Low energy: Estimating electric vehicle electricity use

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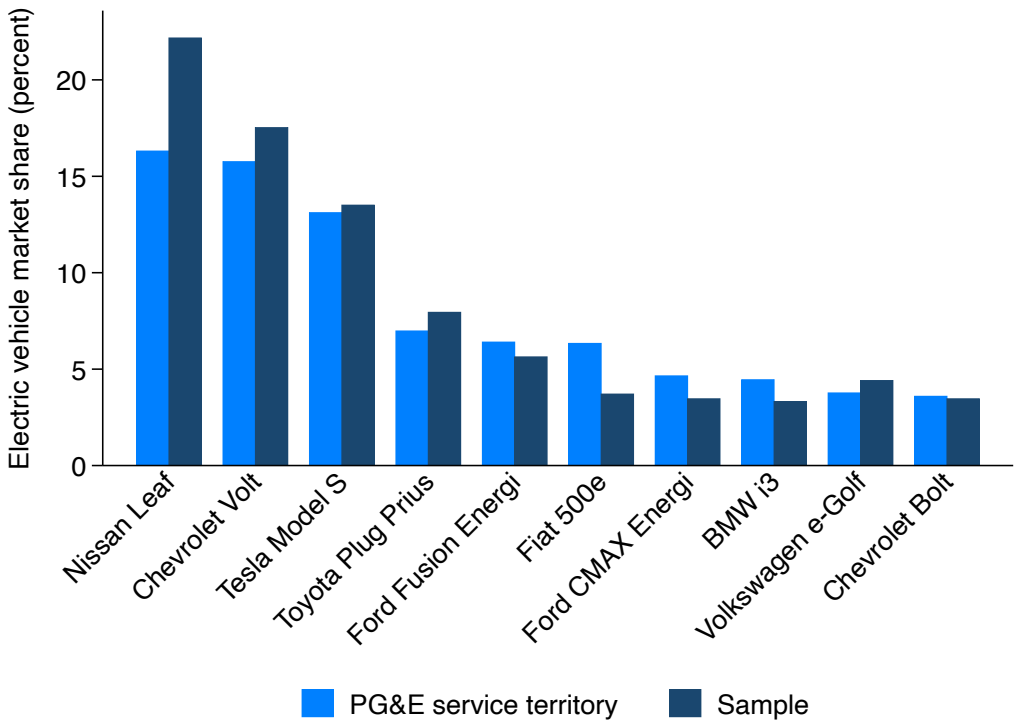
Supplementary Appendix: For online publication

Sample composition of EVs

Figure A1 compares the market shares of EVs in our empirical sample to the overall PG&E population, and demonstrates that our sample has representative coverage of EV models in the utility territory that we study. The sample appears to slightly overweight the most popular cars and slightly underweight less popular cars. This may be an artifact of the sampling frame. As mentioned above, the electricity meter data overweight households in Census Block Groups that have high EV penetration; Figure A1 suggests that these areas may disproportionately own the most popular models.

Figure A1: Composition of EV fleet: Population vs. empirical sample



Notes: This figure presents market shares of the top-ten EV models in the empirical sample and the population of EVs in Pacific Gas & Electric territory from which it was drawn.

Robustness checks

Results presented in the body of the paper are robust to inclusion of control variables. In this Appendix, we present regression counterparts to Figure 1 using various fixed effects. Table A1 shows the average difference-in-differences estimates of the effect on household load resulting from the addition of the average EV in our sample. All columns control for solar installation at the household level. The data are collapsed to the household-by-week-of-sample level.

Table A1: Difference-in-differences: Effect of EV registration on household load

	kWh/hr	kWh/hr	kWh/hr	kWh/hr	kWh/hr	kWh/hr
EV Post	0.339***	0.133***	0.119***	0.123***	0.150***	0.121***
	(0.030)	(0.020)	(0.008)	(0.009)	(0.009)	(0.007)
Solar Post	-0.279***	-0.816***	-0.795***	-0.843***	-0.701***	-0.804***
	(0.024)	(0.036)	(0.025)	(0.030)	(0.028)	(0.025)
HH FEs	No	Yes	No	No	No	No
HHxYear FEs	No	No	Yes	No	Yes	Yes
HHxMofY FEs	No	No	Yes	Yes	No	Yes
Week-of-Sample FEs	No	No	No	Yes	Yes	Yes
Mean Dep. Var	0.77	0.77	0.77	0.77	0.77	0.77
Observations	69,751,085	69,735,740	69,305,961	69,585,082	69,382,114	69,305,961
Within R^2	0.01	0.77	0.91	0.87	0.82	0.91

Moving left to right, specifications include increasingly fine household and time fixed effects. The main conclusion is that controlling for time-invariant household characteristics is important, which can be seen by comparing results in column 1 (which has no fixed effects) and columns 2 through 6. The coefficient on EV arrival is much higher in column 1 due to the fact that households with high baseline electricity usage are more likely to purchase an EV. Coefficient estimates in columns 2 through 6 consistently fall within the range of 0.12-0.15 kilowatt-hours per hour.

Our preferred estimate, 0.12, is in the right-most column. This estimate controls for aggregate patterns in electricity usage by including week-of-sample fixed effects. Household-by-year effects capture factors such as trends in charging station density near each household, and any trends in non-EV electricity usage that may be correlated with the decision to purchase an EV. Household-by-month-of-year fixed effects control for seasonal patterns in electricity demand at the household level, which may confound estimates of the treatment effect if EVs purchases are concentrated in particularly low- or high-electricity usage months.

Table A2 decomposes the difference-in-differences result by car type. Once again, the importance of controlling for household fixed effects is apparent. This table also confirms the main conclusions from Figure 1. Overall, Teslas consume more than twice the amount of electricity via

Table A2: Difference-in-differences: Effect of EV registration on household load, by car type

	kWh/hr	kWh/hr	kWh/hr	kWh/hr	kWh/hr	kWh/hr
Tesla Post	0.542***	0.242***	0.233***	0.223***	0.314***	0.236***
	(0.039)	(0.029)	(0.015)	(0.017)	(0.022)	(0.014)
Non-Tesla BEV Post	0.147***	0.116***	0.106***	0.108***	0.114***	0.103***
	(0.020)	(0.016)	(0.008)	(0.008)	(0.010)	(0.008)
PHEV Post	0.472***	0.104***	0.086***	0.094***	0.119***	0.090***
	(0.055)	(0.023)	(0.013)	(0.012)	(0.011)	(0.013)
Solar Post	-0.281***	-0.817***	-0.796***	-0.844***	-0.702***	-0.804***
	(0.024)	(0.036)	(0.025)	(0.029)	(0.028)	(0.025)
HH FEs	No	Yes	No	No	No	No
HHxYear FEs	No	No	Yes	No	Yes	Yes
HHxMofY FEs	No	No	Yes	Yes	No	Yes
Week-of-Sample FEs	No	No	No	Yes	Yes	Yes
Mean Dep. Var	0.77	0.77	0.77	0.77	0.77	0.77
Observations	69,751,085	69,735,740	69,305,961	69,585,082	69,382,114	69,305,961
Within R^2	0.01	0.77	0.91	0.87	0.82	0.91

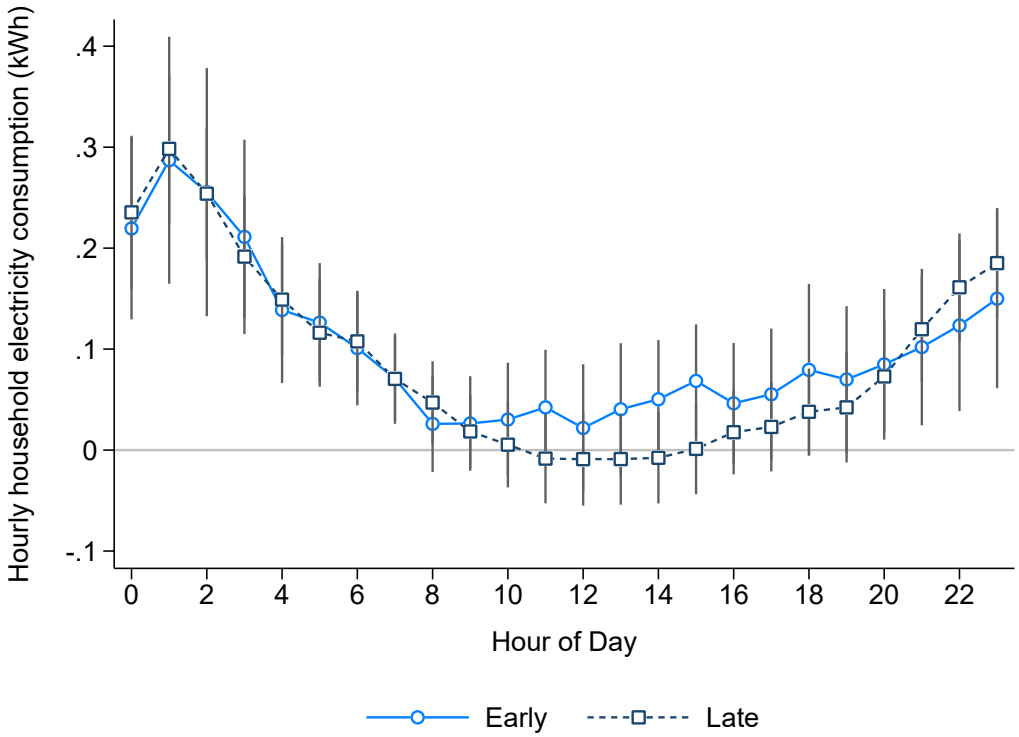
home charging than other BEVs and PHEVs. Moreover, there is little difference in average household charging load between non-Tesla BEVs and PHEVs. Some readers may have expected (as we did) PHEVs to exhibit lower home charging load due to the availability of an internal combustion engine that can run on gasoline. However, these results imply that PHEV owners likely charge their EV battery regularly.

Early vs. late adopters

Figure A2 plots difference-in-differences estimates of the change in household load, by hour-of-day, arising from the addition of an EV. "Early" adopters buy an EV in 2014 and "Late" adopters buy in 2017. Overall, there is little difference in home charging load across these two groups, although late adopters home-charge their EVs slightly less, on average, than early adopters. This is particularly true during the workday.

The implications for eVMT are unclear. If the fraction of overall charging that occurs at home remains constant across years, these results imply that eVMT is slightly decreasing over time. On the other hand, increases in EV battery capacity over the period of study have expanded EV range, and away-from-home charging is unobserved. It is possible that these effect outweigh any decline in home charging. California Air Resources Board (2020) indicates that the share of commercial charging is increasing slowly since 2018, but their published data do not go back far enough to confirm whether this trend was occurring during our sample. More research is needed.

Figure A2: Impacts of EV adoption on household electricity use: Early vs late adopters



Notes: This figure presents our estimates of the impact of EV adoption on household electricity consumption, comparing early (2014) and late adopters (2017). Standard errors are two-way clustered at the Census block group and week-of-sample level.

Appendix References

California Air Resources Board. 2020. *Low Carbon Fuel Standard Quarterly Summary of Data.* Technical report.