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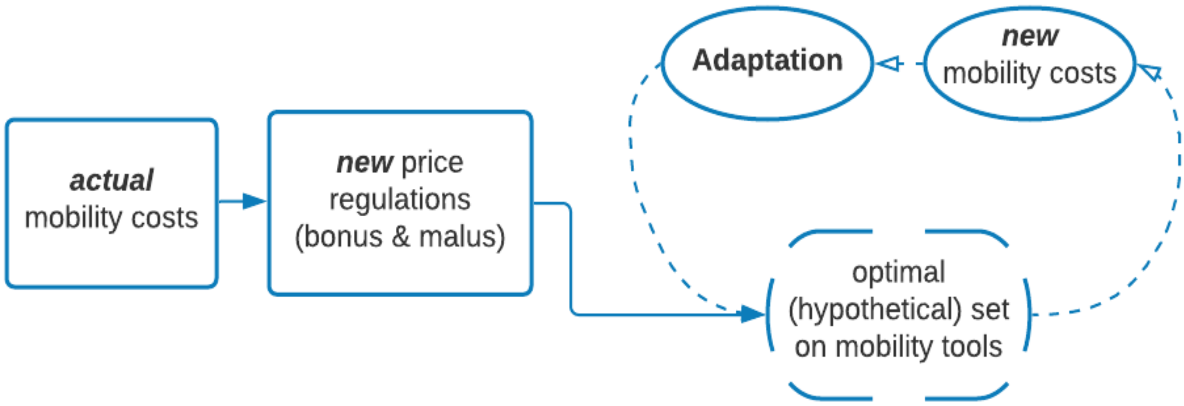

Electro mobility acceptance: The influence of political bonus and malus factors

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1 Introduction

With a share of almost 20%, the transport sector is one of the largest sources of greenhouse gas emissions in Germany, whereby road traffic is the biggest polluter within this sector (Salb et al., 2018). In 2017, Germany initiated the program “Sofortprogramm Saubere Luft 2017-2020” to improve the air quality in cities. It aims to promote electric vehicles (EV) by providing incentives for purchasing them and by developing charging infrastructure. Within this program, a large-scale project “Electric City Rüsselsheim” (*Electric City Rüsselsheim*, n.d.) has been initialized. Rüsselsheim am Main, a medium-sized city in Germany, will be equipped with 650 charging stations for EVs. As a result, the city will offer a total of 1,300 charging points to EV drivers (*Electric City Rüsselsheim*, n.d.) and is expected to be the city with the densest charging infrastructure in Europe.

The installation of the charging infrastructure for EVs is accompanied by a social research study, which aims to get insights about the acceptance of EVs in the population. Firstly, it aims to investigate, which political bonus and malus factors have the potential to promote EVs and under which conditions people are willing to include an EV into their household fleet. Further, the study is interested to measure people’s preferences for the configuration of charging points. The paper presents the research design in more detail and provides preliminary results from the field.

2 Research questions

The German government has recorded a total of 239,250 new registrations for plug-in hybrids in 2019 with an increase to 527,864 in 2020, as well as 63,281 electric cars in 2019 and 194,163 in 2020 (Statista, 2021a). Despite the clear increase over the last year, alternative fuel vehicles have not yet gained widespread acceptance, since new registrations for all types of vehicles have been in total about 3.61 million in 2019 and 2.92 million in 2020 (Statista, 2021b). To overcome the obstacle to buy EVs due to higher purchase prices in comparison to cars with internal combustion engine (ICE) (ADAC, 2020; Kurz, 2017), German government provides a financial bonus of 6,000€ currently (BAFA, 2020). Further bonus factors to promote EVs as well as malus factors to reduce usage of cars with ICE are possible and discussed. In the German context, a previous study compared the economic profitability of EVs with ICE-cars including the effects of the financial bonus provided by the government (Kurz, 2017). However, to our knowledge, yet, there are no studies on the impact of political incentives on the decision to add an EV to the household fleet.

For Switzerland, Erath and Axhausen (2010) examined the effects of political price regulations on the choice of mobility tool-ownership by focusing on gasoline and diesel-powered vehicles. Their research methodology for measuring the effect of price regulations on the purchase of mobility tools is adopted to the objectives of this study: The main focus of analysis will be the willingness to purchase EVs, as wells as price regulations relevant for the German context. The study intends to answer the following research questions:

- Which political bonus and malus factors have the potential to promote EVs in Germany?
- Which effect do the bonus and malus factors have individually and in combination?
- At which threshold values do the factors have an effect?

To get a deep understanding of the decision process with respect to mobility behavior, the study includes measurements of the socio-demographic and economic background, since these variables are expected to have an effect on purchasing vehicles (Liao et al., 2017). Moreover, since socio-psychological constructs have been shown to explain the usage of transport (Haustein & Hunecke, 2007; Heath & Gifford, 2002), this research will consider people's attitudes towards EVs and environmental awareness in the analysis.

For the spread of electric cars, it is not only necessary to install a nationwide charging infrastructure, but also to increase the user-friendliness of the charging stations. Currently, in Germany, the configurations of charging stations are very heterogeneous (Kistner & Kowald, 2019), making simple and user-friendly handling difficult. However, preferences for charging station configurations have rarely been studied and mainly focused on willingness to pay (Wolff & Madlener, 2019, 2020) but did not consider a user-friendly design. Therefore, an additional research question of the present survey is:

- Which preferences do potential users have for the design and configuration of charging stations?

To answer the outlined research questions, given study conducted a survey including two choice experiments: 1) Stated Adaptation experiment to measure respondent's choice of mobility tools for the household as reaction to different price regulations (bonus and malus factors), 2) Stated Preferences experiment to assess the preferences for the configuration of charging stations.

3 Methods

3.1 Study area, data and sample

The survey area is Russelsheim am Main, a medium-sized city in the South-West of Germany with about 65,440 inhabitants (Stadt Rüsselsheim am Main, 2019). To be able to control for spatial structure, surrounded municipalities like Ginsheim-Gustavsburg and Bischofsheim have been considered, as well as the city of Wiesbaden with 223,369 inhabitants (ZENSUS 2011, 2011).

Since the purchase of mobility tools is often a matter of the household, one adult person of 18 years and older has been interviewed for every participating household. This respondent provided information for the whole household. The participants have been recruited on a sample of 6,107 addresses, which was bought from a commercial address dealer. Potential respondents were contacted with an introduction letter and a follow-up recruitment phone call to make an appointment for the interview. An incentive of 20 euros was offered to the respondents as suggested in literature on survey designs (Dillman et al., 2014; Schnell, 2019).

Data were collected in computer-assisted personal interview (CAPI), providing the opportunity that interviewers can answer questions and provide support in handling the choice experiments. The fieldwork started in January 2020 as Face-to-Face interviews in respondent's household. Due to COVID-19 this procedure had to be paused in March to be adopted to online CAPI-interviews conducted via Webex, an online video-based communication tool (*CISCO Webex*, n.d.). The new field work period started in May to be finished in December 2020. A total sample of n=468 respondents/households has been achieved.

3.2 Survey Design

The method for the first choice experiment was adapted from the previously mentioned study by Erath and Axhausen (2010) and adopted to meet the research questions of the given study. During the survey, participants should be confronted with changing price regulations for both, their current mobility tools and for their hypothetical household fleet as reaction to the new regulations. This procedure requires a live calculation of the mobility costs during the survey. To meet this requirement, the survey has been programmed as a Java application.

In addition to the choice experiments, the survey will assess relevant information on the household and household members to explain the decisions on mobility tools. To calculate household's mobility costs, detailed information on all mobility tools available in the household will be asked, including cars, motorcycles and tickets for public transport (for detailed description of costs calculation in this study see Reckermann et al. (2021)). An overview on the survey topics is provided in Table 1 (for more details see Gutjar et al. (2021)). Both choice experiments and the measurements of social-psychological constructs will be explained below in Section 3.3 and 3.4.

Table 1. Survey topics and issues

Order	Topic	Variables	Purpose
1	Living situation of the household	address data / housing type / household type / ownership status / housing costs / household income / distance to public transport (in m) / distance to charging station (in m) / importance of traffic criteria in the selection of the residential location	Explain decision processes on mobility tools (see topic 5)
2	Passenger cars in the household	amount / segment class / car size (cylinder volume) / engine type / annual mileage / frequency of use	Calculate mobility costs
3	Motorcycles in the household	amount / segment class / annual mileage	Calculate mobility costs
4	Persons in household	age, gender, education, employment / distance to work / car availability / trips >300km / public transport subscription / bike usage	Explain decision processes on mobility tools (see topic 5)
5	Experiment 1	Behavioral decision: Adaptation of the household fleet as reaction to new price regulations	Assess decision on mobility tools as reaction to new price regulations
6	Experiment 2	Behavioral decision between two charging stations (attributive composition)	Assess preferences for charging stations
7	Socio-psychological constructs	Constructs to explain adoption of EV: attitude, subjective norm, Intention, perceived behavioral control; environmental awareness	Explain decision processes on mobility tools (see topic 5)

3.3 Stated Response Techniques

The two central research questions of this study deal with decisions of individuals and their preferences. As previously mentioned, EVs are still a new technology that have reached the German society only to a limited extent (Kurz, 2017; Statista, 2021b, 2021a). Therefore, it is not possible to measure people's revealed preferences by asking them about their actual choices or actions. When examining the acceptance of innovations, Stated Response (SR) techniques should be applied, in which respondents are confronted with hypothetical situations and asked about their preferences (Axhausen & Sammer, 2001; Erath & Axhausen, 2010; Lee-Gosselin, 1996).

As defined by Lee-Gosselin (1996) and presented in Table 2, SR techniques are classified along two dimensions: a) *constraints of the choice situation*, and b) behavioral *outcomes*, which refer to what individuals might do as responses to a). Both, constraints and outcomes, can be either *pre-defined* by the study design or *elicited freely* by the respondents in an open-ended manner.

Table 2. Stated Response (SR) techniques with corresponding template questions, classified by Lee-Gosselin (1996, p. 124)

Behavioral Outcomes	**Situational Constraints**	
	Pre-defined	Elicited freely
Pre-defined	**Stated Preference** *Given the levels…, which would you prefer…?*	**Stated Tolerance** *Under what circumstances could you imagine yourself doing…?*
Elicited freely	**Stated Adaptation** *What would you do differently, if you were faced with …?*	**Stated Prospect** *Under what circumstances would you be likely to change your behavior?*

For the two previously mentioned choice experiments, this research applies the Stated Adaptation (SA) approach to measure people's stated responses to different price regulations (experiment 1) and the Stated Preference (SP) approach to measure the preferences for charging stations (experiment 2). For both approaches, some attributes and levels have to be defined for the pre-defined situational constrains as in the SR case or even for both, situational constraints and behavioral outcomes, as in the SP case. Depending on the number of attributes and levels selected, an experimental design with all possible combinations (full factorial design) can quickly contain hundreds or thousands of choice tasks (Louviere et al., 2000). Since such an experiment cannot be implemented with a limited sample size and without respondents' fatigue (Lee-Gosselin, 1996; Rose & Bliemer, 2009), a *fractional factorial design* is useful, in which only a subset of the possible choice tasks is used (Louviere et al., 2000; Rose & Bliemer, 2009, 2014). Doing so, instead of a random selection, researchers recommend to conduct *efficient* designs aiming to find designs with small standard errors of the estimates for the parameters (Rose & Bliemer, 2009, 2014). The efficiency of an experimental design is measured by the so called *D-error,* where a small D-error means a more efficient design (Rose & Bliemer, 2009, 2013). Further, such design requires the definition of *priors* for the parameters to be estimated (Rose & Bliemer, 2009), which can be set to zero as long as previous knowledge about the priors (e.g. from pilot studies) does not exist (Huber & Zwerina, 1996). Lastly, depending on the number of choice tasks in the defined fractional factorial design, it might be practical to divide them to several blocks, so that each respondent gets only one block of choice tasks. For both experiments, SA and SP, the experimental design has been created with the software Ngene version 1.2 (*ChoiceMetrics*, n.d.) by referring to the user manual (ChoiceMetrics, 2018).

3.3.1 Stated Adaptation Experiment

In the SA experiment (experiment 1), the respondents are confronted with new price regulations concerning mobility costs and asked "*What would you do differently, if you were faced with …?*" to measure their stated responses to given situational constraints (Lee-Gosselin, 1996). The selection of the attributes for the situational constraints was based on currently possible and applicable price regulations to achieve environmental friendlier mobility in the German context: A financial support (environmental bonus) for the purchase for an EV is already provided by the German government (BAFA, 2020; Kurz, 2017). Further, a price reduction of public transport tickets is a reasonable bonus factor in order to reduce the usage of ICE-vehicles. However, malus factors for ICE-vehicles such as increased fuel costs and CO_2-surcharges are also conceivable. With regard to EVs, the price for electricity at charging stations and taxes for the EVs should be considered. When defining the levels for the situational constraints (attributes), important rules have to be considered: a) for efficient designs, the range of the levels needs to be as wide as possible by keeping the values to be realistic (Rose & Bliemer, 2014), b) to be able to estimate non-linear effects a minimum of three levels is necessary (Rose & Bliemer, 2009). For every attribute, the current value at the time of study planning is always used. This value also serves as a guideline for the definition of two further levels, which were selected as a variation with regard to possible future price regulation to promote environmentally friendly mobility (higher / lower value). The attributes of interest together with the variation levels in the experimental design are presented in Table 3.

Table 3. Stated Adaptation experiment: attributes and levels (varying in choice situations)

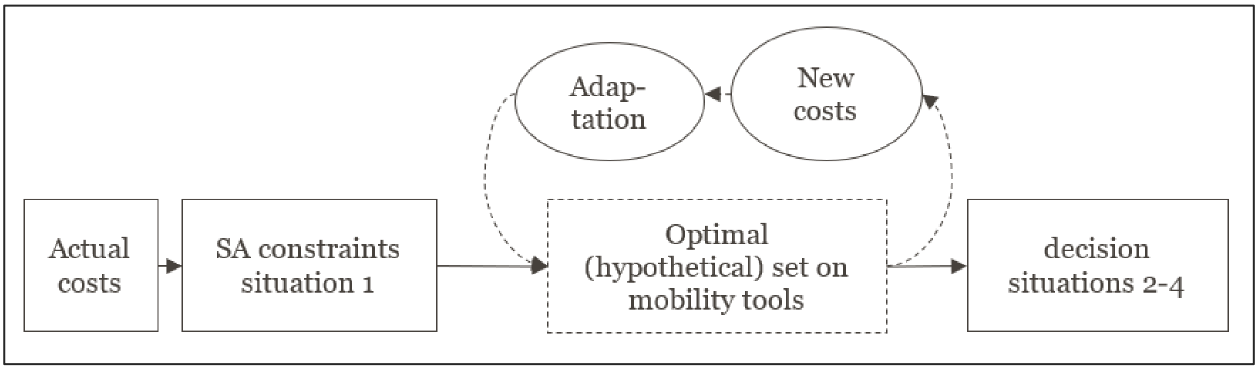
Attributes	Level 1	Level 2	Level 3
fuel costs (€/l)	1.50*	3.00	4.50
electricity price (€/100km)	0.00	3.50*	7.00
CO_2 surcharge (€/ liter of fuel)	0.00*	0.20	0.60
tax for EV	free*	50% of ICE vehicle	like ICE vehicle
environmental bonus (€ per EV)	2,000	6,000*	10,000
public transport price	free	50% of today's price	as today*

Note: * = today's value (at the time of survey design)

The applied efficient design showed a very low D-error of .0641 and resulted in 20 choice situations. Since this decision process is expected to be a cognitively demanding task, the situations have been divided into five blocks. Every respondent was randomly assigned to one block with four choice situations.

In every choice situation, respondents are faced with new price regulations as defined by the experiment design. At the same time, based on previously surveyed information on actual mobility tools in the household (see Table 1), the survey program calculates the resulting changes in the household's annual and monthly mobility costs and allows comparisons to the actual costs. Now, respondents are asked what they would do differently, if they were faced with this situation. They are reminded to consider all household specific characteristics (e.g. all persons, financial restrictions, mobility behavior) when defining a set of mobility tools for the household as reaction to the new price regulations. To collect the decision data as reliable and realistic as possible, the program calculates the new changes in costs after every adaptation of the mobility tools, so that the respondent can adapt the set of mobility tools as long as he/she is satisfied with the decision before proceeding with another choice situation. The iterative decision process in such a choice situation is visualized in Figure 1.

Figure 1. SA experiment: Iterative adaptation process in a choice situation



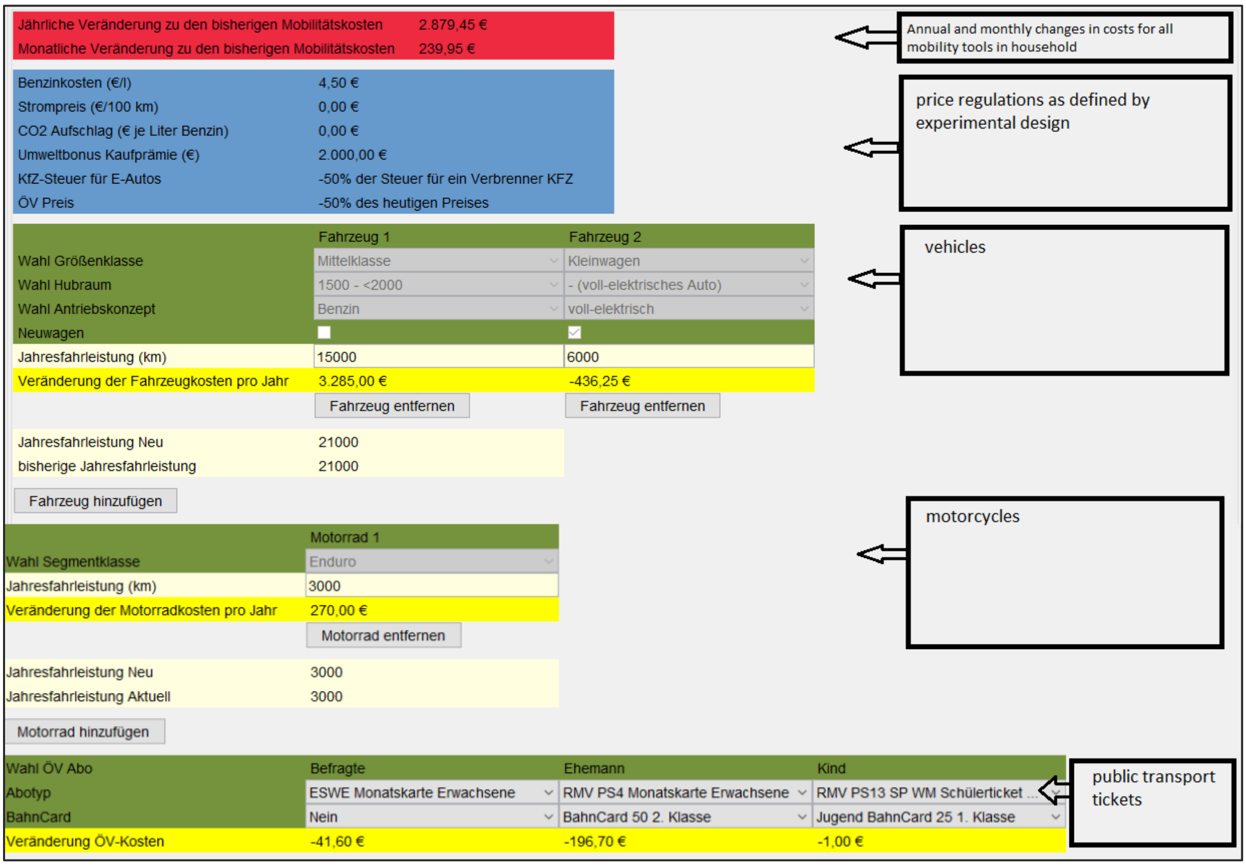
Hereby, the offered mobility tools for the experiment are aggregated to a limited set of categories in order to a) not to overburden the respondents with all possible cars, motorbikes and tickets for public transport, and b) to be able to calculate the costs during the interview. The costs on tickets for public transport can be calculated based on a previously defined database with actual prices. The calculation of costs for motorcycles and especially for cars is challenging. For this reason, a method has been developed and implemented by Reckermann et al. (2021) to calculate both, actual costs and changes in costs (new costs) due to hypothetical price regulations defined for the experiment situations. The calculation method does not only consider purchasing costs of mobility tools but also running costs for vehicles and motorcycles. For both, the depreciation in value, costs for fuel/electricity, and service charges are considered. For cars, additionally costs for maintenance, taxes, insurance, parking, and for tires are calculated (for more details see Reckermann et al. (2021)). A brief summary of all possible mobility tools and options to choose is presented in Table 4.

An example of a choice situation during survey is presented in Figure 2 for a fictive household. For a description in English see the black boxes.

Table 4. Adaptation of mobility tools in SA experiment: Tools and levels

Mobility tool	Option
Vehicle	
Segment class	Minicompact / Compact-size / Mid-size / Full-size / Sports car / Mini Multi-Purpose Vehicle (MPV) / Large MPV / SUV / Utilities / Off-road vehicle
Car size (cylinder volume)	< 1,500 ccm / 1,500 – 2,000 ccm / 2,000 – 2,500 ccm / 2,500 – 3,000 ccm / > 3,000 ccm / battery electric vehicle (BEV)
Engine type	gasoline / diesel / battery electric vehicle (BEV) / plug-in-hybrid
Purchase as new car	yes / no
Annual mileage	*Open answer*
Motorcycle	
Segment class	All types available in Germany
Annual mileage	*Open answer*
Deutsche BahnCard (discount cards for public transport)	
type	BahnCard 25 / BahnCard 50 / BahnCard 100 / My BahnCard 25 / My BahnCard 50
class	class 1 / class 2
Public transport abonnements	All tickets available in the study area (ESWE Verkehr, 2021; RMV, 2021)

Figure 2. Example of a choice situation of SA during the survey



3.3.2 Stated Preference Experiment

To be able to provide recommendation for the configuration of charging stations, this study aims to assess people's preferences by applying the SP approach. The focus for the configuration attributes includes authentification method, payment opportunities, billing, and share of electricity from regenerative resources (for details see Kistner and Kowald (2019); Nienhueser and Qiu (2016); Vogt and Fels (2017)).

In the SP experiment (Lee-Gosselin, 1996), respondents can decide between two different charging stations with the same attributes but different levels (conditions). In such attribute-based stated choice situations, respondent's decisions serve as *discrete choices* between provided alternatives (Adamowicz et al., 1994; Rose & Bliemer, 2014), whereby individuals are expected to choose the alternative with the highest utility (Adamowicz et al., 1994; Huber & Zwerina, 1996; Louviere et al., 2010). In this experiment, respondents will state their choice between two unlabeled alternatives of two different configurations of charging stations ("configuration 1" / "configuration 2"). The generic labels do not have a meaning and thus have the same utility for the respondents (Louviere et al., 2000; Rose & Bliemer, 2014). Additionally, a labeled alternative "I do not choose any option" is provided. The variation of the levels for the attributes authentification, payment and billing has been defined by referring to previous literature review on all possible configurations in

Germany (Kistner & Kowald, 2019; Vogt & Fels, 2017). All attributes together with levels varying in the experiment are presented in Table 5.

Table 5. Stated Preferences experiment: attributes and levels (varying in choice situations)

Attributes	Level 1	Level 2	Level 3	Level 4
Authentication	Plug & Charge	RFID	App	
Payment	web-based	cards based	automatic debit transfer	
Billing	according to the amount of electricity	by time	fixed fee	flat rate
Share of electricity from regenerative energy sources	0%	50%	100%	

Further, some restrictions had to be imposed for the experimental design (Kistner & Kowald, 2019): The authentification per Plug & Charge and the billing as flat rate should be presented only in combination with payment method per automatic debit transfer. When developing the experimental design, a prior of .0002 for Plug & Charge has been imposed to indicate the expected preference over other authentification levels (Vogt & Fels, 2017). For the fixed fee as billing method, a prior of -.0001 has been applied to indicate the least preferred billing method (Vogt & Fels, 2017). Further, the share of electricity from regenerative energy sources has been varied as well as people are expected to prefer charging stations with green energy (Nienhueser & Qiu, 2016).

In the SP experiment, a fractional factorial design (Louviere et al., 2000; Rose & Bliemer, 2009, 2013, 2014) was implemented with a total of 72 choice situations divided in five blocks. One block with 12 situations has been randomly assigned to every respondent. Finally, an efficient design generated by Ngene with a D-error of .0517 has been applied. On pretest data collected from 48 respondents, a first model has been estimated in order to use the estimated parameters as priors to optimize the efficient design for the main study (Rose & Bliemer, 2009) (results will be presented in section 4.3). An example of a choice task is presented in Table 6.

Table 6. Stated Preference experiment: example of a choice task

Authentication	RFID	Plug & Charge	
Payment	web based	automatic debit transfer	
Billing	fixed fee	according to the amount of electricity	
Share of electricity from regenerative resources	100%	50%	
	○ *Configuration 1*	○ *Configuration 2*	○ *I do not choose any option*

3.4 Socio-psychological constructs to explain mobility behavior

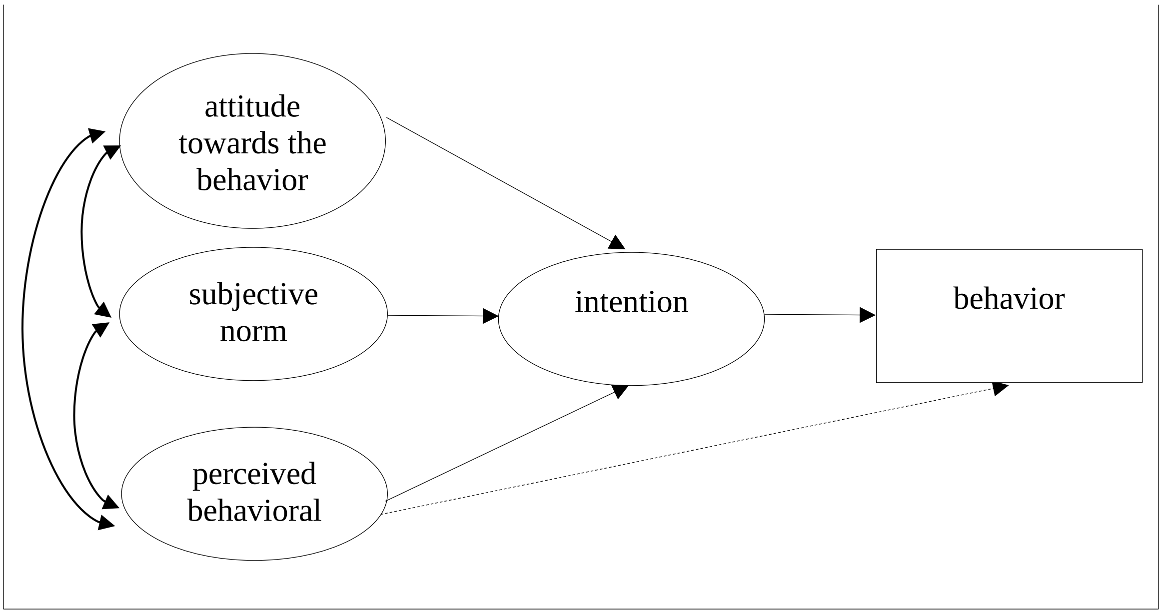
As mentioned previously, not only socio-economic and demographic characteristics, but also socio-psychological factors are expected to have an impact towards mobility behavior (Berneiser et al., 2021, 2021; Haustein & Hunecke, 2007; Heath & Gifford, 2002). Therefore, measurements for socio-psychological constructs to explain mobility behavior with respect to EVs as well as for general environmental awareness have been included and are explained below.

3.4.1 Socio-psychological constructs to explain adoption of EV

Among others, this study aims to support the understanding of a possible inclusion of an EV as response to new price regulations in the SA experiment. Due to the purpose to explain an intended behavior, the measurements of attitudes are based upon the Theory of Planned Behavior (TPB) by Ajzen (1991), where the *intention* to show a certain behavior is the central predictor of the actual behavior. The stronger the intention to show a certain behavior, the more motivated the person is to put the required effort, which leads to a higher probability that the behavior will actually be performed. However, intention depends on the ability to perform the behavior as well as the resources of the individual. According to TPB, intention is influenced by three factors as presented in Figure 3 (latent constructs are presented in oval shapes):

1. The *attitude towards the behavior*, which corresponds to the evaluation of how positive or negative the person is towards the behavior.
2. The *subjective norms* represent the perception of social pressure to perform or avoid a certain behavior. It illustrates an individual's believes about what behavior is expected by others.
3. The *perceived behavioral control*, describes how far an individual perceives himself/herself to have the necessary resources to perform a certain behavior. This factor is assumed to have an effect not only on intention to perform a behavior but also directly on the behavior itself.

Figure 3. Theory of Planned Behavior by Ajzen (1991, p. 182)



Socio psychological constructs are not manifest but latent and cannot be measured directly. Therefore, several items need to be developed for each factor of interest in order to assess, how they are reflected by the latent construct (e.g. intention) (Brown, 2015). According to the TPB, all items need to refer exactly to the behavior of interest (Ajzen, 1991). For this study in particular, it means that for example all items for the factor *intention* have to refer to the "intention to include an EV for the household fleet" and not simply to the "intention to buy a vehicle". To construct these items, a preliminary qualitative study with males and females of all age groups (n=9) has been carried out to measure their opinion towards EVs. They statements have been counted and frequently used statements have been used as items to which respondents can agree or not agree on a seven-point Likert-Scale.

3.4.2 Environmental Awareness

Since the demand for EVs increases with higher environmental awareness of the population (Nguyen & Schumann, 2020), this construct has to be measured to explain decision process to buy or not to buy an EV. The items were taken from a representative study on environmental awareness in Germany (BMU, 2019). The construct is measured using three factors: *environmental cognition* (objective statements), *environmental affect* (emotional reactions), and *environmental behavior* (behaviors in environmentally relevant areas). All items are measured on a seven-point Likert-Scale.

4 Preliminary Results and Outlook for Further Research

4.1 Descriptive analysis

To describe the sample, first descriptive results are presented in Table 7. The sample consists of n=322 males and n=144 females. Almost 50% of the respondents are 50 to 64 years old, whereas about 17% are 49 years or younger. Most households are represented in middle to higher income categories. In total, 36 % of households do not have any cars in their household. More than a half of the households do have one car (56%), almost one third households (28%) have two cars, and about 8% have three or more cars in their household.

Table 7. Descriptive analysis of the sample (n=468)

	n	%
Gender		
male	322	68.80
female	144	30.77
Age		
18-29 years	20	4.3
30-39 years	17	3.7
40-49 years	42	9.0
50-64 years	230	49.5
65-74 years	110	23.7
75 years and older	46	9.9
Household income		
<900 euro	5	1.0
900 - <1,500 euro	15	3.2
1,500 - <2,000 euro	24	5.1
2,000 - <3,000 euro	59	12.6
3,000 - <4,000 euro	95	20.3
4,000 - <5,000 euro	87	18.6
5,000 - <6,000 euro	59	126
6,000 - <7,000 euro	44	9.4
7,000 euro and more	39	8.3
Car ownership		
No car	36	7.7
1 car	263	56.20
2 cars	132	28.2
3 cars or more	37	7.9

4.2 Stated Adaptation Experiment

The number of EV cars actually in ownership and the number of cars selected in the SA experiment situations has been compared and results are presented in Table 8. While actually only 12 battery electric vehicles (BEVs) are owned, in total 402 BEVs have been included after being faced with the price regulations varying in the SA experiment. For Plug-In-Hybrids, whereas actually 9 cars are owned, the number raised to 163 vehicles after being faced with new price regulations.

Table 8. Ownership of EV: actual ownership vs. decision in SA experiment

	n Actual ownership of EV	**n EV included (in 4 situations)**
Battery electric vehicle (BEV)	12	402
Plug-In-Hybrid	9	163

Even though it should be noted that in the SA experiment each respondent participated in four choice situations, the clear increase in EVs indicate that some price regulations, individually or in combination, do have the potential to promote EVs. Therefore, further analysis has to be conducted. In particular, this study aims to represent the decision-making process as best as possible and therefore intends not only to analyze the effects of the price regulations, but also to include socio-demographic and socio-economic characteristics as well as living situation and the current mobility behavior to explain the decision to include an EV. Respondent's decision should additionally be explained by respondent's attitudes towards EVs and his/her environmental awareness. Additional dependent variables of interest are changes in annual mileage, and consequently the changes in fuel consumption as well as in CO_2-emissions. The whole complexity of the relationships requires advanced analytical techniques. Structural equation modelling (SEM) will be applied allowing to include intermediate effects (like mediators) and latent socio-psychological constructs (Byrne, 2010, 2016; Feskens & Hox, 2012; Kline, 2016).

4.3 Stated Preference Experiment

A first Multinominal Logit Model (MLM) (Rose & Bliemer, 2009, 2013) has been applied on the data after two months of field work and on a sample of n=48 respondents, which resulted in 550 choices. The results of the MLM model are presented in Table 9. As mentioned previously, the estimates of the parameters have been used as priors in order to develop a more efficient design for the study. Although, a new MLM model on the full sample needs to be run by adding some additional control variables, the preliminary results already indicate first impression of individual's preferences for the configuration of charging stations.

For the respondents, the authentication method Plug & Charge has the highest utility in comparison to Apps and is significant (β=0.511, t-test=2.14), whereas the estimate of RFID has a positive but smaller parameter (β=0.188, t-test=0.134) and thus a lower utility. As payment method, respondents prefer a card-based method: When automatic debit transfer is used as reference category, the utility for card-based method is positive but small (and insignificant) (β=0.114, t-test=0.63), whereas web-based payment shows a lower utility for respondents (β=-0.389, t-test=-2.55). As billing, respondents mostly prefer to pay according to the amount of electricity they used, since with reference to the flat rate option, it has a significantly higher utility (β=0.851, t-test=3.14), whereas the utility for billing by time is also positive, but the effect is smaller (β=0.111, t-test=0.39). Further, the billing as fixed fee has a negative utility in comparison to flat rate (β=-0.389, t-test=-1.31). Respondents prefer charging stations with higher share of electricity from regenerative sources as utility increases by 1.220 points (t-test=8.01). The specified model shows an adjusted Rho-squared (ρ^2) of .160 when comparing the Null Log-Likelihood (-604.27) and the Final Log-Likelihood (-498.540). It can be considered as a good model fit, since values between .2 to .4 are recognized to be indicators of good models (Louviere et al., 2000, p. 54).

Table 9. Multinominal Logit Model: preliminary results on pretest data

Attributes	**Levels**	**Estimate**	**Std. E.**	**t-test**
	ASC1 *Constant of Configuration 1; ASC2 is fixed*	-0.4	0.289	-1.39
Authentication	Plug & Charge	0.511	0.238	2.14
	RFID	0.188	0.134	1.41
	Apps	*reference*		
Payment	web-based	-0.389	0.152	-2.55
	card-based	0.114	0.181	0.63
	automatic debit transfer	*reference*		
Billing	according to the amount of electricity	0.851	0.271	3.14
	by time	0.111	0.281	0.39
	fixed fee	-0.389	0.298	-1.31
	flat rate	*reference*		
% regenerative energy	*as continuous variable*	1.220	0.152	8.01

n=48 respondents, n=550 choices
Adjusted Rho-squared = 0.160, Null Log-Likelihood = -604.27, Final Log-Likelihood = -498.540

4.4 Socio-psychological constructs to explain mobility behavior

As presented in Appendix 1 and Appendix 2, the items to assess respondent's socio-psychological determinant of mobility behavior are measured on a seven-point Likert-Scale, where value 1 is associated with agreement or positive attitude and 7 with disagreement or negative attitude.

Further, some items are formulated positively (+ polarity) and some negatively (- polarity). To make interpretation more intuitive, the scale has been reversed for items with positive polarity so that for all items a higher value corresponds to a stronger agreement and positive attitude.
To check the internal reliability of the scales Cronbach's alpha has been computed for every factor of TPB and environmental awareness (Gliem & Gliem, 2003). For the evaluation of reliability, recommended thresholds in literature have been consulted (Gliem & Gliem, 2003; Tavakol & Dennick, 2011). All results are presented in Table 10. For the TPB, all factors are evaluated to have a good reliability. The factor *perceived behavioral control* however, has not. At the same time, all factors of environmental awareness have poor to low reliability. However, Cronbach's alpha frequently underestimates the reliability and commonly serves to measure the scale reliability when scores are constructed by averaging or summing up the items (Brown, 2015). In this study, the aim is not building one single score per factor, but to include latent constructs reflected by their indicators into the model (Brown, 2015; Byrne, 2016).
A confirmatory factor analysis (CFA) has been performed for every factor to measure construct validity and to check, which indicators (items) can be omitted (Brown, 2015). As an example of such a measurement model, the CFA model for *intention* can be seen in Appendix 3. To evaluate the global model fit, this study consults approved recommendations (Hu & Bentler, 1999; Marsh et al., 2004; West et al., 2012). Precisely, a comparative fit index (CFI) greater than .90, root mean square error of approximation (RMSEA) values up to .08, and standardized root mean square residual (SRMR) less than .10 are considered as indicators of an adequate model fit. For a very good model fit, a CFI greater than .95 and values of RMSEA and SRMR below .05 are needed. Further, standardized factor loadings above .4 are considered to be good (Brown, 2015). The model fit statistics for every measurement model of each factor together with evaluation is presented in Table 10. Factor loadings for each item are presented in Appendix 1 for TPB factors and in and Appendix 2 for environmental awareness. To sum up the preliminary results, for TPB, the factors *subjective norm* and *intention* are considered to have good measurements. In contrast, for *attitudes* and for *perceived behavioral control* further CFA models have to be run by excluding all indicators with standardized factor loadings below .4 and, if necessary, specifying error covariances for correlated items.
For *environmental affect*, the model fit is perfect by definition, since with only three indicators, the measurement model for this factor is just identified (Brown, 2015). For *environmental cognition* and *behavior*, the model fit is good, but for further analysis, models should be specified by omitting items with standardized factor loadings below .4.

Table 10. Attitudes factors: Cronbach's alpha and model fit statistics from CFA

	Cronbach's alpha		**CFA model fit**			
Factor	alpha	evaluation	CFI	RMSEA	SRMR	evaluation
Theory of Planned Behavior (TPB)						
attitude	0.83	good	0.839	0.108	0.072	not good
subjective norm	0.86	good	0.983	0.089	0.028	good
perceived behavioral control	0.50	poor	0.770	0.098	0.062	not good
intention	0.80	good	0.996	0.058	0.014	very good
Environmental awareness						
environmental affect	0.67	low	1.000	0.000	0.000	very good
environmental cognition	0.60	low	0.978	0.045	0.028	very good
environmental behavior	0.54	poor	0.989	0.049	0.025	very good

5 Discussion

The survey study aims to perform analysis and provide insights on political bonus and malus factors and their importance in the promotion of EVs. Further, people's preferences in terms of design of the charging stations for EVs have been measured.

The paper provides information about the study design, presents preliminary results and gives an outlook for further research. With respect to the effect of political bonus and malus factors, descriptive results illustrate that some price regulations have the potential to promote EVs, since the hypothetical ownership of EVs in the experiment has increased in comparison to actual ownership. Therefore, further analysis by performing SEM has to be conducted to understand the decision-making process. For the purpose to enrich the analysis by including attitudes to the models, CFA have been performed for every factor. Even though, the initial results indicate that some further modifications of the measurement models of some factors (TPB attitude, TPB perceived behavior control, environmental cognition, environmental behavior) need to be done, the constructs do work well and can be included to the SEM.

The preliminary results already provide insightful results for respondent's preferences with respect to configuration of charging stations. For authentication, Plug & Charge is the mostly preferred method. Respondents prefer to pay with a card-based method or via an automatic debit transfer and do not want use web-based procedures. The billing according to the amount of electricity actually used is the most preferred option. In addition, a higher share of electricity from regenerative sources is preferred.

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Appendix

Appendix 1. TPB factors: items with scale, polarity, mean, standard deviation and factor loadings from CFA

Factors with items	Scale (1-7)	Polarity	M	SD	FL
Attitude towards the behavior					
Die Vorstellung als nächstes Auto ein Elektroauto zu kaufen finde ich ...	angenehm - unangenehm	+	4.9	1.9	0.8
Der Kauf eines Elektroautos ist für die Lösung aktueller Herausforderungen	nützlich - schädlich	+	4.6	1.5	0.8
Die gebotenen Anreize zum Kauf von Elektroautos finde ich …	attraktiv - unattraktiv	+	4.3	1.9	0.4
In Bezug auf den Kauf eines Elektro-autos ist die Reichweite dieser Fahr-zeuge für mich …	angenehm - unangenehm	+	3.2	1.9	0.5
In Bezug auf den Kauf eines Elektro-autos ist die Ladezeit dieser Fahrzeuge dieser für mich …	angenehm - unangenehm	+	3.2	1.8	0.4
Durch die Nutzung eines Elektroautos hebe ich mich … von anderen Verkehrsteilnehmern ab.	positiv - negativ	+	5.0	1.5	0.6
Die Risiken für Leib und Leben bei einem Unfall sind in einem Elektroauto…	tragbar - untragbar	+	5.4	1.7	0.4
Insgesamt wären der Kauf und die Nutzung eines Elektroautos für mich …	nützlich - schädlich	+	4.8	1.6	0.8
Die Kaufanreize und die Verbreitung von Elektroautos sind für mich eine … Angelegenheit.	kurzfristige - langfristige	-	4.5	2.0	0.1
Alles in allem leistet der Kauf eines Elektroautos einen … Beitrag zur Lösung der aktuellen Herausforderungen.	positiven - negativen	+	4.6	1.6	0.8

Appendix 1. Continued

Factors with items	Scale (1-7)	Polarity	M	SD	FL
Ich halte die staatlichen Kaufanreize für Elektroautos für …	angemessen - unangemessen	+	4.3	1.9	0.4
Die Zeit zum Laden eines Elektroautos ließe sich … zur Erledigung anderer wichtiger Dinge nutzen.	gut - schlecht	+	4.3	1.8	0.5
Subjective norm					
Menschen, die mir wichtig sind, betonen die Vorteile der Nutzung von Elektroautos.	trifft zu - trifft nicht zu	+	3.4	1.9	0.8
Menschen, die mir wichtig sind, hoffen auf eine schnelle Verbreitung von Elektroautos.	trifft zu - trifft nicht zu	+	3.7	1.9	0.8
Menschen, die mir wichtig sind, haben selbst ein Elektroauto gekauft bzw. planen einen Kauf.	trifft zu - trifft nicht zu	+	2.8	2.1	0.5
Menschen, die mir wichtig sind, denken, dass ich als nächsten Wagen ein Elektroauto kaufen sollte.	trifft zu - trifft nicht zu	+	3.1	2.0	0.8
Menschen, die mir wichtig sind, sehen im Umstieg auf Elektroautos einen Teil der Lösung aktueller Herausforderungen.	trifft zu - trifft nicht zu	+	4.2	1.8	0.8
Perceived behavioral control					
Die Nutzung eines Elektroautos würde mir in technischer Hinsicht … fallen.	leicht - schwer	+	6.1	1.4	0.6
Die Durchführung eines Ladevorgangs würde mit … fallen.	leicht - schwer	+	5.9	1.6	0.5
Der Kauf eines Elektroautos wäre für mich in finanzieller Hinsicht möglich.	stimme zu - stimme nicht zu	+	5.5	1.9	0.4
Die Fördermöglichkeiten zum Kauf eines Elektroautos sind mir bekannt.	stimme zu - stimme nicht zu	+	5.4	1.9	0.3

Appendix 1. Continued

Factors with items	**Scale (1-7)**	**Polarity**	**M**	**SD**	**FL**
Die Auswahl eines individuell passenden Elektroautos wäre für mich ...	leicht - schwer	+	4.1	2.1	0.4
Zum Laden eines Elektroautos wären mir eine ausreichende Anzahl an Ladesäulen bekannt.	stimme zu - stimme nicht zu	+	2.5	1.9	0.2
Intention					
Ich spiele mit dem Gedanken, auf ein Elektroauto umzusteigen.	stimme zu - stimme nicht zu	+	3.6	2.3	0.9
Beim nächsten Fahrzeugkauf werde ich den Erwerb eines Elektroautos in Erwägung ziehen.	stimme zu - stimme nicht zu	+	4.7	2.3	0.7
Ich habe die feste Absicht, mir ein Elektroauto zu kaufen.	stimme zu - stimme nicht zu	+	3.0	2.1	0.8
Ich habe mich bereits über den Kauf eines Elektroautos informiert.	stimme zu - stimme nicht zu	+	3.5	2.5	0.5

Note: M = mean, SD = standard deviation, FL = standardized factor loading from CFA

Appendix 2. Environmental awareness factors: items with scale, polarity, mean, standard deviation and factor loadings from CFA

Factors with items	Scale (1-7)	Polarity	M	SD	FL
Environmental affect					
Ich freue mich über Initiativen, die nachhaltige Lebensweisen einfach ausprobieren, zum Beispiel Ökodörfer, oder Slow-Food-Bewegungen.	stimme zu - stimme nicht zu	+	5.5	1.7	0.6
Die Umweltproblematik wird von vielen Umweltschützerinnen und Umweltschützern stark übertrieben.	stimme zu - stimme nicht zu	-	5.3	1.9	0.6
Es macht mich wütend, wenn ich sehe, dass Deutschland seine Klimaziele verfehlt.	stimme zu - stimme nicht zu	+	5.0	1.9	0.7
Environmental cognition					
Es gibt natürliche Grenzen des Wachstums, die unsere industrialisierte Welt längst erreicht hat.	stimme zu - stimme nicht zu	+	5.5	1.7	0.5
Zugunsten der Umwelt sollten wir alle bereit sein, unseren derzeitigen Lebensstandard einzuschränken.	stimme zu - stimme nicht zu	+	5.6	1.5	0.5
Für ein gutes Leben sind andere Dinge wichtiger als Umwelt und Natur.	stimme zu - stimme nicht zu	-	5.7	1.6	0.3
Wir brauchen mehr Wirtschafts-wachstum, auch wenn das die Umwelt belastet.	stimme zu - stimme nicht zu	-	5.6	1.5	0.5
Mehr Umweltschutz bedeutet auch mehr Lebensqualität und Gesundheit für alle.	stimme zu - stimme nicht zu	+	6.3	1.2	0.6
Environmental behavior					
Beim Kauf von Haushaltsgeräten wähle ich besonders energieeffiziente Geräte (A+++ oder A++ Energieeffizienz-siegel).	trifft zu - trifft nicht zu	+	6.5	0.9	0.3
Beim Einkaufen wähle ich Produkte mit Umweltsiegel, zum Beispiel Blauer Engel, EU-Biosiegel oder EU-Ecolabel.	trifft zu - trifft nicht zu	+	5.1	1.7	0.8

Appendix 2. Continued					
Factors with items	**Scale (1-7)**	**Polarity**	**M**	**SD**	**FL**
Ich kaufe Lebensmittel aus kontrolliert ökologischem Anbau.	trifft zu - trifft nicht zu	+	5.1	1.5	0.7
Zu den Hauptmahlzeiten esse ich Fleisch.	trifft zu - trifft nicht zu	-	4.1	1.7	0.3

Note: M = mean, SD = standard deviation, FL = standardized factor loading from CFA

Appendix 3. CFA of intention: with factor loadings next to the arrows and error variances of indicators