Household Solar Panel Adoption

Victor Besse

December 9, 2024

Introduction

- Increasing focus on renewable energy to combat climate change.
- Residential solar panels are a key component of energy transition.
- Adoption rates vary significantly across regions and households.
- Aim: To understand factors influencing adoption and evaluate policy impacts.

Motivation and Research Questions

- Policymakers need insights on:
  - Effectiveness of subsidies and tariffs.
  - Hetereogeneity in responses to policy.
- Research Questions:
  - How do households decide to adopt solar panels?
  - What policies best incentivize adoption given state of "nature"?

Literature Review

- **Dynamic Adoption Models:**
  - Souyris, Duan, et al. (2022): Forward-looking model of solar adoption, accounting for policy incentives and energy demand.
  - De Groote and Verboven (2019): Effects of subsidies on solar panel adoption.
- **Policy Analysis:**
  - Borenstein (2017): Efficiency and distributional impacts of energy policies.
- These papers integrate dynamic modeling with spatial and heterogeneity considerations to evaluate adoption and policies.

Contribution

- All of these papers estimate ex-post utility as a function of government rebates/bill savings
- Essentially, households get around having to forecast utility bills
- **Literature:**
  - Multiple papers, such as Ito (2014), Jessoe & Rapson (2014), Langer & Myers 2021, and other study the topic of expectations on utility prices
  - In short: People aren't too fancy, usually form expectations based on the previous period or some moving average of recent periods.
  - Risk aversion plays a role
- **Contribution:** We can incorporate a model of consumer expectations for "on-grid" electricity to DDC.

(Very Rough) Model Specification

Dynamic Discrete Choice Model:

- Household i decides at time t to install solar panels ($d_{it} = 1$) or not ($d_{it} = 0$).
- Value function:

$$V_{it}(d_{it}) = U_{it}(d_{it}) + \beta E[V_{i,t+1}(d_{i,t+1}) \mid \Omega_{it}]$$

  where Ω_{it} is the state vector including:
  - Household income and demographics.
  - Building characteristics (roof size, sunlight exposure).
  - Energy prices and policy incentives.
- Utility includes:

$$U_{it}(d_{it} = 1) = -C_{it} + \theta_1 S_{it} - \theta_2 P_{it}$$

  where:
  - C_{it}: Installation cost.
  - S_{it}: Savings from reduced energy bills.
  - P_{it}: Policy incentives (subsidies or tariffs).

Key Data Sources

Publicly Available Data in the U.S.

- **Residential Energy Consumption Survey (RECS):**
  - Household energy use, building characteristics, demographics.
  - Provider: U.S. Energy Information Administration (EIA).
- **Open PV Project:**
  - Installation details: size, cost, location, and date.
  - Provider: National Renewable Energy Laboratory (NREL).
- **California Distributed Generation Statistics:**
  - Data on solar installations under California's NEM program.
  - Provider: California Public Utilities Commission (CPUC).
- **Electricity Price Data:**
  - State and utility-level electricity prices.
  - Provider: U.S. Energy Information Administration (EIA).

Key Data Sources

- **Database of State Incentives for Renewables and Efficiency (DSIRE):**
  - Comprehensive database on state-level renewable energy policies and incentives.
- **PVWatts Calculator:**
  - Estimates solar energy production for specific locations.
  - Provider: National Renewable Energy Laboratory (NREL).
- **Census Bureau Data:**
  - Demographic and socioeconomic data for integration.

Counterfactual Analysis

- Evaluate policies to achieve renewable energy targets:
  - Increase subsidies for installation.
  - Modify marginal electricity prices.
- Simulate impacts on:
  - Adoption rates.
  - Household welfare.
  - Equity across income groups.

Conclusion

- Proposed a dynamic discrete choice framework for solar panel adoption.
- Model inspired by Souyris, Duan, et al. (2022).
- Future work:
  - Data collection and model estimation.
  - Figure out utility function specification in detail.
  - Expand counterfactual scenarios.