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Multi-Criteria Decision Analysis during Selection of Vehicles for Car-Sharing Services—Regular Users' Expectations

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Abstract: Car-sharing systems, i.e., automatic, short-time car rentals, are among the solutions of the new mobility concept, which in recent years has gained popularity around the world. With the growing interest in services in society, their demands for the services offered to them have also increased. Since cars play a key role in car-sharing services, the fleet of vehicles should be properly adapted to the needs of customers using the systems. Due to the literature gap related to the procedure of proper selection of vehicles for car sharing and the market need for car-sharing service operators, this work has been devoted to the selection of car models for car sharing from the perspective of users constantly using the systems (regular users). This paper considered the case of the Polish who are constantly using car-sharing service systems. Vehicle selection was classified as a multi-faceted, complex problem, which is why one of the ELECTRE III multi-criteria decision support methods was used for this study. This study focused on the classification of vehicles from the user's perspective. Twelve modern and most popular car models in 2021 with internal combustion, electric and hybrid engines were considered. The results indicate that the best choice from the point of view of regular customers is large cars (representing vehicle classes C and D), with a large luggage compartment capacity, the highest possible ratio of engine power to vehicle weight, and the ratio of engine power to energy consumption. Importantly, small urban vehicles, which ideologically should be associated with car-sharing services due to occupying as little urban space as possible, were classified as the worst in the ranking. The results support car-sharing operators during the process of completing or upgrading their vehicle fleets.

Keywords: car sharing; car-sharing services; e-car-sharing systems; electric car sharing; hybrid car sharing; short-term car rentals; shared mobility; modern mobility; sustainable transport systems; multi-criteria decision analysis; fleet management

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1. Introduction

Modern cities are developing at a very fast pace. Currently, 55% of the world's population is urban residents, and statistics indicate that this percentage is expected to increase to 68% by 2050 [1]. It is projected that the phenomena of globalization and urbanization, as well as the gradual shift of public habitation from rural areas, could add another 2.5 billion people to urban areas [2]. Such an increase is to be particularly noticeable in the case of cities with a population of less than 1 million [3], which makes the issue important for both small urban centers and large agglomerations.

The dynamic development of urban centers, in addition to several advantages, is also associated with many problems, including difficulties with one of the key factors of their economic development—transport and the elementary need of society, which is mobility [4]. To ensure efficient, cost-effective, and, above all, sustainable urban mobility, so-called new transport mobility services are offered [5]. As part of new mobility, many different forms of transport are offered. These include, inter alia, all services offering shared mobility services [6]. These services derive from the trend of the sharing economy, according to which, using publicly available cooperation platforms (websites, mobile applications), it is possible to temporarily use given goods or services by several different people [7]. In addition to the use of web-based systems, companies offering services within the sharing economy also rely on three main assumptions [8]:

- Ensuring the greatest possible time flexibility in terms of the availability of a full range of services for the user;
- Having a rating system for users, aimed at increasing trust in the user's offer;
- Basing this mainly on rented, shared, or borrowed resources.

Of all the forms of shared mobility offered, car-sharing services are among the most affordable in terms of convenience and autonomy [9]. Car-sharing services are systems that give the possibility of renting a motor vehicle for a short time via a website or mobile application. There are four main types of car sharing [10,11]:

- Roundtrip car sharing (roundtrip station-based, back-to-base car sharing)—when the vehicle is rented and returned always in the same location—a dedicated parking space;
- Roundtrip home-zone-based car sharing—when the vehicle is rented and returned in specific zones of operation of the operator of a given system in the city;
- One-way (station-based) car sharing—when the vehicle is rented, e.g., at point A, and is returned at another point, e.g., at point B, but limited only to rental points established by the system operator;
- Free-floating car sharing—when the vehicle is rented and returned anywhere in the city, within the entire area of operation of the car sharing.

From year to year, car-sharing services are gaining more and more popularity. The latest data indicate that vehicle-sharing systems are currently in operation in 59 countries around the world [12]. They are offered by 236 operators and are available in 3128 cities [12]. Statistics estimate that the fleet of vehicles will grow from the current 380,000 available cars to almost 7.5 million units in 2025 [13], and the global car-sharing market will be worth over USD 11 billion [12].

Since car-sharing services are developing very dynamically both in terms of the growing number of operators, vehicles, and users, there are also more and more problems related to their proper and, above all, effective functioning in cities. The literature review indicates the occurrence of numerous problems covering a very wide range of issues. These include, inter alia [14–21]:

- Economic and technical problems (e.g., the problem of proper adjustment of systems to a given area of operation in terms of business model; the problem of defining operating rules and the need for system location restrictions for a given area of the city; the problem of inadequate pricing policy);
- Transport problems (e.g., the problem of appropriate adjustment of the number of vehicles to the given system of services offered; the problem of determining the location of system operation areas, the location of parking spaces or charging stations for electric vehicles; problems with the technical maintenance of vehicles);
- Environmental problems (e.g., problems related to exhaust emissions of conventionally powered vehicles used in car sharing);
- Social problems (e.g., problems with meeting society's expectations of the services offered);
- Legal problems (e.g., the problem of identifying privileges that can promote this way of traveling, and at the same time not adversely affect other pro-ecological solutions—sharing bus lanes or entering zones available only for public transport).

Making a detailed analysis of the indicated problems, it can be seen that most of them are directly related to one aspect—the fleet of vehicles offered for rental in car-sharing services. This is a factor directly related to the quality of services provided and attractiveness for potential users. The fleet of vehicles available in car sharing has been the research topic of many scientific studies. These studies involved various research areas. One of them was the issue of vehicle rotation within the scope of the zone provided and the appropriate number of vehicles offered. This aspect was called the 'Fleet Position

Problem' and was considered for appropriate vehicle optimization, accessibility of cars for customers in the city area, or proper placement of cars using specially dedicated parking spaces [22–26].

Another current trend was the analysis of all kinds of improvements and systemic changes implemented in car sharing during the COVID-19 pandemic. At that time, the researchers focused on defining the right framework for disinfecting vehicles and actions that users believe increase their comfort and safety level [27–29].

A separate group of studies was the issue of the impact of vehicles used in car sharing on society, the economy, and the environment. The change, i.a., social decisions in the field of giving up one's vehicle in favor of cars from car sharing was analyzed. For example, Jain et al. have shown that Melbourne residents are able to give up having a second car in their family in favor of a properly functioning car-sharing system [30]. In turn, Liao et al. emphasized that in their analyses of Dutch society, 20% of respondents are able to give up buying the first car in the family in favor of car sharing, which would be close to their place of residence [31]. Similar results with a result of 50% abandonment of car purchase were achieved by Hui et al. for Hangzhou in China [32]. Restrictions on purchasing decisions are topics that were also directly related to the impact of car sharing on the environment. Many scientists also took up topics related to vehicles equipped with alternative drives and the possibilities of their use in car sharing. For example, Shaheen et al. showed that users in the U.S. increased their interest in car sharing after the deployment of electric and hybrid vehicles [33]. Migliore et al. pointed to the numerous benefits of making changes to car-sharing fleets and reducing the harmful impact of cars on the environment by significantly reducing exhaust emissions [34]. Many studies were also closely related to the spectra of the direct impact of vehicles on the environment through, for example, exhaust emissions analysis, the possibility of replacing internal combustion engine cars with hybrid or electric vehicles, as well as many detailed studies on electric vehicle batteries and their tests in various road conditions [35–46].

In a broad literature review, one can notice a research gap related to the selection of the right type of vehicle models for the car-sharing fleet. In the maze of car-sharing research, the factors influencing car-sharing systems are widely considered, but the factors determining the selection of given models are ignored. It should be borne in mind that car models, and hence their detailed equipment, are the main element needed to provide the car-sharing service. Meeting the appropriate requirements of the society by the vehicle may become among the factors that will change their transport behavior and, as a result, allow them to use car sharing instead of their own car. Moreover, the car can become among the main factors that will determine whether the car-sharing service is successful and whether the customer will use the services of a given operator more often than once. Analyzing the literature on the specific social needs of vehicles, one can find my previous research focused on the requirements of operators [42] or research on users who use car sharing up to ten times a month [47]. Noticing this niche, I dedicated a research cycle to the subject of fleet selection for car-sharing vehicles, considering the needs in its scope from the point of view of various groups of users of car-sharing systems. This article was devoted to the analysis of vehicle selection from the perspective of users constantly using car-sharing systems, i.e., people who regularly rent cars from car-sharing systems more often than ten times a month.

This study was conducted in the case of a car-sharing operator providing services in the territory of Poland. The Polish car-sharing market is considered to be among the most dynamically developing in terms of shared mobility [12,44]. Concerning the European market, car-sharing systems in Poland appeared relatively late—in 2016—despite this, since their appearance on the market, they have gained great interest, to the extent that at the peak of market development in Poland there were 17 car-sharing operators, and the services could be used in over 250 cities [44]. This type of expansion also translated into significant financial results. Annual revenues in 2019 amounted to over PLN 50 million, while in 2021 it was already over PLN 100 million [44]. The Polish car-sharing market, despite many good practices, is also associated with numerous imperfections, which in many cases led to the closure of numerous service systems or a significant reduction in the zones of operation of the systems [42,45,46]. The literature states that the causes of market failures were often inadequately adapted to the needs of customers' rental service, which was based on the use of vehicles that did not meet the expectations of customers [42,45,46]. This work was therefore a response to a real market needs and an attempt to improve the functioning of car-sharing systems operating in the Polish area.

This article consists of four chapters. The first chapter refers to the literature review and the definition of the purpose of the work. The second part was devoted to presenting the research process and the detailed methodology used to achieve the results of this study. The third part presents the obtained research results. The fourth chapter contains a discussion of the results and a summary, as well as limitations on the conducted research and future research plans about vehicle selection for car sharing.

2. Methodology

2.1. Multi-Criteria Decision Making

Choosing the right type of vehicle for the needs of users of car-sharing systems is a problem that requires making the right decisions. Decision making is a difficult task for the person responsible. Usually, along with the question of choice, there are thoughts about other possible alternatives or ways in which you can check whether a given decision will have a positive impact on the analyzed issue or not. The problem becomes even more complicated if it turns out that many different factors can affect the accuracy of a given decision. Then, all kinds of methods for performing decision analysis come to the rescue. These include i.a., multi-criteria decision support methods.

Multi-criteria decision making (MCDM) or multi-criteria decision analysis (MCDA) methods are a subdiscipline of operations research [48]. Their task is to provide tools that, in the presence of many, often contradictory, criteria, will be used to evaluate and rank decision options, to facilitate the decision-making process [48–50]. What is more, methods help to structure and formalize decision-making processes transparently and consistently [51].

The methods are based on elements of knowledge from such fields as decision theory, mathematics, economics, computer science or information systems [51]. Many methods can be used for solving problems and they can be arranged according to different parameters and different stakeholders [51]. Due to the high level of utilitarianism, the methods are successfully used in the case of individuals, enterprises, and government institutions [51]. In the case of transport issues, the methods were used for, inter alia, during selection the Paris Metro project to choose the right types of scooters for sharing companies, to decide what type of car-sharing services should be provided in Shanghai, to assess the overall state of transport in Istanbul, to improve the bike rental station for the city located in Beijing, China, when making decisions on the availability of air connections with Pittsburgh, analyzing the functioning of shared mobility services in the post-COVID-19 era, or improving the quality of bike-sharing services in the Chinese city of Xi'an [52–58].

There are many different methods of multi-criteria decision support that are widely used. There are three main groups of methods—methods based on overshooting rations, aggregate measures, and utility functions. Each MCDA method has its calculation method by which alternatives are queued [51]. Since different types of vehicles are considered when selecting vehicles, the ELECTRE III method is often contradictory to comparing and evaluating them in pairs and used to obtain a ranking of variants in the work.

The ELECTRE III is among the ELECTRE collection methods, named after *Elimination Et Choix Traduisant la Realitè*. The ELECTRE III method owes its widespread popularity to the fact that among other methods of the ELECTRE family, it is possible to perform analyses with the indication of a ranked final ranking [59]. It is the possibility of obtaining a hierarchy among the objects under consideration that makes the method widely popular [59–61]. The ELECTRE III method is a particularly frequently used tool when solving various types of transport issues. It has been used, inter alia, during the evaluation of urban transportation projects [62], during the selection of means of urban passenger transport [63], safety analysis in a suburban road network [64,65], evaluation of environmental indicators for transport [64], evaluation service quality of international airports in Sicily [66] or during choosing a route for Dublin port motorway [67]. Due to the possibility of obtaining an ordered final ranking, detailed pairwise comparisons of individual criteria, and the universality of application to the problem of selection for analysis, the use of the ELECTRE III method was proposed.

2.2. Research Process

To obtain results on the selection of appropriate vehicle models for the needs of regular users of car-sharing systems, a four-stage research process was proposed, which was shown in Figure 1.

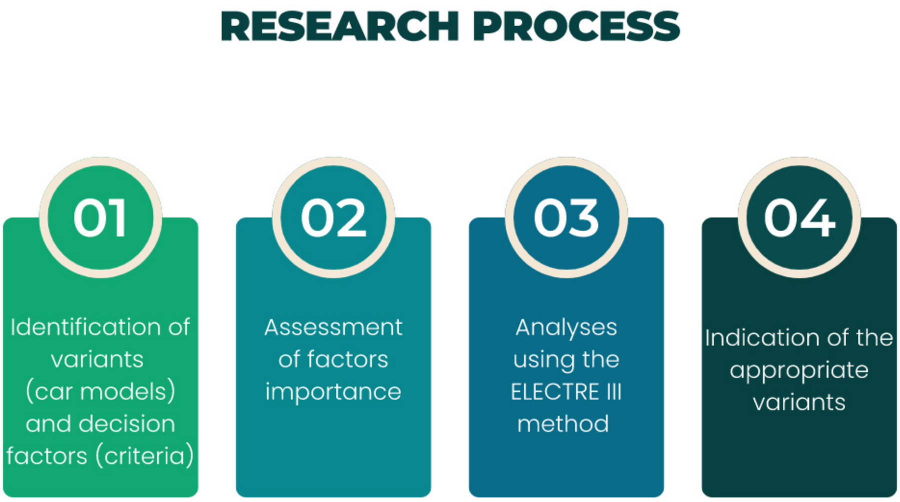

Figure 1. Research process.

The proposed research process was directly related to the algorithm of conduct in the ELECTRE III method. In the first step, the decision variants and a set of factors (criteria characterizing vehicle models parameters), which were used for detailed analyses were identified [60,61]. In the analyzed case study, the variants were car models considered for implementation in car-sharing systems. A detailed list of vehicles and the criteria considered is presented in the Results section. In the second step, research was carried out with the participation of users who constantly use car sharing. Their task was to assess the importance of individual factors considered when selecting vehicles. The evaluation was carried out by performing a pairwise comparison of each of the analyzed factors.

The criteria were assessed by comparing them in pairs and giving ratings from 1 to 9, according to Saaty's scale. The values of the scale ratings are presented in Table 1. Then, by comparing the two analyzed criteria, the exceedance index was calculated. A detailed pairwise comparison matrix is presented in the Results section.

Table 1. Saaty's Scale.

Weight	Detailed Description
"1"	Equal importance of the criteria
"2"	Very weak advantage of one criterion over the other
"3"	Weak advantage of one criterion over the other
"4"	More than a weak advantage of one criterion over the other, but less than a strong advantage
"5"	Strong advantage of one criterion over the other
"6"	More than a strong advantage of one criterion over the other, but less than very strong
"7"	Very strong advantage of one criterion over the other
"8"	More than a very strong advantage of one criterion over the other, less than an extreme
"9"	Extreme, total advantage of one criterion over the other

In the third stage, detailed analyses were carried out using the ELECTRE III method. Based on the calculated exceedance index, it was determined whether the first of analyzed variant is not worse than the second analyzed variant due to the indicated factor. Consequently, calculations of the compliance rate should be performed to obtain the level of advantage of one variant over the other in terms of all analyzed factors [53,54]. The compliance rate is the sum of the weights of the criteria for which the evaluation value of one variant is greater than or equal to the evaluation value of the other variant [52,53]. ELECTRE III introduces three main parameters that allow determining the relationships between the analyzed variants [61]:

- The maximum difference of factors values Δ—the difference between the highest and lowest value in the assessment of two variants;
- Indifference threshold Q—is the biggest difference between the performance of the variants and profiles on the factors;
- Preference threshold *p*—the greatest difference between the performance of the variants and profiles such that one is preferable to the other on the considered factor;
- Veto threshold V—the difference in the assessment of two variants concerning a given factor.

Sequentially, an altitude difference matrix is created. Variants should be arranged sequentially, starting from their initial ordering using classification procedures of ascend distillation and descend distillation [51–53]. Both distillations rate the variants from best to worst [51–53]. Ascend distillation is a planning process that begins with selecting the best variant and placing it at the top of the ranking [51–53]. The best variant is selected one by one from the remaining variants and placed in the next position in the classification. This procedure is repeated until all possible variants have been analyzed [51–53]. Descend distillation is a planning process that starts with selecting the worst variant and placing it at the end of the ranking. Subsequently, similarly, to ascending distillation, further analyses should be performed, bearing in mind that in the subsequent iterations of the variants to be considered, the worst variant is always selected and placed in the next positions from the end of the ranking [55,56]. After the distillation has been performed, a final ranking is made. The results are presented in the next chapter.

3. Results

This study was conducted in June 2022 for a case study of a car-sharing company operating in Poland. Currently, the company has a fleet of 2000 cars. Cars owned by the operator are vehicles of one type constituting urban, small-sized cars, which are equipped with three or five doors. The operator expected to receive indications as to the possibility of modernizing the fleet, and to check what factors were the most crucial for users during the process of choosing vehicles.

To determine the fleet of implementable cars, twelve modern vehicles were selected to represent different types of drives including cars with internal combustion engine, cars with hybrid engines and cars with electric engines. To consider the vehicles attractive to users, the focus was on the selection of vehicles that were the most popular cars in Europe in 2021 according to the list published by Automotive News Europe [68]. The vehicles published in the report were representatives of different classes of cars. Car classes are a standard used in Europe that specifies the regulations, description, and detailed categorization of vehicles according to ISO 3833-1977. The standard distinguishes nine classes of vehicles from A to M which distinguish cars from small and city to medium, large, family, vans, off-road and luxury vehicles. From a wide range of vehicles presented in the report, vehicles representing car classes from A to D were selected, following the fact that vehicles of these classes are the cars most often chosen by Poles [69]. Moreover, vehicles from classes A to D are also the most frequently used cars in European car sharing involving passenger cars [45]. Van and combivan cars are offered in Poland in cargo car-sharing systems. Since the operator does not provide this type of service, this study was limited to models of classes from A to D. Detailed characteristics of the selected car classes are presented in Figure 2.

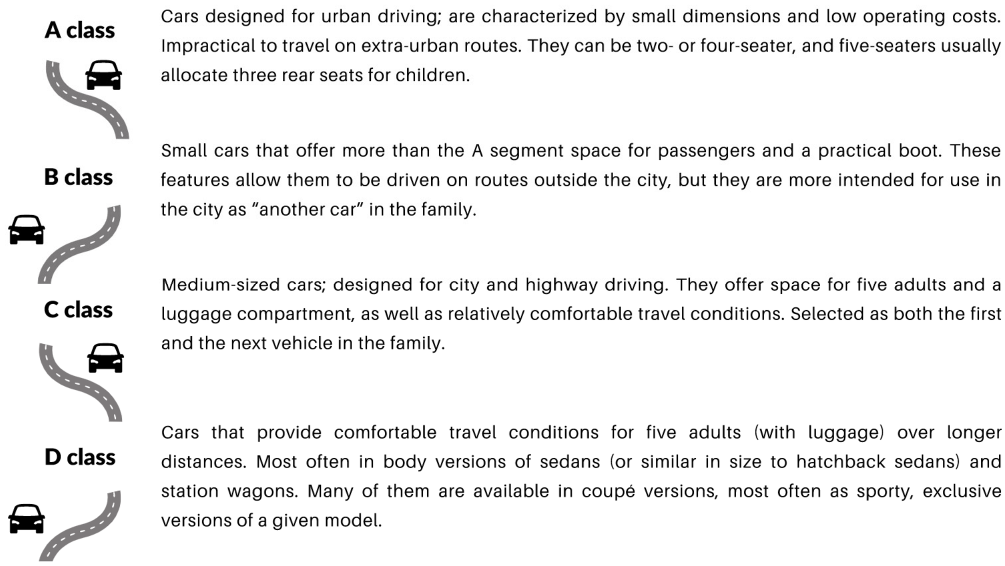

Figure 2. Characteristics of the analyzed vehicle classes.

Since the preferences of Poles who most often choose vehicles from classes A to D also correspond to the fleets of cars used in the Polish car-sharing market, twelve vehicle models were selected, which were considered in further analyses. The selection of vehicles did not favor any of the specific brands of vehicles. A detailed list of vehicle models considered in the analyses is presented in Table 2.

Table 2. Analyzed car models.

Vehicle Model Number	Car Class	Type of Engine
VM1	C class	Internal Combustion Engine
VM2	B class	Internal Combustion Engine
VM3	B class	Hybrid Engine
VM4	D class	Hybrid Engine
VM5	B class	Internal Combustion Engine
VM6	C class	Hybrid Engine
VM7	C class	Internal Combustion Engine
VM8	A class	Electric Engine
VM9	D class	Hybrid Engine
VM10	A class	Electric Engine
VM11	D class	Electric Engine
VM12	D class	Electric Engine

Subsequently, a detailed list of factors that were used to evaluate the various variants was indicated. A detailed list is presented in Table 3.

Table 3. Set of factors considered during car-sharing fleet selection analysis.

Factor Number	Factor Characteristics
F1	Rental fee [€]
F2	The ratio of engine power to vehicle weight [kW/kg]
F3	The ratio of engine power to consumption [kW/kWh]
F4	Time of battery charging/time of refueling [min]
F5	Boot capacity [l]
F6	Number of doors in the vehicle [-]
F7	Vehicle length [m]
F8	Euro NCAP rating [-]
F9	Safety equipment [-]
F10	Warranty period in years [-]

The list of factors for the assessment of individual vehicles was prepared based on the author's previous research [47], in which slight modifications were made, inter alia, in terms of costs, considering the cost of renting cars instead of the cost of purchasing vehicles. In the case of vehicle rental costs, due to the lack of use in the current Polish car-sharing systems indicated in Table 2 of vehicle models, Formula (1) has been developed, which considers the costs of renting vehicles depending on the time of their use and the distance traveled. Stopover costs are also included.

$$rental_{fee}(a,b) = (f_{min} + s_{min})a + f_{km}b\ [€] \tag{1}$$

where a—rental time [min], b—travel distance [km],

$$f_{min} = \begin{cases} 0.14\,€\ for\ A - class\ cars \\ 0.17\,€\ for\ B - class\ cars \\ 0.21\,€\ for\ C - class\ cars \\ 0.27\,€\ for\ D - class\ cars \end{cases}$$ —rental cost for 1 min,

$$f_{km} = \begin{cases} 0.24\,€\ for\ A - class\ cars \\ 0.24\,€\ for\ B - class\ cars \\ 0.24\,€\ for\ C - class\ cars \\ 0.28\,€\ for\ D - class\ cars \end{cases}$$ —rental cost for 1 km,

$s_{min} = 0.03\,€\ for\ A, B, C, D - class\ car$—stopover fee for 1 min

The next step was to establish the importance of individual indicators when selecting vehicles. For this purpose, pairwise comparisons of all factors were developed. The factors were assessed by the car-sharing service users. The questionnaire was available online by using the CAWI (Computer-Assisted Web Interview) method. The aim of this study was to obtain a pairwise comparison of each of the factors and assign an appropriate weighting according to the Saaty scale presented in Table 1. The respondents indicated appropriate weights by filling in the matrix presented in Figure 3. This study included 250 people who use car-sharing systems very often (more often than ten times a month) and were considered regular customers of the systems. The survey was conducted anonymously in June 2022. The users who participated in this study represented a population of 200,000 users of the system of the analyzed enterprise. For the research sample, the confidence level was 95% (α = 0.95). The fraction size was 0.5 and the maximum error was estimated at 7%.

The next step was to prepare a summary of the values of individual criteria for each of the analyzed variants. A detailed list is presented in Table 4.

Table 4. Summary of the values of individual factors for each of the considered car models.

Variant	Rental Cost	The Ratio of Engine Power to Vehicle Weight	The Ratio of Engine Power to Energy Consumption	Charging Time/ Refueling Time	Boot Capacity	Number of Doors	Vehicle Length	Euro NCAP Rating	Safety Equipment	The Warranty Period in Years
	F1 [€]	F2 [kW/kg]	F3 [kW/kWh]	F4 [min]	F5 [l]	F6 [-]	F7 [m]	F8 [-]	F9 [-]	F10 [-]
VM1	0.48	0.051	0.475	2	380	5	4.28	5	10	2
VM2	0.44	0.077	0.511	2	311	5	4.05	4	9	2
VM3	0.44	0.078	0.388	1.5	286	3	3.94	5	8	3
VM4	0.58	0.154	0.062	2	480	4	4.70	5	11	2
VM5	0.44	0.049	0.613	1.5	391	5	4.05	5	10	2
VM6	0.48	0.078	0.327	2.5	361	4	4.37	5	10	3
VM7	0.48	0.075	0.420	2.5	600	5	4.68	5	10	3
VM8	0.41	0.034	0.421	90	300	5	3.73	1	6	2
VM9	0.58	0.056	0.229	2	443	5	4.47	5	8	5
VM10	0.41	0.070	0.157	240	363	3	3.63	4	8	2
VM11	0.58	0.051	0.132	360	585	5	4.49	5	8	2
VM12	0.58	0.063	0.133	450	543	5	4.58	5	8	3

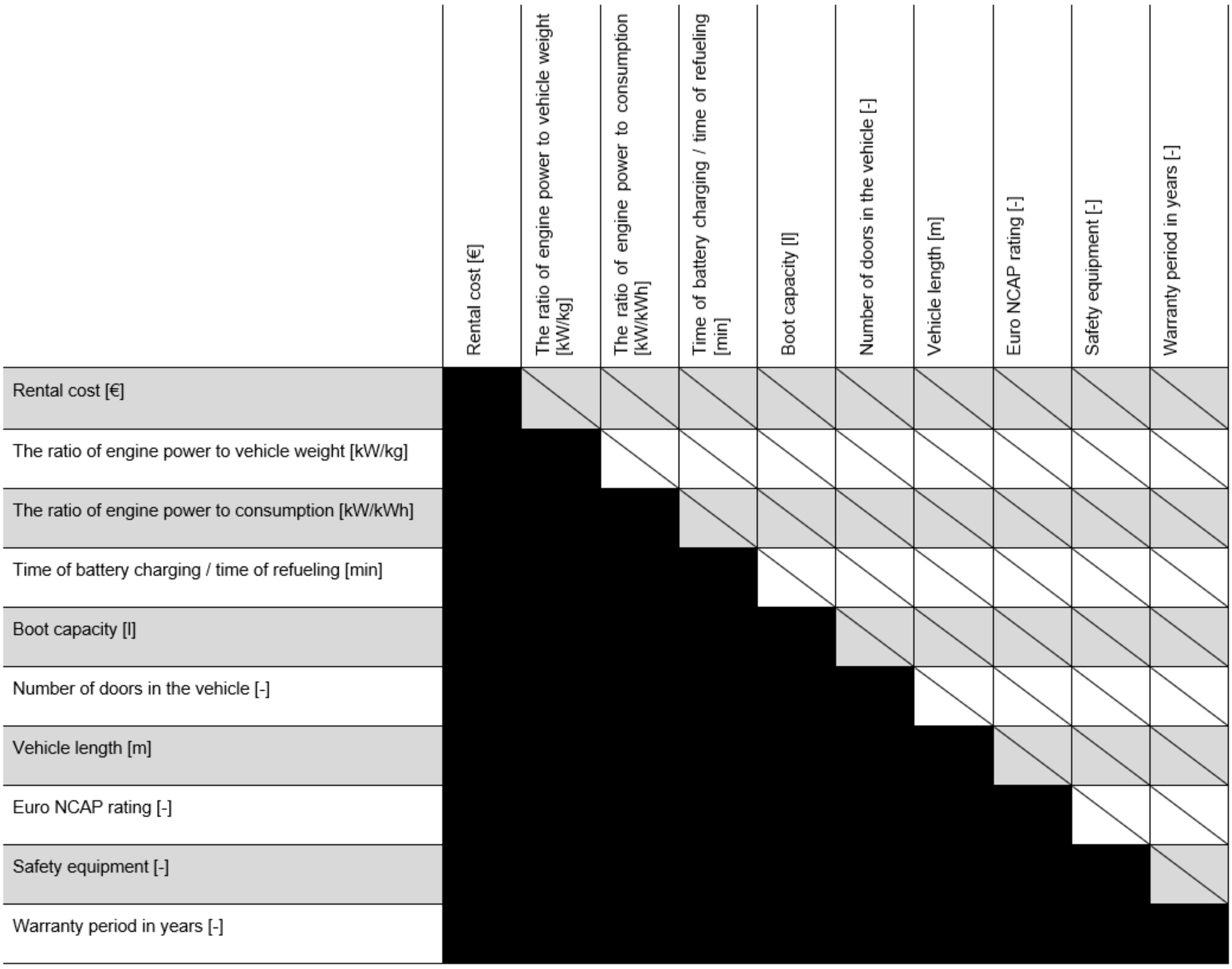

Figure 3. Pairwise comparison matrix provided to respondents.

Then, based on the ELECTRE III methodology, the maximum difference of criteria values, equivalence threshold, preference threshold, and veto threshold values were determined. Detailed data were presented in Table 5.

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

Factor Number	Maximum Difference of Factors Values Δ	Indifference Threshold Q	Preference Threshold *p*	Veto Threshold V
F1	0.17	0.0425	0.085	0.17
F2	182	45.5	91	182
F3	27.5	6.875	13.75	27.5
F4	448.5	112.125	224.25	448.5
F5	314	78.5	157	314
F6	2	0.5	1	2
F7	1.07	0.2675	0.535	1.07
F8	4	1	2	4
F9	5	1.25	2.5	5
F10	3	0.75	1.5	3

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.

Variants	VM1	VM2	VM3	VM4	VM5	VM6	VM7	VM8	VM9	VM10	VM11	VM12
VM1	-	1.0	0.9977	0.8564	0.9994	0.9977	0.8578	1.0	0.911	0.916	0.7617	0.8694
VM2	1.0	-	0.9977	0.7317	1.0	0.9765	0.7707	1.0	0.8452	0.916	0.6454	0.7122
VM3	0.8491	0.918	-	0.5999	0.7322	0.8128	0.6514	0.918	0.6955	0.916	0.525	0.609
VM4	0.6875	0.6875	0.7672	-	0.6875	0.7844	0.6852	0.6875	0.8619	0.916	0.834	0.9157
VM5	1.0	1.0	0.9977	0.81	-	0.9765	0.8136	1.0	0.8494	0.916	0.7023	0.7868
VM6	0.9007	0.8404	1.0	0.8928	0.6875	-	0.7968	0.918	0.829	0.916	0.6619	0.7851
VM7	1.0	1.0	1.0	0.918	0.9073	1.0	-	1.0	0.911	0.916	0.834	0.918
VM8	0.5719	0.7435	0.8121	0.543	0.6208	0.5696	0.5696	-	0.5624	0.7028	0.4854	0.5671
VM9	0.779	0.7695	0.9643	0.934	0.7299	0.9604	0.8436	0.909	-	0.916	0.9025	1.0
VM10	0.4868	0.6259	0.8242	0.662	0.5863	0.6609	0.4029	0.7065	0.721	-	0.6113	0.6767
VM11	0.7299	0.7695	0.7995	0.934	0.7299	0.8621	0.7276	0.7695	0.993	1.0	-	0.9977
VM12	0.7299	0.7695	0.8035	0.934	0.7299	0.8661	0.7299	0.7695	0.993	0.9434	0.916	-

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

Table 7. Dominance matrix values.

Variants	VM1	VM2	VM3	VM4	VM5	VM6	VM7	VM8	VM9	VM10	VM11	VM12
VM1	-	B+	B+	B+	W−	B+	W−	B+	W−	B+	W−	B+
VM2	W−	-	B+	B+	W−	B+	W−	B+	W−	B+	W−	B+
VM3	W−	W−	-	W−	W−	W−	W−	W−	W−	B+	W−	W−
VM4	W−	W−	B+	-	W−	W−	W−	B+	W−	B+	W−	W−
VM5	B+	B+	B+	B+	-	B+	W−	B+	W−	B+	R	B+
VM6	W−	W−	B+	B+	W−	-	W−	B+	W−	B+	W−	R
VM7	B+	B+	B+	B+	B+	B+	-	B+	R	B+	R	B+
VM8	W−	W−	B+	W−	W−	W−	W−	-	W−	B+	W−	W−
VM9	B+	B+	B+	B+	B+	B+	R	B+	-	B+	B+	B+
VM10	W−	W−	W−	W−	W−	W−	W−	W−	W−	-	W−	W−
VM11	B+	B+	B+	B+	R	B+	R	B+	W−	B+	-	B+
VM12	W−	W−	B+	B+	W−	R	W−	B+	W−	B+	W−	-

where (B+)—the first variant is better than the second variant; (R) — a pair of variants are equivalent; (W−)—the first variant is worse than the second variant.

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 was presented in Table 8.

Table 8. Variants final ranking.

Dominance Matrix	Ascend Distillation	Descend Distillation
VM1	3.0	5.0
VM2	4.0	5.0
VM3	6.0	9.0
VM4	5.0	7.0
VM5	3.0	3.0
VM6	5.0	5.0
VM7	2.0	1.0
VM8	6.0	8.0
VM9	1.0	2.0
VM10	7.0	9.0
VM11	1.0	4.0
VM12	4.0	6.0

The graphical arrangement of the variants is shown in Figure 4.

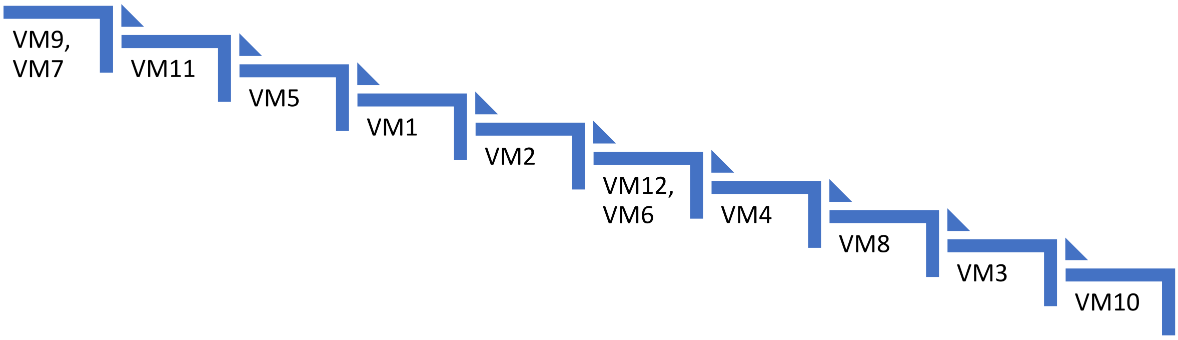

Figure 4. Ranking of car models best suited to car sharing from the perspective of regular users.

4. Discussion and Conclusions

Research carried out using the ELECTRE III multi-criteria decision support method allowed obtaining the final ranking of ranked vehicle models for the car-sharing system, which best meet the expectations of people regularly using car-sharing systems. In the first place, ex aequo placed two models of vehicles—VM9 and VM11. The second place was taken by VM5.

When making detailed analyses in terms of the size of the winning vehicles, it should be stated that the models represented C and D class cars. They are therefore vehicles with medium and large dimensions providing comfortable travel conditions simultaneously for five adults on urban routes, but also over long distances. The vehicles are also equipped with large cargo space. In the case of class D, these were family cars. Interestingly, the worst place in the ranking was achieved by a vehicle representing class A, the smallest of the car models under consideration.

Considering the obtained results in terms of the car propulsion, it should be stated that hybrid and conventionally powered vehicles ranked highest in the ranking. In turn, the second place was taken by an electric vehicle. Interestingly, the last places in the ranking were also taken by vehicles with conventional and hybrid drives. This means that for the respondents, the type of drive was not a key factor, and the ecological thread is debatable. Research indicates that it was not the type of power supply but only more detailed technical parameters, inter alia, the ratio of engine power to fuel consumption or engine power to vehicle weight characterizing specific car models played a key role. This indicates that over time if electric vehicles are equipped with more and more capacious batteries and achieve greater ranges, these vehicles will reach higher places in the rankings.

Analyzing the obtained results from the point of view of the importance of individual criteria for users, it should be mentioned that the most important issues were the ratio of engine power to energy consumption, the ratio of engine power to vehicle weight, boot capacity, and vehicle length. In the case of the ratio of engine power to energy consumption, this means that for users, the issue of eco-friendliness and economy of cars is important. In turn, the ratio of engine power to vehicle weight is directly related to the dynamics of the vehicle. The higher the ratio, the greater the dynamics and driving comfort for the users. Analysis of the most important factors shows that that regular customers of car-sharing systems prefer vehicles with high engine power, which at the same time are economy cars, providing the opportunity to overcome the longest possible reach. What is more, it is worth emphasizing that it was particularly important for users that the vehicles were large, comfortable spacious, and roomy cars. Therefore, the relatively smallest cars were placed in the worst positions. Such conclusions show that regular users of car-sharing systems treat rental vehicles as classic, large family cars owned, which means that in their case car-sharing cars can replace ownership of their car. On the one hand, this is a very interesting conclusion, because it indicates that car sharing fulfills the basic task of exchanging a single vehicle for a rented one. On the other hand, it is worth emphasizing that the idea of carsharing was to ensure the high availability of small, urban cars that do not take up much public space [70,71]. However, the conducted research indicates the opposite. This kind of conclusion is in line with the realities of the Polish car-sharing market because many systems that were based on fleets comprised of small, city cars have been closed.

Comparing the results on the choice of vehicles by regular users using the systems more than 10 times a month, to less using cars up to ten times a month, it should be emphasized that they have similar preferences in terms of size and type of vehicles. Such results can be an important indication for operators when composing the composition of their fleet because frequent customers and regular customers can be included in one group of service recipients. It is also an important tip for researchers when further considering the segmentation of car-sharing customers.

To sum up, based on the research carried out, operators of Polish car-sharing services, when composing their fleet tailored to the needs of users constantly using the systems, should focus on large and long C or D class vehicles, equipped with engines with high parameters and at the same time low energy consumption and equipped with the largest luggage space. This type of fleet should also find interest among customers who often use car-sharing systems. Since the systems are also used by occasional customers who rarely use the systems, it is recommended to use fleet differentiation. This article has some limitations. This article focuses on analyses concerning only one group of users—regular users. The analyses were performed exclusively for the Polish market and focused on vehicles representing classes from A to D. The respondents assessed the criteria indicated arbitrarily by the author, without the possibility of indicating their own proposals of factors that could affect the choice of vehicles.

In the following articles, the author plans to analyze the composition of the car-sharing fleet, considering the opinions of people who rarely use the systems, to obtain the full social perspective. Moreover, the author would also like to consider in the analyses the vehicle classes that were not included in this article, i.e., E, F, J, and M. This will allow for a possible consideration of the operators' approach to the implementation of cargo services. The author also plans to introduce the possibility for users to indicate their own factors which, in their opinion, affect the choice of car-sharing vehicles. The author would also like to perform similar research for other countries to obtain a comparison of the approach to the car-sharing fleet on the world market.

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Institutional Review Board Statement: According to our University Ethical Statement, following, 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 21 March 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: 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 mental health, 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 intended intervention is intended to benefit (this also applies when the intended intervention is o 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) minority groups); research that is prolonged, tiring, physically or mentally exhausting. Our research is not done on people meeting the mentioned condition. Any of the researched people: any of them had limited capacity to be informed, any of them had been susceptible to psychological trauma and mental health disorders, the research did not concern the mentioned-above controversial issues, the research was not prolonged, tiring, physically or mentally exhausting.

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