Driving Change: Assessing the Impact of Electric Vehicle Charging Infrastructure on Gasoline Consumption across California Counties

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Introduction

- California reached 1.26 million light-duty EV registrations by 2023
- Despite rapid EV uptake, **gasoline consumption remains a key environmental challenge**
- This research project answers **how effective public charging infrastructure translate EV presence into reductions in gasoline use**.
- This project integrates charger to EV ratios, median household income, and spatial coverage into a county-level two-way fixed-effects model for the time range from 2014 to 2023.

Data

- **EV registrations and adoption rate:** Annual county counts from California Energy Commission (CEC) reports.
- **Charger inventory:** Level 1, Level 2, DC fast counts from US Department of Energy's Alternative Fuels Data Center (AFDC), aggregated per county-year.
- **Income:** Median household income from US Census Bureau's Small Area Income and Poverty Estimates (SAIPE).
- **Fuel use:** Gasoline sales per capita from CEC reports.

Methodology

- **Panel setup:** 52 counties x 10 years (2014-2023), merging EV population data, charger counts, income and gasoline use.
- **Key variables:** EV adoption rate, number of chargers per 100 EVs, charging capacity per EV, geographic coverage percentage (percentage of area within 5 miles of a charger).
- **Linear regression:** Two-way fixed-effects OLS:

$$gasPerCapita_{it} = \beta_1 L1_{it} + \beta_2 L2_{it} + \beta_3 \cdot DCFast_{it} + \beta_4 \cdot evAdoption_{it} + \beta_5 \cdot income_{it} + \beta_6 \cdot chargerRatio_{it} + \beta_7 \cdot capacityRatio_{it} + \beta_8 \cdot coverage_{it} + \alpha_i + \gamma_t + \epsilon$$

where α_i and γ_t are county and year fixed effects respectively.

- **Visuals:** Faceted scatterplots, correlation matrix, county spatial maps.

Results

Table 1: Fixed Effects OLS Estimates

Predictor	Estimate	Standard Error	p-value
Level 1 chargers	+0.0967	0.1046	0.3599
Level 2 chargers	−0.0225	0.0130	0.0902
DC fast chargers	+0.1237	0.0667	0.0695
EV adoption rate	−0.0330	0.1391	0.8132
Median household income (USD)	−0.00045	0.0006	0.4569
Chargers per 100 EVs	−0.4899	0.3650	0.1854
Charging capacity (mi/EV)	+1.0383	0.7934	0.1965
Geographic coverage (%)	+0.3679	0.7454	0.6237

Notes: Number of observations: 483. Fixed effects: County, Year.
Adjusted $R^2 = 0.8911$. Within $R^2 = 0.0465$.

- Each additional Level 2 charger **reduces around 0.02 gallons in fuel use per capita**.
- Negative coefficient estimate for number of chargers per 100 EVs suggests that **greater charger sufficiency drives behavior change.**
- Positive coefficient estimate for number of DC fast chargers implies that **focusing only on raw charger counts may overlook congestion and equity issues.**
- High adjusted R^2 but low within R^2 suggests most of the explanatory power of the regression comes from the fixed effects, but within-county, year-to-year changes still matter.

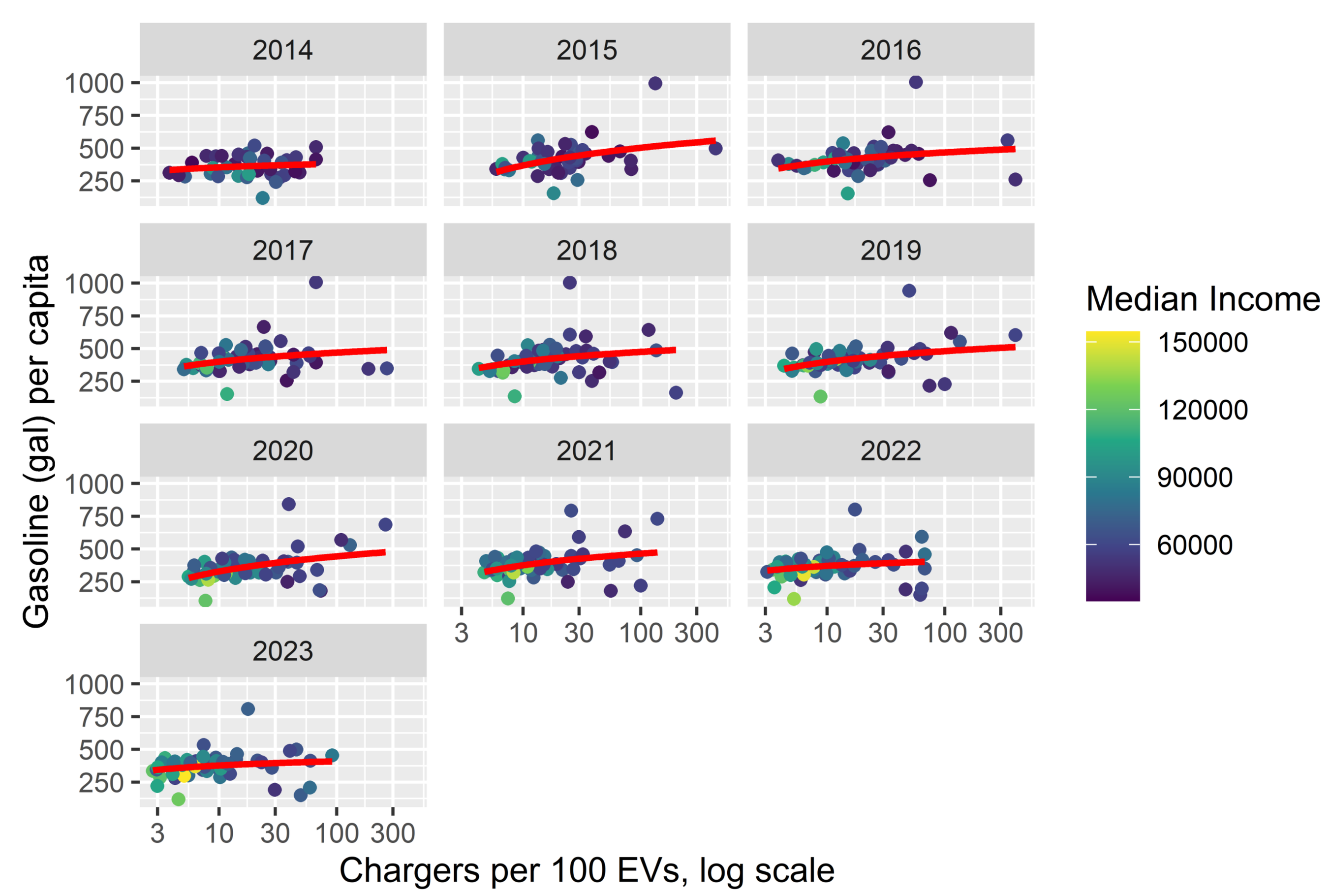

Figure 1: Correlation between number of chargers and gasoline consumption per capita, faceted by year and median income

- Counties with **higher charger to EV ratios** also show **higher gasoline use per capita**.
- This reflects that such counties tend to have **larger EV fleets and greater overall travel demand**, not a casual effect of chargers driving up fuel use.
- County fixed-effects regression then isolates the true within-county impact of charger sufficiency on gasoline consumption overtime.

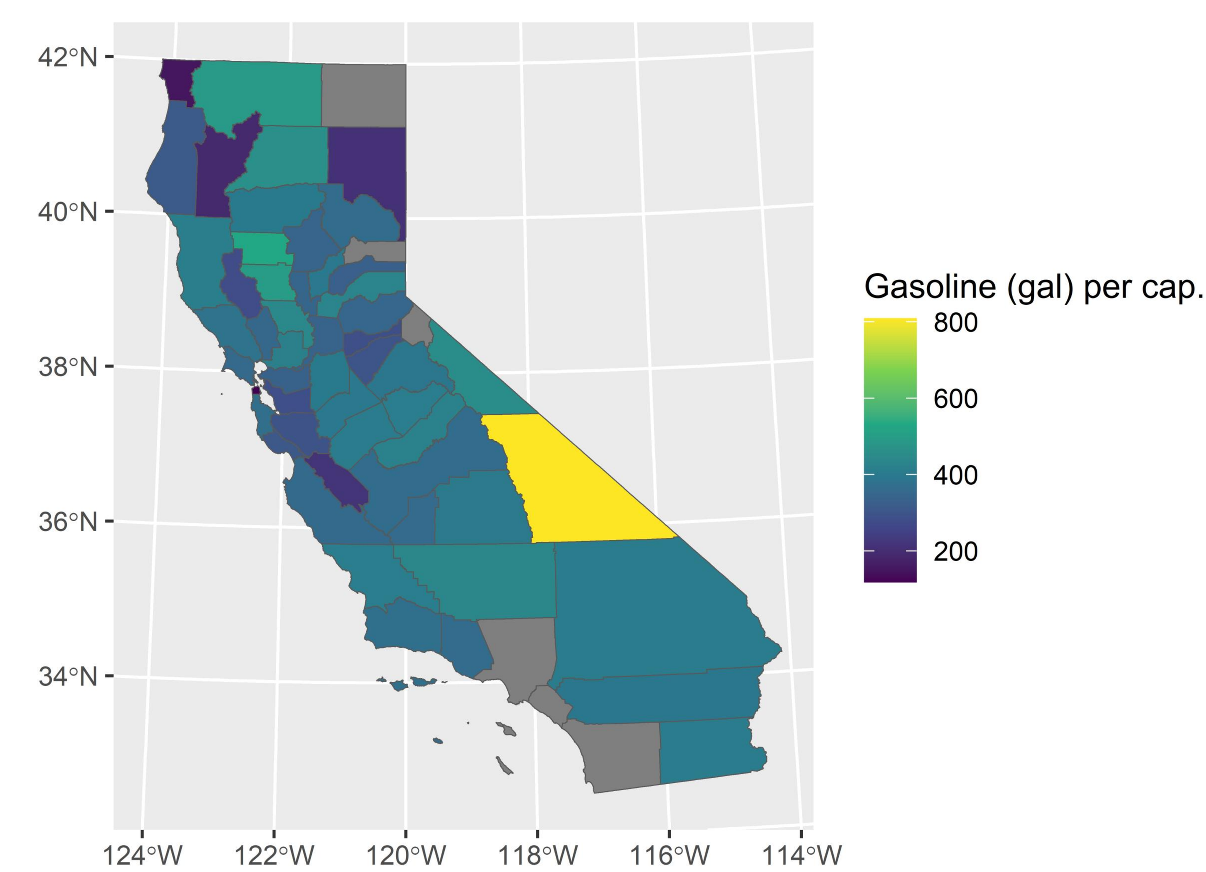

Figure 2: Gasoline consumption per capita by county, 2023

- **Coastal urban counties** (e.g. San Francisco) see **lower** gasoline consumption per capita, consistent with denser charging networks.
- **Inland rural counties** (e.g. Inyo) maintain **high** gasoline use despite charger growth, highlighting persistent "charging deserts".

Conclusion

- Our model show that **number of Level 2 chargers** and **number of chargers per 100 EVs** are associated with **declines** in gasoline use per capita, while **number of DC fast chargers** sees a counterintuitive **positive** link.
- Our model captures a majority of the cross-county variation but only a minority of year-to-year, within-county changes, though it still confirm that expanding charger access can drive behavioral change.
- **Infrastructure sufficiency** (chargers relative to fleet size) matters more for gasoline reduction than raw charger counts.

Policy Recommendations

- **Target charger deployment** where EV fleets are growing, prioritize Level 2 stations in underserved areas.
- Pair infrastructure building with **demand management** and **consumer incentives** to maximize impacts on fuel use.

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