# The Impacts of Policies and Business Models on Income Equity in Rooftop Solar Adoption

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**Presentation based on paper published in *Nature Energy* of the same title**

**See: https://emp.lbl.gov/publications/impact-policies-and-business-models.**

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# Summary

- Low- and moderate-income (LMI) households are less likely to adopt solar photovoltaics (PV) than higher-income households.
- PV adoption inequity may perpetuate energy justice issues and decelerate PV deployment.
- We explore the impacts of five policy and business model interventions on PV adoption equity.

## Key findings:

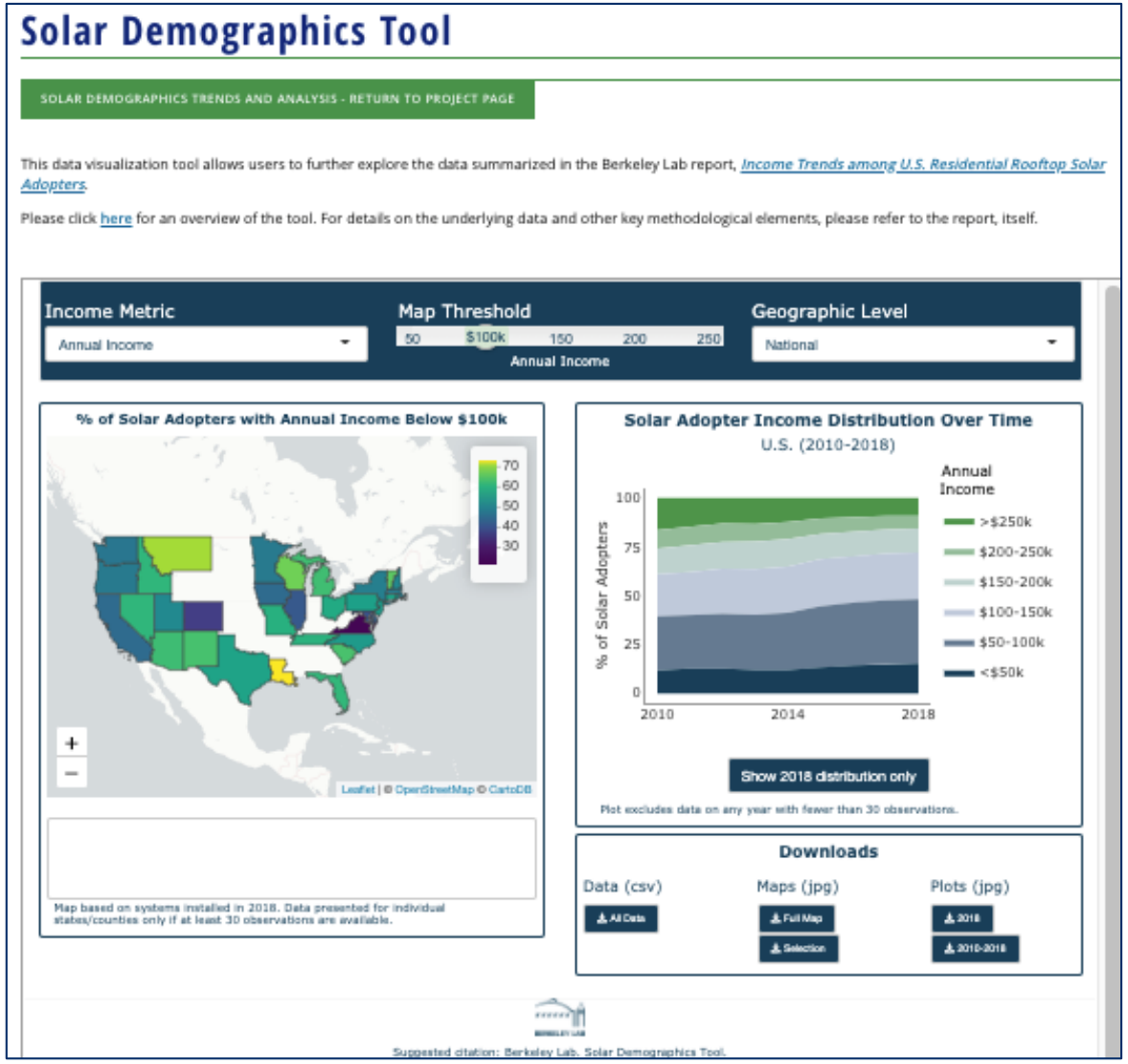
Three of the five interventions are associated with more equitable PV adoption: LMI-targeted incentives, leasing, and property-assessed financing

The interventions increase adoption equity in existing markets (deepening the market) and push PV deployment into under-served low-income communities (broadening the market).

Photo by Dennis Schroeder, NREL 45243

# LBL Solar Demographics Tracking

- This presentation is part of a broader Lawrence Berkeley National Laboratory effort to collect and analyze rooftop solar adopter demographic data.
- Additional resources, including an interactive tool and data, are available at: https://emp.lbl.gov/projects/solar-demographics-trends-and-analysis



# Solar Adopter Income Trends

- High-income households have adopted rooftop PV at higher rates than LMI households.
- LMI adoption has steadily increased over time, increasing solar adoption equity.[1]

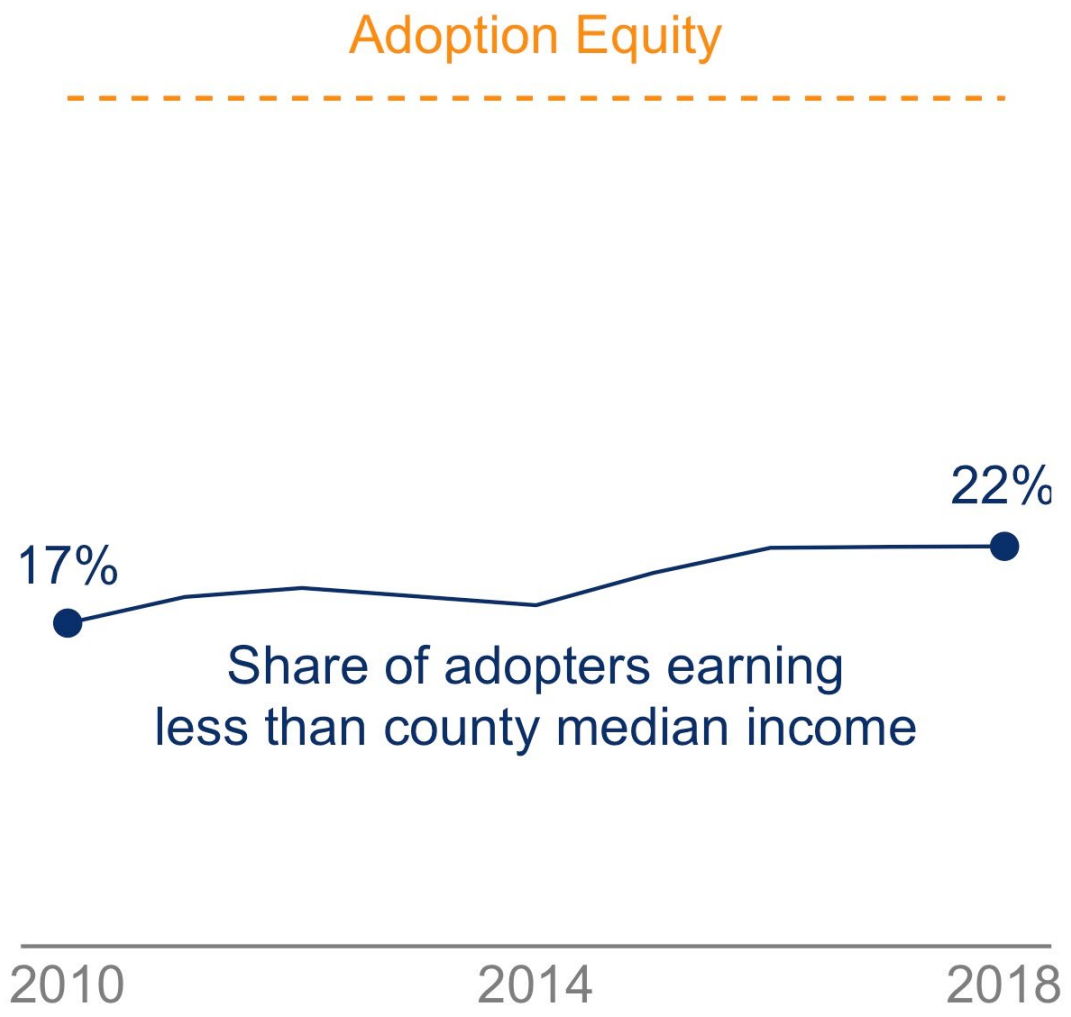



**Figure:** Share of PV adopters earning less than county median income. Based on data from the LBL Solar Demographics Tool.

[1] Barbose et al. (2020)

# Solar PV Adoption Inequity

- High-income households remain about 4 times more likely to adopt PV than low-income households.
- PV adoption inequity is reinforced by deployment patterns that funnel systems into relatively affluent areas.

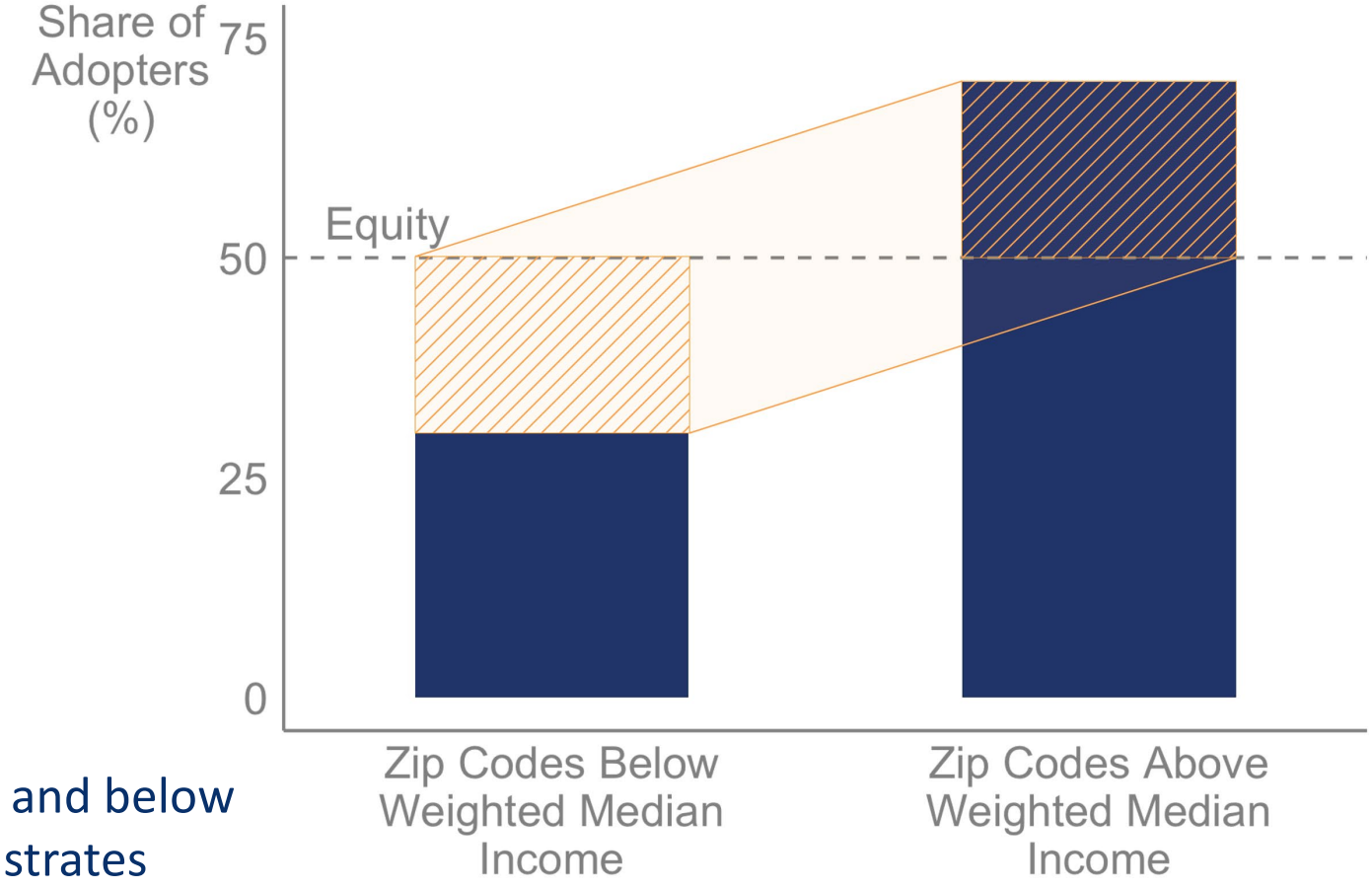



**Figure:** Share of PV adopters in zip codes above and below weighted median income. The line of equity illustrates where shares would fall if PV were distributed equitably.

# The Problem

- **Energy justice:** PV adoption inequity could perpetuate energy justice issues.[1,2]
- **Energy burden:** PV could reduce LMI energy burdens—the disproportionately large shares of LMI household budgets dedicated to energy expenses. PV adoption inequity limits LMI access to these benefits.
- **Cross-subsidization:** Under typical residential electricity rate structures, PV adoption by non-LMI households may increase LMI energy bills.[1]
- **Decelerated deployment:** PV adoption inequity could decelerate PV deployment. About 42% of PV-viable rooftop space is on LMI buildings.[3]

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[1] Brown et al. (2020); [2] Carley & Konisky (2020); [3] Sigrin & Mooney (2018)

# Potential Solutions

- LMI households face several barriers to PV adoption, including cash constraints, lower home ownership rates, and language barriers.
- Certain policy and business model interventions may address these barriers and increase PV adoption equity.
- Here, we explore the impacts of five policy and business model interventions on PV adoption equity:

| Incentives | LMI Incentives | Leasing | PACE | Solarize |
|---|---|---|---|---|
| Financial incentives available to all adopters | Incentives restricted to income-eligible adopters | Business model allowing customers to lease rather than buy PV system* | Property-assessed clean energy financing | Bulk PV purchasing campaign |

* For the purposes of our study, we use the term "leasing" to refer to all third-party owned PV products, including power purchase agreements.

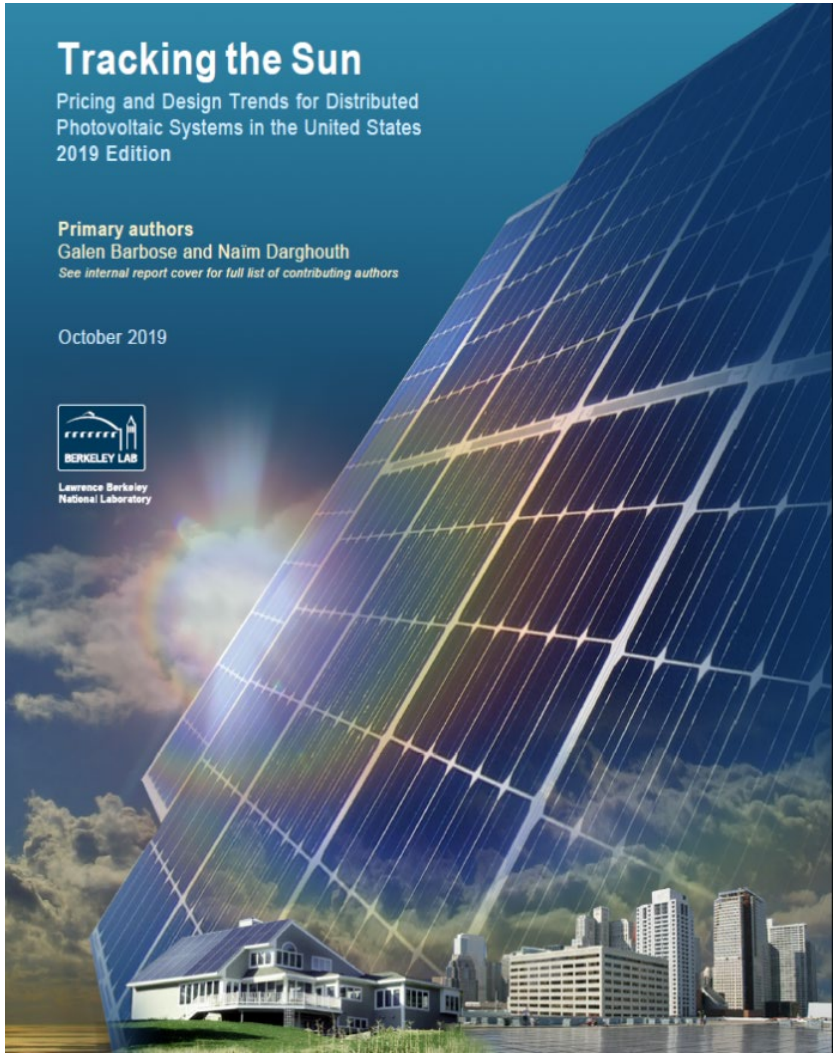
# Research Questions

Which interventions are associated with higher PV adoption equity?

Do these effects stem from increasing LMI PV adoption in existing markets ("deepening" markets) or by driving PV deployment into under-served LMI communities ("broadening" markets)?

# Data

- Our study leverages Lawrence Berkeley Lab's *Tracking the Sun* (TTS) data set. Most of the TTS data are publicly available, see: https://emp.lbl.gov/tracking-the-sun.
- We combine the TTS data with modeled household-level income estimates from Experian.
- The final data set comprises 1,007,459 records on PV systems installed from 2010 to 2018 on single-family homes in 18 states.
- We use U.S. Census data to generate demographic variables for the general population.



# Metrics

**LMI Household**
Household earning less than their county's median income

**Adopter Income Bias**
Difference between adopter's modeled income and their county's median income.

**Low-Income Community**
Zip code in the bottom quartile of median household incomes relative to other zip codes in the same state

**LMI PV Adoption Rate**
Number of LMI households that adopted PV in a given zip code in a given quarter per 1,000 owner-occupied LMI households

# Methods

**Analysis of Income Bias**

We assess relationships between the interventions and adopter income bias through a fixed-effects regression.

**Effects on LMI PV Adoption Rates**

We test changes in LMI PV adoption rates before and after interventions were implemented.

**See paper for methodological details**

# Analysis of Income Bias

- Three of the five interventions are associated with lower adopter income bias:
  - LMI incentives
  - Leasing
  - PACE
- These effects are robust to numerous alternative model specifications
- Incentives and Solarize were not associated with less income bias

**Table:** Regression Results – Analysis of Adopter Income Bias

| | Y = Adopter Income Bias |
|---|---|
| Incentives | 5.97* |
| LMI incentives | -47.20* |
| Leasing | -11.31* |
| PACE | -8.70* |
| Solarize | 1.41 |

# LMI Adopters Use the Interventions at Higher Rates

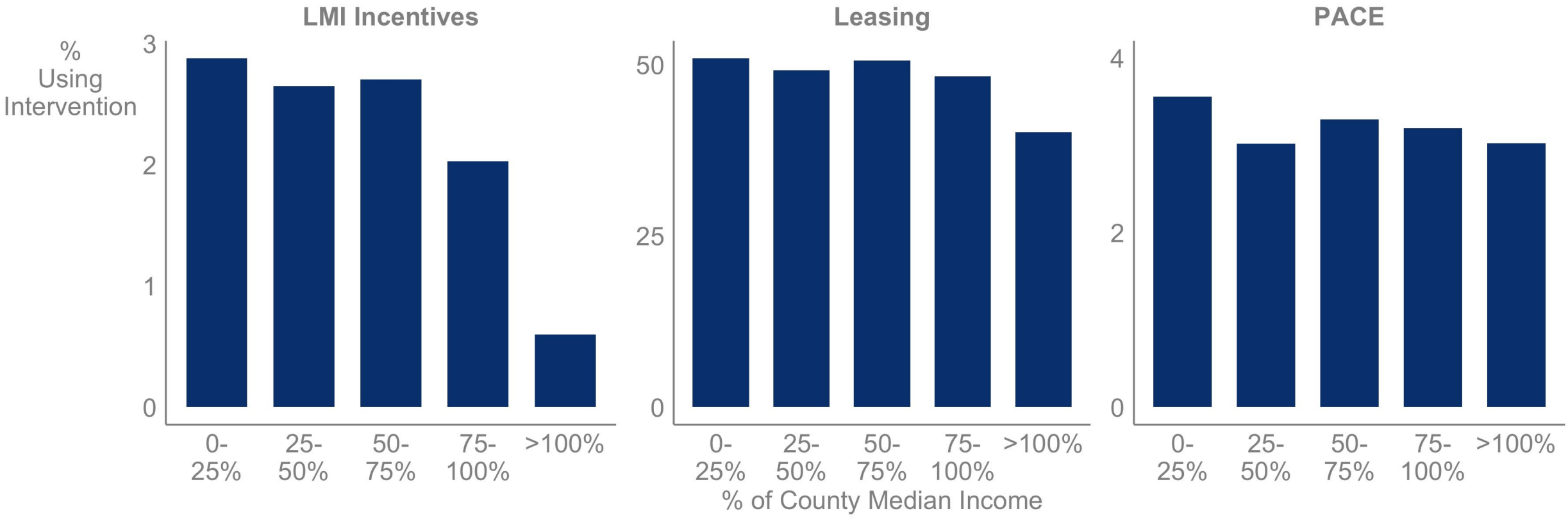



**Figure:** Share of adopters using interventions by household income as percentage of county median income

# Effects on LMI PV Adoption Rates

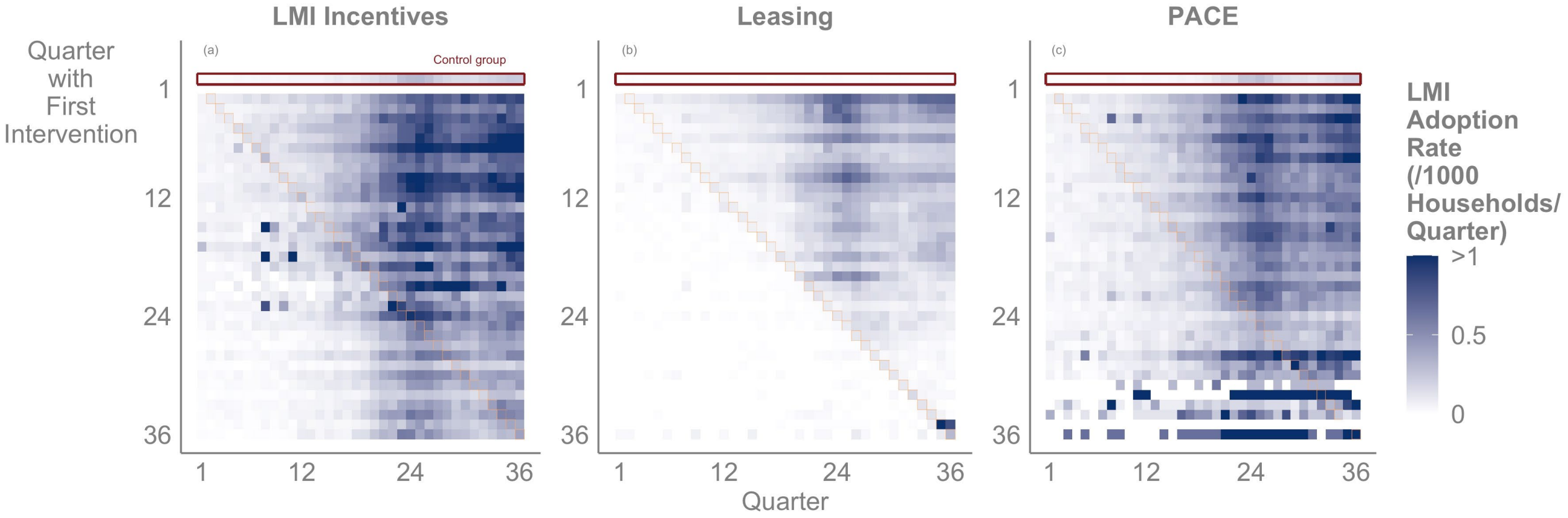



**Figure:** LMI adoption rates by quarter in groups of zip codes that first used interventions in the same quarters (see paper for further clarity)

# Effects on LMI PV Adoption Rates

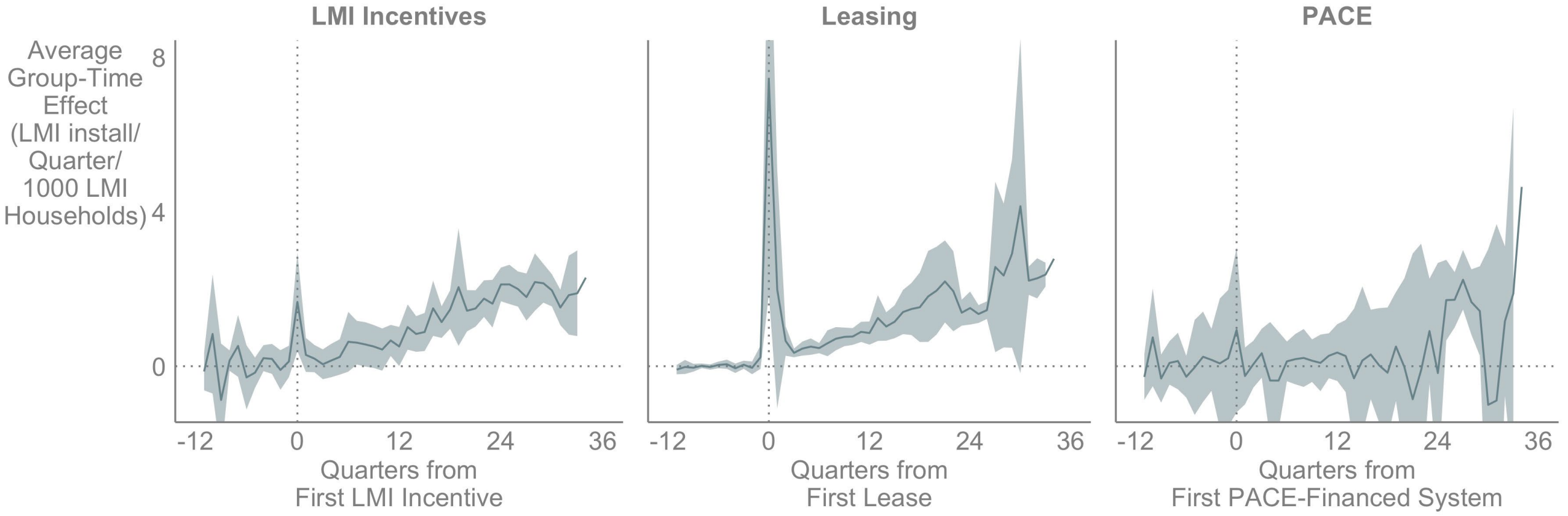



**Figure:** Average group-time effects by intervention. Positive group-time effects represent higher LMI adoption rates. LMI incentives and leasing are associated with significant initial and lagged increases in PV adoption rates (see paper for further clarity).

# Deployment Shifting

The data suggest that the interventions are used disproportionately in LMI communities, providing evidence that the interventions shift deployment into previously under-served communities.

4.7%
of adopters in
**low-income communities** receive
**LMI Incentives**
compared to
0.7%
in other areas

48.6%
of adopters in
**low-income communities** use
**leasing**
compared to
41.5%
in other areas

3.4%
of adopters in
**low-income communities** receive
**PACE**
compared to
3%
in other areas

# Deployment Shifting

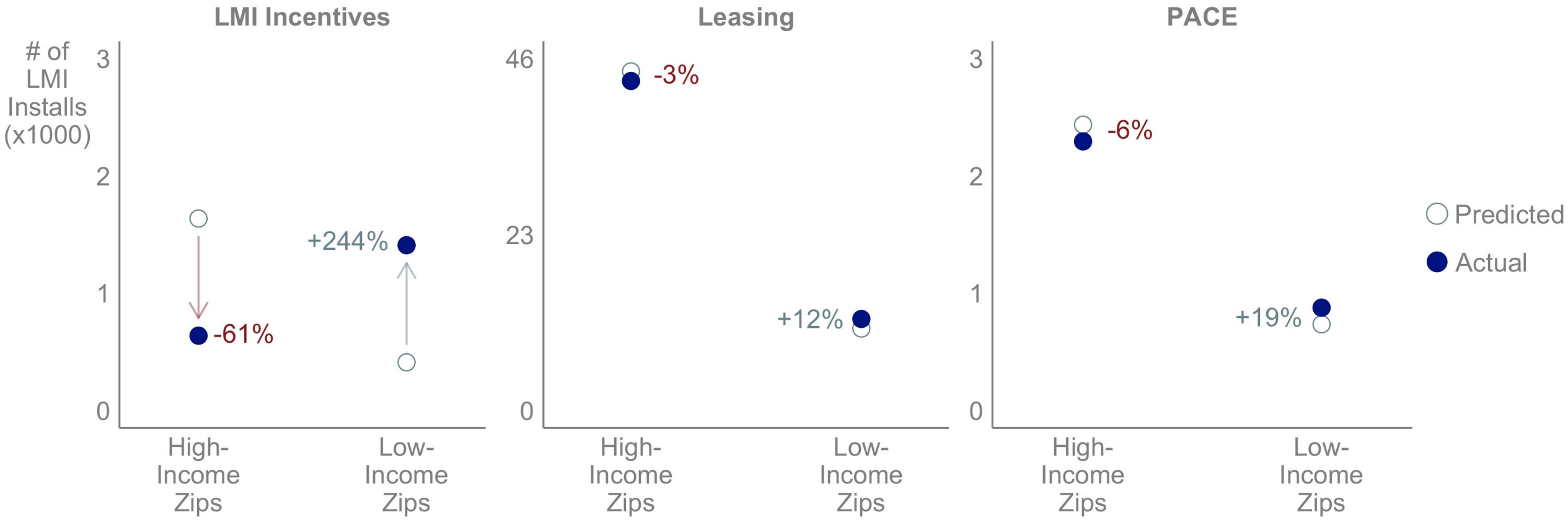
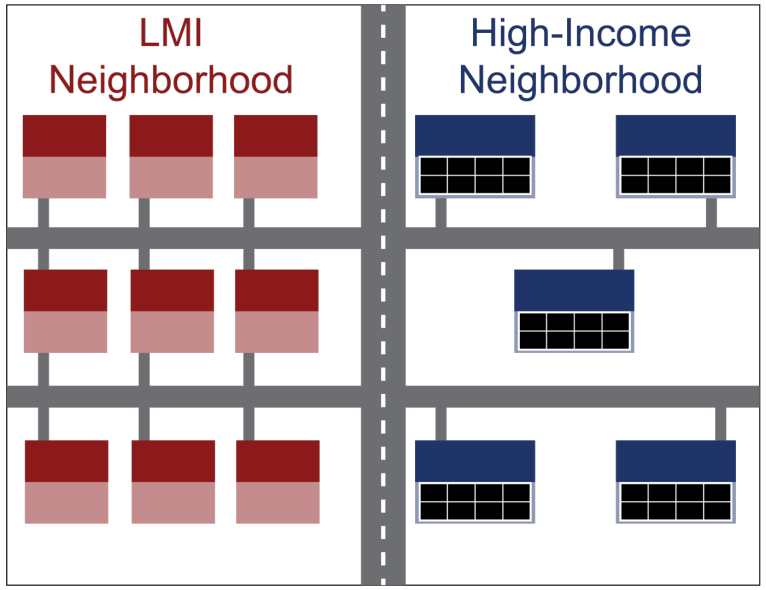
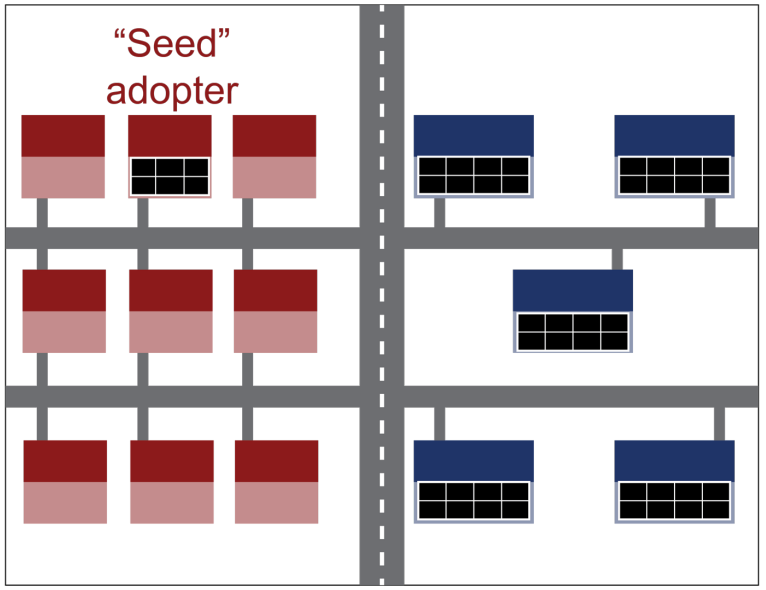



**Figure:** Predicted and actual LMI deployment levels in high- and low-income zip codes by intervention. In each case, LMI adoption rates of intervention-supported systems exceed projections in low-income zips, consistent with deployment shifting (see paper for further clarity)

# Discussion: The Implications of Deployment Shifting




Traditional PV deployment patterns funnel PV systems into high-income neighborhoods




Interventions could create a “seed” adopter in an LMI neighborhood


By driving systems into LMI neighborhoods, interventions could catalyze spillover impacts from forces such as peer effects or by attracting more installers into LMI areas

# Conclusions

Three of the five interventions are associated with more equitable PV adoption: LMI-targeted incentives, leasing, and property-assessed financing

The interventions increase adoption equity in existing markets (deepening the market) and also push PV deployment into under-served low-income communities (broadening the market).

Photo by Dennis Schroeder, NREL 45243

# Further Research

- Future research can explore how effectively more equitable PV adoption could address energy justice issues (e.g., energy burden) relative to other potential pathways.
- Future research can explore the potential spillover impacts associated with deployment shifting.
- Future research can explore other potential interventions, including interventions not designed specifically for rooftop PV, such as community solar.

## Contacts

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