What Does an Electric Vehicle Replace?

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Abstract

By reducing reliance on gasoline, the plug-in electric vehicles (EVs) provide a potential pathway to mitigate the externalities associated with gasoline use. Federal, state and local government agencies have all implemented various subsidy programs in recent years to promote the adoption of EVs for the purpose of reducing air pollution, carbon emissions and oil consumption. However, the effectiveness of the subsidy policies in terms of addressing those environmental issues greatly hinges on the emissions of vehicles that EVs replace: the smaller the relative difference in emissions between EVs and the vehicles households would have bought in the absence of incentives, the lower the emissions reductions. Estimating the emissions consequences from incentives for EVs therefore depends on how consumers substitute between vehicles of different fuel types and emissions ratings. A potential efficiency loss could arise if the subsidy does not induce people to switch from a gas guzzler to an EV but from another fuel-efficient vehicle (such as a hybrid vehicle) to an EV, making little net gain of environmental benefits. With the expiration of tax credits for hybrid vehicles, the introduction of the income tax credits for EVs are much likely to encourage consumers who would otherwise purchase hybrid vehicles to purchase EVs. If taking account of the emissions of EVs from consuming electricity at the national average grid fuel mix, EVs may not have an advantage over hybrid vehicles in emissions reduction and some EV models even generate more emissions than hybrid vehicles. Moreover, the EV subsidy programs could also suffer from the problem of non-additionality in the sense that the subsidies may not always result in additional EV sales since many of the buyers who claim the subsidy may still purchase EVs even if there were no subsidy policy. The problem could be especially pronounced at the early deployment stage of EVs since the early adopters are more likely to be those who favor the newest technology, have stronger environmental awareness and have higher income.

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Our estimation framework leverages detailed micro and macro data on new automobile purchases between 2010-2014, a period of rapid growth of EV sales. Using unique survey data of new vehicle buyers that includes information on vehicles buyers considered in addition to those that they purchased, we estimate the substitution patterns of EVs with other fuel types with a household level mixed logit model. Following Berry, Levinsohn and Pakes (1995, 2004) and Train and Winston (2007), maximum likelihood estimation approach is employed to estimate the preference parameters of the random coefficients discrete choice model. The survey data include detailed demographic information for the consumers who purchased different vehicle models such as household income, education, family size, driving habits, financing methods and zip code. Information on the alternative vehicle models that consumers consider while making their purchase decisions provides additional variation to identify the random coefficient parameters that govern substitution patterns. The survey data is further complemented by the data of fuel prices and the number of charging stations, which allows us to estimate consumer vehicle demand more accurately. The preference estimates are then used to recover cross-price elasticities between different vehicle models to reflect substitution patterns.

With our demand parameter estimates, simulation analysis is conducted to examine the counterfactual vehicle sales when the EV subsidy is removed, and the magnitude of the resulting sales change of the other fuel types could suggest what types of cars were replaced by EVs. The estimated substitution patterns are also translated into emissions reductions from various incentives for EVs to evaluate their environmental benefits. Counterfactual exercises are also conducted to examine the policy impact of the EV subsidy in terms of boosting EV demand and alternative policy designs are compared to evaluate the relative policy effectiveness of existing subsidy programs. Our research results could provide guidance for future policy designs to better promote alternative fuel technologies.

Keywords: electric vehicles, subsidy, substitution, policy design