The Environmental Cost of Land Use Restrictions

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Research Question

Household carbon emissions vary by location due to:

- Temperature differences
- Variation in carbon efficiency of local power plants

Question:

How do land use regs impact national HH household carbon emissions?

- Stricter land-use regulations $\implies$ higher rents
- Higher rents $\implies$ reallocation of households across cities

What we do:

Use a spatial equilibrium model to quantify effects of land use restrictions on national household carbon emissions

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Plan

Structure of Presentation

- Data
  - Sources
  - Descriptive Statistics
- Model
  - Overview
- Results & Implications

Data

To estimate HH carbon emissions we combine:

- Individual HH-level energy *expenditure* data
- State-level *energy prices*
- Plant-level *emissions* data

Primary Sources:

(1) **ACS** - Individual-level data for 2012-2016

(2) **EIA** - State-level energy prices

(3) **EPA** - Plant-level electricity generation data

All data: publicly available

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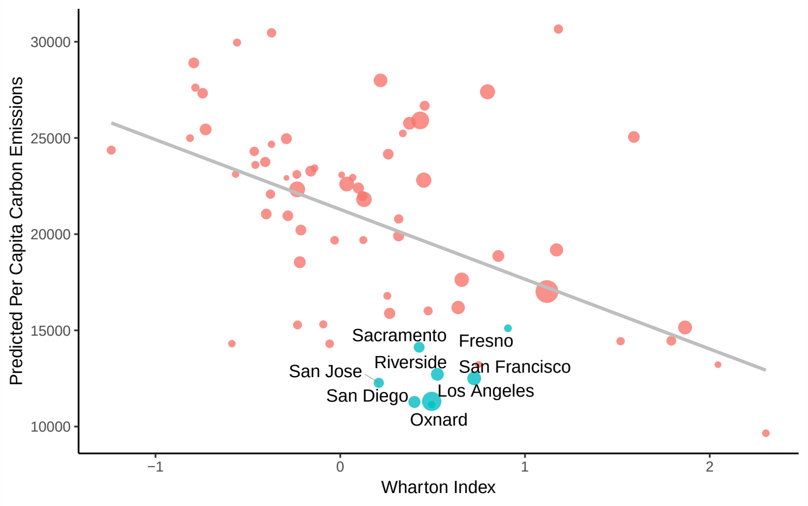
Data: Emissions

CBSA	Rank	Emissions (1000 lbs)	Nat. Gas Emissions (1000 lbs)	Fuel Oil Emissions (1000 lbs)	Electricity Use (MwH)	Electricity Conversion (1000 lbs per MwH)	Electricity Emissions (1000 lbs)
Lowest emissions							
Honolulu, HI	1	9.65	0.30	0.07	6.10	1.52	9.29
Oxnard, CA	2	11.14	5.29	0.11	7.18	0.80	5.75
San Diego, CA	3	11.28	4.65	0.15	8.10	0.80	6.48
Los Angeles, CA	4	11.31	4.95	0.08	7.85	0.80	6.28
San Jose, CA	5	12.27	5.70	0.11	8.08	0.80	6.46
San Francisco, CA	6	12.50	5.94	0.13	8.04	0.80	6.43
Middle emissions							
Austin, TX	33	20.96	3.87	0.13	16.71	1.01	16.96
Charlotte, NC-SC	34	21.05	4.91	0.24	15.36	1.04	15.90
Houston, TX	35	21.81	3.92	0.10	17.52	1.01	17.78
Virginia Beach, VA	36	21.98	4.51	0.43	16.46	1.04	17.04
Richmond, VA	37	22.08	4.39	0.69	16.41	1.04	16.99
Dallas-Fort, TX	38	22.33	3.89	0.13	18.04	1.01	18.31
Highest emissions							
Tulsa, OK	65	27.61	7.54	0.16	15.67	1.27	19.92
Detroit, MI	66	27.99	14.97	0.28	11.53	1.11	12.75
Kansas City, MO-KS	67	28.90	8.77	0.18	15.69	1.27	19.95
Omaha, NE	68	29.96	13.02	0.26	13.66	1.22	16.68
Oklahoma City, OK	69	30.46	7.21	0.19	18.14	1.27	23.06
Memphis, TN-MS-AR	70	30.66	6.70	0.15	23.00	1.04	23.81

Table 1: CBSA-level emissions by fuel type

Policy & Emissions



▸ Details

Recap

So far:

- Cities vary drastically in terms of avg HH carbon emissions
- This variation stems from:
  - Differing carbon efficiencies of local power plants
  - Spatial variation in the marginal benefit of energy use
- Cities with low carbon emissions have more land-use regs

Up next:

- Build a structural model to estimate the impact of greater land use restrictions on national carbon emissions

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Model: Overview

(1) **Locations**

- Vary in wages, rents, energy prices, and amenities
- Vary in carbon efficiencies of regional power plants
- Vary in marginal benefits of use, for different energy types

(2) **Agents**

- Endowed with demographics and birth locations
- Demand a numeraire consumption good, housing, energy services.
  - Demands vary by demographic group
- Decide where to live

(3) **Emissions**

- Use of energy leads to carbon emissions
- Emissions factors for electricity use vary by location
- Carbon emissions are a function of both (1) energy use (endogenous) and (2) local emissions factors (exogenous)

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Workers

- Agents are endowed with demographic d
- Agents pick a location, j, to solve:

$$\text{Max}\left(\alpha_d^c \log c + \alpha_d^h \log h + \sum_m \alpha_{jd}^m \log x^m + \lambda_{ij}\right)$$

$$s.t. \quad I_{jd} = c + r_j h + \sum_m P_j^m x^m$$

- x^m = household consumption of **fuel type** m
- λ_{ij}= amenities term (more on this next slide)

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Amenities

We decompose amenities into 3 distinct components:

$$\lambda_{ij} = \xi_{jd} + f\left(j \in Bstate_i\right) + \sigma_d \epsilon_{ij}$$

- ξ_{jd} = common, unobservable set of amenities
- $f\left(j \in Bstate_i\right)$ = function of distance from location j to the state where agent was born
- ϵ_{ij} = idiosyncratic, stochastic term. We assume it follows an EV1 distribution with dispersion parameter σ

Model: Details

Our model is a **locational equilibrium model**

- In equilibrium: all workers reside at a location that yields maximal utility
- Their location choices impact wages, rents, and energy consumption (and thus emissions) at each location

Housing Supply Curve

- Parameterized as a function of
  - Land-use restrictions (measured via the Wharton Index)
  - Quantity of land that is available for construction (Saiz, 2010)

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Counterfactual

Main Counterfactual: Relax land use regulations in California to match the national median

Mechanism

- Rents will fall. Workers will move into California
- Effects on cities in California?
    - Low marginal benefit of energy use (temperate climate)
    - Carbon-efficient power plants
    - Thus, HH carbon emissions should fall as a result

Use model to estimate amount by which carbon emissions fall

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Results

	Baseline	Relax CA	% Change
I. **Usage**			
N.Gas (1000 cu.ft)	53.18	52.58	-1.13
Electricity (MwH)	13.27	13.04	-1.73
Fuel Oil (gallons)	28.47	26.84	-5.73
II. **Emissions (lbs of CO_2)**			
N.Gas	6228	6157	-1.13
Electricity	12804	12465	-2.65
Fuel Oil	765	721	-5.73
Total	19796	19343	-2.29

Table 2: Counterfactual results

Additional Results

Explore effects on national carbon emissions if we:

- Relax land-use regulations in all cities (not just CA cities):
  - Leads to $\approx 8\%$ decrease in national carbon emissions

▸ Details

- Implement a nationwide carbon tax of \$31 per ton[1]
  - Leads to $\approx 12.3\%$ decrease in national carbon emissions
  - Substantial *distributional consequences*

▸ Details

[1] This is the social cost of carbon as computed in Nordhaus (2017)

Conclusion

Primary Results:

- Land-use policies that change where workers live have important implications for national carbon emissions
- Estimates of the impacts of relaxed land-use regs in CA (set to the national median):
  - National carbon emissions predicted to **drop by 2.3%**
  - **Wages:**
    - For skilled workers, rise by 2% (nationally)
    - For unskilled workers, rise by 1% (nationally)

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Thank You

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Predicted per capita Carbon Emissions

We estimate the following regression:

$$x_i^m = \gamma_{\mathrm{CBSA}(i)} + \beta_1 \log(\mathrm{Income}_i) + \beta_2 \mathrm{HHsize}_i + \beta_3 \mathrm{Agehead}_i + \varepsilon_i$$

We then take median values for regressors and use coefficients to predict per capita emissions in each CBSA

Back

All Cities

	Baseline	Relax All	% Change
I. Usage			
Gas (1000 cubic feet)	53.18	53.96	1.47
Electricity (MwH)	13.27	12.08	-8.97
Fuel Oil (gallons)	28.47	45.66	60.38
II. Emissions (lbs of CO_2)			
Gas	6228	6318	1.47
Electricity	12804	10651	-16.82
Fuel Oil	765	1226	60.38
Total	19796	18196	-8.08

Table 3: Counterfactual results: relax all cities land use regulations to the national median.

Carbon Taxes

	Baseline	Carbon Tax	% Change
I. Usage			
Gas (1000 cubic feet)	53.18	45.50	-14.44
Electricity (MwH)	13.27	11.85	-10.70
Fuel Oil (gallons)	28.47	25.37	-10.89
II. Emissions (lbs of CO_2)			
Gas	6228	5328	-14.44
Electricity	12804	11351	-11.35
Fuel Oil	765	681	-10.89
Total	19796	17360	-12.31

Table 4: Counterfactual results: implement a carbon tax of \$31 per ton.