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Multi-Criteria Analysis of the Selection of Vehicles with Electric, Hybrid, and Conventional Drive for Car-Sharing Services from the Perspective of Polish Occasional System Users

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Abstract: Car-sharing systems, i.e., short-term car rentals, are one of the solutions that can be an alternative to individual motorization in cities. However, these services must adapt well to customers' needs to develop appropriately. Currently, there have been attempts in scientific research to make numerous optimizations of car-sharing systems, but little emphasis was placed on the type of car fleet used in the systems, which is particularly important at the stage of transformation of the automotive industry towards electric mobility. In response to this research gap, this article was dedicated to the selection of vehicles for car-sharing systems. The work focuses on users of Polish car-sharing systems who use the services of short-term vehicle rental occasionally, i.e., up to five times a year. The research made it possible to determine the types of vehicles (cars with electric, hybrid and internal combustion engines) that the users are interested in and to indicate the specific features that the cars should have. Interestingly, large family vehicles with hybrid engines turned out to be the leading ones. In turn, small city cars, so far dominant in car-sharing, turned out to be the worst choice from the point of view of occasional users. This showed that the current systems are not properly adapted to the needs of society. The results support car-sharing operators who want to upgrade their vehicle fleet accordingly to encourage the public to use car-sharing more often. It is also a guide to identifying a vehicle for fleet modernization towards hybrid and electric vehicles.

Keywords: car-sharing systems; electric car-sharing systems; e-car-sharing; electric mobility; electromobility; shared mobility; sustainable transport systems; transportation engineering; civil engineering and transport; multi-criteria data analysis; mobility management

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1. Introduction

The use of various solutions to reduce the negative impact of transport on the environment is a standard that has become part of the behavior of cities and countries around the world. Among the full range of solutions that offer new mobility, car-sharing services are one of the travel options that replace individual motorization. Car-sharing services are systems that allow for automated car rental "by the minute". Services are usually offered in urban areas. To use them, the operator's application, installed on a smartphone, is required. Unlike classic car rentals, car-sharing provides much more freedom of movement [1]. It also allows users to have the system available 24 h a day, provides the possibility of returning the vehicle at a convenient time without the need to contact the customer service office, and offers additional profits in the form of, for example, paid parking spaces within the operator's zone or moving along lanes intended for buses [1,2]. Due to numerous superlatives, car-sharing systems are described as the most convenient form of new mobility for users compared to sharing scooters or bicycles [3]. Due to their wide availability and the possibility of eliminating numerous social and economic barriers related to, for example, the lack of funds for the purchase of one's car [4] or the lack of access to other forms of

transport [5,6], car-sharing services began to be increasingly promoted by city authorities as forms of travel in cities, which resulted in service operators' boom in the market [7–9]. This interest translated into numerical values. Current statistics show that worldwide car-sharing systems are provided in 59 countries by 236 operators [10]. This means that 380,000 cars are available to end-users under the schemes, and this number continues to grow [10]. Forecasts indicate, however, that in 2025 the number of cars that will be available in car-sharing systems will amount to over 7.5 million vehicles, which will translate into a market value of over 11 billion dollars [11]. The idea seems to be a promising transport alternative. However, to achieve the system's full development, apart from the high interest on the part of business and city authorities, the most important is the interest of the public. Analyzing the world literature in the field of public interest in car-sharing systems, one can find many studies trying to identify the main reasons for the failure of system development. The main research areas related to the car-sharing fleet are presented in Figure 1.

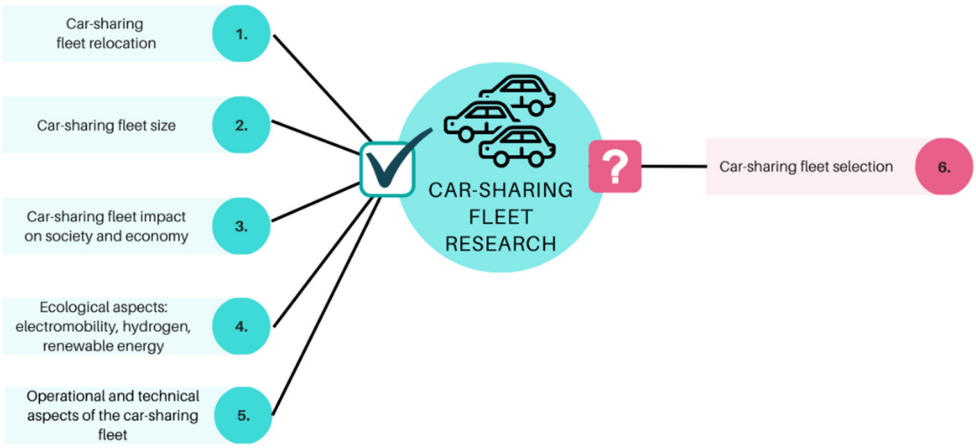

Figure 1. Car-sharing fleet research topics and indicated research gap.

In the literature, among the research devoted to car-sharing, it is possible to identify the reasons for the failure of car-sharing related to [12–17]:

- mismatch between the systems and the lifestyle of potential users,
- too high travel costs,
- having insufficient knowledge about the principles of system operation,
- making too few rentals for it to become a habit,
- insufficient promotion of car-sharing systems in the city,
- insufficient vehicles in cities or systems malfunctioning due to inadequate vehicle relocation.

The indicated problems are mainly related to improper management of systems, incorrect optimization, or inadequate promotion, and are widely discussed and solved in the literature.

However, in the search for opportunities to improve car-sharing performances, the issue of cars is insufficiently emphasized in the studies. While there are works on the implementation of electric vehicles and their infrastructure [18–20], the impact of the fleet on environmental factors [20,21], and the location or relocation of cars [22,23], the issues related to detailed analyses of the fleet of cars used in the systems and specific preferences of society towards vehicles are ignored. At this point, it is worth emphasizing that it is cars that are the main element of car-sharing. Without cars, the systems would not function properly. Car-sharing vehicles' technical conditions and availability will determine whether the service will be provided and how it will be assessed. And what is more, in a broader perspective, the cars are responsible for the quality of the trip and relate to the decision process of whether users will want to use the car-sharing service again. Noticing this research gap, the author dedicated a research cycle to the selection of a fleet of cars for

car-sharing systems and the preferences of various system customers. This study aims to present the preferences regarding the selection of vehicles and their features by people who occasionally (one to five times a year) use car-sharing systems. The research was carried out for the Polish market. The article is intended to encourage the public to use car-sharing services and to support car-sharing service operators in completing a new fleet or modernizing the current fleet of vehicles.

The article is divided into five chapters. The first one presents an introduction and a general outline of the concept of car-sharing, and the second chapter is devoted to the presentation of the research methodology. The third chapter presents the results of the research, which are discussed in the fourth chapter. The last chapter presents conclusions, as well as research limitations and further research plans for the presented subject.

2. Methodology

Choosing a car that will suit the needs of society is a very complex matter, both in the case of selecting a car to suit one's own needs as well as car-sharing systems. It requires considering many possible variants (car models) and their attributes (individual features, technical data, performance, equipment level, etc.). These attributes, depending on their preferences, will play a greater or lesser role for decision-makers. Therefore, it is important to achieve a proper societal assessment of them. These assessments serve as weights that constitute input data to the analytical process when deciding based on a multi-factor examination of a given problem, which uses Multiple-Criteria Decision Analysis (MCDA) methods. MCDA methods allow access to decision variants and create their final sequence [24–26]. Among the many MCDA methods that are used to solve real transport problems [27], it is a commonly used tool in the case of comparing individual attributes, isolating the relationships between analyzed variants, and obtaining the final sequence of variants [28]. Its main advantage is the direct participation of the decision-maker in the decision-making process [28]. The method enables the decision-maker to analyze both qualitative and quantitative criteria at different levels of ambiguity [28], therefore the method was used in these analyses.

The research was carried out for a case study of the Polish car-sharing services market. The Polish car-sharing market is considered one of the most dynamically developing shared mobility markets in Europe [29,30]. At the peak of interest in car-sharing services of the business community in 2017, the services were provided by 17 operators in more than 250 Polish cities [30]. This translated into monetary results at the level of annual revenues of 50 million PLN in 2019 and 100 million PLN in 2021 [30]. However, the streak ended with many unexpected shutdowns and restrictions on their operations. Currently, there are 5 car-sharing system operators available in Poland [31]. Due to numerous limitations in the functioning of the systems, there is a real need to conduct research on all kinds of system improvements, including the modernization of the vehicle fleet.

To answer the question of which vehicles will best meet society's expectations, this study was proposed according to the following scheme:

(1) Identification of variants or models of vehicles that can be implemented in car-sharing services. Specifying the attributes describing each of the variants with an indication of the numerical values of individual attributes, e.g., performance or technical data.
(2) Conducting social research aimed at making comparisons by the society in pairs of individual attributes (without knowing what vehicle model the attributes apply to, to avoid possible selection suggestions) to evaluate them by assigning appropriate values to Saaty's scale from 1 to 9 [32]. The scale determines the importance level of one attribute concerning the other according to the level that both attributes considered are of equal importance to the respondent (value 1), to the overall and extreme advantage of one attribute over the other in the analyzed pair (value 9) [32]. The average value of the weights of the individual criteria is prepared from the obtained scores.
(3) Carrying out mathematical analysis using the ELECTRE III method along with the definition of its basic parameters, including the difference, Δ, between the maximum

and minimum values of a given attribute, equivalence threshold Q, preference threshold p, and veto threshold V, thus creating a difference matrix and determining the ascend and descend distillation (appropriate ordering of variants in the ranking).

(4) Obtaining an ordered ranking of vehicle models and indicating the importance of individual attributes.

The detailed research process is presented in the form of the scheme in Figure 2.

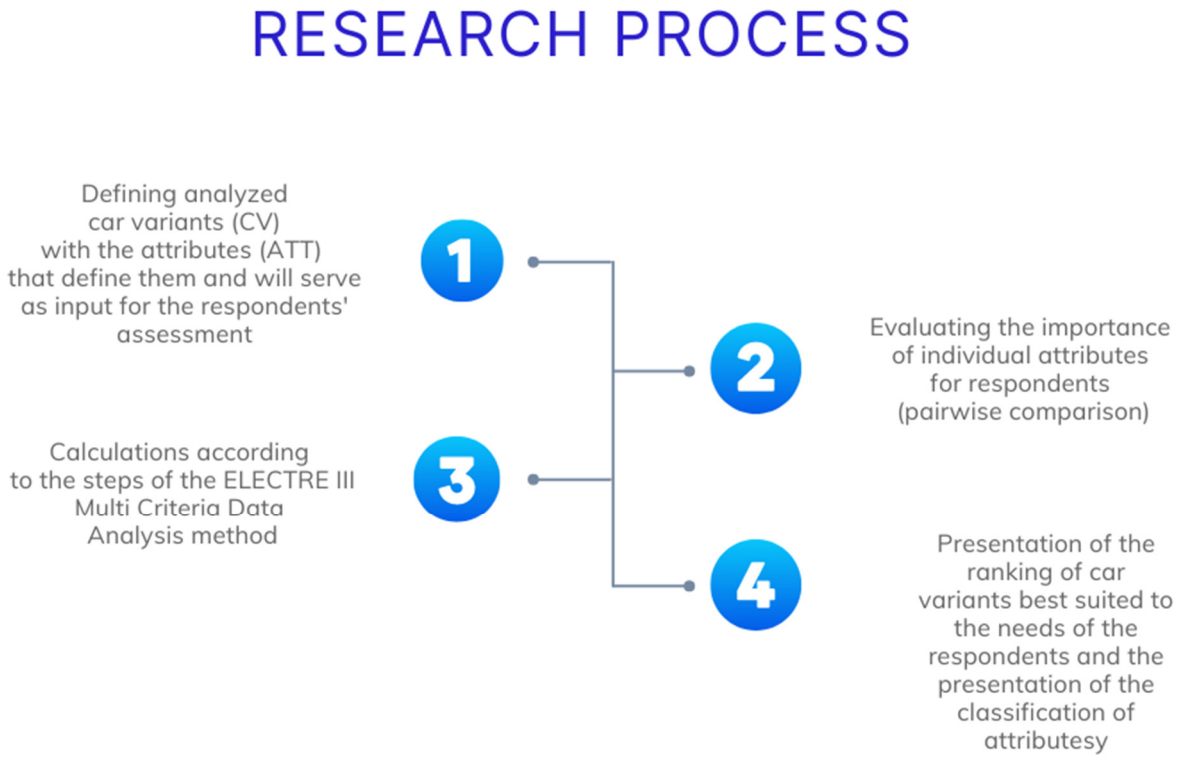

Figure 2. Research process.

Based on the above scheme, the research was carried out, the results of which are presented in Section 3.

3. Results

The research was commissioned by one of the car-sharing system operators operating in the Polish market, who wanted to know whether the currently offered vehicle fleet fully meets the expectations of its customers. The operator currently has a fleet of 2000 cars, which includes small city cars from the B segment, referred to as sub-compact cars. Currently, the vehicles on offer are equipped mainly with internal combustion engines. In line with the guidance received from the operator, he also wished to consult on the possible implementation of more electric vehicles and their adoption by users.

For the analysis of vehicles that can be covered by the implementation of car-sharing systems, 12 different car models were selected, representing different car brands and vehicle sizes, and belonging to different segments, price ranges, and engine types. The models that were the most popular, and at the same time had the most ecological solutions, were considered. Both combustion engine vehicles as well as electric and hybrid vehicles were included. When identifying the list of vehicles that can be implemented in the systems, the focus was on new, popular, and most environmentally friendly cars. The latest automotive reports, "The best-selling cars in Europe in 2022" [33] and "The best low-emission green cars 2022" [34] were used. What is more, efforts were made to consider vehicle models that are now successfully used in foreign car-sharing systems. The models considered, together with the indicated engine type, are presented in Table 1.

Table 1. Considered decision variants.

Analyzed Car Variants	Power Type
CV_1	Internal Combustion Engine
CV_2	Internal Combustion Engine
CV_3	Internal Combustion Engine
CV_4	Internal Combustion Engine
CV_5	Hybrid Engine
CV_6	Hybrid Engine
CV_7	Hybrid Engine
CV_8	Hybrid Engine
CV_9	Electric Engine
CV_10	Electric Engine
CV_11	Electric Engine
CV_12	Electric Engine

Successively, following the research plan scheme, the attributes that were considered in the analysis of individual vehicles were determined. Thirteen attributes presented and characterized in Table 2 were indicated. The factors were partly selected based on the literature [35–37], supplemented by arbitrary indications of the author.

Table 2. Factors characterizing decision variants.

Factor No.	Factors Describing Vehicle Models	Characteristics of Factors
ATT_1	Vehicle length [mm]	Distance from the front to the rear of the vehicle in millimeters.
ATT_2	Maximum speed [km/h]	The maximum rate of change in the position of the body concerning the frame of reference.
ATT_3	Acceleration [s]	Physical quantity informs about how quickly the vehicle speed changes from 0 [km/h] to 100 [km/h].
ATT_4	Luggage compartment capacity (seats up) [l]	The size of the luggage space expressed in the number of liters it can accommodate, considering the folded-up seats.
ATT_5	Engine power [kW]	Engine power is the amount of work an engine can do in a given time.
ATT_6	Energy consumption [kwh/100 km]	The average value of fuel consumption in the combined cycle (city and highway driving).
ATT_7	Time of battery charging/time of refueling [min]	Minimum charging time with DC fast charger in the case of electric car or minimum amount of time to refuel an internal combustion engine car's fuel tank.
ATT_8	Maximum range [km]	Maximum route distance to be traveled with a full tank of fuel/fully charged battery.
ATT_9	Rental fee [€]	The average cost of 1 min of travel and 1 km of travel, including a minute stop-over fee.

Table 2. *Cont.*

Factor No.	Factors Describing Vehicle Models	Characteristics of Factors
ATT_10	Euro NCAP rating [-]	Five-star safety rating system to help consumers identify the safest choice for their needs. The safety rating is determined from a series of vehicle tests designed and carried out by the Euro NCAP organization.
ATT_11	Number of seats in the car [-]	The number of seats the car model is fitted with.
ATT_12	Number of doors in the car [-]	The number of doors the car model is fitted with
ATT_13	CO_2 emission [g/km]	The amount of carbon dioxide produced by the vehicle's engine per kilometer of traveled route.

Successively, individual attributes were assigned values corresponding to the performance and technical data of individual vehicle models, which are presented in Table 3.

Table 3. The values of the attributes describing the analyzed variants of cars.

Car Variant	Vehicle Length [m]	Maximum Speed [km/h]	Acceleration [s]	Luggage Compartment Capacity [l]	Engine Power [kW]	Energy Consumption [kwh/100 km]	Time Of Battery Charging/Time Of Refueling [Min]	Maximum Range [km]	Rental Fee [€]	Euro NCAP Rating [-]	Number of Seats in the Car [-]	Number of Doors in the Car [-]	CO_2 Emission [g/km]
	ATT_1	ATT_2	ATT_3	ATT_4	ATT_5	ATT_6	ATT_7	ATT_8	ATT_9	ATT_10	ATT_11	ATT_12	ATT_13
CV_1	3600	196	8.8	251	85	24.17	3	729	0.41	3	5	5	110
CV_2	4154	210	8.2	400	110	30.02	3	625	0.44	5	5	5	112
CV_3	4060	188	9.9	309	74	31.48	3	672	0.44	4	5	5	130.7
CV_4	4869	238	7.7	625	140	31.99	3	1065	0.58	5	5	5	139
CV_5	4689	230	8.5	600	110	29.93	60	948	0.48	5	5	5	30
CV_6	4050	180	9.9	301	103	26.32	60	765	0.44	5	5	5	87
CV_7	4515	193	7.7	591	169	36.12	55	915	0.48	5	5	5	135
CV_8	4500	193	8	616	169	30.44	55	881	0.48	5	5	5	140
CV_9	3632	150	9	185	87	14.3	50	470	0.41	4	4	3	0
CV_10	4490	144	7.9	435	110	16.6	60	285	0.48	5	5	5	0
CV_11	4261	160	8.9	370	110	14.9	52	351	0.48	5	5	5	0
CV_12	4584	160	9	543	125	16.9	60	343	0.58	5	5	5	0

Vehicle performance values based on technical data provided by vehicle manufacturers.

Then, the importance of individual attributes describing the vehicles was determined. For this purpose, a social survey was carried out with the participation of respondents who were users of the operator's system who use the services occasionally, i.e., up to five times a year. The survey was conducted anonymously online via the operator's application in June 2022. A total of 404 people took part in the study. For the tested sample, the confidence level was 96% ($\alpha = 0.96$). The fraction size was 0.6 and the maximum error was estimated at 5%. The respondents were presented with a pairwise comparison questionnaire. Their job was to compare each pair of attributes and assign them appropriate weight values from one to nine on Saaty's scale. It is worth noting that when comparing in pairs, the respondents compared individual attributes and not the values that describe them. As a result, they were not aware of which car models the data related to, which allowed them to achieve impartiality. The research questionnaire is presented in Figure 3.

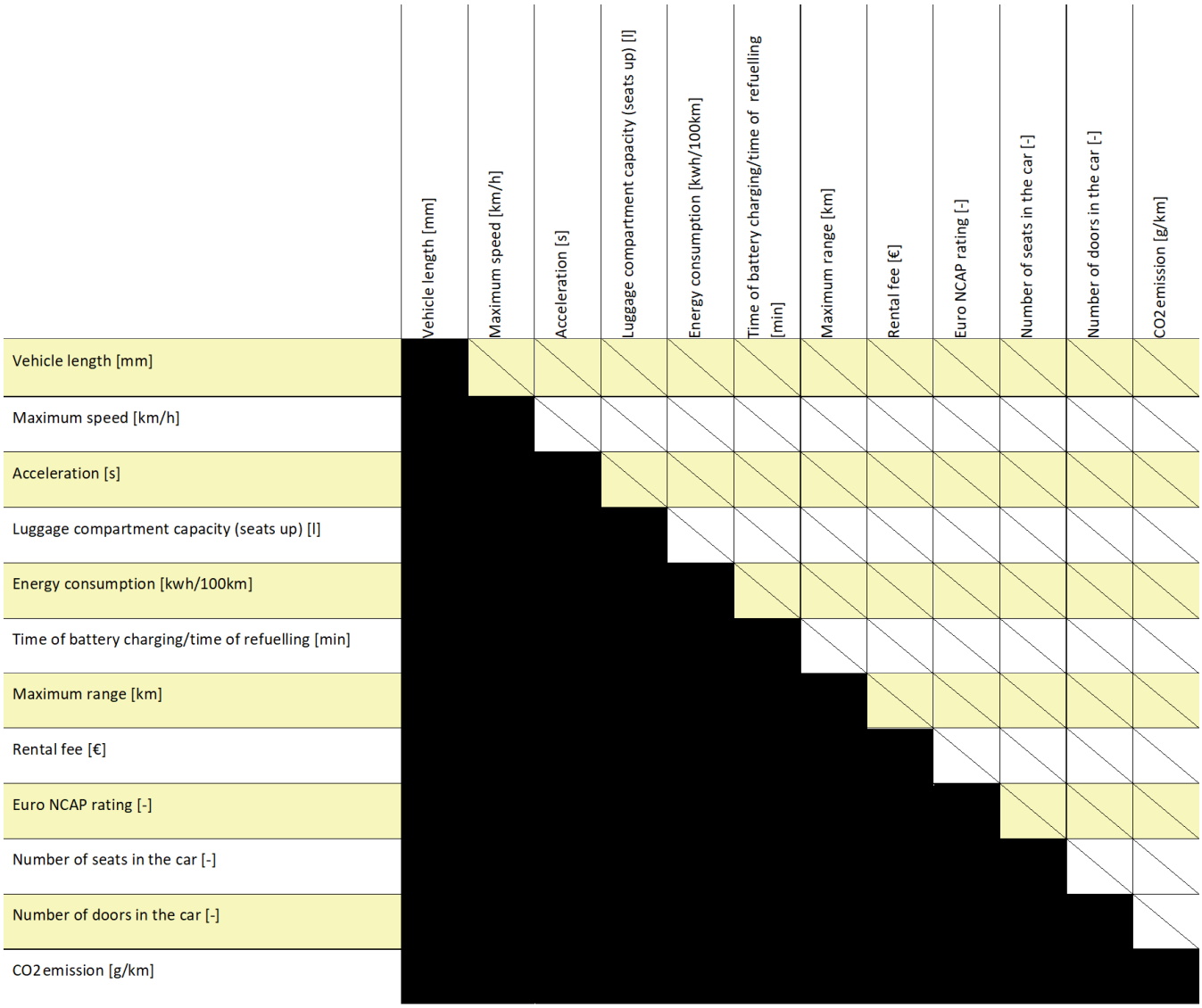

Figure 3. Pairwise matrix research questionnaire.

The obtained averaged weights of the individual attributes are presented in Table 4.

Table 4. Attribute weights.

	ATT_1	ATT_2	ATT_3	ATT_4	ATT_5	ATT_6	ATT_7	ATT_8	ATT_9	ATT_10	ATT_11	ATT_12	ATT_13
Average attributes weights	0.054	0.07	0.113	0.1	0.088	0.101	0.04	0.094	0.07	0.09	0.06	0.03	0.09

The next step following the ELECTRE III methodology was to determine the parameters characterizing the relationships between the studied factors, i.e., the maximum difference of criteria values, equivalence threshold, preference threshold, and veto threshold. Detailed data are presented in Table 5.

Table 5. The set of equivalence, preference, and veto thresholds.

	ATT_1	ATT_2	ATT_3	ATT_4	ATT_5	ATT_6	ATT_7	ATT_8	ATT_9	ATT_10	ATT_11	ATT_12	ATT_13
Maximum Difference of Attributes Values	4869	238	9.9	625	169	36.12	60	1065	0.58	5	5	5	140
Equivalence Threshold	1217.25	59.5	2.475	156.25	42.25	9.03	15	266.25	0.145	1.25	1.25	1.25	35
Preference Threshold	2434.5	119	4.95	312.5	84.5	18.06	30	532.5	0.29	2.5	2.5	2.5	70
Veto Threshold	4869	238	9.9	625	169	36.12	60	1065	0.58	5	5	5	140

The next step according to the ELECTRE III methodology was to create the concordance matrix. The matrix is presented in the form of Table 6.

Table 6. Concordance matrix values.

Car Variants	CV_1	CV_2	CV_3	CV_4	CV_5	CV_6	CV_7	CV_8	CV_9	CV_10	CV_11	CV_12
CV_1	-	0.946	1.0	0.7855	0.798	0.892	0.6784	0.711	0.946	0.8753	0.892	0.7983
CV_2	1.0	-	1.0	0.8934	0.8984	0.946	0.8813	0.8752	0.946	0.946	0.946	0.946
CV_3	1.0	1.0	-	0.8089	0.8613	0.946	0.7823	0.7673	0.946	0.946	0.946	0.881
CV_4	1.0	1.0	1.0	-	0.946	0.946	0.946	0.946	0.946	0.946	0.946	0.946
CV_5	0.97	0.97	0.97	0.97	-	0.9811	0.9351	0.9351	1.0	1.0	1.0	1.0
CV_6	1.0	1.0	0.9925	0.8788	0.9141	-	0.8503	0.8411	1.0	1.0	1.0	0.9484
CV_7	1.0	1.0	1.0	1.0	1.0	1.0	-	1.0	1.0	1.0	1.0	1.0
CV_8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-	1.0	1.0	1.0	1.0
CV_9	0.9186	0.8171	0.8368	0.5589	0.6796	0.8838	0.5831	0.6173	-	0.9016	0.9407	0.8519
CV_10	0.9032	0.8834	0.8592	0.7264	0.8066	0.882	0.7341	0.7664	1.0	-	1.0	1.0
CV_11	0.9253	0.899	0.865	0.6925	0.7726	0.8878	0.6952	0.7092	1.0	1.0	-	0.9899
CV_12	0.925	0.9183	0.8844	0.7742	0.8394	0.9071	0.7654	0.8159	1.0	1.0	1.0	-

The next stage in the ELECTRE III method was to perform the ascend and descend distillation against each of the variants, and, in the final step, to create the dominance matrix. The dominance matrix is presented in Table 7.

The last step was to prepare the final ranking, presenting the ranking of variants in terms of the preferences of experts and the adopted factors. The final ranking is presented in Table 8.

Table 7. Dominance matrix values.

Car Variants	CV_1	CV_2	CV_3	CV_4	CV_5	CV_6	CV_7	CV_8	CV_9	CV_10	CV_11	CV_12
CV_1	-	P−	P−	P−	P−	P−	P−	P−	P−	P−	P−	P−
CV_2	P+	-	R	P−	P−	R	P−	P−	P+	R	P+	R
CV_3	P+	R	-	P−	P−	P−	P−	P−	P+	I	P+	I
CV_4	P+	P+	P+	-	I	P+	I	P−	P+	P+	P+	P+
CV_5	P+	P+	P+	I	-	P+	I	P−	P+	P+	P+	P+
CV_6	P+	R	P+	P−	P−	-	P−	P−	P+	P+	P+	P+
CV_7	P+	P+	P+	I	I	P+	-	P−	P+	P+	P+	P+
CV_8	P+	P+	P+	P+	P+	P+	P+	-	P+	P+	P+	P+
CV_9	P+	P−	P−	P−	P−	P−	P−	P−	-	P−	P−	P−
CV_10	P+	R	I	P−	P−	P−	P−	P−	P+	-	P+	I
CV_11	P+	P−	P−	P−	P−	P−	P−	P−	P+	P−	-	P−
CV_12	P+	R	I	P−	P−	P−	P−	P−	P+	I	P+	-

Where: (I)—a pair of car variants are equivalent; (P+)—the first car variant is better than the second car variant; (P−)—the first car variant is worse than the second car variant; (R)—car variants are incomparable.

Table 8. Final ranking.

Dominance Matrix	Ascend Distillation	Descend Distillation	Average	Podium Classification
CV_1	5.0	4.0	4.5	
CV_2	1.0	4.0	2.5	ex aequo 3rd place
CV_3	3.0	3.0	3.0	
CV_4	1.0	2.0	1.5	ex aequo 2nd place
CV_5	1.0	2.0	1.5	ex aequo 2nd place
CV_6	2.0	3.0	2.5	ex aequo 3rd place
CV_7	1.0	2.0	1.5	ex aequo 2nd place
CV_8	1.0	1.0	1.0	1st place
CV_9	4.0	4.0	4.0	
CV_10	3.0	3.0	3.0	
CV_11	3.0	4.0	3.5	
CV_12	3.0	3.0	3.0	

4. Discussion

Based on the research, it can be concluded that by using the multi-criteria decision support method, ELECTRE III is suitable for solving the problem of selecting vehicles for car-sharing systems. In the analyzed case study, the use of the ELECTRE III method allowed indication of which car models best meet the expectations of Polish users occasionally using car-sharing systems.

Based on the obtained results, it should be stated that the best solution to be used in car-sharing systems turned out to be the CV_8 variant, which is a large family car representing the D-vehicle segment longer routes. Interestingly, ex aequo, the models CV_4, CV_5, and CV_7 took the second position. In the case of the CV_4, it is also a large family vehicle, representing a D-vehicle segment, similar to the winning model. In the case of the CV_5 and CV_7 models, these are cars representing the so-called "lower average" class C, which are vehicles characterized by a compact design that provide relative driving comfort for four adults and a moderately large space for luggage. The third place in the ranking ex aequo was taken by the CV_2 and CV_6 cars, i.e., city vehicles from segment B. These are vehicles intended mainly for city driving, allowing a moderately comfortable ride for four people on the road. However, they are usually characterized by a small luggage space and dimensions. Interestingly, the last and penultimate place in the ranking was taken by the CV_1 and CV_9 models, i.e., cars representing the smallest possible class of cars, segment A, which includes small cars intended for city driving, characterized by small dimensions and

small luggage space. An important conclusion is the fact that large-size cars turned out to be the leading vehicle. Interestingly, small vehicles, ideologically dedicated to car-sharing systems, were not of interest to users.

When analyzing vehicle models from the point of view of the importance of individual attributes, it should be stated that the leading features turned out to be acceleration, luggage compartment capacity, and maximum range. Such results indicate that users want to use cars that will provide them with agile acceleration in urban conditions, as well as the ability to cover the longest possible distance, which is important especially in the case of electric vehicles. It is also worth pointing to the importance of the size of the luggage space, which turned out to be crucial for users. On the other hand, the number of seats in the car, number of doors, and rental fee turned out to be the least important. These conclusions are very interesting because they show that the users, although they would be willing to rent large vehicles, would not use them for more than four people. What is more, an important conclusion is also the approach to the rental fee, which showed little importance among the attributes. This proves that if the operators' offer would include vehicles that meet the expectations of users, they would be willing to pay more to be able to make a journey in a car compatible with their preferences.

The users' approach to the issue of ecology is also important. A vehicle equipped with a hybrid engine took the leading position. Moreover, hybrid vehicles also came second. This may indicate the fact that users are aware of the need for environmentally friendly transport, but due to the desire to travel as long as possible with cars, electric cars did not manage to win over hybrid cars. It is also worth emphasizing that the aspect of carbon dioxide emissions was not indifferent to users.

Comparing the obtained results with the research on other groups of users using car-sharing systems in Poland, i.e., frequent and regular users, it should be mentioned that the preferences of occasional users are very similar to them [35–37]. This is a very valuable tip for both the operator for whom the tests were performed and the entire Polish car-sharing market, as it indicates that the vehicles that would be most interesting for users are large family cars with high engine performance and a large trunk. Interestingly, such preferences differ from those currently used in car-sharing systems in Poland. It is worth mentioning that the systems are dominated by small and city cars of B and C classes, which, as research shows, do not fully meet the expectations of society. It is also an important conclusion from the point of view of car-sharing research because so far it was believed that small and city cars of A and B classes are vehicles that should consist of a car-sharing fleet [38].

5. Conclusions

Summarizing, the conducted research allowed the achievement of the goal of indicating the type of vehicles that meet the expectations of customers who occasionally use car-sharing systems. Research has shown that the best solution is to use large and family vehicles with the best possible engine performance and the largest possible cargo space in fleets. It is important that they are hybrid cars that will allow covering the greatest possible distances ecologically. The research showed that ecological issues are important for occasional users, which was confirmed by the fact that cars with combustion engines were placed in the leading positions. The results indicate, however, that due to the importance of the ability to cover the longest distances, electric cars did not take the main places in the ranking. However, this is an important tip, because along with the development of technology used in electric cars and the extension of their travel distances, it will be possible to successfully replace hybrid cars with electric ones, which will also meet the expectations of users.

Moreover, the conducted research showed little interest in users of small vehicles, which are commonly dedicated to car-sharing services. This can answer the question of why users use car-sharing systems occasionally, because currently in Poland car-sharing systems are based on this type of small and city vehicles. This is an important conclusion

for operators wishing to modernize their vehicle fleets. It is also worth mentioning that the results obtained for the analyzed group of occasional users coincide with the expectations of frequent and regular car-sharing users. From the point of view of mobility management, it is therefore worth optimizing car-sharing fleets and deciding whether replacing the current small cars with even a smaller number of large vehicles that meet the expectations of users would not make much sense, for example, from the point of view of "freeing" public space that is occupied by unused cars. It is also worth considering whether, in the case of customers who want to rent large vehicles, it would not be better to use classic daily rental instead of car-sharing. Considering the high costs of replacing the car fleet, it is worth considering the change of business models and finding a group of recipients who would be interested in the current fleet of small cars. The currently obtained results allow us to assume that these would be customers not currently using car-sharing services, because the remaining groups of customers, from occasional, though rare, frequent, and regular, are interested in large vehicles.

This article, like any other research work, has its limitations. The main limitation is the research conducted in terms of the area of the Polish market. The second limitation is a strictly defined group of users for which the research was carried out. Due to this, in the next work the author plans to expand the group of analyzed users to obtain the full range of the fleet tailored to the needs of each of them. What is more, the author also plans to carry out this type of research for other countries to show differences in the approach to the vehicle fleet, especially in countries with a highly developed approach to using car-sharing systems.

The main limitation is that the research was conducted in terms of the area of the Polish market. The second limitation is the method of pairwise comparisons used in the work. According to its assumptions, the respondents assessed attributes on the Saaty scale, which limits the possibility of expressing opinions in numerical form (weights from one to nine). For the researcher, this is a convenient form due to numerical standardization, but it limits the respondents' ability to express their own opinions, for example, in a qualitative rather than quantitative form. Another limitation is the lack of similar studies in other geographical areas in the literature. The lack of such publications makes it impossible to conduct an extensive discussion of the results concerning studies by other authors. Another of the limitations can be considered to be the narrowing of the research only to a specific group of respondents. It is also impossible to determine the detailed market value of the analyzed group of respondents in relation to the entire car-sharing market in Poland. Therefore, the author's research plans include the development of an article where a coherent summary of the expectations of various social groups will be presented, which will be important for car-sharing operators who want to know the results for the full range of system customers in Poland. The author also plans to conduct similar research for other geographical areas, especially those where car-sharing systems are highly developed. The author also plans to study the value of individual user segments for the Polish car-sharing services market.

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Institutional Review Board Statement: According to our University Ethical Statement, the following shall be regarded as research requiring a favorable opinion from the Ethic Commission in the case of human research (based on document in Polish: https://prawo.polsl.pl/Lists/Monitor/Attachments/7291/M.2021.501.Z.107.pdf, accessed on 22 November 2022): research in which persons with limited capacity to give informed or research on persons whose capacity to give informed or free consent to participate in research and who have a limited ability to refuse research before or during their implementation. In particular, this includes children and adolescents under 12 years of age, persons with intellectual disabilities, persons whose consent to participate in the research may not be fully voluntary, prisoners, soldiers, police officers, employees of companies (when the survey is conducted at their workplace), persons who agree to participate in the research on the basis of false information about the purpose and course of the research (masking instruction. i.e., deception) or do not know at all that they are subjects (in so-called natural experiments), research in which persons

particularly susceptible to psychological trauma and mental health disorders are to participate (in particular: mentally ill persons, victims of disasters, war trauma, etc.), patients receiving treatment for psychotic disorders, family members of terminally or chronically ill patients, research involving active interference with human behavior aimed at changing it, research involving active intervention in human behavior aimed at changing that behavior without direct intervention in the functioning of the brain (e.g., cognitive training, psychotherapy, psychocorrection, etc., (this also applies if the intervention is intended to benefit the subject, e.g., to improve his/her memory), research concerning controversial issues (e.g., abortion, in vitro fertilization, death penalty) or requiring particular delicacy and caution (e.g., concerning religious beliefs or attitudes towards minority groups), and research that is prolonged, tiring, and physically or mentally exhausting. Our research is not done on people meeting the mentioned conditions. None of the researched people had limited capacity to be informed, and none of them had been susceptible to psychological trauma and mental health disorders. The research did not concern the above-mentioned controversial issues. The research was not prolonged, tiring, or physically or mentally exhausting.

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References

1. Shaheen, S.; Chan, N.; Bansal, A.; Cohen, A. *Shared Mobility—A Sustainability & Technologies Workshop. Definitions, Industry Developments and Early Understanding*; University of California, Transportation Sustainability Research Center: Barkele, CA, USA, 2015; pp. 1–30.
2. Golalikhani, M.; Oliveira, B.B.; Carravilla, M.A.; Oliveira, J.F.; Antunes, A.P. Carsharing: A Review of Academic Literature and Business Practices toward an Integrated Decision-Support Framework. *Transp. Res. Part E Logist. Transp. Rev.* **2021**, *149*, 102280. [CrossRef]
3. Shaheen, S. Carsharing Trends and Research Highlights. Available online: https://www.epa.gov/sites/production/files/2017-06/documents/05312017-shaheen.pdf (accessed on 5 October 2022).
4. Turoń, K. Social Barriers and Transportation Social Exclusion Issues in Creating Sustainable Car-Sharing Systems. *JESI* **2021**, *9*, 10–22. [CrossRef] [PubMed]
5. Abouee-Mehrizi, H.; Baron, O.; Berman, O.; Chen, D. Adoption of Electric Vehicles in Car Sharing Market. *Prod. Oper. Manag.* **2021**, *30*, 190–209. [CrossRef]
6. Tarnovetckaia, R.; Mostofi, H. Impact of Car-Sharing and Ridesourcing on Public Transport Use: Attitudes, Preferences, and Future Intentions Regarding Sustainable Urban Mobility in the Post-Soviet City. *Urban Sci.* **2022**, *6*, 33. [CrossRef]
7. Julsrud, T.E.; Standal, K. Developing B2B Electric Car Sharing as a Sustainable Mode of Work Travels. A Community-Based Affordances Perspective. *Int. J. Sustain. Transp.* **2022**, 1–12. [CrossRef]
8. Nansubuga, B.; Kowalkowski, C. Carsharing: A Systematic Literature Review and Research Agenda. *J. Serv. Manag.* **2021**, *32*, 55–91. [CrossRef]
9. Schlüter, J.; Weyer, J. Car Sharing as a Means to Raise Acceptance of Electric Vehicles: An Empirical Study on Regime Change in Automobility. *Transp. Res. Part F Traffic Psychol. Behav.* **2019**, *60*, 185–201. [CrossRef]
10. Research and Markets. Car Sharing Market: Global Industry, Trends, Share, Size, Growth, Opportunity and Forecast 2021–2026. Available online: https://www.researchandmarkets.com/reports/5483424/car-sharing-market-global-industry-trends?gclid=Cj0KCQiAg_KbBhDLARIsANx7wAwu3FD0-eUeYdxZZQ_qtTYEijaNKLC6gwGPSOUPK-_T3J0l7VsLwnwaAvwgEALw_wcB (accessed on 14 October 2022).
11. ING Forecast. Car-Sharing Unlocked. Available online: https://www.ing.nl/zakelijk/kennis-over-de-economie/uw-sector/automotive/car-sharing-unlocked-english.html (accessed on 15 August 2022).
12. Jochem, P.; Frankenhauser, D.; Ewald, L.; Ensslen, A.; Fromm, H. Does Free-Floating Carsharing Reduce Private Vehicle Ownership? The Case of SHARE NOW in European Cities. *Transp. Res. Part A Policy Pract.* **2020**, *141*, 373–395. [CrossRef]
13. Caulfield, B.; Kehoe, J. Usage Patterns and Preference for Car Sharing: A Case Study of Dublin. *Case Stud. Transp. Policy* **2021**, *9*, 253–259. [CrossRef]
14. Nguyen, Q. Factors Affecting the Willingness to Use Car Sharing Service: A Case Study of Stavanger. University of Stavanger | Spring. 2020. Available online: https://uis.brage.unit.no/uis-xmlui/bitstream/handle/11250/2690135/Quyen_Nguyen.pdf?sequence=1&isAllowed=y (accessed on 15 October 2022).
15. Hahn, R.; Ostertag, F.; Lehr, A.; Büttgen, M.; Benoit, S. "I like It, but I Don't Use It": Impact of Carsharing Business Models on Usage Intentions in the Sharing Economy. *Bus. Strategy Environ.* **2020**, *29*, 1404–1418. [CrossRef]
16. Soppert, M.; Steinhardt, C.; Müller, C.; Gönsch, J.; Bhogale, P.M. Matching Functions for Free-Floating Shared Mobility System Optimization to Capture Maximum Walking Distances. *Eur. J. Oper. Res.* **2022**, *205*, 1194–1214. [CrossRef]
17. Hardt, C.; Bogenberger, K. Empirical Analysis of Demand Patterns and Availability in Free-Floating Carsharing Systems. In Proceedings of the 2018 21st International Conference on Intelligent Transportation Systems (ITSC), Maui, HI, USA, 4–7 November 2018; pp. 1186–1193. [CrossRef]

18. Kubik, A. Impact of the Use of Electric Scooters from Shared Mobility Systems on the Users. *Smart Cities* **2022**, *5*, 1079–1091. [CrossRef]
19. Yao, Z.; Gendreau, M.; Li, M.; Ran, L.; Wang, Z. Service Operations of Electric Vehicle Carsharing Systems from the Perspectives of Supply and Demand: A Literature Review. *Transp. Res. Part C Emerg. Technol.* **2022**, *140*, 103702. [CrossRef]
20. Shaheen, S.; Martin, E.; Totte, H. Zero-Emission Vehicle Exposure within U.S. Carsharing Fleets and Impacts on Sentiment toward Electric-Drive Vehicles. *Transp. Policy* **2020**, *85*, A23–A32. [CrossRef]
21. Ma, Y.; Miao, R.; Chen, Z.; Zhang, B.; Bao, L. An Interpretable Analytic Framework of the Relationship between Carsharing Station Development Patterns and Built Environment for Sustainable Urban Transportation. *J. Clean. Prod.* **2022**, *377*, 134445. [CrossRef]
22. Lu, M.; Chen, Z.; Shen, S. Optimizing the Profitability and Quality of Service in Carshare Systems under Demand Uncertainty. *Manuf. Serv. Oper. Manag.* **2018**, *20*, 162–180. [CrossRef]
23. Lemme, R.F.F.; Arruda, E.F.; Bahiense, L. Optimization Model to Assess Electric Vehicles as an Alternative for Fleet Composition in Station-Based Car Sharing Systems. *Transp. Res. Part D Transp. Environ.* **2019**, *67*, 173–196. [CrossRef]
24. Kubik, A. Selection of an Electric Scooter for Shared Mobility Services Using Multicriteria Decision Support Methods. *Energies* **2022**, *15*, 8903. [CrossRef]
25. Martyn, K.; Kadziński, M. Deep Preference Learning for Multiple Criteria Decision Analysis. *Eur. J. Oper. Res.* **2022**, *305*, 781–805. [CrossRef]
26. Athanasakis, K.; Igoumenidis, M.; Boubouchairopoulou, N.; Vitsou, E.; Kyriopoulos, J. Two Sides of the Same Coin? A Dual Multiple Criteria Decision Analysis of Novel Treatments against Rheumatoid Arthritis in Physicians and Patients. *Clin. Ther.* **2021**, *43*, 1547–1557. [CrossRef] [PubMed]
27. Kobryń, A. *Wielokrotne Wspomaganie Decyzji w Gospodarowaniu Przestrzenią*; Difin: Warszaw, Poland, 2014.
28. Hashemi, S.S.; Hajiagha, S.H.R.; Zavadskas, E.K.; Mahdiraji, H.A. Multicriteria Group Decision Making with ELECTRE III Method Based on Interval-Valued Intuitionistic Fuzzy Information. *Appl. Math. Model.* **2016**, *40*, 1554–1564. [CrossRef]
29. Global Market Insights. Car Sharing Market Size by Model (P2P, Station-Based, Free-Floating), by Business Model (Round Trip, One Way), by Application (Business, Private), COVID-19 Impact Analysis, Regional Outlook, Application Potential, Price Trend, Competitive Market Share & Forecast, 2021–2027. Available online: https://www.gminsights.com/industry-analysis/carsharing-market (accessed on 12 July 2022).
30. Statista. Forecast Revenues from Carsharing Services in Poland from 2019 to 2025. Available online: https://www.sta-tista.com/statistics/1059362/poland-carsharing-revenues/ (accessed on 5 June 2022).
31. Auto na Minuty Portal. Available online: https://autonaminuty.org/uslugi-polska/ (accessed on 4 November 2022).
32. Saaty, T. How to make decision: The analytic hierarchy process. *Eur. J. Oper. Res.* **1990**, *48*, 9–26. [CrossRef]
33. Auto Espress Portal. Best Low Emission Green Cars. 2022. Available online: https://www.autoexpress.co.uk/best-cars-vans/86338/best-low-emission-green-cars-2022 (accessed on 17 October 2022).
34. Auto Car Portal. Best-Selling Cars in Europe in 2022. Available online: https://www.autocar.co.uk/car-news/new-cars/best-selling-cars-europe-2022 (accessed on 17 October 2022).
35. Turoń, K. Multi-Criteria Decision Analysis during Selection of Vehicles for Car-Sharing Services—Regular Users' Expectations. *Energies* **2022**, *15*, 7277. [CrossRef]
36. Turoń, K. Selection of Car Models with a Classic and Alternative Drive to the Car-Sharing Services from the System's Rare Users Perspective. *Energies* **2022**, *15*, 6876. [CrossRef]
37. Turoń, K. Carsharing Vehicle Fleet Selection from the Frequent User's Point of View. *Energies* **2022**, *15*, 6166. [CrossRef]
38. Brychcy, M.; Przybyłowski, A. Funkcjonowanie i rola carsharingu w równoważeniu mobilności na przykładzie Trójmiasta. *Studia Pr. Kol. Zarządzania Finans.* **2018**, *169*, 43–56. Available online: https://ssl-kolegia.sgh.waw.pl/pl/KZiF/czasopisma/zeszyty_naukowe_studia_i_prace_kzif/Documents/169_04_Brychcy__1.pdf (accessed on 6 October 2022). [CrossRef]