Exploring consumer heterogeneity in willingness to pay for electric vehicle product bundles

Themenbereich: Verkehr (8)
Alfons PRIESSNER [1(1)], Nina HAMPL [(1)]
[(1)] Alpen-Adria-Universität Klagenfurt

Motivation and Research Questions

To contribute to the global targets for reduced carbon emission, electric vehicles (EVs) need to be powered with electricity produced by renewable energy sources (Bleijenberg and Egenhofer 2013). Consequently, a better grasp of EVs bundled with photovoltaic (PV) and battery storage (BS) systems is highly relevant for promoting the diffusion of EVs in individual transportation in a way that limits environmental damage.

However, consumer preferences and willingness to pay (WTP) for such bundles have been limitedly researched. Our literature review points out two gaps in research, which we aim to address with this study. First, to date, research has covered only the impact of single add-on services and not how multiple product or service add-ons affect the preference for EVs (Hinz et al. 2015; Fojcik and Proff 2014). Cherubini et al. (2015) even called for research on EV product bundles, since they suggested bundling as one lever to increase EV adoption. Second, although several studies analyze the socio-demographic characteristics, psychological motives and experiences of EV lead users and potential EV adopters, to date there is no analysis of how potential EV adaptor characteristics and EV experiences can influence consumer preferences and their WTP for EV product bundles.

Hence, this paper has aims to advance our current understanding of such EV-PV-BS product bundles by investigating private individuals' preferences and their WTP for such bundles. Further, our study aims to shed light on how customers' assessing these values are influenced by socio-demographic and psychological variables, as well as by self-assessed EV experience.

Methods and Data

Methods & Sample: In the marketing as well as clean technology preference literature conjoint analysis is one of the most widely applied methodology to investigate consumer preferences and WTP (Green and Srinivasan 1990; Kaenzig et al. 2013; Hackbarth and Madlener 2016). Hence, to answer our research questions, we conducted a web-based survey and conjoint experiment with 616 potential EV drivers (i.e., with a positive attitude toward EVs and a concrete purchase intention) in Austria.

Conjoint Attributes: Selecting the relevant attributes and levels is the most critical part in a conjoint analysis. Hence, we choose an elaborated iterative process between literature review, web research, sales conversations with EV, PV, and BS sellers and over a dozen lead user and expert interviews. To reduce the complexity of the choice experiment with three products (EV, PV, and BS) for respondents, we decided to ask our interviewees whether they would be interested in purchasing a PV power plant with or without BS as add-on, bundled with an EV[2]. After verifying the interpretation of the attributes and levels in a pre-study with 45 respondents, we finally selected six attributes for the CBC experiment, namely *PV/BS add-on (ownership), self-sufficiency rate, amortization period, policy incentive, provider, and purchase price* (see Figure 1 for details on attribute levels).

Data Analyses: Based on this data we could determine customer preferences and the importance of individual product attributes in consumer choice. For data analysis we estimated individual part-worth utilities using a Hierarchical Bayes (HB) model (Rossi and Allenby 2003) implemented in Sawtooth Software[3]. HB model has the advantage of measuring preferences both on an individual level and, as is traditional, on an aggregated level.

We then also calculated the WTP for attribute levels (cf. approach in Salm et al.(2016)).

$$WTP\ (u_{ij}) = \ (u_{ij} - u_{ij\ Default}) * \frac{p_{max} - p_{min}}{u_{pj\ max} - u_{pj\ min}}$$

This approach involves calculating the difference between the part-worth utility (u_{ij}) of one attribute level (j) (e.g., 8 years) and the default part-worth utility ($u_{ij\ Default}$) (i.e., 20 years) within the same attribute (i) (e.g., amortization period). This difference is then multiplied by the *price of one utility unit*

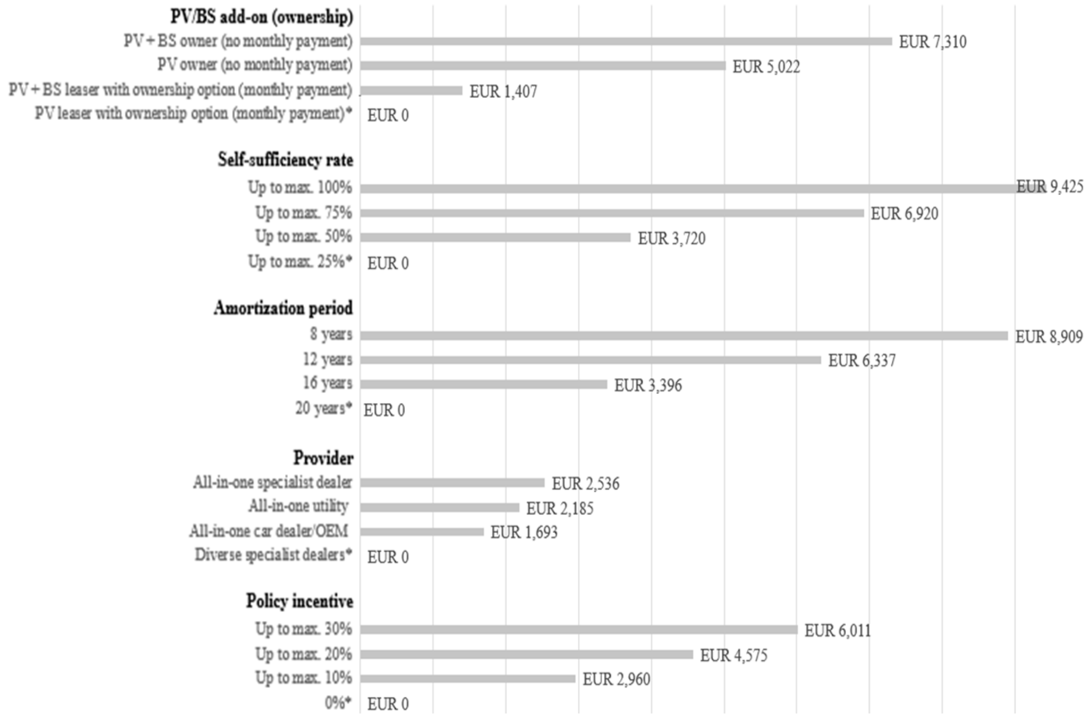
[1] Jungautor: Universitätsstraße 65-67, 9020 Klagenfurt, Austria, alfons.priessner@gmail.com
[2] The car of choice had the same characteristics as the Nissan Leaf 2.0, which was released at the beginning of 2018. The Nissan Leaf model was the world's best-selling electric car in 2017 (Bloomberg 2017).
[3] One of the frequently used conjoint analysis software solutions in marketing research (cf., Hinnen et al. 2017; Kaenzig et al. 2013; Kaufmann et al. 2013; Salm et al. 2016).

(i.e., difference between the highest (p_{max}) and lowest (p_{min}) possible price) divided by the utility difference between the highest and lowest price ($u_{pj\ max} - u_{pj\ min}$).
In addition, we modelled the impact of socio-demographic characteristics, psychological characteristics, and EV experience on consumer preferences and WTP for EVs (cf. approach in Gamel et al.(2016)).

Results and Conclusions

Our WTP results (see Figure 1 for further details) show that the expressed WTP for EV add-on products (PV and BS) is still fixed on amounts below current market prices. We noted an average WTP of approximately EUR 9,500 for an increased self-sufficient energy supply (from 25% to 100%). By comparing the estimated WTP figures to current market prices for PV and BS in the Austrian market (cf. KELAG, 2018; Wien Energie, 2018), we identified a potential gap of 15-30%. Further studies can build on our insights and try to simulate the uptake in market share by cost digression of EV, PV, or BS.
Moreover, potential EV drivers have some WTP a premium for purchasing an EV-PV-BS bundle from an all-in-one provider in a bundle. This is especially interesting, since many major car manufacturers and utility companies are planning to position themselves as all-in-one players (cf. Tesla, Porsche, EnBW) to create a platform strategy similar to Apple's (cf. Gawer and Cusumano 2014). Hence, the role of brands and customer loyalty in positioning the firm as an all-in-one provider related to EV-PV-BS product bundles suggests a promising avenue for further research.
Further, higher EV subsidies appear generally to be less valued. This implies that potential EV users appreciate some level of policy incentive, but from an input-output perspective government subsidy should not be too high. Nevertheless, we agree with Bauner and Crago (2015) to maintain policy incentives in markets with high uncertainty regarding technological development and price forecasts (such as the EV, PV, BS market), to reduce delays in potential adopters' investment timing.
Our study found also influencing effects of socio-demographic (e.g., gender) and psychological (e.g., environmental attitude) variables, and of self-assessed EV experience on product bundle preferences as well as WTP (see Table 1 for details). Socio-demographic variables have a significant, but rather small effect on the respondents' preferences and WTP. Psychological variables, in contrast, show a significant impact. For instance, technology-minded people are willing to pay more for EV-PV-BS bundles, and environmentally-conscious respondents are more willing than non-environmentalists to accept longer amortization periods and lower self-sufficiency rates. Overall, these results suggest that future research attending to consumer preferences and WTP in EV product bundling literature, should strive to comprehensively evaluate potential driver characteristics, and not only focus on a single dimension, such as socio-demographics only or psychological characteristics only.

Figure. 1. WTP for attribute levels of EV-PV-BS product bundle (relative to default).



Note: Attribute levels of default product (PV leaser with ownership option, 25% sufficiency rate, 20 years amortization period, diverse specialist dealers, 0% policy incentive) are marked with an asterisk (*).

Table 1. Results of the parameter estimation with use of covariates.

Attributes and attribute levels	Intercept	Age	Education	Income	Gender (Men)	Housing (Apart-ment)	EV experience	WV Communi-tarian	Pro-Envir. Attitude	Tech. Readiness
PV/BS add-on (ownership)										
PV owner *(no monthly payment)*	0.86*	0.00	0.05	0.00	-0.44*	-0.48*	-0.06	0.07	0.12	-0.21*
PV + BS owner *(no monthly payment)*	1.21*	-0.02*	0.12†	0.00	0.00	-0.89*	0.17*	-0.24*	-0.16†	-0.05
PV + BS leaser with ownership option *(monthly payment)*	-1.11*	0.01†	-0.10	0.00†	0.10	0.76*	-0.01	0.07	0.26*	0.02
PV leaser with ownership option *(monthly payment)*	-0.95*	0.01†	-0.06	0.00	0.33*	0.61*	-0.10	0.09	-0.22*	0.24*
Self-sufficiency rate										
Up to max. 25%	-1.07*	0.02*	0.00	0.00*	-0.22	0.15	-0.11	-0.26*	0.34*	0.02
Up to max. 50%	-0.06	0.02*	0.14*	0.00†	-0.28*	-0.14	-0.34*	-0.10	0.00	0.04
Up to max. 75%	0.24*	-0.01*	-0.01	0.00*	0.25*	0.11	0.16*	0.13†	-0.05	-0.08
Up to max. 100%	0.89*	-0.03*	-0.12*	0.00	0.25†	-0.11	0.29*	0.22*	-0.29*	0.02
Amortization period										
8 years	0.68*	0.00	0.02	0.00	0.29†	0.16	-0.01	-0.05	-0.23*	-0.03
12 years	0.31*	0.00	-0.03	0.00*	0.09	0.11	0.05	-0.10	-0.20*	0.10
16 years	-0.16	-0.01	0.12*	0.00	-0.07	-0.18	-0.04	0.19*	0.11	-0.06
20 years	-0.83*	0.00	-0.11†	0.00*	-0.31*	-0.09	0.01	0.12	0.32*	-0.02
Provider										
All-in-one car dealer/OEM	0.19	-0.01*	-0.06	0.00	-0.32*	0.04	-0.01	0.02	-0.03	-0.05
All-in-one utility	0.05	0.02*	0.03	0.00*	0.34*	-0.33*	0.04	0.19*	0.09	0.11
All-in-one specialist dealer	0.23*	0.01	0.07	0.00*	-0.09	0.09	-0.05	-0.14*	-0.09	-0.03
Diverse specialist dealers	-0.47*	-0.02*	-0.03	0.00	0.08	0.20†	0.01	-0.07	0.02	-0.02
Policy incentive										
0%	-0.67*	0.01*	-0.05	0.00†	-0.02	-0.09	-0.04	-0.22*	0.44*	-0.01
Up to max. 10%	0.05	0.01†	0.03	0.00*	-0.26*	0.05	0.13	0.09	0.02	0.07
Up to max. 20%	0.07	-0.01*	0.00	0.00*	0.09	0.23†	-0.05	-0.01	0.01	-0.15†
Up to max. 30%	0.55*	-0.01*	0.02	0.00	0.19	-0.19†	-0.04	0.18†	-0.46*	0.08
Purchase price										
EUR 25,000	1.95*	0.01	0.04	0.00	-0.18	0.43*	-0.01	0.19	-0.37*	-0.36*
EUR 30,000	1.01*	0.00	0.09	0.00	-0.17	0.46*	-0.03	0.06	-0.16	-0.21*
EUR 35,000	0.43*	-0.01	0.07	0.00	-0.05	-0.20	-0.32*	-0.04	-0.11	-0.13

EUR 40,000	-1.24*	0.01	-0.04	0.00	0.45*	-0.22†	0.10	-0.15	0.28*	0.35*
EUR 45,000	-2.15*	0.00	-0.16*	0.00	-0.05	-0.47*	0.24*	-0.06	0.37*	0.35*
None-option	-0.78*	0.10*	0.33	0.00	-1.38*	1.56*	0.34	0.37	-0.05	-0.02

*Significant at the 0.05 level (parameter estimates are significantly positive/negative if more than 95% of the estimated parameter values in each iteration of the algorithm are positive/negative)
† Significant at the 0.1 level (parameter estimates are significantly positive/negative if more than 90% of the estimated parameter values in each iteration of the algorithm are positive/negative).

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