Preferences For Electric Vehicle Charging: A Latent Class Approach

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Overview

Electric vehicle charging behavior is a pivotal point between the sustainable energy and sustainable mobility transitions. The energy transition is characterized by a reduction in fossil fuel usage as well as of related CO_2 emissions in the energy sector, while the mobility transition aims at achieving these goals in the transportation sector. Specifically, the mobility transition includes changes in the individual mobility behavior towards more sustainable solutions. The increased market penetration of electric vehicles (EV) should contribute to both the energy transition and the mobility transition. From a user perspective, standard charging of the EV battery takes considerably longer than filling the gasoline tank. Thus, EV charging options will have to be adjusted to better fit user expectations, needs, habits, and planned behavior. From a business perspective, clearly defined use cases are still missing. In Germany, up until now, necessary EV infrastructure investments are substantial, whereas revenue streams are too low even at a relatively high electricity price in the residential sector (0.29 €/kWh). Also, it is not clear which actor/s are the preferred ones for installing and running EV infrastructure; this role could be filled by car manufacturers, government, municipalities, and/or energy companies. EV infrastructure poses a case of the 'chicken and egg' problem in that few actors are wiling to invest in infrastructure given the low market penetration, but at the same time, few potential customers are willing to switch to EV given the lack of infrastructure.

Consequently, it is crucial to understand the charging preferences of current and potential future EV drivers in a more mature EV market for policy makers as well as electric mobility providers. Some studies exist that investigate single attributes of the charging process; Hackbarth and Madlener (2013, 2016), Hidrue et al. (2011), and Tanaka et al. (2014), for instance, investigate the willingness to pay (WTP) for the EV adoption whereas Ito et al. (2013) examine the willingness to pay for the EV-charging infrastructure. Franke et al. (2012) find factors influencing range anxiety. However, none of the mentioned studies has systematically studied the charging preferences in a holistic manner (i.e. including related services).

Therefore, we employ a Discrete Choice Experiment among German potential EV users to assess EV drivers' valuation of six different attributes of the charging process: charging speed, location, share of renewables, waiting time for an available charging station, charging technology, and price. By extracting consumers' marginal WTP, we elicit the preferences of potential future EV customers. We then derive policy and business implications both for specific attributes and for complete mobility solutions. For example, if EV drivers assign a high value to the charging duration, this could be an area to put a special focus on when offering new charging solutions and services. The sample size for our experiment is 4,101 respondents, with each participant answering 12 choice cards, for a total sample size of 49,212 observations.

Methods

In our base case model specification, we use a Multinomial Logit (MNL) model to estimate the influence of the different attributes on the choices made by the respondents. MNL models suffer from several limitations, in particular the IIA (Independence of Irrelevant Alternatives) assumption and the lack of random preference heterogeneity. To solve these issues, we employ a Latent Class approach (applied to our Discrete Choice Experiment data) which separates the sample into distinct classes that may have different preferences regarding the charging attributes. Statistical tests and measures of parsimony – such as Log-Likelihood, AIC, and BIC – show the superiority of the latent class model over the standard MNL model.

Results

For our Latent Class model, we choose six classes based on statistical diagnostics and economic reasoning. We find distinct preference heterogeneity between the classes. Most of the coefficient estimates have the expected signs and are statistically significant. While all groups prefer lower costs, the largest group (class share: 31.2%) has a stronger than average aversion against higher cost. While the average consumer prefers a higher share of renewables in the electricity mix used for charging, two classes disregard this attribute completely, indicated by non-significant coefficients. In contrast, one class places particularly high emphasis on a high share of renewables. Another class shows a strong preference for faster charging, which translates to a WTP of €106.69 per month to reduce charging duration from 8 hours to 4 hours, compared to €33.56 for the average consumer.

Conclusions

Residential households in Germany prefer to charge at lower costs, for shorter durations, and charging at home. They also prefer a higher share of renewables, lower waiting times, and have a weak, but statistically significant, preference for inductive over tethered charging. We find significant preference heterogeneity between classes. This indicates that the perfect charging solution that fits everyones' needs does not exist. Rather, charging suppliers should offer different options for the different groups to capture larger portions of the market.

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