Staggered Electric Vehicle Adoption, Air Pollution Disparities, and Subsidy Policy

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Question: How does the staggered adoption of electric vehicles paired with neighborhood segregation affect disparities in urban air pollution? What are the distributional impacts of targeting electric vehicle subsidies by income, location, or both?

Motivation: The number of electric vehicles (EVs) in California increased 35% from 2018 to 2020, but only 4 percent of all new vehicles were battery electric. The transition to a fully electric vehicle fleet could take decades. Adoption of electric vehicles tracks closely with household income (Borenstein and Davis, 2016; Canepa, Hardman and Tal, 2019), so the electrification of urban vehicle fleets will likely start in affluent neighborhoods and conclude in lower-income neighborhoods.

This pattern of staggered adoption may exacerbate neighborhood-level disparities in ambient air pollution. Both EVs and gasoline vehicles produce non-exhaust particulate emissions from tire, brake, and road wear (Timmers and Achten, 2018), but EVs generate no exhaust (tailpipe) emissions, which include particulates, nitrogen oxides and carbon monoxide. Because non-exhaust emissions are an increasingly large share of total emissions, the average local emissions benefits of replacing a gas vehicle with an EV may be small. Yet, Holland et al. (2019) finds large net benefits in some counties, implying substantial reductions in on-road emissions. These EVs enter an already-unequal landscape: Figure 1 shows adoption in the Los Angeles area maps closely to household income and is inversely related to pollution. We know from a large literature that pollution disparities have implications for health and home values.[1]

This matters because EVs are heavily subsidized, and the design of these subsidies affects which households adopt EVs. Subsidies that drive uptake only in affluent neighborhoods may inadvertently worsen environmental justice. Because replacing gasoline vehicles with EVs unambiguously mitigates global climate change, subsidies for EVs are likely to become more common. While most existing subsidies are a flat rebate for EV purchase, a handful of states

[1]Low socioeconomic status communities tend to experience higher traffic pollution, and exposure to traffic pollution diminishes health (Hajat, Hsia and O'Neill, 2015; Knittel, Miller and Sanders, 2016; Nguyen and Marshall, 2018; Barnes, Chatterton and Longhurst, 2019; Heissel, Persico and Simon, 2019; Anderson, 2020).

tie subsidies to income.[2] California's Enhanced Fleet Modernization Program goes one step further and targets subsidies using both household income and location (Muehlegger and Rapson, 2021). This type of targeting may result in a more equitable distribution of local emissions, noise pollution, and consumer surplus across households.

Project description: Our project will evaluate the distributional effects of alternative subsidies for electric vehicles, accounting for both consumer surplus and pollution damages. To do so, we will estimate a model of EV demand that incorporates household characteristics. We will also develop a model of how an additional EV in a zip-code affects the distribution of on-road emissions across surrounding neighborhoods.

We will first estimate a structural model of EV demand that allows preferences to vary with demographic characteristics. Our main data set is a panel of zip-code level vehicle registrations from a subset of U.S. states. We will combine these with demographic characteristics (e.g., income, race, household size, and commuting behavior) from the American Community Survey, housing stock characteristics from Zillow (e.g., fraction of homes with attached garages), gasoline and electricity prices from the EIA, charging station data from NREL, and car prices and characteristics from Intellichoice.com, as well as data on local subsidy policies. Using these data, we will estimate a discrete choice model of new vehicle demand following Berry, Levinsohn and Pakes (1995), Nevo (2001), Li (2019), and Durrmeyer (2020).

We will also use data on traffic flows to allocate on-road damages from EVs across space. Our preferred approach would be to use exogenous variation in EVs to estimate the marginal impact of replacing a gas-powered vehicle with an EV, especially since recent work suggests laboratory-based measures of emissions understate on-road emissions (Reynaert and Sallee, 2021). Yet, we likely would not have enough power to estimate these effects because EV penetration in the US is still low. Instead, we will combine estimates from the literature with data on traffic flows from sources like Caltrans Traffic Volumes. EV non-exhaust emissions depend on driving behavior, including speed, idling, and braking. Estimates for the size of these damages vary, and we will quantify them under a range of assumptions.

Once we have models of both vehicle demand and the local emissions of vehicles in different locations, we can simulate counterfactual subsidy policies that change the price of electric vehicles. These can include uniform subsidies, income-based subsidies, or place-based subsidies. Because we focus on counterfactual local policies of the type states and utilities across the U.S. are considering, we can likely assume subsidies reduce prices one-for-one and abstract from the supply-side response by global automakers.[3] Our model will allow us to

[2] https://www.tesla.com/support/incentives#state-local-and-utility-incentives

[3] This assumption is consistent with Muehlegger and Rapson (2021)'s finding of that the pass through of EV subsidies to buyers is indistinguishable from one.

calculate both total consumer surplus and the distribution of this surplus under alternative policies. In addition to reducing inequities, targeting subsidies may increase the elasticity of EV purchases with respect to the total subsidy bill by reducing the fraction of subsidy that goes to inframarginal consumers.

Our analysis is explicitly short-run for two reasons. First, a longer-run projection would involve making strong assumptions about the evolution of both EV and conventional vehicle technology, as well as charging networks. Second, it may not be reasonable to assume household preferences are fixed over a longer time horizon. Our findings will be directly relevant to states currently considering EV subsidies.

Contribution: In contrast to the literature on the incidence of subsidies by household income (e.g., Borenstein and Davis, 2016), we explore how subsidies affect urban air pollution and inequities in its distribution. This remains an open question: the distributional impacts of pollution exposure during the transition to electric vehicles depend on the neighborhoods in which EVs are driven. Our focus on tailpipe emissions at a fine geographic level differs from Holland et al. (2019)'s emphasis on the distributional effects of on-road and power plant emissions at the county level. The on-road portion of emissions will become increasingly relevant as electricity generation becomes cleaner.

Our project is complementary to Muehlegger and Rapson (2021), which evaluates the impact of a California policy targeting subsidies toward low and middle-income households. While the focus of that paper is on the taxpayer cost to achieve widespread adoption of EVs, ours is on the short-run distributional impacts of subsidy targeting.

While our demand model and estimation strategy will be similar to Durrmeyer (2020), our focus will be on electric vehicles rather than gasoline-powered vehicles. This allows us to add flexibility along the dimensions most relevant for their adoption, such as preference heterogeneity based on home type and average commuting distance. Similarly, our focus on distributional impacts will motivate more flexibility than Li (2019) with respect to demographic characteristics.

Finally, a growing literature explores the optimal time path of subsidies given improving technology and falling emissions from electricity generation (Langer and Lemoine, 2018; Holland, Mansur and Yates, 2020). We instead study how subsidy design affects adoption across households at a point in time, and aim to help policymakers understand whether EV subsides can also be a tool to address local environmental injustice.

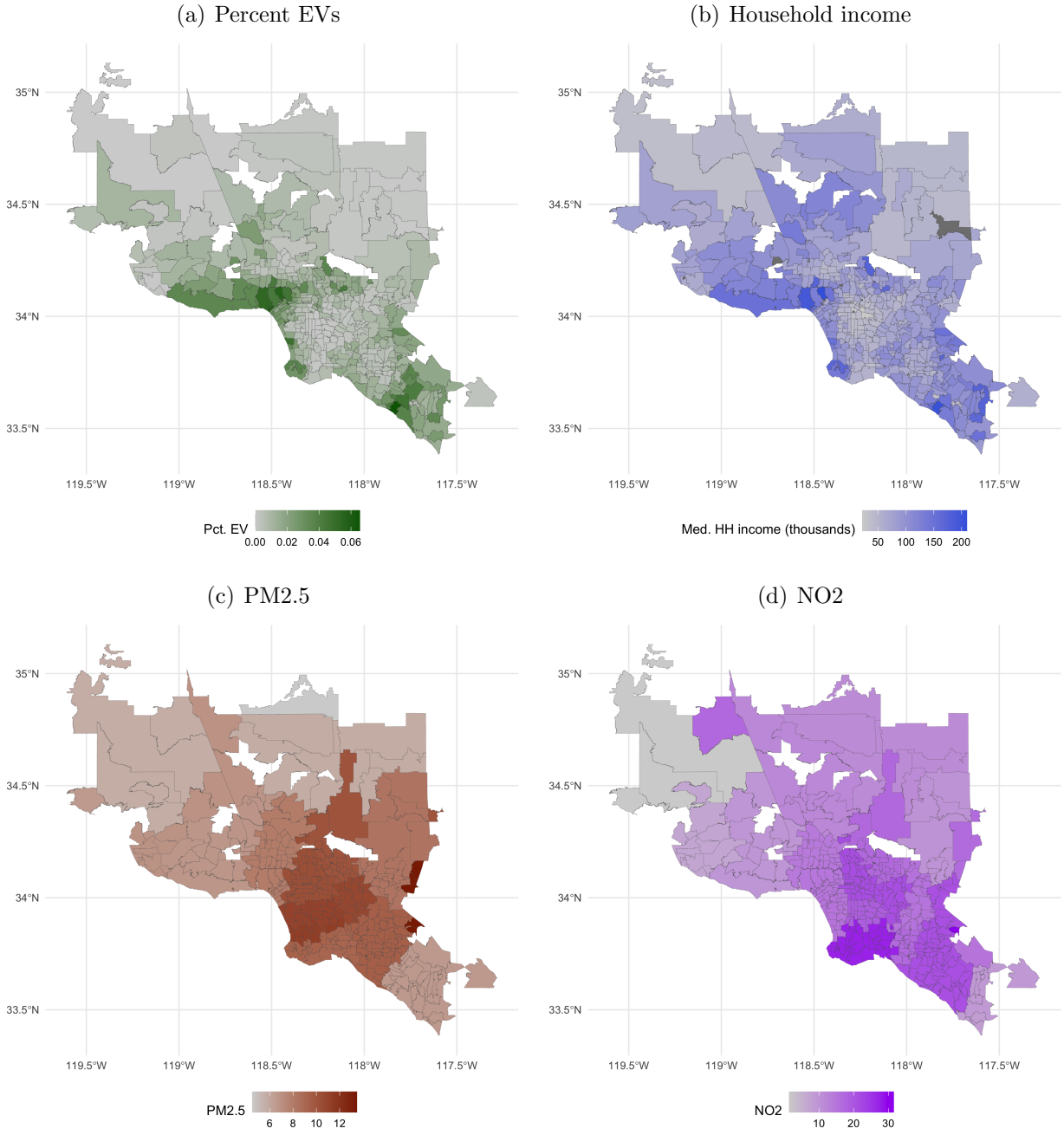


Figure 1: Zip code-level EV ownership, median household income, and average ambient air pollution in Los Angeles, Ventura, and Orange counties in 2020

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