POLICY COMPLEMENTARITIES IN THE PROMOTION OF ELECTRIC VEHICLES: SUBSIDIES AND CHARGING INFRASTRUCTRUE

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Overview

The promotion of electric vehicles (EVs) is increasingly seen to be instrumental in not only abating CO2 emissions, but also in improving local air quality. As in many countries, the German government has consequently pursued a two-pronged approach to promote EV uptake: In 2016, the government allocated a budget of €1.2 billion for subsidies to support the purchase of EVs and another €300 million for subsidies to support the construction of public charging infrastructure. Progress was sluggish, however, leading the government to double the budget for EV promotion in June 2020. Purchase subidies were increased to €2.09 while infrastructure subsidies were increased to €500.

Since these measures, EV uptake skyrocketed. According to statistics from the European Alternative Fuel Observatory (EAFO, 2022), the market share of new EV registrations in Germany reached 25.7% (13.4% BEVs and 12.3% PHEVs) in 2021, compared to just 2.9% (1.7% BEVs and 1.2% PHEVs) two years ago. The question arises as to the roles played by purchase subsidies and subsidies for infrastructure in driving this growth, recognizing that the latter led to a 280% increase in the number of charging stations between 2016 and 2021. A plethora of studies in the literature have focused on understanding factors affecting EV adoption. Among various external factors, the availability of charging stations has been found to play a key role in affecting consumers' decisions to purchase EVs across countries. The evidence from Germany likewise reveals that charging infrastructure is a binding constraint on a more rapid uptake of EVs (Illmann and Kluge, 2020; Sommer and Vance, 2021), but to date there has been no investigation of the potentially complementary role of purchase subsidies.

The present study takes up this question with an analysis of county-level panel data from Germany covering the years 2016-2021, a period that straddles the increase in the subsidy in 2019. The study contributes to the existing literature in two respects. First, we build on a growing body of studies that have explored complementarities in policies that promote EV uptake directly through purchase subsidies, and indirectly through subsidies for charging infrastructure. Studies based on detailed data on EV sales, charging stations, and government incentives from the United States (Li et al., 2017), Norway (Springel, 2021), and China (Li et al., 2021) all find that subsidization of charging station deployment is at least twice as effective as subsidizing consumer purchases on a per-dollar basis. Second, ours is the first study, to our knowledge, that differentiates the markets for private EVs and company EVs. As the purchasing rationales of electric cars registered with companies may not be comparable to private households, the role played by public charging infrastructure in fostering their uptake might differ. Company cars comprise almost 50% of the overall EV car fleet in Germany, so it is important to measure their response to public charging network and policy incentives.

Ultimately, we use the econometric estimates to calculate the optimal allocation of the government budget among the two subsidies to achieve the biggest 'bang for the buck' concerning EV adoption in Germany.

Methods

Our main focus is on EV uptake, with separate models estimated for private and copmany owned cars. We are particularly interested in the differential effect of public charging station network (measured by the total capacity of charging stations) across different level of subsidy periods. By exploiting the panel dimension of our data set, we use the following dynamic fixed-effects specification:

$$\mathrm{EV}_{it} = \beta_0 + \beta_l \mathrm{EV}_{i,t-1} + \beta_c \mathrm{cap}_{it} + \beta_{cs} \mathrm{cap}_{it} \cdot \mathrm{S}_{it} + \beta_s \mathrm{S}_{it} + \beta_x \mathrm{X}_{it} + \theta_t + \mu_i + \lambda_{it} + \varepsilon_{it}$$

where EV_{it} is the number of electric vehicles purchased in county *i* in month *t*; cap measures the total capacity of the charging infrastructure; and S is a dummy variable which equals unity after the amount of the subsidy was increased in June 2020 and zero otherwise. The relatively large time dimension of roughly 66 months obviates concerns of Nickell bias that might otherwise emerge given the inclusion of the lagged dependent variable $\mathrm{EV}_{i,t-1}$. The set of controls X include the gasoline price, purchase power per capita, the number of houses, population density, average age of population, and unemployment rate. Finally, time fixed effects (θ_t) control for any demand shocks at the national level, while the state-by-year fixed effects (λ_{it}) control differential effects across states and years, and county fixed effects (μ_i)capture time-invariant unobservable characteristics at the county level.

Recognizing the possible simultaneity of charging infrastructure and EVs, we employ a two-stage least squares model to account for endogeneity. Following Sommer and Vance (2021), we instrument charging infrastructure with the number of transformers along the electric grid at the county level, since they act as a regulator to bring down the transmission voltages that can be supported by charging points.

Results

For private electric cars, we consistently find that charging infrastructure capacitiy has a statistically significant and positive effect on the uptake of EVs after increase in the purchase subsidy. However, unlike private EVs, we find no evidence of an increase in the effect of charging infrastructure with the EV subsidy, indicating that the uptake of electric cars owned by companies is not significantly affected by variations in subsidy offered by the government.

By adopting the model estimates, we explore the short- and long-run effects of local charging infrastructure with and without the interaction effects of subsidy. In the long run, with the initial subsidy, a unit increase in the capacity of charging stations would have resulted in a greater rate of EV adoption by companies when compared to that of private customers. However, with a strong complementarity between the EV subsidy and available charging station network, we observe a stronger effect of public charging infrastructure on the uptake of private EVs when compared to that of company cars after the increase in subsidy. As one would expect, companies depend less on public charging infrastructure in the long run as they would most likely build their own charging stations at the workplace.

Additionally, we calculate the marginal increase in EVs per million euros spent by the government during the lower and higher subsidy periods. These results suggest that subsidizing consumer purchases was nearly 3.5 times as effective as charging stations in promoting private EV sales during the lower subsidy period. However, after the increase in the subsidy, there is a reversal: Station subsidies are roughly 9 times more effective than consumer incentives in terms of promoting private EVs. More precisely, a million euros spent in station subsidies would result in the purchase of 40.54 EVs, whereas the same amount spent on subsidizing private consumers would result in only 4.65 EVs. Regardless of the subsidy level, purchase subsidies are very poorly effective in promoting EV ownership by companies when compared to private buyers. Overall, we observe a relatively greater cost effectiveness of subsidizing charging stations, which is in line with studies from other countries.

Conclusions

Over the last decade, the development and adoption of electric vehicles have increased significantly in many countries and are leading the way to a low-carbon future. To facilitate the acceleration of electric vehicle adoption, governments have implemented various subsidy programs. This paper explores the promotion of electric mobility via subsidies for electric vehicles (EVs) and charging infrastructure as well as their interaction. To this end, we use German panel data on vehicle registrations spanning July 2016 to December 2021 to quantify the effect of public charging points on EVs, distinguishing between private and company cars.

Our results suggest a positive and statistically significant effect of charging infrastructure on the uptake in EVs, one that increases in magnitude with the introduction of a higher purchase subsidy in the case of private cars. We take two main messages from these results. In the long run, private individuals are predicted to have a greater dependence on public charging infrastructure provided they are offered a higher EV subsidy. On the other hand, adoption of EVs by institutional buyers is relatively less dependent on public charging stations.

From a cost-effectiveness perspective, we find evidence that the charging station subsidy is more effective than the purchase subsidy on a per euro basis. Furthermore, we use our model estimates to calculate the optimal balance of subsidies for charging infrastructure and EVs, and conclude that policymakers could get the biggest “bang for the buck” if money was reallocated to support the deployment of charging infrastructure. The findings of this study suggests that in order to have equal marginal return per euro spent on subsidies (i.e., optimal balance) for charging infrastructure and EV purchases, the money spent on building charging network should be four times that spent on subsidies for EV purchases.

References

1. Illmann, U. and Kluge, J., 2020. Public charging infrastructure and the market diffusion of electric vehicles. Transportation Research Part D: Transport and Environment, 86, p.102413.
2. Li, S., Tong, L., Xing, J. and Zhou, Y., 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.
3. Li, S., Zhu, X., Ma, Y., Zhang, F. and Zhou, H., 2022. The role of government in the market for electric vehicles: Evidence from China. *Journal of Policy Analysis and Management*, *41*(2), pp.450-485.
4. Sommer, S. and Vance, C., 2021. Do more chargers mean more electric cars?. *Environmental Research Letters*, *16*(6), p.064092.
5. Springel, K., 2021. Network externality and subsidy structure in two-sided markets: Evidence from electric vehicle incentives. *American Economic Journal: Economic Policy*, *13*(4), pp.393-432.