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## Article

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# What do people think about electric vehicles? An initial study of the opinions of car purchasers in Poland

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## Abstract

Road transport causes one fifth of the EU's total emissions of carbon dioxide (CO<sub>2</sub>), which are especially high in cities. A suggested solution to this situation is the introduction of electric vehicles (EV). However, evidence from European countries shows that, without any governmental support, the sales of EVs are low in comparison to other vehicles. Our pilot study, conducted in Wrocław (Poland), shows that car purchasers in Poland are aware of the difference between pure electric and hybrid vehicles (HEVs). As most car purchasers buy on the second-hand market, the potential for sales of EVs and HEVs still seems limited. Our study confirmed that consumers have a generally positive opinion about EVs. However, they expect that the purchase of EVs should be subsidized.

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**Keywords:** Electric vehicle; Hybrid electric vehicle; Consumers; Willingness to pay; Survey

## 1. Introduction

According to data published by the European Automobile Manufacturers Association, in the first half of 2018 only 279 battery electric vehicles, 393 plug-in hybrids and 10 805 hybrid electric vehicles were sold in Poland [1]. These numbers are not sufficient to claim the successful diffusion of EVs in Poland. The research conducted so far in Poland shows that 75% of Poles think that EVs are too expensive. However, at the same time, 64% declare that they would be willing to pay more for an electric car than a conventional car in the same class [2]. Polish consumers face strong barriers to adopting EVs in significant numbers and see the significant disadvantages of these vehicles, as 92% declare that accessibility to charging stations is limited; 91% that the rate of recharging is too slow and 85% that the range of the vehicles is too low.

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This paper presents the results of a pilot study conducted on car purchasers from the Wrocław district. The aim of the study is to get better knowledge about drivers' opinions regarding EVs. Surveys from other countries are briefly discussed in the literature review (Section 2). Further, the characteristics of our sample are described, and then the results and conclusions from this survey are discussed.

## 2. Literature review

The European Union has proposed various tools, such as: financial incentives, infrastructure developments, and strategies to encourage people to purchase (EVs), Hawkins et al. [3], Sierzechula et al. [4], Pasaoglu et al. [5]. Although there are many barriers to adopting EVs, there are already positive examples of their diffusion across Europe. Norway, Germany, France, Great Britain and the Netherlands together account for more than 80% of the EV sales in the EU. According to the International Energy Agency, the number of EVs should continue to grow globally, because of changes in the preferences and attitudes of customers, technical progress in constructing cars and ways of charging, global economic and environmental trends, together with strong incentives from government subsidies, IEA [6]. Research shows that the diffusion of EVs is hard to achieve without government subsidies, Rahmani [7] and incentives play a crucial role in the first stage of the diffusion of an innovation, Davies et al. [8], Figenbaum et al. [9], Phillips [10], Praetorius [11] and Bakker et al. [12].

## 3. Characteristics of the sample

To learn more about the preferences of Polish car purchasers living in one of the largest Polish cities – Wrocław – we conducted a pilot study, where 52 valid questionnaires were collected. The survey was conducted in January–March 2019 in Wrocław city hall. The survey was focused on people who have recently purchased a car, as we assume that this is the best moment to check their true preferences. Respondents were asked to fill in the questionnaire while waiting for procedures connected with vehicle registration, however they could proceed other issues at the city hall. The questionnaire includes 25 closed-ended questions.

## 4. Results and discussion

Within the questionnaire, the following blocks of questions were included: demographic variables, basic knowledge about EVs, transportation and environmental behaviour, attitudes towards EVs, willingness to pay for EVs and HEVs and, finally, factors that would motivate them to buy an EV. The list of variables and their codes are presented in Table 1.

**Table 1.** Definitions of the variables and their coding (N = 52).

Variable	Code	Description
Gender	D1	Binary variable
Age	D2	Ordinal variable
Household size	D3	Ordinal variable
Material situation	D4	Ordinal variable
Level of education	D5	Ordinal variable
Size of home town	D6	Ordinal variable
Type of vehicle and method of purchase	R1–R3	Nominal variables
Basic knowledge about EVs	K1–K2	Nominal variables
Environmentally friendly behaviour	E1–E5	Scale from 1 to 5
Household use of private vehicles	T1–T2	Yes/no/hard to say
	T3	scale from 1 to 4
Willingness to pay extra for EVs	W1–W2	Ordinal scale of payments
Respondents' attitudes towards EVs	A1–A5	Scale from 1 to 5
Peers' attitudes towards EVs	S1–S5	Scale from 1 to 5
Attitudes towards innovations	I1	Nominal variable
Motivating factors in the decision to buy an EV	M1–M7	Nominal variable
Facilities for using EVs	F1–F4	Scale from 1 to 6

#### 4.1. Description of the sample (D1–D6; R1–R3)

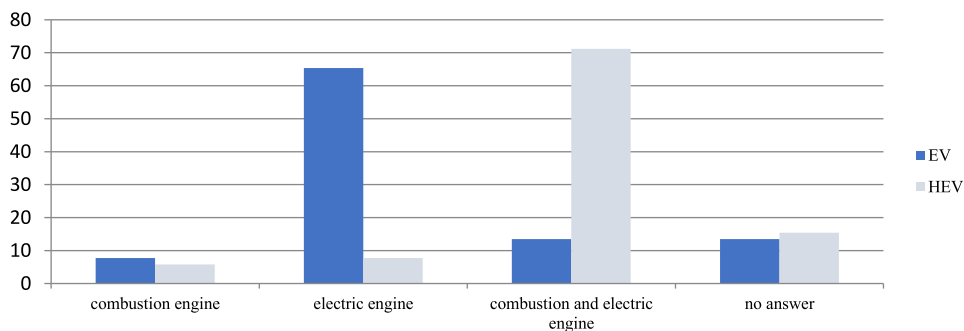
57.7% of respondents were male. The majority of respondents were relatively young, between 25–35 years old (36.5%) and between 36–45 years old (32.7%) with secondary (34.6%) or higher education (57.7%). The respondents evaluate their current material situation with respect to the average in Poland fairly positively (the mean value on a scale from 1 to 5 is 2.67, where 1 and 5 denote that the respondent's material situation is perceived to be much better and much worse, respectively, than the average in Poland. The majority of respondents stated that they lived in a village (71.2%).

The majority of respondents (82.7%) were registering a vehicle for private purposes, not for the needs of a company. Approximately two thirds of the respondents (67.3%) had purchased a car on the second-hand market, whereas 11.5% had purchased a new car, and 7.7% were leasing a car 13.5% claimed not to purchase a car at all.

80.8% of respondents had bought a car with a conventional engine and only a few of them chose an electric vehicle (1.9%) or hybrid electric vehicle (3.8%). 9.6% had not decided to buy any type of a car, and 3.8% did not answer the question.

#### 4.2. Basic knowledge about EVs (K1–K2)

Most of the respondents have some basic knowledge that allows them to distinguish EVs and HEVs from each other. However, at the same time, there are many respondents who either chose a wrong answer or did not answer the question at all, see Fig. 1.



**Fig. 1.** Respondents' knowledge about EVs and HEVs. Note: respondents had to mark which type of engines EVs and HEVs are equipped with.

#### 4.3. Environmentally friendly behaviour (E1–E5) and household use of domestic vehicles (T1–T3) and facilities for using EVs (F1–F4)

In order to investigate environmental friendly behaviour, respondents were asked to mark on a Likert scale (where 1 denotes “I agree”, 2: “I rather agree”, 3: “hard to say”, 4: “I rather do not agree” and 5: “I do not agree”) their assessment of the level at which they exhibit the five following environmentally friendly activities:

- I use energy efficient home appliances ( $M = 1.56$ ;  $SD = 0.958$ ).
- I use energy efficient bulbs ( $M = 1.23$ ;  $SD = 0.783$ ).
- I use multi-use bags for shopping ( $M = 1.48$ ;  $SD = 1.038$ ).
- I segregate waste ( $M = 1.58$ ;  $SD = 1.126$ ).
- I limit water consumption when it is possible ( $M = 1.50$ ;  $SD = 1.019$ ).

Generally, respondents reported that they exhibit a relatively high level of environmentally friendly behaviour.

For approximately two thirds of the respondents (67.3%), the vehicle being registered is not the only one used in the household or company. Almost half of the respondents (46.3%) stated that they do not have access to recharging points (i.e. charging stations or private garages), while 42.3% stated that they have such access. At the same time, 10.2% were either unsure about whether they have access or did not want to answer this question. The majority of respondents drive more than 50 km in a day several times a week (42.3% every day, and 28.3% several times a week). Free parking areas, the use of bus lanes and parking in zero-emissions zones (in the city centre) are most often perceived by respondents to be the most important factors facilitating the use of EVs.

#### 4.4. Attitudes of respondents (A1-A5) and their peers (S1-S5) towards EVs

In order to evaluate the opinions of respondents and their peers regarding EVs, the six following statements were assessed on a Likert scale (where 1: denotes “I agree”, 2: “I rather agree”, 3: “hard to say”, 4: “I rather do not agree”, and 5: “I do not agree”):

1. EVs should be introduced onto the market on a large scale (A1:  $M = 1.69$ ;  $SD = 0.829$ , S1:  $M = 1.67$ ;  $SD = 1.043$ ).

2. EVs are environmentally friendly (A2:  $M = 1.69$ ;  $SD = 1.020$ , S2:  $M = 1.48$ ;  $SD = 1.075$ ).

3. EVs will improve air quality (A3:  $M = 1.54$ ;  $SD = 0.851$ , S3:  $M = 1.38$ ;  $SD = 0.953$ ).

4. Owning an EV is associated with greater social prestige (A4:  $M = 2.69$ ;  $SD = 1.076$ , S5:  $M = 2.25$ ;  $SD = 1.297$ ).

5. EVs are safer than those with a combustion engine (A5:  $M = 2.71$ ;  $SD = 1.109$ ; S5:  $M = 2.44$ ;  $SD = 1.320$ ).

These answers reveal that respondents rather agree that EVs are beneficial to the environment and should be introduced onto the market on a large scale, but at the same time they doubt whether EVs are really safer than CVs or whether possessing an EV is associated with greater social prestige. It was observed that in most cases respondents assessed the opinions of their peers to be similar to their own. As respondents reported some difficulties in assessing the opinions of their peers, we suppose that they often assume that their peers hold the same opinion as themselves, or give the answer “I do not know”. For this reason, the variables S1-S5 are not taken into account in the further analysis.

#### 4.5. Attitudes towards innovations (II)

The majority of respondents (65.4%) buy an innovative product only when it is really needed. 25% decide to purchase an innovative good if some of their peers already possess it and are satisfied with the purchase. At the same time, 7.7% of the respondents revealed that they make their consumption decisions independently of the opinion of their peers.

#### 4.6. Factors motivating respondents to buy an EV (M1-M7)

Finally, the respondents were asked to choose not more than 3 important factors that would motivate them to purchase an EV. The following options were available: M1 — use of free parking zones for EVs; M2 — use of bus lanes, M3 — access to zero-emissions zones; M4 — the possibility of tax relief (exemption from excise tax); M5 — subsidies for purchasing EVs; M6 — access to public charging stations; M7 — extended warranties on EVs.

The largest share of the responses, 26%, indicated that a financial subsidy (M5) is necessary. Second, the possibility of using free parking zones (M1) and exemption from excise tax (i.e. lowering the purchase price) constituted 19% of the responses. Extended warranties (M7) and access to recharging stations (M6) composed 15% and 13% of responses, respectively. The use of zero-emission zones and bus lanes are not so important to respondents (in both cases, mentioned by only 4% of responses) (see Fig. 2).

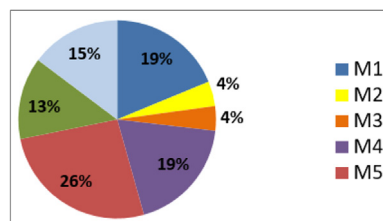


Fig. 2. Factors motivating the purchase of an EV.

#### 4.7. Willingness to pay (W1-W2)

We have used the contingent valuation method to evaluate respondents' willingness to pay (WTP) for an electric vehicle (variable W1) and for a hybrid electric vehicle (variable W2). The respondents chose how much more they would pay for an EV/ HEV than for a similar car with a combustion engine (CV) from an ordered price scale. As presented in Fig. 3, the majority of respondents were not ready to pay more for an EV or HEV than for a conventional car with a combustion engine in the same class (similar design and/or other technical parameters).

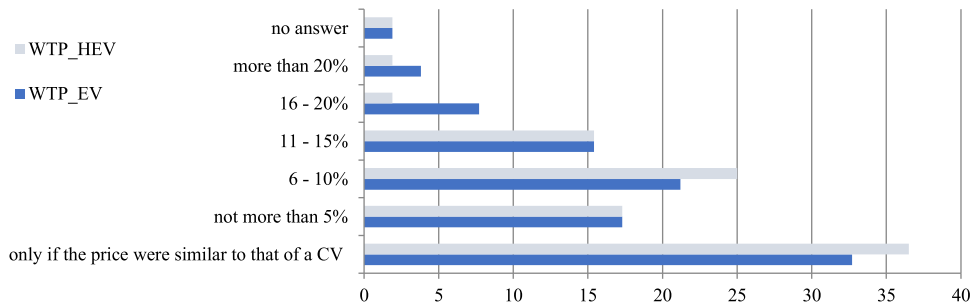


Fig. 3. The frequencies of the respondents' willingness to pay for an EV or HEV.

#### 4.8. Ordered logit model

An ordered logit model is useful in the context of WTP analysis due to its natural interpretation. Since the actual values of  $WTP_i$  are not observed, the regression Eq. (1) cannot be estimated directly, but model (2) can serve to approximate the effects of factors on WTP.

In the ordered logit model, it is assumed that there is a linear relationship between the unobserved value of the willingness-to-pay ( $WTP^*$ ) and the exogenous variables

$$WTP^*_i = a + X_i b + \mathcal{E}_i, \quad (1)$$

where  $a$  is the intercept,  $X_i$  is the vector of exogenous variables for individual  $i$ , excluding the constant, and  $\mathcal{E}_i$  is a residual.

Based on this model, the probabilities of belonging to a certain class for  $WTP \in \{0, \dots, 6\}$  become

$$Prob(WTP_i = 0) = Prob(WTP^* \leq 0) = \Lambda(\alpha_1 - X_i \beta) \quad (2)$$

$$Prob(WTP_i = 1) = Prob(0 < WTP^* \leq \mu_1) = \Lambda(\alpha_2 - X_i \beta) - \Lambda(\alpha_1 - X_i \beta) \quad (3)$$

$$Prob(WTP_i = 2) = Prob(\mu_1 < WTP^* \leq \mu_2) = \Lambda(\alpha_3 - X_i \beta) - \Lambda(\alpha_2 - X_i \beta) \quad (4)$$

...

$$Prob(WTP_i = 6) = Prob(\mu_5 < WTP^*) = 1 - \Lambda(\alpha_6 - X_i \beta), \quad (5)$$

where  $\Lambda()$  is the logit function and the  $\alpha_k$ 's are thresholds such that  $\alpha_1 < \alpha_2 < \dots < \alpha_6$ .

Two separate models were built to reveal factors affecting the WTP for EVs (variable W1) and HEVs (variable W2). Moreover, for each type of vehicle (EV and HEV), two different sets of variables were taken into account: firstly, including the variables F1-F4 representing the consumers' preferences regarding facilities for using EVs and, secondly, without these variables. The coefficients of these models are presented in Table 2.

The results reveal that, in the case of electric vehicles, consumers' willingness to pay increases with: number of household members, the size of the home town, basic knowledge (recognition) of EVs and HEVs, positive opinions regarding the positive impact of EVs on the environment (A3), their safety (A5) and social prestige (A4). If the variables F1-F4 are excluded, two additional demographic variables become significant: age and education.

In the case of hybrid electric vehicles, consumers' willingness to pay increases with: the number of members of a household, the size of the home town, the regularity of travelling at least 50 km in a day, opinions regarding the positive impact of EVs on the environment (A2–A3). If the variables F1–F4 are excluded, environmental behaviour (aggregate variable E) becomes significant as well.

Surprisingly, the perceived material situation (D4) of the respondent was not found to be related significantly to the WTP by any of the models.

**Table 2.** Coefficients of the ordered logit models for EV (W1) and HEV (W2).

Variable	Ordered logit models with variables (F1–F4) included		Ordered logit models with variables (F1–F4) excluded	
	W1	W2	W1	W2
D1	0.295 (0.902)	1.223 (0.968)	−0.176 (0.663)	0.063 (0.692)
D2	0.579 (0.397)	0.477 (0.397)	0.627 (0.381)*	0.514 (0.380)
D3	1.259 (0.369)***	0.668 (0.329)**	1.133 (0.338)***	0.629 (0.303)**
D4	0.031 (0.327)	0.232 (0.324)	0.147 (0.298)	−0.053 (0.286)
D5	0.891 (0.680)	−0.289 (0.624)	1.198 (0.549)**	0.741 (0.541)
D6	0.577 (0.317)*	−.658 (0.314)**	0.482 (0.299)	0.558 (0.295)*
R3	−0.227 (0.443)	−0.694 (0.439)	−0.227 (0.378)	−0.318 (0.394)
E = E1 + ... + E5	0.084 (0.128)	0.299 (0.149)	0.062 (0.116)	0.342 (0.154)**
K1	2.259 (0.966)**	0.904 (0.854)	2.263 (0.916)**	1.087 (0.801)
K2	1.769 (0.666)***	0.708 (0.586)	1.822 (0.636)***	0.66 (0.525)
T2	0.255 (0.589)	0.057 (0.578)	0.296 (0.532)	0.402 (0.551)
T3	0.339 (0.485)	0.948 (0.500)*	0.320 (0.451)	0.839 (0.481)*
A1	−0.043 (0.509)	−0.516 (0.525)	−0.196 (0.466)	−0.412 (0.454)
A2	0.475 (0.655)	1.494 (0.579)***	0.721 (0.511)	1.038 (0.487)**
A3	1.734 (0.685)**	2.209 (0.742)***	1.907 (0.616)***	1.892 (0.665)***
A4	1.619 (0.550)***	0.680 (0.486)	1.363 (0.485)***	0.398 (0.443)
A5	1.478 (0.415)***	−0.626 (0.383)	1.349 (0.389)***	0.406 (0.348)
I1	−0.213 (0.373)	−0.035 (0.384)	0.062 (0.117)	0.073 (0.316)
F1	−0.136 (0.471)	−0.004 (0.446)		
F2	0.525 (0.353)	0.100 (0.380)		
F3	−0.069 (0.296)	0.890 (0.317)		
F4	0.005 (0.264)	−0.446 (0.280)		
Cut 1	3.797 (4.341)	−1.491 (4.279)	3.035 (3.288)	−1.602 (3.502)
Cut 2	10.063 (4.689)**	4.245 (4.412)	8.765 (3.552)**	3.580 (3.436)
Cut 3	11.537 (4.750)**	5.813 (4.208)	10.222 (3.622)***	4.761 (3.468)
Cut 4	13.263 (4.833)***	7.733 (4.266)*	11.938 (3.719)***	6.415 (3.519)*
Cut 5	15.049 (4.943)***	10.082 (4.357)**	13.736 (3.844)***	8.553 (3.612)**
Cut 6	16.467 (4.983)***	10.873 (4.422)**	15.201 (3.899)***	9.311 (3.685)**
Log likelihood	−61.838	−57.604	−63.289	−64.007

Note: Standard errors in brackets.

\*p < 0.05 (two-tailed test).

\*\*p < 0.01 (two-tailed test).

\*\*\*p < 0.001 (two-tailed test).

## 5. Conclusion

Our study has indicated that as most Polish consumers purchase cars on the second-hand market, the potential for the diffusion of EVs and HEVs seems limited. The cost of EVs and HEVs seems to be the most important obstacle. Consumers expect to obtain a subsidy or tax exemption that would lower the financial burden. At the same time, our study has shown that consumers have rather positive opinions about EVs and generally are able to distinguish between EVs and HEVs.

Both ordered logit models for EVs and HEVs indicate that consumers' willingness to pay depends on their basic ability to distinguish between the categories of cars, consumers' belief that EVs have a positive impact on the environment and the size of the household and home town. Size of home town may well have a positive impact, because as it increases, access to recharging stations increases and the advantage of priority for EVs (e.g. use of bus lanes, free parking places) becomes more noticeable. Additionally, the model for HEVs shows that environmentally friendly behaviour is associated with the consumers' WTP.

Last but not least, we must emphasize that this initial study has enabled us to draw some basic conclusions regarding consumers' opinions and purchasing behaviours on the EVs market. In the future we plan to perform a similar study, but on a much larger sample of respondents.

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