

# **WILLINGNESS-TO-PAY FOR ALTERNATIVE FUEL VEHICLE CHARACTERISTICS: A STATED CHOICE STUDY FOR GERMANY**

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## **(1) Overview**

Both within and outside the European Union, the transportation sector has risen on the agenda of energy and climate policy-makers, and energy efficiency and greenhouse gas mitigation legislation, which can be explained by its strong dependence on fossil fuels. Consequently, to promote the substitution of alternative fuels or electricity for gasoline and diesel, the EU has defined legally binding CO<sub>2</sub> emission abatement targets for newly registered vehicles, and the German government has set the goal to get 1,000,000 battery electric vehicles (BEVs) on the roads by 2020. This goal was to be accompanied by all kinds of governmental monetary and non-monetary purchase incentives. As a first result, a growing alternative fuel vehicle (AFV) model line-up, progress in battery technology, and a steadily expanded refueling station network can be recorded. However, despite these efforts on the part of vehicle manufacturers and policy-makers, the reluctance of car buyers towards all kinds of AFVs, especially BEVs, remains very high. Hence, detailed information on the main reasons for the absence of a widespread acceptance and adoption of AFVs, and the possibilities to circumvent them, is needed even more urgently. Presumable taste differences of a heterogeneous population of private car buyers concerning the importance of specific vehicle attributes, the thresholds for adoption the attribute values have to reach, and their different impacts on the potential demand for AFVs are of special interest.

The aim of this study is to determine the amount that different groups of vehicle buyers are willing to pay for improving important vehicle characteristics, e.g. a range extension system or a fast-charging infrastructure for BEVs, and how and why the willingness-to-pay (WTP) and the compensating variation (CV) differ both between consumer groups and amongst vehicle alternatives. The results are then used to calculate the potential need for governmental action to foster vehicle attribute improvements. Furthermore, the monetary and non-monetary incentives already granted today, or currently planned by the German government, are evaluated regarding their effectiveness to accelerate vehicle adoption. Finally, the characteristics of the potential car buyers that are open for all kinds of AFVs or related governmental incentives are analyzed.

## **(2) Methods**

This research builds upon, and contributes to, a rich body of stated preferences discrete choice experiment (DCE) literature on the demand for AFVs (e.g. Hidrue et al., 2011; Mabit and Fosgerau, 2011; Achtnicht, 2012; Ziegler, 2012; Beck et al., 2013; Hackbarth and Madlener, 2013) and focuses on the German market. Our empirical analysis is based on a nation-wide web-based DCE, carried out in Germany among 711 potential car buyers in July and August of 2011 for a broad range of hypothetical alternatively and fossil-fueled vehicles. (gasoline/diesel, natural gas, hybrid, plug-in hybrid (PHEV), electric, biofuel, and hydrogen). The seven types of vehicles considered were additionally described by up to eight attributes: (1) purchase price, (2) fuel cost, (3) CO<sub>2</sub> emissions, (4) driving range, (5) fuel availability, (6) refueling time, (7) battery recharging time, and (8) policy incentives.

Additionally to a standard multinomial logit (MNL) model, and to take the preference heterogeneity in the population into account, we apply a latent class model (LCM), which allows for the accounting of taste differences between consumer segments concerning the preferences for the different propulsion technologies and the vehicle features.

### **(3) Results**

The estimation results obtained show that preference heterogeneity in the population of potential vehicle buyers exists regarding the different propulsion technologies and the importance of vehicle attributes. This heterogeneity is best displayed by six distinct consumer groups, which can be explained by differences in age, educational level, daily mileage, technophilia, environmental awareness, vehicle segment of the last/next vehicle purchase and whether it is/was an additional vehicle. We find that individuals, who apparently and at first sight share many socio-demographic characteristics, actually show quite a heterogeneous adoption behavior. Furthermore, our results can be summarized as follows: (1) purchase price and fuel cost are relatively unimportant for those individuals who prefer AFVs; (2) vehicle attributes are evaluated very differently in the different groups, i.e. attributes that are important in one class are irrelevant in another class (e.g. monetary attributes (purchase price and fuel cost) are the most decisive factors in vehicle choice in two segments, while driving range, recharging time, and fuel availability are in another one); (3) incentives have a large impact on vehicle choice; (4) on average, AFVs are disliked in the adopter population, but two segments exist who favor at least some types of AFVs (PHEVs, BEVs, BVs, and FCEVs in one class and PHEVs in another class).

This preference heterogeneity is also reflected by car buyers' WTP and CV values. We find that, on average, individuals are willing to pay significant amounts for the improvement of vehicle attributes, but that the distinct consumer groups attach different importance to these vehicle features, so that not every attribute improvement is valued with its actual cost in every consumer group. Furthermore, we find that car buyers have some minimum requirements, which have to be met so that they are willing to pay significant amounts of money for improvements of vehicle attributes, whereas improvements beyond these minimum requirements are not appreciated as much unless certain thresholds are actually exceeded (e.g. the WTP for fast-charging increases only after the recharging process undercuts the 30-minute mark).

### **(4) Conclusions**

Our study reveals that vehicle adopters are not a homogeneous group, but that they do assess the various vehicle alternatives and their features very differently from each other, depending on socio-demographic and attitudinal characteristics. Our findings show further that potential early adopters of electric vehicles are often young and environmentally aware individuals who intend to purchase a small car and have a high daily mileage. Furthermore, we show that the acceleration of the diffusion of AFVs in general, and BEVs in particular, could be fostered cost-effectively through monetary and non-monetary governmental incentives and also the extension of fuel availability (or fast-charging infrastructure, respectively, as in the case of electrified vehicles), which could help car buyers to condone especially the limited driving range of BEVs. Improvements of other vehicle features (e.g. driving range, CO<sub>2</sub> emissions) would need governmental financial support, as consumers' WTP is insufficient for their cost-effective and thus private provision.

This study and our results establish a good starting point for political decision-makers and car manufacturers to review their strategic decisions on how the acceptance of and the

demand for AFVs could be raised most cost-effectively, which areas most urgently need governmental subsidies to support actions from car manufacturers, and which ones could be provided by the private sector alone without governmental support.

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