Minimizing Fleet Emissions through Optimal EV Subsidy Design and Vehicle Replacement

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In the wake of mounting attention toward investment in energy efficiency and renewable resources, the US allocated approximately $400 million of the 2009 American Recovery and Reinvestment Act in part toward investment and research into electric vehicles (EVs). State and municipal governments, notably in California, concurrently rolled out other incentive programs to encourage the adoption of EVs, including rebates, tax credits, and electricity discounts. Recent research has redirected its attention toward the question of how effective these programs are at reducing carbon emissions.

For a policy maker designing a subsidy program to minimize fleet emissions, several factors disconnect this objective from maximizing EVs on the road. The first requires accounting for power grid emissions when charging an EV as compared to the comparable emissions from driving a gas vehicle. A second issue is determining what vehicles consumers replace when purchasing a new vehicle. The net emissions impact of replacing a Tesla with a newer Tesla is substantially different than that of replacing a mid-90s Toyota Camry. This dimension is similar to, yet distinct from, the substitution question addressed in papers like "What Does an Electric Vehicle Replace?" by Xing, Leard, and Li (2019), that is, what vehicles consumers would purchase in the absence of a subsidy regime.

In this paper, Seo and Shapiro address this second set of factors with the ultimate goal of producing an optimal subsidy design to maximize the expected reduction of emissions per dollar spent. Theoretically, the researchers consider a Pigouvian subsidy design through the lens of a policy maker with instruments that can discriminate based on income (or vehicle type). The optimal subsidy schedule is then dependent on the marginal emissions contribution of a consumer per unit of the subsidy offered. Identifying marginal consumers requires consideration of both a targeted consumer's vehicle replacement and induced substitution from a subsidy. In the simplest case when one limits a consumer to a single car, she can impact emissions in two ways. The first is to introduce a more efficient vehicle into the fleet. The second is to remove a low-mileage vehicle from the fleet by scrapping it.

Ultimately, identifying these marginal consumers based on consumer characteristics is an empirical question. The researchers characterize them in the context of the California EV market over the period 2014 to 2016, during most of which the state offered flat subsidies based on vehicle efficiency. This time period is particularly interesting for study as municipalities in California implemented their own financing programs and the state began to introduce a progressive subsidy schedule. The researchers treat the cutoffs and regional plans as a source of exogenous variation in subsidy levels to help identify price elasticities. The researchers pair the setting with a unique combination of granular, vehicle-level purchase and ownership data and a stated preference survey of California drivers to start addressing these questions. With the high spatiotemporal variation in subsidy levels in California from localized vehicle incentive programs, the discontinuities permit a cleaner analysis of the impact of these policies on the consumer choices described previously.

The researchers find suggestive evidence that both low- and high-income consumers can be marginal consumers. The low-income group tends to be more price sensitive compared to the high-income group, implying that the marginal increase in EV purchasing probability is higher from a subsidy. Moreover, the low-income group on average owns less fuel efficient vehicles than the high-income group at any point in time, implying that the marginal reduction in emissions on the road by replacing the old vehicles is larger for the low-income group. However, the high-income group exhibits a higher substitution effect because they consider fuel inefficient vehicles to be close substitutes to EVs. The researchers show that the high-income group purchases EVs not because they value the fuel efficiency but because they prefer luxury vehicles, which includes Tesla. Therefore, if the high-income group were not to purchase an EV, namely Tesla, it is highly likely that they end up purchasing, for example, a fuel inefficient BMW. The researchers also confirm existing findings in the literature that the flat subsidy across income levels results in half of subsidy recipients being inframarginal.

The researchers continue to work on a nonlinear optimal subsidy to minimize vehicle emissions on the road for a fixed budget planner, using vehicle registration data in California. This subsidy design maximizes the expected reduction of emissions per dollar spent by targeting marginal consumers with the highest impact on vehicle emissions.