***Preferences for alternative vehicles : an analysis of barriers to adoption through a discrete choice experiment.***

Alexandre Cambo, IFP Energies Nouvelles and EconomiX-CNRS University of Paris Nanterre, + 33 1 47 52 88 15, alexandre.cambo@ifpen.fr

Benoît Chèze, IFP Energies Nouvelles and EconomiX-CNRS University of Paris Nanterre, + 33 1 47 52 51 26 ,

 benoit.cheze@ifpen.fr

Johanna Etner, EconomiX-CNRS University of Paris Nanterre, +33 1 40 97 40 85, johanna.etner@parisnanterre.fr

## Overview

In France the transportation sector accounts for 34% of all the final energy consumed, and accounts for 92% of all petroleum products consumed (ADEME, 2020). It is responsible for 26% of the national green house gas emissions, which makes the transportation sector the biggest GHG emitting sector in France. The transportation sector is also a source of health concerns at the local level because of the emanation of carbon dioxide and particle pollution that results from the use of transport vehicles. The french government has set an aim of reducing it's emissions by 6 by 2050 (SNBC, 2020). In order to deal with the emissions from the transport sector, the french government has created several public policies. In 2021, french car manufacturers will have to conform to a limit of 95g/km of CO2 emissions for their new vehicles. The french government has also contributed towards the switch towards alternative vehicle technologies such as Plug-in Hybrid vehicle and Battery electric vehicles through the implementation of subsidies called "bonuses" for the purchase of those vehicle technologies.

However in 2019, only 200 000 vehicles out of 32 million vehicles in France were battery electric vehicles (ADEME, 2020). This low proportion of electric vehicles in the total fleet may be caused by internal factors such as vehicle characteristics or external factors such as the technology reputation or the development of it's refueling infrastructure. In our study, we aim to identify the cause of such low adoption rates. Our analysis consists of a choice experiment aiming at analysing vehicle's users preference towards alternative technologies. We give 8 choice cards to each respondents and ask them to choose between a conventional vehicle (CV), a battery electric vehicle (BEV) and a plug-in hybrid vehicle (PHEV) based on their respective attributes. Our results suggest that the purchase price, fuel and maintenance cost, driving range and level of recharging infrastructure are the most important adoption factors in the vehicle adoption decision.

## Methods

## We seek to identify the main barriers to electric vehicle adoption with the aim of finding what we can do in terms of public policies in order to overcome the barriers to entry and increase the electric vehicle adoption rates. To this end we used two discrete choice experiment to analyze vehicle user's preference for battery electric vehicles, one for small "city" sized vehicles, and one for medium "family" sized vehicles. We used data from an online survey with 1000 french respondents allocated to 500 respondents for the small vehicle choice experiment and 500 respondents for the medium vehicle choice experiment.We measure our respondent's knowledge about electric cars, attitude towards technology and the environment, risk preferences, in order to seek the effects of latent attitudes or of belonging to a group of "early adopters" has any effect on BEV adoption rates. This paper adds to the existing literature by taking into account the uncertainty around the future level of electric fast-charging infrastructure and inputting this uncertainty into one attribute inside our choice experiment. This addition helps by bringing more realism into the hypothetical situations described by the choice experiment which would ultimately lead to better responses.

## Results

Our results are that for both vehicle categories, purchase price, fuel cost and maintenance costs are all significant at the 1% level. This goes against the results by (Giansoldati et al., 2020) which suggest that respondents are more receptive to immediate lump sum costs rather than future savings made by purchasing an alternative vehicle technology with lower fuel and maintenance costs.

The proportion of fast charging infrastructure, with or without risk has a positive sign and is statistically significant. The vehicle driving range was found to be significant for small vehicle users which goes with the results of the studies by (Chorus et al., 2013), (Hackbarth et al., 2013), (Hidrue et al., 2011), (Hoen et al., 2014), (Rasouli et al., 2016), (Jensen et al., 2013), (Mabit et al., 2011), (Tanaka et al., 2014), (Valeri et al., 2015) who found it to be positive and significant.

We can claim that medium vehicle users take into account the vehicle's fuel cost, maintenance cost and vehicle range as much as small vehicle users when reviewing adoption factors for a new vehicle. Similarly to the papers by (Achtnicht et al., 2012), (Jensen et al., 2013), (Hackbarth et al., 2013), (Hidrue et al., 2011), (Potoglou et al., 2007) we found that the amount CO2 emissions was a significant factor for vehicle adoption. Both choice experiment show that vehicle emissions negatively affect respondent's utility, showing that respondents do take into account environmental factors when reviewing a vehicle.

Both vehicle samples took into account outside factors such as proportion of charging stations with fast-charging infrastructure, however only the medium vehicle sample has shown that outside factors such as technological mistrust and psychological barriers affected utility. To our knowledge no other papers using stated preferences methods for vehicle transport has included uncertainty for the levels of their attribute, and even less so for the future level of fast-charging infrastructure.

## Conclusion

Our findings suggest that the anxiety surrounding the future level of charging infrastructure is a barrier to electric vehicle adoption. Vehicle users seem to not only be willing to charge their battery electric vehicle at home. Respondents tend to prefer vehicle technologies where the recharging infrastructure is fully developed such as for PHEV and CEV's.The main barrier to electric vehicle adoption remains to be the high price of those vehicles, while the lower fuel and maintenance costs and lower vehicle emissions are attractive characteristics.

The public policy insights from these results are that for both vehicle categories an increase in subsidies for battery electric vehicles and taxes for conventional vehicles, as well as an increase in investment into electric refueling infrastructure will have a large impact on BEV's adoption rates.

Our results also suggest that guaranteeing a low energy price for battery electric vehicles, and increasing the cost of fossil fuels for conventional vehicles through taxes will have a positive effect on BEV's adoption rates. Policy makers should consider creating investment into the improvement of battery for electric electric vehicles until they match the range of conventional vehicles, this is especially true for medium and above vehicles where the driving range is a main adoption factor for vehicle users. To sum up, we suggest that policy makers should focus on increasing subsidies on electric vehicle, increasing penalties on higher green house gas emitting vehicles and increase taxes on fossil fuels and focusing on investing into electric fast-charging public infrastructure.

## References

ADEME (2020). Transports Mobilité, Une stratégie au service de la transition ecologique et solidaire. Technical report.

Caspar G. Chorus, Mark J. Koetse, and Anco Hoen (2013). Consumer preferences for alternative fuel vehicles: Comparing a utility maximization and a regret minimization model. Energy Policy, 61:901–908

Giansoldati, M., Rotaris, L., Scorrano, M., and Danielis, R. (2020). Does electric car knowledge influence car choice? evidence from a hybrid choice model. Research in Transportation Economics.

André Hackbarth and Reinhard Madlener (2013). Consumer preferences for alternative fuel vehicles: A discrete choice analysis. Transportation Research Part D: Transport and Environment, 25:5–17.

Michael K. Hidrue, George R. Parsons, Willett Kempton, and Meryl P. Gardner (2011). Willingness to pay for electric vehicles and their attributes. Resource and Energy Economics, 33(3):686–705.

Anco Hoen and Mark J. Koetse (2014). A choice experiment on alternative fuel vehicle preferences of private car owners in the netherlands. Transportation Research Part A: Policy and Practice, 61:199–215

Anders Fjendbo Jensen, Elisabetta Cherchi, and Stefan Lindhard Mabit (2013). On the stability of preferences and attitudes before and after experiencing an electric vehicle. Transportation Research Part D: Transport and Environment, 25:24–32.

Stefan L. Mabit and Mogens Fosgerau (2011). Demand for alternative-fuel vehicles when registration taxes are high. Transportation Research Part D: Transport and Environment, 16(3):225–231.

Dimitris Potoglou and Pavlos S. Kanaroglou (2007). Household demand and willingness to pay for clean vehicles. Transportation Research Part D: Transport and Environment, 12(4):264–274.

Rasouli, S. and Timmermans, H. (2016). Influence of social networks on latent choice of electric cars: A mixed logit specification using experimental design data. Networks and Spatial Economics, 16(1):99–130.

SNCB (2020). Stratégie nationale bas-carbone. Technical report.

Makoto Tanaka, Takanori Ida, Kayo Murakami, and Lee Friedman (2014). Consumers’ willingness to pay for alternative fuel vehicles: A comparative discrete choice analysis between the us and japan. Transportation Research Part A: Policy and Practice, 70:194–209.

Eva Valeri and Romeo Danielis (2015). Simulating the market penetration of cars with alternative fuelpowertrain technologies in italy. Transport Policy, 37:44–56.