Policy Feedback, Energy Equity, and Climate Justice: Can Existing Policies Improve Solar Access for Low- and Moderate-Income Communities in the United States?

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ABSTRACT Despite the proliferation of rooftop solar in the United States, its deployment and associated benefits have not been distributed equitably. Many states have adopted targeted incentives to improve access to rooftop solar and increase its uptake among low- and moderate-income (LMI) communities. This article examines the policy feedback effects of energy efficiency policies and electricity-sector portfolio standards on the adoption and diffusion of LMI solar incentives across states. Event History Analyses indicate that between 2010 and 2019, the adoption and diffusion of the incentives have been conditional on a state's portfolio standards but independent of energy efficiency policies. Feedback effects from the portfolio standards in neighboring states are found to have a regressive impact on the likelihood of adoption. Hence, the feedback effects of previously adopted renewable energy policies are helping states to better serve vulnerable communities. However, there is no evidence of geographic clustering in the diffusion of incentives.

Access to affordable, reliable, and sustainable energy is central to a just and equitable energy transition (Krishnamoorti 2020), especially because the impacts of climate change are becoming more pronounced and frequent (Lee et al. 2023). One way that this is being achieved in the United States is by increasing the share of solar energy in the electricity mix. As deployment increases, the cost of installing residential rooftop solar has been reduced by more than half during the past decade (Feldman et al. 2021). State-level policies and cross-state policy feedback have been critical determinants of increasing the uptake of rooftop solar in general (Trachtman 2023). However, with income-skewed adoption (O'Shaughnessy et al. 2021), many states have attempted to address the inequities and improve access by adopting targeted financing mechanisms and incentives for underserved communities such as low- and moderate-income (LMI) households. Through the Inflation Reduction Act (2022), the Infrastructure Investment and Jobs Act (2021), and the Justice40 Initiative (US White House 2022), the federal government is also aiming to increase access to renewable energy, low-carbon technologies and supply chains, clean energy jobs, and the benefits of decarbonization for vulnerable communities. To maximize energy equity and climate justice benefits for vulnerable populations, it is crucial to understand the determinants of how these policies are created and how they diffuse between states. Can previously adopted energy policies accelerate the adoption and diffusion of these incentives and improve access to rooftop solar for LMI communities? This article evaluates the policy feedback effects—measured by policy choice and output—of energy efficiency policies and electricity-sector portfolio standards on the adoption and diffusion of LMI solar incentives across states between 2010 and 2019.

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Since 2010, the deployment of residential rooftop solar in the United States has increased by approximately 30 times, from 625 to 19,100 megawatts, and costs per installed megawatt have been reduced by more than half (Solar Energy Industries Association 2023). However, the deployment of residential rooftop solar remains skewed by income, and LMI communities are less likely to adopt rooftop solar than higher-income households (O'Shaughnessy et al. 2021). Moreover, under typical utility-rate structures, the cost of supporting the traditional electricity grid disproportionately shifts to vulnerable communities. As a result, the benefits of declining costs, a diversified energy mix, and emissions reduction are not being shared equitably. Many states have adopted LMI solar incentives to address this challenge. By 2020, 27 states had adopted at least one statewide solar incentive for LMI communities. Incentives include direct-financing mechanisms to reduce upfront costs, loans, rebates, revised underwriting mechanisms, and group and third-party ownership mechanisms for rooftop solar in their homes or through community solar projects (O'Shaughnessy et al.2021).

This study integrates theories of policy feedback and policy diffusion to understand the determinants of the adoption and diffusion of LMI incentives. Policy feedback theory evaluates how policies, once created, reshape politics (Mettler and SoRelle 2018). One approach that is central to the theory is the analysis of how previously developed policies affect the likelihood and form of future policy creation. Previous policies impact how social problems are understood; whether they are on the policy agenda and attract government action; and how new policy issues are viewed (Weible and Sabatier 2017).

Feedback effects lead to path dependence in the policy-making process. Path dependence in policy making is a social process in which specific patterns of timing and sequence are significant. This leads to a wide range of social outcomes and consequences from relatively small or contingent events (Pierson 2000). Given the entrenched nature of the status quo in energy policies, policy feedback effects have impacted the likelihood of adoption and diffusion of LMI solar incentives. Most studies on residential rooftop solar either focus on broad state-level policies (Trachtman 2023) or account for the policy challenges of only low-income households (Malhotra 2022; Si and Stephens 2021). This research also includes middle-income households in the discourse because they face policy challenges and barriers to access and solar adoption similar to those experienced by low-income households (Heeter et al. 2021).

The results indicate that the portfolio standards have a positive feedback effect on the likelihood of adoption of LMI solar incentives. States that have a combination of clean, alternate, and renewable portfolio standards are almost 350% more likely to adopt an LMI solar incentive than a state that has none. In contrast, the adoption and diffusion of incentives are independent of the feedback from energy efficiency policies. The likelihood of adoption and diffusion is impacted regressively by previously adopted portfolio standards in neighboring states. That is, states with more neighboring states that have adopted renewable portfolio standards are almost 90% less likely to adopt incentives than states that do not have any neighbors with portfolio standards.

Hence, path dependence in policy making results in positive feedback effects for the adoption and diffusion of LMI solar incentives. The entrenched nature of the policy status quo and stringent renewable policy environments are inducing policy movements to increase the uptake of renewable energy and to focus on the needs of LMI communities through these incentives. At the same time, there is no evidence of geographic clustering in how the incentives are diffusing, and the renewable energy policies adopted by neighboring states do not have positive feedback effects for LMI solar incentives.

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Policy feedback answers the core question of how previously created policies impact subsequent policy making, the policy

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change can be achieved only if the effects of self-reinforcing policy feedback are better understood (Béland, Campbell, and Weaver 2022). Feedback effects may even advance energy and climate policies if the processes of entrenchment and positive triggers for incrementalism are identified appropriately (Hacker 2002; Levin et al. 2012; Page 2006).

Energy efficiency policies have encouraged technologies and practices that use less energy to perform the same activity and, in the process, reduce energy costs and emissions. Similarly, portfolio standards were introduced with the dual objective of reducing emissions and supporting in-state renewable energy production to reduce the cost of electricity. The choice of policy instrument; the decision to adopt a policy; its diffusion, output, and outcomes; and the decision to retain or abandon it shape the feedback effects.

A state's choice and output of these policies are captured using an original metric that measures the decision to adopt the policy, its mechanism, and stringency and scope toward meeting its policy goals. Event History models are used to evaluate how the landscape, and citizens' policy preferences and political behavior (Weible and Sabatier 2017). It builds on historical institutionalism (Pierson 2016; Schattschneider 1935) to link institutional development and path dependence to the study of political behavior (Mettler and SoRelle 2018).

Once they are created and adopted, policies impact how social problems are viewed, what is on the policy agenda and invites government action, how new policy issues are viewed, and how policies change (Weible and Sabatier 2017). Policy changes include those in formal policies (choices), the policy that is delivered (output), and policy impacts and goals (outcomes). This introduces path dependence, wherein the policy choices at a particular time and sequence determine the future of policymaking (Mahoney 2000; Pierson 2000). This can have enduring effects on policy change, new policies, and new politics (Jacobs, Mettler, and Zhu 2022).

Policy adoption and diffusion form the basis of understanding policy innovation and change (Shipan and Volden 2012). One jurisdiction's decision to adopt a policy typically influences another jurisdiction's policies—that is, policy diffusion (Graham, Shipan, and Volden 2013; Shipan and Volden 2008, 2012). Policy adoption and diffusion research has focused primarily on understanding the mechanisms and determinants that facilitate why policies are adopted and why they diffuse between jurisdictions. The pattern that has emerged from this stream of research is that the processes are contingent on the policy itself, the characteristics of the policy areas, and the complexity and compatibility of different policy instruments.

Feedback effects and path dependence in policy making can lead to movement toward a shared policy goal (Pierson 2000). For energy and climate policies especially, these feedback effects tend to lock in policy and institutional arrangements over time. This is due to the sunk costs associated with the current system; the policy experience accumulated around established technologies, standardized mechanisms, and methods of financing; and the increasing benefits of moving toward an established policy direction with the accumulated experience (Unruh 2000). This can result in interrelationships between different policy instruments addressing the same policy challenge, rendering new policies conditional on previously adopted policies (Mahajan and Peterson 1978).

Positive feedback effects result in a higher likelihood of stringent and stable policy environments (Moore and Jordan 2020). Simultaneously, more stringent policies targeted at emissions reduction have had positive feedback effects that have spurred greater industrial and policy innovations and resulted in better public health outcomes than less stringent policies (Ahmad and Zheng 2021; Porter and ven der Linde 1995; Prokop et al. 2023). Energy efficiency policies, portfolio standards, and solar incentives have the common policy goals of reducing costs and lowering emissions. If the feedback effects of energy efficiency policies and portfolio standards have impacted the adoption and diffusion of LMI solar incentives, then it can be hypothesized that:

H*$_1$*: States with more stringent energy efficiency policies will be more likely to adopt LMI incentives than states with less stringent energy efficiency policies.

H*$_2$*: States with more stringent portfolio standards will be more likely to adopt LMI incentives than states with less stringent portfolio standards.

If these hypotheses hold, then states with more stringent energy efficiency policies and portfolio standards will experience positive feedback effects and be more likely to adopt LMI solar incentives.

Many studies of policy diffusion relied on the lens of geographic clustering; that is, how proximity between neighboring states influences policy innovation, adoption, and diffusion (Savage 1985). The diffusion and adoption of more than 700 state-level policies from the 1950s to the 2000s across areas of public service, criminal justice, economics, and civil rights were found to be best predicted by geographic clustering (DellaVigna and Kim 2022). As solar deployment greatly depends on the incidence of solar energy and geographic location (Adeh et al. 2019), adjacent states may be more likely to adopt similar policies.

Recent scholarship on rooftop solar policies suggests that cross-state feedback effects have resulted in the mobilization of installers across state lines and have impacted policy decisions across all states (Trachtman 2023). Similar to Trachtman (2023), this study does not investigate the diffusion mechanisms of learning, coercion, competition, and imitation (Shipan and Volden 2008) or argue that the mechanisms have not impacted the adoption and diffusion of LMI solar incentives. Instead, it theorizes that policy feedback effects coexist with these mechanisms. To account for the feedback effects of geographic clustering, it can be hypothesized that:

H*$_3$*: States with a greater proportion of neighboring states with energy efficiency policies and portfolio standards will be more likely to adopt LMI incentives than states with a lower proportion of neighboring states with these policies.

If this hypothesis holds, states with a greater proportion of neighboring states with energy efficiency policies and portfolio standards will experience positive feedback effects and be more likely to adopt LMI solar incentives.

DATA AND MEASUREMENT

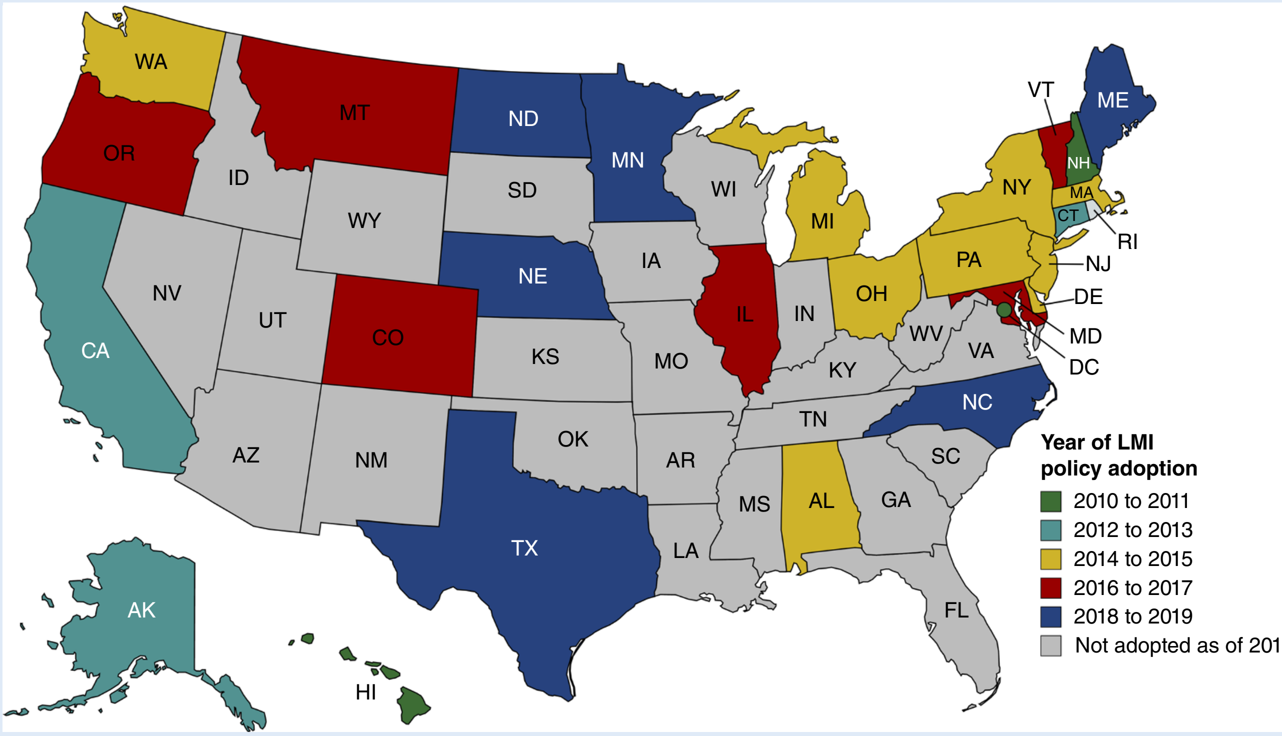
This study uses panel data from US states between 2010 and 2019. The dataset was constructed to account for the adoption of LMI solar incentives across states and the year of adoption, resulting in 406 observations that comprise state–year pairs (Datta 2024).

Dependent Variable

National Renewable Energy Laboratory (2021) guidelines on the policy and financing mechanisms used by state, local, and tribal governments to support the development of efficient, affordable, and resilient energy systems were used to determine the policies that qualify as LMI solar incentives. These incentives are administered as Solarize, Residential Property Assessed Clean Energy programs, financial rebates, Smart-E Loans, solar rewards programs, the Multi/Single-Family Affordable Solar Housing Program, Solar for All community programs, and pilot programs. After these programs were identified, the Database of State Incentives for Renewables & Efficiency (DSIRE) was used to code where and when LMI solar incentives have been adopted (North Carolina State University 2021). The DSIRE database includes a list of policies and incentives in each state that support renewables and energy efficiency. The database helped to identify whether the LMI incentive was adopted statewide, the year of its adoption, and a summary of the benefits.

The dependent variable was the duration or the time until a state adopted a statewide LMI solar incentive. The dataset ranged from 2010, when the first statewide adoption occurred, to 2019. To calculate the time to adoption, the event occurrence was calculated first and coded dichotomously: 0 for the year(s) when the state did not have an incentive and 1 for the year the policy was adopted (figure 1). The time to LMI adoption variable was calculated based on the number of years for the event to occur since the beginning of the dataset. After a state adopted an LMI incentive, it was deleted from the dataset. For example, Alabama adopted a statewide LMI solar incentive in 2015. Hence, the event-occurrence variable for Alabama was coded as 0 from 2010 to 2014 and 1 for 2015; the time until adoption was six years; and the state was deleted from the database thereafter. States without an LMI solar incentive at the end of 2019 had a time to adoption of 11 years.

Figure 1
Adoption of LMI Solar Incentives in US States, 2010–2019



Independent Variables

The key independent variables captured whether a state has energy efficiency policies and electricity-sector portfolio standards; the sectoral scope of these policies in the state; and their stringency in terms of advancing decarbonization of the electricity grid, in general, and aiding solar energy. US Energy Information Administration (2021) data on the types of energy efficiency policies and electricity-sector portfolio standards were used to identify the categories for the independent variables. The Center for Climate and Energy Solutions (2021) provides a map of the categories of policies in each state for energy efficiency and electricity-sector portfolio standards, similar to figure 2. The database summarizes the policy and links it to the legislative text for each state that has adopted it.

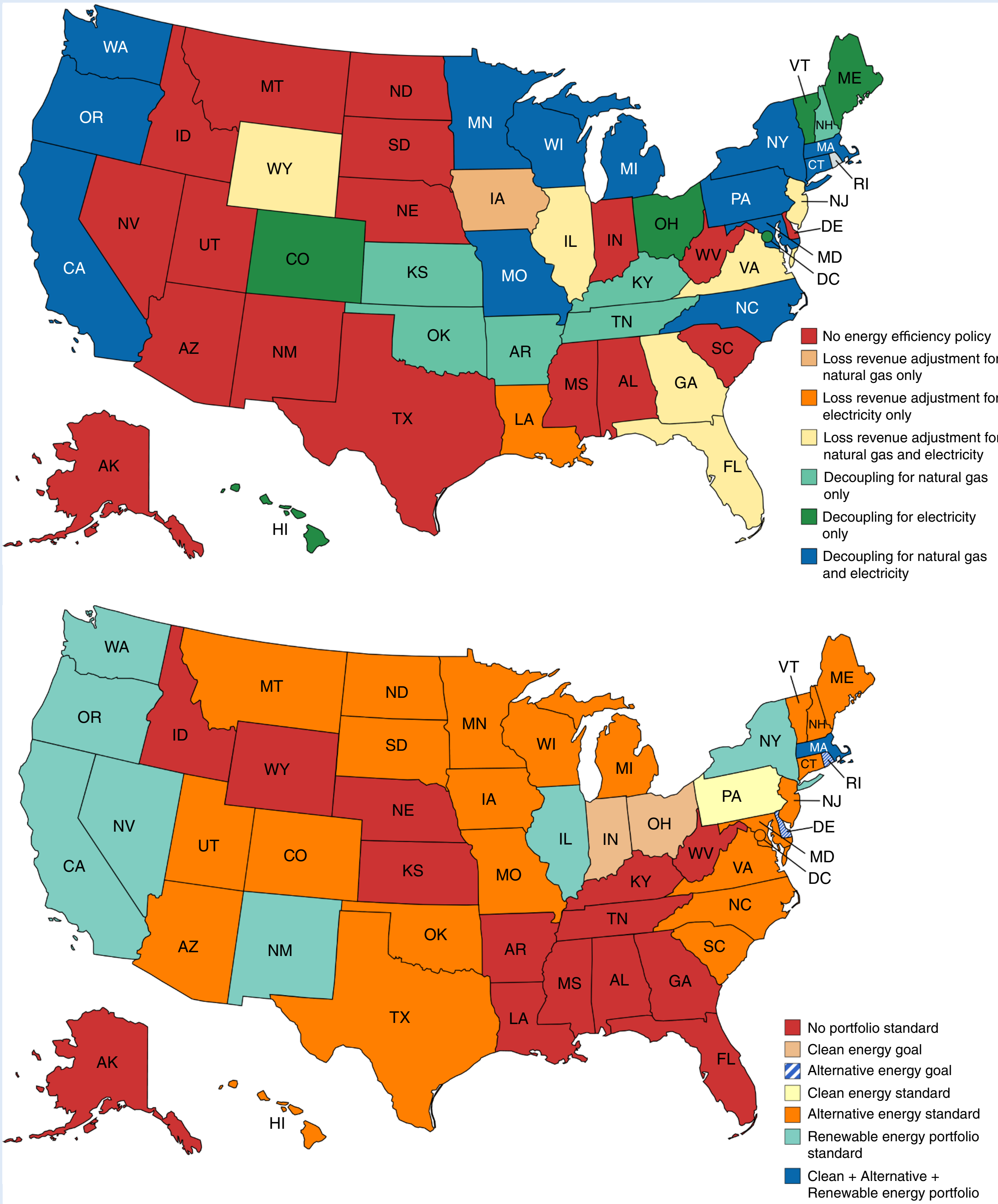
These data were used to develop the key independent variables on an ordinal scale to quantify their stringency and scope, wherein 0 indicated the state's choice of not adopting a policy and 1–6 captured the output in terms of sectoral scope and design and how it aims to achieve its policy goal. Additionally, any policy changes between 2010 and 2019 were captured on this scale. A limitation of this operationalization is that the policies were measured on a continuous scale that distinguishes within the policy types to capture their stringency but treats a unit increase as meaningful and similar across the categories. However, by using this scale, this study differentiates between the type of policy, which much past research has not used (Greenstone and Nath 2019; Shrimali et al. 2015), and it aims to simplify the challenges associated with modeling these policies (Wiser, Porter, and Grace 2005; Zhou, Solomon, and Brown 2024). Additional details of the measurement and alternative model specifications that were used as robustness checks to mitigate the limitations are in the online appendix.

Whether or not (choice) a state has an energy efficiency policy and portfolio standard in place and the type of policy adopted and delivered (output) in each state were used to determine the stringency and scope of the policy. For energy efficiency policies, the output was measured in terms of lost revenue adjustment (LRA) programs and decoupling programs. An LRA allows rate adjustment such that a utility—natural gas–based, electricity, or both—can recover any revenue that may be reduced specifically because of energy efficiency policies (Gilleo et al. 2015). Whereas energy efficiency leads to financial benefits for the consumer, the producer incurs a loss from the sale of fewer units of energy. Decoupling allows regulators to adjust utility rates to break the link between the natural gas or electricity sold by the utility company and the revenue (National Renewable Energy Laboratory 2009). In doing so, decoupling allows for electricity rates to fluctuate such that revenue is fully recovered and is indifferent to changes in sales due to any factor, including energy efficiency programs and weather patterns.

LRA requires utilities to pre-assess energy savings over a specific timeframe, whereas decoupling does not mandate this and therefore is adjusted to demand. In this study, decoupling is considered more stringent because it accounts for factors outside

Figure 2

Energy Efficiency Policies and Portfolio Standards for Renewable Energy in US States, as of 2019



of sales (e.g., new standards and codes) and reduces the incentives for demand-side management programs (Electricity Consumer Resource Council 2009). The scope was analyzed based on the policy sectors: any policy that applied to only natural gas sales was considered less impactful for solar than policies that were applied to all electricity utilities.

Therefore, states without any LRA or decoupling measures were scored the lowest (0); LRA for gas utilities was coded as 1; LRA for electricity utilities was 2; LRA for electricity and gas utilities was 3; decoupling revenue from the volume of sale for gas utilities was 4; decoupling revenue from the volume of sale for electricity utilities was 5; and those with decoupling for both gas and electricity utilities were coded as 6. Hence, the stringency was determined by the type of policy in terms of its impact on revenue, and the scope was determined by whether policies applied to natural gas, electricity utilities, or both.

For electricity-sector portfolio standards, output was measured in terms of clean energy goal/standard, alternate goal/standard, and renewable portfolio goal/standard. Typically, each state defines qualifying electricity sources and, over time, increases the amount of clean, alternate, or renewable capacity or generation to meet the standard least expensively (Rabe 2010). Although the policy has many types and categories, these are known collectively as electricity-sector portfolio standards (Lawson 2020).

The clean energy types encourage low-carbon electricity generation from all eligible sources, including fossil fuels (US Energy Information Administration 2022). Because these types do not focus specifically on renewable sources, they were considered less stringent for solar energy than the alternative and renewable types. The alternative type encourages alternate sources of only thermal energy and includes production technologies such as combined heat and power and energy-efficient steam technology. The alternative policies encourage reduced reliance on fossil fuels and, therefore, were considered more stringent than the clean energy type but less stringent than the renewable type, which includes wind, solar, hydro, geothermal, and biomass (Lawson 2020). Finally, the scope was determined based on statutory limits. A goal is not statutorily binding and signals only the intent to achieve a policy benchmark; however, a standard is more stringent and is statutorily binding (Center for Climate and Energy Solutions 2021; Solomon and Zhou 2021; Zhou and Solomon 2020). Any goal was considered less impactful than a standard because there are no statutory obligations to achieve it.

Therefore, having no portfolio goal or standard was scored as 0; a clean energy goal as 1; an alternative energy goal as 2; a clean energy portfolio standard (CPS) as 3; an alternative energy portfolio standard (APS) as 4; a renewable portfolio standard (RPS) as 5; and a combination of all three (i.e., CPS, APS, and RPS) as 6. Hence, the stringency was determined by the type of the policy in terms of its impact on solar energy, and the scope was determined by whether policies are statutorily binding.

The proportion of neighboring states that have energy efficiency policies and portfolio standards for renewable energy was calculated based on each of those states that had the policy in place for a given year. The categories for measurement and the state of the policies in 2019 are presented in Figure 2.

The data are suited for Event History Analyses that incorporate time-varying covariates. The hypotheses were tested using Cox Proportional Hazard models. Model 1 evaluated the feedback effects of energy efficiency policies and portfolio standards; Model 2 evaluated the feedback effects of geographic clustering; Model 3 served as a robustness check and evaluated the competing effect of vertical diffusion; and Model 4 was the full model.

Two additional model specifications were tested as robustness checks. First, an Event History Analysis used the key independent variables as a battery of dummies in which the baseline category was no energy efficiency policy and no electricity-sector portfolio standards, respectively (see online appendix table S3). Second, a dynamic logistic regression with state-fixed effects that specified the likelihood of LMI solar incentive adoption, based on the event-occurrence variable, was the independent variable (see online appendix table S4). Both models support the substantive results discussed in the next section.

RESULTS

The Schoenfeld residuals diagnostic test was used to check for the proportional hazards assumption. The results (see online appendix table S2) confirm that the full model did not violate the proportional hazards assumption; all p-values were greater than 0.05; and the global test on 12 degrees of freedom resulted in a p-value (0.27) that was not statistically significant. Hence, the proportional hazards assumption holds.

As Cox Proportional Hazard models were used for the Event History Analyses, the results in Table 1 are discussed based on the hazard ratio (exp(b)). Model 1 suggests that a one-unit increase in energy efficiency policies results in a 17.8% increase in the probability of LMI solar incentive adoption while holding other factors constant. Model 1 also suggests that a one-unit increase in portfolio standards for renewable energy results in a 43.9% increase in the probability of adoption. However, the full model disproves Hypothesis H_1. Specifically, a one-unit increase in energy efficiency policies results in a 1.8% decrease in the probability of adoption. However, the evidence is not statistically robust and does not support the hypothesis that those states with more stringent energy efficiency policies will be more likely to adopt LMI incentives than states with less stringent energy efficiency policies. The effect size of portfolio standards is greater in the full model as compared to Model 1. The full model suggests that a one-unit increase in portfolio standards results in a 57.5% increase in the probability of LMI solar incentive adoption. The results provide robust and consistent evidence confirming that those states with more stringent portfolio standards will be more likely to adopt LMI incentives than those with less stringent portfolio standards.

Whereas Model 2 provides statistically significant evidence that energy efficiency policies in neighboring states increase the probability of adoption, the effect size is reduced and the statistical significance for energy efficiency policies is eliminated in the full model. Moreover, portfolio standards have a regressive impact on the probability of adoption. The full model suggests that a one-unit increase in the proportion of neighboring states with portfolio standards results in an 88.9% decrease in the probability of adoption. This disconfirms that those states with a greater proportion of neighboring states with energy efficiency policies and portfolio standards will be more likely to adopt LMI incentives than states with a lower proportion of neighboring states with these policies.

To evaluate whether this could be a result of competing vertical diffusion based on the intergovernmental transfer of funds, Model 3 analyzes the impact of federal spending on renewable energy in

Table 1
Results from the Event-History Analysis

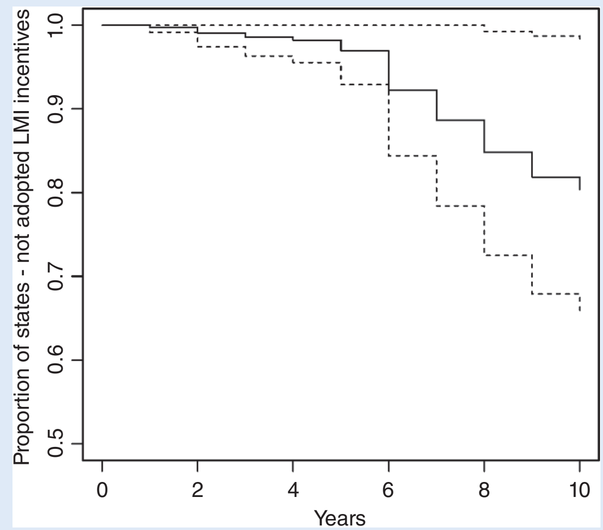
	Dependent Variable: Time to LMI Adoption			
	(1)	(2)	(3)	(4)
Efficiency Policy	0.164*			–0.018
	(0.084)			(0.111)
Electricity-Sector Portfolio Standards	0.364***			0.454**
	(0.141)			(0.213)
Solar Potential				–0.113***
				(0.039)
Proportion of Solar in Energy Mix				28.983
				(51.253)
Average Annual Electricity Bill				0.028**
				(0.012)
Renewable Energy Interest Groups				–0.0002
				(0.004)
Proportion of Population Living Below Federal Poverty Level				–0.166
				(0.103)
Federal Spending on Renewable Energy			0.015	0.101
			(0.064)	(0.080)
Governor's Party				0.331
				(0.259)
Legislative Control				0.368
				(0.366)
Neighboring States' Efficiency Policies		1.428*	1.467*	0.854
		(0.759)	(0.779)	(0.922)
Neighboring States' Electricity Portfolio Standards		–0.259	–0.283	–2.196*
		(0.539)	(0.567)	(1.159)
Observations	406	406	406	405
R^2	0.031	0.011	0.011	0.096
Maximum Possible R^2	0.339	0.339	0.339	0.339
Log Likelihood	–77.696	–81.823	–81.796	–63.579
Wald Test	12.040***	4.040	4.010	27.590***
	(df=2)	(df=2)	(df=3)	(df=12)
Likelihood Ratio Test	12.680***	4.425	4.480	40.775***
	(df=2)	(df=2)	(df=3)	(df=12)
Score (Logrank) Test	12.955***	4.174	4.188	39.324***
	(df=2)	(df=2)	(df=3)	(df=12)

Notes: *p<0.1; **p<0.05; ***p<0.01

each state. However, there is no statistically significant evidence for competing vertical diffusion.

The likelihood-ratio, Wald, and Score chi-square statistics are asymptotically equivalent tests of the omnibus null hypothesis that all of the coefficients are 0. The omnibus null hypothesis was rejected because the test statistics are comparable across and within the models. Figure 3 plots the survival function for the full model, with the number of years to LMI solar incentive adoption on the x-axis and the proportion of states that have not adopted an incentive on the y-axis. The proportion of states that have not adopted incentives declines over time. Specifically, in year 10, the survival proportion is approximately 0.80. It is noteworthy that a small proportion of states had adopted the incentives until 2015, and a majority of the uptake for the incentives occurred around or after 2016 (year 6). These trends corroborate the adoption patterns presented in Figure 1.

Figure 3
Survival Function for the Full Model



DISCUSSION

Despite prolific growth across US states, the deployment of rooftop solar remains skewed by income, and the benefits are not reaching vulnerable populations (O'Shaughnessy et al. 2021). One solution to increase deployment and share the benefits equitably is to improve access to solar through targeted incentives that can increase the uptake among LMI communities.

By integrating policy feedback theory and theories of policy diffusion, this article evaluates the feedback effects of energy efficiency policies and electricity-sector portfolio standards on the adoption and diffusion of LMI solar incentives. The results suggest that a state's decision to adopt an LMI incentive has been conditional on its portfolio standards but independent of energy efficiency policies. Overall, policy choices and policy output indeed are impacting policy change for both low- and middle-income communities faced with barriers to solar adoption and access.

The feedback effects of a state's decision to increase the proportion of renewable energy in its energy mix through portfolio standards have impacted the adoption of targeted benefits for vulnerable LMI communities and how LMI solar incentives have diffused across states. US states that have adopted a combination of clean, alternate, and renewable portfolio standards are almost 350% more likely to adopt an LMI solar incentive than a state that has not adopted a portfolio standard. Hence, path dependence in policymaking, the entrenched nature of the status quo in energy policies, and stringent renewable policy environments have led to positive feedback effects for LMI communities.

The portfolio standards in neighboring states have a regressive impact on the probability of adoption. States that have more neighboring states that have adopted renewable portfolio standards are almost 90% less likely to adopt an LMI solar incentive than states that have none that have adopted portfolio standards. Therefore, even though more than half of the states had adopted a statewide LMI incentive between 2010 and 2019, and solar adoption is dependent on solar incidence and geographic location, there is no evidence of positive feedback effects from clustering.

The finding that portfolio standards have positive feedback effects for the adoption and diffusion of LMI solar incentives underscores that the policy experience accumulated around established technologies, standardized mechanisms, and methods of financing; the benefits of moving toward an established policy direction; and locked-in institutional and policy arrangements (Unruh 2000) from previously adopted policies is valuable. Theoretically, this finding highlights that path dependence can lead to positive feedback effects. Using feedback effects from previously adopted policies can help policy makers and practitioners better serve the policy needs of vulnerable communities.

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...path dependence in policy making, the entrenched nature of the status quo in energy policies, and stringent renewable policy environments have led to positive feedback effects for LMI communities.

Proximity does not matter in the context of LMI solar incentives. Although rooftop solar policies, in general, have been influenced by cross-state policy feedback effects (Trachtman 2023), neighboring states' policy choices do not have the same effect on LMI solar incentives. Although this finding is not as expected, the absence of clustering supports the theoretical argument that while analyzing geographic clustering provides a good starting point, the approach can be overly limiting and sometimes misleading (Shipan and Volden 2012). State policy makers may not be relying on the determinants of diffusion that impacted state policy and politics from the 1950s to the 2000s (DellaVigna and Kim 2022), and they might be looking beyond their neighboring states for lessons in prioritizing the policy needs of vulnerable communities.

Past studies on the cross-state and regional impacts of electricity-sector portfolio standards have found strong positive effects (Bowen and Lacombe 2017; Zhou, Solomon, and Brown 2024). However, they evidence that regional interconnections and electricity markets choose the lowest-cost locations to serve renewable load in states with more stringent policies. For states that do not have a low-cost advantage, this typically means trading renewable energy certificates (RECs) with their neighboring states to meet the state's policy goals while benefiting from the regional increase in the production of renewable energy (Yin and Powers 2010). However, this would likely lower the likelihood of the state adopting LMI solar incentives if its electricity-sector targets are met through RECs purchased from neighboring states instead of more in-state solar deployment. From a policy choice and implementation perspective, this could explain the strong negative effect of neighboring states' electricity-sector portfolio standards on a state's decision to adopt LMI solar incentives. As more states adopt policies directed at LMI households, future research can explore the cross-state effects of LMI policies while also accounting for the electricity-sector portfolio standards and adding the stringency of LMI incentives.

Previous policies impact which issues are on the policy agenda and attract government attention in the form of new policies. Hence, understanding the adoption and diffusion of new policies in conjunction with the feedback effects can lead to new theoretical insights and new avenues for research in the study of public policy, state policy and politics, and energy and climate policy making. This introduces new learning opportunities for energy and climate policy makers and practitioners as well. At the same time, cross-state feedback effects may not always be positive, especially for protecting vulnerable communities against the worst impacts of climate change. Future research that builds on this study can focus on the differences in access and uptake for LMI incentives between low- and middle-income communities and the policies and programs that states can adopt to improve energy equity and climate justice for both communities.

SUPPLEMENTARY MATERIAL

To view supplementary material for this article, please visit http://doi.org/10.1017/S1049096524000635.

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DATA AVAILABILITY STATEMENT

Research documentation and data that support the findings of this study are openly available at the *PS: Political Science & Politics* Harvard Dataverse at https://doi.org/10.7910/DVN/ML09LM.

CONFLICTS OF INTEREST

The author declares that there are no ethical issues or conflicts of interest in this research. ■

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