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Selection of an Electric Scooter for Shared Mobility Services Using Multicriteria Decision Support Methods

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Abstract: In recent years, the electromobility market has been growing faster and faster. Electric scooters and scooter-sharing services offered for them, available in many cities around the world, have a special impact on its intensification. The constantly growing number of scooters and service operators brings many problems related to the proper functioning of services. In the literature, one can find attempts to solve the problems of scooters with references to the issues of transport, modeling and optimization, as well as legislative and social aspects. Technical issues, however, are overlooked. Among them, however, there is a problem with the appropriate selection of scooter models that can be used in scooter-sharing systems. Solving this type of problem may allow systems to be better matched to urban transport systems, increase the development of electromobility and encourage societies to transition from current means of transport (e.g., cars) to scooters. Paying attention to this research niche, the article is devoted to the selection of electric scooters for scooter sharing. This paper presents the author's own research for the Polish market of scooter-sharing services. As part of the work, the author's own list of factors from the point of view of which scooters can be assessed was developed; social research was conducted, considering the opinions of experts in the field of scooter sharing; and it was proposed to treat the problem of selecting scooters as a complex multicriteria decision-making problem. Moreover, the ELECTRE III method was used to solve this research problem in an innovative way. The research results indicate that when choosing a scooter, you should be guided primarily by such factors as the greatest range, equipping the vehicles with safety systems and the most powerful engine. Interestingly, the price of vehicles does not have to be the lowest possible. The article presents guidelines that support operators when upgrading or equipping systems with scooters and support individual users at the stage of deciding to buy a scooter.

Keywords: e-scooter sharing; electric scooters; e-mobility; e-kick-scooter sharing; shared mobility; sustainable development; multicriteria data analysis; civil engineering and transport

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1. Introduction

The European Union, in its main guidelines and projects, places great emphasis on the more and more effective use of the opportunities offered by ecological electric transport [1]. Among the promoted electric means of transport, eclectic scooters are becoming one of the most popular electric vehicles in recent years. The significant development of interest in electric scooters is related to the emergence of a new transport service on the market that provides the possibility of traveling with a scooter without having to own it, i.e., short-term electric scooter rentals—scooter sharing [1].

Every year, electric scooter-sharing systems appear in more and more cities around the world [1]. Their popularity is associated with offering the public a convenient means of transport, which, without the need for permission or appropriate physical condition, revolutionizes so-called "last mile" logistics [2]. The growing interest in scooter sharing translates into statistics that indicate that the number of users is expected to reach 124.8 million users by 2026 [3], and the number of vehicles will increase by 15.42% (2022–2026), which in

2026 will translate into the size of the market for USD 2818.00 million [3]. Along with the growing interest in scooter-sharing systems, more and more problems with their proper functioning in urban conditions have appeared. Among them, the following issues can be distinguished [3–9]:

- Improperly adjusted zone of the scooter-sharing system to the needs of a given urban area;
- An inadequate number of vehicles to meet the needs of the service and society;
- Improper relocation of vehicles in urban conditions, especially during rush hours;
- An inappropriate type of systems management;
- Technical issues related to vehicles and their operation;
- Improper scooters models for the needs of society, e.g., too heavy, unstable, with operational problems, damaged, etc., negatively affecting user safety.

Scientists around the world have been trying to solve the above problems. Among the literature, one can find many scientific and research studies that try to find solutions for the proper functioning of scooter-sharing services from the point of view of legislation [10], management [11,12], optimization or modeling [13,14] and social sciences [15].

For example, from the legislative point of view, Sareen et al. in their work emphasized that regulatory challenges are an obstacle to implementing innovative solutions in the field of shared micromobility in the public interest. Thanks to these activities, it is possible for micromobility to be a factor conducive to low-emission mobility [10]. In turn, Carroll focused on determining the public's approach to scooters before the implementation of legislative provisions, pointing to the factors determining the willingness to use the systems [11]. Subsequently, Song et al., while analyzing scooter sharing from the management point of view, tried to extend the existing business models of sharing systems to include electric scooters [12]. The results of the research indicate that the extension of the existing business models allows for their optimization and focuses on the needs of consumers—users of the systems [12]. In turn, Shaheen et al., making strategic analyses of the functioning of shared mobility systems, showed that in the future these systems will spread more to suburban and rural locations; therefore, these services must be properly tailored to the needs of users and given location conditions [13].

In turn, Huang determined that to improve social issues, users of sharing systems should be more effectively involved in the development of a mobile application that manages the vehicle-sharing system [14]. All these activities are aimed at increasing the freedom of using vehicle-sharing services by young and old people [14]. From the point of view of modeling and optimization, detailed research was conducted on the optimal system for parking scooters and creating mobility hubs [15], modeling the demand for scooters with an indication that issues such as weather, transport infrastructure (including types of vehicles), land use and neighborhood features have an impact on using scooter-sharing systems [16]. Extensive analyses were devoted to the improper use of scooters in urban conditions that negatively affect the level of safety of both scooter users and others, especially unprotected road users [7]. Meanwhile, Montella et al. defined design criteria for sustainable complete streets that integrate complete streets by adding socioenvironmental design criteria related to aesthetics, environment, habitability and safety, including the use of e-scooters [17].

While the indicated literature items can successfully affect the condition of scooter systems in the city, they are not widely discussed in the literature. Among the literature items, one can find only a few studies partially related to technical topics. For example, Popowa et al. analyzed several aspects of electric scooters used in smart cities [18]. They developed several indicators that should be considered when using this type of vehicle [18]:

- Ensuring self-confidence when moving an electric scooter;
- Having the ability to anticipate phenomena on the path or road;
- Owning and increasing the experience of driving an electric scooter;
- Ability to move the scooter on different surfaces;
- Knowledge of equipping the electric scooter with safety systems when moving the vehicle.

In turn, Kazemzadeh et al. determined that an important aspect of constructing an electric scooter is the assessment of user experience, which allows us to determine important factors describing the vehicle [19]. The main factor is the speed, which is defined by the power of the motor mounted in the electric scooter. Another is the appropriate behavior of the user when moving on the sidewalk or public road [19]. Safety and travel comfort are the last indicators to be considered [19].

Subsequently, Şengül et al. determined that electric scooters most often move on a single trip over a distance of 0.7 to 2.4 km, which translates into selecting the battery in such a way that it is possible to make several trips before the battery in the vehicle is discharged [20].

In turn, Leoni et al., by analyzing the driving properties of an electric scooter, determined that the key factor ensuring safety is the permissible weight of the vehicle and the ratio of weight to the power of the electric scooter [21]. In addition, equipping the vehicle with shock absorbers that dampen vibrations or a system that blocks wheel slip or increases comfort has a significant impact, as does having a cruise control [21].

Gössling proved in his article that electric scooters can be a transport innovation that can be a challenge for urban transport systems [22]. In addition, Gössling showed that electric scooters are also a source of conflict due to the speed of scooter movement in cities, or the insufficient level of safety when using an electric scooter [22].

In turn, D'Andreagiovanni et al. studied several shared mobility systems in Italy. They presented regulations introduced by local governments, as well as some experimental recommendations aimed at eliminating the problems that occurred during the rapid increase in the number of electric scooters in the analyzed areas, also pointing to the need to pay attention to the operational aspects of the systems [23].

Among the extensive literature review, however, one can find an overlooked issue—the approach to the fleet of scooters used in systems. Due to the identified research niche, the purpose of this article is to present the method of selecting a scooter fleet for electric scooter-sharing systems. This aspect is particularly important because scooters in scooter-sharing systems are the basic factor determining whether to travel. Scooters are also an element that may affect the decision "to share or not to share?" and assess its quality or level of comfort while moving and whether the user will want to use the service again. When comparing the importance of the fleet of vehicles to other forms of transport, it is worth noting, for example, the increased interest of passengers in using rail journeys equipped with specific types of trains, or the improvement in the attractiveness of public transport thanks to the modernization of the bus fleet [24–27].

Moreover, it is worth emphasizing that in the case of users of scooter systems, we are dealing with two groups of people—experienced users and people unfamiliar with electromobility. The former already have defined preferences as to scooters and their performance, while the latter may encounter electromobility for the first time thanks to scooter sharing and be afraid of too much scooter power, too fast acceleration or the need to have special skills to drive it. In addition, the growing number of scooter-sharing operators, and at the same time the increasing number of available vehicles, increase the competition that can be provided by vehicles tailored to customer needs. Furthermore, the proper adjustment of scooters to the preferences of society may encourage them to buy scooters on their own and give up using other means of transport, e.g., by car, in favor of a scooter.

In the work, the issue of scooter selection was defined as a multicriteria and complex decision-making problem. The author proposes an innovative application of one of the methods of multicriteria decision support—ELECTRE III—to solve the problem of selecting vehicles for systems. The paper presents the results of an innovative and first study on the selection of the type of scooters for the needs of the Polish market of scooter-sharing services. The analysis takes into account the latest models of scooters that can be implemented in the systems. The article defines its own set of factors from the point of view of which scooters can be assessed, which can be used as a model for evaluating vehicles for other geographical areas. Research on the importance of factors based on the opinions of experts who participated in the social study was also carried out. The main assumption during the work was that it is possible to use the ELECTRE III method in the proposed problem of selecting scooters.

This work aims to support mobility service operators in selecting vehicles for their fleets. Furthermore, it allows both operators and individual users to identify which aspects should be paid attention to when choosing a scooter for their needs. The article also supports the development of electromobility following the assumptions of sustainable transport and mobility.

The article consists of five sections. The first section presents an introduction to the research work carried out. The second section presents a literature review of this issue. The third section presents the research methodology used in the conducted research. The fourth section presents the results of the obtained analyses. The last fifth section summarizes the work and includes a discussion of the results obtained in the study. The work supports the development of the field of vehicle sharing, which is currently a research niche of scientists.

2. Materials and Methods

The selection of appropriate transport services, as well as the related means of transport, is a decision-making problem that requires the consideration of many, often very contradictory, factors. This contradiction is related to the use of services of a wide social group, which expresses different preferences for the way of moving. To make optimal choices in complex decision problems, many tools of so-called multicriteria decision support are used.

Multicriteria decision-making methods (MCDM) or multicriteria decision analysis (MCDA) are subdisciplines of operations research used to solve complex decision-making problems [28]. Their task is to provide mathematical tools, thanks to which it is possible to carry out an analytical process of various types, often contradictory aspects, from the point of view of which a given phenomenon is assessed. The main purpose of their use is to provide support to the analyst during the ordering and formalization of the decision-making process [28–30].

In fact, these are mathematical methods to help the analyst in the calculation process, which are based on cross indicators, aggregate measures and utility functions. These methods are characterized by its own calculation procedure, with which it is possible to determine the final ranking of variants [29]. The appropriateness of using methods depend on the type of final ranking that the analyst wishes to obtain [29].

In this study, devoted to the selection of scooters to the needs of users using scooter-sharing systems, various models of scooters that can be used in the systems are considered. Due to the differentiation of models in terms of technical data, the author desires to obtain an ordered variant (scooters) that can be considered, by using the ELECTRE III method.

The ELECTRE III method gained its great popularity due to the possibility of using many factors for the analysis and obtaining a hierarchy among the considered variants [31–33]. ELECTRE III is a particularly frequently used tool in all transport issues, compared to other multicriteria methods. It was used in various types of issues, from the issue of public transport (buses), and new mobility (car sharing) to the analysis of transport and infrastructure projects, as well as aviation projects [33–46].

The method, apart from its wide utilitarianism, is also characterized by many advantages distinguishing it from other MCDMs. Among other things, it allows for [47,48]:

- Precise modeling of the decision maker's preferences to each of the criteria, as well as the precise determination of the importance of the criteria;
- Considering subcriteria;
- Considering a large (more than >7+/−2) number of criteria;
- Applicable to a single decision maker as well as to a group of decision makers;
- Use of actual and not relative values of criteria assessments for individual variants;
- The use of preference thresholds both in the form of fixed values and in the form of proportional (linear) to the compared criteria values;

- Relatively low time consumption of the preference modeling stage by the decision maker;
- The ability to graphically present the results.

The procedure algorithm in the ELECTRE III method includes 3 stages of the procedure, which are presented in Figure 1.

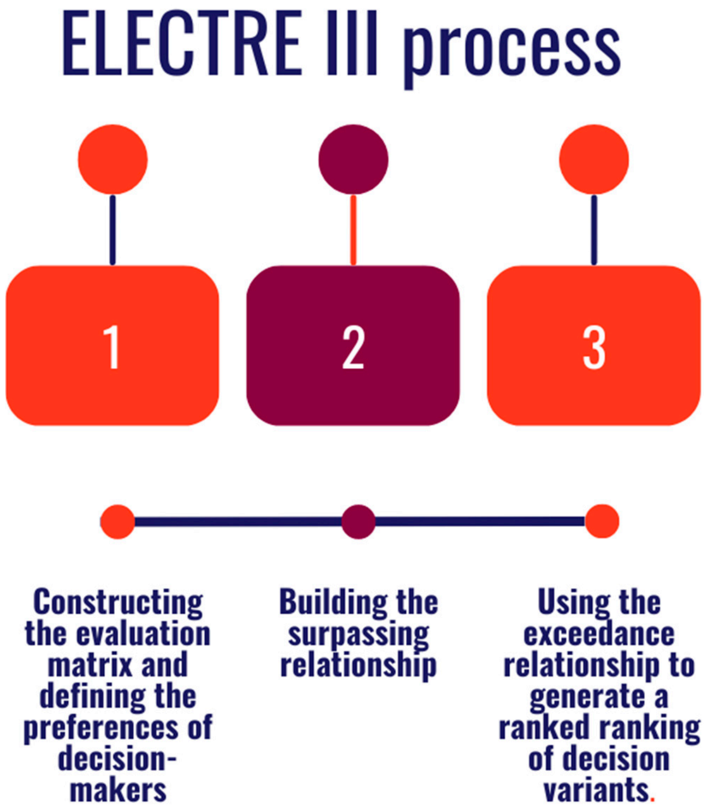

Figure 1. ELECTRE III process.

In the first step, the decision variants, factors characterizing individual variants, and their values are defined, and a social study is carried out consisting of determining the importance of individual factors by the society [43]. The factors are compared pairwise according to the Saaty scale by assigning them weight values from 1 to 9 [44–49].

In the second stage, it is possible to compare individual variants based on the exceedance rate, which is iteratively repeated until all variants are considered. Then, the compliance rate is determined so that it is possible to determine the superiority of a given variant over another variant, considering all the criteria. The compliance ratio is the sum of the weights of the criteria for which the evaluation value of the variant is greater than or equal to the evaluation value of the second variant [29]. The compliance indicators are determined for each pair of analyzed decision variants and then compared with the compliance thresholds set by the decision maker, the value of which should be at least half of the sum of the weights of the criteria (0.5) [29].

The third step is to create the altitude difference matrix. Scenario sequencing begins with their initial ordering using the classification procedures: ascend distillation and descend distillation [29]. Based on the distillation (ascend distillation and descend distillation) and the two rankings created, the final variant ranking is created [30].

Although the ELECTRE III method is not new, so far it has not been applied to the problem of selecting vehicles for scooter sharing, which is considered novelty in this article. Due to the fact that the ELECTRE III method is not used in similar topics related to selection vehicles to scooter sharing, the author is unable to directly refer to the results obtained by other authors. The research was carried out based on the successive steps of the ELECTRE III method. Detailed results are presented in Section 3.

3. Results

The use of the ELECTRE III method, which was presented in the second section, made it possible to determine the factors for choosing the optimal means of transport. The analysis selected nine factors (C1–C9) describing the features of nine electric vehicles (a1–a9) subject to the selection analysis. The factors were set arbitrarily by the author and based on literature referring to research on the selection of vehicles for sharing services on the example of car sharing [40,42], because the literature dedicated to scooter sharing has not yet been specified. The number of factors was selected by the guidelines for the ELECTRE III method, which assumes the separation of 7+/−2 criteria for analysis. The factors are presented in Table 1 and the weights of the criteria in Table 2.

Table 1. Criteria for selecting an electric scooter in shared mobility systems.

Factor Abbreviation	Factor	Factor Description
C1	Vehicle price [EUR]	The market purchase price of a scooter for the scooter-sharing system.
C2	Range [km]	The maximum distance that can be covered with one full use of the maximum battery capacity.
C3	Battery capacity [Ah]	The maximum ability to supply an electrical circuit with a given amount of current for a given time.
C4	Charging time [min]	Number of minutes needed to fully charge the electric battery.
C5	Engine power [kW]	A parameter expressed in Watts (W), which means the work that the motor is able to perform in a given time
C6	Capacity [kg]	Maximum weight of scooter rider.
C7	Number of driving modes [-]	The number of riding modes that can be selected by the scooter user while riding.
C8	Number of driving assistance systems [-]	The number of driving assistance systems that are helping user during riding.
C9	Number of safety systems [-]	The number of safety systems that the electric scooter is equipped with.

Table 2. Weights of the criteria.

Criteria	C1	C2	C3	C4	C5	C6	C7	C8	C9
Weight	0.04	0.20	0.10	0.05	0.18	0.10	0.08	0.10	0.15

The next step was to complete the values of individual criteria for selected vehicle variants. The nine most popular vehicles available on the market were selected for the analysis, without their trade names. The data of the individual criteria for each variant are presented in Table 3.

Table 3. Technical data of the vehicles used during the tests.

	C1 [EUR]	C2 [km]	C3 [Ah]	C4 [min]	C5 [kW]	C6 [kg]	C7 [-]	C8 [-]	C9 [-]
a1	850	25	8	300	350	100	3	3	0
a2	525	20	5	120	350	120	3	1	1
a3	340	18	7.5	240	350	120	3	0	0
a4	575	35	10	560	350	120	3	0	1
a5	525	35	10	560	350	120	3	1	0
a6	635	15	4	240	300	100	4	3	0
a7	375	20	5	210	250	100	3	3	2
a8	425	30	8	330	250	100	3	3	2
a9	575	45	12	510	300	100	3	3	2

The next step in the analysis was to determine the importance of individual criteria. For this purpose, a survey was conducted among 21 experts from the electromobility industry (representatives of shared mobility companies, professors that deal with shared mobility in their scientific works and city authorities' representatives that are responsible for shared mobility issues). The research was dedicated to the Polish shared mobility market conditions. The study was conducted online in October 2022, based on the interviews with every one of the experts. They determined the significance of individual factors according to the pairwise assessment of individual criteria, following the Saaty principle. It is important to emphasize that respondents assessed individual factors without knowing the actual technical characteristics of the vehicles. This type of procedure allowed us to obtain reliable and reliable answers without suggesting a specific make or model of the vehicle. Then, for each factor, the equivalence threshold, the preference threshold and the veto threshold were determined, which are presented in Table 4.

Table 4. The values of the indicators: equivalence, preference and veto thresholds.

	C1	C2	C3	C4	C5	C6	C7	C8	C9
Maximum Difference of Criteria Values: $\Delta = \max - \min$	510.00	30.00	8.00	440.00	100.00	20.00	1.0	3.00	2.00
Equivalence Threshold: $Q = 0.25 \times \Delta$	127.50	7.50	2.00	110.00	25.00	5.00	0.25	0.75	0.50
Preference Threshold: $P = 0.5 \times \Delta$	255.00	15.00	4.00	220.00	50.00	10.00	0.50	1.50	1.00
Veto Threshold: $V = \Delta$	510.00	30.00	8.00	440.00	100.00	20.00	1.0	3.00	2.00

Maximum Difference of Criteria Values—maximum difference of factor values; Equivalence Threshold—the threshold on which it depends whether the variants are considered equivalent; Preference Threshold—minimal difference in the assessment of the two variants; Veto Threshold—maximum difference in the assessment of the two variants.

The concordance matrix and the dominance matrix, which are presented in Tables 5 and 6, were developed successively.

Table 5. Compatibility matrix of tested vehicles.

Compatibility Matrix	a1	a2	a3	a4	a5	a6	a7	a8	a9
a1	0.00	0.85	1.00	0.82	0.97	1.00	0.85	0.85	0.64
a2	0.86	0.00	1.00	0.83	0.83	0.90	0.75	0.73	0.41
a3	0.85	0.82	0.00	0.70	0.82	0.88	0.75	0.74	0.46
a4	0.88	0.97	1.00	0.00	0.97	0.90	0.75	0.75	0.75
a5	0.87	0.85	1.00	0.85	0.00	0.90	0.75	0.75	0.75
a6	0.96	0.85	0.98	0.55	0.70	0.00	0.85	0.75	0.51
a7	0.92	0.97	0.97	0.80	0.80	0.98	0.00	1.00	0.66
a8	0.92	0.97	0.97	0.95	0.95	1.00	1.00	0.00	0.87
a9	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00

Table 6. Matrix of domination of the tested vehicles.

Matrix of Domination	a1	a2	a3	a4	a5	a6	a7	a8	a9
a1	0	U+	U+	E	L−	U+	L−	L−	L−
a2	L−	0	U+	L−	L−	E	L−	L−	L−
a3	L−	L−	0	L−	L−	L−	L−	L−	L−
a4	E	U+	U+	0	L−	E	L−	L−	L−
a5	U+	U+	U+	U+	0	U+	L−	L−	L−
a6	L−	E	U+	E	L−	0	L−	L−	L−
a7	U+	U+	U+	U+	U+	U+	0	L−	L−
a8	U+	U+	U+	U+	U+	U+	U+	0	L−
a9	U+	U+	U+	U+	U+	U+	U+	U+	0

(U+)—the first variant is better than the second variant; (L−)—the first variant is worse than the second variant; E—variants are incomparable.

Thanks to the development of the dominance matrix, it was possible to determine the final ranking using up and down distillation. The final ranking is presented in Table 7.

Table 7. Final survey ranking.

	Ascend Distillation	Descend Distillation	Final Ranking
a9	1.00	1.00	1.00
a8	1.00	2.00	1.50
a7	2.00	3.00	2.50
a4	3.00	6.00	3.50
a5	3.00	4.00	3.50
a1	4.00	5.00	4.50
a2	4.00	6.00	5.00
a6	5.00	5.00	5.00
a3	6.00	7.00	6.50

4. Discussion

Based on the conducted research, it can be concluded that using the multicriteria decision support method, ELECTRE III is suitable for solving the problem of selecting vehicles for scooter-sharing systems.

In the analyzed case study, the use of the ELECTRE III method allowed one to indicate which scooter models and factors related to their technical conditions best meet the expectations of experts from the Polish market.

According to the obtained results, the best solution was the a9 model, which is characterized by the largest available range that an electric scooter can cover. This is evidenced by the largest battery installed among all other electric scooters. In addition, this model has three driven assistance systems and two user safety systems.

The factors considered, after consulting experts, allowed for the final classification of electric scooters. It is worth emphasizing, however, that the a9 model was not characterized by the highest engine power, but only an average of 300 W. The second place in the ranking was taken by the a8 model, which was characterized by the smallest engine power offered (250 W), but it had a large battery and was much cheaper to buy than the a9 model. The third position was taken by the a7 model, which was characterized by a relatively low engine power, but a considerable range. In addition, it was equipped with security systems, which allowed it to be classified highly. The last position was taken by the a3 model, which, despite its high engine power, has a short range and is not equipped with any driving assistance or safety system.

Based on the received weights of factors indicated by experts (Table 2), the classification of factors was determined. The most important factor was the range of the scooter, which is also the most important for the operators, due to the smaller number of needs to recharge the scooter. The second factor is the engine power, the adequate supply of which allows for a wider range of energy consumption by the scooter. Appropriate use of the engine power can increase the range; unfortunately, it is also possible to move the scooter incorrectly, which can cause the battery to discharge faster. Factors responsible for safety and assisting scooter movement have been classified in the next position. These are the factors without which an electric scooter should not be made available to users. Unfortunately, the operator does not have confirmation that a given user has the experience and ability to move an electric scooter. Having protection in the form of appropriate systems will limit or protect the user from a collision. The criterion of the scooter price has the lowest validity. Due to the small differences in the purchase price of an electric scooter, the importance of this aspect can be minimized.

Referring to the author's previous research [50–52], it can be confirmed that the range and power of the scooter are important factors, which in turn translates into different energy consumption. In the case of electric scooters, the energy consumption may be significantly different from that declared by the manufacturer. The author in [51], presenting the results of energy consumption research, showed that riding a scooter according to specific guidelines may lead to significant consumption of electricity by the scooter. The manufacturer of the scooter that was used in the tests declared that the level of energy consumption was significantly lower than the results obtained during the tests. This type of solution can lead to the wrong selection of electric scooters in public transport systems, as well as translate into a wrong vehicle choice when choosing a scooter for a fleet of vehicles. This also confirms the importance of choosing an electric scooter in terms of energy consumption and a built-in battery, which in turn translates into the value of energy consumption by the scooter. With controlled energy consumption, lower CO_2 emissions can be obtained, which will result from charging the battery [51].

Kubik's [52] research determined the impact of vibrations generated by electric scooters on the user and assessed the level and frequency range of these vibrations. Based on the recorded vibration signals, as well as the vibration acceleration spectrum, the range of occurring vibration frequencies was identified, the components of which consist of the scooter's speed and the type of surface. This proves that the selected scooters should be constructed to be able to move on various types of surfaces. Unfortunately, you can now find electric scooters that are not equipped with any user safety systems. Moreover, the results indicate that the generated vibrations may be harmful to the user's health if the appropriate guidelines for moving the vehicle at the appropriate speed and on the appropriate surface are not followed [52].

Due to the fact that, unfortunately, no similar research has been carried out for scooter sharing, the discussion referred to the results obtained in the research for other forms of shared mobility, e.g., car sharing—Turoń [37,41,43] conducted a series of articles on the selection of a motor vehicle for vehicle-sharing systems, focusing only on motor vehicles. She used ELECTRE III as a research method, which proves the appropriate selection of research methodology used by other scientists. This is also confirmed by the fact that multicriteria decision support methods are ideally applied in the field of vehicle selection for vehicle-sharing systems [37,41,43]. Sequentially, Stoychevaet [53] et al. in their research used multicriteria decision analysis, which was used to combine the values of industry leaders and decision makers with performance criteria of various materials for the production of cars. In addition, they demonstrated how sensitivity analyses are used to assess the resistance of the resulting alternative selection. These are great examples of the wide application of multicriteria methods in various scientific disciplines [53].

Atac [54] et al. in their review article highlighted many research gaps and directions of development regarding the subject of vehicle sharing. They argue that different vehicle-sharing systems using different vehicle types have the same management and optimization challenges that need to be addressed. This is confirmed by the fact that the research methodology of other authors has been applied, which, after appropriate adaptation, will reflect the studied case [54].

5. Conclusions

Summarizing, the conducted research allowed one to achieve the goal of the work in the form of proving that it is possible to use the ELECTRE III method to identify vehicles that can be implemented in scooter-sharing systems.

The assumed goal of the work was achieved, which was to classify electric vehicles of the electric scooter type to vehicle sharing systems in cities. Research has shown that the optimal choice was the vehicle with the greatest range, although this vehicle is not the cheapest to buy. The research also indicated that vehicles should also be selected in terms of the users' sense of safety.

Based on the research results obtained, guidelines were also developed for operators of shared scooter vehicles to optimally select vehicles in their fleets:

- When creating a fleet of vehicles, you should first focus on the greatest possible range of a given vehicle and the number of security systems;

- Operators should focus on vehicles with the best engine power, which translates into more efficient driving around the city;
- Operators should also pay attention to the manufacturer of a given vehicle, whether it has the experience and its products are recognizable on the market;
- Theoretically, the vehicle fleet should be adjusted to meet all user preferences, but unfortunately, depending on the city/country in which the electric scooter-sharing system is located, you need to familiarize yourself with the legal requirements that can significantly exclude vehicles with higher engine power (exceeding 350 W);
- It is also worth equipping the vehicles with batteries with the largest possible capacity so that the operator in crises will be able to manage a given vehicle and limit its engine parameters, which will increase the range of the vehicle;
- The criterion of the cost of purchasing an electric scooter is a less significant criterion, as the ranking was won by a vehicle worth EUR 575, and the cheapest a6 vehicle was classified in the last position in the ranking.

The article, like any research work, has some limitations that result from the methodology used. The main limitation of the article is the fact that the analysis selected "commercial" vehicles, which are offered on the market for every consumer, and did not focus on "specialist" vehicles. It is worth noting that it would be ideal to construct an electric scooter dedicated to a given system, or even a city. Moreover, the second limitation is the fact that the research was conducted in the Polish market, and thus with the participation of experts from the Polish market. It should be emphasized that they may have local preferences and experiences that may not be current or identical to other geographic areas. Therefore, if you want to replicate similar research for other areas, it is recommended to conduct your research on the validity of the criteria, considering the opinions of experts from a given market. Another limitation is the methodological limitation resulting from the use of the Saaty scale, which limits the possibility of expressing the respondents' opinions in the form of numerical standardization. Thanks to this, it was possible to obtain quantitative results, but without the possibility of making detailed qualitative analyses, as in the case of typical social research. Another limitation is the lack of similar studies for other geographical areas, which makes it impossible to refer to other studies in the discussion.

In subsequent works, the author plans to conduct research considering another group of electric vehicles with different parameters to obtain an even wider range of results, thanks to which operators will be able to select vehicles for their fleets even more precisely. Furthermore, the author also plans to research the links between individual factors. The author also plans to carry out research for many regions of the world, which will enable the creation of "local" guidelines for the selection of a vehicle for given areas.

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