Entry and Coordination in the Electric Vehicle Charging Industry

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Entry and coordination in network settings

- Spillovers in entry decisions
  - Usually negative from business stealing
  - Positive in network settings (ride-sharing, telecommunications, etc.)
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  - Usually negative from business stealing
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- Potential for inefficiently low entry, which could warrant government policies
- This project: Elecric vehicle charging station entry decisions
  - Does the market coordinate entry efficiently?
  - Can targeted subsidies improve market efficiency?

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- The last entrant to "connect the dots" can increase value of far-away incumbents
- The last entrant's private value of entry also depends on the set of incumbents
- Positive spillovers + independent entry decisions $\Rightarrow$ inefficiently low entry

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"Do we need support for gas stations? We don't [...] Delete it."

Research questions

1. Are there positive spillovers across electric vehicle charging sites?
2. Is entry inefficiently low in some places?
3. What are the efficiency implications of the IIJA guidelines compared to alternative policies, such as a uniform subsidy?

Project roadmap

- **Reduced-form estimates**
  - Spillover test 1: impact of entry on incumbents at different distances
  - Spillover test 2: impact of a route becoming connected on incumbents along the route
  -
- **Model**
  - Consumer demand for vehicles and charging services
  - Entry decisions by charging station site hosts
  - Charging network pricing for both sides of the market
- **Counterfactuals:** simulate charging network build-out and utilization for:
  1. A uniform subsidy and the US government NEVI program guidance (February 2022, completing highway corridors at most 50 miles apart)
  2. Charging network merger

Plan for today

- **Reduced-form estimates**
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- **Model sketch**
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Literature

EV markets

- Charging networks: Springel (2021), Li (2019), Li, Tong, Xing, & Zhou (2017),
- Energy and emissions: Gillingham et al (2022), Holland et al (2022), Holland et al (2016)
- Driver behavior: Sinyashin (2022), Dorsey et al (2022), Houde (2012)
- This paper: Whether charging station entry subsidies should be targeted, novel data

Firm entry

- Endogenous product/location: Holmes (2011), Jia (2008), Seim (2006), Mazzeo (2002)
- Competitive effects: Arcidiacono et al (2020), Goolsbee & Syverson (2008), Whinston & Collins (1992)

Assortment optimization with multiple categories basket shoppers

- Cachon and Kök (2007)

Bargaining in platforms and vertical markets

- Ho and Lee (2019), Collard-Wexler et al (2018), Crawford et al (2018), Crawford & Yorukoglu (2012)

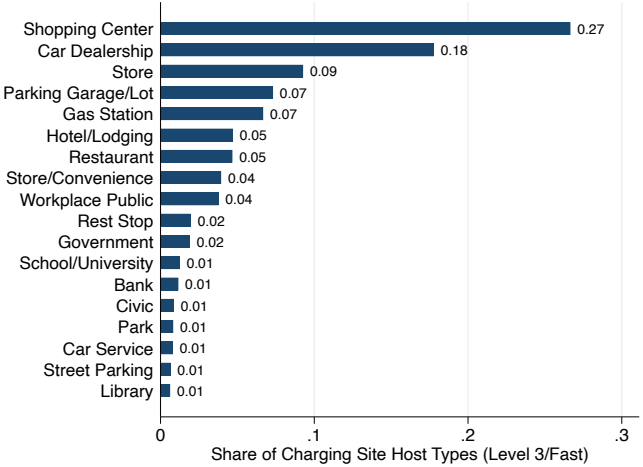
Roadmap of talk

1. **Industry background & Data**
2. Reduced-form estimates
   a. Spillover test 1: station-level
   b. Spillover test 2: route-level
3. Model

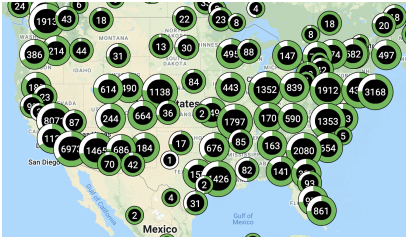
Electric vehicle charging primer

- Charging stations
  - Collections of charging posts
  - Offered by site hosts
  - Independent or affiliated with a network
- Standards: still 3 different Level 3 (fast) standards in the U.S.
- Retail prices
  - Set by site hosts or network
  - Linear, nonlinear, TOU
  - In energy or time

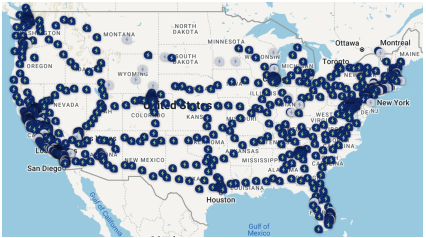
Charging site hosts vary in their primary purpose or business



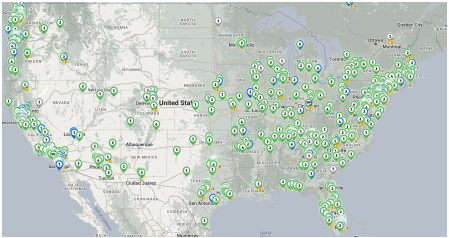
Charging network companies differ in build-out strategies



(a) ChargePoint



(b) Electrify America



(c) Blink

(d) Tesla

Data

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- **Charging location utilization**
  - Status by station at 30-min intervals; 2015, 2016 (all US) and Nov 2021 - present (CA only)
  - 1.6 million check-ins and reviews from a crowd-sourced website/app from 2011 - present

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$$y_{jt} = \beta_0 + \sum_d \beta_d \Delta \text{Competitors}_{jdt} + \gamma_j + \gamma_t + u_{jt},$$

  where d denotes distance bands from incumbent j.

- Caveat: (currently) no instrument for entry (suggestions welcome!)
  - Key identification assumption: Unobserved demand shocks are local $\Rightarrow$ no common unobserved demand shocks far away.
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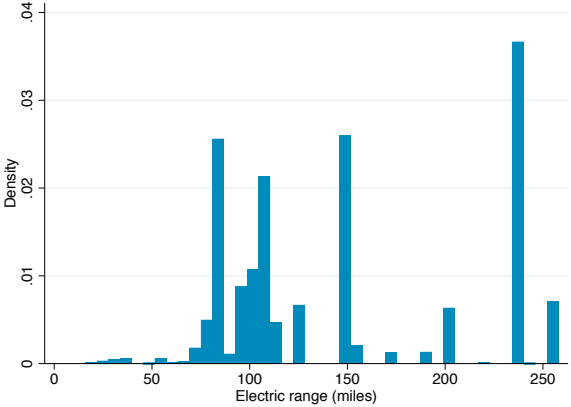
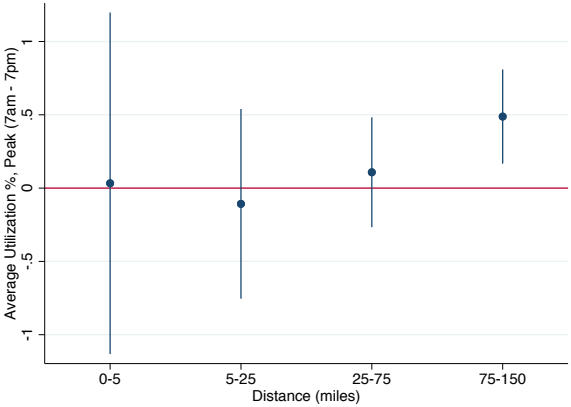
- Expect differences depending on whether charging standards are shared. Two cases:
  1. Entrants and incumbents share charging standards
  2. Entrant on a different charging standard

At what distances should we expect effects?



- Car range is upper bound on spacing of charging trips.
- Significant share of cars charging at these stations have range of 75-150 miles.
- For now: focus on distances of 75-150 miles vs. shorter distances.
- Work in progress: explore impact of changes in range of EV fleet over time.

Impact of entrants on incumbents with shared standard



- Preliminary estimate (please do not cite): Adding a station 75-150 miles away increases incumbent utilization during peak hours by .49 percentage points (or 3.1%).

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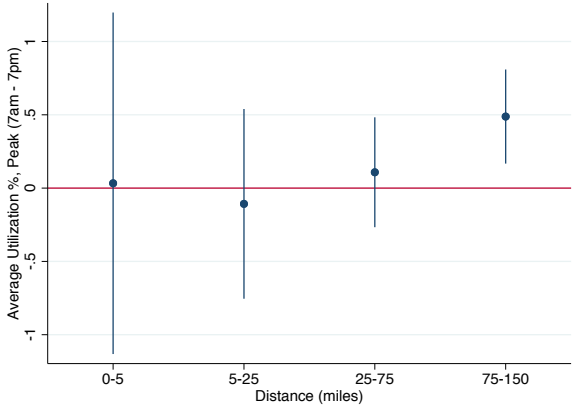
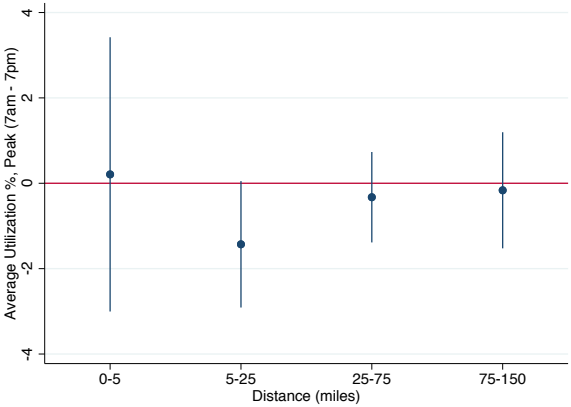


- Preliminary estimate (please do not cite): Adding a station 75-150 miles away increases incumbent utilization during peak hours by .49 percentage points (or 3.1%).
- No evidence of business stealing for short distances (but noisy estimates)

Impact of entrants on incumbents with *different* standard

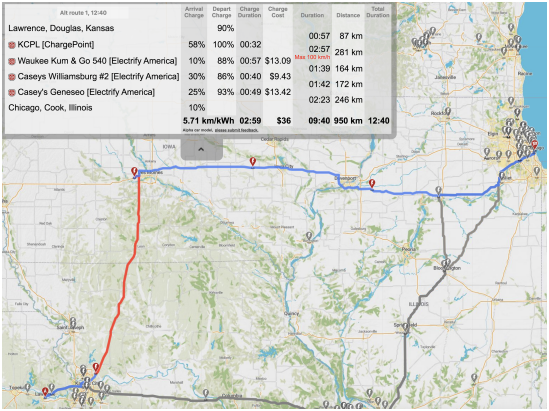


- Entry is not associated with significant (positive or negative) changes in utilization for incumbents with different standards.
- Exception: positive increases in demand 0-1 miles away. Interpretation: common demand shock.

Route-level analysis

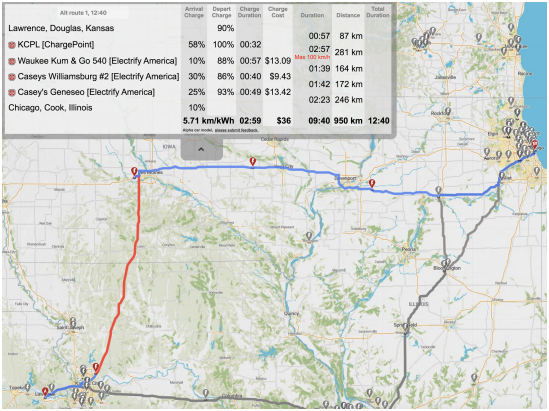
- So far: effect of entry at different distances from the incumbent, relatively coarse
- Road network allows for more structured tests
- Study impact of entry on incumbents along the same route
  - Compare impacts of entrants that 'complete' routes vs. earlier entrants that do not
  - Expect larger effects on previously disconnected routes
  - Plan to use state EV subsidies as a demand shifter for charging demand (not implemented in today's results)

Illustration of entry on a specific route



(a) Lawrence, KS to Chicago, IL, 2019

Illustration of entry on a specific route



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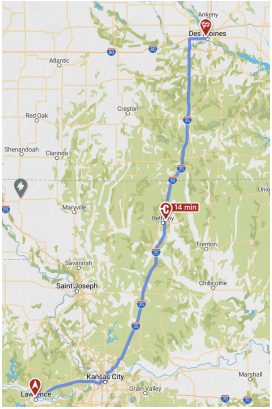
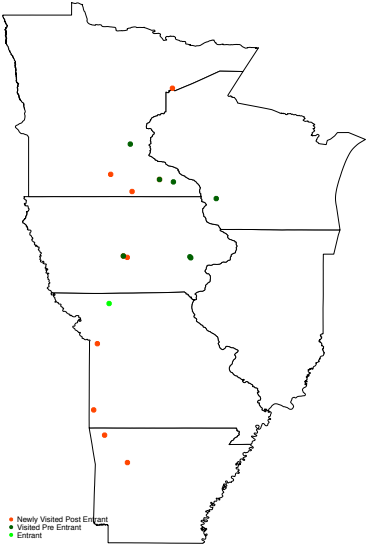


(b) 2021

Figure: EV routing in the Midwest; Source: `abetterrouteplanner.com`

User-specific data suggest spillovers from the entrant

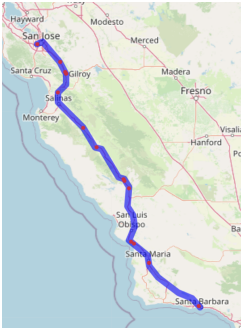


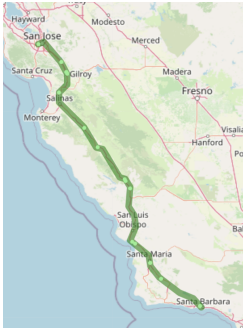
Comments about the entrant:

- "It works! Now I can get from Des Moines to Kansas City w/o major range anxiety or having to do mental math while driving."
- "Very happy to see this charging void getting filled for non-Teslas!"
- "About 8 degrees outside. Arrived with 40% SOC. Working well. Without this Bethany station I wouldn't make it from Des Moines to KC!"

Data construction steps with example of San Jose to Santa Barbara, CA

- Set of origins and destinations: FHWA Adjusted Urban Areas (493)
- Intersect charging stations with routes between each origin-destination pair
- Calculate distance between adjacent charging stations; a route is connected for a certain range if maximum distance is less than that range





- The new station that "electrifies" this route at the 50-mile range for the SAE J1772 Combo standard is in Los Alamos (Electrify America, entered May 2022).

Route-level analysis

- **Estimating equation:**

$$y_{rt} = \beta_0 + \beta_c \text{Connected}_{rt} + \gamma_r + \gamma_t + u_{rt},$$

  where r denotes a route, and y_{rt} is average utilization of incumbents on route r.
- β_c interpretation: impact of a route becoming connected at a certain range on incumbent utilization rates
- Identification assumption: unobserved (common) demand shocks are uncorrelated with whether a new entrant connects a route

$\Rightarrow$ Preliminary estimate, please do not cite: An entrant that "electrifies" a route at 50-mile intervals increases utilization of incumbent stations by .63 percentage points (or 25.9%) on average (in California, 2021 - present).

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- **Next question**: Do charging networks help coordinate charging locations entry?

How do charging networks compare in entry patterns?

- For each charging standard, route, and time period, compute location share by network (e.g. ChargePoint, Electrify America)
- Each route, at the time of becoming connected, has a dominant network and a set of newly arriving stations that contribute to it becoming connected.
- On a small sample of routes, YTD 2022, for the Combo standard
  - 69% of entrants are on the dominant network (EVConnect, Electrify America) when the network becomes connected, compared to
  - 62% of all entrants being on the dominant network (ChargePoint)
- Working on formulating this empirical test to something between 0 and 1 so that we have a sense of magnitude or what to make of this (e.g. how close to vertically integrated or centrally planned is this network)

Roadmap of talk

1. Industry background & Data
2. Reduced-form estimates
   a. Spillover test 1: station-level
   b. Spillover test 2: route-level
3. **Model sketch**

Model sketch

- **Goal:** Compare welfare of the 'every-50-mile' policy to a uniform charging station subsidy
- **Ingredients:**
  1. How drivers demand charging services given the charging network
  2. Which charging stations would be induced to enter with different subsidy eligibility rules
  3. Charging networks set entry and network fees to maximize profits

Model ingredient 1: Consumers

- Live in a market and have mobility needs
- Given charging network and their vehicle from prior choice, where to recharge when away from home.
- Disutility from time and monetary cost of charging
  - Cost of time or location distortion for charging compared to "natural" dwell time/location
  - "Opportunistic charging" (at work, shopping, waiting at a kid's weekend activity) vs. twiddling thumb at a highway rest stop
- Identification:
  - Price elasticity: Energy cost shifters from utility rates and structures
  - Elasticity w.r.t. location and inconvenience: Prior charging station subsidies, Alternative Fuel Corridor designation program

People look for charging near where they already go

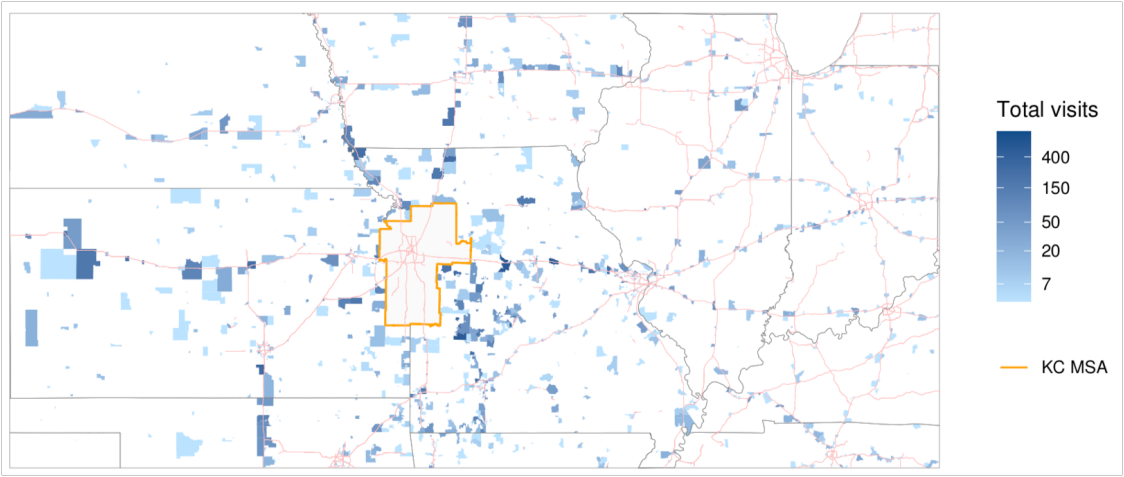
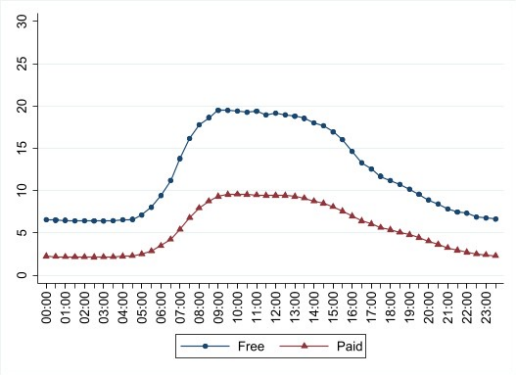
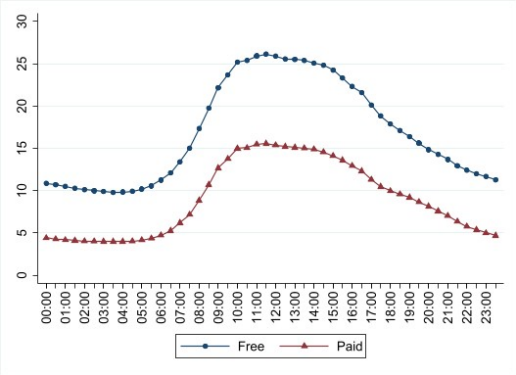


Figure: Visits to Gas Stations by People Who Live in KC, MO, Aug 2020; SafeGraph

Free stations have higher utilization than paid stations.



(a) Network X (Nationwide), Sep 2015



(b) Network X (CA Only), Nov 2021 - Feb 2022

Figure: Average Over Station-Day Observations

Model ingredient 2: Site hosts

- Endowed with a location and on-site amenity/business
- Set of possible charging station site hosts:
  - Any hotel, retail establishment, parking garage, municipal parking lot
  - Subsidy policy changes which sites are eligible
- Each period, given the charging network
  - If never entered, pay entry cost to enter
  - If previously entered, pay network fee/maintenance cost to remain active
  - If active, choose prices
- Multiple equilibria, depending on expectations (Katz and Shapiro (1985))
  - Use crowd-sourced check-in data to 'cut up' the network into independent charging markets
  - Identification from government coordination activity (Alternative Fuel Corridor designation program) and prior charging station subsidies

Model ingredient 3: Charging networks

- Intermediate between drivers and charging station site hosts.
  - Drivers pay membership fees (to the network) and marginal usage fees (split between site host and network).
  - Charging station site hosts pay a per-period network fee.
- Choose how much to subsidize either side of the market
- In counterfactual:
  - Hold fixed the organizational form of the network (e.g. vertical integration with sites)
  - Subsidy eligibility changes the entry profitability of different sites

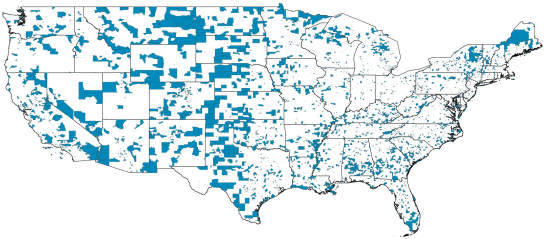
Summary and next steps

- U.S. charging station subsidy policy can be rationalized by positive entry spillovers across charging locations.

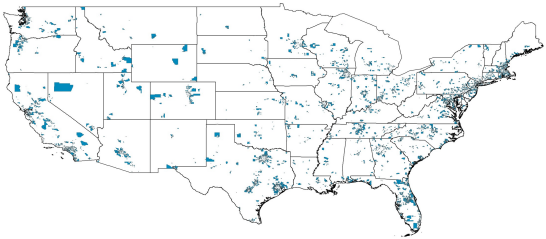
- **Next steps:**
  - Specify and estimate a structural model of the charging industry
  - Evaluate impact of a targeted every-50-mile subsidy policy compared to a uniform subsidy

THANK YOU!

Census tracts at 10th and 90th percentile by population count



(a) 10th percentile



(b) 90th percentile

BACK

Census tracts at 10th and 90th percentile by population count

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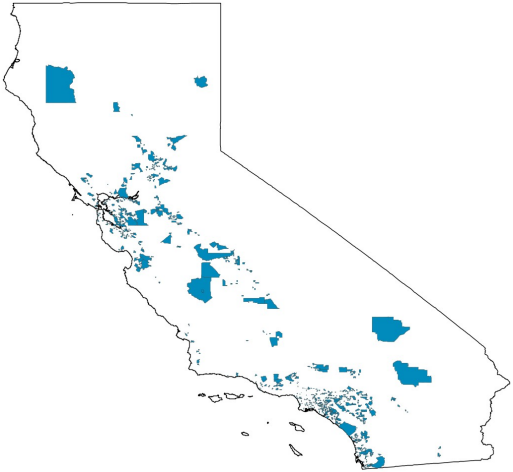

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