Electric Vehicle Adoption, Air Pollution Disparities, and Subsidy Policy

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The transition to EVs will take decades

Vehicle electrification seen as essential climate policy, but adoption is slow

In the meantime...

- EVs are expensive
- Neighborhoods are segregated by income
- EVs lessen some local externalities from cars

CARS

Another EV Benefit: Less Noise Pollution

One well known electric vehicle (EV) benefit is that EVs don't produce tailpipe emissions from directly burning fossil fuels — emissions that contribute to climate change and harmful air pollution.

Subsidy design has distributional consequences

EV purchases are heavily subsidized in the U.S.

- Federal subsidies up to \$7,500 + a patchwork of state and local incentives

These subsidies may increase inequality

1. Individual inequality: subsidies go to wealthy households who would have purchased them anyway
2. Neighborhood inequality: EVs go to households in just a few neighborhoods

Where “should” EVs to go, for climate, local pollution, or equity reasons?

That is, where might a new EV have the highest social benefit?

A hypothetical neighborhood where...

- The air is clean, and
- the average household has 2 cars,
- with a mean age of 4 years,
- and a typical daily VMT of 29 miles

Or a hypothetical neighborhood where...

- The air is smoggy, and
- the average household has 1.5 cars,
- with a mean age of 9 years,
- and a typical daily VMT of 37 miles

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Which of these neighborhoods probably has a higher median income?

Research focus

1. What's the relationship between EV adoption (and subsidy receipt), neighborhood affluence, and neighborhood air pollution?
   - Link new vehicle registrations to neighborhood chars. and ambient air pollution
2. What are the distributional impacts of targeting EV subsidies by location?
   - Combine a model of vehicle demand with implied changes in emissions at the neighborhood level

We contribute to a growing understanding of EV adoption

What we already know:

- EV subsidies drive EV adoption
  Li, Tong, Xing, Zhou (2017); Jenn, Springel, Gopal (2018); Clinton, Steinberg (2019); Springel (2020)
- EVs go to affluent households who often would have bought them without subsidies
  Borenstein, Davis (2016); DeShazo, Sheldon, Carson (2017); Sheldon, Dua (2019); Xing, Leard, Li, (2021)
- EV adoption has mixed environmental benefits in the short-run
  Holland, Mansur, Muller, Yates (2016, 2019)

What we add:

- Spatial detail on EV adoption within metro areas
- Recent data on registered motor vehicles in multiple states
- Simulation of changes in distribution of on-road criteria emissions from counterfactual subsidies

Base data: New vehicles at the zip code level for 2015–2020

We construct a new vehicle panel for 5 metro areas: Phoenix, AZ; Los Angeles, CA; Chicago, IL; Houston, TX; and Seattle, WA

- Motor vehicle registrations (VIN + zip + date) from AZ, IL, TX, WA + the Los Angeles CBSA
- Make, model, model year, and fuel type from NHTSA's VIN decoder API
  - Throughout, EVs = BEVs + PHEVs
- Prices (MSRP) and characteristics from Autotrader.com

Key limitation: we observe vehicles and their neighborhoods, not households

Vehicle data is linked by zip code to demographics, traffic flows

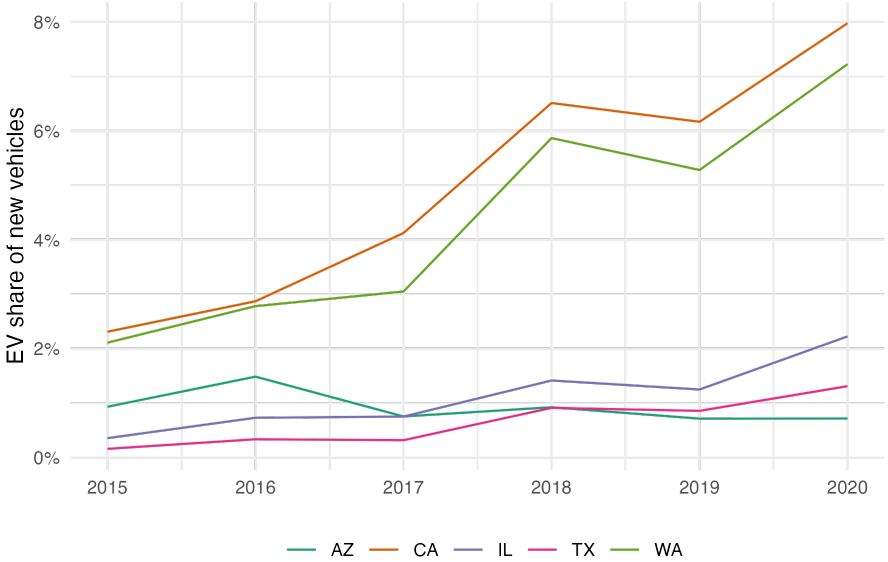
What do neighborhoods look like?

- Zip codes match to ZCTA geographies (typically 1:1)
- Census ACS: ZCTA-level demographics (income, race/ethnicity, household size)
- Annual satellite PM2.5 and NOx (van Donkelaar et al., 2019)

Where do EVs travel?

- Census LODES: ZCTA-level home-work commuter flows
- Census ACS: ZCTA-level commute mode shares
- Google Maps API: likely driving routes

EVs are a small share of new cars → electrification will take time



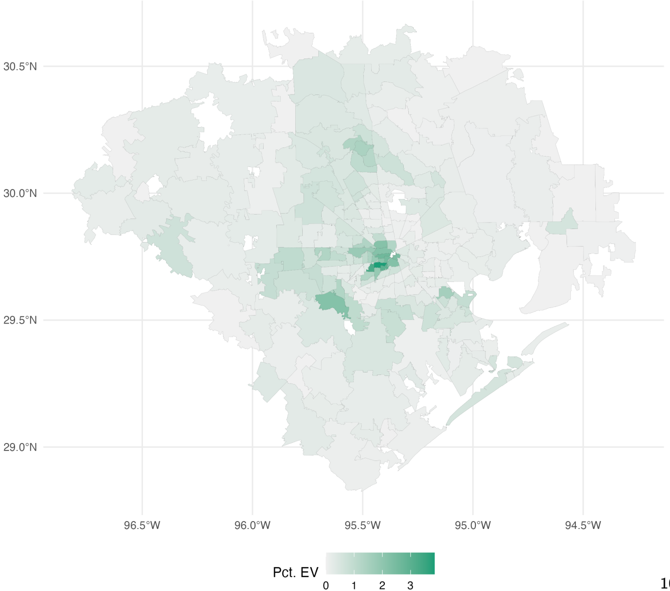
Metro areas:
Phoenix
Los Angeles
Chicago
Houston
Seattle

Metro-wide uptake hides neighborhood-level differences

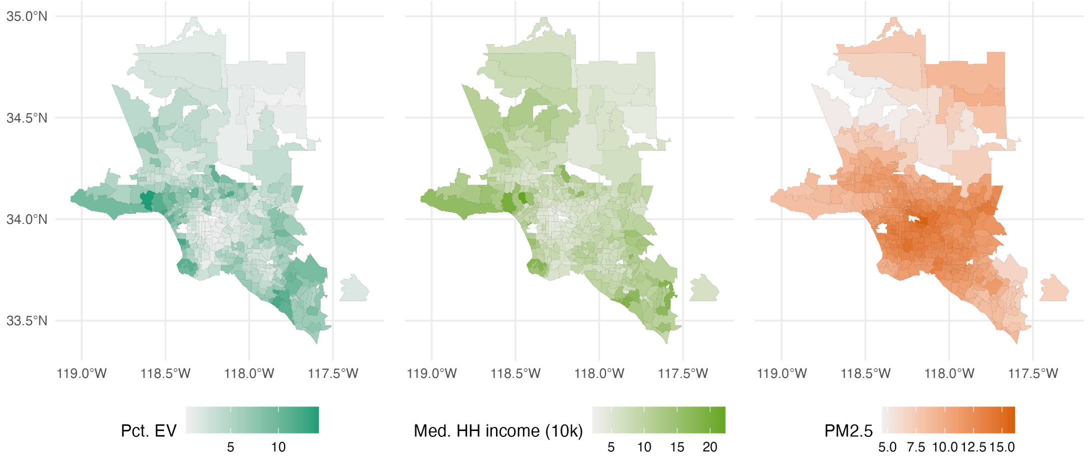
EV share of new cars in 2020 for the Houston metro area

Fastest-electrifying zips: 8%

Slowest-electrifying zips: 0%



EV share, income, and pollution in Los Angeles



What about the distribution of EV subsidies?

We identify available subsidies from government, policy org., and news media websites

Subsidies vary across space and time:

- flat amount or percentage per car
- restrictions on car price, make
- CA targets by income and zip-code
- state subsidies $\approx$ \$1,500-\$5,000

Looking for extra cash? Illinois will give you \$4,000 for buying an electric car

EV charging stations (WVIR)

By WIFR Newsroom

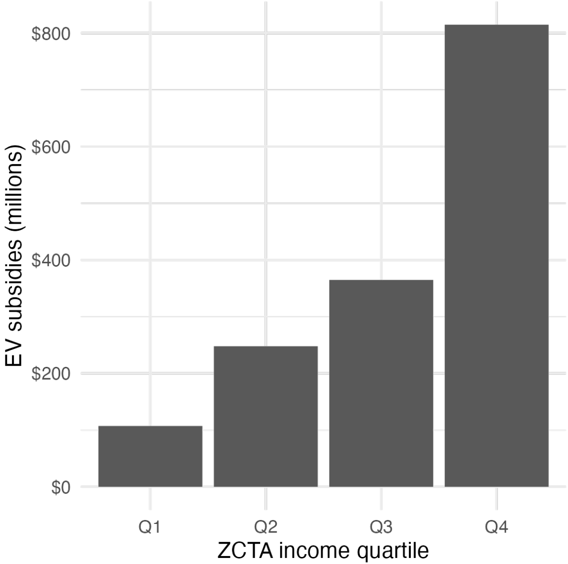
Published: Sep. 15, 2021 at 11:32 AM CDT

Key limitation: We observe subsidies available, not received

Subsidies go to affluent neighborhoods

Subsidy receipt is more unequal across neighborhoods than income

Almost half of subsidy dollars went to the highest income quartile



This distribution of subsidies does not obviously align with climate goals

EV subsidies go to neighborhoods with

- Fewer car commuters
- Shorter commutes
- Newer vehicles

Instead, neighborhood advantage predicts subsidy receipt

- Wealthier
- Whiter
- More educated
- More homeowners
- Less polluted

Suggests room to improve climate, public health, and equity impacts

We model demand for new vehicles

We use observed choices made by households...

- We construct a BLP-style discrete choice model of vehicle demand
  - Markets are CBSA $\times$ year, 2015–2020
  - Price sensitivity varies with income
  - Preferences vary with household characteristics
  - Subsidies are modeled as fully passed-through, and valued like $

...to make predictions about hypothetical choices under different circumstances

- What new car would a household buy with larger EV subsidies?

We compare a flat to a targeted subsidy for the Chicago metro area

Illinois/Chicago did not have a subsidy during our sample

Using the demand model, we simulate counterfactual purchases for two EV subsidies:

1. $2,500 available to all households
2. $5,000 available only to households in lower income zip codes

Targeting	Subsidy	Eligibility
None	2,500	All
Zip income	5,000	Q1,Q2

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Targeting	Subsidy	Eligibility	Δ EV	Cost (mil.)	Cost/additional EV
None	2,500	All	2,179	14.6	6,702
Zip income	5,000	Q1,Q2	2,280	18.6	8,149

We next model the resulting changes in criteria pollution

Simulate changes in on-road emissions caused by the policies under two scenarios

1. Assume all new cars are additional
2. Assume a new car replaces an ICEV at the 75th percentile of zip-level vehicle ages

Modeled changes in emissions are higher when

- More households commute alone by car
- Households commute farther distances
- Existing fleet is older (with replacement)

Limitations: assumptions about new EV drivers' behavior; not (yet) incorporating vehicle-specific emission rates

Targeting is more effective at reducing emissions of criteria pollutants

Model	Pollutant	Un-targeted	Targeted
Only new cars	NOx	-0.5%	-1.1%
Only new cars	PM2.5	-0.2%	-0.4%
With replacement	NOx	-0.8%	-1.9%
With replacement	PM2.5	-0.8%	-1.8%

Greater decreases come from longer commutes among HHs in the targeted group

- Negative correlation btw. median household income and commute length typical of largest MSAs

Targeting shifts decreases in emissions to lower-income zip codes

Pattern for changes in PM2.5 is similar

EVs unequally distrib. across neighborhoods, targeting subsidies can help

Within cities, EV adoption has been extremely geographically uneven

- EV subsidies flow to higher-income, less polluted neighborhoods

For Chicago, targeting subsidies to lower-income zip codes:

- Shifts EVs to lower-income neighborhoods at a slightly higher cost per EV
- Induces adoption in neighborhoods with longer commutes $\rightarrow$ local pollution benefits

Thanks, and comments welcome: jacqz@iastate.edu