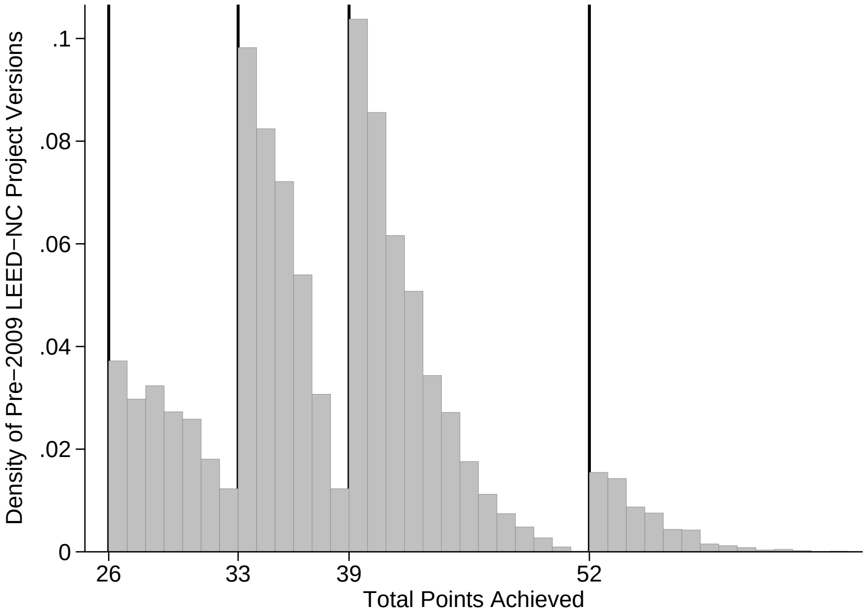
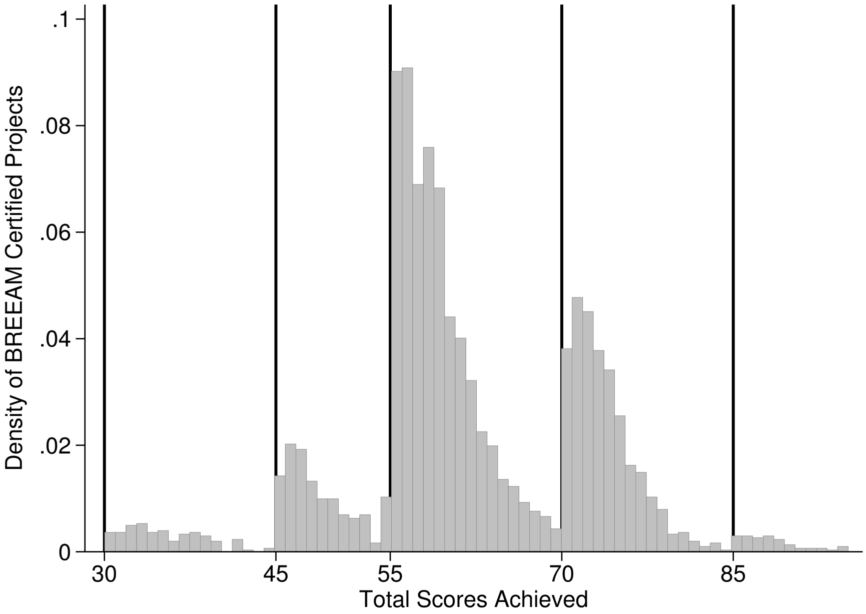


Figure 1: Frequency Distribution of LEED v3 Project Points (N=9,845)

Figure 2 depicts the histograms of certified building projects from the second-most frequent LEED rating system's (v2) scheme, which consists of LEED-New Construction (NC) projects prior to 2009 covering 8,469 projects. The black vertical lines represent the respective threshold points for the v2 scheme. The graphical evidence suggests a similar pattern of response as in Figure 1. Figure 2 further provides the histogram for the BREEAM certified projects, in which the frequency distribution of achieved scores are spiked at the threshold points and decrease thereafter, with the least frequent number of projects falling short before the BREEAM certification notches.



(a) LEED v2 Project Points

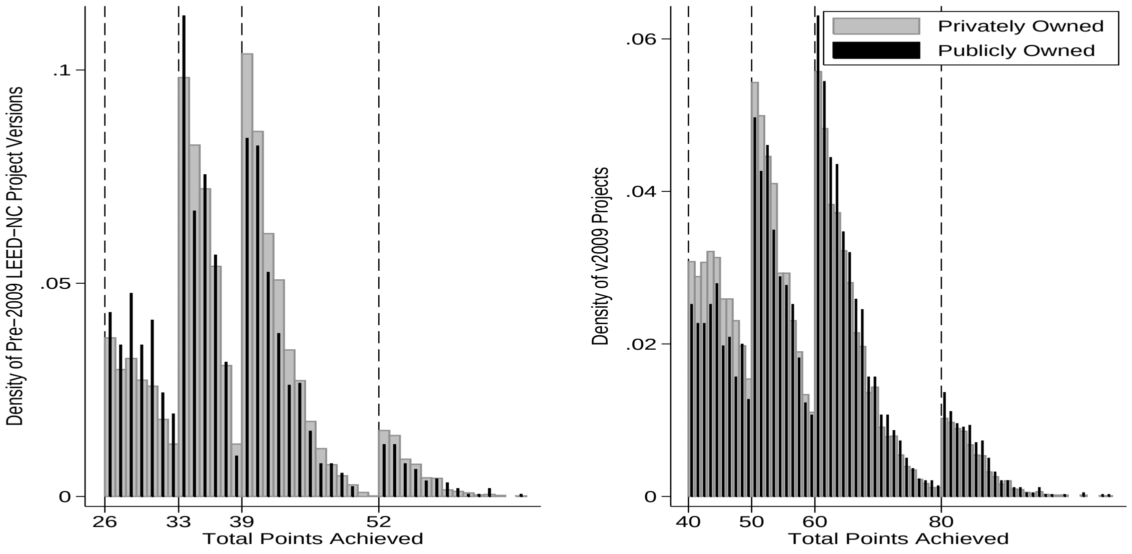


(b) BREEAM Project Points

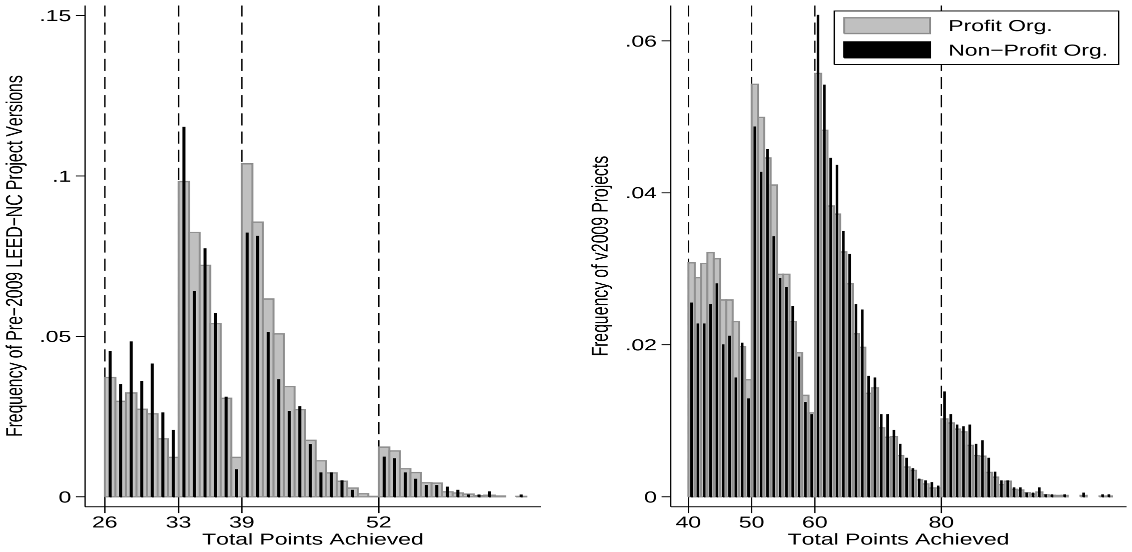
Figure 2: Density Distribution of BREEAM and LEED v2 Projects

4.1 Different Owner and Project Types

The dataset from the USGBC provides information on project types and on types of ownership attached to each project. By recoding the information available, I create new variables for different project and owner types. I categorize the owner types denoted as publicly and privately owned projects, to exploit whether the type of ownership plays a role in bunching response.[15] Different owner or project types do not provide different results graphically on the response pattern. Privately and publicly owned projects follow a similar data pattern under both rating systems.



(a) Privately and Publicly Owned Projects



(b) Profit and Non-Profit Owner Organizations

Figure 3: Owner Types for LEED Pre and 2009 Rating Systems

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[15] Rental status and the type of occupancy (tenancy and/or ownership) might also have an effect on the bunching response; however, this information is not available under the USGBC registry.

However, the pattern is less clear for publicly owned buildings at the ‘certified’ level. This may explain the presence of potentially low key targeting for the least ambitious certification bracket. I also observe similar graphical evidence for the commercial and public buildings. Additionally, I classify the building types into the five following building types: commercial, public, educational, industrial, and residential buildings and re-examine the classification made for the owner types and exploit potential differences driven by the variation in building types. Figure 4 illustrates different types of certified projects and the points they have achieved within the LEED 2009 rating system.[16] Unlike the other project types, industrial buildings have a less noticeable response pattern. This can explain the less vulnerable nature of industry to variation concerning energy-related issues. In contrast, I observe stronger targeting for commercial and government buildings, which can relate to the fact that these building types might be ‘better’ informed about the institutional set-up. Likewise, one can argue that the marketing value of holding a certain certification label might be less important for the industrial buildings category, whereas it may play a role in terms of prestige and signaling environmental concerns in the case of commercial or government buildings. In addition to this, Figure 5 shows that there is more variation at the bottom certification level relative to other certification tiers. This might signal a low key targeting for the least ambitious certification bracket.

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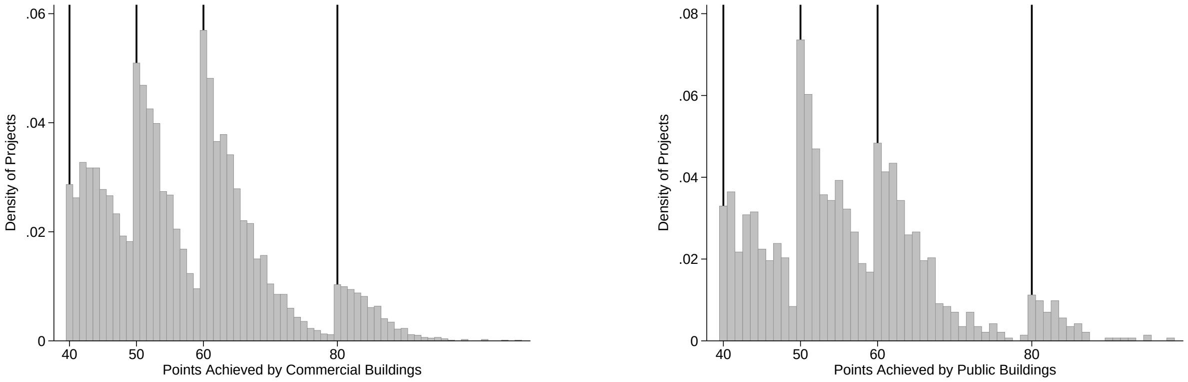
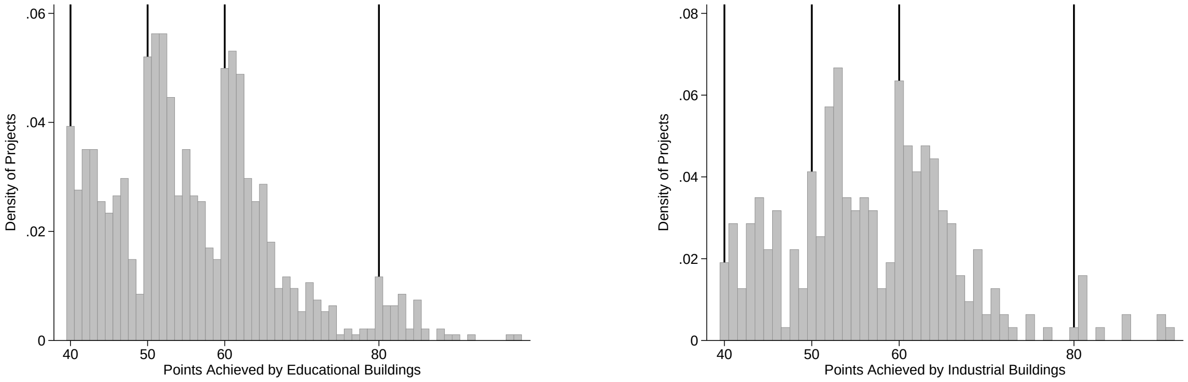
[16] Focusing on 2009 rating system is reasonable, since some of the building types have not been certified under those pre-2009 LEED system versions, namely industrial and residential buildings, and version 2009 is the most frequent rating system in the dataset.



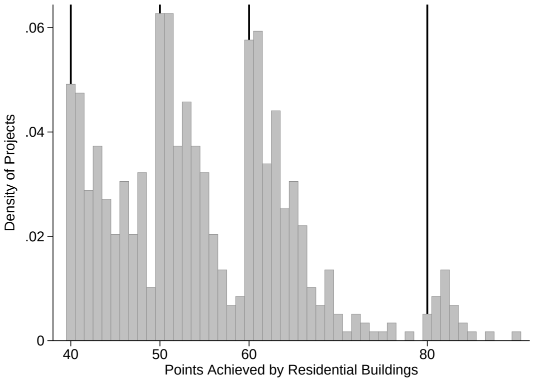
(a) Commercial Buildings (N=7,130)

(b) Public Buildings (N=1,169)



(c) Educational Buildings (N=704)

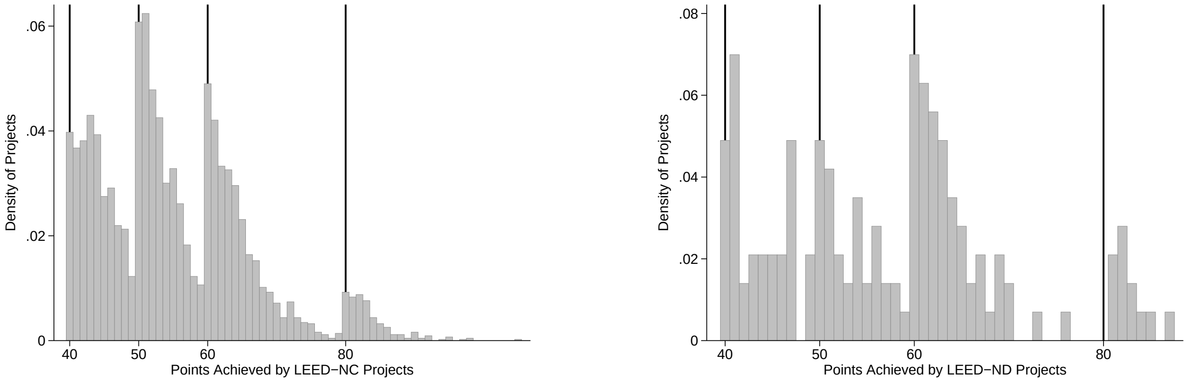
(d) Industrial Buildings (N=271)



(e) Residential Buildings (N=473)

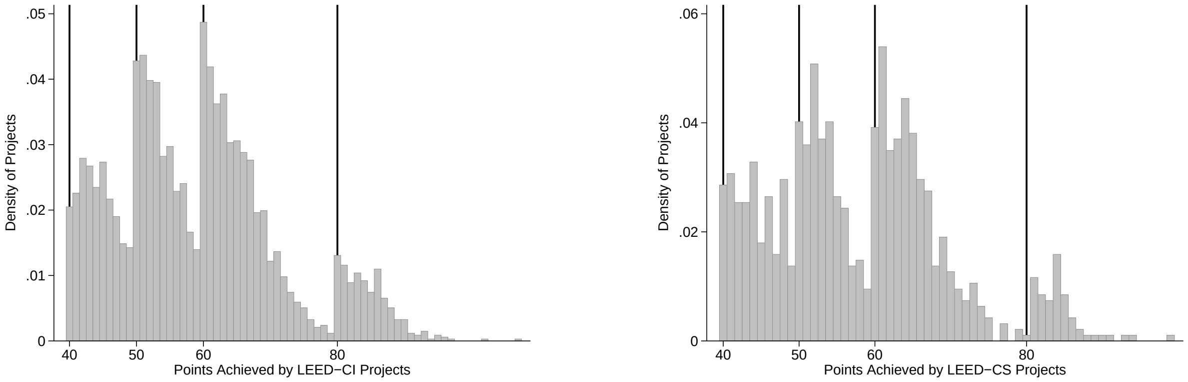
Figure 4: Building Types/LEED v2009

Additionally, Figure 5 looks at the frequency distribution of manifold LEED system versions, certified under the rating system version 3.



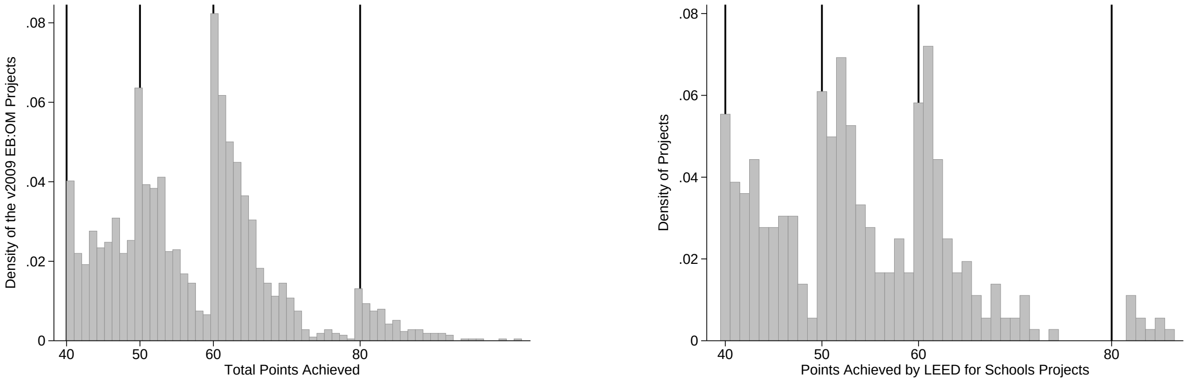
(a) LEED for New Construction (N=3,550)

(b) LEED for Neighborhood Development (N=142)



(c) LEED for Commercial Interiors (N=3,054)

(d) LEED Core & Shell (N=665)



(e) LEED for Existing Buildings: Operations & Maintenance (N=1,996)

(f) LEED for Schools (N=259)

Figure 5: Building Types/LEED v2009

4.2 Pre-certification

An earlier version of the available data from the USGBC has provided information on levels of pre-certification, which allows builders to market the green attributes of their buildings to potential tenants searching for a LEED-certified building to occupy. The projects with pre-certification are not certified, but they are on the path toward a certification. A pre-certification is conducted in the same way as the other certification types; however, no credits are awarded during pre-certification phase.[17] Only the projects that are registered under the LEED for Core & Shell system version can apply for pre-certification. The data include 730 pre-LEED certified buildings. I thus merge that information with the recent data and matched the datasets with the unique identification numbers to also better understand whether pre-certification correlates with bunching response. Figure 6 shows the distribution of pre-LEED certified projects.[18]

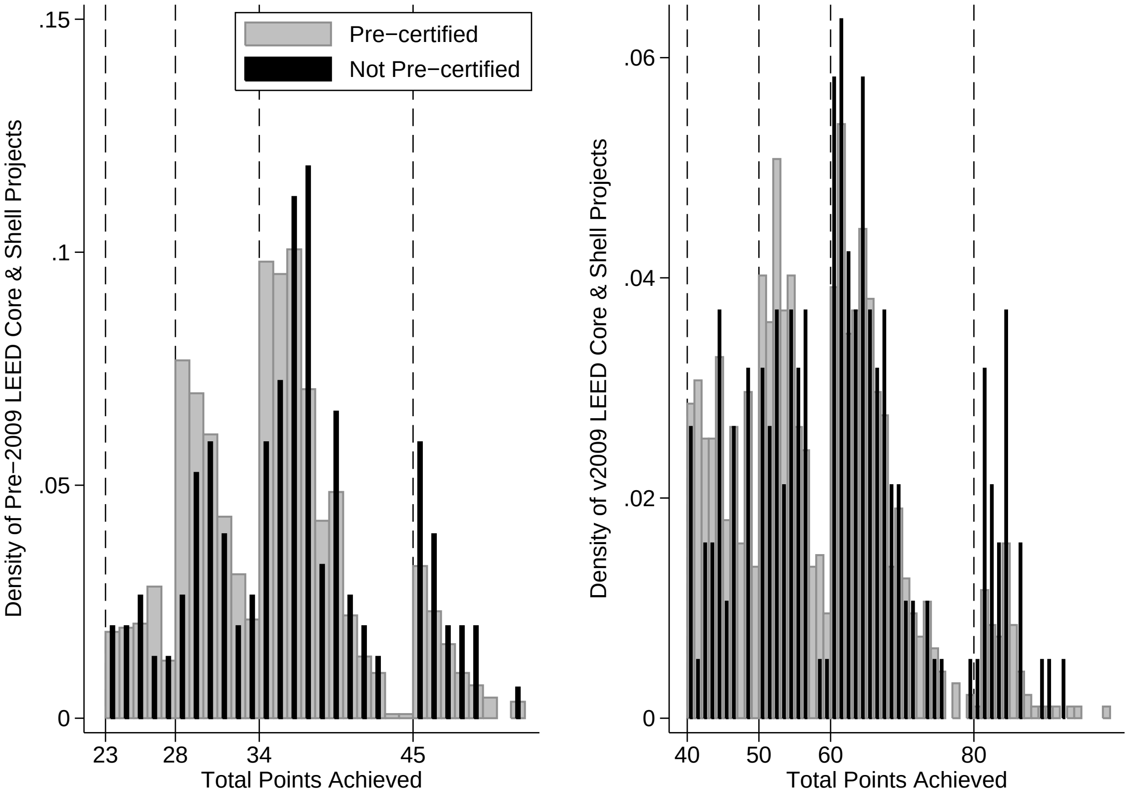


Figure 6: Pre-certified Projects (LEED Core & Shell Rating System)

The graphical evidence suggests that bunching for the pre-certification category slightly differs from those that are not pre-certified. For the case of pre-2009 Core & Shell system version, the pre-certified buildings seem to pile up more pronouncedly than those for buildings that are certified under LEED Core & Shell version 2009.[19] This may explain the small proportion of

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[17] It is possible to obtain a pre-certification uniquely under the Core & Shell program, in which official acceptance is given to project when the owner/developer has established a goal to develop a LEED for Core and Shell building. It is not required nor is it a commitment to achieve certification.

[18] Some of pre-LEED certified projects in Figure 6 have also received LEED-certification after obtaining pre-certification.

[19] By running a simple linear probability regression model (LPM) in the following form: $\text{Bunching}_i = \beta_0 + \beta_1 \text{X}_i + \epsilon_i$ ($\forall\ i = 1, ..., n$), where Bunching_i takes the value of 1 in the presence of building i being certified at or

buildings (around one-fifth) for version 2009 being certified and pre-certified at the same time, whereas nearly all the pre-certified projects are also certified for the pre-2009 Core & Shell system version. This strengthens the argument of strategic targeting at the cutoff points, since during certification the pre-certified buildings are better positioned.

4.3 Time Span between Registration and Certification Dates

The dataset contains information on the registration and certification dates. Considering the general attribute of the LEED labelling program (third party verified) and the evidence on bunching behavior, presumptions regarding the scope for re-targeting or negotiating might be a potential response channel. Intuitively, the ability to make adjustments on the final points received may increase, as the time span between registration and certification becomes lengthier. Conversely, I may observe builders who situate at the threshold point and have a short(er) time span between registration and certification, which potentially refer to fine-tuned pre-targeting.[20]

5 Results

5.1 Estimating the Quantity of Bunching

The graphical evidence indicates strong response across various building projects, which suggests that the builders earn points strategically as to be at the 'more favorable side' of a threshold value.[21] Exploiting the point scheme in this way however might refer to an overvaluation of points that are at or just to the right of a certification threshold value and likewise to an undervaluation of those points that are just below a certification threshold value by developers and certifiers. There must be counterbalancing benefits attributable to having distinct label categories – i.e., either with respect to salience, implementation or administrative costs – contrary to a system with simple reporting of exact number of LEED points projects acquire. An alternative certification design possibility would be to either increase the number of certification tiers and/or to have a scheme, which reports the precise number of points achieved within each project, rather than introducing discretized certification tiers. This raises the question of how the building projects would be distributed if we did not observe the cutoff points in the actual distribution. Hence, I study the counterfactual distribution as if there were no threshold points and quantify the magnitude of bunching I observe in the actual distribution relative to the counterfactual case. There are a few studies, which investigate econometric estimation of excess bunching in notched (or kinked) tax schedules (e.g., Chetty et al., 2011; Kleven and Waseem, 2013; Saez, 2010). I employ an approach similar to these studies from the public finance literature to quantify the magnitude of bunching. Different from this strand of literature however, I do not use the bunching estimator to make structural statements, but rather for making different group and cross-sectional comparisons. In a first step, I estimate the counterfactual distribution

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one point above the threshold and 0 otherwise, pre-certification has a significant (at a 1% level) positive effect on the bunching probability, everything else equal, it increases the probability of bunching by 3%.

[20] Although it might not be orthogonal to the probability of bunching, again the results from a simple LPM indicate that, everything else equal, one year increase between registration and certification decreases the probability of bunching by 2.7%.

[21] Informal qualitative interviews held with LEED consultants, architects, and engineers working either for the certification and/or the standardization has revealed that it is perceived as low performance if the certification project has not been completed near the threshold value.

as if there were no bunching at the threshold points. I begin the analysis by grouping (collapsing) buildings into integer point bins. For each bin j, I indicate the number of buildings in that bin by N_j and the exact point by point(j). I then create dummy variables for different threshold points, denoted by the index function I, for each point $j = k$ for all k in the set κ. By excluding observations at the threshold points and fitting a polynomial of order p to the point bin counts in the actual distribution, I estimate the following regression:

$$N_j = \sum_{i=0}^{p} \beta_i^0 \,\text{point}(j)^i + \sum_{k \in \kappa} \gamma_k \cdot \mathbf{I}[j = k] + \epsilon_j \tag{1}$$

In estimating the above equation, I exclude cutoff points 'slightly above' ($[c_\ell, c_\ell + \delta^u]$) and 'slightly below' ($[c_\ell - \delta^l, c_\ell]$) the threshold points, in which the observations at each cutoff are denoted by c_ℓ. For the analysis, I consider the case, where $\delta^u = \delta^l = \delta$. Based on the β-estimates from equation (1), I then predict an initial proxy for the counterfactual numbers, $\hat{N}_j^0$, as denoted in the following equation:

$$\hat{N}_j^0 = \sum_{i=0}^{p} \hat{\beta}_i^0 \text{point}(j)^i \tag{2}$$

As the prediction from equation (2) excludes the γ coefficients from the equation (1), the bunching measure fails to fulfill the condition that the area under the counterfactual distribution must equal the area under the actual distribution.

$$\sum_j N_j \neq \sum_j \hat{N}_j^0.$$

The estimation of $\hat{N}_j^0$ from equation (2) results in β-estimates that lead to an overestimation of bunching, as it underestimates the counterfactual distribution. To account for this problem, I calculate the following coefficient α, which computes a proportion of total empirical area relative to the total counterfactual area.

$$\alpha = \frac{\sum_j N_j}{\sum_j \hat{N}_j^0}, \tag{3}$$

I use the coefficient α from equation (3) to inflate (shift) each value of $\hat{N}_j^0$ to predict the new counterfactual distribution $\hat{N}_j$ to account for the bias[22] in the initial counterfactual estimation from equation (2):

$$\hat{N}_j = \alpha \cdot \hat{N}_j^0. \tag{4}$$

I then define the bunching range to study in this case as $[c_\ell, c_\ell + \delta^u]$. This approach reflects that the builders would potentially target points above the threshold and would not mistakenly fall behind it. I focus on this range, as we observe significant bunching right at and slightly right of each cutoff. That is, there is a discernable amount of excess mass peaking at the cutoff and one notices shifting from the side on the left of a threshold to the side on the right of it.

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[22] As this does not shift the mass overproportionately in the range where it should be missing (i.e., to the left of the cutoffs), the estimation of the counterfactual is potentially biased. However, as I do not use the bunching estimations for doing structural statements as in the taxation literature, it is not crucial for the analysis I carry out that the 'true' counterfactual is identified.

In addition, it is evident that massive density holes exist below the cutoff points. I discern this pattern for the three cutoff points 50, 60, and 80, respectively.[23] Thus, I predict a bunching measure denoted as follows:

$$\hat{b}_\ell = \sum_{j=c_\ell}^{c_\ell+\delta} \frac{N_j - \hat{N}_j}{\hat{N}_j} \tag{5}$$

Equation (5) provides a bunching measure that estimates the excess number of buildings relative to the counterfactual number of buildings for all the points in the bunching range defined. I first use this measure to estimate bunching for the LEED v3[24], wherein the estimations are based on the full point range and I predict bunching for the three certification tiers: ‘Silver’, ‘Gold’, and ‘Platinum’. The δ range – which defines the range to study bunching[25] – is defined as the cutoff point and up to two more points above the cutoff. There are two different δ ranges specified, i.e., $\delta = 1, 2$. Looking into cases beyond this δ range demonstrates high variance, as the estimations on the counterfactual numbers then would derive from a few points after setting dummies for those observations to the left and the right side of a local threshold. To decide on the model specification, i.e., on the polynomial of order p, while keeping δ fixed, I look at the Akaike Information Criterion (AIC) and decide for the best polynomial fit p depending on the lowest AIC.

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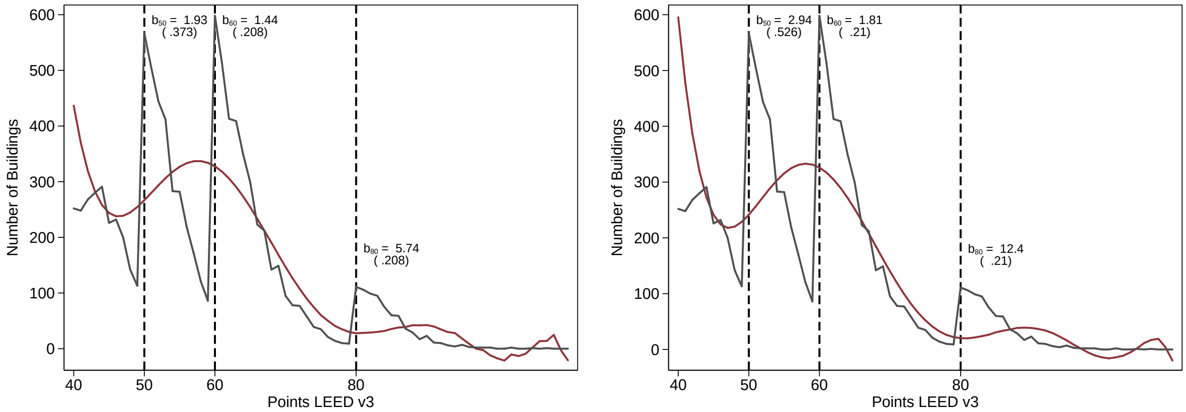
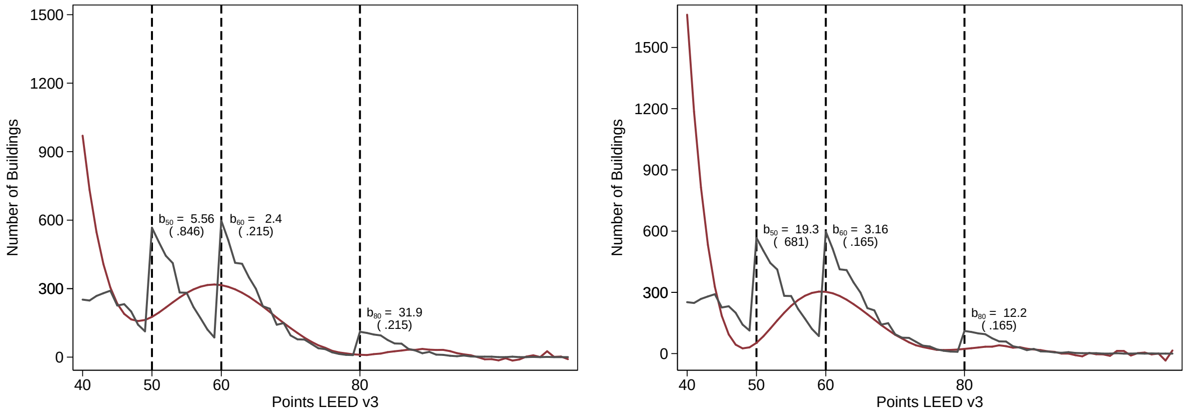
[23] I do the computation of the counterfactual distribution both by excluding the 40 threshold, as the dataset does not include points below the ‘certified’ threshold and by excluding the delta range to the right of the 40 threshold. This difference in the computation does not pose a significant discrepancy in the results I obtain. Therefore, I mostly report the bunching estimates from the latter, where we exclude the points to the right of the threshold.

[24] The analysis mainly focuses on v3 as the points range within this version facilitates the application of the method I implement. I also report the results for v2.

[25] That is, the points range to be excluded.



(a) ($\delta = 1$, $p = 10$) (b) ($\delta = 2$, $p = 10$)



(c) ($\delta = 3$, $p = 10$) (d) ($\delta = 4$, $p = 12$)

Figure 7: Estimation of the Counterfactual Distribution: Full Range

Figure 7 represents the estimated counterfactual distribution $\hat{N}_j$ by the red line and the actual distribution of buildings with the grey line for LEED version 3. It denotes for each δ specification the best polynomial fit, which is chosen based on the lowest AIC.

Table 3: Full-Range Bunching Estimation Results (LEED v3)

δ	p	AIC	AdjR2	$\hat{b}_\ell^{50}$	$\hat{b}_\ell^{60}$	$\hat{b}_\ell^{80}$	$\hat{b}_\ell^{average}$
2	2	774.10	0.84	2.297	4.243	0.661	3.256
				(0.245)***	(0.254)***	(0.458)***	(0.216)***
2	3	761.19	0.86	2.048	3.076	1.240	2.553
				(0.212)***	(0.314)***	(0.617)***	(0.230)***
2	4	754.56	0.88	1.442	2.478	3.414	1.951
				(0.238)***	(0.307)***	(2.042)	(0.255)***
2	5	760.50	0.88	1.485	2.472	3.581	1.970
				(0.263)***	(0.308)***	(3.152)	(0.252)***
2	6	739.19	0.90	2.400	2.031	15.867	2.218
				(0.462)***	(0.246)***	(314.098)	(0.280)***
2	7	751.62	0.89	2.054	2.068	14.530	2.059
				(0.386)***	(0.279)***	(2,444.541)	(0.250)***
2	8	736.25	0.91	2.968	1.976	8.314	2.488
				(0.471)***	(0.237)***	(39.952)	(0.271)***
2	9	741.74	0.91	2.923	1.818	12.292	2.384
				(0.466)***	(0.235)***	(740.419)	(0.271)***
2	10	726.00	0.91	2.893	1.824	12.345	2.371
				(0.509)***	(0.211)***	(508.603)	(0.300)***
2	11	735.99	0.91	2.859	1.794	11.140	2.338
				(0.437)***	(0.208)***	(119.096)	(0.249)***
2	12	734.66	0.91	2.950	1.743	10.657	2.360
				(0.608)***	(0.246)***	(56.799)	(0.343)***

Bootstrapped standard errors are in parentheses, * $p < .10$, ** $p < .05$, *** $p < .01$.

Table 3 presents the bunching estimations from a sample consisting of LEED v3 certified projects and the results are based on the full points range between 40 and 100. It indicates estimation statistics from combinations of fitted polynomial degree p and the excluded δ range. The results are robust for each $\hat{b}$ specification, both for $\hat{b}_\ell^{50}$ and $\hat{b}_\ell^{60}$, whereas the $\hat{b}_\ell^{80}$ estimations appear to be sensitive to the delta range beyond a small polynomial degree p. This may be due to an overestimation of bunching around the , as I assume that the buildings that are around the 80 threshold have a similar bunching pattern as the ones that are around the 50 and 60 cutoff points.[26] Hence, in a next step I predict an 'average' bunching measure by pooling 50 and 60 thresholds and ignoring the 80 threshold. First, I restrict the points bin range to between 40 and 70 points by dropping the building projects that achieve points higher than 70. For the average bunching measure, I weight each $\hat{b}_\ell$ by the share of all observations that are at and 'slightly above' the cutoff. Therefore, I compute for each cutoff c_ℓ, the sum of actual observations in $[c_\ell, c_\ell + \delta^u]$ range defined as $\widetilde{N}_\ell$, with a functional form of the following:

$$\widetilde{N}_\ell = \sum_{j=c_\ell}^{c_\ell+\delta} N_j \tag{6}$$

We then have an 'average' bunching estimator denoted as $\hat{b}_\ell^{average}$ in the following form:

$$\hat{b}_\ell^{average} = \frac{\sum_\ell \widetilde{N}_\ell \, \hat{b}_\ell}{\sum_\ell \widetilde{N}_\ell} \tag{7}$$

Following a similar approach, I estimate the counterfactual distribution for the LEED 'silver',

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[26] However, the graphical evidence in Figure 7 suggests that the excess bunching around the 'Platinum' tier is relatively smaller.

‘gold’, and ‘platinum’ thresholds. The local estimations for each cutoff point are presented in the figure B1.[27]

Adopting the same approach, I also compute bunching estimators for distinct label cutoffs for the projects that are certified under LEED v2 based on the full point range from 26 to 69.

Table 4: Full-Range Bunching Estimation Results (LEED v2)

δ	p	AIC	AdjR2	$\hat{b}_\ell^{33}$	$\hat{b}_\ell^{39}$	$\hat{b}_\ell^{52}$	$\hat{b}_\ell^{average}$
2	2	494.15	0.88	2.955	4.657	-0.202	3.769
				(0.361)***	(0.371)***	(0.605)***	(0.294)***
2	3	480.03	0.91	2.246	2.804	0.914	2.509
				(0.288)***	(0.389)***	(1.286)*	(0.305)***
2	4	451.62	0.96	0.587	1.340	229.710	0.948
				(0.192)***	(0.236)***	(265.620)	(0.206)***
2	5	444.31	0.96	0.203	1.233	11.908	0.699
				(0.227)**	(0.248)**	(149.085)	(0.223)**
2	6	429.51	0.98	1.463	1.378	-16.034	1.434
				(0.335)***	(0.158)***	(49.500)	(0.235)***
2	7	439.58	0.97	0.921	1.197	-16.531	1.057
				(0.301)***	(0.157)***	(52.518)	(0.208)***
2	8	397.40	0.99	2.896	1.850	40.470	2.469
				(0.362)***	(0.114)***	(710.148)	(0.246)***
2	9	398.22	0.99	2.259	1.408	-72.369	1.892
				(0.343)***	(0.098)***	(1,256.348)	(0.218)***
2	10	381.40	0.99	2.495	1.534	-278.946	2.086
				(0.418)***	(0.141)***	(27,674.077)	(0.289)***
2	11	393.54	0.99	2.224	1.373	-6,340.559	1.857
				(0.359)***	(0.136)***	(322.380)	(0.241)***
2	12	392.16	0.99	2.895	1.688	20.481	2.395
				(0.434)***	(0.160)***	(334.723)	(0.316)***

Bootstrapped standard errors are in parentheses, * $p < .10$, ** $p < .05$, *** $p < .01$.

Table 4 reports the estimators for the distinct certification thresholds 33, 39, and 52 as well as the average bunching predictor, which I compute by pooling 33 and 39 cutoff bunching estimators and excluding the 52 ‘platinum’ labelled projects from the sample.

5.2 Bootstrapping the Standard Errors

To report on the statistical significance of the reported bunching estimations, I compute the standard errors by using a bootstrapping technique. This bootstrapping procedure consists of the following steps; (i) I first create a new response variable by resampling the residual values from the regressions in equation (1), (ii) I run the regressions from equation (1) with the new response variable computed in step (i), (iii) I compute the bunching estimates again based on the regression output from step (ii) following the equations 3 and 4, (iv) I save these estimates into matrices from which I then compute the variance and the standard errors.[28]

I compute the bootstrapped standard errors both for the full range sample and for the state-level bunching estimates. I report the statistical significance of across states estimates in Table 6 for LEED v3-certified and in Table 7 for LEED v2-certified projects. I compute the state level

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[27] I include points to the right of the LEED ‘certified’ 40 cutoff for the estimation of the counterfactual distribution but not for the computation of the bunching estimations as the dataset does not include building projects that are not certified.

[28] The bootstrapped statistics I report have been computed using 150 replications, I currently cannot repeat this beyond 150 as I reach the memory limits of the software I use.

bunching estimators and the bootstrapped standard errors for the states in which there are at least 100 projects certified.[29]

5.3 Bunching Estimator across Building and Owner Types

I compute the bunching estimations as described in Section 5.1 for different building categories. Table 5 documents the average and the separate bunching estimators $\hat{b}_\ell^{50}$ and $\hat{b}_\ell^{60}$ for different building types.

Table 5: Bunching Estimates for Different Building Types

Building Types	δ	p	AIC	AdjR2	$\hat{b}_\ell^{50}$	$\hat{b}_\ell^{60}$	$\hat{b}_\ell^{average}$
Commercial Buildings	2	8	622.47	0.87	2.945	2.226	2.587
					(0.332)***	(0.130)***	(0.499)***
Public Buildings	2	8	312.89	0.94	3.518	1.356	2.642
					(2.374)	(0.979)**	(41.770)
Educational Buildings	2	6	286.00	0.90	3.900	2.241	3.120
					(2.862)	(2.369)	(36.616)
Industrial Buildings	2	5	200.33	0.63	1.425	1.404	1.396
					(19.283)	(21.596)	(23.873)
Residential Buildings	2	8	240.20	0.78	3.551	1.883	2.752
					(17.776)	(5.643)	(7,012.815)

Bootstrapped standard errors are in parentheses, * p<.10, ** p<.05, *** p<.01.

These bunching estimators indicate a considerable variation across building types. Despite this variance in the point estimators, and all bunching estimators for the commercial buildings are statistically significant as well as the $\hat{b}_\ell^{50}$ estimator for the public buildings in both model specifications. Further, I observe the highest bunching estimations for the residential buildings and lowest for the industrial buildings, however both estimations are statistically insignificant. One explanation for this might be the resilient nature of industry to energy performance-related regulations and implementations.[30] Additionally, the potential effect of holding a specific certification label on the real estate value might be more prominent for the residential sector, which in turn might induce the investors to bunch pronouncedly at the label cutoff points.

Further I look into bunching estimates across different owner and organization types. For the owner type, I categorize the building projects into two simple classes as privately and publicly owned building projects. Table 6 documents the average and the seperate bunching estimators $\hat{b}_\ell^{50}$ and $\hat{b}_\ell^{60}$ for different project owner types.

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[29] For v2 projects, I also include the states that have at least 80 certified building projects. I do this as (i) I have a few states with the number of certified building projects between 80 and 100 and (ii) v2 sample size is substantially lower than the v3 sample size in the dataset.

[30] Industry is often exempted, for instance from energy-related taxation, receives electricity supply at a relatively lower cost, *etc.*

Table 6: Bunching Estimates for Different Owner Types (Private and Public)

Owner Types	δ	p	AIC	AdjR2	$\hat{b}_\ell^{50}$	$\hat{b}_\ell^{60}$	$\hat{b}_\ell^{average}$
Privately Owned	2	8	558.42	0.86	3.747 (0.867)***	2.177 (0.243)***	2.938 (1.866)
Publicly Owned	2	6	513.83	0.89	2.507 (0.275)***	2.302 (0.338)***	2.406 (0.839)***

Bootstrapped standard errors are in parentheses, * p<.10, ** p<.05, *** p<.01.

The results provide mixed evidence on both the magnitude and the significance across different estimators for the two owner as well as the organization types. Higher bunching estimations around the silver cutoff $\hat{b}_\ell^{60}$ for the publicly owned buildings can be partly explained by a number of incentive schemes that target specifically public buildings to achieve a silver certification.[31]

Table 7: Bunching Estimates for Different Organization Types (Profit and Non-Profit)

Organization Types	δ	p	AIC	AdjR2	$\hat{b}_\ell^{50}$	$\hat{b}_\ell^{60}$	$\hat{b}_\ell^{average}$
Profit	2	8	550.45	0.86	3.718 (0.869)***	2.197 (0.245)***	2.928 (1.883)
Non-Profit	2	8	508.70	0.89	2.438 (0.509)***	2.014 (0.316)***	2.234 (0.685)***

Bootstrapped standard errors are in parentheses, * p<.10, ** p<.05, *** p<.01.

Results confirm a similar pattern for the two organization types classified as profit and non-profit organizations.[32]

5.4 Bunching Estimator across States

Since I hypothesize that the variation in strategic responses (bunching estimations) might be correlated with differences across states, in a subsequent step of the analysis, I estimate bunching for different US states. I collapse the data by state and points into point bins and restrict the sample to those states that have a number of observations greater or equal to 100.[33] Following the same steps as described in Section 5.1, I make the general observation that the bunching estimators have a high variance for the 'platinum' cutoff and this holds especially true for some of the states, which have a very small share of project points around the 'platinum' certification cutoff. This leads to negative estimations of $\hat{b}_\ell$ for the 80 threshold. The high variation of bunching estimates around the 80 cutoff might also be due to the approach of shifting the counterfactual estimation, in which I assume a similar bunching pattern from each cutoff, including 80. However, the graphical evidence suggests that bunching around the 80

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[31] We confirm this information by a qualitative expert view reflected on building types and owner types for different certification cutoffs.

[32] While most of the privately owned building project registries in the sample are for profit organizations, the publicly owned projects are mostly also not for profit organization types. Hence, the results in both Table 6 and Table 7 are comparable with only slight difference in magnitude.

[33] After excluding those states that have a number of projects lower than 100, I end up with a subsample of 22 states.

cutoff is relatively smaller.[34] Thus, I also use the average bunching estimator for the state-level analysis. Table 8 reports the best estimates, which are picked by the lowest AIC. Deciding on the specification with differing polynomial degree p and obtaining the best bunching estimates for each specification – while keeping the δ range fixed – allows for heterogeneity across states regarding the distribution of projects. To compute the best state level estimates, I set the maximum polynomial degree p to 8, as I exclude the points above the 70 range.[35]

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[34] The estimated counterfactual distribution is skewed towards the lower end of the distribution around the 80 cutoff, suggesting possibly deviations from the 'true' counterfactual distribution, however the identification of the 'true' counterfactual is negligibile for the type of analysis conducted in the present study as the bunching estimations are mainly used in making group comparisons.

[35] For the computation of these estimates, I include the states that have at least 100 projects certified.

Table 8: Best State Level Estimates (LEED v3)

State	δ	p	AIC	AdjR2	$\hat{b}_\ell^{50}$	$\hat{b}_\ell^{60}$	$\hat{b}_\ell^{average}$
Arizona	2	4	94.91	0.81	2.061	1.682	1.877
					(44.486)	(16.298)	(23.694)
California	2	8	214.19	0.84	2.928	1.914	2.413
					(0.184)***	(0.191)***	(0.311)***
Colorado	2	5	153.59	0.44	0.704	1.196	0.949
					(0.369)**	(0.471)*	(116.303)
Florida	2	8	129.39	0.87	3.353	3.993	3.662
					(0.920)***	(1.550)**	(2.388)
Georgia	2	8	132.47	0.62	0.641	7.736	4.841
					(0.441)***	(15.204)	(24.391)
Illinois	2	3	157.00	0.80	3.774	2.585	3.225
					(1.026)***	(0.497)***	(5.331)
Maryland	2	3	140.28	0.61	6.204	0.838	3.938
					(2.776)	(1.677)**	(1,154.593)
Massachusetts	2	8	149.08	0.47	0.752	1.894	1.592
					(5.449)	(1.336)	(585.273)
Michigan	2	2	120.88	0.57	2.952	2.943	2.988
					(1.374)*	(8.495)	(4.315)
Minnesota	2	3	83.18	0.73	1.661	3.340	2.554
					(27.907)	(15.329)	(158.650)
Missouri	2	2	112.49	0.59	3.165	1.304	2.539
					(1.552)	(3.332)	(52.599)
New Jersey	2	5	125.39	0.53	-0.551	5.175	2.652
					(0.520)***	(3.088)	(1.863)
New York	2	8	143.94	0.88	1.891	3.517	2.724
					(0.367)***	(1.107)**	(0.996)**
North Carolina	2	6	112.11	0.73	2.399	6.028	4.132
					(4.707)	(1.865)**	(59.444)
Ohio	2	8	133.55	0.78	1.324	12.572	6.519
					(0.332)***	(217,435.985)	(16.940)
Oregon	2	8	125.14	0.40	2.001	5.352	4.026
					(2.151)*	(33.860)	(192.126)
Pennsylvania	2	4	77.70	0.94	3.804	5.120	4.500
					(0.893)***	(0.726)***	(6.991)
Tennessee	2	2	109.12	0.50	1.530	0.766	1.171
					(1.852)	(2.172)	(32.518)
Texas	2	8	179.28	0.72	2.813	11.012	6.026
					(0.386)***	(54.722)	(4.732)
Virginia	2	2	143.25	0.77	1.678	2.445	2.054
					(0.614)***	(0.592)***	(263.084)
Washington	2	8	123.26	0.75	1.134	9.345	5.373
					(0.403)***	(11.056)	(434.320)
Wisconsin	2	5	90.01	0.73	-0.470	3.164	1.096
					(0.369)**	(0.844)	(28.576)

Bootstrapped standard errors are in parentheses, * p<.10, ** p<.05, *** p<.01.

Following the same method, I also run the bunching estimations for v2-certified projects. I exclude those states from the analysis within which there are less than 80 certified building projects.[36] Following the aforementioned steps for the computation, I report the best estimates for the three different certification classifications for $\hat{b}_\ell^{33}$, $\hat{b}_\ell^{39}$, and $\hat{b}_\ell^{52}$, as well as the average bunching estimator. For computing the average bunching estimator, I drop project points that are beyond 46 and pool the projects that are either in the 'silver' or 'gold' certification distribution.

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[36] After excluding the states with less than 80 building projects, I arrive at a sample size of 27 states.

Table 9: Best State Level Estimates (LEED v2)

State	δ	p	AIC	AdjR2	$\hat{b}_\ell^{33}$	$\hat{b}_\ell^{39}$	$\hat{b}_\ell^{average}$
Arizona	2	6	43.94	0.95	2.872	-0.847	1.461
					(6.011)	(0.218)**	(10.505)
California	2	6	98.03	0.96	8.203	-0.371	5.486
					(0.718)**	(0.046)***	(8.653)
Colorado	2	4	66.88	0.89	1.693	-0.024	0.787
					(2.411)	(0.553)	(17.136)
Florida	2	8	58.44	0.98	3.481	2.938	3.291
					(0.407)**	(0.303)***	(0.612)**
Georgia	2	6	81.11	0.82	4.017	-1.205	1.998
					(5.698)	(0.320)**	(31.788)
Illinois	2	6	56.07	0.96	0.072	1.133	0.534
					(0.329)	(0.172)*	(59.464)
Indiana	2	6	17.81	0.95	3.037	1.090	2.175
					(128.986)	(0.619)*	(56.689)
Iowa	2	8	-55.86	1.00	-82.305	-0.418	-7.656
					(813.488)	(1.299)**	(152.398)
Maryland	2	4	69.53	0.90	1.914	2.383	2.261
					(4.214)	(1.437)	(35.377)
Massachusetts	2	6	69.76	0.77	-65.897	0.990	-6.510
					(1,642.128)	(0.443)***	(234.601)
Michigan	2	6	69.82	0.92	5.522	0.606	3.664
					(10.344)	(0.374)**	(48.074)
Minnesota	2	7	72.78	0.33	1.539	3.086	2.473
					(0.844)*	(46.938)	(2.258)
Missouri	2	6	31.66	0.88	0.209	3.836	1.938
					(12.686)	(1.768)	(10.344)
New Jersey	2	8	-2.13	0.99	0.438	-0.382	0.142
					(0.539)	(0.313)	(26.386)
New Mexico	2	2	44.77	0.94	0.463	1.156	0.907
					(331.590)	(1.576)	(37.218)
New York	2	6	65.35	0.94	0.079	-0.285	-0.101
					(0.491)	(0.187)	(26.210)
North Carolina	2	8	89.22	0.80	1.607	-0.820	0.629
					(0.857)	(0.160)*	(16.837)
Ohio	2	4	53.37	0.97	0.826	1.665	1.223
					(2.128)	(1.080)	(11.525)
Oregon	2	6	48.87	0.96	-0.278	4.607	3.224
					(10.914)	(0.744)**	(32.561)
Pennsylvania	2	6	33.47	0.99	2.545	1.359	2.031
					(0.628)*	(0.127)***	(1.905)
South Carolina	2	2	68.41	0.82	2.248	2.380	2.256
					(4.574)	(1.037)	(98.067)
Tennessee	2	6	6.08	0.98	15.596	5.153	12.999
					(36.095)	(115.203)	(136.590)
Texas	2	6	69.34	0.97	1.891	0.117	1.162
					(0.526)	(0.108)***	(3.826)
Virginia	2	6	41.17	0.99	3.006	0.779	2.010
					(0.937)	(0.210)**	(2.252)
Wisconsin	2	7	59.03	0.54	2.010	27.583	15.875
					(0.866)***	(310.528)	(33.864)

Bootstrapped standard errors are in parentheses, * $p<.10$, ** $p<.05$, *** $p<.01$.

To exploit the cross-sectional variation in bunching across US states and to distinguish the behavioral responses to threshold-based certification system from other potential response margins, I compare the bunching estimators for different US states with parameters for corruption levels and energy prices. As greater bunching estimates might refer to 'manipulation' of the point scheme given the underlying distinct thresholds, I presume to observe a relationship, under which greater bunching estimates are observed in states that have higher corresponding corruption levels. Although I find a downward sloping relationship,[37] I find no significant correlation within the US, between the bunching responses and the corruption indicators. However, the evidence suggests that there is a significantly negative correlation (with a correlation coefficient of -0.26[38]) between bunching predictions and energy prices. Figure 8 illustrates the scatter diagrams for two different δ specifications with a linear fit obtained from the weighted least squares by using the building count.[39]

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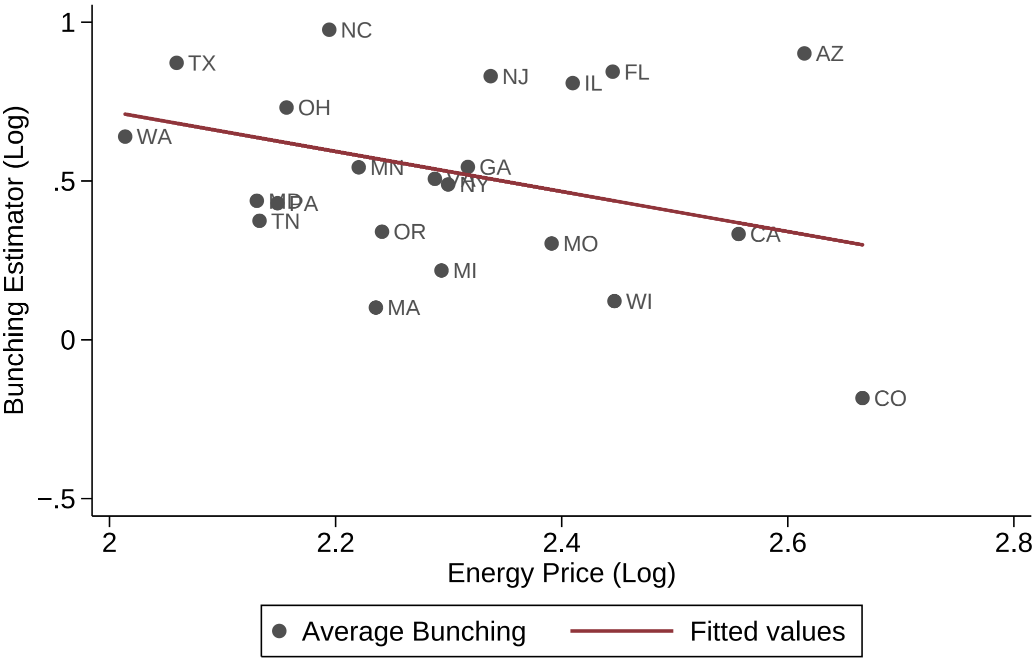
[37] The corruption score I use reads high scores in the presence of less corruption and vice versa. This relationship is in line with the expectation of higher bunching estimates observed when a particular state is more corrupt.

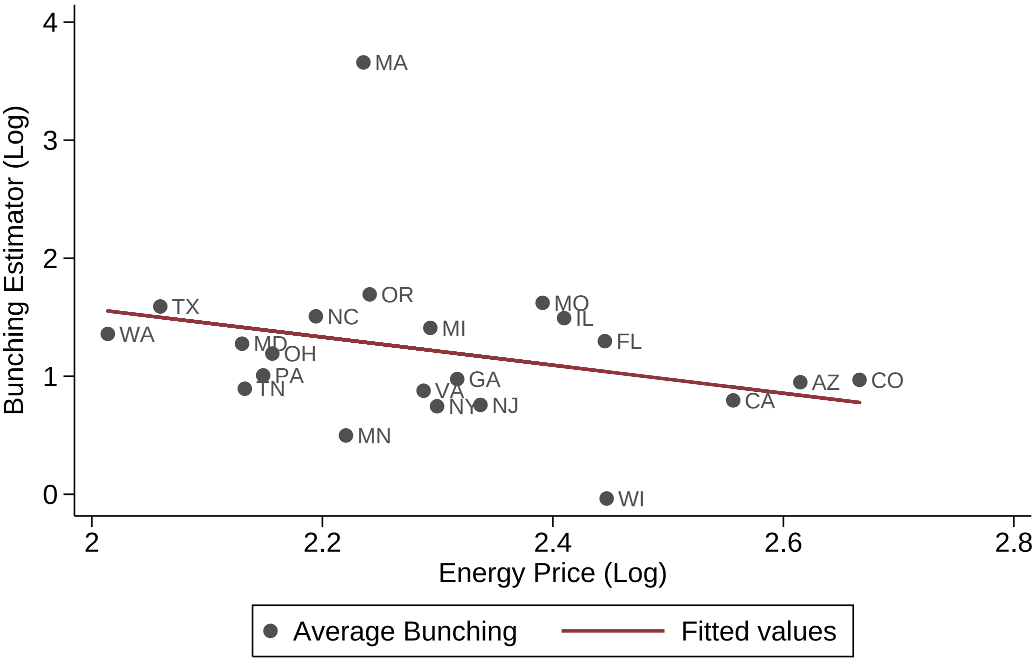
[38] Note that for the specification with $\delta = 3$, when the outlier state 'MA' is excluded from the data, the correlation coefficient increases to -0.30 with a p-value of 0.006.

[39] For the case under which δ equals 2, I observe a negative, but insignificant relationship between the two indicators with a correlation coefficient of -0.20.



*Weighted Least Squares (building count)
y = −.6306x + 1.9805, p = 0.053
R−squared=0.1707

(a) (Bunching Estimator Across States: $\delta = 1$)



*Weighted Least Squares (building count)
y = −1.189x + 3.948, p = 0.011
R−squared=0.1238

(b) (Bunching Estimator Across States: $\delta = 3$)

Figure 8: Average Bunching and Energy Prices

I additionally report in figure B2 the correlation between energy prices and the average bunching estimators computed by restricting the polynomial degree p to 8 ($p \leq 8$). Although not statistically significant for the case in which $\delta = 1$, I still find a statistically significant negative correlation between the two indicators for the model specification of $\delta = 2$.

This preliminary evidence suggests that there is less bunching in states where the energy prices are higher. This is consistent with the observation that higher prices give investors stronger incentives to compare and concentrate on the details of distinct product characteristics (i.e., details on a buildings' energy efficiency and other possible metrics), which in turn diminishes the building developers' incentive to situate themselves right at the cutoff by meeting the minimum points to obtain a specific certification.

6 Conclusions

I study strategic responses of building developers to threshold-based rating scheme introduced by the LEED green building certification program, under which a building that passes a predetermined point threshold may hold four different certification levels. By using micro data on LEED-certified buildings, I present robust evidence of bunching at these threshold points. I document a similar pattern for different LEED versions and for a building certification system from the UK; BREEAM. Further, by employing methods from the public finance literature, I quantify bunching around the threshold points and apply this estimation method to a context that is beyond the taxation domain. Moreover, I exploit the cross-sectional variation in bunching by investigating how bunching predictions change when controlling for other indicators on corruption levels and energy prices. Finding suggest that there is less bunching in the states that observe higher energy prices, there is a significant negative correlation between bunching estimations and the energy prices observed. This observation is in line with the conjecture that higher prices provide stronger incentives to possible investors to compare the detailed product features (i.e., attributes on a buildings' energy efficiency and sustainability measures), which in response reduces the building developers' incentive to situate right at the certification cutoff.

This study contributes to the existing literature in various ways: first, by focusing on green building certification systems and exploring the behavioral responses to a threshold-based classification schedule in a considerably distinc t framework from the consumer markets (i.e., appliances market) studied previously, I am able to provide evidence from a different setting. The building market differs itself from the aforementioned market(s) concerning its investment and operation scale. Hence, one might expect 'well-informed' choices in the building market, rather than the close attention dedicated to salient, discrete product attributes. Yet, the provided evidence in this study rejects this presumption. Further, I discern behavioral responses to certification scheme from different possible margins by utilizing methods that stem from the public finance literature to study 'notches'. Ultimately, the analysis points to a different perspective compared to the studies concerning green buildings by providing evidence via concentrating on the attributes of a rating scheme rather than focusing on the real estate value or financial aspects.

Consequently, it is essential to examine the strategic behavioral responses (and their potential drivers) to salient, discrete label categories, since there are numerous instances for notched schedules in the energy and environmental performance domain, unlike the limited evidence suggested on the possible responses. Quantifying the extent of this response by comparing the actual distribution, i.e., bunching mass, with a hypothetical rating scheme without the threshold points is of high relevance from a policy design point of view. The analysis helps us add to the ongoing discussion on the behavioral responses to labels defining energy efficiency performance. This research idea raises a significant point in this domain as the discrete label categories alter one's valuation of – otherwise equally valued – points around the label cutoffs. These rating schemes consist of points that are roughly standardized – based on engineering calculations – in terms of energy efficiency performance. I find evidence that the discrete labels distort individual valuation of points around the cutoff value. Labelling in this context, amongst other domains, might have unintended, secondary effects as the salience of label categories overrides the deliberate attention paid to environmental performance. Understanding the behavioral implications of a specific policy design is therefore crucial for planning effective policies.

One has to be cautious in interpreting the evidence presented in this paper as a direct measure of effectiveness of discrete label schemes in terms of welfare implications. The results cannot conclude whether implementing such a scheme is welfare enhancing or welfare decreasing, further research is needed to find out about the effectiveness of these schemes.

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Appendix A: Additional Tables

Table A1: Full-Range Bunching Estimation Results (LEED v3)

δ	p	AIC	AdjR2	$\hat{b}_\ell^{50}$	$\hat{b}_\ell^{60}$	$\hat{b}_\ell^{80}$	$\hat{b}_\ell^{average}$
1	2	807.92	0.77	1.743 (0.200)***	3.156 (0.236)***	0.309 (0.302)***	2.459 (0.193)***
1	3	796.35	0.80	1.551 (0.180)***	2.282 (0.240)***	0.744 (0.419)***	1.921 (0.187)***
1	4	794.02	0.82	1.205 (0.190)***	1.976 (0.234)***	1.791 (1.184)	1.595 (0.196)***
1	5	799.37	0.82	1.320 (0.264)***	1.936 (0.230)***	2.181 (1.810)	1.632 (0.209)***
1	6	786.63	0.84	1.769 (0.315)***	1.588 (0.209)***	6.282 (187.363)	1.678 (0.196)***
1	7	797.05	0.83	1.649 (0.299)***	1.626 (0.215)***	6.701 (90.852)	1.637 (0.190)***
1	8	787.12	0.84	1.906 (0.332)***	1.541 (0.195)***	3.940 (84.106)	1.723 (0.195)***
1	9	785.60	0.85	1.943 (0.334)***	1.463 (0.203)***	5.069 (124.471)	1.701 (0.217)***
1	10	775.34	0.84	1.919 (0.369)***	1.441 (0.208)***	5.741 (29.747)	1.678 (0.223)***
1	11	785.15	0.84	1.936 (0.373)***	1.434 (0.209)***	5.443 (50.869)	1.683 (0.219)***
1	12	784.78	0.84	1.987 (0.346)***	1.399 (0.210)***	5.455 (41.848)	1.690 (0.226)***
2	2	774.10	0.84	2.297 (0.245)***	4.243 (0.254)***	0.661 (0.458)***	3.256 (0.216)***
2	3	761.19	0.86	2.048 (0.212)***	3.076 (0.314)***	1.240 (0.617)***	2.553 (0.230)***
2	4	754.56	0.88	1.442 (0.238)***	2.478 (0.307)***	3.414 (2.042)	1.951 (0.255)***
2	5	760.50	0.88	1.485 (0.263)***	2.472 (0.308)***	3.581 (3.152)	1.970 (0.252)***
2	6	739.19	0.90	2.400 (0.462)***	2.031 (0.246)***	15.867 (314.098)	2.218 (0.280)***
2	7	751.62	0.89	2.054 (0.386)***	2.068 (0.279)***	14.530 (2,444.541)	2.059 (0.250)***
2	8	736.25	0.91	2.968 (0.471)***	1.976 (0.237)***	8.314 (39.952)	2.488 (0.271)***
2	9	741.74	0.91	2.923 (0.466)***	1.818 (0.235)***	12.292 (740.419)	2.384 (0.271)***
2	10	726.00	0.91	2.893 (0.509)***	1.824 (0.211)***	12.345 (508.603)	2.371 (0.300)***
2	11	735.99	0.91	2.859 (0.437)***	1.794 (0.208)***	11.140 (119.096)	2.338 (0.249)***
2	12	734.66	0.91	2.950 (0.608)***	1.743 (0.246)***	10.657 (56.799)	2.360 (0.343)***
3	2	726.29	0.90	2.736 (0.216)***	5.437 (0.273)***	1.282 (0.545)***	4.056 (0.211)***
3	3	712.91	0.92	2.483 (0.204)***	4.086 (0.347)***	1.841 (0.616)***	3.265 (0.244)***
3	4	699.26	0.93	1.605 (0.244)***	3.092 (0.348)***	5.388 (2.662)	2.332 (0.276)***
3	5	700.96	0.93	1.488 (0.359)***	3.078 (0.370)***	4.979 (2.811)	2.266 (0.324)***
3	6	691.37	0.95	3.058 (0.550)***	2.617 (0.267)***	41.369 (657.550)	2.847 (0.337)***
3	7	699.60	0.94	2.283 (0.404)***	2.648 (0.279)***	22.910 (211.066)	2.460 (0.282)***
3	8	658.69	0.97	5.553 (0.903)***	2.576 (0.164)***	19.560 (48.157)	4.195 (0.533)***
3	9	652.47	0.97	4.631 (0.625)***	2.235 (0.167)***	56.783 (1,030.784)	3.505 (0.337)***
3	10	650.64	0.97	5.305 (0.764)***	2.429 (0.216)***	30.018 (160.559)	3.980 (0.448)***
3	11	659.33	0.96	4.413 (0.762)***	2.270 (0.214)***	22.230 (475.059)	3.402 (0.434)***
3	12	658.03	0.97	5.918 (0.945)***	2.394 (0.224)***	15.056 (42.357)	4.317 (0.590)***
4	2	683.41	0.94	2.680 (0.187)***	6.489 (0.229)***	2.237 (0.786)***	4.542 (0.163)***
4	3	672.65	0.95	2.532 (0.187)***	4.987 (0.427)***	2.286 (0.733)***	3.729 (0.263)***
4	4	648.25	0.96	1.166 (0.251)***	3.130 (0.412)***	9.744 (7.889)	2.133 (0.313)***
4	5	637.37	0.97	0.303 (0.274)***	2.667 (0.368)***	7.900 (3.129)	1.474 (0.301)***
4	6	651.89	0.97	1.273 (0.476)***	2.571 (0.311)***	27.657 (1,221.857)	1.925 (0.334)***
4	7	649.70	0.97	0.744 (0.320)***	2.546 (0.304)***	16.482 (3,228.082)	1.639 (0.269)***
4	8	585.71	0.99	5.567 (0.950)***	2.718 (0.189)***	43.327 (3,686.655)	4.451 (0.626)***
4	9	595.43	0.98	3.278 (0.476)***	2.253 (0.182)***	94.943 (567.876)	2.857 (0.276)***
4	10	584.93	0.99	5.290 (0.973)***	2.663 (0.188)***	43.783 (114.286)	4.254 (0.635)***
4	11	596.68	0.98	2.877 (0.512)***	2.297 (0.221)***	30.901 (298.065)	2.657 (0.315)***
4	12	521.29	0.99	12.767 (2.627)***	3.224 (0.167)***	11.542 (2.127)***	11.123 (335.047)

Note: Table reports full range bunching estimates for the LEED v3 for all different δ and polynomial degree p combinations. Bootstrapped standard errors are in parentheses, * $p < .10$, ** $p < .05$, *** $p < .01$.

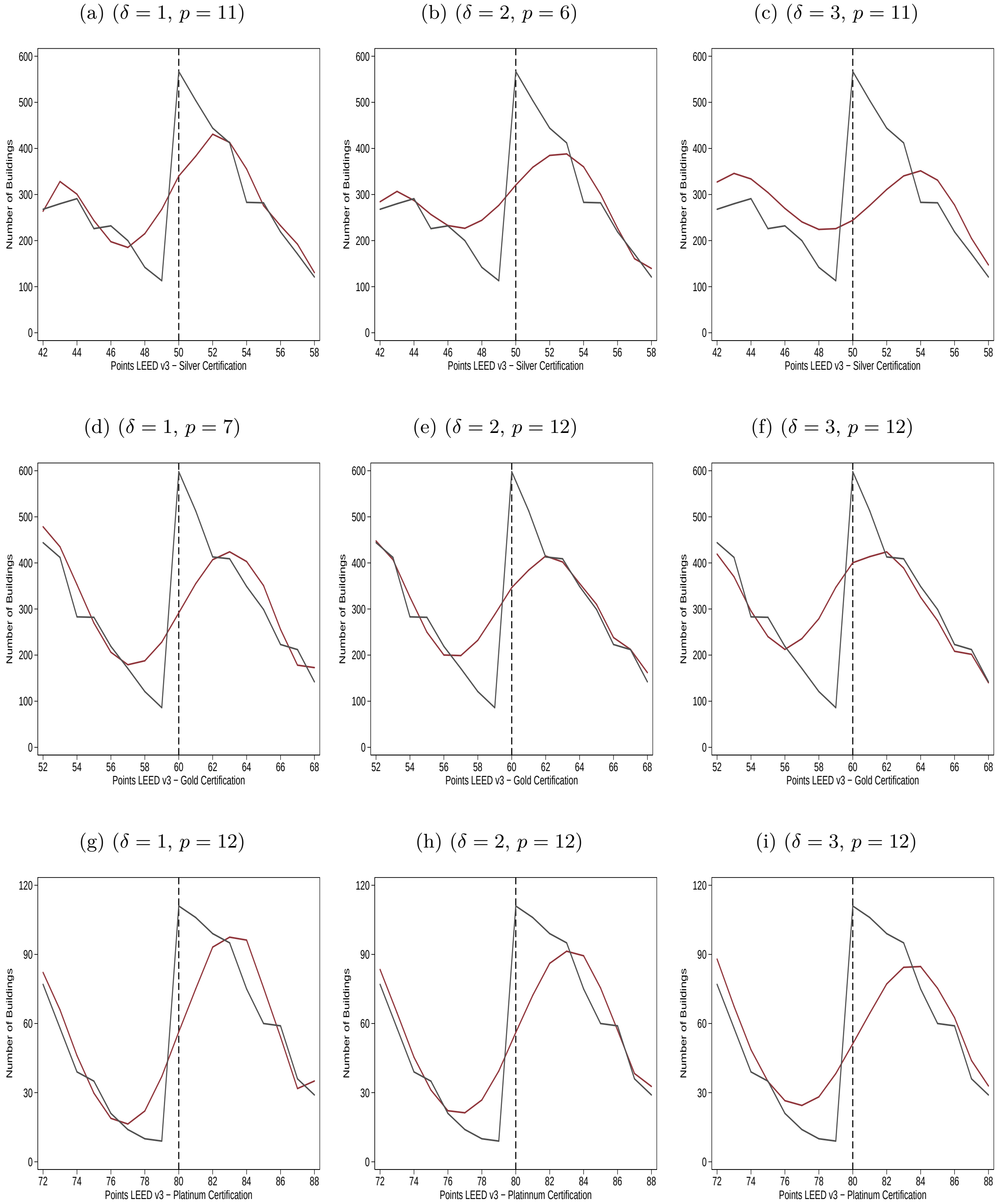
Table A2: Full-Range Bunching Estimation Results (LEED v2)

δ	p	AIC	AdjR2	$\hat{b}_\ell^{33}$	$\hat{b}_\ell^{39}$	$\hat{b}_\ell^{52}$	$\hat{b}_\ell^{average}$
1	2	534.25	0.76	2.244	3.505	-0.141	2.883
				(0.358)***	(0.357)***	(0.369)***	(0.312)***
1	3	520.10	0.83	1.653	2.032	0.888	1.846
				(0.247)***	(0.351)***	(1.091)	(0.280)***
1	4	511.35	0.87	0.867	1.457	5.349	1.168
				(0.248)***	(0.282)***	(854.027)	(0.255)***
1	5	510.73	0.87	1.003	1.434	10.036	1.223
				(0.276)***	(0.259)***	(92.480)	(0.236)***
1	6	497.52	0.91	1.812	1.241	-16.242	1.536
				(0.380)***	(0.173)***	(132.515)	(0.233)***
1	7	506.15	0.90	1.582	1.174	-11.091	1.383
				(0.401)***	(0.206)***	(346.538)	(0.266)***
1	8	483.83	0.92	2.039	1.337	15.241	1.706
				(0.339)***	(0.179)***	(168.048)	(0.224)***
1	9	487.10	0.92	2.025	1.189	24.239	1.621
				(0.392)***	(0.161)***	(135.826)	(0.235)***
1	10	490.72	0.92	2.033	1.183	34.784	1.623
				(0.474)***	(0.201)***	(494.749)	(0.293)***
1	11	490.52	0.92	2.019	1.149	37.775	1.599
				(0.417)***	(0.185)***	(435.613)	(0.262)***
1	12	492.57	0.91	2.073	1.195	12.839	1.650
				(0.483)***	(0.205)***	(56.171)	(0.303)***
2	2	494.15	0.88	2.955	4.657	-0.202	3.769
				(0.361)***	(0.371)***	(0.605)***	(0.294)***
2	3	480.03	0.91	2.246	2.804	0.914	2.509
				(0.288)***	(0.389)***	(1.286)*	(0.305)***
2	4	451.62	0.96	0.587	1.340	229.710	0.948
				(0.192)***	(0.236)***	(265.620)	(0.206)***
2	5	444.31	0.96	0.203	1.233	11.908	0.699
				(0.227)**	(0.248)**	(149.085)	(0.223)**
2	6	429.51	0.98	1.463	1.378	-16.034	1.434
				(0.335)***	(0.158)***	(49.500)	(0.235)***
2	7	439.58	0.97	0.921	1.197	-16.531	1.057
				(0.301)***	(0.157)***	(52.518)	(0.208)***
2	8	397.40	0.99	2.896	1.850	40.470	2.469
				(0.362)***	(0.114)***	(710.148)	(0.246)***
2	9	398.22	0.99	2.259	1.408	-72.369	1.892
				(0.343)***	(0.098)***	(1,256.348)	(0.218)***
2	10	381.40	0.99	2.495	1.534	-278.946	2.086
				(0.418)***	(0.141)***	(27,674.077)	(0.289)***
2	11	393.54	0.99	2.224	1.373	-6,340.559	1.857
				(0.359)***	(0.136)***	(322.380)	(0.241)***
2	12	392.16	0.99	2.895	1.688	20.481	2.395
				(0.434)***	(0.160)***	(334.723)	(0.316)***
3	2	406.59	0.98	2.531	6.539	7.093	4.393
				(0.108)***	(0.184)***	(3.770)	(0.091)***
3	3	367.76	0.99	2.510	11.919	-211.019	7.030
				(0.029)***	(0.409)***	(804.534)	(0.209)***
3	4	301.43	1.00	3.308	21.270	192.140	12.229
				(0.031)***	(0.490)***	(69.467)	(0.275)***
3	5	309.48	1.00	2.744	16.634	271.099	9.572
				(0.023)***	(0.356)***	(5,468.896)	(0.197)***
3	6	265.78	1.00	3.640	27.149	105.236	15.540
				(0.073)***	(1.116)***	(9.827)	(0.640)***
3	7	270.63	1.00	2.031	14.515	64.061	8.205
				(1.168)***	(6.264)	(22.055)	(3.751)*
3	8	263.23	1.00	2.655	18.095	77.030	10.331
				(0.535)***	(4.019)**	(14.354)	(2.328)***
3	9	266.11	1.00	2.038	14.635	59.303	8.274
				(1.092)***	(5.447)	(24.799)	(3.283)**
3	10	262.41	1.00	2.396	16.738	67.102	9.522
				(0.382)***	(2.923)**	(10.767)	(1.691)***
3	11	252.32	1.00	-15.538	-13.173	-26.627	-25.326
				(186.845)	(8.772)**	(21.567)	(95.840)
3	12	247.76	1.00	-4.058	-4.078	-4.189	-4.068
				(17.699)	(5.856)	(14.841)	(6.525)
4	2	366.10	0.99	2.581	7.066	5.006	4.543
				(0.126)***	(0.178)***	(2.026)*	(0.079)***
4	3	345.98	0.99	2.592	13.332	608.332	7.544
				(0.038)***	(0.721)***	(2,846.799)	(0.362)***
4	4	273.83	1.00	3.656	26.222	886.601	14.761
				(0.040)***	(0.632)***	(3,303.411)	(0.367)***
4	5	289.38	1.00	2.924	20.297	-957.959	11.328
				(0.031)***	(0.486)***	(4,867.321)	(0.276)***
4	6	222.40	1.00	4.273	36.252	146.083	20.674
				(0.064)***	(1.029)***	(12.732)	(0.625)***
4	7	196.22	1.00	5.720	57.405	180.679	33.734
				(0.210)***	(3.893)***	(10.735)**	(2.509)***
4	8	203.90	1.00	4.674	44.912	149.542	26.024
				(0.132)***	(2.314)***	(8.383)**	(1.457)***
4	9	195.57	1.00	4.761	47.491	135.783	27.741
				(0.164)***	(2.489)***	(8.570)**	(1.587)***
4	10	181.90	1.00	3.930	38.059	102.499	21.951
				(0.092)***	(1.520)***	(5.163)***	(0.959)***
4	11	187.31	1.00	4.507	44.562	124.578	25.941
				(0.313)***	(4.434)***	(14.146)	(2.781)***
4	12	185.97	1.00	4.091	40.248	108.510	23.309
				(0.241)***	(3.409)***	(10.561)*	(2.121)***

Note: Table reports full range bunching estimates for the LEED v2 for all different δ and polynomial degree p combinations. Bootstrapped standard errors are in parentheses, * $p < .10$, ** $p < .05$, *** $p < .01$.

Appendix B: Additional Figures

Figure B1: Estimation of the Counterfactual Distribution: 50, 60, and 80 Thresholds



(a) ($\delta = 1$, $p = 11$) (b) ($\delta = 2$, $p = 6$) (c) ($\delta = 3$, $p = 11$)

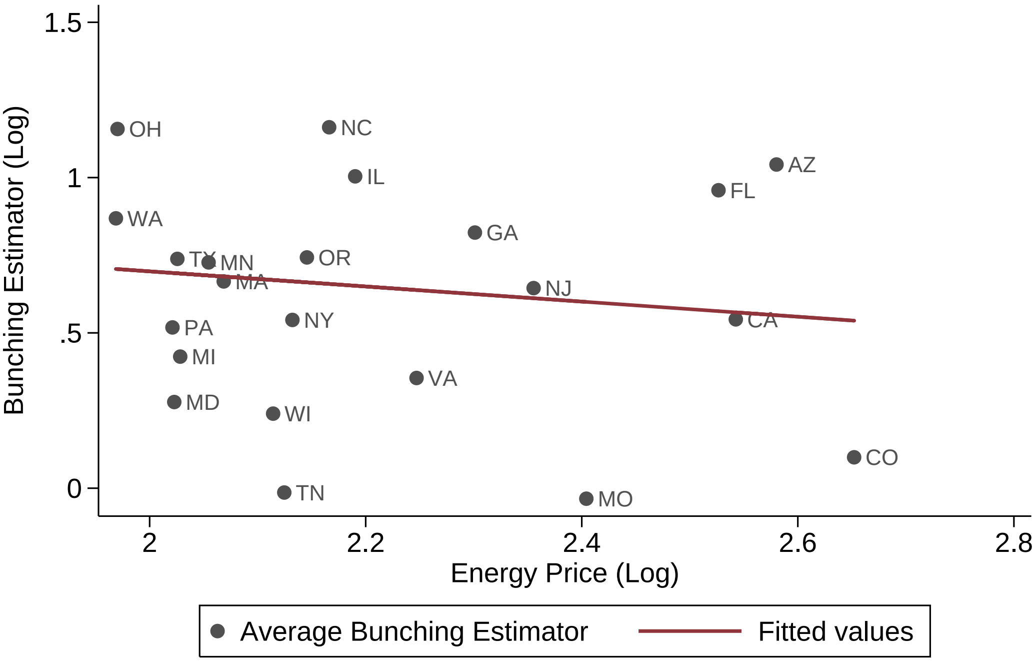
(d) ($\delta = 1$, $p = 7$) (e) ($\delta = 2$, $p = 12$) (f) ($\delta = 3$, $p = 12$)

(g) ($\delta = 1$, $p = 12$) (h) ($\delta = 2$, $p = 12$) (i) ($\delta = 3$, $p = 12$)

Note: This figure depicts both the actual (gray line) and the estimated counterfactual distribution(red line) for the 50, 60, and 80 thresholds, respectively. For each defined δ range, it reports the best polynomial degree fit p picked based on the AIC.

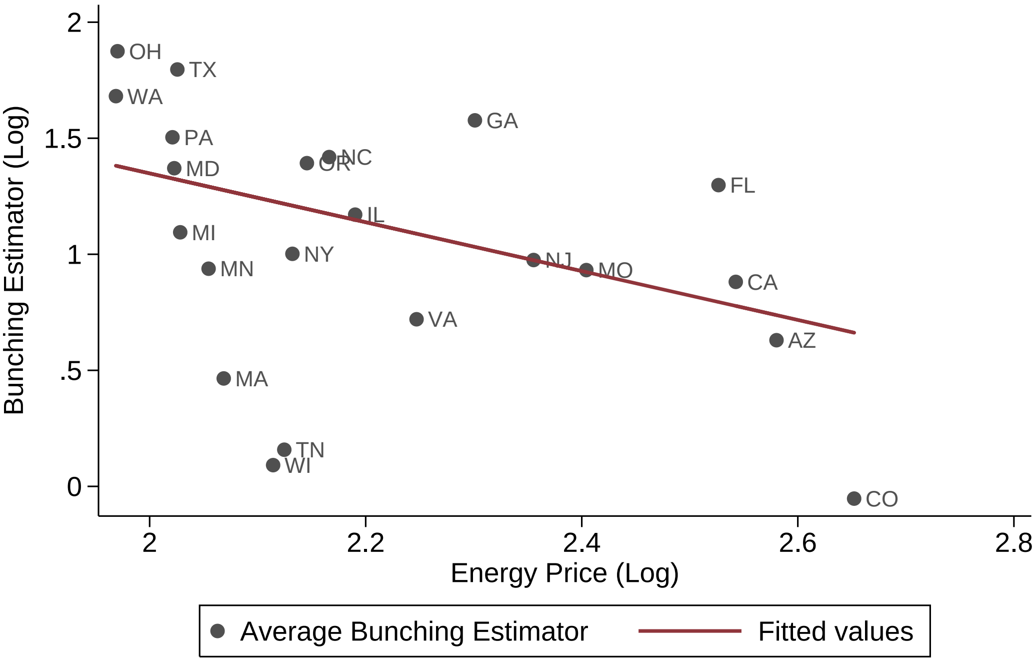
Figure B2: Average Bunching and Energy Prices with the Restricted Polynomial Degree Range

(a) (Bunching Estimator Across States: $\delta = 1$)



*Weighted Least Squares (building count)
y = −.24329x + 1.1846, p = 0.374
R−squared=0.0357

(b) (Bunching Estimator Across States: $\delta = 2$)



*Weighted Least Squares (Building Count)
y = −1.0524x + 3.4534, p = 0.021
R−squared=0.2515

Note: This figure indicates the relationship between average (pooled) bunching estimators and energy prices across US states. It reports results for the two different estimators based on the δ range specifications ($\delta \leq 2$). The state-level average bunching estimators pick up the best polynomial degree p for each state from a restricted polynomial degree fit ($p \leq 8$). The figure further indicates weighted least squares regression output for each specification.

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