https://doi.org/10.1016/j.trd.2017.01.001

Consumer purchase intentions for electric vehicles: Is green more important than price and range?

Kenan Degirmenci [a,*], Michael H. Breitner [b]

[a] *School of Management, Queensland University of Technology, 2 George Street, Brisbane QLD 4000, Australia*
[b] *School of Economics and Management, Leibniz University Hannover, Königsworther Platz 1, 30167 Hannover, Germany*

Abstract

In view of global warming and climate change, a transition from combustion to electric vehicles (EVs) can help to reduce greenhouse gas emissions and improve air quality. However, high acquisition costs and short driving ranges are considered to be main factors which impede the diffusion of EVs. Since electricity needs to be produced from renewable energy sources for EVs to be a true green alternative, the environmental performance of EVs is also presumed to be an important factor. This paper investigates the role of environmental performance compared to price value and range confidence regarding consumer purchase intentions for EVs. To develop our hypothesis, we interview 40 end-user subjects about their beliefs toward EVs. Then, we perform 167 test drives with a plug-in battery EV and conduct a survey with the participants to test the hypothesis. Results of a structural equation modeling support the hypothesis that the environmental performance of EVs is a stronger predictor of attitude and thus purchase intention than price value and range confidence.

Keywords: Electric vehicles, environmental performance, price value, range confidence, purchase intention, structural equation modeling

1. Introduction

Increasing greenhouse gases (GHG) are considered as the major challenge for global warming, climate change, and air quality (Intergovernmental Panel on Climate Change, 2008, p. 39; National Academy of Sciences, 2005). Transport accounts for 23 percent of worldwide carbon dioxide (CO_2) emissions which are an important ingredient of GHGs and contribute to global warming, and three quarters of these are generated by road transport (International Energy Agency, 2016). In this context, electric vehicles (EVs) are considered to have the potential to reduce CO_2 emissions substantially, given that electricity is produced from renewable energy sources (Asamer et al., 2016; Bickert et al., 2015; Khoo et al., 2014; Mersky et al., 2016; Zhang and Yao, 2015). From an economic perspective, compared to combustion vehicles, the main factors which impede the diffusion of EVs are high acquisition costs and limited driving range due to insufficient battery technologies (Busse et al., 2013; Pasaoglu et al., 2014; Wagner et al., 2013). Regarding McKinsey's EV index that assesses a nation's readiness to support an EV industry based on supply and demand, as of January 2012, the leading countries in the field of electric mobility in descending order are Japan, the United States, France, Germany, and China (Krieger et al., 2012). Among automotive manufacturers, there is a competition to lower operating costs and lower CO_2 emissions. The global market for EVs is expected to grow from 137,950 vehicles in 2012 to 1.75 million in 2020 (Hurst and Gartner, 2012).

* Corresponding author. Tel.: +61 7 3138 2663.
E-mail address: kenan.degirmenci@qut.edu.au (K. Degirmenci).

There has been increasing research in the area of EV adoption and purchase intentions (see, e.g., Bockarjova and Steg, 2014; Carley et al., 2013; Junquera et al., 2016; Mersky et al., 2016; Plötz et al., 2014; Rezvani et al., 2015; Sang and Bekhet, 2015). Previous research suggests that price and range are main predictors of EV purchase. We aim to extend this research by examining EVs' environmental performance regarding the green contribution EVs can bring to environmental sustainability. This paper contributes to this research field by investigating the role of environmental performance compared to price value and range confidence regarding consumer purchase intentions for EVs. Two empirical studies are conducted: First, 40 end-user subjects are interviewed about their beliefs, attitudes, and purchase intentions for EVs. Second, 167 test drives are performed with a plug-in battery EV and participants of the test drives are surveyed. The collected data is used for structural equation modeling to test influencing factors of environmental performance, price value, and range confidence. This paper makes a theoretical contribution by conceptualizing that the environmental performance of EVs is a stronger predictor of attitude and thus purchase intention than price value and range confidence. The paper is structured as follows: First, a literature review is presented and the research gap is described. After developing our hypothesis, the research design is developed to test the hypothesis by outlining the process of data collection, data analysis, and structural equation modeling. Then, we discuss results and give limitations and implications for further research. Finally, we close with conclusions.

2. Literature review, research gap, and hypothesis development

Previous research has investigated EV consumer purchase intentions. For example, Carley et al. (2013) measure advantages and disadvantages of EVs and, besides other factors, include price, range, and the environmental aspect. Regarding the environmental aspect, they measure environmental image in a sense that "owning an electric vehicle will indicate care for the environment" (ibid., p. 44). In our study, we are interested in the environmental performance, meaning EVs will contribute to environmental sustainability, will help to reduce environmental pollution, and are important to save natural resources. We believe this is an important difference because consumers might be interested much more in EVs' actual contribution to the natural environment rather than their own personal image because they own an EV. In their study, environmental image results in a coefficient of –0.0987 ($p < 0.05$), showing a significant negative effect. We anticipate different results for environmental performance. Bockarjova and Steg (2014) also focus on EV purchase intention but measure environmental risks caused by combustion vehicles. Junquera et al. (2016) consider price and range for purchase intentions but do not measure the environmental perspective. A differentiated approach between participants with high and low EV purchase intentions was chosen by Plötz et al. (2014). Their study covers the environmental perspective but rather generic than EV-specific in a way that "it is important to drive a car that harms the environment as little as possible" (ibid., p. 106). Hence, the environmental performance of EVs is not measured in their study and there is no comparison of environmental performance to price and range. In Sang and Bekhet's (2015) study, it is environmental concerns that is measured which they define as "the degree to which people are aware of problems regarding the environment and support the effort to solve them or indicate the willingness to contribute personally to the solution" (ibid., p. 77). Again, this is a generic approach regarding the environmental aspect which does not cover the investigation of the impact of EVs' environmental performance on consumers' purchase intention with a comparison to price and range perceptions. With our study, we aim to fill this research gap.

As the purpose of this study is to investigate consumer purchase intentions for EVs and thus behavioral intention as such, we build on the theory of planned behavior (Ajzen, 1991). Intention is defined as an indication "of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behavior" (ibid., p. 181). In the context of this study, the behavior is the actual purchase of EVs. According to the theory of reasoned action (Fishbein and Ajzen, 1975), which is a predecessor of the theory of planned behavior, the most immediate antecedent of intention is attitude, which is "determined by salient beliefs regarding the consequences of performing the behavior" (Ajzen and Fishbein, 2008, p. 2224). We aim to identify these salient beliefs in an EV context in order to find which factors predict the intention of consumers to purchase EVs.

For this reason, we conducted semi-structured, open-ended interviews with 40 participants (see Appendix A for a detailed description of our interview protocol and Appendix B for interview participant profiles). The findings of the interviews suggest three salient beliefs: environmental performance, price value, and range confidence. Further, the environmental performance of EVs appears to be more important than the price value and range confidence regarding attitude and purchase intentions for EVs. This has several reasons: First, almost all of the participants (39 out of 40) think that EVs' contribution to environmental sustainability is a positive, main factor and 18 participants state that electricity for EVs should be produced from renewable energy sources in order for EVs to be a true green alternative. Concerning negative aspects, 23 participants say that EVs are in their opinion too expensive. For 16 participants, there are not enough charging stations, 14 find the range of EVs too low, and 13 think that the charging of EVs takes too long. Second, most answers of the participants refer to the environmental performance of EVs (70 answers), whereas answers regarding the price value (42 answers) and range confidence (50 answers) are evenly distributed. Hence, we present the following hypothesis:

> H1: For electric vehicles, environmental performance is a stronger predictor of attitude and thus purchase intention than price value and range confidence.

3. Research design

3.1 Data collection

To test our hypothesis, test drives with an all-electric, lithium-ion battery powered, small passenger city car were performed from July 24, 2015 to December 19, 2015 with 167 participants (see Appendix B for test drive participant profiles). The test drives were conducted in order to allow participants experience an EV for a more accurate evaluation of their beliefs, attitudes, and intentions toward EVs. Participants were selected by offering the opportunity to take a test drive with an EV (via social networking sites, email, and personal recruitment through professional and campus networking). For reasons of regional proximity, the test drives were arranged in the city of Hanover, Lower Saxony, Germany, which allowed real-life conditions in city traffic for the test vehicle in the city car class. This is also the reason why student participants were students from the University of Hanover, and all other participants were from the region of Hanover. The participants did not know each other and were randomly selected. On average, the participants drove approximately 6 km in around 15 minutes per test drive. Before each test drive, the participants were briefly introduced to the test vehicle. To collect data, a survey was designed and the participants were asked to complete the questionnaire after each test drive. To reduce bias, the questionnaire was provided in the

German language. In order to ensure objectivity, the authors engaged a student assistant who supervised and executed the test drives and survey completion. The student assistant accompanied the participants during the test drives and presented the survey in an objective manner to minimize influence on response behavior. Prior to the main test, a pretest with 24 test drives and survey participations were conducted. The pretests were realized by means of intensive discussions with the participants in order to receive feedback concerning the validity and comprehensibility of the survey questions. Comments and opinions on the survey questions were collected and used to revise the final questionnaire and to modify several items, especially in their wording.

Multiple item constructs were chosen for our reflective measurement model using a seven-point Likert scale, which ranged from "strongly disagree" to "strongly agree", and semantic differentials scale, drawn from pre-validated measures (see Appendix C for the survey instrument). All questions related to the individual beliefs, attitudes, and intentions of the participants. The scale of environmental performance was used from McCarty and Shrum (1994), who originally measured recycling attitudes in their study, which we adapted in an EV context regarding the contribution of EVs to environmental sustainability, pollution reduction, and natural resources savings. Price value was measured using the three-item scale used by Venkatesh et al. (2012), to which we added a fourth item by asking participants how much they would be willing to pay for an EV. In order to allow participants to compare the prices between a combustion vehicle and an EV, in the survey we provided the price for an EV and a reference price of the same car model with an internal combustion engine. Range confidence was measured with four items, which we adapted from Garbarino and Johnson (1999) to our research context. In this regard, range confidence relates to the knowledge about range (Bunce et al., 2014; Franke et al., 2012) which alleviates range anxiety, the "fear of becoming stranded" (Tate et al., 2009). We also argue that range confidence depends on the advancement of battery technology, the diffusion of charging infrastructure, and the experience and knowledge about the range of EVs. Since our belief constructs are distinct in nature and we are interested in learning which beliefs are most important (Bagozzi, 1984; Davis et al., 1989), environmental performance, price value, and range confidence are not multiplied by self-stated evaluation weights as suggested in expectancy-value theory (for further explanation, see, e.g., Bagozzi, 2007; Pavlou and Fygenson, 2006; Ryan and Holbrook, 1982; Vanden Abeele, 1989). Regarding the scale of attitude toward electric vehicles, we adapted measures from Ajzen and Fishbein (2008) as well as Schniederjans and Starkey (2014). Finally, purchase intention was measured with reference to purchase intention scales from Pavlou and Fygenson (2006) as well as Grohmann (2009). We believe that further insights could be gained by also measuring actual purchase. At this stage, however, our sample frame did not allow us to do so because none of the participants of our study ever bought an EV and most of them (135 out of 167 subjects) never experienced an EV prior to participating in our test drives. Our model also acknowledges several control variables, i.e., demographic variables regarding gender, age, and profession, and a variable that measures participants' experience with electric vehicles. For gender, age, and profession we used binary, ordinal, and nominal scales, and for experience we used a binary code ("0" for no experience with electric vehicles before the test drive participation, and "1" indicates experience with electric vehicles before the test drive participation).

3.2 Data analysis

To analyze the collected data, structural equation modeling (SEM) was conducted. SEM provides the ability to model relationships among multiple predictor and multiple criterion variables, which is why SEM is appropriate for analyzing multivariate models (Chin, 1998). All indicators were modeled as being reflective of their respective constructs. Concerning the predictiveness of the model, factor loadings should be "at least 0.60 and ideally at 0.70 or above, indicating that each measure is accounting for 50 percent or more of the variance of the underlying LV [latent variable]" (Chin, 1998, p. xiii). The measurement items in the model of this study load between 0.63 and 0.93 on their respective constructs, thus demonstrating adequate reliability and convergent validity. The internal consistency of the scales was validated with the analysis of Cronbach's alpha ranging from 0.79 to 0.87, and composite reliability (CR) ranging from 0.87 to 0.92. To establish acceptable model reliability, the recommended values for construct reliability are above 0.70 (Gefen et al., 2000); the internal consistency criteria are therefore met. Average variance extracted (AVE) ranged from 0.64 to 0.79, Fornell and Larcker (1981) recommend a lower limit of 0.50 for convergent validity. Discriminant validity is assessed observing cross loadings in the model. All items should load more highly on their constructs (above 0.50) than they load on any other constructs (Thong et al., 1996; Wixom and Todd, 2005; Xu et al., 2013), and in all cases the items in this study load above 0.63 and the differences are greater than 0.28 (see Appendix D for loadings and cross loadings of measures). A further indicator for discriminant validity is the square root of the AVE, which should be greater than the variance shared between the construct and other constructs in the model (Wixom and Todd, 2005; Xu et al., 2013). Table 1 provides the correlation matrix with correlations among constructs and the square root of the AVE on the diagonal. In all cases, the square root of the AVE for each construct is larger than the correlation of the construct with all other constructs in the model.

Table 1
Correlation matrix.

	EP	PV	RC	ATT	PI	SEX	AGE	PRO	EXP
EP	0.89								
PV	0.17	0.81							
RC	0.04	0.34	0.82						
ATT	0.34	0.34	0.37	0.80					
PI	0.27	0.35	0.33	0.33	0.85				
SEX	−0.05	−0.01	0.09	0.09	0.14	1.00			
AGE	0.07	−0.08	−0.11	0.05	0.08	−0.15	1.00		
PRO	0.04	0.03	0.08	−0.03	−0.01	0.25	−0.26	1.00	
EXP	−0.12	−0.08	−0.02	0.12	0.16	0.12	−0.11	−0.02	1.00

Notes: EP = environmental performance, PV = price value, RC = range confidence, ATT = attitude toward electric vehicles, PI = purchase intention, SEX = gender, AGE = age, PRO = profession, EXP = experience with electric vehicles; value on the diagonal is the square root of average variance extracted (AVE)

In order to examine potential impacts of the selection criteria of participants on the outcome of this study, correlations of the variables were further analyzed regarding participants' demographics and the latent variables of the measurement model. According to Gaskin (2013), variables such as age, gender, education, etc. must be controlled for in order to account for potential confounding effects. The results of the correlation matrix indicate no confounding effects of the demographics on the latent variables, which is why such a bias can be excluded. Considering common method variance (CMV) in survey research, ex ante and ex post controls were implemented in order to reduce CMV. In the research design stage, the measures for the constructs were compiled from various sources ex ante (Chang et al., 2010). Anonymity and confidentiality of the study were also guaranteed in order to reduce the probability that respondents provided answers they believe were expected. Ex post, Harman's single-factor test was conducted in order to examine CMV (Lowry and Gaskin, 2014; Podsakoff et al., 2003). All items from all of the constructs were included in an unrotated exploratory factor analysis (EFA) to determine whether the majority of the variance could be ascribed to one general factor. Harman's single-factor test in this study produced 22 distinct factors, the largest of which explained only 29.17 percent of the variance of the model. This suggested that the data did not suffer from CMV.

3.3 Structural equation modeling

The hypothesis was tested by analyzing the structural equation modeling (SEM). Partial least squares (PLS) was chosen to estimate the parameters of SEM using SmartPLS version 2.0.M3 (Ringle et al., 2005). Unlike covariance-based SEM (CB-SEM) such as LISREL, which relies primarily on maximum likelihood as the estimation method (Lowry and Gaskin, 2014), the variance-based PLS approach is able to obtain robust estimates with small sample sizes like ours ($n = 167$) and does not require multivariate normal distribution for the underlying data (Bhattacherjee and Premkumar, 2004; Fornell and Bookstein, 1982; Hsieh et al., 2008). Minimal recommendations for the sample size in PLS-SEM range from 30 to 100 cases (Urbach and Ahlemann, 2010). PLS is also considered appropriate for early stages of research (Gefen et al., 2000; Thong et al., 1996) such as in the case of EV research regarding consumer purchase intentions. Compared to CB-SEM, PLS-SEM does not generate an overall goodness of fit index, but assesses predictive validity by examining the R^2 and the structural paths (Chin, 1998; Teo et al., 2003). The nonparametric technique of bootstrapping was used with 1,000 samples to test the causal relationships between the constructs (Efron and Tibshirani, 1993; Gefen et al., 2000; Lowry and Gaskin, 2014; Urbach and Ahlemann, 2010).

By looking at the R^2 values, 33 percent of the variance of attitude ($R^2 = 0.33$) is explained by environmental performance, price value, and range confidence, and 36 percent of the variance of purchase intention ($R^2 = 0.36$) is explained by attitude (see Figure 1). As thresholds in social science research, Cohen (1988, 1992) suggests values of 0.02 for a small R^2, 0.13 for a medium R^2, and 0.26 for a large R^2. The influence of attitude on the intention to purchase EVs is described by a beta coefficient of 0.60 ($p < 0.001$). The beta coefficients of environmental performance, price value, and range confidence toward attitude show that environmental performance ($\beta = 0.33$, $p < 0.001$) is the strongest of the three predictors of attitude toward EVs, followed by range confidence ($\beta = 0.30$, $p < 0.001$) and price value ($\beta = 0.21$, $p < 0.01$). This supports our hypothesis. With regard to the control variables, the demographics have no significant influence on attitude. However, experience shows a beta coefficient of 0.19 ($p < 0.01$).

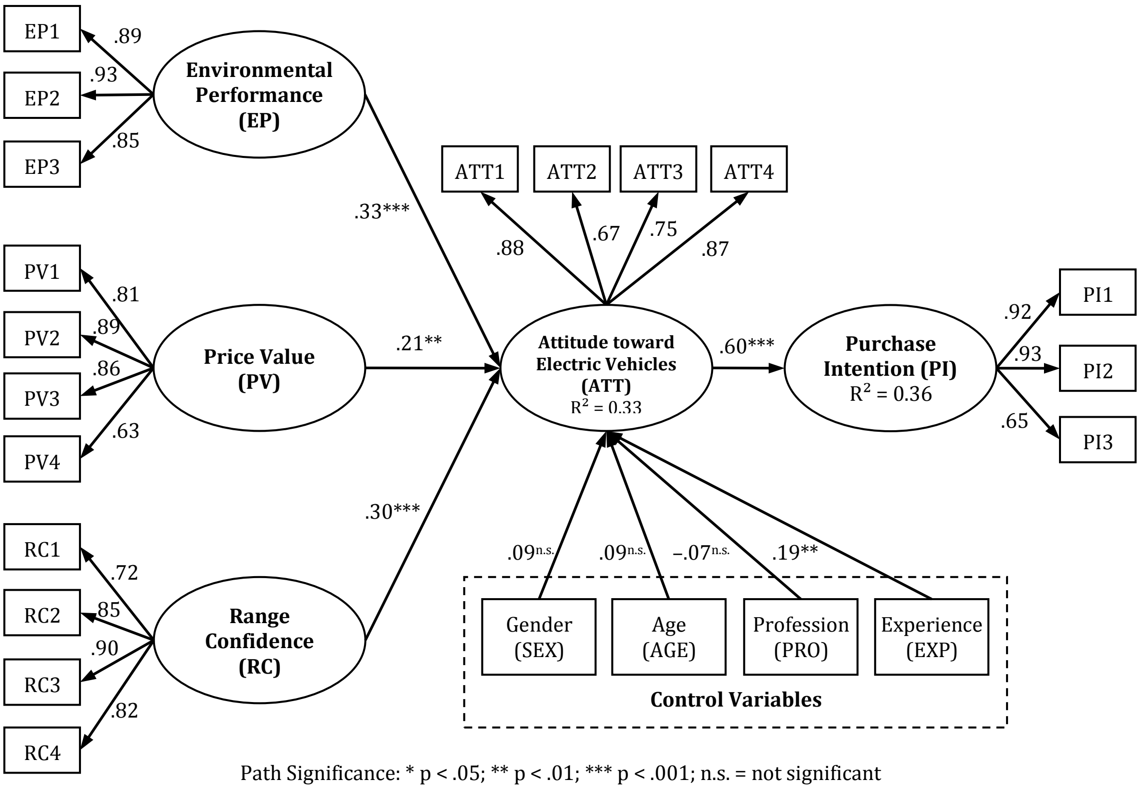

Fig. 1. Results of structural equation modeling.

In addition to statistical significance, we also report on practical significance by analyzing effect sizes of the constructs. Measuring the effect size of empirical observations is considered a supplement to the statistical significance test, and it also determines the practical significance of the results (Kirk, 1996). The effect sizes of the measures are calculated referring to Cohen (1988) in order to analyze practical significance of the constructs. Effect sizes have the advantage of being independent of the sample size and the measures of the effect sizes allow a direct comparison of different quantities measured also on different scales (Selya et al., 2012). Referring to Kirk (1996), "Cohen's definitions of small, medium, and large effects represent a good beginning" (p. 756) in terms of the analysis of the practical significance. Cohen's f^2 provides information about the size of the effects, nevertheless, a small f^2 measure does not necessarily imply an unimportant effect (Chin et al., 2003). The effect sizes are presented in Table 2.

Table 2
Effect sizes.

Latent variable being explained (endogenous)	**Explanatory latent variable (exogenous)**	$R^2_{incl.}$ [a]	$R^2_{excl.}$ [b]	f^2
Attitude toward electric vehicles	Environmental performance	0.33	0.23	0.15
	Price value	0.33	0.27	0.09
	Range confidence	0.33	0.26	0.10
	Gender	0.33	0.32	0.01
	Age	0.33	0.35	–0.03
	Profession	0.33	0.33	0.00

	Experience with electric vehicles	0.33	0.29	0.06

Notes: a -> R^2 of the latent variable being explained (endogenous), together with the explanatory latent variable (exogenous); b -> R^2 of the latent variable being explained (endogenous), in the absence of the explanatory latent variable (exogenous). Cohen's f^2 statistics = [R^2incl. – R^2excl.] / [1 – R^2incl.] (Cohen 1988). $f^2 \geq 0.02$, 0.15, and 0.35 are termed small, medium, and large effect sizes. The rationale for these benchmarks (f^2) can be found in Cohen (1988) on the following pages: pp. 413–414.

4. Discussion

The empirical study supports the hypothesis that environmental performance of EVs is a stronger determinant of attitude and thus purchase intention than price value and range confidence. Since EVs are perceived as a sustainable alternative to combustion vehicles as per the results of our interviews have shown, the environmental performance of EVs is an important factor which can help the diffusion process of EVs. Our interviews also revealed that the majority of the participants place great emphasis that electricity for EVs should be produced from renewable energy sources in order for EVs to be a true green alternative to combustion vehicles. However, there exists a critical perspective on a transition. For example, in the United States a transition from combustion to EVs would in fact increase CO_2 emissions, because half of the electricity is produced from coal (Hasan and Dwyer, 2010). Against this backdrop, for a substantial reduction of CO_2 emissions, electricity needs to be produced from renewable energy sources. Our study also shows as in previous studies that price value and range confidence are also crucial for EV diffusion. With regard to the control variables of our study, experience with electric vehicles is an important factor as well. Based on our results, we recommend that institutions that promote EVs, such as automotive manufacturers, energy companies, and governments, educate consumers about (1) the difference between on-road and well-to-wheel emissions and in this regard the importance of renewable energy sources (to teach about the environmental performance of EVs), (2) the range of EVs and that driving experience can teach people that they do not necessarily need such long range (to build range confidence through experience), and (3) provide government subsidies which can help to make EVs more affordable for consumers (to attract consumers by improving EVs' price value).

This study is subject to the following limitations, which present useful opportunities for further research. First, the interviews and test drives were conducted in Germany. Measures in other countries may lead to different results. This can be due to several reasons, including different values and beliefs due to cultural differences, but also due to diverse conditions regarding the progress of EVs in various countries. Prices, charging infrastructure, and the share of electricity from renewable energy sources may differ which can involve different perceptions of consumers regarding the environmental performance, price value, range confidence, attitude, and purchase intentions for EVs. For example, in Norway approximately 98 percent of electricity is produced from renewable energy sources (European Environment Agency, 2013), but only around 30 percent in Germany (Burger, 2015). Further research should be conducted in other countries to generate insights into the context of regional differences regarding the role of environmental performance compared to price value and range confidence regarding consumer purchase intentions for EVs. Second, in terms of generalizability, another limitation relates to the demographic characteristics of the sample. Most of the participants were male and under 30 years old (see Appendix B for participant profiles). While the participants may fall into the category of future target consumers for EVs, their beliefs, attitudes, and intentions may change over time. Current potential consumers may have a different attitude toward EVs, which is why care must be taken when choosing an approach to generalize the findings beyond the confines of the sample. Further research is recommended to repeat this study with a more diverse sample for enhanced generalizability. Most of the participants did not have any experience with EVs, thus, this could influence the results. Conditions regarding EV diffusion may also change, which should be observed when comparing results from other studies with our study. Third, considering the precision of sample estimates, which is mainly affected by the sample size (Baroudi and Orlikowski, 1989), another limitation of this research relates to a small sample size (n = 167).

Cohen (1992) argues that "the investigator needs to know the n necessary to attain the desired power for the specified α and hypothesized effect size," and hereby refers to the balance between statistical power and the investigator's resources (p. 156). On average, the participants drove approximately 6 km and 15 minutes per test drive, resulting in a total of about 1,000 km and 40 hours for 167 test drives. Regarding the supervision of the test drives and survey administration, this resulted in a high amount of effort and time required to conduct the test drives and survey administration. Nevertheless, further studies should explore a bigger sample size to further examine the results. Fourth, since we offered test drives for participants who were interested in experiencing an EV, another bias possibility is self-selection among the survey respondents (Kankanhalli et al., 2005). Participants of the test drives who responded to the survey may be those who are more likely to endorse EVs. These participants may also tend to have a more positive attitude and higher purchase intentions for EVs. Fifth, social desirability may also bias the results. EVs are generally considered as a sustainable form of transportation, which is why participants might tend to respond to our survey in a manner that will be viewed favorably by others, particularly regarding the environmental performance of EVs. However, we tried to minimize social desirability bias by presenting the survey in an objective way and ensuring anonymity in the survey administration. Sixth, participants may downplay price value due to the hypothetical nature of our survey. In a real situation, they might fall outside a set price frame and thus not consider EVs when choosing a car. Seventh, for the test drives we chose an all-electric, lithium-ion battery powered, small passenger city car. Another car model with different characteristics (regarding factors such as price and range) may lead to different results. Seventh, through the interviews we identified three factors affecting the attitude toward EVs, i.e., environmental performance, price value, and range confidence. It cannot be precluded that unacknowledged factors are not considered which is why we do not claim complete comprehensiveness of our study. We recommend that further research should consider conducting further interviews to unveil possible additional factors that may play a role in the diffusion of EVs.

5. Conclusions

This paper investigated the role of environmental performance compared to price value and range confidence regarding consumer purchase intentions for EVs. Two empirical studies were conducted: Interviews with 40 end-user subjects and a survey with further 167 subjects who participated in test drives with a plug-in battery EV. Collected data was used for structural equation modeling to test the influence of environmental performance, price value, and range confidence on attitude and thus purchase intention. Environmental performance of EVs was found to be a stronger predictor than price value and range confidence. Considering the importance of global warming, climate change, and air quality, the transportation sector has the potential to substantially reduce GHG emissions. In this context, EVs are regarded as a promising transportation alternative, given that electricity is produced from renewable energy sources.

Acknowledgements

The authors are grateful for the constructive comments provided by the associate editor and the three anonymous reviewers. They would like to thank Raphael Kaut for conducting the interviews, Sören Meyer for his support in arranging the test drives, and Bernadette Nüß for supervising and executing the test drives and survey completion. They also thank Professor Jan Recker for the encouragement to write this paper. This research was funded by a grant provided by the German Federal Ministry for Economic Affairs and Energy (16SNI011B). Dr Degirmenci's contributions were supported by a grant from the Australian Research Council (DP150100163).

Appendix A. Interview protocol

As a preliminary study, we conducted semi-structured, open-ended interviews with employed and student participants (see Appendix B for participant profiles). Interviews were conducted from April 5, 2015 to April 28, 2015 by means of face-to-face conversations in Germany. In order to reduce bias, the interviews were conducted in the German language and translated to English as shown below. The interview questions evolved through the study and were driven by the issue what consumers generally think about electric vehicles, what hampers the acceptance and diffusion of electric vehicles, and how electric vehicles are perceived in media.

Interview questions

Part 1: Knowledge about electric vehicles

- Which electric vehicle models do you know?
- How high do you estimate the range of an average electric vehicle?
- How long does it take in average to charge an electric vehicle?
- How do you estimate the acceleration of an electrically driven vehicle?
- What do you think, how high is the price difference between a conventional car and an electric car?
- How do you think are the maintenance costs of electric cars compared to combustion cars?
- Do you think you are well informed about electric cars?

Part 2: Acceptance of electric vehicles

- Have you ever possessed or do you possess a car and which type of car (gas, electric, etc.)? Have you ever possessed an alternative fuel car?
- Have you ever drove or traveled with an electric vehicle? Which impression did you get about the car?
- In general, what do you rate as positive and negative regarding electric cars?
- Could you think of buying an electric vehicle? What needs to happen that you prefer an electric vehicle over a combustion vehicle?
- Do you think research and development in the area of electric mobility is important and why?
- Do you commonly perceive a change of thinking in Germany towards electric mobility? Is there an increase of the diffusion of electric vehicles?

Part 3: Perception in media

- Do you perceive much advertising for cars?
- Compared to this, how much advertising do you perceive for electric cars?
- Can you consciously remember an advertisement for electric cars?
- Do you think there should be more advertising for electric cars?
- Do you see a difference in media between foreign and German manufacturers?
- Do you know the Ford advertisement, where the SMS reading function of the car is advertised?

Transcripts of all interviews were generated for formal data analysis and to code the interview transcripts. An interview protocol served as the coding structure for the interview data. According to Boyatzis (1998), a thematic analysis was used for the coding. The code structure was iteratively revised until all relevant themes were reflected (Eisenhardt, 1989). Thus, we identified three main areas, i.e., environmental performance, price value, and range confidence, regarding participants' beliefs about electric vehicles. Table A1 shows a summary of participants' responses.

Table A1
Interview responses regarding participants' beliefs about electric vehicles (n=40).

Environmental performance (70 answers)	
Electric vehicles contribute to environmental sustainability.	39
Electricity should be produced from renewable energy sources.	18
Electric vehicles produce less noise pollution than conventional vehicles.	13
Price value (42 answers)	
The price of purchase for electric vehicles is too expensive.	23
Consumption costs of electric vehicles are lower compared to combustors.	13
The government should subsidize the purchase of electric vehicles.	4
Maintenance costs of electric vehicles are lower compared to combustors.	1
The resale value of electric vehicles will be low.	1
Range confidence (50 answers)	
There are not enough charging stations for electric vehicles.	16
The range of electric vehicles is too low.	14
The charging of electric vehicles takes too long.	13
The infrastructure for electric vehicles needs to grow.	2
You always have to charge electric vehicles quite frequently.	2
You can charge electric vehicles at home.	2
The battery technology of electric vehicles is insufficient.	1
Further aspects (43 answers)	
Fossil fuel resources are scarce and will soon be exhausted.	10
The overall performance of electric vehicles is immature and needs improvement.	7
I prefer the sound of an internal combustion engine.	5
There is a need for more information about electric vehicles due to low experience.	5
Electric vehicles accelerate faster than most equivalent combustors.	4

Electric vehicles are fun and easy to drive.	3
Electric vehicles offer an opportunity to get independent from petroleum countries.	3
The quiet motor of electric vehicles can lead to accidents.	3
You need special repair services for electric vehicles.	2
I like the design of electric vehicles.	1

Appendix B. Participant profiles

	Interview participants (n=40)		**Test drive participants (n=167)**	
Gender				
Female	15	37.5%	33	19.8%
Male	25	62.5%	124	74.3%
Missing	0	0.0%	10	6.0%
Age				
≤ 20	1	2.5%	37	22.2%
21-30	23	57.5%	115	68.9%
31-40	8	20.0%	5	3.0%
41-50	4	10.0%	2	1.2%
> 50	4	10.0%	7	4.2%
Missing	0	0.0%	1	0.6%
Profession				
Employed	23	57.5%	19	11.4%
Homemaker	0	0.0%	1	0.6%
Self-employed	0	0.0%	4	2.4%
Student	16	40.0%	135	80.8%
Other	1	2.5%	7	4.2%
Missing	0	0.0%	1	0.6%
Experience with electric vehicles				
Yes	13	32.5%	31	18.6%
No	27	67.5%	135	80.8%
Missing	0	0.0%	1	0.6%

Appendix C. Survey instrument

Environmental performance (EP): Seven-point Likert scale (highly disagree to highly agree); Sources: McCarty and Shrum (1994); Cronbach's alpha: 0.87; Composite reliability (CR): 0.92; Average variance extracted (AVE): 0.79	
EP1	Electric vehicles will contribute to environmental sustainability.
EP2	Electric vehicles will help to reduce environmental pollution.
EP3	Electric vehicles are important to save natural resources.
Price value (PV): Seven-point Likert scale (highly disagree to highly agree); Sources: Venkatesh et al. (2012); Cronbach's alpha: 0.81; Composite reliability (CR): 0.88; Average variance extracted (AVE): 0.65	
PV1	Electric vehicles are reasonably priced.
PV2	Electric vehicles are a good value for the money.
PV3	At the current price, electric vehicles provide a good value.
PV4	How much would you be willing to pay for [electric vehicle]? (An example was given for the list price of an electric

	vehicle with a reference price of the same car model with an internal combustion engine.)
Range confidence (RC): Seven-point Likert scale (highly disagree to highly agree); Sources: Garbarino and Johnson (1999); Cronbach's alpha: 0.84; Composite reliability (CR): 0.89; Average variance extracted (AVE): 0.68	
RC1	The range of electric vehicles meets my expectations.
RC2	The range of electric vehicles can be counted on to reach my destination.
RC3	I can trust the range of electric vehicles.
RC4	The range of electric vehicles is reliable.
Attitude toward electric vehicles (ATT): Seven-point semantic differentials; Sources: Ajzen and Fishbein (2008), Schniederjans and Starkey (2014); Cronbach's alpha: 0.81; Composite reliability (CR): 0.87; Average variance extracted (AVE): 0.64	
ATT1	Bad/good
ATT2	Foolish/wise
ATT3	Unfavorable/favorable
ATT4	Negative/positive
Purchase intention (PI): Seven-point Likert scale (highly disagree to highly agree); Sources: Pavlou and Fygenson (2006), Grohmann (2009); Cronbach's alpha: 0.79; Composite reliability (CR): 0.88; Average variance extracted (AVE): 0.72	
PI1	Assuming I had the opportunity, I would intend to buy an electric vehicle.
PI2	Given that I had the opportunity, I predict that I would buy an electric vehicle.
PI3	I will probably buy an electric vehicle in the near future.

Appendix D. Loadings and cross loadings of measures

	EP	PV	RC	ATT	PI	SEX	AGE	PRO	EXP
EP1	**0.89**	0.12	0.00	0.28	0.27	0.00	0.02	0.08	−0.06
EP2	**0.93**	0.19	−0.02	0.36	0.30	−0.06	0.11	0.04	−0.09
EP3	**0.85**	0.14	0.14	0.29	0.14	−0.07	0.04	0.00	−0.18
PV1	0.07	**0.81**	0.19	0.19	0.24	0.04	−0.07	0.08	0.03
PV2	0.27	**0.89**	0.29	0.33	0.35	0.03	−0.07	0.08	−0.04
PV3	0.09	**0.86**	0.28	0.25	0.28	−0.06	−0.11	0.05	−0.10
PV4	0.07	**0.63**	0.29	0.28	0.24	−0.02	0.01	−0.09	−0.11
RC1	−0.06	0.31	**0.72**	0.29	0.18	0.03	−0.06	0.04	−0.05
RC2	−0.01	0.26	**0.85**	0.31	0.37	0.12	−0.13	0.10	−0.01
RC3	0.06	0.27	**0.90**	0.33	0.28	0.08	−0.11	0.13	0.01
RC4	0.15	0.27	**0.82**	0.28	0.24	0.08	−0.06	−0.03	−0.03
ATT1	0.30	0.34	0.36	**0.88**	0.59	0.18	0.06	−0.07	0.18
ATT2	0.34	0.34	0.36	**0.67**	0.34	0.04	0.02	0.00	0.12
ATT3	0.23	0.25	0.34	**0.75**	0.42	0.02	−0.02	0.05	−0.01
ATT4	0.27	0.24	0.30	**0.87**	0.51	0.02	0.08	−0.04	0.08
PI1	0.24	0.32	0.30	0.56	**0.92**	0.12	0.01	0.04	0.16
PI2	0.28	0.27	0.33	0.57	**0.93**	0.14	0.08	−0.04	0.16
PI3	0.15	0.33	0.17	0.37	**0.65**	0.09	0.14	−0.05	0.07
SEX	−0.05	−0.01	0.09	0.09	0.14	**1.00**	−0.15	0.25	0.12
AGE	0.07	−0.08	−0.11	0.05	0.08	−0.15	**1.00**	−0.26	−0.11
PRO	0.04	0.03	0.08	−0.03	−0.01	0.25	−0.26	**1.00**	−0.02
EXP	−0.12	−0.08	−0.02	0.13	0.16	0.12	−0.11	−0.02	**1.00**

Notes: EP = environmental performance, PV = price value, RC = range confidence, ATT = attitude toward electric vehicles, PI = purchase intention, SEX = gender, AGE = age, PRO = profession, EXP = experience with electric vehicles

References

Ajzen, I., 1991. The Theory of Planned Behavior. Organizational Behavior and Human Decision Processes 50 (2), 179–211.

Ajzen, I., Fishbein, M., 2008. Scaling and Testing Multiplicative Combinations in the Expectancy–Value Model of Attitudes. Journal of Applied Social Psychology 38 (9), 2222–2247.

Asamer, J., Graser, A., Heilmann, B., Ruthmair, M., 2016. Sensitivity analysis for energy demand estimation of electric vehicles. Transportation Research Part D 46, 182–199.

Bagozzi, R.P., 1984. Expectancy-value attitude models: An analysis of critical measurement issues. International Journal of Research in Marketing 1 (4), 295–310.

Bagozzi, R.P., 2007. The Legacy of the Technology Acceptance Model and a Proposal for a Paradigm Shift. Journal of the Association for Information Systems 8 (4), 244–254.

Baroudi, J.J., Orlikowski, W.J., 1989. The Problem of Statistical Power in MIS Research. MIS Quarterly 13 (1), 87–106.

Bhattacherjee, A., Premkumar, G., 2004. Understanding Changes in Belief and Attitude Toward Information Technology Usage: A Theoretical Model and Longitudinal Test. MIS Quarterly 28 (2), 229–254.

Bickert, S., Kampker, A., Greger, D., 2015. Developments of CO_2-emissions and costs for small electric and combustion engine vehicles in Germany. Transportation Research Part D 36, 138–151.

Bockarjova, M., Steg, L., 2014. Can Protection Motivation Theory predict pro-environmental behavior? Explaining the adoption of electric vehicles in the Netherlands. Global Environmental Change 28, 276–288.

Boyatzis, R.E., 1998. Transforming Qualitative Information: Thematic Analysis and Code Development. Sage Publications, Thousand Oaks, CA.

Bunce, L., Harris, M., Burgess, M., 2014. Charge up then charge out? Drivers' perceptions and experiences of electric vehicles in the UK. Transportation Research Part A 59, 278–287.

Burger, B., 2015. Stromerzeugung aus Solar- und Windenergie im Jahr 2014. Fraunhofer-Institut für Solare Energiesysteme ISE. <https://www.ise.fraunhofer.de/de/downloads/pdf-files/data-nivc-/stromproduktion-aus-solar-und-windenergie-2014.pdf> (accessed 12/05/2016).

Busse, S., El Khatib, V., Brandt, T., Kranz, J., Kolbe, L., 2013. Understanding the Role of Culture in Eco-Innovation Adoption – An Empirical Cross-Country Comparison. In: Proceedings of the 34th International Conference on Information Systems. Milan, Italy, December 15–18.

Carley, S., Krause, R.M., Lane, B.W., Graham, J.D., 2013. Intent to purchase a plug-in electric vehicle: A survey of early impressions in large US cities. Transportation Research Part D 18, 39–45.

Chang, S.-J., van Witteloostuijn, A., Eden, L., 2010. From the Editors: Common Method Variance in International Business Research. Journal of International Business Studies 41 (2), 178–184.

Chin, W.W., 1998. Issues and Opinion on Structural Equation Modeling. MIS Quarterly 22 (1), vii–xvi.

Chin, W.W., Marcolin, B.L., Newsted, P.R., 2003. A Partial Least Squares Latent Variable Modeling Approach for Measuring Interaction Effects: Results from a Monte Carlo Simulation Study and an Electronic-Mail Emotion/Adoption Study. Information Systems Research 14 (2), 189–217.

Cohen, J., 1988. Statistical Power Analysis for Behavioral Sciences, 2nd ed. Lawrence Erlbaum, Hillsdale, NJ.

Cohen, J., 1992. A Power Primer. Psychological Bulletin 112 (1), 155–159.

Davis, F.D., Bagozzi, R.P., Warshaw, P.R., 1989. User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. Management Science 35 (8), 982–1003.

Efron, B., Tibshirani, R.J., 1993. An Introduction to the Bootstrap. Chapman & Hall, New York.

Eisenhardt, K., 1989. Building Theories from Case Study Research. Academy of Management Review 14 (4), 532–550.

European Environment Agency, 2013. Share of renewable energy in final energy consumption. <http://www.eea.europa.eu/data-and-maps/indicators/renewable-gross-final-energy-consumption-1/assessment> (accessed 12/05/2016).

Fishbein, M., Ajzen, I., 1975. Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research. Addison-Wesley, Reading, MA.

Fornell, C., Bookstein, F.L., 1982. Two Structural Equation Models: LISREL and PLS Applied to Consumer Exit-Voice Theory. Journal of Marketing Research 19 (4), 440–452.

Fornell, C., Larcker, D., 1981. Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. Journal of Marketing Research 18 (1), 39–50.

Franke, T., Neumann, I., Bühler, F., Cocron, P., Krems, J.F., 2012. Experiencing Range in Electric Vehicles: Understanding Psychological Barriers. Applied Psychology: An International Review 61 (3), 368–391.

Garbarino, E., Johnson, M.S., 1999. The Different Roles of Satisfaction, Trust, and Commitment in Customer Relationships. Journal of Marketing 63 (2), 70–87.

Gaskin, J., 2013. Constructive System Use. In: Proceedings of the 34th International Conference on Information Systems. Milan, Italy, December 15–18.

Gefen, D., Straub, D.W., Boudreau, M.-C., 2000. Structural Equation Modeling and Regression: Guidelines for Research Practice. Communications of the Association for Information Systems 4 (7), 1–77.

Grohmann, B., 2009. Gender Dimensions of Brand Personality. Journal of Marketing Research 46 (1), 105–119.

Hasan, H., Dwyer, C., 2010. Was the Copenhagen Summit doomed from the start? Some insights from Green IS research. In: Proceedings of the 16th Americas Conference on Information Systems. Lima, Peru, August 12–15.

Hohenberger, T., Mühlenhoff, J., 2014. Energiewende im Verkehr: Potenziale für erneuerbare Mobilität. Renews Spezial 71, Agentur für Erneuerbare Energien. <https://www.unendlich-viel-energie.de/mediathek/hintergrundpapiere/energiewende-im-verkehrssektor> (accessed 11/08/2014).

Hsieh, J.J.P.-A., Rai, A., Keil, M., 2008. Understanding Digital Inequality: Comparing Continued Use Behavioral Models of the Socio-Economically Advantaged and Disadvantaged. MIS Quarterly 32 (1), 97–126.

Hurst, D., Gartner, J., 2012. Pike Pulse Report: Plug-in Electric Vehicles – Assessment of Strategy and Execution for 16 Leading Electric Vehicle Brands. Research Report. Pike Research, Navigant Consulting, Inc.

Intergovernmental Panel on Climate Change, 2008. Climate Change 2007: Synthesis Report. < http://www.iea.org/publications/freepublications/publication/KeyCO2EmissionsTrends.pdf > (accessed 11/08/2014).

International Energy Agency, 2016. Key CO_2 Emissions Trends. <http://www.iea.org/publications/freepublications/publication/transport-energy-and-co2--moving-toward-sustainability.html> (accessed 16/10/2016).

Junquera, B., Moreno, B., Álvarez, R., 2016. Analyzing consumer attitudes towards electric vehicle purchasing intentions in Spain: Technological limitations and vehicle confidence. Technological Forecasting & Social Change 109, 6–14.

Kankanhalli, A., Tan, B.C.Y., Wei, K.-K., 2005. Contributing Knowledge to Electronic Knowledge Repositories: An Empirical Investigation. MIS Quarterly 29 (1), 113–143.

Khoo, Y.B., Wang, C.-H., Paevere, P., Higgins, A., 2014. Statistical modelling of Electric Vehicle electricity consumption in the Victorian EV Trial, Australia. Transportation Research Part D 32, 263–277.

Kirk, R.E., 1996. Practical Significance: A Concept Whose Time Has Come. Educational and Psychological Measurement 56 (5), 746–759.

Krieger, A., Radtke, P., Wang, L., 2012. Recharging China's electric-vehicle aspirations. <http://www.mckinsey.com/insights/energy_resources_materials/recharging_chinas_electric-vehicle_aspirations> (accessed 12/10/2013).

Lowry, P.B., Gaskin, J., 2014. Partial Least Squares (PLS) Structural Equation Modeling (SEM) for Building and Testing Behavioral Causal Theory: When to Choose It and How to Use It. IEEE Transactions on Professional Communication 57 (2), 123–146.

McCarty, J.A., Shrum, L.J., 1994. The Recycling of Solid Wastes: Personal Values, Value Orientations, and Attitudes about Recycling as Antecedents of Recycling Behavior. Journal of Business Research 30 (1), 53–62.

Mersky, A.C., Sprei, F., Samaras, C., Qian, Z. S., 2016. Effectiveness of incentives on electric vehicle adoption in Norway. Transportation Research Part D 46, 56–68.

National Academy of Sciences, 2005. Joint science academies' statement: Global response to climate change. <http://nationalacademies.org/onpi/06072005.pdf> (accessed 11/08/2014).

Pasaoglu, G., Fiorello, D., Martino, A., Zani, L., Zubaryeva, A., Thiel, C., 2014. Travel patterns and the potential use of electric cars – Results from a direct survey in six European countries. Technological Forecasting & Social Change 87, 51–59.

Pavlou, P.A., Fygenson, M., 2006. Understanding and Predicting Electronic Commerce Adoption: An Extension of the Theory of Planned Behavior. MIS Quarterly 30 (1), 115–143.

Plötz, P., Schneider, U., Globisch, J., Dütschke, E., 2014. Who will buy electric vehicles? Identifying early adopters in Germany. Transportation Research Part A 67, 96–109.

Podsakoff, P.M., MacKenzie, S.B., Lee, J.-Y., Podsakoff, N.P., 2003. Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies. Journal of Applied Psychology 88 (5), 879–903.

Rezvani, Z., Jansson, J., Bodin, J., 2015. Advances in consumer electric vehicle adoption research: A review and research agenda. Transportation Research Part D 34, 122–136.

Ringle, C.M., Wende, S., Will, A., 2005. SmartPLS 2.0.M3. Hamburg: SmartPLS <http://www.smartpls.com>.

Ryan, M.J., Holbrook, M.B., 1982. Importance, Elicitation Order, and Expectancy × Value. Journal of Business Research 10 (3), 309–317.

Sang, Y.-N., Bekhet, H.A., 2015. Modelling electric vehicle usage intentions: an empirical study in Malaysia. Journal of Cleaner Production 92, 75–83.

Schniederjans, D.G., Starkey, C.M., 2014. Intention and willingness to pay for green freight transportation: An empirical examination. Transportation Research Part D 31, 116–125.

Selya, A.S., Rose, J.S., Dierker, L.C., Hedeker, D., Mermelstein, R., 2012. A practical guide to calculating Cohen's f^2, a measure of local effect size, from PROC MIXED. Frontiers in Psychology 3 (111), 1–6.

Tate, E.D., Harpster, M.O., Savagian, P.J., 2009. The Electrification of the Automobile: From Conventional Hybrid, to Plug-in Hybrids, to Extended-Range Electric Vehicles. SAE International Journal of Passenger Cars – Electronic and Electrical Vehicles 1 (1), 156–166.

Teo, H.H., Wei, K.K., Benbasat, I., 2003. Predicting Intention to Adopt Interorganizational Linkages: An Institutional Perspective. MIS Quarterly 27 (1), 19–49.

Thong, J.Y.L., Yap, C.-S., Raman, K.S., 1996. Top Management Support, External Expertise and Information Systems Implementation in Small Businesses. Information Systems Research 7 (2), 248–267.

Urbach, N., Ahlemann, F., 2010. Structural Equation Modeling in Information Systems Research Using Partial Least Squares. Journal of Information Technology Theory and Application 11 (2), 5–40.

Vanden Abeele, P., 1989. Comment on: "An investigation of the structure of expectancy-value attitude and its implications", by Youjae Yi. International Journal of Research in Marketing 6 (2), 85–87.

Venkatesh, V., Thong, J.Y.L., Xu, X., 2012. Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology. MIS Quarterly 36 (1), 157–178.

Wagner, S., Götzinger, M., Neumann, D., 2013. Optimal location of charging stations in smart cities: a point of interest based approach. In: Proceedings of the 34th International Conference on Information Systems. Milan, Italy, December 15–18.

Wixom, B.H., Todd, P.A., 2005. A Theoretical Integration of User Satisfaction and Technology Acceptance. Information Systems Research 16 (1), 85–102.

Xu, J.D., Benbasat, I., Cenfetelli, R.T., 2013. Integrating Service Quality with System and Information Quality: An Empirical Test in the E-Service Context. MIS Quarterly 37 (3), 777–794.

Zhang, R., Yao, E., 2015. Electric vehicles' energy consumption estimation with real driving condition data. Transportation Research Part D 41, 177–187.