DOE Solar Summit 2014, Anaheim, CA

Towards an Emergent Model of Technology Adoption for Accelerating the Diffusion of Residential Solar PV

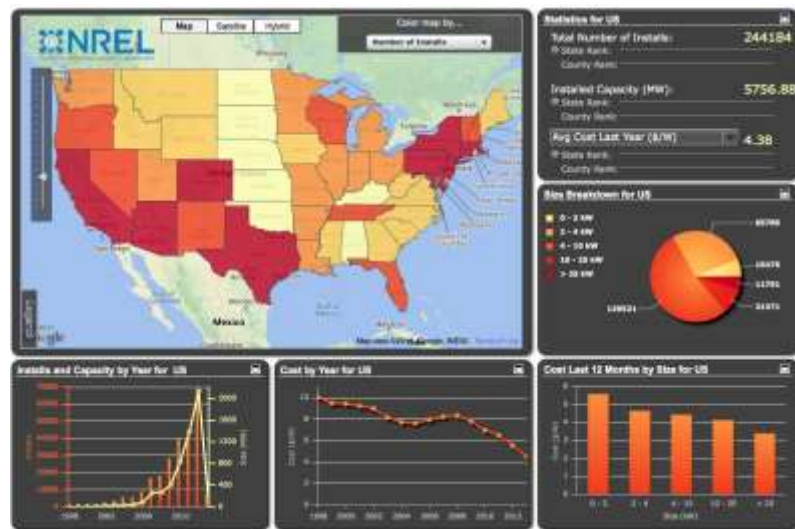## Varun Rai

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Public Affairs and Mechanical Engineering

The University of Texas at Austin

21 May 2014
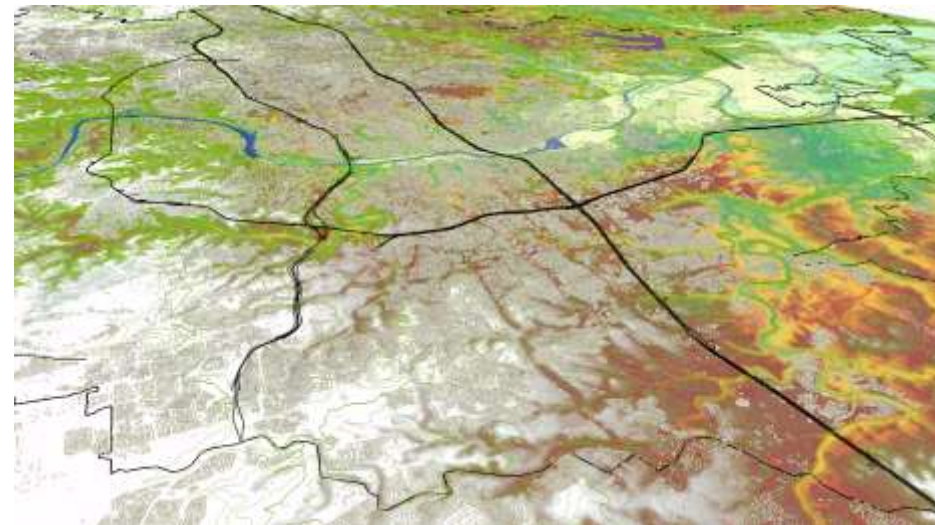
Big Data All Around…

Open PV Project (NREL)

California Solar Initiative

Green Button

## Irradiation/Weather

GIS (Various)

How to Harness that Data for Decision-Making to Better Aid Solar Program Design and Infrastructure Planning?

# High-level Research Questions

- How do contextual, economic, and behavioral factors interact to influence <u>household-level decision to adopt solar</u>? How are these influences mediated, in turn, by information networks and business models?

- Does solar adoption catalyze additional <u>behavior change</u> among customers, including energy conservation efforts or the acquisition of other new energy-related technologies like plug-in electric vehicles?

- What are the effective <u>customer acquisition strategies</u> for reducing soft-costs, and what role does social media play in that? What are the industrial organization implications of technology-intensive customer-acquisition?

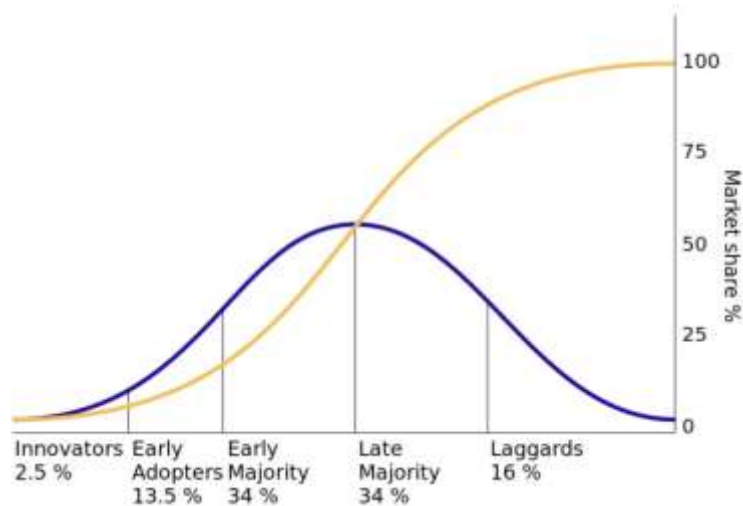# What Drives the Spatio-Temporal Patterns of Solar Diffusion?
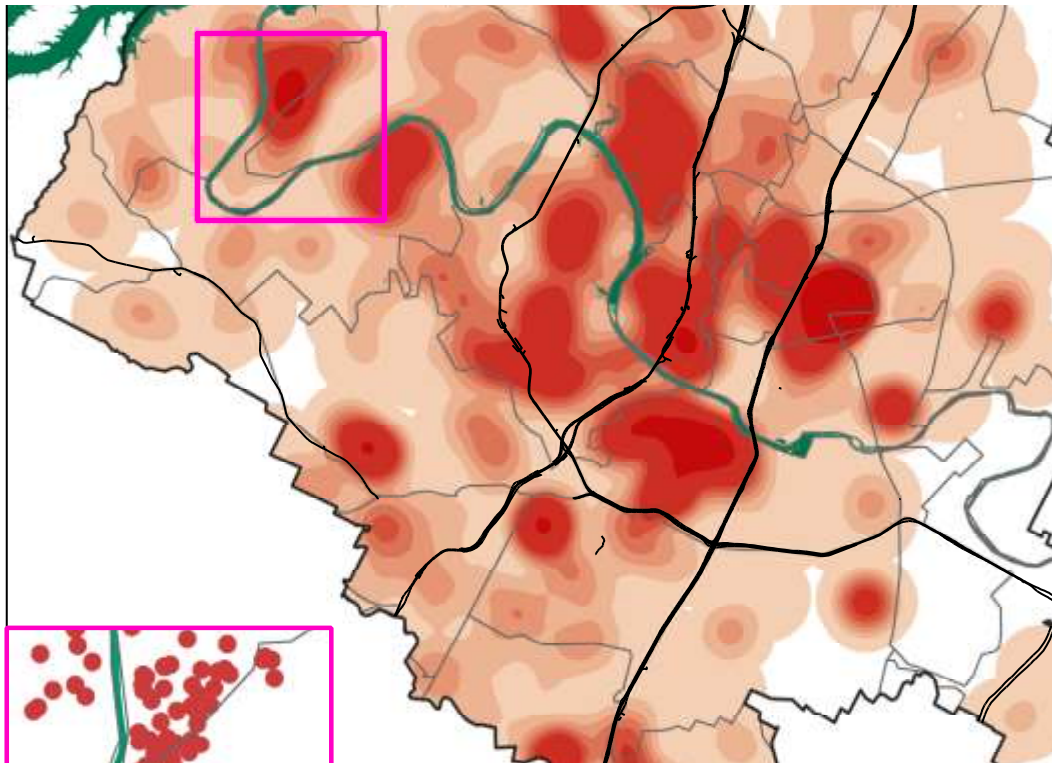
Residential PV in Austin, Texas
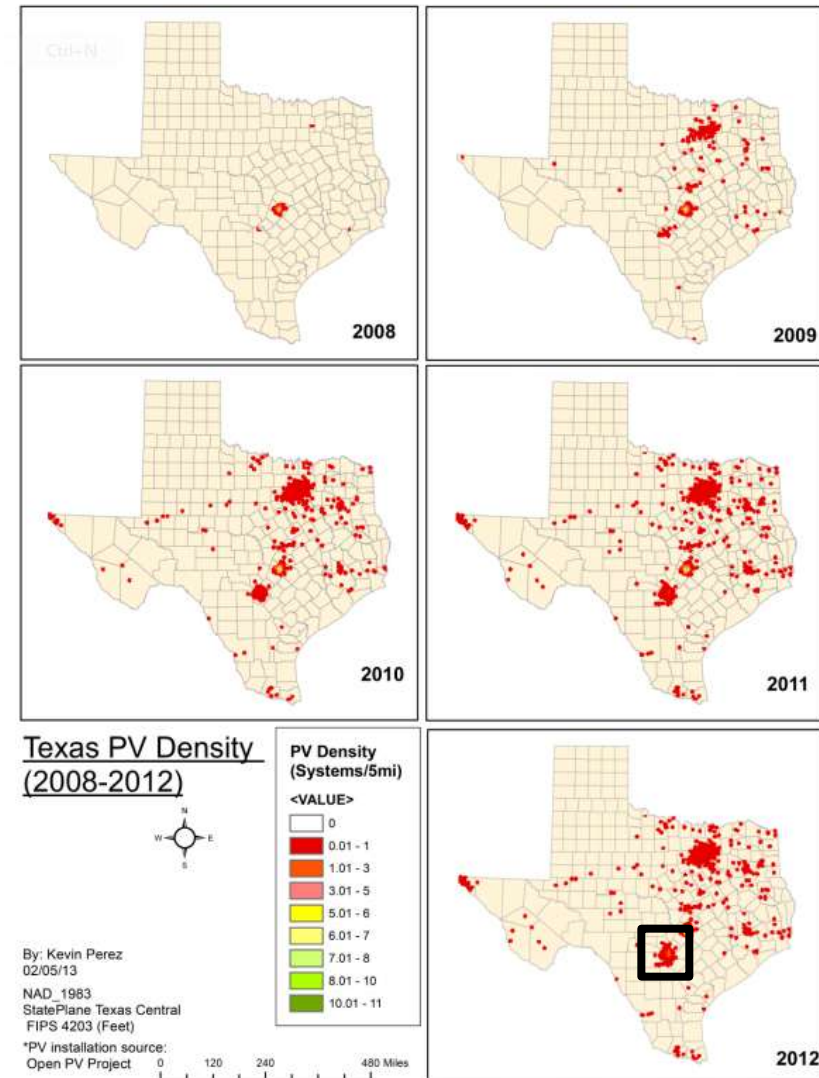
Common Diffusion Models

Econometric/Bass

$$S(t) = m \frac{(p+q)^2}{p} \frac{e^{-(p+q)t}}{1 + (q/p)e^{-(p+q)t2}}$$

Issues: *Heterogeneity, dimensionality, networks, descriptive, no individual uncertainty.*

Contagion

$$S(t) = m \frac{1}{1 + \phi e^{-pmt}}$$

Issues: *Heterogeneity (problem of socially-identical nodes), no complex decisions, over-emphasis on "social"*

LBJ

ENERGY SYSTEMS
TRANSFORMATION
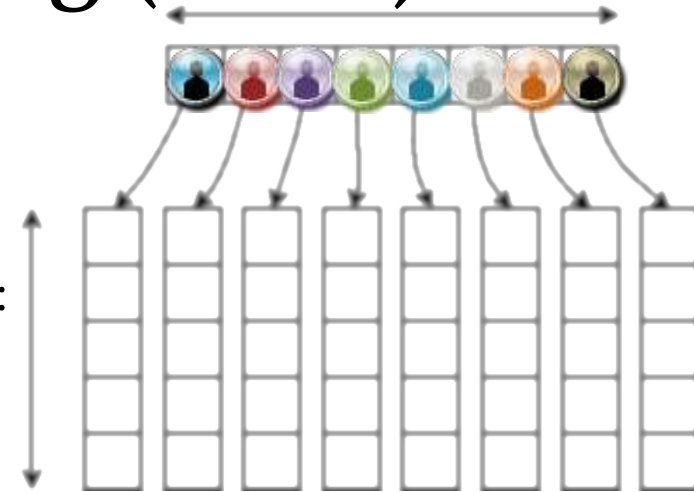
Agent-Based Modeling (ABM)

Agents

Autonomous decision-makers + Attributes

Explicit coded composite (theoretical) decision rules:
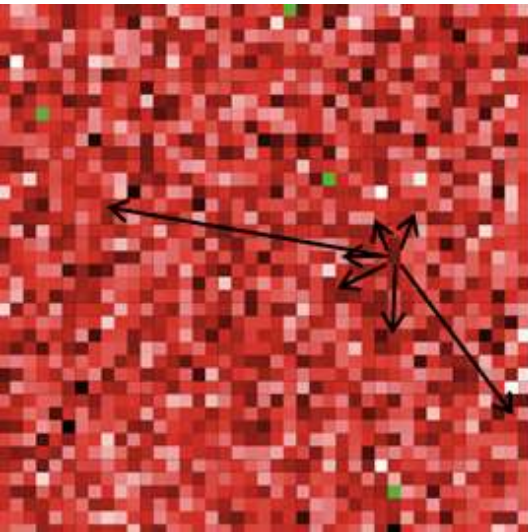D1) I only adopt if I *think* going solar will turn out well
D2) I only adopt if I can afford solar
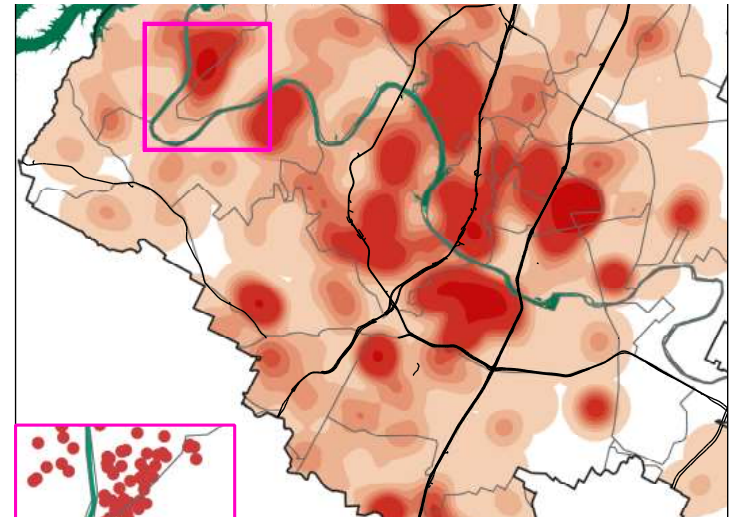
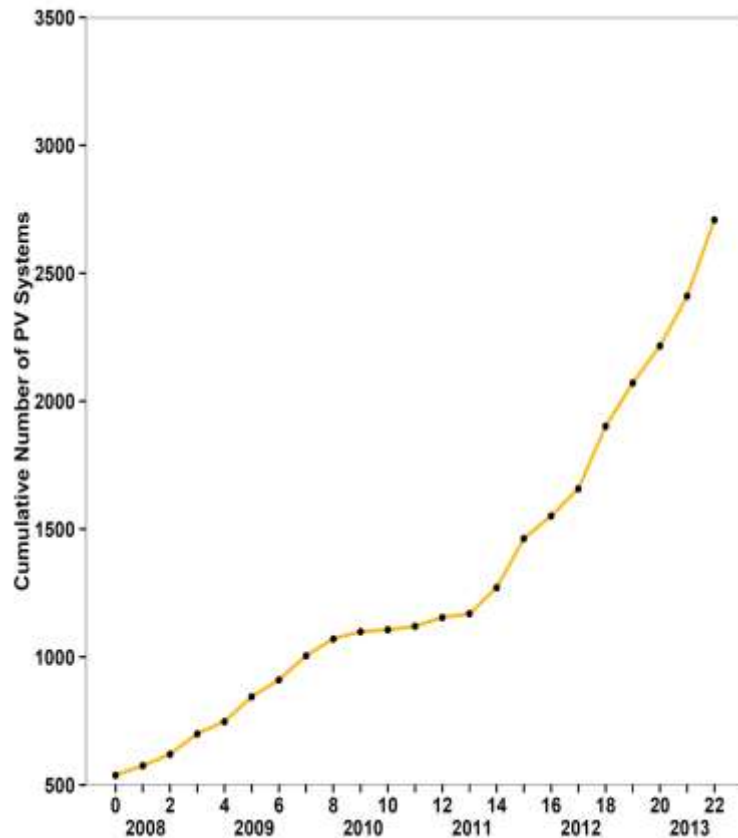I get information about solar through my social network

Dynamic Environment

Influential non-agent variables: prices, geography

Modeling the Speed and Structure of Solar Adoption

Model Scope:

    City of Austin, TX

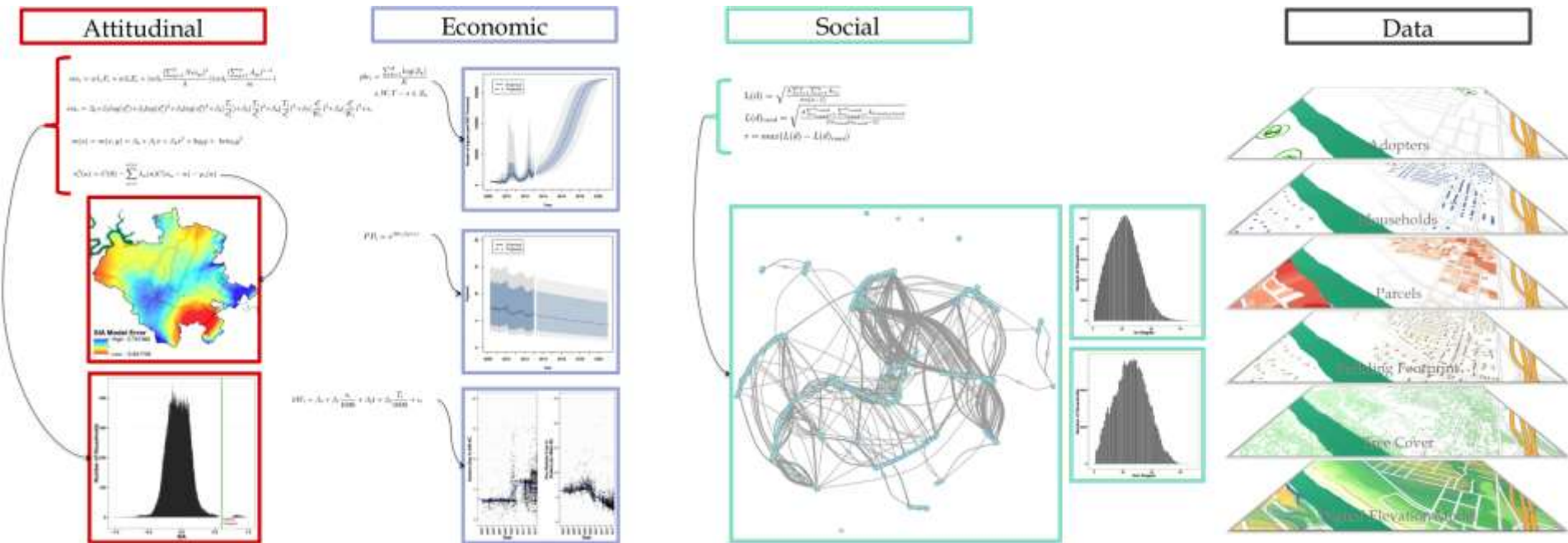   ~170,000 households

    ~3,000 PV Adopters (1.8%) as of Q2 2013

Initialization Time Period:

    Through Q4 2007

Validation Time Period:

    Q1 2008 – Q2 2013

Integrated Decision-Making Framework Based on Deep Data and a Suite of Analytical Tools
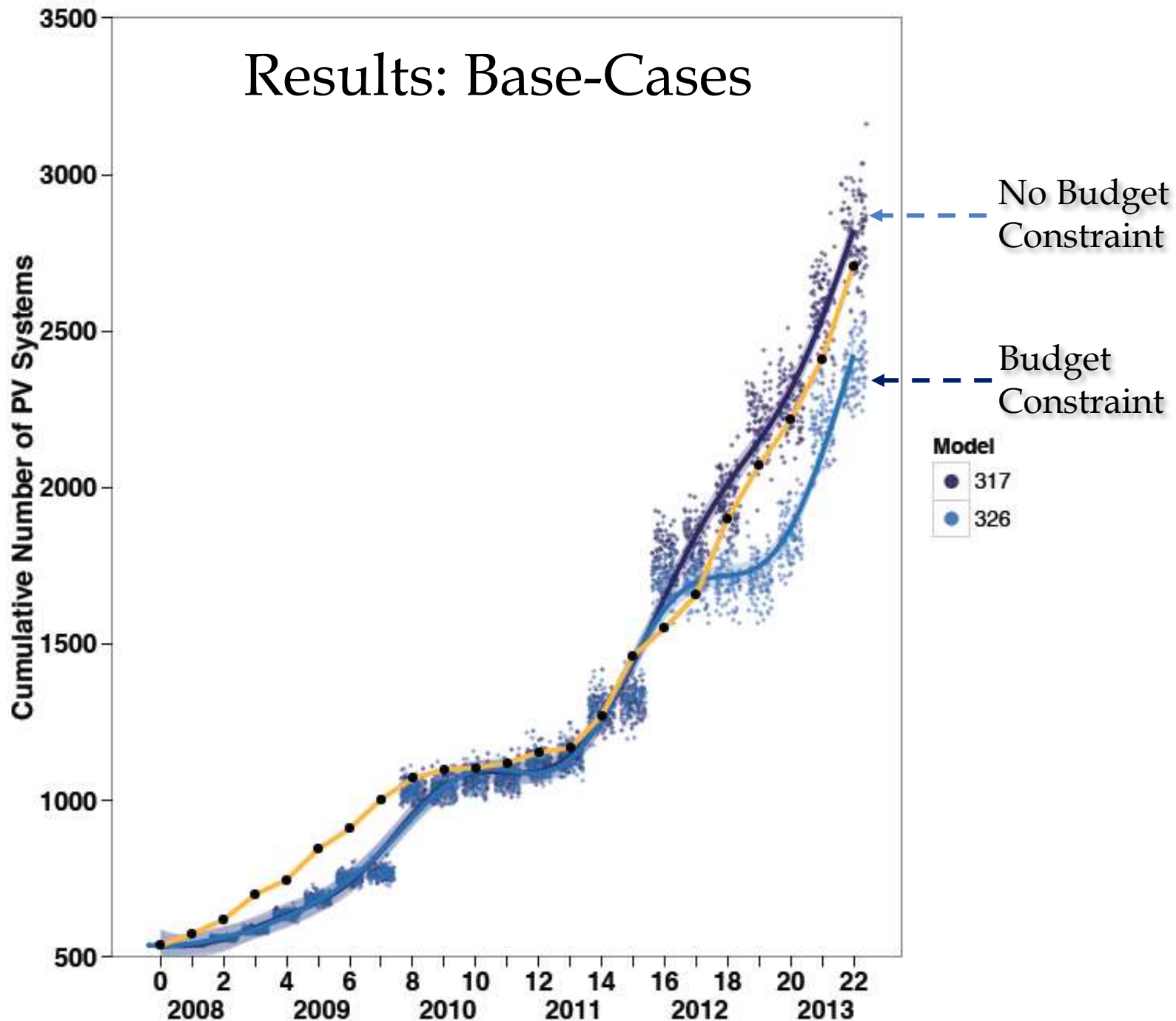

- **Household-level Data**
  - Adopter and non-adopter
    - Surveys
    - Appraisal district rolls
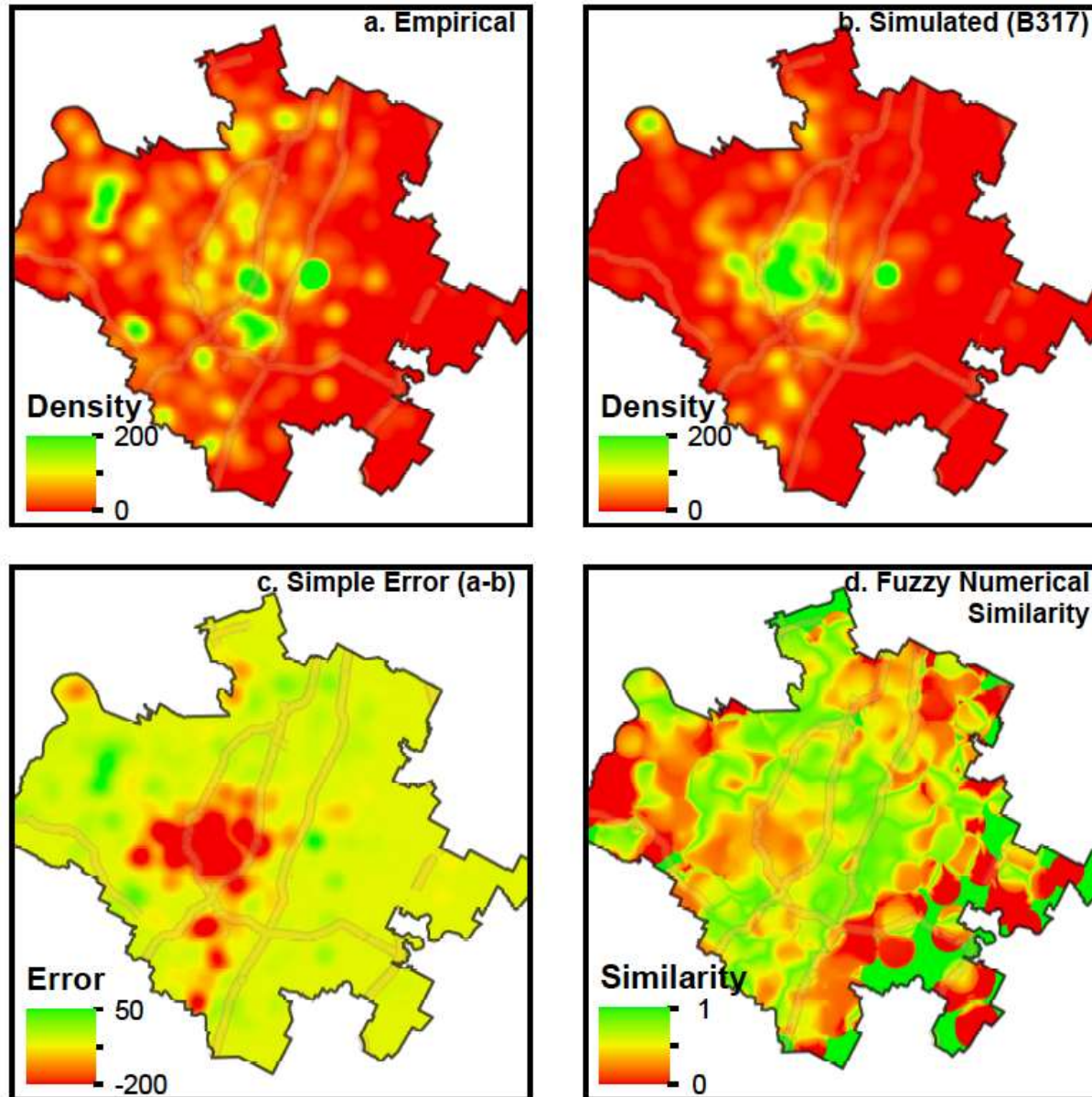 - Solar program data
  - Installer surveys

- **Multi-method**
  - Econometric analyses
  - Financial modeling
  - GIS integration
  - Agent-based modeling (ABM)
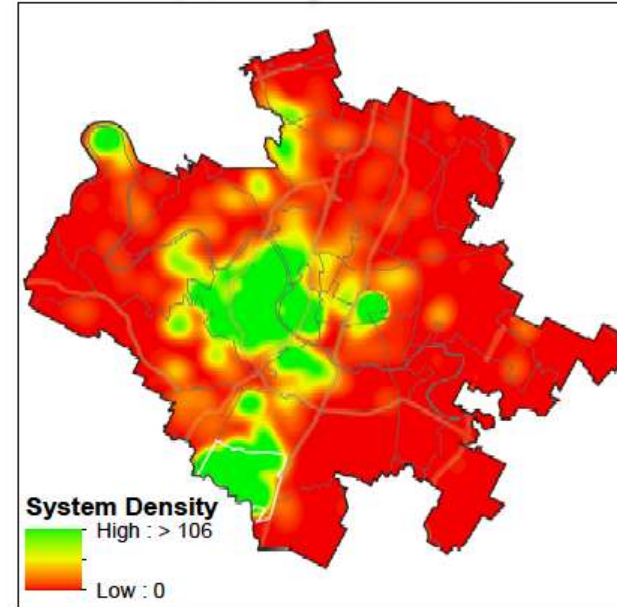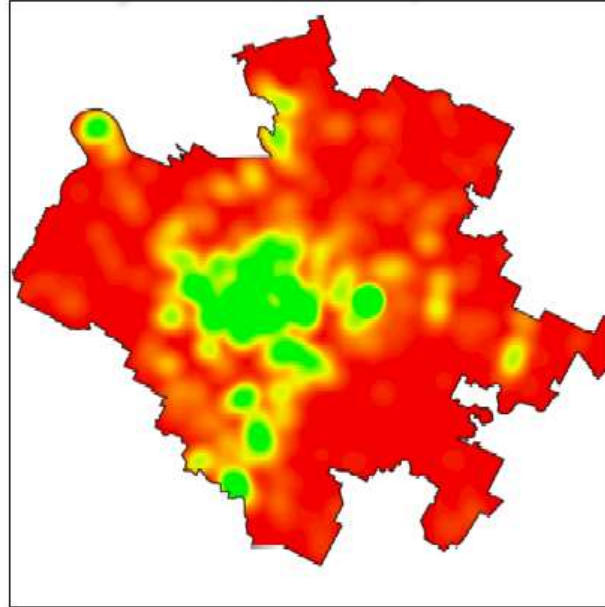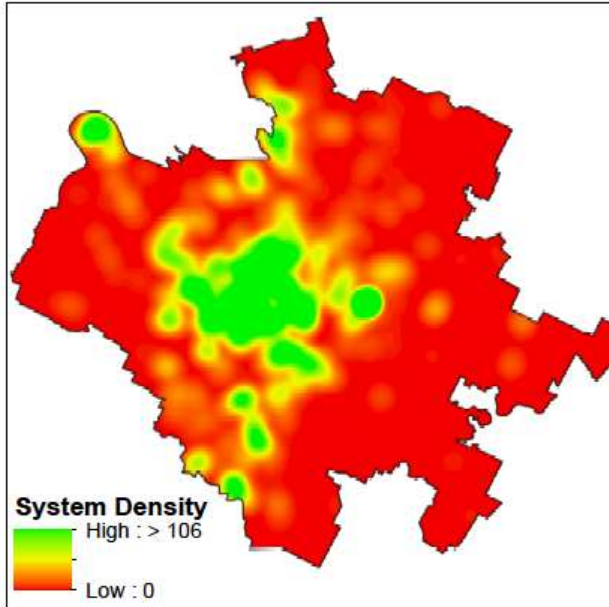
Results: Base-Cases

Results: Base Case with Budget Constraint

Results: Scenario, Tiered Rebates

Lower income quartile, everywhere, $0.25/W more
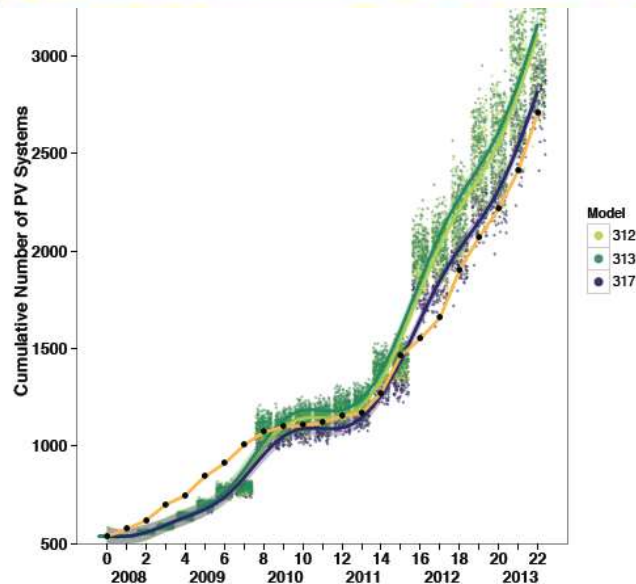
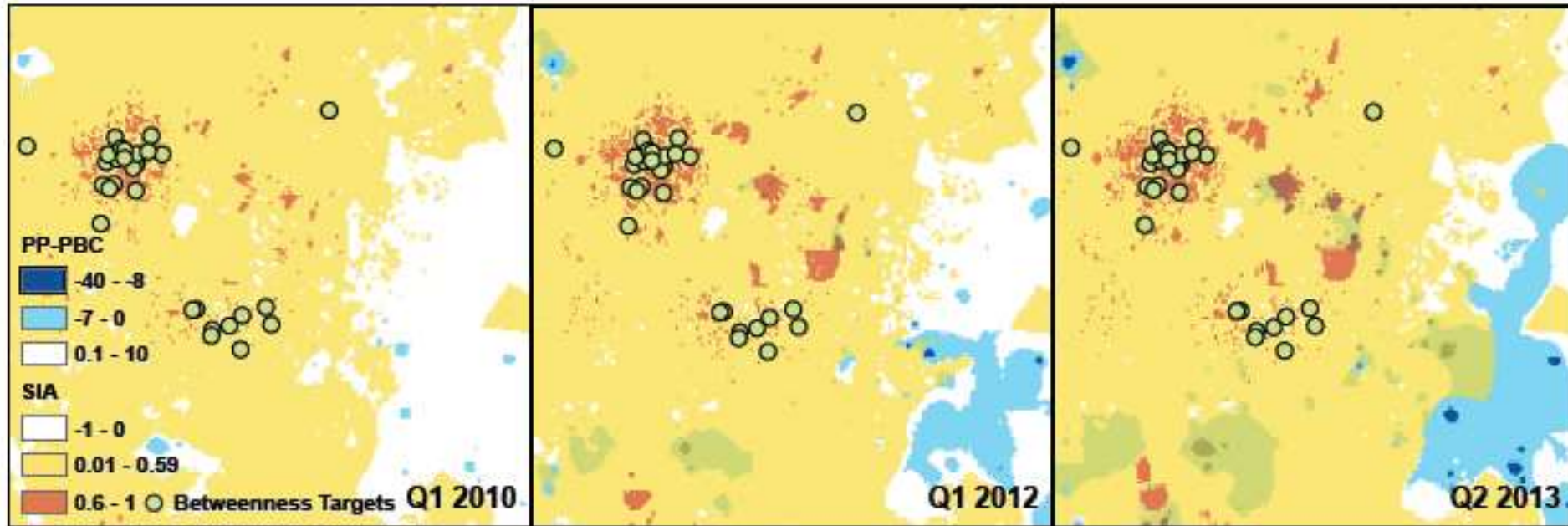Everyone in a target zip code, $0.25/W more

(a) Base-case

(b) Batch 327

(c) Batch 328

**Localized adoption increases from <1% in base-case to ~11% in Sc.328**

Information Campaign, High Betweenness Nodes

- **High betweenness nodes are less clustered around the city**

- **Act as connectors between neighborhoods—more rapid information exchange**

Additional Ongoing Work/Next Steps

- Pilot programs with utilities/solar companies
- Customer acquisitions strategies—The installer "agent"
- Behavioral changes post-adoption
  - Electricity consumption
  - **Co-adoption of other technologies**
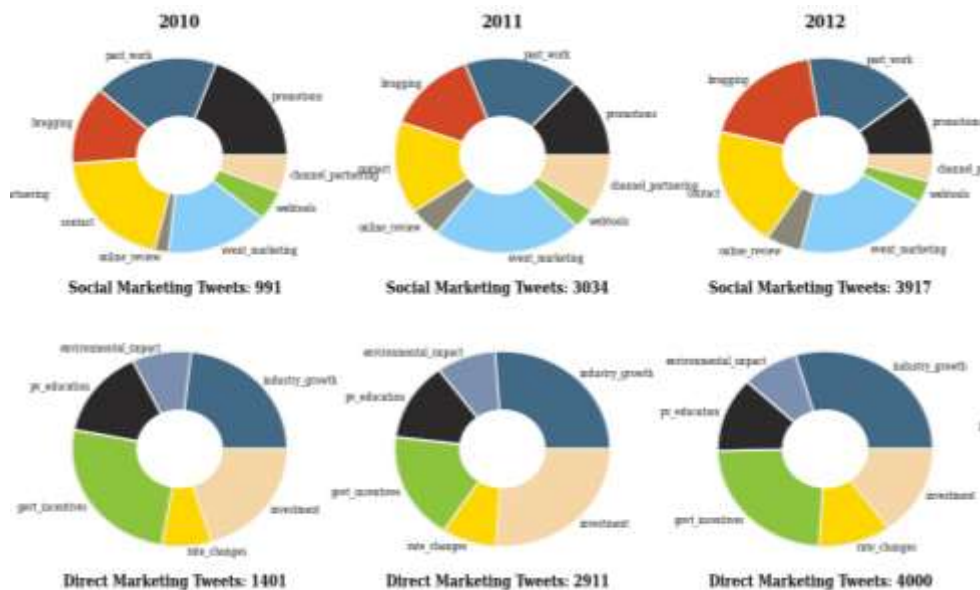
Naïve Bayes Classification of Tweets for Standardized Identification of Customer Acquisitions Strategies

Box plot for **household electricity consumption** for entire data set. boxplots depict each hour of consumption data by household post solar adoption. Households are sorted according to electricity consumption and darker bars represent the earliest adopters while the lighter bars represent the most recent adopters in the data set.