The Influence of Public Charging Infrastructure Deployment and Other Socio-Economic Factors on Electric Vehicle Adoption in France

[Bassem Haidar, CentraleSupélec, bassem.haidar@centralesupelec.fr]
[Maria Teresa Aguilar Rojas, Université Paris Dauphine-PSL, maria-teresa.aguilar-rojas@dauphine.psl.eu]

Overview

Greenhouse gas (GHG) emissions contribute to the climate change phenomenon of the Earth's surface and the atmosphere. France has set itself the ambitious goal to reduce CO2 emissions and the dependency of petroleum products from the transport sector by 20% by 2020, to bring them back to the level they had in 1990. Plug-in Electric Vehicles (PEV) have noteworthy potential to reduce petroleum dependency and GHGs emissions related to the road transportation sector towards global decarbonization. PEVs encompass Battery Electric Vehicles (BEV), which use the electricity stored in the battery as a primary energy source, and Plug-in Hybrid Electric Vehicles (PHEV), which use both fossil fuel and battery as sources of energy. If the electricity is produced using renewable energy sources, the Greenhouse Gas emissions from transportation are significantly lower than fossil-fuel based transport. While this technology's adoption has been rapidly increasing over the last decade, their market share remains in most countries restrained by socio-techno-economic barriers. The reasons for the slow uptake of EVs are generally divided into technical (charging time, limited BEV range), economic (PEV purchase, electricity, and fuel prices), awareness (client behavior towards new inventions, charging stations visibility, number of PEV models), and socio-demographic factors (age, education, income, environmentalism, and urbanity degree) ***(Sykes and Axsen, 2017)***. To overcome these obstacles, governments applied national and local, monetary, and non-monetary policies for all the EV supply chain members: supply and demand.

In France, PEVs presented around 2% of total vehicles sales in 2020 ***(Automobile Propre, 2020)***. To boost market share, the local authorities, such as municipalities, contributed to making EVs more attractive to consumers by offering financial subsidies of a maximum of 5000€ to each driver switching to electric mobility additionally to tax exemption, free parking, and access to bus lanes. Some clients could benefit from additional local incentives from municipalities, such as Ile-de-France, Marseille, and Nice. Since the lack of charging infrastructure still presents a barrier to growth in the EV market, national and local authorities in France boosted the deployment of this infrastructure by both installing more on-street chargers (e.g. Corri-door project) and offering up to 50% of the cost of the charger for both private and public usage (e.g. ADVENIR project).

While the study on the influence of government policies has received widespread attention in the literature ***(Münzel et al., 2019)***, only limited investigation has been carried out about the potential impact of the charging infrastructure on demand for BEV/PHEV. Besides, since the market-booster factors' influence differs significantly between countries, as consumer behaviour varies, the French local-based case study is lacking. This paper seeks to fill the gap by assessing the privately-purchased BEV and PHEV market shares, separately, using a fixed-effect and random-effect panel data regressions on a local level in France from 2015 to 2019, taking into account the charging infrastructure deployment of different power speeds (slow chargers with 0-15 kW power, normal chargers with 16-40 kW, fast chargers with 41-80 kW, and ultra-fast chargers with more than 80 kW), and other socio-economic factors. To the best of our knowledge, our study is the first to isolate the impacts of local-level incentives and four charging speeds, on the rate of adoption of BEVs and PHEVs in France.

To address these research gaps, data, gathered for each French department using a variety of governmental and press sources, are used to determine what factors significantly affect BEV and PHEV purchasing activity. Based on the results, this paper ends with policy recommendations for automotive manufacturers, charging infrastructure operators and public authorities to boost both markets.

Methods

Based on the literature, we chose the panel data regression for the analysis of PEV adoption7. This methodology provides various benefits and overcomes some limitations related to time-series and cross-section studies. Panel data overcome unobserved heterogeneity between departments, resulting from the variation of some unmeasured factors that affect people's behaviour in different departments and reduce the problem of multicollinearity. Also, panel data generate more variation between multicollinear variables by combining the variation across departments with variation over time ***(Soltani-Sobh et al., 2017)***. Both fixed-effects and random-effects are used to estimate the BEV (with one-way error components) and PHEV market shares (two-way error components). The one-way fixed-effects regression defines unobservable specific effects for each department studied, and therefore, captures variances within departments. It also considers the influence and the significance of each explanatory covariates over time, averaged across all the departments in the dataset. The two-way fixed effects regression not only defines unobservable specific effects for each department, but also for each year. We also conducted a random-effects model, which considers variation across different departments and/or years. These intercepts are considered a part of the error term.

We used department-fixed effects, and random effects panel data regressions to analyze the impact of charging infrastructure deployment and other socio-economic factors separately on both BEV and PHEV market shares, per department in France, from 2015 to 2019. Equation (1) describes the model:

$$\begin{aligned} \boldsymbol{log(PEV_{i,t,z})} = {} & \boldsymbol{\beta_1 log\left(d_{slow,normal\ chargers_{it-1}}\right) + \beta_2 \widetilde{d}_{fast\ chargers_{i,t-1}} + \beta_3 \widetilde{d}_{ultra-fast\ chargers_{i,t-1}} + \beta_5 subsidies_{i,t,z}} \\ & \boldsymbol{+ \beta_6 diff_{taxes_{i,t,z}} + \beta_7 nb\ models_{t,z} + \beta_8 p_{gasoline_{i,t}} + \beta_9 income_{i,t-1} + \beta_{10} d_{population_{i,t}} + \beta_{11} age_{i,t}} \\ & \boldsymbol{+ \beta_{12} unemployment_{i,t} + \gamma_{i,z} + \mu_{t,z} + \varepsilon_{i,t,z}} \end{aligned} \quad (1)$$

Observations in our sample are Independent and Identically Distributed8, the subscript i denotes the department (from 1 to 95), t denotes the year (from 2015 to 2019), and z denotes the vehicle type (BEV or PHEV). For each variable, we determined the regression coefficients β. The term γi, corresponds to the department fixed effect, while μt,z, represents the year fixed effect (which only applies for z=$PHEV$). εi,,z is the random disturbance term.

Results

Our BEV and PHEV models present goodness-of-fit measures (R^2>63%). The results show that the variables contributing to the BEV market could differ from those of the PHEV market. We find that the densities of fast and ultrafast chargers, the subsidies, the registration taxes exemption, the number of BEV models, and the gasoline price have a positive and significant relationship with the BEV market share, contrary to the slow-and-normal charger density. Similar to the BEV model, the number of PHEV models and the gasoline price positively influence the PHEV market share, and their regression coefficients are significant. However, the density of fast chargers, the population density, and the unemployment rate are significantly but negatively affecting PHEV sales.
While some of the findings of this study were expected and despite the high resolution of our analysis, further studies are suggested in order to boost these models by taking into account socio-techno-economic factors. Our model can only draw general conclusions since PEV market share in France represents less than 5%. It would be useful to perform a follow-up study in a more developed market.
Results of regression tables will be presented during the conference.

Conclusions

The target of this paper is to explore the impact of different socio-techno-economic factors across the PEV adoption activity in 95 French departments between 2015 and 2019 using department-fixed-effects and random-effects panel data regressions. Therefore, based on extensive literature, we gathered different datasets of factors potentially impacting BEV or PHEV sales, from various sources. We then chose to apply panel data models to investigate the evolution of BEV and PHEV purchasing activity separately. This study has different goals: First, we determine which socio-demographic, economic, technical, and availability factors could boost the electric mobility market. Second, we examine if these factors vary between BEV and PHEV markets separately. Third, we zoom into the French case study. Finally, we identify the charging power with the most significant effect on the BEV and PHEV markets' evolution.

References

Automobile Propre, 2020. Voiture électrique : 42.764 immatriculations en France en 2019. Automobile Propre. URL https://www.automobile-propre.com/voiture-electrique-42-764-immatriculations-en-france-en-2019/ (accessed 7.26.20).

Münzel, C., Plötz, P., Sprei, F., Gnann, T., 2019. How large is the effect of financial incentives on electric vehicle sales? – A global review and European analysis. Energy Economics 84, 104493. https://doi.org/10.1016/j.eneco.2019.104493

Soltani-Sobh, A., Heaslip, K., Stevanovic, A., Bosworth, R., Radivojevic, D., 2017. Analysis of the Electric Vehicles Adoption over the United States. Transportation Research Procedia, 19th EURO Working Group on Transportation Meeting, EWGT2016, 5-7 September 2016, Istanbul, Turkey 22, 203–212. https://doi.org/10.1016/j.trpro.2017.03.027

Sykes, M., Axsen, J., 2017. No free ride to zero-emissions: Simulating a region's need to implement its own zero-emissions vehicle (ZEV) mandate to achieve 2050 GHG targets. Energy Policy 110, 447–460. https://doi.org/10.1016/j.enpol.2017.08.031