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Are They All Equal? Uncovering Adopter Groups of Battery Electric Vehicles

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Abstract: Battery Electric Vehicles are regarded as highly important to reach environmental goals, such as CO_2 savings in the transport sector. Despite governments making strong efforts to encourage their adoption and diffusion, sales still remain at a notoriously low level. One of the reasons may be the lack of a deeper understanding of the differences among potential adopters of Battery Electric Vehicles. To close this research gap, the authors segment adopter groups in a new way. They simultaneously use preferences for product attributes and personal characteristics to identify and characterize adopter groups of Battery Electric Vehicles. In this way, adopters can be effectively segmented, uncovering a more precise picture of adopters' needs. Moreover, the authors introduce a three-step-procedure combining inputs from an adaptive choice-based conjoint experiment with a questionnaire. This approach can be used to segment adopter groups of other eco-innovations, as well. Based on three adopter groups of Battery Electric Vehicles (Utilitarian Savers, Performance Seekers, and Green Technologists), the authors develop tailored measures for decision-makers in policy and management to foster the adoption and diffusion of Battery Electric Vehicles.

Keywords: innovation; adoption; diffusion; battery electric vehicles; segmentation; adopter groups

1. Introduction

Eco-innovations, such as Battery Electric Vehicles (BEVs), have gained increasing attention over the past years [1–3]. The main reason for that is an increasing environmental concern, fostered by the discussion on climate change [4–8]. As road transport causes a high negative impact on the environment [9], governments strive to promote BEVs' market uptake, which run on electricity and are free of CO_2-emissions when driving [10–12]. To decrease road transports' dependence on oil-derived fuels, and thus, to maximize the positive effect of BEVs on the environment, a broad range of consumers need to adopt BEVs [13,14].

Despite Governments' efforts to stimulate the diffusion of BEVs, the number of consumers who have adopted and bought BEVs remains on a notoriously low level [15]. Therefore, a deeper understanding of the adoption of BEVs and the heterogeneity of adopters is needed. Rogers [16] has already started to differentiate between different segments of adopters, e.g., early adopter, early majority, and late majority. Other approaches simply differentiate between adopters and non-adopters of BEVs [17,18]. More detailed approaches differentiate adopter groups based on either their preferences for product attributes [19] <u>or</u> their personal characteristics [20,21].

Although these approaches lead to some insights into the heterogeneity of adopters, comprehensive and in-depth profiles of BEV adopters uncovering their actual needs are still missing. In addition, there is a lack of papers providing holistic guidelines, how to identify, and how to profile different adopter groups in general. Some authors have already criticized these missing guidelines [22–24].

Therefore, this paper makes the following contributions:

1. It provides more precise insights into BEV adopters' heterogeneity by segmenting them based on both preferences for product attributes, and on personal characteristics. In this way, a more detailed picture of the adopter groups' actual needs can be uncovered.
2. It introduces a three-step-procedure on how to identify and to analyze adopter groups in general. This approach is transferrable to the adoption of other eco-innovations, as well.
3. It stimulates the discussion on differences between adopters and develops effective, tailor-made measures for political and managerial decision-makers to foster BEVs' market uptake. More precisely, the presence of different BEV adopter groups with diverging needs requires the development of BEVs that target the specific segments.

The remainder of this article is structured as follows. In Section 2, we introduce the theoretical background of our study. We explicate current research on the adoption of BEVs, in particular focusing on approaches identifying and characterizing adopter groups. In Section 3, we explain the research method, i.e., measurement, data collection, data cleaning, and data analysis, including our three-step-procedure. Subsequently, we outline the adopter groups based on both preferences for product attributes and personal characteristics (Section 4). In Section 5, we discuss the results, derive implications for policy and management, and provide recommendations for future research. The paper finishes with a short conclusion in Section 6.

2. Theoretical Background

2.1. Product Attributes of BEVs

To identify appropriate segmentation criteria for clustering BEV adopter groups, we concentrated on the drivers and barriers of BEV adoption. Among these drivers are product-related attributes that we categorized into 'performance', 'charging', 'prices and costs' and 'additional features'.

Regarding BEV's performance attributes, driving pleasure is one of the major advantages of BEVs [25]. It includes high acceleration, comfortable driving experience, and speed [26–28]. However, this positive experience is highly limited by BEVs' range [27,29,30]. Zhang et al. [31] reported the range of 14 BEVs, reaching from a minimum of 113 km to 480 km. Although nearly every trip on normal days can be realized using BEVs, the perceived uncertainty of a limited range is one strong barrier for adopting BEVs [32].

Furthermore, the availability of charging infrastructure is a crucial attribute determining the adoption of BEVs [27,33,34]. In particular, the time for recharging is important. So far, it takes around eight hours to recharge BEVs at normal charging points, which makes traveling over long distances uncomfortable or even impossible. Thus, long-distance trips are only comfortable if fast-chargers are available, reducing the recharging time down to 30 minutes. Nevertheless, only a small number of fast-chargers are available yet [35].

Prices and costs are a controversially discussed product attribute of BEVs. On the one hand, BEV prices, which are usually much higher than the prices of conventional vehicles, are a strong barrier towards the adoption of BEVs [29,34]. On the other hand, lower costs for maintenance, insurance, and tax as well as lower energy costs reduce the operational costs of BEVs. In sum, BEV owners incur similar expenses over the vehicle's lifetime compared to conventional vehicles from a total cost of ownership perspective [36].

The environmental impact of BEVs, measured by CO_2 emission while driving and for energy production, is a relevant product attribute influencing the adoption. Although it is doubtless, that BEVs do not emit CO_2 when running, the environmental impact can vary. The consumption of energy is mainly determined by the average speed and variance in speed [37]. Driving with relatively low speed and avoiding fast acceleration will decrease the energy consumption of the BEV. In addition, BEVs are only able to exploit their full potential when charged with renewable energy.

The last important product attribute for the adoption of BEVs is the vehicles' brand. As purchasing a car is a highly emotional process, brands play an important role [38]. Research has shown that the same holds for BEVs, and consumers are more likely to choose a BEV of their favorite brand [39].

2.2. Personal Characteristics

In addition to a preference for product attributes, drivers, and barriers of adoption often relate to personal characteristics. For example, environmental friendliness is a strong driver of the adoption of BEVs. In general, environmental friendliness [40] is likely to drive the adoption decision towards BEVs [17,39,41]. Especially, Early Adopters are highly influenced by environmental concerns [42].

Studies dealing with environmental concerns often include the aspect of self-accountability. Self-accountability is important in our context as it determines whether a person thinks that using a BEV adds ethical value by reducing environmental harm [40]. An additional aspect of environmental concern is conspicuous consumption [43], which refers to the degree a person decides to buy eco-friendly products.

A further driver of BEV adoption is personal innovativeness [44]. Research has shown that consumers, who tend to be the first within their peer group to use new technologies, are more likely to adopt BEVs [45,46].

Finally, knowledge of BEVs is a crucial factor influencing the adoption decision [47]. Consumers who have access to widespread information have better knowledge and are more likely to adopt BEVs. For example, well-informed people judge BEV prices based on the total costs over the whole lifecycle, comparable to the total cost of ownership analysis. As BEVs are cheaper regarding costs of energy, maintenance, and taxes, the costs over their lifetimes are comparable to conventional cars [48].

2.3. Adopter Groups

Based on insights regarding the drivers and barriers of BEV adoption, researchers have correspondingly used either (1) product attributes or (2) personal characteristics to identify groups of adopters of BEVs. The first approach characterizes adopter groups based on their preferences for vehicle attributes [49]. For example, Offer et al. [50] found significant differences between adopters' preferences regarding the purchase price and range of BEVs. Additionally, Zhang, Qian, Sprei and Li [31] underline, that time to refuel, environmental impact, fuel economy, the number of seats as well as top speed lead to significantly different adopter groups.

The second approach characterizes BEV adopter groups based on their personal characteristics. In this line of research, studies indicate differences between adopters of BEVs and other alternative-fueled vehicles, such as bio fueled vehicles [18]. The results show that consumers, who have adopted BEVs are willing to be opinion leaders within their peer group and do not care about non-adopters' influences. At the same time, ecological attitudes support both the adoption of BEVs, as well as the adoption of alternative fueled vehicles. These findings are in line with the general assumptions of the theory of diffusion of innovations [51]. In this theory, innovators and early adopters are the first to adopt new technology. They possess a high income and a strong interest in new technologies. For BEVs, this assumption holds, as well [21]. Emerging adopters are the next group to adopt BEVs. They are characterized as relatively young people living in families with middle income. Second, interested retirees, people who are significantly older than other segments, with high income are the next to adopt BEV [30].

Although these findings highlight differences between groups, they mainly provide insights into consumers, who have already adopted BEVs. In addition, the findings do not incorporate product attributes of BEVs and thus are only limitedly appropriate to tailor the design of BEVs and political incentives, addressing specific consumer segments. Table 1 summarizes the two different approaches.

Table 1. Empirical studies segmenting adopter groups of Battery Electric Vehicles (BEVs).

Authors	Focus of the Study	Theoretical Foundation	Key Findings	Adopter Groups Based On: Product Attributes	Adopter Groups Based On: Personal Characteristics
Hardman, Shiu, and Steinberger-Wilckens [49]	Early Adopters of BEV	Studies using actual adopters of BEV	Early adopters differ in their evaluation of product attributes; High-end and low-end early adopters exist	√	
Zhang, Qian, Sprei, and Li [31]	Product Attributes of BEV	Regression models to estimate the influence of different product attributes	Adoption of BEV is influenced by demographical characteristics (especially income) and can be determined by product attributes such as an increase of range, number of charging stations	√	
Jansson, Nordlund, and Westin [18]	Adopters of different AFV [1]	Value Belief Norm Theory; Diffusion of Innovations Theory	Differences in personal characteristics between adopters of BEV and biofuel vehicles		√
Mohamed, Higgins, Ferguson, and Kanaroglou [21]	Personal Character istics of BEV adopters	Theory of Planned Behavior	Profiling three groups: typical Early Adopter; Emerging Early Adopter; Interested Retiree		√
Current Study	Personal Character istics and Product Attributes	Diffusion of Innovations Theory	Three different adopter groups for BEVs: Utilitarian Saver, Performance Seeker, and Green Technologists; Three-step-procedure to profile adopter groups	√	√

[1] AFV: Alternative Fueled Vehicles.

We conclude that first attempts based either on preferences for BEV attributes or on personal characteristics would deepen the necessary understanding of adopter groups. Nevertheless, profiles of adopter groups based on both, preferences for product attributes of BEVs and personal characteristics, are missing so far. In addition, there is a lack of methodological guidelines on how to identify and profile adopter groups of BEVs. This comprehensive knowledge is necessary to develop tailored measures by managers to foster BEV diffusion.

3. Research Method

3.1. Measurement

3.1.1. Preferences for Product Attributes of BEVs

In the first part of our study, we investigated preferences for BEV attributes using an adaptive choice-based conjoint (ACBC) experiment. In this experiment, respondents had to rate different theoretical BEV models composed of different product attributes with two different attribute levels - one indicating a high/positive value and the other indicating a low/negative value. Five experts rated the eligibility of each attribute and assigned the attribute levels. After a discussion of the experts' assessments, we chose the following ten attributes with their relating levels (see Table 2).

Table 2. Product attributes and their levels of BEV models.

No.	Product Attribute	Attribute Levels
1	Range	(a) 150 km (b) 300 km
2	Speed	(a) 100 km/h (b) 160 km/h
3	Recharging Time	(a) 8 h (b) 4 h
4	Availability of Recharging Points	(a) Only at dedicated recharging/refueling stations (b) Everywhere (home, office and recharging stations of any type)
5	Availability of Fast Charge	(a) Not available (b) Available
6	Price	(a) 12.000 Euros (b) 20.000 Euros
7	Fixed Costs	(a) 50 Euros/month (b) 100 Euros/month
8	Energy Costs	(a) 1 Euro/100 km (b) 5 Euros/100 km
9	Environmental Impact	(a) Zero-emission vehicle (b) The vehicle has a significant impact
10	Favorite Brand	(a) A well-known brand, but NOT among your favorites (b) Your favorite brand

To conduct ACBC, we used Sawtooth SSI Web 7.0.30 software. The ACBC experiment started with the selection of the optimal BEV model. Respondents had to configure the best fitting model by indicating their preferred attribute level for each attribute. In the next step, different fictive BEV models were shown to the respondents, who had to indicate whether the proposed models are 'a possibility' or 'won't work'. Alternatively, they could choose the 'none-option', indicating that none of the proposed models would be an alternative to buying. This procedure was iterated. In the last section of the ACBC experiment, the respondents had to make choices between three different BEV models on each page of the questionnaire. For each respondent, seven to nine screens were shown [52].

The selected model on one screen competed with two other models on the next screen, and so on. In this way, respondents chose an overall 'winner' as the most preferred model.

Based on this data, path-worth utilities were computed for each respondent using the Bayesian estimation method (Hierarchical Bayes, HB; [53]). These path-worth utilities decompose each respondent's judgment on the different models into numerical values for each attribute [54]. To compare these utilities, we standardized them to a percentage scale. Subsequently, the standardized utilities sum up to 100 % over all attributes, and thus, explain the relative importance of or preference for each product attribute [52].

3.1.2. Personal Characteristics Influencing Adoption of BEVs

In the second part of the study, we investigated potential adopters' personal characteristics. Respondents were asked to rate items based on the following constructs: 'Conspicuous Consumption', 'Environmental Friendliness', 'Self-Accountability', 'Personal Innovativeness in Technology', 'Price Consciousness', 'Hedonism' and 'BEV Knowledge'. We adapted items from scales developed in recent studies. For their measurement, we used seven-point Likert-scales. We conducted confirmatory factor analysis using SPSS AMOS 21 to assess factor loadings, construct reliabilities, and average variance extracted (AVE). Additionally, we computed Cronbach's α using IBM SPSS Statistics 24. Table 3 summarizes the items, references, and results of the tests of the construct reliability (Cons. Reliab.) and construct validity.

Table 3. Constructs and items regarding personal characteristics.

Construct Reference	Construct and Items	Factor Loading	Cronbach α	Cons. Reliab.	AVE
Environmental Friendliness			0.919	0.920	0.742
Peloza, White and Shang [40]	I value taking care of the environment.	0.844			
	I find it important to make environmentally sustainable choices.	0.900			
	I place a high value on conserving our natural resources.	0.870			
	It is important to consider our impact on the environment.	0.829			
Self-Accountability			0.849	0.852	0.658
Peloza, White and Shang [40]	How accountable are you to behave in an ethical manner?	0.744			
	How strong are you motivated to live up to your own self-standards?	0.825			
	How accountable do you feel to your own self-standard?	0.861			
Conspicuous Consumption			0.798	0.830	0.717
Chaudhuri, Mazumdar, and Ghoshal [43]	I purchase some products because I want to show to others that I respect the environment.	0.995			
	By choosing an eco-friendly product, I show my friends that I am different.	0.667			
Personal Innovativeness			0.722	0.739	0.494
Goldsmith and Hofacker [44]	I am among the last in my circle of friends to use a new technology when it appears.	0.759			
	If I heard that new technology product was available in the store, I would be interested enough to purchase it.	0.504			
	Compared to my friends, I own only a few technology products.	0.808			
Price Consciousness			0.794	0.796	0.567
Ailawadi et al. [55]	I compare prices of at least few brands before I choose one.	0.680			
	I find myself checking the prices even for small items.	0.797			
	It is important for me to get the best prices for the products I purchase.	0.776			
Hedonism			0.711	0.724	0.475
Scale inspired by Voss et al. [56]	To me, a car is simply a means of transportation to get from A to B. (RC) [1]	0.506			
	A car must be fun to drive.	0.755			
	I enjoy driving cars on the road.	0.773			
BEV Knowledge			0.741	0.743	0.493
Scale adapted from Smith and Park [57]	I am very familiar with electric vehicles.	0.773			
	I am aware of some electric car models that are on the market.	0.672			
	I have a good idea about the charging options for electric vehicles in my city and country.	0.655			

[1] RC = reversed coding.

As Table 3 indicates, all constructs meet the required Cronbach's α of 0.7 [58]. Furthermore, the construct reliability of all constructs is above the threshold of 0.6 [59]. Regarding the AVE, a value of 0.5 should be reached [60]. The constructs 'Personal Innovativeness', 'Hedonism', and 'BEV Knowledge' only attain a value slightly below 0.5. All other constructs meet this threshold. To ensure that the constructs are not inter-correlated, we checked the Fornell–Larcker Criterion. As the highest value for inter-construct correlation (0.396, Environmental Friendliness vs. Self-Accountability) clearly falls below the smallest AVE value, this criterion is met [61].

3.2. Data Collection and Sample

We collected the data for our study using an online survey. Since we had access to e-mail addresses of approximately 7,000 students and staff of a French higher educational institution, an invitation to this survey was sent via e-mail. We chose this sampling procedure because it offered a high potential for a large sample size. Simultaneously, we expected that we would reach a variety of different groups due to the composition of the sample by students and staff members. The online-questionnaire consisted of two parts. The first part contained an ACBC conjoint experiment to measure preferences for BEV attributes. In the second part, we conducted a questionnaire consisting of 44 questions on respondents' personal characteristics and demographics.

We cleaned the data, applying the boxplot procedure in IBM SPSS Statistics 24 to identify outliers. We determined an answer to be an outlier if it differs more than one and a half times from the 75 % percentile (up) or from the 25 % percentile (down) of the complete sample [60]. We deleted cases containing two or more outliers, assuming response bias. In total, eight cases were deleted from the sample in this step. Afterward, we checked the time respondents needed to complete the questionnaire. We excluded 31 cases that completed the survey in less than six minutes, as the pretest of the questionnaire showed that meaningful answering needed a minimum of this time. Additionally, we deleted 11 cases that were completed in more than three hours, as we assume technical issues as a reason for this long time for answering. We obtained a sample of 752 cases eligible for data analysis. Table 4 shows the sample's demographic characteristics.

Table 4. Composition of the sample.

Gender	Female	Male		
Relative frequencies	37%	63%		
Age in years	18–29	30–39	40–49	50+
Relative frequencies [1]	58%	22%	14%	6%

[1] Figures have been rounded for reasons of readability.

In the final sample, 37% of the respondents were female, 63% were male. This probably reflects the interests in cars and BEVs, which is traditionally higher in the male target group. The majority of the respondents were 18 to 29 years old (58%), 22% were aged 30 to 39 years, 14% were 40 to 49 years old, while the minority was 50 years and older (6%). This distribution is caused by the sampling procedures addressing students and staff of a higher educational institution. It should be noted that the sampling procedure is subject to limitations regarding the generalizability of the results (see Section 5.3).

3.3. Data Analysis – A Three-Step-Procedure for Segmenting Adopter Groups

3.3.1. Identifying Different Adopter Groups (Step 1)

We used the relative importance of BEV attributes from our ACBC experiment as a basis for segmentation since they play a major role in the adoption process (see Section 2.1). Demographic factors, in contrast, are easier to measure, but they do not necessarily indicate purchasing or adoption behavior [62]. To determine the number of adopter groups in Step 1, we conducted a hierarchical cluster approach. We used the approach developed by Ward [63] as its explorative algorithm seeks to minimize the variance within each cluster. The most similar cases were merged into one cluster, resulting in a hierarchy. We plotted this hierarchy in a dendrogram, displaying the assignment of each case to one cluster. We chose to cluster the complete sample based on the relative importance of different product attributes, computed in the ACBC experiment. The interpretation of the dendrogram showed evidence for three clusters in the sample.

To verify the three clusters in the sample, we followed Milligan and Cooper's procedure [64]. Ten random subsamples were drawn, each containing approximately two-thirds of the cases of the complete sample. Subsequently, Ward's hierarchical cluster algorithm was computed for each subsample. The dendrograms were plotted for each analysis. Interpretation of every one of the ten dendrograms confirmed the decision to form three clusters in the complete sample. We used this procedure to determine the final number of clusters [58].

Finally, we applied k-means clustering to assign each case to one of the three clusters. The algorithm compares the cluster centroids to each case. This results in an optimal assignment of each case to one cluster and thus generates homogenous segments [65].

3.3.2. Profiling Adopter Groups based on Preferences for Product Attributes (Step 2)

In Step 2, the clusters were profiled. We examined potential differences between the clusters using analyses of variance (ANOVA; [66]). For all product attribute importance, ANOVA showed highly significant results, indicating differences between the cluster means. As ANOVA is unable to indicate which group differs from the others, we applied a post-hoc test in IBM SPSS Statistics 24, Duncan's multiple range test (for a similar application in cluster profiling, see: [67]). This test explores, whether all three clusters are significantly different from each other or whether only one cluster differs from the remaining.

3.3.3. Deepening Adopter Group Profiles based on Personal Characteristics (Step 3)

In Step 3, we further analyzed the adopter groups' profiles based on personal characteristics. We checked for differences between cluster means regarding the seven constructs, 'Tendency for Conspicuous Consumption', 'Value Environmental Friendliness', 'Self-Accountability', 'Personal Innovativeness in Technology', 'Price Consciousness', 'Hedonism' and 'BEV Knowledge'. Using the factor scores, we applied the same method as described above including ANOVA and Duncan's multiple range test.

4. Results

In Step 1, we identified three adopter segments (Cluster 1, 2, and 3). In Step 2, we used the relative importance of the product attributes from the ACBC experiment to conduct ANOVA. The relative importance indicates to which extent one attribute is important for the respondent compared to the others. Higher values mean higher importance, and thus, a higher preference of the specific attribute compared to the others.

Table 5 shows the cluster means of the relative importance of the different product attributes and its 95% confidence interval (Conf. Int.). Nearly all means differ significantly ($p < 0.05$*) from each other based on Duncan's multiple range test. Only Clusters 2 and 3 are not significantly different from each other regarding the attributes 'Recharging Time' and 'Brand'.

Table 5. Cluster description based on preferences for specific product attributes.

	Cluster 1			Cluster 2			Cluster 3		
	Mean [1]	95% Conf. Int.		Mean	95% Conf. Int.		Mean	95% Conf. Int.	
		Lower Bound	Upper Bound		Lower Bound	Upper Bound		Lower Bound	Upper Bound
1. Performance									
Speed	9.580	8.738	10.423	22.932	22.280	23.585	6.946	6.387	7.506
Range	8.543	7.819	9.267	15.494	14.627	16.362	10.197	9.308	11.085
2. Charging									
Recharging Time	6.503	5.917	7.089	9.268	8.537	10.000	9.519	8.667	10.371
Recharging Points	9.760	9.016	10.504	12.596	11.796	13.397	17.721	16.574	18.868
Availability of Fast Charge	3.975	3.631	4.318	6.083	5.618	6.547	7.791	7.136	8.447
3. Price and Costs									
Price	26.730	25.980	27.480	6.358	5.747	6.970	8.942	8.171	9.713
Fixed Costs	12.817	12.100	13.534	7.008	6.443	7.574	9.888	9.027	10.749
Energy Costs	8.890	8.270	9.511	7.242	6.666	7.818	9.908	9.106	10.710
Environmental Impact	9.823	9.008	10.637	8.568	7.840	9.296	14.648	13.480	15.816
Brand	3.379	2.997	3.761	4.450	3.938	4.962	4.439	3.862	5.017

[1] Cluster means indicate the percentage, to which an attribute contributes to the overall importance.

Cluster 1 indicates high importance for the attributes ‘Price’ (26.730) and ‘Fixed Costs’ (12.817). As the cluster means reflect a percentage value, these two attributes account for nearly 40% of the attribute importance. Adding the value for ‘Energy Costs’ (8.890) boosts the relative importance of Price and Costs attributes to 48.437%. The next important attribute is ‘Environmental Impact’, accounting for 9.823% of the total importance. The ‘soft’ attribute of ‘Brand’ is least important for this cluster, which underlines our assumption of a high level of utilitarianism in this cluster. Based on this profile, we named this adopter group ‘Utilitarian Savers’.

For Cluster 2, the most important attributes are ‘Speed’ (22.932) and ‘Range’ (15.494). These values indicate that this cluster puts a high emphasis on attributes related to fun and comfort. Persons in this cluster do not want to miss out on performance-related attributes. Based on these characteristics, we named this adopter group ‘Performance Seekers’.

For Cluster 3, ‘Environmental Impact’ (14.648) and ‘Recharging Points’ (17.721) are of the highest importance. On the one hand, Cluster 3 shows the maximum value regarding ‘Environmental Impact’, which is almost 50 % higher than Cluster 1 (9.823). On the other hand, “Availability of Recharging Points”, a purely technical attribute, is of high importance. Cluster 3 is the only group indicating such high importance towards technical issues. Based on these insights, we named this adopter group ‘Green Technologists’.

Figure 1 summarizes the above-outlined results regarding the preferences of BEV product attributes in the three clusters. It highlights the most important attributes for each cluster represented by the points close to the outer edge of the diagram.

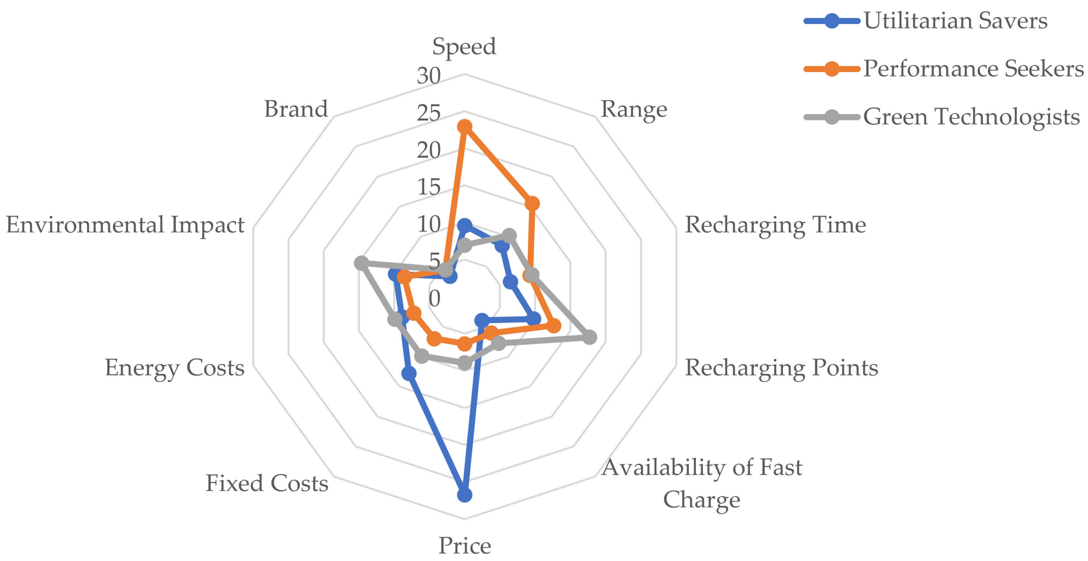

Figure 1. Cluster profiles based on preferences for product attributes.

The line for Utilitarian Savers is extremely stretched towards the attribute 'Price' (see Figure 1). All other attributes range below the other clusters (near the middle of the chart). The line for Performance Seekers is clearly stretched towards the performance attributes (Speed and Range). The line for Green Technologists shows the highest amplitudes for the 'Environmental Impact' (on the left side of the chart) and for 'Availability of recharging Points' (on the rights side of the chart).

To gain a deeper understanding of the adopter groups' profiles, we compared the clusters' means regarding respondents' personal characteristics in Step 3. Table 6 shows the means and the respective standard deviations (SD) of the factor scores of the personal characteristic for each cluster.

Table 6. Differences in personal characteristics of the adopter groups.

Cluster	**Cluster 1**		**Cluster 2**		**Cluster 3**	
Adopter Groups	**Utilitarian Savers (n = 256)**		**Performance Seekers (n = 294)**		**Green Technologists (n = 202)**	
Construct	Mean	SD	Mean	SD	Mean	SD
Environmental friendliness	0.027	0.869	−0.078	0.978	0.080	1,041
Self-accountability	−0.026	0.938	0.037	0.896	−0.021	0.973
Conspicuous consumption	-0.059	0.924	−0.089	0.884	**0.206**	**0.879**
Personal innovativeness	**−0.158**	**0.901**	0.062	0.886	0.111	0.812
Price consciousness	**0.191**	**0.775**	−0.138	0.955	−0.041	0.917
Hedonism	**−0.268**	**0.812**	**0.254**	**0.851**	**−0.030**	**0.865**
BEV Knowledge	**−0.224**	**0.856**	0.080	0.877	0.167	0.846

Notes: Bold cluster means indicate significant differences ($p < 0.05$) based on Duncan's multiple-range test.

Utilitarian Savers show a low level of 'Hedonism'. A factor score of -0.268 indicates that respondents in this cluster are the least likely to report hedonic attitudes. Furthermore, Utilitarian Savers reported the lowest level of 'BEV Knowledge' (−0.224), significantly differing from Cluster 2 and 3 ($p > 0.05$*). To conclude, Utilitarian Savers are mainly interested in BEV prices and associated costs. For those people, driving a car is more a pragmatic means for mobility rather than a self-expressing habit. In addition, Utilitarian Savers show a low level of BEV knowledge.

In contrast, Performance Seekers report a very high value for the construct 'Hedonism' (0.254). This is the highest value of all clusters. Differences were significant between all three clusters. Performance Seekers appreciate aspects like driving pleasure, comfort, or self-expression when driving a car. Price and costs only play a minor role in their purchase decisions. As these characteristics could be associated with the importance of the attribute 'Brand', we assumed high importance for this attribute. Surprisingly, the brand has the lowest importance of all attributes in this cluster (4.450).

Green Technologists exhibit the highest value for 'BEV Knowledge'. The factor means score of 0.167 is significantly different from the other clusters based on Duncan's multiple range test. This underlines that Green Technologists are better informed about BEVs and thus can evaluate BEVs and the associated attributes on a comprehensive knowledge base. Reporting a low level of 'Hedonism' (factor score: -.030*), it is not surprising that 'Brand' (4.439) and 'Speed' (6.964) are the least important BEV attributes for Green Technologists. In addition, Green Technologists are only on a mid-level regarding their sensitivity for price and costs. The least important attribute of the price and costs related attributes is the 'Purchase Price' (8.942). 'Fixed Costs' (9.888) and 'Energy Costs' (9.908) are slightly more important for Green Technologists.

In sum, the results show that there are at least three potential consumer segments for BEVs, i.e., Utilitarian Savers, Performance Seekers, and Green Technologists. They differ regarding their preferences for BEV product attributes and their personal characteristics. Utilitarian Savers look for cheap mobility, serving their needs to get from A to B. They do not put a high emphasis on product attributes such as high speed and range. These latter two are the most important attributes for Performance Seekers. They prefer highly comfortable cars and evaluate BEVs relative to combustion engine cars. For these 'conventional' cars, values of 160 km/h for high speed and 300 km for range can be regarded as normal. At the same time, costs are almost irrelevant to this segment. They are relatively insensitive towards BEV prices but appreciate a high-quality driving experience. The third group of adopters is the Green Technologists, who are likely to adopt BEVs due to technological and environmental advantages.

5. Discussion

5.1. Implications for Policy Makers

Our findings support policymakers when assessing incentives to foster BEVs' market uptake. We pave the way for incentives that are tailored to specific potential consumer segments. Policymakers should first analyze the different consumer segments in their focal area, such as cities, regions, or countries. Based on these insights, policymakers should decide which incentive will address which consumer segment. This approach will adjust the incentives to a specific group of consumers, and thus, will increase the efficiency and effectiveness of such measures.

To specifically address Utilitarian Savers, financial incentives, regardless of which kind (e.g., direct subsidies, tax exemption), could be introduced. Our findings show their strong demand for cheap mobility, bringing them from A to B. Although financial incentives are controversially discussed, this specific group is likely to positively respond to this measure.

In addition, our results show that Utilitarian Savers are the least informed group about BEVs. Thus, campaigns aimed at informing these consumers about the advantages of BEVs should be established. Moreover, platforms to discuss current issues, needs, and preferences for BEVs should be installed. In this way, people will not only get information but will be activated, and thus, be involved in the development of BEVs. Deriving opinions and preferences from these dialogues could serve as a monitoring tool for policymakers. As a result, policymakers can increase their consumer orientation, and thus, improve the applied incentives.

Finally, for 'Green Technologists', the charging points are of relatively high importance for the adoption. Therefore, policy decision-makers should further invest in public charging infrastructure to accommodate this segment. Moreover, 'Green Technologists' are conspicuous consumers. Therefore, the BEVs' green image should be strengthened, and more information communicated on the total green balance of BEVs.

5.2. Implications for Management

For managers in car manufacturing, this study underlines the high importance of consumer orientation. The results show evidence for a variety of consumers' preferences and personal characteristics. Only the minority of BEVs marketed in the past years addressed the preferences of a specific adopter group. Thus, management should improve their understanding of consumer preferences and characteristics to support the successful development and marketing of BEVs.

The adopter group 'Performance seekers' can be addressed using communication campaigns, focusing on the positive driving experience and pleasure due to their values in hedonism. So far, communication activities focused on the environmental impact of BEVs and did only marginally mention the high comfort these vehicles offer. At the same time, communication should not only concentrate on the 'green' image of BEVs but also claim a sort of status symbol. 'Performance seekers' are likely to perceive high acceleration, low driving noise, and innovative features as an advantage.

To address Utilitarian Savers' price consciousness, BEVs with low purchase prices would be required. Nevertheless, prices are highly influenced by technological development. Although these prices have declined over the past years, prices are significantly higher than the prices of conventional cars. Since Utilitarian Savers' level of BEV knowledge is comparatively low, manufacturers should inform this adopter group about the total cost of ownership, i.e., the advantages of low fixed cost and low energy costs. This could improve the adoption of BEVs in the 'Utilitarian Savers' segment.

Finally, 'Green Technologists' are conspicuous consumers who are concerned about the environment. For them, the green image of BEVs is important. Car manufacturers should; therefore, highlight their environmental friendliness specifying the total environmental balance of BEVs and designing environmentally friendly sourcing and production of the cars.

In sum, car manufacturers need to develop BEVs that target the specific segment's needs. One valuable approach to translate these insights into manageable information is to create adopter personas [68,69]. These personas are stereotypes of certain adopter groups and describe the groups' characteristics. Each persona is described by a name, age, and a short story about his/her lifestyle, values, and consumption behaviors. Personas explain adopter groups in a comprehensible way and thus are appropriate to serve as a communication tool, guiding designers, marketers, and other stakeholders involved in the development of BEVs. In this way, managers can improve their understanding of adopter groups.

5.3. Future Research and Limitations

Our findings show evidence for three different groups of the potential of BEV adopters. The identified potential consumer segments extend the current view of the BEV market. Our research shows that there is a need to come up with comprehensive views on consumer segments. Former theories on the adoption of innovations and on consumer segments in general still seem to be valid. For example, our findings support evidence for a consumer segment like early adopters. Nevertheless, research must incorporate widespread factors, which attach importance to more complex products and services as well as heterogeneous consumer needs. In this study, we explicated this instant by incorporating products' attributes and consumers' personal characteristics.

However, future research should scrutinize which of the many factors are appropriate in which setting, such as different innovation types, countries, and market environments. Also, demographic criteria (e.g., gender, income, and age) could be included in future research to further profile and characterize the clusters.

Our insights are based on a convenient sample consisting of students and staff of a French higher educational institution. Therefore, the results may be affected by sampling biases. In the future, studies using a representative sampling procedure could review and extend our findings. In addition, insights from other countries could further help to improve the understanding of the heterogeneous needs of adopter groups in different countries.

6. Conclusions

The aim of this study was to combine preferences for product attributes of BEVs with personal characteristics as a basis for identifying adopter groups of BEVs. In our study, we identified three different adopter groups, i.e., 'Utilitarian Savers', 'Performance Seekers', and 'Green Technologists'. Segments like 'Green Technologists' have been identified in previous studies before. The two other segments, 'Utilitarian Savers' and Performance Seekers', have not been identified so far. Thus, the results provide a more differentiated picture of adopter groups and highlight the necessity for in-depth analysis of such segments. This is a valuable approach, as the insights of this study as well of future studies will lay the basis for the development of tailored measures of decision-makers in management and politics to foster the adoption of BEVs. We demonstrated a three-step-procedure on how to identify different adopter groups, how to profile these segments based on preferences for product attributes, and how to deepen these profiles based on personal characteristics. This approach may serve as a guideline for policymakers and managers to develop practicable adopter personas and effective measures to foster the diffusion of Battery Electric Vehicles.

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