Article

What Car for Car-Sharing? Conventional, Electric, Hybrid or Hydrogen Fleet? Analysis of the Vehicle Selection Criteria for Car-Sharing Systems

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Abstract: Short-term car rental services called "car-sharing" or "carsharing" are systems that in recent years have been an alternative form of transport by individual car in an increasing number of cities around the world. With the growing popularity of services, new decision-making problems have arisen among system operators. Among the challenges faced by operators, due to the constantly growing environmental requirements, is the fleet of vehicles for car-sharing systems-appropriate selection. Noticing this research gap, this article was dedicated to determining the criteria that are important when choosing a fleet of vehicles for car-sharing and to indicate the best suited to the needs of car-sharing vehicles. Own research was proposed, considering desk research, expert research and analyses using the multi-criteria decision support method (ELECTRE III). This research was carried out for the Polish market of car-sharing services. Studying the Polish market is appropriate due to the occurrence of significant difficulties with the fleet incorrectly adjusted to the needs of urban conditions. This study covers vehicles with conventional, electric, hybrid and hydrogen propulsion. The analyses allowed for the determination of the vehicles best suited to the needs of car-sharing. The results show the dominance of hydrogen-powered vehicles over conventional, hybrid and electric vehicles. What is more, it was determined that the most important criteria are the purchase price of the vehicle and energy/fuel consumption per 100 km. The obtained results are a guide to proceeding when making decisions regarding the implementation or modernization of the fleet in car-sharing systems. The results also support achieving more sustainable urban mobility in the zero-emission trend through hydrogen mobility.

Keywords: car-sharing; carsharing; shared mobility; multi-criteria decision analysis; ELECTRE III; MCDA; decision making in transport; transportation engineering; hydrogen mobility; zero emission; green energy

1. Introduction

Short-term car rental services called "car-sharing" or "carsharing" are systems that in recent years have been an alternative form of transport by individual car in an increasing number of cities around the world. The car-sharing market size surpassed USD 2 billion in 2020 [1], and it is expected to grow in 2022 with a Compound Annual Growth Rate (CAGR) of 17.4% [2]. Car-sharing systems have undergone many modifications along with their development. Over the years, system management, the location and relocation of vehicles, price lists and service packages, infrastructure and vehicles have changed [3–6]. These changes resulted from many different factors due to the gradual adaptation of society to new forms of transport [7], and thus changing demand [8,9], due to new

legislation or municipal car-sharing regulations being implemented [10,11], changes in environmental requirements [12–14], etc.

Evaluating car-sharing systems has become an interesting topic for scientists. A frequently studied topic is the car-sharing fleet. However, there are several leading topics in the field of fleet research. The first of the leading themes is the size of the fleet in car-sharing systems. For example, fleet size considerations are among the main motives; Xu et al. dedicated their research to electric vehicle fleet size for car-sharing services considering on-demand charging strategy and battery degradation [15]. In comparison, Monteiro et al. optimized car-sharing fleet size to maximize the number of clients served [16]. In turn, Hu and Liu analyzed the joint design of parking capacities and fleet size for one-way station-based car-sharing systems with road congestion constraints [4]. The second leading topics regarding the car fleet are aspects of vehicle location and relocation. For example, the Chang et al. dealt with the subject of location design and relocation of a mixed car-sharing fleet with a CO_2 emission constraint [17]. Yoon et al. investigated car-sharing demand estimation and fleet simulation with electric vehicle adoption [18]. In turn, Fan et al. dealt with car-sharing dynamic decision-making obstacles for vehicle allocation [19]. There is, however, a literature gap in the research on the car-sharing fleet. The gap concerns analyses directly related to the type of vehicles used in the systems and their use. In our previous works, we dealt with the determination of the fleet which is most often used in car-sharing systems [20] and we analyzed the operational factors of vehicle use [21]. Receiving signals from operators of Polish car-sharing systems that they need to make changes to vehicle fleets, we have dedicated this article to the selection of vehicles for car-sharing systems.

From the point of view of common mobility services, the Polish market is a very interesting field. Although vehicle sharing services appeared relatively late to other European countries, e.g., bike-sharing in 2008 [22–26], car-sharing in 2016 [27], moped-sharing in 2017 [28], and scooter-sharing in 2018 [28], this market is characterized as dynamic and valuable [28]. A significant development of shared mobility services in Poland has been observed since 2017, when more and more car-sharing service operators appeared on the market [29]. At the peak of shared mobility systems development, there were 17 car-sharing operators available in 250 cities [29]. Revenues from car-sharing services in Poland in 2019 amounted to over 50 million PLN, and they achieved a double increase in 2021, reaching over 100 million PLN [30]. However, the market boom of new car-sharing operators has not lasted long. After the opening of many systems, the rapid disappearance of many systems from the market has occurred. The most spectacular closures included closure of the Vozilla electric car-sharing system with a fleet of 240 cars [31], closure of the InnogyGo system! with a fleet of 500 electric cars [32], and a few other operators who had pilot schemes have withdrawn from offering short-term car rental to long-term rental. It is worth mentioning that during the boom, the offered vehicle fleets and rental regulations were very chaotic and contradictory. For example, operators have implemented electric cars without having to consider the presence of infrastructure for electric vehicles in a given area [21]. Moreover, many system regulations prevented the efficient use of electric cars. For example, it was necessary to terminate the rental of a vehicle with an energy level in the car's battery that would allow another user to drive a further 30 km, where in practice there was no charging station in the area of the rental zone up to 30 km. What is more, many regulations forbid the user to connect cars to chargers by themselves, while others ordered the vehicle to be returned only under the charger. In practice, the idea of free-floating electric car-sharing did not take place at that time. The difficulties were not only with electric vehicles fleets. Conventionally fueled cars, on the other hand, were targeted at one car model, which discouraged some users from using the cars [20]. Despite the many challenges that Polish car-sharing has had to face in recent years, it is predicted that Polish car-sharing revenues will reach a value of over 265 million PLN in 2025 [30]. Currently, many Polish cities, striving to limit transport by individual cars [33–35], are implementing new transport policies, leading to a significant development of car-sharing

service systems, which will result in the creation of new systems and modernization of existing systems over several years; therefore, it is particularly important to determine the appropriate fleet to supply car-sharing systems to meet the expectations of stakeholders.

The aim of this study is to determine the criteria that are important when choosing a fleet of vehicles for car-sharing and to indicate the best suited to the needs of car-sharing vehicles. This research was carried out for the Polish market. This study covers vehicles with conventional, electric and hydrogen propulsion.

This article consists of four main sections. The first chapter presents a general description of the research problem and characterizes the Polish car-sharing market along with a historical outline. The second chapter presents information on the methods of multi-criteria decision support, as well as a detailed description of the ELECTRE III method used, together with a test plan. The third chapter shows a detailed analysis and the obtained results. The fourth chapter discusses the obtained results and confronts them with the research of other authors. This article is a guide when making decisions regarding the implementation or modernization of the fleet in car-sharing systems. The results also support achieving more sustainable urban mobility in the zero-emission trend through hydrogen mobility.

2. Materials and Methods

Deciding which vehicle fleet to choose is a problem that requires consideration of many different criteria. In this case, we use multi-criteria decision support methods. Multi-criteria decision making (MCDM), multi-criteria decision analysis (MCDA) or multi-criteria data analysis methods are a sub-discipline of operations research [36]. Their task is to provide a wide range of mathematical tools that can be used in the analytical process of decision making. MCDM means the process of determining the best feasible solution according to established criteria and problems that are common occurrences in everyday life [37]. Their specificity enables defining criteria, their weights and actors appearing in the decision-making process, i.e., stakeholders [38]. With their use, it is possible to obtain the final rankings of scenarios for the analyzed research questions [36–39]. MCDM is used to solve decision-making problems at the strategic, tactical, and operational levels [40].

MCDA is widely used to solve various transport problems, including for solving the problem of selecting projects to build the Paris metro [41], choosing the best transport connection between the city of Pittsburgh and international airport [42], or assessing transport solutions for the metropolitan area of Istanbul [43]. Moreover, these methods have also been applied to car-sharing systems. For example, they were used to determine the location of base stations of the EVCARD car-sharing system operator in the area of Shanghai [44], to analyze the selection of the location of car-sharing stations in Beijing [45] and to determine the location of car-sharing stations in the French city of La Rochelle [46]. Since MCDA is commonly used in decision-making aspects, one of the methods was included in the research process.

The research process considered secondary research on vehicles used in car-sharing systems, expert research among car-sharing service operators and the performance of mathematical analyses, considering the multi-criteria decision support method. The detailed procedure of the procedure is presented in Figure 1.

Figure 1. Research process.

Secondary research was carried out on a group of operators functioning in Poland in May 2022.They concerned the analysis of vehicle fleets in car-sharing systems in order to identify the most frequently used cars. Successively, the most popular and commercially available hydrogen-powered vehicles were added to conventional, electric and hybrid vehicles. Secondary research allowed the building of a database of vehicles that were considered in the calculations.

The next step was to conduct expert research on a group of car-sharing operators present in Poland. The aim of the research was to indicate the importance of individual criteria considered when selecting a vehicle for car-sharing systems. In accordance with the MCDA methodology, the respondents made pairwise comparisons of individual criteria on a scale from 1 to 9, where 1—same meaning; 2—very weak advantage; 3—weak advantage; 4—more than weak advantage, less than strong; 5—strong advantage; 6—more than a strong advantage, less than very strong; 7—a very strong advantage; 8—more than a very strong advantage, less than an extreme; 9—extreme, total advantage. The weights obtained were included in the analyses using the MCDA method.

The last step was to perform analyses using one of the MCDA methods. Among the group of methods frequently used in transport problems is the set of ELECTRE [47]. ELECTRE is an acronym for *Elimination Et Choix Traduisant la Realitè* and represents a set of multi-criteria decision support methods (ELECTRE I, II, III, IV, IS, and TRI), which are based on partial preference aggregation by overrun [47–53]. Different types of ELECTRE methods have different approaches to decision-making problems. The first method produces elections, the others provide ranking [47–53]. The ELECTRE III method is the most popular of the ELECTRE family methods [39]. The ELECTRE III method is most often combined with expert research (e.g., Delphi method) [54]. The method introduces a two-level preference for a given criteria. This means that they may be strongly or slightly better than each other, which means situations when the decision variants differ very or little from each other [39].

The algorithm in the ELECTRE III method includes 3 stages [24]:

(1) Constructing the evaluation matrix and defining the preferences of decision makers,
(2) Building the surpassing relationship,
(3) Using the exceedance relationship to generate an ordered ranking of decision variants.

The first stage of the analysis begins with the definition of a set of criteria that will be used to evaluate the set of decision variants [47–53]. Each criterion from the set is assigned an appropriate weight. Subsequently, by comparing the two decision variants, the exceedance index is calculated [47–53].

In the second step, based on the exceedance index, the answer is whether the first variant is not worse than the second one due to a given criterion. Subsequently, a computation of the compliance rate is performed to be able to obtain a response with the advantage of one option over the other in terms of all criteria [47–53]. 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 [47–53].

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The third stage is based on creating an altitude difference matrix. The scenarios should be ranked sequentially, which begins with their initial ordering by means of the classification procedures: ascend distillation and descend distillation [47–53]. Both distillations rank the best to worst scenarios [47–53].

Ascend distillation is a scheduling process that begins with selecting the best scenario and placing it at the top of the classification [47–53]. The best scenario is then selected again from among the remaining scenarios and placed in the next position in the classification. This procedure is repeated until the set of scenarios is exhausted [47–53].

For descend distillation, the scheduling process begins with the worst-case selection and placement at the end of the ranking. The sequence is the same as in the ascend distillation procedure, with the difference that in subsequent iterations of the remaining scenarios to be considered, the worst scenario is always selected and placed on the next positions "from the bottom" [47–53].

Then, we create the final ranking based on the top-down and bottom-up ordering. The result is a final ranking of the scenarios. The results are presented in the next chapter.

3. Results

When determining which car-sharing vehicle to choose, in the first step, the most frequently used vehicle models on the Polish market, valid as of May 2022, were determined. The most frequently repeated cars are marked in green. The summary is presented in Table 1.

Table 1. Vehicles used in Polish car-sharing systems.

Engine Type		
Internal Combustion	**Electric Drive**	**Hybrid Drive**
Audi A3	BMW i3 (EV)	Toyota Yaris HSD
Audi Q2	BMW i3s (EV)	Toyota Corolla HSD
Citroen Jumper	Dacia Spring (EV)	Toyota CH-R HSD
Cupra Formentor	Nissan eNV 200 (EV)	
Dacia Dokker	Nissan Leaf (EV)	
Daewoo Lanos	Opel Ampera (EV)	
Ferrari F430	Renault Zoe (EV)	
Fiat 125p	Smart ForTwo EQ (EV)	
Fiat 126p	Tesla Model 3 (EV)	
Fiat 500	Tesla Model S (EV)	
Fiat Ducato	VW eGOLF (EV)	
Fiat Multipla		
FSO Polonez		
Mercedes GLA		
Mercedes W124		
Opel Astra		
Opel Corsa		
Opel Movano		
Porsche 911		
Renault Clio		
Renault Express		
Renault Master		
Seat Arona		
Skoda CityGo		
Skoda Fabia		
Skoda Kodiaq		
Skoda Octavia		
Toyota ProAce		
Trabant 1.1		

VW Crafter		
VW Golf II		
VW Scirocco II		

The most common vehicle models with conventional, electric and hybrid drive were selected successively. In line with global trends in reducing transport emissions, hydrogen-powered vehicles were also included. A total of 12 different vehicle models were included, representing a diverse set of vehicle classes. A detailed list of vehicles considered in the analysis is presented in Table 2.

Table 2. Cars included in the analysis that can be used in car-sharing systems.

ID	Vehicle Model	Fuel Type
a_1	Toyota Mirai	Hydrogen
a_2	Hyundai Nexo	Hydrogen
a_3	Honda Clarity	Hydrogen
a_4	Opel Corsa	Petrol
a_5	Renault Clio	Petrol
a_6	Fiat 500	Petrol
a_7	Toyota Yaris	Hybrid
a_8	Toyota C-HR	Hybrid
a_9	Toyota Corolla	Hybrid
a_{10}	Renault Zoe	Electric
a_{11}	Smart Fortwo EQ	Electric
a_{12}	Dacia Spring	Electric

The criteria for selecting the vehicles that have been considered are successively defined. The list of critics is presented in Table 3.

Table 3. Criteria for selecting vehicles for the car-sharing fleet.

Factor ID	Definition of the Criterion
f_1	Vehicle price [€]
f_2	Motor power [kW]
f_3	Range on single battery charge/refueling [km]
f_4	Energy/fuel/hydrogen consumption [kWh/100 km]
f_5	Battery charging time/refueling time [min]
f_6	Luggage compartment capacity [L]
f_7	Number of seats in the vehicle [-]

The preferences of experts were directed towards vehicles with the highest possible comfort of movement, with relatively high engine power, luggage compartment capacity, and the lowest possible exhaust emissions due to possible restrictions on access to city centers in the future. The values of individual criteria have been presented in sequence for a selected fleet of vehicles that can be implemented in car-sharing systems. The results are presented in Table 4.

Table 4. Adopted values for particular criteria.

ID	Definition of the Criterion						
	Vehicle Price	Motor Power	Range on Single Battery Charge/Refueling [km]	Energy/Fuel/Hydrogen Consumption [kWh/100 km]	Battery Charging Time/Refueling Time	Luggage Compartment Capacity [L]	Number of Seats in the Vehicle
	[€]	[kW]			[min]		[-]
a_1	64,400	134	650	33.1128	5	321	5
a_2	70,000	121	666	27.75168	4.5	461	5
a_3	56,852	131	700	39.42	6	439	5
a_4	15,024	55	650	50.02	2	309	5
a_5	14,590	48	1167	29.52	2	391	5
a_6	11,803	63	921	31.16	1.5	185	5
a_7	18,174	74	1029	28.7	1.5	286	5
a_8	21,242	90	1351	30.34	2.5	377	5
a_9	21,028	90	1389	29.52	2.5	361	5
a_{10}	33,231	80	395	13.164	68	338	5
a_{11}	20,783	60	160	15.2	270	260	2
a_{12}	19,711	33	230	13.9	90	300	5

Then, in accordance with the guidelines of the ELECTRE III method, the equivalence, preference, and veto thresholds were determined for each of the criteria, which are presented in Table 5.

Table 5. Values of the equivalence, preference, and veto thresholds in light of the considered criteria.

Factor ID	Maximum Difference of Criteria Values	Equivalence Threshold	Preference Threshold	Veto Threshold
	$\Delta = max - min$	$Q = 0.25 \times \Delta$	$p = 0.5 \times \Delta$	$V = \Delta$
f_1	58,197	14,549.25	29,098.5	58,197
f_2	101	25.25	50.5	101
f_3	1229	307.25	614.5	1229
f_4	36.856	9.214	18.428	36.856
f_5	268.5	67.125	134.25	268.5
f_6	276	69	138	276
f_7	3	0.75	1.5	3

In the next step, the values of the concordance matrix were determined, which are presented in Table 6.

Table 6. Concordance matrix C values.

Concordance Matrix:	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	a_{12}
a_1	0	0.95	0.9645	0.7494	0.931	1	0.9766	0.9	0.9	1	0.9	0.9734
a_2	1	0	0.92	0.7	0.9369	1	0.9819	0.9	0.9	1	0.9	0.9726
a_3	1	1	0	0.9549	0.948	1	0.9929	0.9	0.9	1	0.9	0.9749
a_4	0.6	0.55	0.5558	0	0.9223	1	0.9766	0.8614	0.8614	0.9246	0.9	0.9689
a_5	0.6	0.5993	0.5777	0.7	0	1	0.997	0.9337	0.9337	0.8889	0.9	0.9689
a_6	0.5514	0.55	0.55	0.6601	0.95	0	0.9768	0.9031	0.8908	0.8082	0.8957	0.9348
a_7	0.6	0.5639	0.501	0.7	0.9739	1	0	0.9793	0.9785	0.9895	0.9	0.9682
a_8	0.6257	0.6664	0.6376	0.7	1	1	1	0	1	1	0.9	0.9696
a_9	0.6257	0.6548	0.6088	0.7	1	1	1	1	0	1	0.9	0.9696
a_{10}	0.3	0.4236	0.3898	0.7	0.6675	0.6429	0.6942	0.6408	0.6675	0	0.9	1
a_{11}	0.2074	0.3267	0.1242	0.5905	0.6388	0.6304	0.7105	0.6035	0.6418	0.9435	0	0.95
a_{12}	0.2633	0.3572	0.197	0.6633	0.6755	0.6192	0.6557	0.5589	0.5914	0.9139	0.8931	0

The non-compliance indicators were successively determined for each of the seven considered criteria, which are presented in Tables A1–A7. Based on the non-compliance indicators, the values of reliability indicators were determined, which are presented in Table A8.

The next step was to perform the ascend and descend distillation. The results are presented in the form of a dominance matrix in Table 7.

Table 7. Dominance matrix L.

Dominance Matrix:	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	a_{12}
a_1	0	I	P−	P+	P+	P+	P+	P+	P+	P+	P+	P+
a_2	I	0	P−	P+	P+	P+	P+	P+	P+	P+	P+	P+
a_3	P+	P+	0	P+	P+	P+	P+	P+	P+	P+	P+	P+
a_4	P−	P−	P−	0	P+	P+	P+	P+	P+	P+	R	P+
a_5	P−	P−	P−	P−	0	P+	I	P−	P−	P+	R	P+
a_6	P−	P−	P−	P−	P−	0	P−	P−	P−	P+	R	P+
a_7	P−	P−	P−	P−	I	P+	0	P−	P−	P+	R	P+
a_8	P−	P−	P−	P−	P+	P+	P+	0	I	P+	R	P+
a_9	P−	P−	P−	P−	P+	P+	P+	I	0	P+	R	P+
a_{10}	P−	P−	P−	P−	P−	P−	P−	P−	P−	0	R	P+
a_{11}	P−	P−	P−	R	R	R	R	R	R	R	0	R
a_{12}	P−	P−	P−	P−	P−	P−	P−	P−	P−	P−	R	0

where I—a pair of variants is equivalent; P+—the first option is better than the second option; P−—the first option is worse than the second option.

Based on the value of the exceedance relation matrix, the final ranking of decision values was created, depending on the type of distillation, which are presented in Table 8. The final ranking presented in Table 8 defines which of the considered scenarios is the most optimal in terms of the assumed criteria and the assessment of the preferences of experts

Table 8. Final ranking.

Dominance Matrix:	Ascend Distillation	Descend Distillation	Average
a_1	1	2	1.5
a_2	1	2	1.5
a_3	1	1	1
a_4	3	3	3
a_5	5	4	4.5
a_6	5	5	5
a_7	5	4	4.5
a_8	4	4	4
a_9	4	4	4
a_{10}	6	5	5.5
a_{11}	2	7	4.5
a_{12}	7	6	6.5

Based on the value of the exceedance relation matrix, the final ranking of decision values was created, depending on the type of distillation, which are presented in Figure 2.
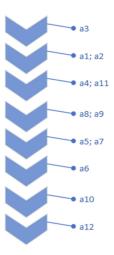

Figure 2. The final ranking of the best vehicles to implement in the car-sharing fleet.

4. Discussion and Conclusions

The research carried out with the use of the ELECTRE III multi-criteria decision support method was used to determine the best selection of vehicles for car-sharing systems based on the criteria established and assessed by experts. The obtained results indicate that of the analyzed car models, Honda Clarity achieved the top ranking and is the optimal vehicle that meets the expectations of experts.

Moreover, the conducted research shows that hydrogen-powered vehicles are on the podium in the obtained ranking. When analyzing the obtained results in detail, it can be noticed that electric vehicles occupy the last places in the ranking. An interesting finding is that conventionally powered vehicles rank better than electric vehicles. This result is mainly caused by a large disproportion between the purchase prices of an electric vehicle and a vehicle with a conventional drive.

Based on the obtained results, it was found that the most important criteria are the purchase price of the vehicle, energy/fuel consumption per 100 km and the time of

refueling/charging the vehicle's battery. The results, therefore, indicate that it is the economic and operational criteria that are of greatest importance for shared mobility cars.

It is worth mentioning that vehicles in car-sharing systems generate profits in terms of traffic. Unfortunately, all vehicles whose battery charging process requires a large amount of time have limited transport availability for users, reducing the often-insufficient vehicle fleet in car-sharing systems.

Therefore, despite the widespread interest in electric vehicles for car-sharing, if the fleet of vehicles is not so large that cars that are being charged cannot be replaced with ready-to-use vehicles, and the infrastructure will not allow the charging time to be reduced to the level of conventional or hydrogen vehicles, electric cars in a car-sharing model will not be the optimal choice.

When translating the obtained results into business practices of car-sharing systems, it is worth emphasizing that hydrogen-powered vehicles are not currently used in systems both in Poland and Europe, and the current trends are directed towards electric vehicles. Unfortunately, the analysis of the market activities of companies shows that most companies with a fleet of electric vehicles in Poland failed, and the systems were closed after several months of operation. This type of practice was also visible in the case of the Paris car-sharing system and the American system in San Diego. Currently, especially in the Polish market, infrastructure for servicing electric vehicles is still too little for individual cars, let alone for servicing car-sharing systems [55]. As Poland is looking for solutions for the development of low-emission transport, more and more hopes are placed on hydrogen. Currently, hydrogen refueling stations are already being created with plans to expand by 2025, when the number of stations will increase by 3200% [56]. Therefore, the dissemination of a hydrogen-powered car for Polish car-sharing is a future-proof scenario.

Due to the area character of the research and the results being limited to the Polish market, the authors plan to expand future research to a larger scale and conduct research considering other European countries. Due to the lack of scientific research on the selection of the vehicle fleet, no direct reference was made in the discussion to the results of other authors' research.

The obtained results support the operators of car-sharing systems in the decision-making process when selecting vehicles for the fleet of their systems.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the authors.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Values of the non-compliance indicators according to the 1st criterion.

Discordance Matrix (f_1):	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	a_{12}
a_1	0	0	0	0	0	0	0	0	0	0	0	0
a_2	0	0	0	0	0	0	0	0	0	0	0	0
a_3	0	0	0	0	0	0	0	0	0	0	0	0
a_4	0.6969	0.8893	0.4375	0	0	0	0	0	0	0	0	0
a_5	0.7118	0.9042	0.4524	0	0	0	0	0	0	0	0	0
a_6	0.8076	1	0.5482	0	0	0	0	0	0	0	0	0
a_7	0.5886	0.7811	0.3292	0	0	0	0	0	0	0	0	0
a_8	0.4832	0.6756	0.2238	0	0	0	0	0	0	0	0	0
a_9	0.4905	0.683	0.2311	0	0	0	0	0	0	0	0	0
a_{10}	0.0712	0.2636	0	0	0	0	0	0	0	0	0	0
a_{11}	0.4989	0.6914	0.2395	0	0	0	0	0	0	0	0	0
a_{12}	0.5358	0.7282	0.2764	0	0	0	0	0	0	0	0	0

Table A2. Values of the non-compliance indicators according to the 2nd criterion.

Discordance Matrix (f_2):	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	a_{12}
a_1	0	0	0	0	0	0	0	0	0	0	0	0
a_2	0	0	0	0	0	0	0	0	0	0	0	0
a_3	0	0	0	0	0	0	0	0	0	0	0	0
a_4	0.5644	0.3069	0.505	0	0	0	0	0	0	0	0	0
a_5	0.703	0.4455	0.6436	0	0	0	0	0	0	0	0	0
a_6	0.4059	0.1485	0.3465	0	0	0	0	0	0	0	0	0
a_7	0.1881	0	0.1287	0	0	0	0	0	0	0	0	0
a_8	0	0	0	0	0	0	0	0	0	0	0	0
a_9	0	0	0	0	0	0	0	0	0	0	0	0
a_{10}	0.0693	0	0.0099	0	0	0	0	0	0	0	0	0
a_{11}	0.4653	0.2079	0.4059	0	0	0	0	0	0	0	0	0
a_{12}	1	0.7426	0.9406	0	0	0	0	0.1287	0.1287	0	0	0

Table A3. Values of the non-compliance indicators according to the 3rd criterion.

Discordance Matrix (f_3):	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	a_{12}
a_1	0	0	0	0	0	0	0	0.1408	0.2026	0	0	0
a_2	0	0	0	0	0	0	0	0.1147	0.1766	0	0	0
a_3	0	0	0	0	0	0	0	0.0594	0.1212	0	0	0
a_4	0	0	0	0	0	0	0	0.1408	0.2026	0	0	0
a_5	0	0	0	0	0	0	0	0	0	0	0	0
a_6	0	0	0	0	0	0	0	0	0	0	0	0

a7	0	0	0	0	0	0	0	0	0	0	0	0
a8	0	0	0	0	0	0	0	0	0	0	0	0
a9	0	0	0	0	0	0	0	0	0	0	0	0
a10	0	0	0	0	0.2563	0	0.0317	0.5557	0.6176	0	0	0
a11	0	0	0	0	0.6387	0.2384	0.4142	0.9382	1	0	0	0
a12	0	0	0	0	0.5248	0.1245	0.3002	0.8242	0.8861	0	0	0

Table A4. Values of the non-compliance indicators according to the 4th criterion.

Discordance Matrix (f_4):	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12
a1	0	0	0	0	0	0	0	0	0	0	0	0
a2	0	0	0	0.2085	0	0	0	0	0	0	0	0
a3	0	0	0	0	0	0	0	0	0	0	0	0
a4	0	0	0	0	0	0	0	0	0	0	0	0
a5	0	0	0	0.1124	0	0	0	0	0	0	0	0
a6	0	0	0	0.0234	0	0	0	0	0	0	0	0
a7	0	0	0	0.1569	0	0	0	0	0	0	0	0
a8	0	0	0	0.0679	0	0	0	0	0	0	0	0
a9	0	0	0	0.1124	0	0	0	0	0	0	0	0
a10	0.0824	0	0.4248	1	0	0	0	0	0	0	0	0
a11	0	0	0.3143	0.8895	0	0	0	0	0	0	0	0
a12	0.0424	0	0.3848	0.9601	0	0	0	0	0	0	0	0

Table A5. Values of the non-compliance indicators according to the 5th criterion.

Discordance Matrix (f_5):	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12
a1	0	0	0	0	0	0	0	0	0	0	0.9739	0
a2	0	0	0	0	0	0	0	0	0	0	0.9777	0
a3	0	0	0	0	0	0	0	0	0	0	0.9665	0
a4	0	0	0	0	0	0	0	0	0	0	0.9963	0
a5	0	0	0	0	0	0	0	0	0	0	0.9963	0
a6	0	0	0	0	0	0	0	0	0	0	1	0
a7	0	0	0	0	0	0	0	0	0	0	1	0
a8	0	0	0	0	0	0	0	0	0	0	0.9926	0
a9	0	0	0	0	0	0	0	0	0	0	0.9926	0
a10	0	0	0	0	0	0	0	0	0	0	0.5047	0
a11	0	0	0	0	0	0	0	0	0	0	0	0
a12	0	0	0	0	0	0	0	0	0	0	0.3408	0

Table A6. Values of the non-compliance indicators according to the 6th criterion.

Discordance Matrix (f_6):	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12
a1	0	0.0145	0	0	0	0	0	0	0	0	0	0
a2	0	0	0	0	0	0	0	0	0	0	0	0
a3	0	0	0	0	0	0	0	0	0	0	0	0
a4	0	0.1014	0	0	0	0	0	0	0	0	0	0
a5	0	0	0	0	0	0	0	0	0	0	0	0
a6	0	1	0.8406	0	0.4928	0	0	0.3913	0.2754	0.1087	0	0

a_7	0	0.2681	0.1087	0	0	0	0	0	0	0	0	0
a_8	0	0	0	0	0	0	0	0	0	0	0	0
a_9	0	0	0	0	0	0	0	0	0	0	0	0
a_{10}	0	0	0	0	0	0	0	0	0	0	0	0
a_{11}	0	0.4565	0.2971	0	0	0	0	0	0	0	0	0
a_{12}	0	0.1667	0.0072	0	0	0	0	0	0	0	0	0

Table A7. Values of the non-compliance indicators according to the 7th criterion.

Discordance Matrix (f_7):	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	a_{12}
a_1	0	0	0	0	0	0	0	0	0	0	0	0
a_2	0	0	0	0	0	0	0	0	0	0	0	0
a_3	0	0	0	0	0	0	0	0	0	0	0	0
a_4	0	0	0	0	0	0	0	0	0	0	0	0
a_5	0	0	0	0	0	0	0	0	0	0	0	0
a_6	0	0	0	0	0	0	0	0	0	0	0	0
a_7	0	0	0	0	0	0	0	0	0	0	0	0
a_8	0	0	0	0	0	0	0	0	0	0	0	0
a_9	0	0	0	0	0	0	0	0	0	0	0	0
a_{10}	0	0	0	0	0	0	0	0	0	0	0	0
a_{11}	1	1	1	1	1	1	1	1	1	1	0	1
a_{12}	0	0	0	0	0	0	0	0	0	0	0	0

Table A8. Credibility matrix values D.

Credibility Matrix :	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	a_{12}
a_1	0	0.95	0.9645	0.7494	0.931	1	0.9766	0.9	0.9	1	0.2346	0.9734
a_2	1	0	0.92	0.7	0.9369	1	0.9819	0.9	0.9	1	0.2011	0.9726
a_3	1	1	0	0.9549	0.948	1	0.9929	0.9	0.9	1	0.3017	0.9749
a_4	0.4547	0.1353	0.5558	0	0.9223	1	0.9766	0.8614	0.8614	0.9246	0.0335	0.9689
a_5	0.321	0.1432	0.4875	0.7	0	1	0.997	0.9337	0.9337	0.8889	0.0335	0.9689
a_6	0.2366	0	0.1948	0.6601	0.95	0	0.9768	0.9031	0.8908	0.8082	0	0.9348
a_7	0.6	0.2831	0.501	0.7	0.9739	1	0	0.9793	0.9785	0.9895	0	0.9682
a_8	0.6257	0.6479	0.6376	0.7	1	1	1	0	1	1	0.067	0.9696
a_9	0.6257	0.6013	0.6088	0.7	1	1	1	1	0	1	0.067	0.9696
a_{10}	0.3	0.4236	0.3674	0	0.6675	0.6429	0.6942	0.6408	0.6675	0	0.9	1
a_{11}	0	0	0	0	0	0	0	0	0	0	0	0
a_{12}	0	0.0605	0.0101	0.0787	0.6755	0.6192	0.6557	0.2227	0.1649	0.9139	0.8931	0

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