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RESEARCH BRIEF

Technology Adoption and Early Network Infrastructure Provision in the Market for Electric Vehicles

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This paper documents non-linear stock effects and initial provision effects between emerging technology adoption and network infrastructure. We do so using data covering nascent to mature electric vehicle (EV) markets across Norwegian municipalities, and employing flexible polynomial control function regressions and synthetic control methods. Our results demonstrate indirect network effects and behavioral bias called "range anxiety," and support policies targeting early infrastructure provision to incentivize EV adoption.

Car use is associated with significant negative local and global external costs (e.g., from pollution), and many consider electrification as the future of on-road transportation. Even in the presence of externality-correcting taxes, however, indirect network effects hamper individual decisions to purchase an electric vehicle (EV) (Greaker and Midttomme, 2016). In particular, the benefit of EV adoption depends on the size of charger networks, whereas providers of charging stations will not invest in infrastructure provision when the number of EVs in circulation is small. Such unpriced benefits to consumers (e.g. lower charger search costs) likely result in suboptimal private deployment of network infrastructure (Farrell and Saloner, 1986; Katz and Shapiro, 1986; Cabral, 2011). Thus, policies supporting early provision of public charging infrastructure can alleviate a chicken and egg dilemma between EV consumers and charging station providers.

This paper provides novel evidence about how increments to charging infrastructure affect EV adoption decisions, and studies how consumers respond to charger installations at early and developed market stages. We employ data for all 422 Norwegian municipalities from 2010-2017 of detailed car model-level data for EV registrations and the number of available charging stations, plus the number of charging points within these. This period covers the modern EV market beginnings through to maturity.

With our first analytical method, we take an instrumental variable approach due to potential endogeneity between municipality-level EV purchases and charger installations, which can both be affected by unobserved factors, and reverse causality from car registrations to charging station provision. In a similar vein to Li et al. (2017) we instrument using public parking spaces in each municipality, arguing that more parking space plausibly exogenously identifies potential for charging station installation. This is then interacted with the lagged national number of charging stations, assuming that municipalities with more parking space are more likely and able to respond to the national EV adoption trend with new chargers.

Using sets of polynomial control function (CF) regressions alternately on charging station and charging point numbers, we demonstrate that the largest return to charger investments is when there is little to no pre-existing network. There is a declining marginal benefit to new charging infrastructure as the network size grows. We further show that consumers exhibit a larger reaction to more charging stations with fewer points than more points across fewer stations, indicating a preference for a more dispersed charger network and potential consumer range anxiety (DeShazo et al., 2017). At the mean we estimate a 10 percent increase in charger stations increases EVs by 1.4 percent. For charging points the corresponding estimate is 0.9 percent.

Our second analytical method focuses on a subset of 64 municipalities that started with zero charging stations in 2010, and who installed one (one-station group) or multiple within a window of four consecutive quarters (multi-station group). We estimate the impact of these initial and one-off infrastructure installations using the synthetic control method (SCM) and the bias-correcting ridge-augmented SCM (Abadie and Gardeazabal, 2003; Abadie et al., 2010; Ben-Michael et al., 2018).

Here we build synthetic comparison units for all treated municipalities using weighted sums of observations from a donor pool of those who never installed any charging stations, giving counterfactual trajectories for each had they not installed the chargers that they did. We find an increasing impact over time after installation. One year after charger provision, one-station and multi-station groups experienced on average 5.4 and 8.0 percent more EV registrations, respectively. One further year on, the average treatment effect rose to 21.7 and 46.2 percent more EVs than the control groups, respectively. This further confirms the large and unpriced benefits of early infrastructure provision, where policy intervention can significantly contribute to initiating adoption dynamics.

Taken together, our results suggest early charging infrastructure support has a sizable impact on EV adoption patterns. The first installations have a lasting and increasing effect, and the number of initial installations also matters. We demonstrate evidence of indirect network effects causing an initial hurdle to EV adoption and a declining effect of new chargers as the network grows. In addition, support for more stations has a larger impact than more access points across fewer stations given evidence of consumer range anxiety.

References

Abadie, A. and J. Gardeazabal (2003) “The Economic Costs of Conflict: A Case Study of the Basque Country,” The American Economic Review, 93, 1, pp. 113–132.

Abadie, A., A. Diamond, and J. Hainmueller (2010) “Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California’s Tobacco Control Program,” Journal of the American Statistical Association, 105, pp. 493–505.

Ben-Michael, E., A. Feller, and J. Rothstein (2018) “The Augmented Synthetic Control Method,” Working Paper, Goldman School of Public Policy, University of California, Berkeley.

Cabral, L. (2011) “Dynamic price competition with network effects,” Review of Economic Studies, 78, pp. 83–111.

DeShazo, J. R., T. L. Sheldon, and R. T. Carson (2017) "Designing policy incentives for cleaner technologies: Lessons from California's plug-in electric vehicle rebate program," Journal of Environmental Economics and Management, 84, pp. 18–43.

Farrell, J. and G. Saloner (1986) "Installed base and compatibility: innovation, product prean- nouncements, and predation," American Economic Review, 76, pp. 940–955.

Greaker, M. and K. Midttomme (2016) "Network effects and environmental externalities: do clean technologies suffer from excess inertia?" Journal of Public Economics, 143, pp. 27–38.

Katz, M. L. and C. Shapiro (1986) "Technology Adoption in the Presence of Network Externali- ties," Journal of Political Economy, 94, 4, pp. 822–841.

Li, S., L. Tong, J. Xing, and Y. Zhou (2017) "The Market for Electric Vehicles: Indirect Network Effects and Policy Design," Journal of the Association of Environmental and Resource Economists, 4, 1, pp. 89–133.

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