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Market Electrification for BEV and PHEV in Relation to the Level of Vehicle Autonomy

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Abstract: The automotive market has been developing very dynamically recently. Contemporary trends focus on the development of the so-called intelligent vehicles, often combined with modern technology and supporting systems. Cars with a large scope of operation in terms of driving autonomy can increasingly be found. These types of solutions can lead to changes in production processes through the emergence and growing importance of new concepts and technologies. The article presents the concept of BEV (Battery Electric Vehicle) and PHEV (Plug-in Hybrid Electric Vehicle) vehicles in relation to modern solutions and their levels of autonomy. The research was conducted in various groups of respondents, while the analyses were carried out mainly with the use of two grouping variables: gender and place of residence. Based on our own research, it can be concluded that due to many different factors, most respondents believe that PHEV hybrid vehicles and electric vehicles (BEV) are currently, and will most likely be in the near future, the dominant type of vehicles appearing on roads in Poland, at the same time indicating the level of advancement of autonomy as average (mainly level 1, 2 and 3).

Keywords: BEV—Battery Electric Vehicle; PHEV—Plug-in Hybrid Electric Vehicle; automotive industry; vehicle autonomy

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1. Introduction

The automotive industry has recently undergone enormous transformations related primarily to technical, legal, social, and environmental factors, in particular, the emission of harmful compounds and energy consumption. These challenges may be an impulse for positive changes but are also associated with a great effort by people and institutions involved in the development of this sector of the economy. One of the directions of change is the change of power supply and drive systems for motor vehicles, which in turn reduces exhaust emissions at the place of use of vehicles. Figure 1 shows the share of motor vehicles with modern types of drivers over the last few years.

When analyzing the data presented in Figure 1, it can be observed that the largest market share—taking into account the cars built on the basis of innovative solutions—is hybrid vehicles. It is also evident that electric vehicles are another group of vehicles that are growing faster and faster in the market. Therefore, this study attempts to evaluate the development of BEV (Battery Electric Vehicle) and PHEV electric vehicles in Poland in relation to the vehicle autonomy levels and their impact on the natural environment.

This article presents an analysis of selected types of vehicles with innovative drives in relation to the level of their autonomy, registered in Poland over the last few years. Firstly, Section 2 is a literature review of the basis of current changes in the automotive sector, taking into account the main issues of the selected means of transport and their impact on the environment. The methods used in this study were described in Section 3, and the statistical analysis of the main results is shown in Section 4. A brief overview of the research results obtained in relation to similar scientific and research works is included in Section 4. On the basis of the performed statistical analyses of the research results, the final conclusions presented in the last part of the article (Section 5) were formulated.

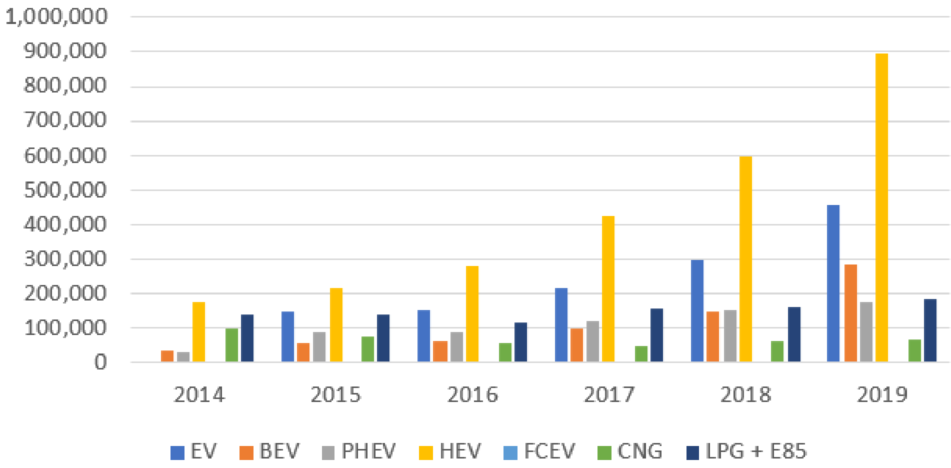

Figure 1. The share of innovative motor vehicles in 2014–2019 in Poland [1]. Where: EV—Electric Vehicle, BEV—Battery Electric Vehicle, HEV—Hybrid Electric Vehicle, PHEV—Plug-in Hybrid Electric Vehicle, FCEV—Fuel Cell Electric Vehicle, CNG—Natural Gas, LPG + E85—Other.

2. Literature Review

The automotive industry has experienced tremendous changes over the past two decades. These changes were especially visible in the improvement of the design of internal combustion engines [2–7] and hybrid drives [8–10]. There has been a lot of research in the field of power supply systems for spark-ignition engines [11–14] and, above all, diesel [15–20]. Common rail high-pressure systems [18,19] and piezoelectric injection systems have appeared on the diesel engine market [18]. More and more stringent exhaust gas standards forced the development of exhaust gas treatment systems, such as SCR and DPF [16,21,22]. The treatment systems mainly concern the reduction of nitrogen oxides and PM particulate matter. Then, in order to reduce exhaust emissions, systems for stopping the engine at a standstill and its automatic restarting, called Start–Stop or Stop and Go, appeared [23]. The issues of reducing the number of aerosol particles and mass concentration are now the main development criteria in transport and production engineering [22].

In the case of internal combustion engines, the production and testing of alternative fuels remain an unflagging interest [24–31]. In the literature, there are numerous scientific papers on the use of gaseous fuels in transport, such as LPG [30]. Great interest is also visible in research on the use of natural gas [32,33] or CNG [34–36]. In addition, over the past decade, liquefied natural gas (LNG) has attracted attention as a sustainable energy source [37–39]. The interest in LNG applies not only to road transport but also to sea transport. In addition, significant research is carried out in the field of other fuels and their blends [40–44] used to power internal combustion engines.

According to a report from 2021 [45] of the European Automobile Manufacturers Association, in 2019 the share of passenger cars with diesel engines dropped to 42.3%. The maximum share of vehicles with diesel engines was 50% and it fell in 2015. On the other hand, hybrid systems [8–10,46] or battery electric vehicles (BEV) [9,47–49] are becoming more and more popular in the market, which is already shown in Figure 1.

A BEV (Battery Electric Vehicle) is a vehicle powered exclusively by electricity, the batteries are charged via a special charger, e.g., a wallbox or a fast-charging station. A PHEV (Plug-in Hybrid Electric Vehicle) is a type of hybrid car that can be charged from an external energy source via a charging socket. Compared to classic hybrids (HEV), PHEV vehicles have larger batteries. The high cost of lithium-ion batteries combined with their low gravimetric energy density makes mass reduction strategies (lightweight measures) particularly attractive for BEVs [50]. Thus, reducing the capacity by a few kWh may result in a significant reduction in the mass of the battery [51], leading to a further decrease in energy consumption by the vehicle. Therefore, we obtain double benefits in relation to vehicles powered by internal combustion engines, we reduce the weight of the vehicle, which reduces energy consumption, and consequently, we reduce emissions.

Currently, vehicle manufacturers have more and more hybrid and electric vehicle models in their commercial offers and some of them have already completely abandoned the installation of internal combustion engines in their vehicles. The change in the power system is also evident among manufacturers of buses for urban public transport [52]. Limiting the use of internal combustion engines minimizes their negative impact on the environment; the integration of the internal combustion engine with electric motors in the form of a hybrid also gives good results. Many researchers are interested in the issues of electric vehicles operation—for example [47–49,53–57]—they are concerned with operational road tests [9,47,49,53–55] and the issues of energy consumption and battery charging of these vehicles [47,56–59]. It should be added that electric vehicles are fully ecological means of transport only when the electricity required to charge them comes from renewable energy resources (RES) [59]. In their work, Synak et al. [60] made an attempt to determine the energy efficiency of a selected electric car. Another important operational aspect of electric vehicles is the disposal of lithium-ion batteries [61]. In turn, Król and Król in [62] highlight the risk of an electric vehicle resulting in fire. When a lithium-ion battery is burned, large amounts of harmful hydrogen fluoride are released, which poses a great risk to rescue teams and people in the vicinity of the fire.

The transport sector is experiencing a rapid increase in the number of vehicles and energy consumption related to transport [52]. The change in the drive system of vehicles causes big changes also for the energy sector, which was observed in the works [60,63]. Currently, a big challenge for all stakeholders is also emissions from the transport sector [64,65], which has a fairly large share of global emissions. According to Skrucany [66], it has about a 30% share of air pollution. Hence, attempts by city boards to limit the entry to city centers of vehicles powered by combustion engines, including public transport vehicles, seem to be justified. This action allows the reduction of air pollution by the emission of particulate matter PM and NO_x. The target adopted by the European Union to reduce greenhouse gas emissions by 55% by 2030 and achieve full climate neutrality by 2050 forces the development of alternative energy sources [67]. For these reasons, solutions for low-emission or zero-emission energy sources with economical and ecological means of transport are sought.

The development of electric drives in motor vehicles is also important for the development of autonomous vehicles (AV), as it enables them to be controlled more easily. Vehicles of this type, however, constitute a separate chapter, and their development is possible due to the integration of technical, IT, information, and measurement sciences. Various types of development research in the field of autonomous technologies have been going on for many years. Many publications on AV technology and legal and social issues have appeared in the literature [68–75].

The ability of AVs to operate without human intervention depends on their level of technological sophistication, in accordance with the current six-degree autonomy scale proposed by the International Society of Automotive Engineers (SAE) [68,76–81] from Level 0 (without automation) to Level 5 (full unlimited automation); Levels 1 to 3 are considered “semi-autonomous” (Table 1).

Table 1. Characteristics of the types of autonomy levels implemented in vehicles [76–81].

Autonomy Level	A Kind of Autonomy	
Level 0	no automation	The driver performs all tasks related to driving.
Level 1	driver's assistant	The driver controls most driving functions, but under certain conditions, the vehicle may be able to adjust the cruise control speed or stay on the road lane—this level is achieved due to systems that automate a specific driving element, however, the driver is required to keep his hands on the steering wheel and observe the traffic on the road.
Level 2	partial automation	This level corresponds to semi-autonomous driving—the vehicle can take over driving, steering, and braking autonomously, e.g., in traffic jams—the car can both accelerate/decelerate and perform basic steering functions. The driver is still responsible for the navigation controls (e.g., changing lanes, exiting a motorway, or turning into a new street).
Level 3	conditional automation	The on-board systems are already able to take over all driving functions, but only in certain cases—the car can monitor the driving environment as well as accelerate, turn or brake, but still wait for human intervention after notification. The driver must therefore remain alert at all times and ready to take control of the vehicle.
Level 4	high automation	Fully autonomous driving—the car can control all aspects of driving and operate without human intervention, but only under certain conditions. The vehicles communicate with each other and inform about, e.g., a lane change, and the driver does not have to constantly observe the surrounding traffic on the road.
Level 5	full automation	The car is fully autonomous in all driving conditions and does not require any human intervention—the technological system can perform all driving tasks in all driving conditions, and the driver is only a passive passenger and never has to participate in driving or perform any tasks related to driving the vehicle.

According to the literature review, the automotive market is currently undergoing enormous transformations. Various trends in the development of motor vehicles can be observed there, the main purpose of which is to reduce the negative impact of the automotive industry on the natural environment. Unfortunately, even the greatest efforts of designers and the development of technology are not able to ensure full success when there is no social acceptance of their solutions. Therefore, despite numerous studies in the field of electric vehicles, there is a lack of research that allows the assessment of development trends in developing countries such as for example, Poland. For this reason, the authors made an attempt to research the market and determine the preferences of consumers in Poland in relation to the selected type of vehicles with modern electric and hybrid drives.

Hence, the main goal of the study is to determine the significance of the development of the automotive market in Poland in relation to the preferences of drivers and the type of vehicle they choose, and thus to the level of autonomy of the vehicle concerned. In addition, the aim of the work is also to determine the level of vehicle autonomy by current or potential drivers in the context of BEV and PHEV vehicles.

3. Materials and Methods

In order to assess the prospects for the development of the electric vehicle (BEV) and hybrid PHEV market, from the point of view of their potential users, as well as to present the significance of the development of the automotive market in relation to the level of autonomy with which they are associated—and thus to achieve the main aim of the research—own research (using a diagnostic survey method) was carried out on a group of 579 adults over 18 years of age (who are or potentially may be drivers). A structured proprietary questionnaire was used as the research tool. The selected form of research allows obtaining information on both subjective and objective states of the respondents.

The questionnaire contained closed questions, which were developed in an unambiguous way so that they did not require additional comments, and the respondents were asked to indicate one correct answer from several available options that best or most precisely reflects their attitudes, preferences, feelings, and behaviors. In addition, several of the questions were multiple-choice questions, also with the option of giving their own, different answer. Due to the current epidemic situation, the questionnaire was distributed only via the Internet. The research was conducted in 2021. The questionnaire was anonymous and the respondents voluntarily decided to complete it.

The survey, apart from metric questions, enabled the socio-demographic characteristics of respondents due to various grouping variables (respondent's descriptive features such as: gender, age, education, place of residence, professional status, etc.), included questions mainly about: respondents' attitude to modern technology, whether they think that electric or hybrid cars will appear more often in the near future in the market, what is important, and which level of development of autonomy in these vehicles will develop most dynamically in the near future. The questionnaire also contained an introduction, which presented the essence and purpose of the research, as well as a short instruction on how to fill it in correctly.

It was assumed that the research sample would be at least 500 units. A targeted non-random selection of the research sample was used—the criterion of targeted selection was the fulfillment by the participants of the study of the criteria defining the categories of grouping variables included in the metric part of the questionnaire. The aim of this method of selecting the research sample was to create a sample close to the representative sample. Hence the research sample was mainly differentiated by gender, age, and place of residence. Due to the fact that the data were obtained from population samples, they can be considered descriptive studies based on the data collection method, more specifically—a research survey.

Data analyses were carried out on the basis of the statistical processing software Statistica 13.3 and Excel 2013. Correspondence analysis was carried out in relation to three selected variables, i.e., the level of autonomy, type of car, and place of residence. Correspondence analysis is a descriptive and exploratory technique for analyzing two-way and multi-way tables, containing certain measures that characterize the relationship between columns and rows. The obtained results provide information and allow for the analysis of the structure of qualitative variables making up the table. Therefore, as a result of the analyses, a two-dimensional contingency table was obtained, where the frequencies in the contingency table were first standardized in such a way that the relative frequencies were calculated, which when summed up in all fields (cells) of the table give 1.0. One way to show the goals of a typical analysis is to express the relative frequencies by the distance between individual rows or columns in a space with a small number of dimensions.

In correspondence analysis, inertia is defined as the quotient of the Pearson Chi-square statistic calculated from the two-way table by the total count (in the example presented, the total count is 579). On the other hand, the total inertia is a measure of the profile dispersion around the corresponding average profiles. It should be added that the dimensions are determined in such a way as to maximize the distances between the points representing the rows or columns, and the subsequent dimensions (which are independent or orthogonal to each other) explain smaller and smaller parts of the general Chi-square (i.e., also inertia).

In addition, the results of the analyses are presented using histograms categorized in relation to selected grouping variables—gender of respondents, place of residence, and the level of vehicle autonomy.

In order to show the importance of the development of the electromobility market and in order to present the phenomenon of the constantly growing share of the share, a regression analysis was also carried out in relation to two years—2020 and 2021—and in relation to the BEV and PHEV car market.

4. Results and Discussion

In order to verify the collected data, a statistical analysis was performed with the use of Statistica 13.3 SW.

In the further part of the study, an analysis of the correspondence between the individual groups of autonomy, the type of vehicle, and the differentiating variable, i.e., the place of residence, was carried out in order to select the most characteristic groups. In addition, based on the analysis of multi-way tables, the results were presented in the form of categorized histograms showing consumer preferences in terms of the type of car preferred by the type of drive—BEV or PHEV. A regression analysis was also performed with the use of data provided by the Polish Automotive Industry Association.

The Polish Automotive Industry Association (PAIA) is the biggest Polish organization of automotive industry employers. The PAIA associate 50 companies, representatives of producers, and manufacturers of vehicles: buses, trucks, cars, motorcycles, mopeds, and body manufacturers in Poland.

4.1. Statistical Analysis

Based on the results of our own research, in the first stage of the applied research procedure, an analysis of correspondence between two groups of features was carried out, i.e., the level of autonomy (Level 1, 2, 3, 4, and 5) and the type of vehicle (electric or hybrid) and the place of residence respondent (RA-rural areas, C100—city with up to 100,000 residents, C100-300—city with 100,000–300,000 residents, C > 300—city with more than 300,000 residents). A two-dimensional factor space was chosen to present the configuration of the points representing the input data.

The first factor allows for reproducing 72.69% of the input data variation (i.e., total inertia), and the second factor is 18.8% (Table 2).

Table 2. Information resources' factors.

Number of Dimensions	Eigenvalues and Inertia, Total Inertia = 0.1668 χ^2 = 96.389, df = 28, p = 0.0001				
	Singular Value	**Eigenvalues**	**Percentage of Inertia**	**Cumulative Percentage**	χ^2
1	0.3482	0.1212	72.69	72.69	70.0689
2	0.1771	0.0314	18.80	91.49	18.1204
3	0.1166	0.0136	8.16	99.65	7.8645
4	0.0241	0.0006	0.35	100.00	0.3349

Level 1 and Level 4—I coordinate as well as Level 5 and Level 2 and 3—II coordinate had the largest share in the creation of the two-dimensional factor space by the levels of autonomy.

On the other hand, the greatest share in the creation of the two-dimensional factor space by the vehicle type and place of residence was recorded by people living in the average city size, i.e., C100–300 residents who would choose a hybrid car and people living in cities with more than 300,000 residents choosing electric cars as a solution to meet their communication needs—1st dimension.

In the case of the second dimension, the greatest share in creating space had people living in rural areas, who would also choose hybrid cars as a solution for mobility, and similarly to the first dimension—people living in cities with more than 300,000 inhabitants residents choosing electric cars (Figure 2).

When analyzing the information presented in Figure 2, we can distinguish four groups with a similar structure of the car preferences indicators by type. The first is made up of residents of cities over 300,000 who prefer hybrid cars, and residents of cities of C100–300 and over 300,000 who choose electric cars. The second group consists of inhabitants of medium-sized cities (100,000–300,000 residents) who choose hybrid cars, while the third group consists of people living in rural areas who choose electric cars, and people living in cities with up to 100,000 residents who choose hybrid cars. The fourth group consists of people living in rural areas who choose hybrid cars. The most average structure is represented by people living in cities of up to 100,000 choosing electric cars.

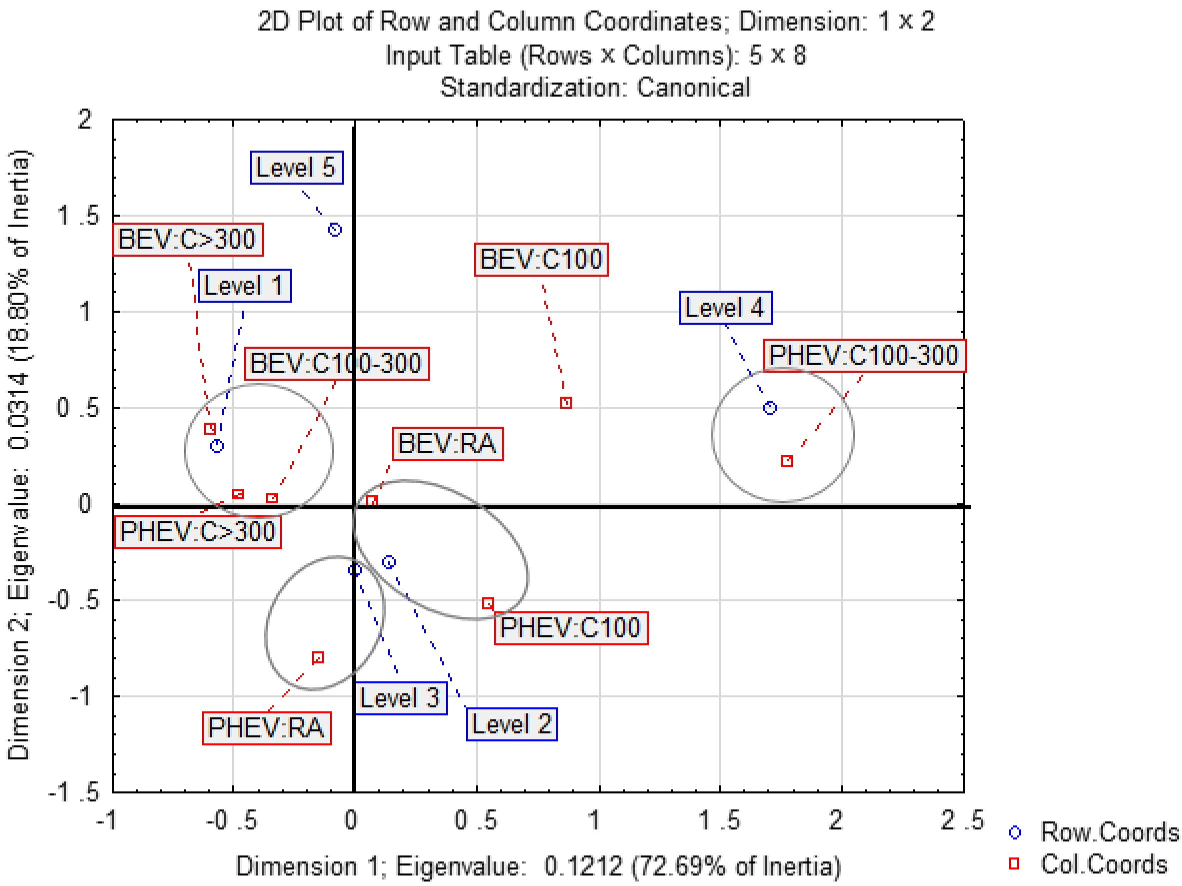

Figure 2. Correspondence analysis results between two groups of characteristics: autonomy level, type of car and places of living, standardization canonical. Where: Level 1—driver's assistant, Level 2—partial automation, Level 3—conditional automation, Level 4–high automation, Level 5—full automation, RA—rural areas, C100—city with up to 100,000 residents, C100-300—city with 100,000–300,000 residents, C > 300—city with more than 300,000 residents.

On the other hand, Level 1 shows the greatest correlation between the level of autonomy, place of residence, and the type of vehicle, with residents of cities over 300,000 preferring hybrid cars, and residents of cities of C100–300 and over 300,000 choosing electric cars; it is a relatively strong relationship, as shown in Figure 2. Due to the value of the indicator of this relationship, the group in question differs from other groups.

The autonomy Level 2 is most strongly related to people living in rural areas choosing electric cars, and people living in cities with up to 100,000 residents choosing hybrid cars. The autonomy Level 3 is quite strongly related to people living in rural areas who choose hybrid cars. On the other hand, the inhabitants of cities of C100–300 are quite strongly associated with autonomy Level 4, choosing hybrid cars. Importantly, autonomy Level 5 showed no apparent link to any of the groups. This is because it is still too advanced and high for the current infrastructural possibilities of Polish roads.

Figure 3 shows a graph of the eigenvalues of the discussed relations between the two dimensions and the four characteristic groups distinguished in relation to them.

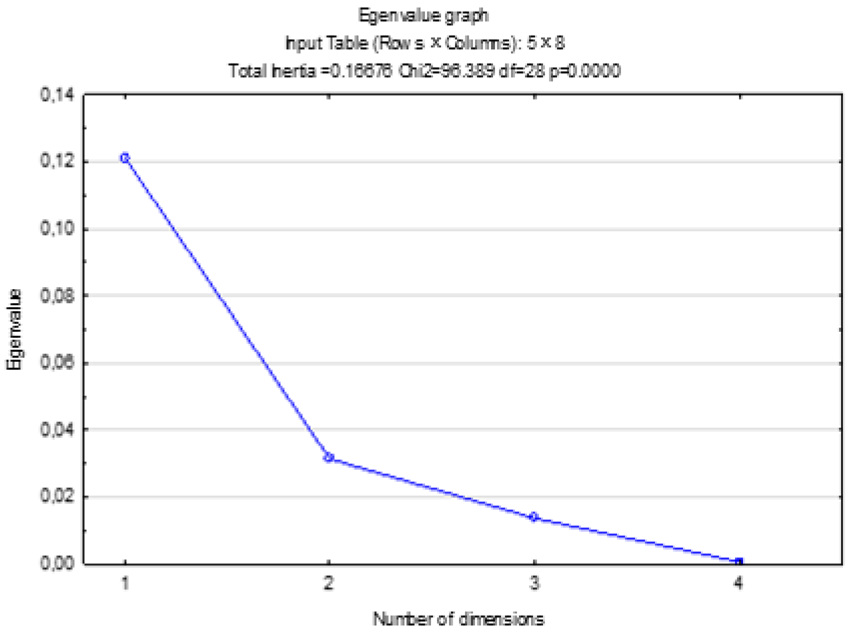

Figure 3. Scree plot of eigenvalues.

It should be added that referring to Figures 2 and 3, on the basis of the results carried out, it can be seen that the successive dimensions (which are orthogonal to the others) explain smaller and smaller parts of the overall value of the Chi-square statistic (i.e., inertia). Figure 3 and Table 2 show four eigenvalues, due to the four dimensions distinguished in the statistical program, but for further more in-depth analyses, only two were selected. The reason was that the first dimension can reproduce as much as 72.69% of total inertia, and the second dimension included increases in the percentage of explained inertia to 91.49% of total inertia. Therefore, based on this criterion, it is advisable to position the profiles in a two-dimensional space. After determining the number of dimensions, in the next step, the coordinates of the column profiles were calculated in a new orthonormal coordinate system defined by singular vectors. In order to interpret the coordinates of the points representing the columns, the row–column standardization method was used, where the coordinates are calculated from the matrix of column profiles. This standardization made it possible to obtain coordinates of points representing the ratio of respondents with regard to the place of residence to the type of selected car and the level of autonomy represented.

In the further part of the study, the significance of BEV and PHEV vehicles for the respondents/drivers was also analyzed, due to various differentiating variables, such as gender, place of residence, or the level of autonomy. A total of 38% of women and 62% of men took part in the study. The presented data show that both men and women were more likely to choose (or would choose in the future) electric cars—BEV over PHEV. The results are presented in the categorized histogram in Figure 4.

In the case of another analysis presenting, in turn, data on the choice of the preferred BEV and PHEV vehicle by respondents based on the place of residence, it shows that both electric cars—BEV and PHEV—are more likely to be chosen (or would be chosen in the future) by people living in rural areas and by residents of large cities, but electric cars are still the dominant set among these two groups (Figure 5).

Figure 6 presents a categorized histogram of the frequency of respondents' responses to the level of autonomy according to the respondent's place of residence.

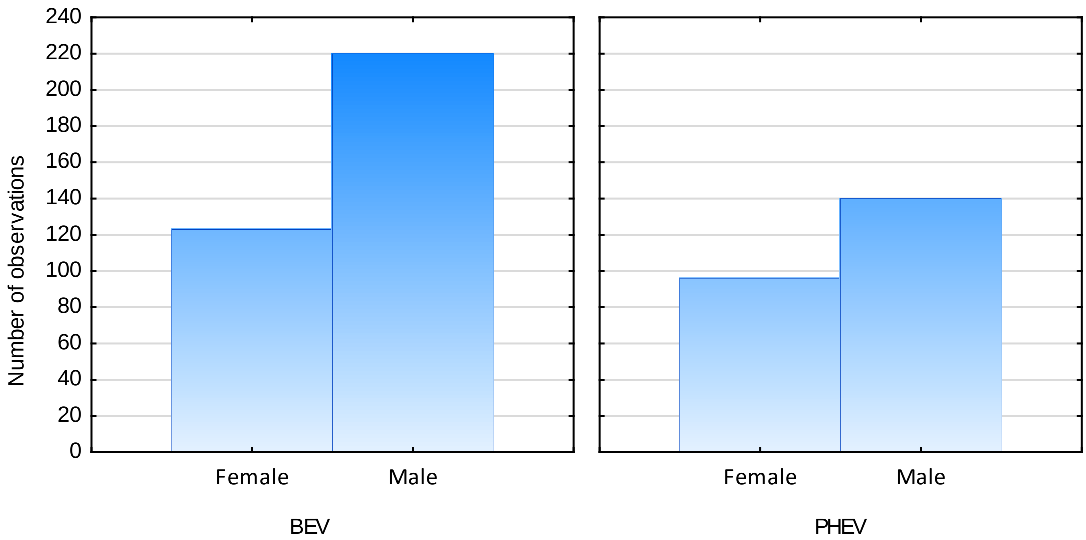

Figure 4. Categorized data histogram showing respondents' opinions by gender in terms of BEV or PHEV vehicle type.

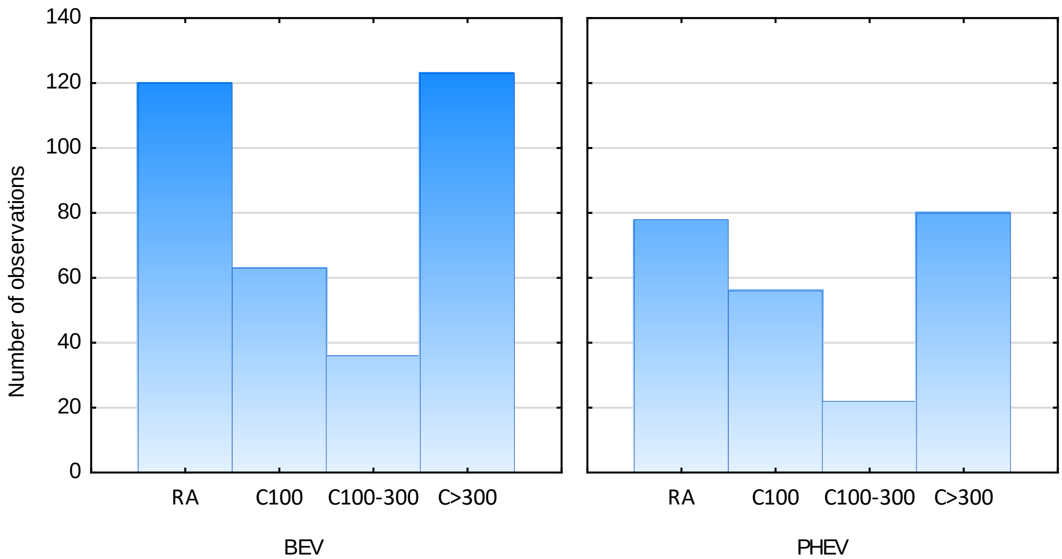

Figure 5. Categorized data histogram showing respondents' opinions by place of residence in terms of BEV or PHEV vehicle type.

Regarding the preferences of respondents with regard to the place of residence and the level of autonomy of these cars (and here, the respondents were asked both about electric cars—BEV and PHEV), the opinions of the respondents referred to the popularity of autonomy Levels 1, 2, and 3. Additionally, in autonomy Level 1, there were respondents living in large cities with more than 300,000 inhabitants, and in Levels 2 and 3, there were respondents living in rural areas. The remaining levels, i.e., the 4th and 5th Levels of autonomy, are still perceived as a level that will not be introduced so quickly due to advanced technology and the need to adapt the road infrastructure.

In the further part of the assumed research procedure, an analysis of the linear correlation between the number of BEV and PHEV vehicles on the market in Poland in 2020 and 2021 was carried out. As already mentioned, the data were obtained from reports on the monitored situation of electromobility in Poland provided by the Polish Automotive Industry Association. Figures 7 and 8 show observations (blue dots) and regression lines (red line). The histogram shows the distribution functions and descriptive statistics for the correlation between the number of BEVs and the PHEV hybrid drive.

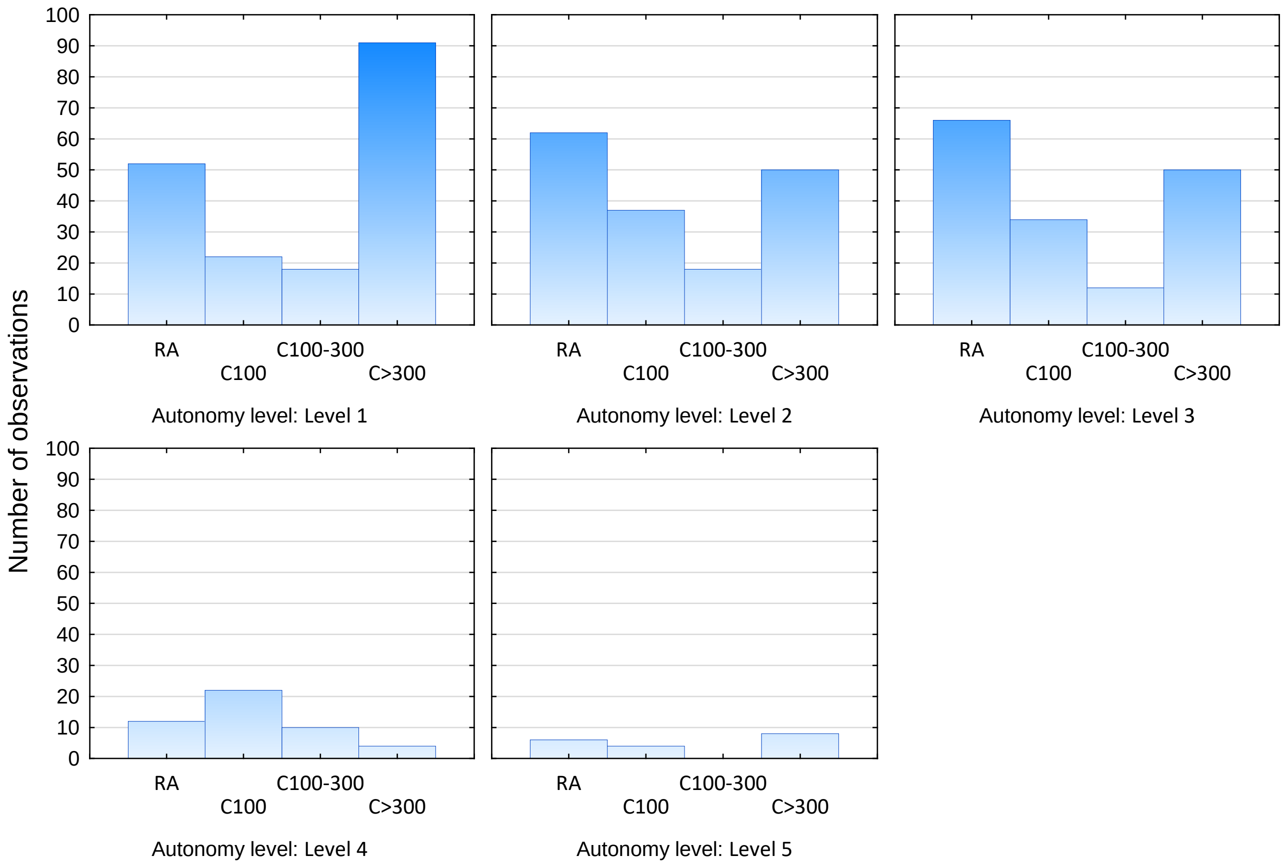

Figure 6. Categorized data histogram showing respondents' opinions by place of residence in relation to the level of autonomy.

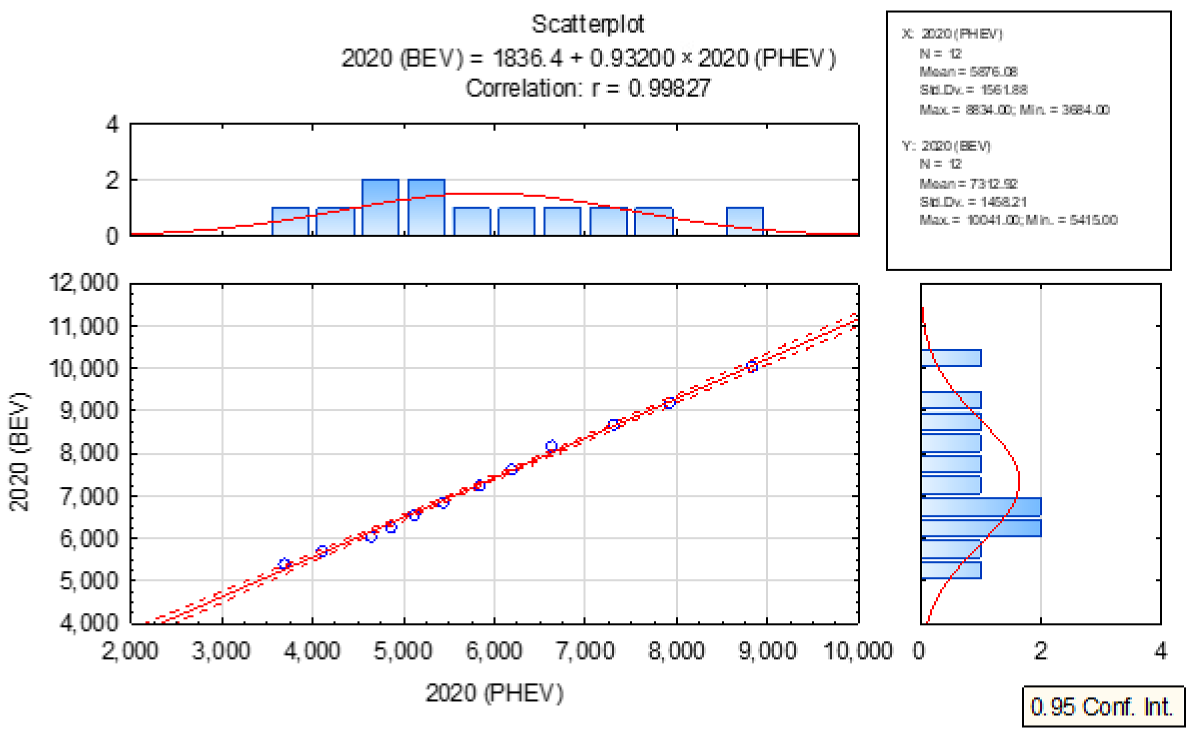

Figure 7. Scatterplot—linear correlation between the number of BEV and PHEV vehicles on the market in Poland in 2020.

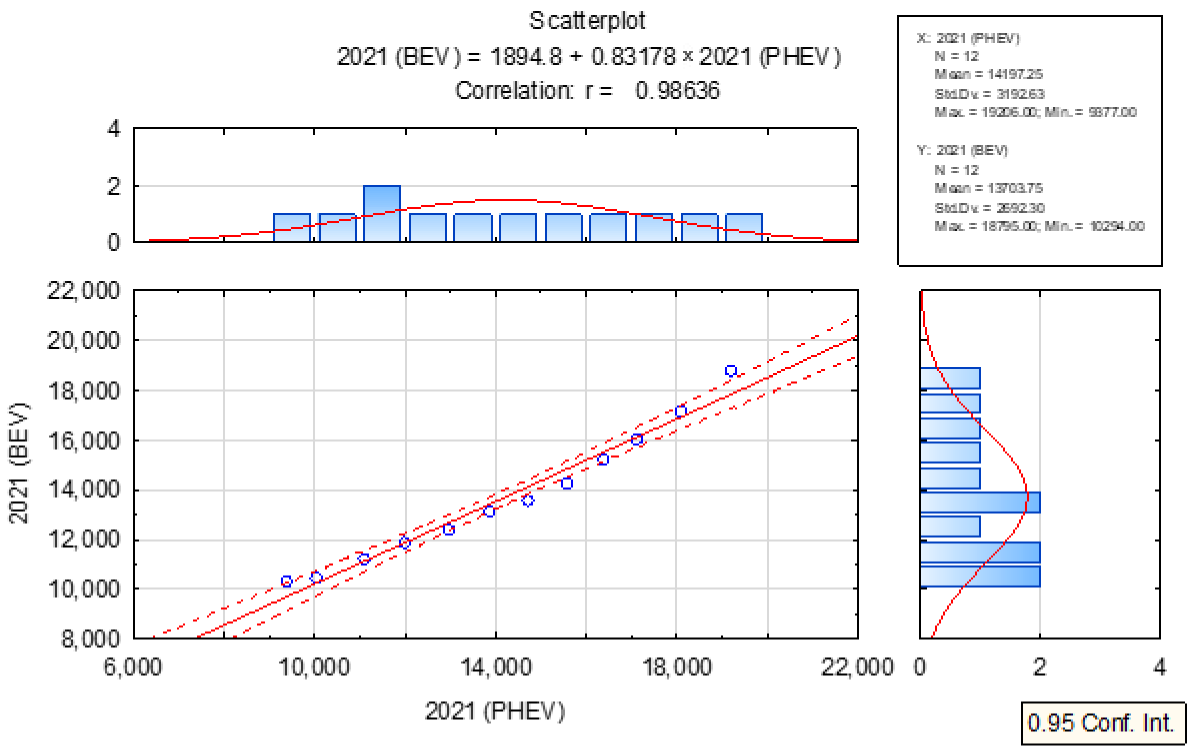

Figure 8. Scatterplot—linear correlation between the number of BEV and PHEV vehicles on the market in Poland in 2021.

The dependence presented in Figures 7 and 8 shows that both the number of electric cars—BEV and PHEV—is strongly related to each other; their number is growing rapidly on Polish roads. On the other hand, the correlation coefficient between the number of cars with a hybrid PHEV drive and cars with electric drive registered in 2020 (correlation 0.9983) and in 2021 (correlation 0.9864) showed a positive and strong correlation between the studied variables (Figures 7 and 8).

Table 3 shows the correlation between the number of registered BEV and PHEV for two years—i.e., 2020 and 2021. It is clearly visible that all correlations are strong and this relationship has a tendency, which indicates the large, growing popularity of both electric and hybrid cars.

Table 3. Correlations, marked correlations are significant at $p < 0.0500$, $n = 28$ (Casewise deletion of missing data).

	2021 (PHEV)	**2021 (BEV)**
2021 (PHEV)	1.0000	**0.9864**
	p = —	$\boldsymbol{p}$ **= 0.0001**
2021 (BEV)	**0.9864**	1.0000
	$\boldsymbol{p}$ **= 0.0001**	p = —
	2020 (PHEV)	2020 (BEV)
2020 (PHEV)	1.0000	**0.9983**
	p = —	$\boldsymbol{p}$ **= 0.0001**
2020 (BEV)	**0.9983**	1.0000
	$\boldsymbol{p}$ **= 0.0001**	p = —

4.2. Discussion of the Results

The results of the research conducted among current and potential Polish drivers (adults over 18 years of age) indicate a fairly large interest in modern solutions in the automotive field in relation to the drive used in the vehicle. Both the interviewed men and women willingly use or would use BEV or PHEV vehicles in the future.

The information obtained in our own research is consistent with the data on the number of BEV and PHEV vehicles on the market in Poland in 2020–2021 (data provided by the Polish Automotive Industry Association), which shows that both the number of electric cars—BEV and PHEV—is closely related, and their number is rapidly growing on Polish roads.

Taking into account, in turn, the dependence of the type of vehicle preferred by respondents (BEV and/or PHEV) on the place of residence, it can be noted that both types of modern vehicles—both BEVs and PHEVs—are most often chosen or would be chosen as a means of transport by people living in rural areas and by residents of large cities. This may result primarily from the professional situation and, consequently, the financial status of this group of respondents—because often people with good and very good professional and material situations live either in large urban agglomerations, or "run away" to less crowded, less noisy and cleaner areas—settling in the countryside but in close proximity to large cities.

Further analyzing the dependence of the vehicle type preferred by the respondents (BEV and/or PHEV) on the place of residence, it should be added that—despite declarations of interest in both types of vehicles under consideration (BEV and PHEV)—electric cars are the dominant choice among these two groups of respondents.

Initial research on the relationship between the place of residence and preferences regarding the type of modern vehicle, e.g., [82,83], began to appear in the literature. However, research in this area has not yet been carried out on a large scale, which highlights the need for such analyses in the near future.

A further in-depth analysis, in which—in relation to the preferences of respondents regarding a given type of innovative vehicle—apart from the place of residence, also the level of autonomy of these cars was taken into account, allows us to state that the respondents took into account mainly the first 3 levels of autonomy vehicles. Respondents living in large urban agglomerations with over 300,000 residents, indicated mainly the first level of autonomy, while respondents living in rural areas mainly Levels 2 and 3. Greater interest in a higher level of autonomy among the respondents living in rural areas may result—in addition to the aforementioned material and professional situation—also from smaller and more difficult travel opportunities. This is confirmed by the research carried out by Losada-Rojas and Gkritz [84], which—using a combination of available secondary data and responses from an online survey of adult residents of the Chicago metropolitan area—obtained results aimed at better understanding individual and location-based characteristics that may affect the level of AV adoption. They stated, inter alia, that the innovators in the analyzed area are mainly people living in areas with lots of greenery, where there is no possibility of active travel—i.e., in rural areas.

The preliminary results were obtained by Kim et al. [85] who found that modern vehicles with varying degrees of autonomy can operate in accordance with attitudinal preferences; what is more, they can stimulate changes, e.g., they can motivate people to change their place of residence. Carrese et al. [86] reached a similar conclusion—they estimated the logit model with a binary index of readiness for relocation on the basis of 201 inhabitants of Rome in Italy—according to them, the gradual introduction of increasingly higher levels of autonomy on a larger scale may generate a relocation of housing from the city center to suburbs or rural areas, due to different perceptions of time—the willingness to change the place of residence was expressed by about 40% of the respondents. Similarly, the results obtained by Zhang and Guhathakurta [87] indicated that commuters may move to better districts, more distant from centers or even from cities, due to the reduced costs of commuting. On the other hand, Milakis et al. [88] expect that AV will change the urban form in two opposite but simultaneous ways: on the one hand, the density of city centers, but on the other, the extended expansion of cities, as some people may move away from city centers and transfer to rural areas for typical reasons (larger and/or cheaper apartments, more amenities), taking advantage the lesser inconvenience of traveling, which is possible due to the possibility of performing a wider range of activities during the trip.

However, it should be remembered that these results should be treated with caution because the research conducted so far does not take into account other variables, such as travel time and costs, housing costs, and the choice of means of transport.

Moreover, as Fevang and his team [89] show—based on the analysis of the Norwegian market of innovative vehicles, especially those with electric drive (Norway is the country with the highest share in the market of low-emission vehicles)—socio-economic features are strong predictors of the car portfolio, hence they should be taken into account when designing research. The aforementioned authors stated, among others, that the possession of an electric vehicle (BEV) is strongly correlated with such grouping variables as socio-professional status, financial situation, and the level of education.

After analyzing the obtained results, it also seems that the people taking part in the study are aware of the current situation in the automotive market, where vehicles that are characterized by autonomy Levels 4 and 5 are still in the field of research and are not yet known and used widely, mainly due to their cost, resulting from the use of technologically advanced solutions in such vehicles. No less important seems to be incomplete compatibility and adaptation of road infrastructure, as well as not having the highest level of awareness (in the area of autonomy and safety) among all road users, not only drivers. This is confirmed by the results of studies by other authors, according to which it is expected that fully autonomous mobile robots, which do not have a manual driving mode, will be available only from 2030, while optimistic forecasts assume that in 2035, highly and fully automated vehicles will achieve a share of the market at a level of 11 to 42 percent [90,91].

Summarizing the above, it can be concluded that the rapid development of modern technologies used in contemporary vehicles has led to widespread interest in how and to what extent they will affect the society, economy, and market, including primary mobility, lifestyle, and the built-up environment of cities. The impact of autonomous vehicles seems to be particularly important, as they are perceived as a breakthrough solution in areas such as system management, transport planning, and land use policy, among others [85]. However, in order to take full advantage of the potential benefits of these vehicles, it should be remembered that city and transport planners need to include autonomous vehicles even more proactively in their planning activities [92], and companies in the automotive industry need to put even more emphasis on activities aimed at improving public knowledge and awareness of various aspects, as well as the effects of autonomy.

5. Conclusions

As was shown in many different studies, vehicles with different levels of autonomy, i.e., those using both PHEV and BEV, can have a huge impact on many aspects of a social, economic, and environmental nature, including increased mobility in different groups of people.

Therefore, in order to present the significance of the development of the automotive market in relation to the level of autonomy with which they are associated, research was carried out, which made it possible to summarize these relationships. The presented analysis of the selected types of vehicles with modern drives in relation to the level of their autonomy, registered in Poland over the last few years, as well as the obtained results of our own research, analyses, and considerations, allowed us to draw the following conclusions:

– The automotive market is dynamically developing and changing its structure;
– Drivers are increasingly choosing PHEV and BEV cars, both in 2019 and 2020, which is confirmed by both market data and correlation results obtained in our own research;
– Solutions used in modern vehicles are—according to the respondents—well developed, and the vehicles themselves are more and more often equipped with various driving assistance systems;
– In the context of the levels of autonomy, however, most often Levels 1, 2, and 3 are indicated as those that will play the leading role in the near future.

However, it should be remembered that along with the development of the vehicle market, the development of infrastructure must also follow it, because these are two inherent elements that will enable the development of electromobility and make it even more effective.

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