Econ 330: Urban Economics

Lecture 16

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Lecture 18: Urban Sorting & The Environment

Schedule

Today

1) **Household Sorting, Land-use Restrictions, and Carbon Emissions**

- Walkthrough of Colas & Morehouse (2021)

Upcoming

- **Book Report Due May 30th**
- **HW4 due June 6th**

Intro

Households emit carbon and other pollutants for many reasons.

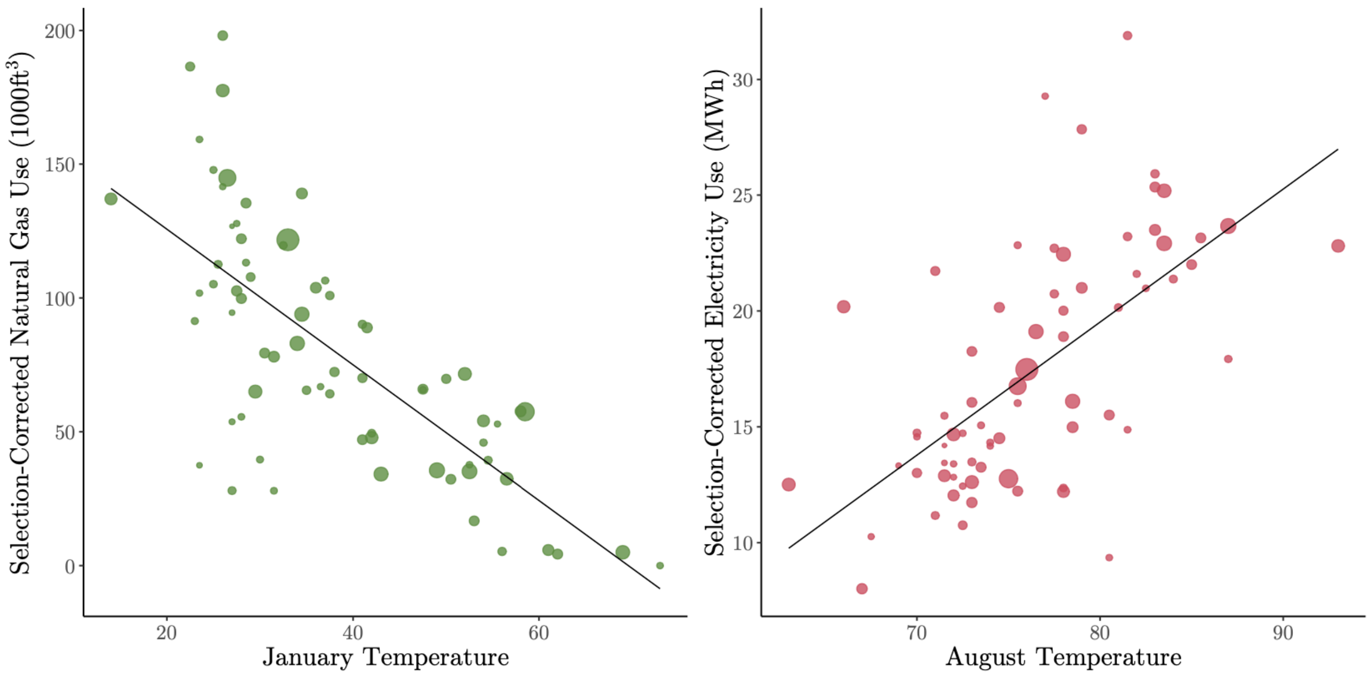
1) **Use of appliances**. Main Culprits:

- Air conditioning (electricity)
- Heating (natural gas)

2) **Driving**

We will focus on 1). The amount of electricity and natural gas a household consumes varies considerably across cities

Energy Use and Climate



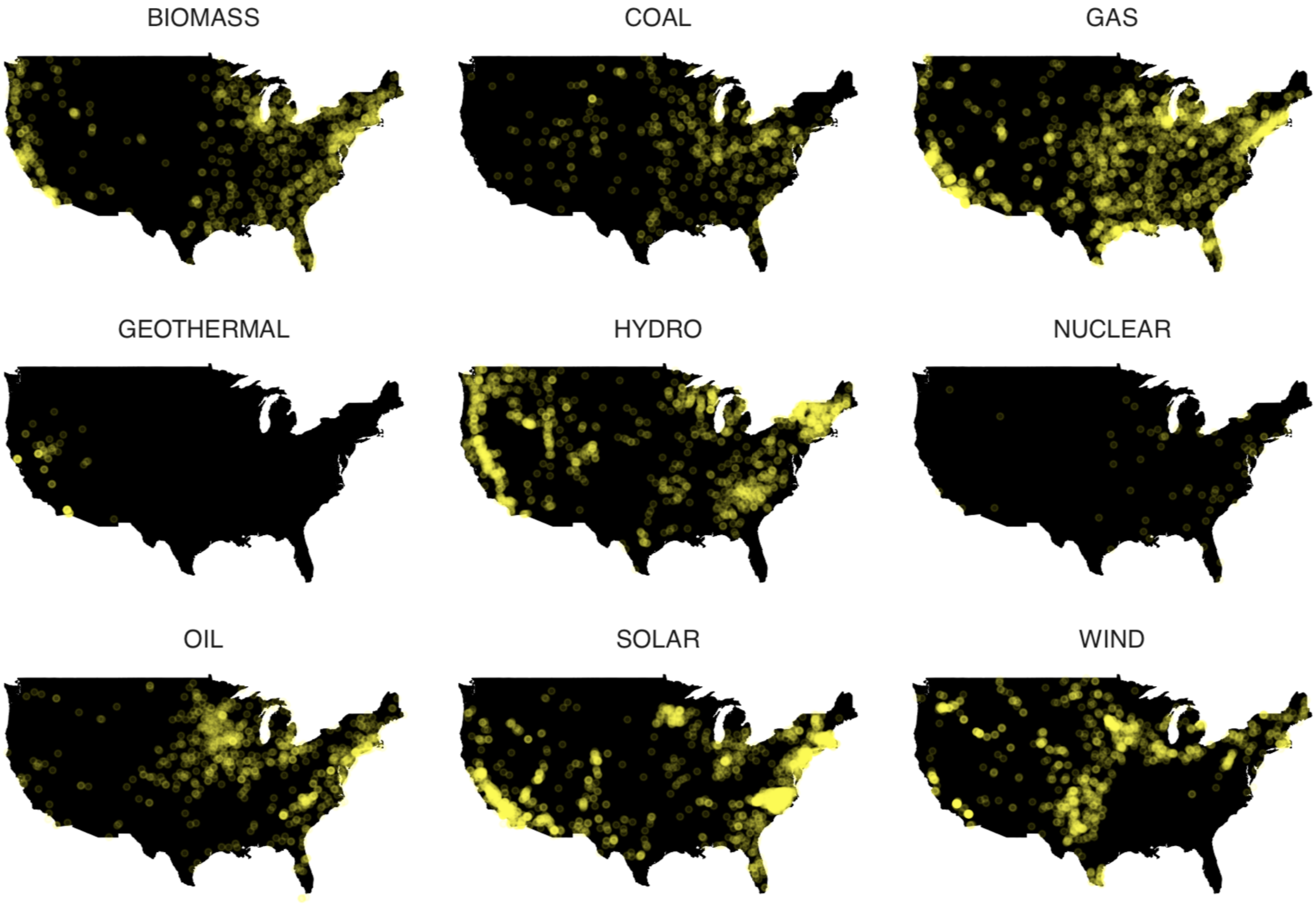
Emissions

The utilization of energy (natural gas, electricity) leads to carbon and other pollutant emissions

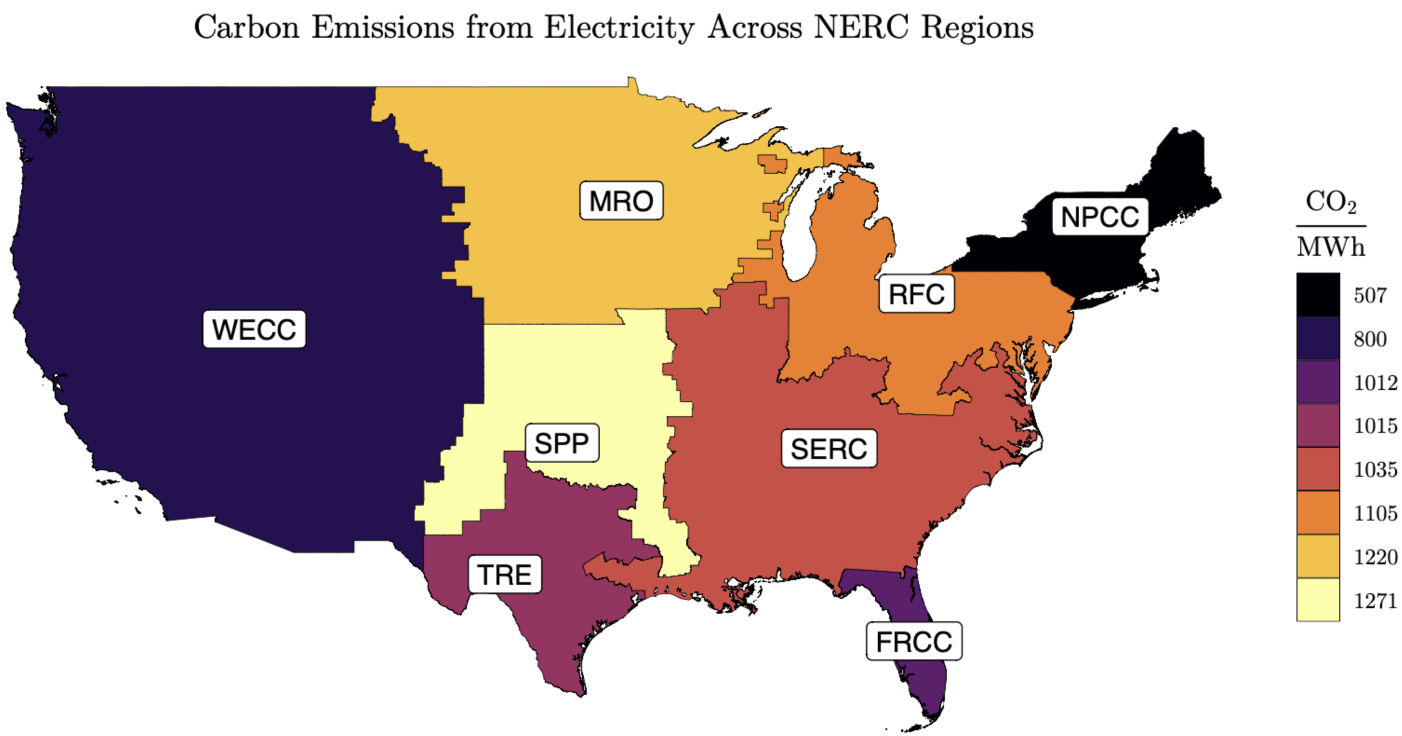
- Natural gas directly emits carbon (so the emissions factor is independent of location)
- Electricity needs to be produced at a power plant.
    - Power plants use different fuels
    - Different fuels $\implies$ different emissions factors for electricity use across locations

Example of clean energy? Dirty Energy?

Plant Types



NERC Regions



So Far

Household carbon emissions vary by location due to

1. Temperature Differences
2. Variation in the carbon intensity of local power plants

Question: A representative household in San Diego is responsible for 16.71 thousands pounds of carbon emissions per year from electricity and natural gas usage. How much is the same family in Memphis responsible for?

Data

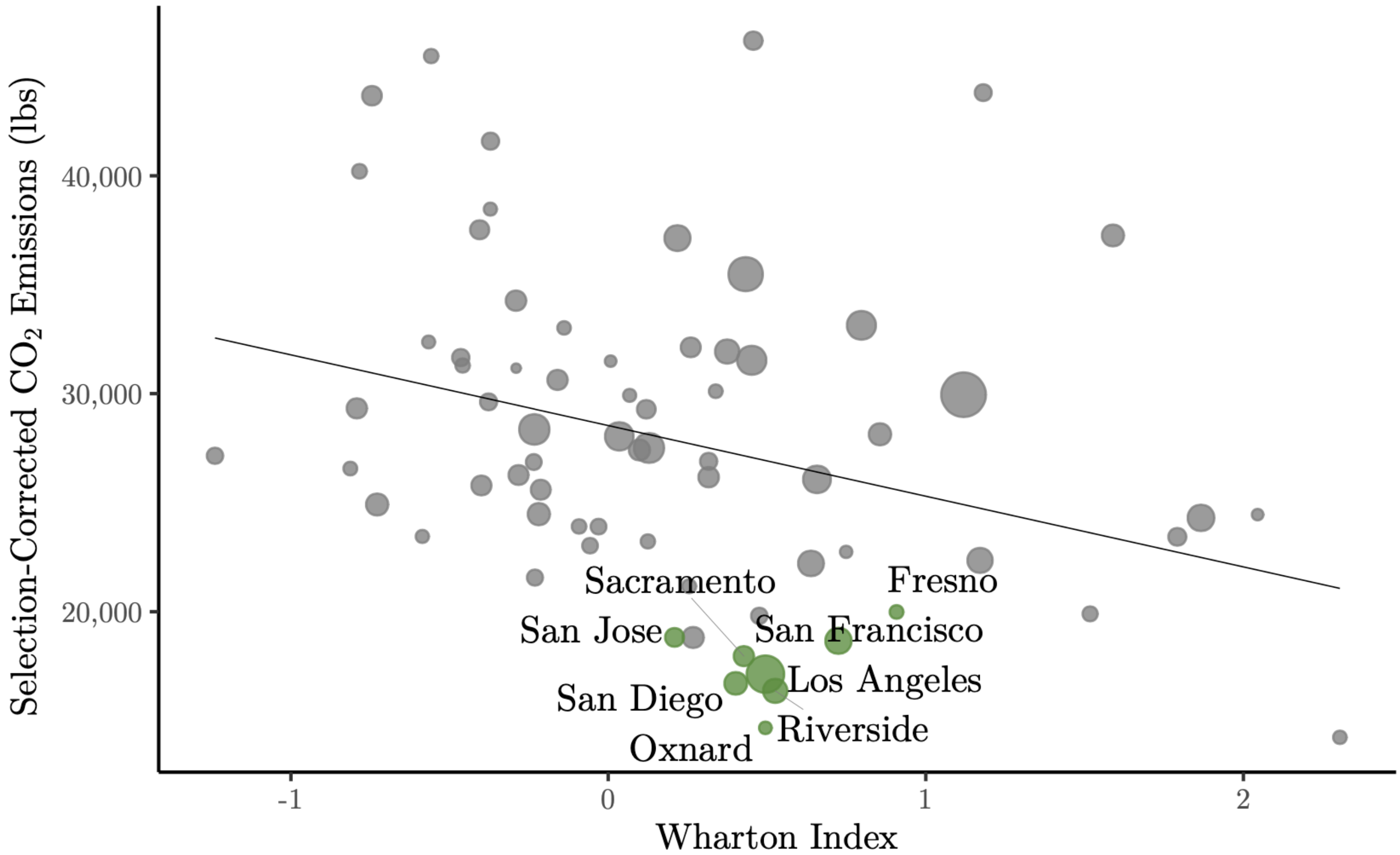
CBSA	Rank	Emissions (1000 lbs)	Gas Emissions (1000 lbs)	Fuel Emissions (1000 lbs)	Electricity Use (MwH)	Electricity Conversion (1000 lbs/MwH)	Electricity Emissions (1000 lbs)
Lowest							
Honolulu, HI	1	14.24	0.00	0.00	9.36	1.52	14.24
Oxnard, CA	2	14.67	6.19	0.27	10.26	0.80	8.21
Riverside, CA	3	16.37	6.33	0.27	12.21	0.80	9.76
San Diego, CA	4	16.71	6.75	0.33	12.04	0.80	9.63
Los Angeles, CA	5	17.14	6.73	0.20	12.76	0.80	10.21
Sacramento, CA	6	17.96	7.72	0.47	12.23	0.80	9.78
Middle							
Baton Rouge, LA	33	26.56	4.41	0.43	20.98	1.04	21.72
Birmingham, AL	34	26.86	5.79	0.21	20.15	1.04	20.86
Jacksonville, FL	35	26.90	0.62	0.06	25.92	1.01	26.22
New Orleans, LA	36	27.15	4.61	0.41	21.38	1.04	22.13
Pittsburgh, PA	37	27.41	12.02	2.43	11.73	1.11	12.97
Houston, TX	38	27.51	4.12	0.13	22.92	1.01	23.25
Highest							
Tulsa, OK	65	40.21	12.47	0.28	21.60	1.27	27.46
Oklahoma City, OK	66	41.59	11.81	0.27	23.21	1.27	29.50
Indianapolis, IN	67	43.67	23.20	0.30	18.26	1.11	20.18
Memphis, TN	68	43.81	10.56	0.23	31.89	1.04	33.02
Omaha, NE	69	45.49	17.31	0.31	22.84	1.22	27.87
Milwaukee, WI	70	46.19	21.84	0.34	21.72	1.11	24.01

Land-Use Restrictions

Cities also vary in the amount of land use restrictions they have. In some cities, land use restrictions are tight, meaning lots of costs and restrictions from building more housing.

- Measured by the Wharton Land Use Regulation Index
- What we have talked about before!

Policy and Emissions



Recap

So Far

- Cities vary drastically in terms of average household carbon emissions
  - This variation stems from:
  - Differing carbon intensities of local power plants
  - Spatial variation in the *marginal benefit* of energy consumption
- Cities with lower per capita carbon emissions have stricter land-use regs (on average)

Up Next

- Develop a quantitative model to estimate the impact of land-use restrictions on national carbon emissions. Specifically, relax land-use regulations in CA to a "reasonable" level

Model: Overview

1) **Locations** vary by

- Wages, rents, energy prices, and amenities
- Carbon Intensity of regional power plants
- Marginal benefit of energy use for different energy types

2) **Households**

- Demand a composite consumption good, housing, and energy
- Decide where to live (and thus work)
- Vary by demographic, birth locations, and an unobservable component (to the researchers) to location preferences

3) **Emissions**

- Use of energy leads to carbon emissions
- Emissions factors for electricity use vary by location

Simplified Model

Suppose we have two locations. Utility in location j is given by:

$$U(w_j, R_j, P_j^{elec}) = w_j - \frac{1}{2} * R_j - \frac{1}{10} P_j^{elec}$$

- Rents in each city are given by $R_j = (1 + k_j) * L_j$ where:
  - k_j is the level of land-use restrictions in location j
  - L_j is the population of location j
- Carbon emissions in location 1: 10 per 1 unit of electricity
- Carbon emissions in location 2: 5 per 1 unit of electricity
  - Denote carbon emissions per unit in city j as δ_j

Example

Suppose $k_1 = 2$, $k_2 = 4$. Also suppose $P_1^{elec} = 10$ and $P_2^{elec} = 10$.

- Assume $w_1 = 200, w_2 = 205$ and total population is fixed at 1000.

Q1: Compute equilibrium population levels in each city

Example

Example

Furthermore, let e_j^* be the households optimal consumption of electicity in location j. This is given by:

$$e_j^* = \frac{\frac{1}{10} \times w_j}{P_j^{elec}}$$

Q2: Compute emissions in each city and total emissions. Hint: Emissions in each city is given by:

$$\mathbf{Emis}_j = \delta_j \times e_j^* \times L_j^*$$

Example

Recompute total emissions when $k_2 = 2$.

Example

Example

Local Pollutants

In addition to carbon emissions, I have mentioned "other pollutants" from HHs

- We focus on emissions of $PM_{2.5}$
  - Widely studied and regulated measure of air quality
  - At the helm of US air quality regulation since late 90s
  - Associated with detrimental health and economic outcomes such as: higher infant mortality, increased cognitive decline in seniors, reduced property values

Local Pollutants

- $PM_{2.5}$ is considered a *local* pollutant because it affects those directly exposed
  - Emissions of PM2.5 from a given location can impact air quality locally, regionally, and nationally
  - Ed and I estimate that 90% of particulate matter emissions from coal-power plants leave their state of origin within 48 hours
- Thus: Electricity demand in CA leads to an increase in PM from power plants in CA
  - The additional emissions also travel to other states

So What?

So: we want to model how HH energy consumptions impacts $PM_{2.5}$

- But we are economists and do not know how to model chemical transport!
- Luckily, we don't have to. We employ the Intervention Model for Air Pollution (InMAP)

InMAP is an "off-the-shelf" chemical transport model that maps emissions to concentration across the US

- Very smart -- takes local atmospheric conditions, stack height of emissions, and chemical decay into account
- Very easy to use, as well. Python code already written for you to use. Just feed it your data

Model Fit

- Mark and I estimate the model on publicly available data
  - This part is the hard part, so I won't go into detail
- Can check how well the model fits the data by solving the equilibrium in the model and compare the model's outputs to the data.

Model Fit

Counterfactual

- We estimate the model on publicly available data. Then:

Main Counterfactual: Relax land-use regulation in CA to match the national median

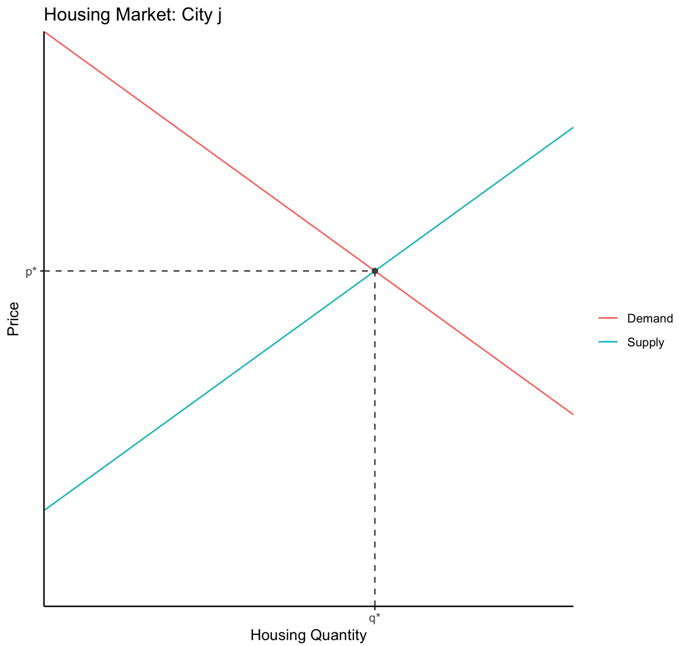
Mechanism:

- Mechanically, relaxing land-use regs decrease rents in CA
- Households move to CA due to cheaper rents
- Economy reaches a new equilibrium in rents, wages, and location choices

Carbon Emissions:

- **CA**: low marginal benefit of energy use (temperate climate)
- Carbon efficient power plants
- Thus, should expect equilibrium emissions to fall as a result

Graph



Housing Market: City j
p*
Price
q*
Housing Quantity
Demand
Supply

Housing Market: City j
p*'
Price
q*'
Housing Quantity
Demand
Supply

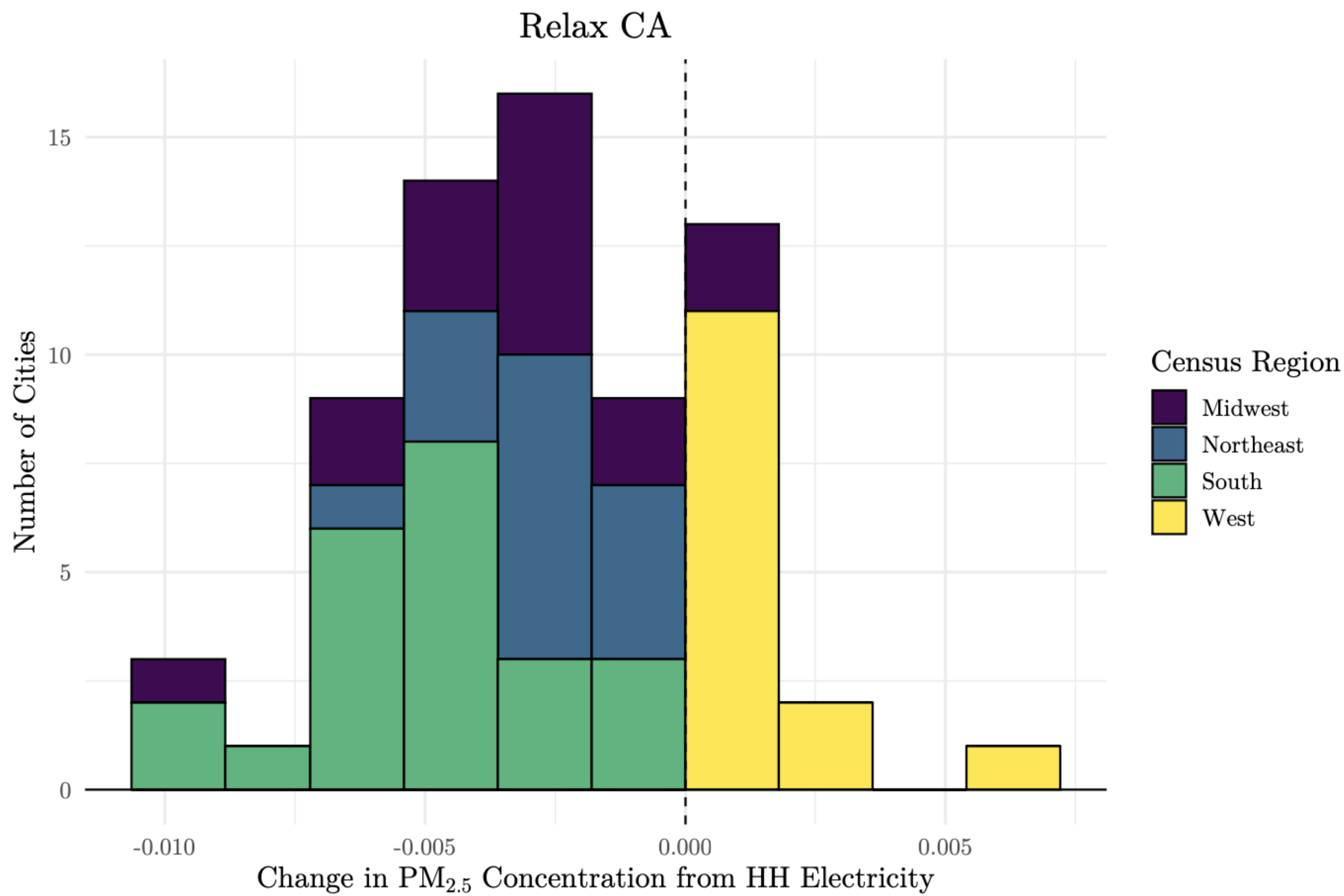
SB501


Support the
More HOMES Act
to solve the California housing crisis


STOP SB50
SAY NO TO MORE DISPLACEMENT

Results

Results


Relax CA
Number of Cities
15
10
5
0
-0.010
-0.005
0.000
0.005
Change in $PM_{2.5}$ Concentration from HH Electricity
Census Region
Midwest
Northeast
South
West

Conclusion

Takeaways

- Land-use policies that change where workers live have important implications for national carbon emissions
- Estimated the impact of relaxed land-use regulations in CA
    - Predicted national household carbon emissions fall by .6%
    - Doesn't seem like much but this is equivalent to a savings of $310 million dollars annually (using Social Cost of Carbon)

What do we not do? Do you have any thoughts/comments/questions?