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Willingness-to-pay for alternative fuel vehicle characteristics: A stated choice study for Germany

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ABSTRACT

In the light of European energy efficiency and clean air regulations, as well as an ambitious electric mobility goal of the German government, we examine consumer preferences for alternative fuel vehicles (AFVs) based on a Germany-wide discrete choice experiment among 711 potential car buyers. We estimate consumers' willingness-to-pay and compensating variation (CV) for improvements in vehicle attributes, also taking taste differences in the population into account by applying a latent class model with 6 distinct consumer segments. Our results indicate that about 1/3 of the consumers are oriented towards at least one AFV option, with almost half of them being AFV-affine, showing a high probability of choosing AFVs despite their current shortcomings. Our results suggest that German car buyers' willingness-to-pay for improvements of the various vehicle attributes varies considerably across consumer groups and that the vehicle features have to meet some minimum requirements for considering AFVs. The CV values show that decision-makers in the administration and industry should focus on the most promising consumer group of 'AFV aficionados' and their needs. It also shows that some vehicle attribute improvements could increase the demand for AFVs cost-effectively, and that consumers would accept surcharges for some vehicle attributes at a level which could enable their private provision and economic operation (e.g. fast-charging infrastructure). Improvement of other attributes will need governmental subsidies to compensate for insufficient consumer valuation (e.g. battery capacity).

1. Introduction

In the past decades, the transportation sector came increasingly to the fore of policy-makers and energy efficiency and greenhouse gas mitigation legislation in the US, the European Union, and other countries.[1] This can be explained by its strong dependence on carbon-based fuels, and, consequentially both its significant contribution to climate change and local air pollution and its vulnerability to fluctuations in crude oil prices. Hence, general environmental considerations and increased energy security concerns led to attempts of policy-makers to tackle the oil dependency of road transport and to bring alternative fuel vehicles (AFVs)[2]

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[1] A comprehensive overview of the evolution of worldwide fuel economy and GHG emissions regulations over the years is given in, e.g., An and Sauer (2004), Onoda (2008), Atabani et al. (2011), or Kodjak et al. (2012).

[2] AFVs encompass vehicles that do not run on conventional fuels (gasoline and diesel) or are propelled electrically at least to some extent, e.g. biofuel vehicles (BVs), natural gas (liquefied petroleum gas, LPG, or compressed natural gas, CNG) vehicles (NGVs), hydrogen (fuel cell electric) vehicles (FCEVs), hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and fully battery electric vehicles (BEVs).

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into the market, e.g. by the introduction or tightening of clean-air legislation and incentive programs. For instance, the European Union has defined legally binding CO_2 emission abatement targets for newly registered vehicles (EC, 2014). Furthermore, the German government stipulated the very ambitious electric mobility goal of 1 million registered vehicles by the year 2020 (Federal Government, 2009), which has been accompanied by governmental purchase incentives and funding of technology research.

Despite of these efforts on the part of policy-makers and, as a consequence, also vehicle manufacturers, the reluctance of car buyers towards all kinds of AFVs, especially BEVs, remains very high. Consumer demand thus has to increase drastically in the upcoming years to reach the diffusion targets and to meet the requirements of the European clean-air legislation.[3] Hence, detailed information on the main reasons for such an absence of a widespread adoption of AFVs, especially by buyers of privately used personal cars, and the possibilities to circumvent them, is needed even more urgently. Presumable taste differences of a heterogeneous population concerning the importance of specific vehicle attributes, the thresholds they have to meet, and their different impacts on the potential demand of AFVs are of special interest. Knowledge about such taste differences could be particularly instructive for the German legislature and decision-makers in the automotive industry, in order to accelerate the adoption of AFVs in the future by specifically customizing their products or incentive schemes subject to the differences in preferences between consumer segments.

The aim of this paper is to study the heterogeneity of car buyers' preferences, i.e. to determine the amount that different groups of vehicle buyers are willing to forfeit for improving important vehicle characteristics and how and why the sum differs between the groups. For this reason, two welfare measures are calculated: The willingness-to-pay (WTP) and the compensating variation (CV), which explicitly takes the diverse choice probabilities of the various vehicle alternatives into account. The results are then compared to current market prices for a provision of such attribute improvements to assess the potential of a cost-effective provision or the need for governmental action. Finally, the characteristics of the potential car buyers that are open for all kinds of AFVs are determined.

Our empirical analysis is based on a nation-wide web-based stated preferences discrete choice experiment (DCE), carried out in Germany among 711 potential car buyers in July and August of 2011. To take the preference heterogeneity in the population into account, we apply a latent class model (LCM), which allows for taste differences between consumer groups, in addition to a standard multinomial logit model (MNL).

Our research builds on a comprehensive body of stated preferences DCE literature on the demand for AFVs (see Table A1 in the appendix for on overview of selected studies). Especially the works of Abdoolakhan (2010), Hidrue et al. (2011), Beck et al. (2013), and Parsons et al. (2014), which to the best of our knowledge are the only ones so far applying an LCM approach, are closely related to our work. Furthermore, our study is linked to the research of Daziano (2013) who calculated the WTP and CV of Californian car buyers for driving range improvements of BEVs. Finally, the studies by Eggers and Eggers (2011), Achtnicht (2012), Achtnicht et al. (2012), Ziegler (2012), Daziano and Achtnicht (2013), and Hackbarth and Madlener (2013) ought to be mentioned as they also focus on the case of Germany, covering the following topics: (1) the differences in the WTP for CO_2 emission mitigation between groups of potential car buyers (Achtnicht, 2012; Hackbarth and Madlener, 2013); (2) the influence of fuel availability, especially for BEVs and FCEVs, on vehicles' market shares (Achtnicht et al., 2012; Daziano and Achtnicht, 2013; Hackbarth and Madlener, 2013); (3) the impact of car buyers' socio-demographic characteristics on their potential demand for AFVs (Achtnicht et al., 2012; Ziegler, 2012; Hackbarth and Madlener, 2013); and (4) the prediction of the adoption and diffusion of AFVs under various monetary and non-monetary attribute improvement scenarios in a dynamic (Eggers and Eggers, 2011) and static analysis (Hackbarth and Madlener, 2013).

Our research, however, differs to these studies also focusing on Germany at least in three respects: Firstly, we use an LCM to evaluate German car buyers' vehicle choices, which allows for a segmentation of the population into distinct consumer groups, a specification of the size of these consumer groups, and their detailed description by socio-demographic characteristics and attitudes. Secondly, we calculate CV values for a number of vehicle-specific attribute improvement scenarios, which are more informative for decision-makers than unspecific WTP values alone. Finally, as suggested and applied by several authors (see Table A1), we consider the effect of decreasing marginal utilities of attribute improvements, which is a more realistic representation of human behavior, and assess this non-linear consumer valuation for driving range, fuel availability, recharging time, and CO_2 emissions.[4]

The remainder of this paper is organized as follows: Section 2 describes the survey generation and the data gathered. In Section 3, the methodological approach is introduced. Empirical results are reported in Section 4 and discussed in Section 5. Section 6 concludes.

2. Survey design and data

The examination of new car buyers' potential demand for AFVs is based on data collected in a Germany-wide survey that was conducted in July and August 2011 (see also Hackbarth and Madlener, 2013). Participants were recruited from the probability-based online panel of the Dialego AG, and comprise persons who provided their intention to purchase a new car within the next year or such that made an actual vehicle purchase in the last 12 months. 711 respondents completed the web-based survey.

[3] For instance, today, only a small fraction of the postulated electric mobility goal is accomplished – at the end of 2013 only about 12,000 BEVs were registered in Germany, mainly by commercial users (KBA, 2014) – and also other AFVs exhibit a very modest market penetration.

[4] Eggers and Eggers (2011) and Achtnicht et al. (2012) also accounted for the non-linear impact of driving range and fuel station density, respectively.