


## Article

# Factors Affecting Car-Sharing Services

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**Abstract:** Car-sharing systems, i.e., short-term car rental services, are solutions indicated as an alternative to individual motorization; they can be used in an increasing number of cities around the world. These services, along with their intensive development, are becoming more and more complex. Due to their complexity, they involve not only an increasing number of stakeholders or infrastructure elements, but also indicate numerous links with the functioning of cities, especially smart cities. To properly implement or improve the car-sharing system, both in terms of operational issues regarding the system's functioning or changes in the vehicle fleet, it is important to be familiar with the elements that make up car-sharing, as well as the factors that affect it. This work aims to present the factors affecting car-sharing, as well as the transport model of car-sharing services. This work fills the research gap stemming from the lack of comprehensive studies and knowledge on car-sharing. A detailed analysis of the literature shows that there are six main groups of factors affecting car-sharing: economic and technical, transport, social, environmental, organizational, and other issues; among these factors, more than 150 quantitative and qualitative criteria can be distinguished. Furthermore, the work also showed factors that are a niche in the literature and can be the basis for further research on car-sharing. Detailed familiarity with these factors could translate into increased profitability and, above all, success in the functioning of on-the-market services. This article supports the implementation and improvement of car-sharing services. In addition, it supports scientists in the preparation of scientific papers and mathematical models in the field of car-sharing and the factors that affect it.



**Citation:** Turoń, K. Factors Affecting Car-Sharing Services. *Smart Cities* **2023**, *6*, 1185–1201. <https://doi.org/10.3390/smartcities6020057>

Academic Editors:  
Véronique Flambard,  
Sadia Benamrouz-Vanneste and  
Abir Karami

Received: 5 April 2023  
Revised: 18 April 2023  
Accepted: 19 April 2023  
Published: 20 April 2023



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**Keywords:** car-sharing systems; car-sharing services; car-sharing functioning; car-sharing operation; shared mobility; mobility management; smart cities; smart cities development; new mobility; transportation engineering

## 1. Introduction

In recent years, we have been dealing with the very intensive development of urban centers due to the migration of society. Current figures indicate that 55% of the world's population now lives in urban centers [1] and this proportion is expected to increase by at least 13% by 2050, adding approximately 2.5 billion people to urban centers [2]. Along with the shift in society, the growing interest in the universality of 5G networks [3], and the desire to make ever-more services available remotely [4], this will translate into a even greater propagation of smart cities. It is worth emphasizing, however, that the increased influx in communities, apart from many advantages that will translate into the development of urban centers, will require an efficient transport system. Proper mobility will be possible thanks to the use of new mobility services that will replace classic forms of transport. New mobility services will also be one of the leading elements in Smart City 4.0 [5] and Smart City 5.0 [6].

Car-sharing systems are one of the numerous solutions aimed at improving mobility in cities. The principle of its operation is the use of one vehicle by many renters for short-term trips. Although the first car-sharing systems date back to 1948 [7], the numerous recent developments in car-sharing services are related to the ongoing technological progress in

the field of digitization [8]. Statistics show that car-sharing systems are currently offered by 236 operators in 59 countries around the world [9]. It is forecast that revenues in the car-sharing segment will reach USD 12.88 billion in 2023 [10]. Furthermore, revenues are expected to show an annual growth rate (CAGR 2023–2027) of 5.64%, which translates into a projected market size of USD 16.04 billion by 2027 [10]. The intensive development of systems is also associated with the growing number of users of car-sharing services. This number is growing every year around the world, regardless of continent. An increase in interest in these services has been particularly visible since 2015 when the number of system users reached 5.8 million worldwide; this figure further increased to 36.02 million in 2017 [11].

Currently, among other forms of shared mobility, such as scooters or bicycles, car-sharing services are considered to be one of the most convenient and autonomous forms of new mobility solutions [12]. Despite this fact, among the car-sharing services available on both the European and global markets, one can observe the number of closures, takeovers of companies, or implementation of services on only a pilot basis. In such situations, various arguments are given, including that the system had an ill-matched business model [13], funds were not properly managed, the project turned out to be economically unprofitable [14], information found about the fleet of vehicles was improperly matched to the needs of users [15], customer expectations were not met [16], or that the scope of operation of the services was incorrectly defined [17]. Observing the reasons for the malfunctioning of the systems, it can be argued that car-sharing services are very complex and susceptible to numerous multi-criteria external factors. Many researchers emphasize that there is a real need for thorough research motives to participate in the processes of the shared economy and the criteria involved [18–21] because knowledge of the complexity of shared mobility is necessary to increase public awareness of shared mobility services [22–24]. Based on this assumption, a lot of scientific studies have been conducted in the field of factors affecting both the shared economy, shared mobility, and car-sharing. These studies include both theoretical and practical issues based on various types of field research, surveys, and research experiments. The results are very diverse in terms of, i.e., the type of factors, the level of their importance for various stakeholders, and the location area for which the case was considered. For example, Böcker and Meelen pointed out that motivations to participate in the sharing economy depend on the sociodemographic characteristics of the participants, the role of the participant as a user or supplier of goods, and the types of common goods [25]. A Deloitte study, in turn, showed that the key to the success of the sharing economy is lower costs, the possibility of using sustainable consumption, and the convenience of use [26]. In comparison, Smith showed that convenience in terms of reducing time and stress is a key advantage of shared mobility [27]. In the case of car-sharing, Szymkowiak and Żelichowska indicated savings (time, money), atmosphere (attitude to the brand, relationship with other users of the system), and expectations (user opinions, type of car affecting the comfort of travel) as key factors influencing the popularity of services [28]. However, Jie et al. indicated that gender is the most important factor in predicting whether a person will use short-term car rentals [29]. Furthermore, they emphasized that also employment status, annual income, attitude toward the benefits of shared mobility, the possibility of accessing shared mobility, and the reasons for shared mobility positively correlated with the possibility of using shared mobility [29]. In turn, Nicholas and Rajon Bernard, in analyzing car-sharing success factors, emphasize the importance of aspects such as parking policies [30]. They indicate that the parking policies for car-sharing must be at least equal to those for private cars [30]. As an incentive for electric vehicles, city parking can be given away as an in-kind contribution [30]. For less densely populated cities and rural areas, the city government will likely be required to provide financial support and aid in charger installation [30]. For comparison, Alzahrani et al. suggest that the most essential criteria for car-sharing consumers are insurance coverage, reliability, rental cost, drop-off options, and gas cost [31].

Despite the indication that many factors influence car-sharing, in numerous scientific works no study was found that would constitute a compendium of factors segregated depending on the subject area. To fill this research gap, this work is devoted to an interdisciplinary determination of factors affecting car-sharing systems. For this purpose, a comprehensive literature review was carried out. Creating a knowledge summary containing a full list of factors influencing car-sharing, along with references to individual literature items, will eliminate problems related to the multitude of factors indicated in individual research works or the lack of indication of a given factor which, for one given territory, may not be important yet may be important to another urban center. This study may be helpful to a large group of stakeholders, such as:

- Scientists (when looking for variables that could describe a given system during mathematical modeling of car-sharing, creating optimization models, or building surveys and indicating alternatives to the assessment for respondents);
- Practitioners—operators (when making analyses on how to manage a company or modernize business models);
- Municipal authorities (when assessing projects or analyzing public–private car-sharing partnerships);
- People unfamiliar with car-sharing who want to check what shared mobility entails.

The work has been divided into four sections. Section 1 presents the general scope of the article, while Section 2 is devoted to the adopted research methodology. In Section 3, the results of the analysis are indicated. Section 4 provides a summary, further research plans, and limitations.

## 2. Methodology

To develop a knowledge base on the factors affecting car-sharing services, it was decided to review the literature. The task of the selected research method was to define the research query, indicate keywords, define the database to which the search will be directed, indicate whether reviews of the literature fill the research gap of the query to which the article refers, determine what type of documents are in the database, specify inclusions and exclusions, conduct a detailed analysis, synthesize documents, and indicate the results [18].

Among the various available methods for literature analysis, we selected the method based on the current state of knowledge and the integrative method [32]. This complex type of literature review requires a systematic approach, is inclusive, and reduces bias without highlighting the importance of the particular topics under consideration [33,34]. In addition, the proposed method also differs from other types of classical reviews, such as the realistic review or the so-called realistic synthesis, which focus primarily on understanding the forces behind the success or effectiveness of the intervention, or the integrative method, which covers a wide range of perspectives on a given problem [35,36].

The proposed method considers all the factors influencing car-sharing specified in the given research works without indicating the factors of influence determining whether a given factor turned out to be crucial for a given area or not. It aimed to develop a compendium of factors without imposing on the recipient an aspect that, in the case of his research, could turn out to be less important than another. The indicated research method applies to topics related to urban aspects, such as smart cities and the forms of transport used in them, which is confirmed by the works of Yigitcanlar, et al., Butler et al., and Rana et al. [37–41]. The literature review was performed using the methodology of Booth et al. [42]. The analysis included the following steps [42]:

- (1) Indicating of the research objective of the literature review;
- (2) Conducting a full search, acquisition, and download of articles in the literature;
- (3) Extracting and evaluating items of the obtained literature;
- (4) Synthesizing and analyzing the obtained results in detail;
- (5) Presenting and sharing results and conclusions.

The first step in following the methodology was to define the research goal. Our goal was to define the factors affecting car-sharing. The scope of the study was defined through an extensive review of documents available on car-sharing in the publicly available scientific database Scopus. The Scopus database was indicated because it is a leading scientific database widely used for systematic literature reviews [43]. Boolean functions were used to search for individual volumes in the database. Such functions provide the possibility of a thorough logical analysis, ensuring the sense and truthfulness of the theorems sought during the literature reviews [44]. In the first stage, the term “car-sharing” was searched in the titles, abstracts, and keywords contained in the Scopus document database. The focus was on works written in English. The author’s name was excluded from the search to avoid citing their research. The detailed search formula was as follows (1):

$$GS = DOC_{TIT\ ABS\ KEY} = (car - sharing) AND !EX_{AN} = (TURO\acute{N}) = 1701\ documents \quad (1)$$

where:

$GS$ —general search,

$DOC_{TIT\ ABS\ KEY}$ —documents including “car-sharing” phrase in the titles, abstracts, and keywords,

$EX_{AN}$ —exclusion of the name of the author of this article.

Based on a general search, 1701 documents in the form of articles, monographs, books, and conference papers that contained the phrase “car-sharing” in their titles, abstracts, or keywords. The number of searches turned out to be very high because the term “car-sharing” is used both in many different meanings and in various scientific disciplines not necessarily related to transport. The results showed that the term car-sharing is presented by scientists in a very broad and multi-criteria way. Therefore, in the next step works were sought that would focus on the factors affecting car-sharing both at the stage of implementation and operation of services. The detailed search formula was as follows (2):

$$\begin{aligned} DS &= DOC_{TIT\ ABS\ KEY} \\ &= (factors) OR DOC_{TIT\ ABS\ KEY} (implementing) OR DOC_{TIT\ ABS\ KEY} \\ &= (operation) OR DOC_{TIT\ ABS\ KEY} = (functioning) AND DOC_{TIT\ ABS\ KEY} \\ &= (car - sharing) AND !EX_{AN} = (TURO\acute{N}) = 136\ documents \end{aligned} \quad (2)$$

where:

$DS$ —detailed search,

$DOC_{TIT\ ABS\ KEY}$ —documents including the terms “factors”, “implementing”, “operation”, “functioning”, and “car-sharing” in titles, abstracts, and keywords.

A detailed search found 136 documents; more importantly, a more precise analysis of the obtained excerpts showed that, among the documents, there were works that referred to car-sharing in a very general way, for example, indicating it only in the form of a keyword of a given scientific work. Therefore, it was decided to perform a third, even more, precise and limited search, according to the Formula (3):

$$\begin{aligned} PS &= DOC_{TIT\ ABS\ KEY} = (factors) OR DOC_{TIT\ ABS\ KEY} \\ &= (functioning) OR DOC_{TIT\ ABS\ KEY} (implementing) OR DOC_{TIT\ ABS\ KEY} \\ &= (operation) OR DOC_{TIT\ ABS\ KEY} = (functioning) AND DOC_{TIT\ ABS\ KEY} \\ &= (car - sharing) AND !EX_{AN} = (TURO\acute{N}) = 41\ documents \end{aligned} \quad (3)$$

where:

$PS$ —precise search.

### 3. Car-Sharing Factors—Results and Discussion

As a result of the literature review in the form of precise searches, 41 documents were obtained. Among the 41 analyzed documents, a total of 151 individual criteria affecting car-sharing were identified at the stages of implementation and operation. The specified factors were both quantitative and qualitative variables. Due to the multitude of factors, a synthesis was completed; the factors were then divided depending on the thematic areas to which they belonged. Six thematic areas were identified:

- Economic and technical issues;
- Transport issues;
- Social issues;
- Environmental issues;
- Organizational issues;
- Other issues.

Each of the identified thematic areas is described in detail in Section 3.

#### 3.1. Economic and Technical Factors

The first of the thematic areas are aspects related to financial matters. This area is very complex. Interestingly, it includes not only costs related to the operation of the car-sharing service itself and the related operating costs, such as the costs of the service, additional services or packages [45–52], but also the accompanying car-sharing services offered on the market by competitors [53–58]. Detailed factors related to the functioning of the car-sharing system are presented in Table 1.

**Table 1.** Costs of car-sharing.

Detailed Factors	Variable Type	Investigation Method	Reference
	Quantitative		
The cost of the car-sharing service per kilometer	X	Literature review; survey	[45–47]
The cost of the car-sharing service per minute	X	Survey	[45,46]
Stop-over cost	X	Survey, case study	[45,46]
Daily tariff	X	Case study	[48]
Night tariff	X	Case study	[48]
The cost of registering in the system	X	Case study	[48]
Deposit amount	X	Case study	[48]
The cost of the car-sharing service package	X	Case study	[49]
Financial bonuses for using car-sharing	X	Case study	[50]
Additional costs, i.e., the possibility to go outside the zone	X	Case study	[45,46,49]
The cost of violations (e.g., improper use, parking)—fines	X	Case study	[50,51]

The analysis conducted indicates that the costs of other forms of transportation available in the city, ranging from public transport to new mobility services, are also significant factors that influence car-sharing [32–35]. Detailed factors are connected to the costs of other means of transport in Table 2.

**Table 2.** Costs of using other means of transport.

Detailed Factors	Variable Type	Investigation Method	Reference
	Quantitative		
The cost of renting a vehicle in a classic rental company	X	Case study	[55,56]
TAXI service cost	X	Case study	[57]
Amount of discount on urban collective transport	X	Empirical study	[56]
The cost of a ticket in urban collective transport	X	Empirical study	[47]
The cost of the bike-sharing service	X	Case study	[58]
The cost of the scooter-sharing service	X	Case study	[58]

It is worth mentioning that the literature also indicates several costs related to the maintenance and use of personal vehicles as factors affecting car-sharing. Detailed factors for maintaining an individual vehicle are presented in Table 3.

**Table 3.** Costs of maintaining an individual vehicle.

Detailed Factors	Variable Type	Investigation Method	Reference
	Quantitative		
Vehicle service cost	X	Trip data	[52]
Vehicle insurance cost	X	Trip data	[31,53]
The cost of 1 L of fuel	X	Survey, Trip data	[31,52,53]
Car loan/leasing installments	X	Trip data	[52–54]
The cost of additional services (e.g., vehicle washing, tire change, etc.)	X	Survey, literature review	[52–54]

An additional important group of factors are the aspects related to the costs of public transport available in the place where car-sharing operates or is to operate. Detailed factors are presented in Table 4.

**Table 4.** Costs of using the urban transport system for users of individual vehicles.

Detailed Factors	Variable Type	Investigation Method	Reference
	Quantitative		
Environmental fee for entering the city	X	Survey	[59]
Public parking cost	X	Trip data	[51]
The cost of private parking	X	Trip data	[51]

Analyzing in detail the literature on the indicated economic costs of car-sharing, it is worth emphasizing that no factors were found that would be directly related to the operating costs of car-sharing operations resulting from business models, which seem to be important issues for the correct and, above all, profitable operation of the enterprise.

### 3.2. Transport Factors

Another thematic group of the analyzed factors are issues related to factors related to the implementation of the transport service. The group of such factors is quite extensive. Among the analyzed literature, factors related to the car fleet used in car-sharing services found include defining issues related to the size of the vehicle, its engine performance and safety, and environmental issues [15,37]. Fleet considerations are presented in Table 5.



**Table 5.** Factors related to car-sharing fleet.

Detailed Factors	Variable Type		Investigation Method	Variable Type
	Qualitative	Quantitative		
Car class	X		Survey	[15]
Car size	X		Survey, Case study	[60]
Boot capacity		X	Survey	[15]
Convenience of use		X	Survey	[27]
Engine performance		X	Case study	[60,61]
Energy/fuel consumption		X	Trip data, Survey	[27,62]
Vehicle cost		X	Survey	[15]
Vehicle safety level		X	Survey	[62]
Vehicle warranty		X	Survey	[62]

The second thematic group in the field of transport is aspects related to shared transport. It includes factors related to the presence of other forms of shared mobility, such as short-term bicycle, car, or scooter rentals in the city, as well as factors directly related to the operator's service, e.g., the availability and attractiveness of the vehicle, distance to the nearest vehicle, car relocation issues, or accessibility of the system or type of system from the point of view of the business model. Detailed factors related to shared mobility are presented in Table 6.

**Table 6.** Factors related to shared transport.

Detailed Factors	Variable Type		Investigation Method	Variable Type
	Qualitative	Quantitative		
Availability of the bike-sharing service	X		Survey	[59]
Availability of an already existing car-sharing service	X		Literature review	[49,62]
Availability of the scooter-sharing service	X		Survey	[58]
Availability of the kick-scooter-sharing service	X		Survey	[58]
Availability of car-sharing parking spaces	X		Survey	[47,62]
Vehicle location		X	Trip data	[49,62,63]
Actual vehicle availability	X		Case study	[49,63]
Vehicle fuel/charge level		X	Trip data	[43,44]
fleet attractiveness	X		Survey	[63]
Distance to the nearest vehicle		X	Trip data, case study	[49,63]
Number of operator-owned charging points		X	Case study	[43]
Number of vehicles available		X	Case study	[62]
The possibility of leaving the vehicle in another city	X		Case study	[63]
System area limitations	X		Case study	[62]
Availability of dedicated operator parking spaces	X		Case study, survey	[30,54]
Number of dedicated operator parking spaces		X	Case study, survey	[30,54]
Range of the car-sharing operator (local/global)	X		Literature review	[62]
Vehicle fleet diversity (vehicle classes)	X		Survey	[15,49]

**Table 6.** *Cont.*

Detailed Factors	Variable Type		Investigation Method	Variable Type
	Qualitative	Qualitative		
Possibility of self-refueling of the vehicle by the user	X		Survey	[49]
Relocation of vehicles in the city	X		Case study	[43,62]
Minimum age required to use the system		X	Case study	[14]
System type	X		Case study, literature review	[43,49,63]

Factors related to transport infrastructure constitute a separate subgroup. They are presented in Table 7. Interestingly, in its scope the literature defines only issues such as bus lanes, parking spaces dedicated to electric vehicles, or park and ride car parks. To the best of the authors' knowledge, no issues related to the total number of parking spaces or places dedicated to car-sharing (and not only car-sharing based on electric vehicles) were found.

**Table 7.** Factors related to infrastructure.

Detailed Factors	Variable Type		Investigation Method	Reference
	Qualitative	Qualitative		
Number of bus lanes	X		Trip data	[64]
Number of parking spaces dedicated to electric vehicles	X		Trip data	[65]
Number of park and ride car parks	X		Trip data	[66]

Moreover, no reference was made to the number and availability of public electric vehicle charging stations or mobility hubs dedicated to car-sharing.

Another sub-group within transport issues is issues related to the organization of transport in a given area. These aspects concern both traffic engineering and transport management in the city, e.g., traffic volume, speed limits, the availability of public charging stations and their capacity, or the presence of intelligent transport systems. A detailed summary is presented in Table 8.

**Table 8.** Factors related to organizational issues.

Detailed Factors	Variable Type		Investigation Method	Reference
	Qualitative	Qualitative		
Traffic		X	Trip data	[67]
Speed limit zone		X	Trip data	[67]
Restricted vehicle entry zones	X		Case study	[47]
Privileges for urban collective transport	X		Case study	[47]
Information integration about all means of public transport	X		Case study	[68]
Operating costs of collective transport		X	Case study	[68]
Spatial and functional integration with other means of public transport	X		Case study	[69]
Convenience of transfers	X		Trip data	[70]
Mass transit travel speed		X	Trip data	[70]
Availability of information (e.g., timetables)	X		Trip data	[70]
Level of public transport driving safety	X		Case study	[69]



Table 8. Cont.

Detailed Factors	Variable Type		Investigation Method	Reference
	Qualitative	Qualitative		
Level of personal safety of public transport passengers	X		Case study	[69]
Waiting time at stops for a public transport vehicle		X	Case study	[69]
The convenience of the ticketing system (ease of purchase, variety of the ticket offer, ticket validity with different carriers, etc.)	X		Case study	[47]
Privileges for electric/hybrid vehicles	X		Case study	[71]
Number of electric vehicle charging stations		X	Case study	[71]
Electric vehicle charging time using a public charging station		X	Case study	[71]
The presence of parking spaces dedicated to electric vehicles	X		Case study	[71]
Number of TAXI service operators		X	Trip data, case study	[57]
Presence of the ITS system	X		Case study	[64]

A separate group within the thematic area of transport is factors directly related to urban collective transport occurring in the area where the car-sharing system is or would be operating. A detailed summary is presented in Table 9.

Table 9. Factors related to urban collective transport.

Detailed Factors	Variable Type		Investigation Method	Reference
	Qualitative	Qualitative		
Accessibility of urban collective transport	X		Case study	[47]
Punctuality of urban public transport	X		Case study	[69]
Diversity of urban collective transport	X		Case study	[68]
Level of comfort of urban collective transport	X		Case study	[68]
Condition of urban collective transport rolling stock	X		Case study	[68]
Travel time by public transport		X	Case study	[68]
Time loss/delays in urban collective transport		X	Case study	[47]
Service for socially diverse groups of residents	X		Case study	[69–71]
Frequency of transport means (number of daily trips)	X		Case study	[72]
Number of operators servicing urban collective transport		X	Case study	[69]
Direct connections (no transfers)	X		Case study	[68]
Percentage chance of securing a seat		X	Case study	[69,73]
Operating range of the municipal public transport operator (local/global)	X		Case study	[69]
The failure rate of vehicles used in public transport		X	Case study	[47]
Number and length of routes		X	Trip data	[69]

### 3.3. Social Factors

The third of the thematic areas is factors covering social issues. These include detailed information on users or potential users of car-sharing systems, such as their age, education, or earnings. Interestingly, among the factors, there are also aspects referring to the experience of using shared mobility services and the general approach to sustainable and

ecological forms of transport. It seems that the range of factors is wide and related to both personal and professional issues, as well as TO the approach to transport. Detailed factors are presented in Table 10.

**Table 10.** Social factors related to current or potential car-sharing users.

Detailed Factors	Variable Type		Investigation Method	Reference
	Qualitative	Qualitative		
Sex	X		Survey	[49,59,74]
License to drive motor vehicles	X		Survey	[14,74]
Domicile	X		Survey	[49,59,74,75]
Home-work distance	X		Survey	[75]
Education	X		Survey	[50]
Social status	X		Survey	[76,77]
earnings		X	Survey	[14,75,76]
Possessed electronic equipment, e.g., a smartphone with the Internet	X		Survey	[14,75]
Number of owned vehicles		X	Survey	[77]
Number of kilometers driven by car per year/month		X	Survey	[77]
Number of kilometers driven by car per day in the city		X	Survey	[14,75,77]
City travel time		X	Survey	[14,75]
Accessibility to a family vehicle	X		Survey	[14,75]
Technological advancement	X		Survey	[14,75,77]
Using car-pooling services such as Uber	X		Survey	[64]
Pro-ecological attitude of users	X		Survey	[67,78]
Passion for a particular brand of vehicles	X		Survey	[74]
Perception of the vehicle as a luxury good	X		Survey	[74]
Willingness to test drive a given vehicle	X		Survey	[74]
Sharing economy experience	X		Survey	[75]
Brand perception	X		Survey	[28]
Opinions of other customers about the brand	X		Survey	[28]

### 3.4. Environmental Factors

The fourth of the thematic groups is aspects related to environmental issues. In this group, there are factors directly related to the characteristics of individual cities and the occurrence of certain levels of pollution or noise in their area. The presence of policies or restrictions directly related to the issue of sustainable development was also indicated. Among the indicated factors, for example, the factor defining urban plans in the field of development of pro-ecological solutions was missing, as was a detailed definition of good and bad practices characteristic of a given urban center. A detailed list of factors is shown in Table 11.

**Table 11.** Factors related to city features.

Detailed Factors	Variable Type		Investigation Method	Reference
	Qualitative	Qualitative		
Ecological restrictions in cities, e.g., eco-zones	X		Case study, Survey	[75]
The noise level in the city		X	Case study	[79]
Pollution level in the city		X	Case study	[80]
The policy of sustainable transport development in the city	X		Case study	[67,78]
Ecological restrictions in cities, e.g., eco-zones	X		Case study	[67]

A separate group of factors is issues related to the environmental performance of the vehicle fleet. It defines both the number of vehicles with alternative drives and their emissions. A detailed summary is presented in Table 12.

**Table 12.** Factors related to environmental issues associated with the car-sharing fleet.

Detailed Factors	Variable Type		Investigation Method	Reference
	Qualitative	Qualitative		
Number of electric cars	X		Case study	[67,78]
Number of hybrid cars	X		Case study	[81]
Number of EURO6 cars	X		Case study	[81]
CO <sub>2</sub> emission level of car-sharing vehicles	X		Case study	[82]

### 3.5. Organizational Factors

The fifth group of factors is aspects related to the organizational issues of the functioning of car-sharing systems. These include, for example, the method of registration in the system implemented by the operator, the approach to customer service, or the accessibility of the system application offered. A detailed summary is presented in Table 13.

**Table 13.** Organizational factors of car-sharing functioning.

Detailed Factors	Variable Type		Investigation Method	Reference
	Qualitative	Qualitative		
Accessibility of the IT system for the user	X		Case study	[49,63,83]
Contacting customer service	X		Case study	[68]
Location of customer service offices	X		Case study	[62,68]
Method of data verification during registration	X		Survey	[44]
Accessibility of the system for people from abroad	X		Survey	[58,68]
Operators liability for damage to the vehicle	X		Case study	[68]
The users responsibility for damage to the vehicle	X		Case study	[68]
How to book a vehicle	X		Case study	[43]
How to open the vehicle	X		Case study	[68]
Additional vehicle equipment, e.g., a child seat	X		Case study	[68]

### 3.6. Other Factors

The sixth group consists of other factors that influence car-sharing. These are factors over which neither operators nor users have influence. These issues include weather and atmospheric changes, as well as weather forecasts and predicted rainfall or temperature

changes that affect consumers' attitudes to using car-sharing services. A detailed list is shown in Table 14.

**Table 14.** Factors related to weather conditions.

Detailed Factors	Variable Type		Investigation Method	Reference
	Qualitative	Qualitative		
Season	X		Empirical study	[49]
Temperature		X	Empirical study	[49]
Rainfall		X	Empirical study	[49]
Weather changes	X		Empirical study	[49]
Weather forecasts	X		Empirical study	[49]
Season	X		Empirical study	[49]

In addition to the weather, other factors over which neither users nor operators have influence are issues related to the type and time of day. A detailed summary is presented in Table 15.

**Table 15.** Factors related to days of using the systems.

Detailed Factors	Variable Type		Investigation Method	Reference
	Qualitative	Qualitative		
The time of the day		X	Survey, case study	[49,74]
Working days	X		Survey, case study	[49,74]
Weekends	X		Survey, case study	[49,74]
Holidays	X		Survey, case study	[49,74]

The last group of factors that are not influenced by users or operators are factors directly related to the type of city or its history, administrative issues, or the number of inhabitants. A detailed summary is presented in Table 16.

**Table 16.** Factors related to the demographic and social structure of the city.

Detailed Factors	Variable Type		Investigation Method	Reference
	Qualitative	Qualitative		
Cty area	X		Survey	[58]
city type (administrative)	X		Survey	[83]
The number of residents		X	Survey	[58]
Tourist attractiveness	X		Survey	[58]
Number of inhabitants in given transport zones		X	Case study	[83]
Monuments in different locations	X		Survey	[58]
Location of strategic places, e.g., railway stations	X		Case study	[83]
Distance of the main city from other cities		X	Case study	[49,63]
City type (historical/modern)	X		Case study	[49,63]

#### 4. Conclusions

To sum up, this work made it possible to achieve the goal of developing a comprehensive list of factors affecting car-sharing services. In its scope, six main thematic groups of areas with which the factors are related, i.e., economic, transport, environmental, social,

organizational, and other issues, have been defined. Among the indicated thematic groups, over 150 criteria have been identified that have an impact on car-sharing services. These factors have been cataloged and presented with references to the literature. The largest group of factors is issues related to transport. That list is a collection of information that can be used both by scientists when preparing research in the field of car-sharing or building identification or optimization models. It also supports operators in carrying out analyses on the implementation or functionality of their current services.

Although many factors have been identified in the literature, it seems that the list is not exhaustive. Among the indicated aspects, several important aspects were excluded. The first is the lack of factors related to the financial operational issues of car-sharing services. These factors seem to be very important, especially from the point of view of the need to determine the profitability of the project. Another aspect not discussed in the literature is the lack of references to the transport infrastructure directly dedicated to car-sharing of any type, rather than just electric vehicles. The literature does not mention mobility hubs or public parking spaces for car-sharing. Such initiatives are becoming increasingly common solutions in the era of implementing sustainable transportation schemes. In the literature on the factors affecting car-sharing, little is said about business models. Although the type of system is an important factor, there is no information related to the individual elements that make up the business model, e.g., relations with the environment, revenue streams, etc. From a legislative point of view, there is also no indication of the rights or restrictions imposed on car-sharing services. Factors related to cooperation with, for example, urban centers, which seems to be crucial, especially in the implementation of public-private car-sharing, have not been noted either. The indicated aspects may become a guideline for further research exploration when performing analyses on car-sharing services because they constitute the current research gaps.

Like any research paper, this study also has limitations. The main limitation is the focus on researching the literature only within the scope of the Scopus database. This database, despite being the most valued in the academic community, may not contain all works on factors affecting car-sharing. The limitations introduced by the research method may not cover all studies presenting factors influencing car-sharing. Moreover, it should be emphasized that there may be works where the authors mentioned factors affecting car-sharing using different nomenclature; in these cases, the publication could not be included in the searches.

In future scientific works, the authors plan to analyze the importance of individual factors for various groups of stakeholders to indicate the leading trends and maps on the impact of individual criteria. Moreover, the authors also plan to analyze the factors affecting car-sharing based on other literature search methods, as well as bibliometric databases alternative to the Scopus database, such as Web of Science. This type of study will allow comparisons regarding the repeatability of criteria, as well as determine the selection of the appropriate research methods for literature analysis in the field of shared mobility.

**Funding:** This research received no external funding.

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

**Conflicts of Interest:** The author declare no conflict of interest.

## References

1. United Nations. Revision of World Urbanization Prospects. Available online: <https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf> (accessed on 18 March 2023).
2. United Nations. Analysis and Policy Recommendations from the United Nations Secretary-General's High-Level Advisory Group on Sustainable Transport, Mobilizing Sustainable Transport for Development High-Level Advisory Group on Sustainable Transport. 2016. Available online: <https://sustainabledevelopment.un.org/index.php?page=view&type=400&nr=2375&menu=1515> (accessed on 18 March 2023).

3. Liu, B.; Han, C.; Liu, X.; Li, W. Vehicle Artificial Intelligence System Based on Intelligent Image Analysis and 5G Network. *Int. J. Wirel. Inf. Netw.* **2021**, *30*, 86–102. [\[CrossRef\]](#)
4. Sahut, J.M.; Lissillour, R. The Adoption of Remote Work Platforms after the COVID-19 Lockdown: New Approach, New Evidence. *J. Bus. Res.* **2023**, *154*, 113345. [\[CrossRef\]](#) [\[PubMed\]](#)
5. Balletto, G.; Borruso, G.; Ladu, M.; Milesi, A.; Tagliapietra, D.; Carboni, L. Smart City and Industry 4.0: New Opportunities for Mobility Innovation. In *Computational Science and Its Applications—ICCSA 2022 Workshops*; Gervasi, O., Murgante, B., Misra, S., Rocha, A.M.A.C., Garau, C., Eds.; Lecture Notes in Computer Science; Springer International Publishing: Cham, Switzerland, 2022; Volume 13378, pp. 473–484. [\[CrossRef\]](#)
6. Svítek, M.; Skobelev, P.; Kozhevnikov, S. Smart City 5.0 as an Urban Ecosystem of Smart Services. In *Service Oriented, Holonic and Multi-Agent Manufacturing Systems for Industry of the Future*; Borangiu, T., Trentesaux, D., Leitão, P., Giret Boggino, A., Botti, V., Eds.; Studies in Computational Intelligence; Springer International Publishing: Cham, Switzerland, 2020; Volume 853, pp. 426–438. [\[CrossRef\]](#)
7. Harms, S.; Truffer, B. *The Emergence of a Nationwide Carsharing Co-Operative in Switzerland, Research Report*; EAWAG: Niemcy, Germany, 1998.
8. Gonzalez, P.P.; Quadros, R. Digital Transformation and New Business Models in Urban Mobility: The Case of Carsharing in Brazil. In *2022 Portland International Conference on Management of Engineering and Technology (PICMET)*; IEEE: Portland, OR, USA, 2022; pp. 1–12. [\[CrossRef\]](#)
9. Research and Markets. Car Sharing Market: Global Industry, Trends, Share, Size, Growth, Opportunity and Forecast 2021–2026. Available online: [https://www.researchandmarkets.com/reports/5483424/car-sharing-market-global-industry-trends?gclid=Cj0KCQiAg\\_KbBhDLARIsANx7wAwu3FD0-eUeYdxZZQ\\_qtTYEijaNKLC6gwGPSOUPK-\\_T3J0l7VsLwnwaAvwgEALw\\_wcB](https://www.researchandmarkets.com/reports/5483424/car-sharing-market-global-industry-trends?gclid=Cj0KCQiAg_KbBhDLARIsANx7wAwu3FD0-eUeYdxZZQ_qtTYEijaNKLC6gwGPSOUPK-_T3J0l7VsLwnwaAvwgEALw_wcB) (accessed on 18 March 2023).
10. Car-Sharing—Worldwide. Available online: <https://www.statista.com/outlook/mmo/shared-mobility/shared-rides/car-sharing/worldwide> (accessed on 18 March 2023).
11. Finger, M.; Bert, N.; Kupfer, D.; Montero, J.J.; Wołek, M. *Research for TRAN Committee: Infrastructure Funding Challenges in the Sharing Economy*; European Parliament, Policy Department for Structural and Cohesion Policies: Brussels, Belgium, 2017. Available online: [https://www.europarl.europa.eu/RegData/etudes/STUD/2017/601970/IPOL\\_STU\(2017\)601970\\_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/STUD/2017/601970/IPOL_STU(2017)601970_EN.pdf) (accessed on 18 March 2023).
12. Jung, J.; Koo, Y. Analyzing the Effects of Car Sharing Services on the Reduction of Greenhouse Gas (GHG) Emissions. *Sustainability* **2018**, *10*, 539. [\[CrossRef\]](#)
13. Alencar, V.A.; Pessamilio, L.R.; Rooke, F.; Bernardino, H.S.; Borges Vieira, A. Forecasting the Carsharing Service Demand Using Uni and Multivariable Models. *J. Internet Serv. Appl.* **2021**, *12*, 4. [\[CrossRef\]](#)
14. Schiffer, M.; Hiermann, G.; Rüdel, F.; Walther, G. A Polynomial-Time Algorithm for User-Based Relocation in Free-Floating Car Sharing Systems. *Transp. Res. Part B Methodol.* **2021**, *143*, 65–85. [\[CrossRef\]](#)
15. Turoń, K.; Kubik, A.; Chen, F. What Car for Car-Sharing? Conventional, Electric, Hybrid or Hydrogen Fleet? Analysis of the Vehicle Selection Criteria for Car-Sharing Systems. *Energies* **2022**, *15*, 4344. [\[CrossRef\]](#)
16. Hahn, R.; Ostertag, F.; Lehr, A.; Büttgen, M.; Benoit, S. “I like It, but I Don’t Use It”: Impact of Carsharing Business Models on Usage Intentions in the Sharing Economy. *Bus. Strategy Environ.* **2020**, *29*, 1404–1418. [\[CrossRef\]](#)
17. Brandstätter, G.; Kahr, M.; Leitner, M. Determining Optimal Locations for Charging Stations of Electric Car-Sharing Systems under Stochastic Demand. *Transp. Res. Part B Methodol.* **2017**, *104*, 17–35. [\[CrossRef\]](#)
18. Andreotti, A.; Anselmi, G.; Eichhorn, T.; Hoffmann, C.P.; Micheli, M. Participation in the Sharing Economy. *SSRN J.* **2017**. [\[CrossRef\]](#)
19. Schaefer, C.; Stelter, A.; Holl-Supra, S.; Weber, S.; Niehaves, B. The Acceptance and Use Behavior of Shared Mobility Services in a Rural Municipality. *Smart Cities* **2022**, *5*, 1229–1240. [\[CrossRef\]](#)
20. Kubik, A. Impact of the Use of Electric Scooters from Shared Mobility Systems on the Users. *Smart Cities* **2022**, *5*, 1079–1091. [\[CrossRef\]](#)
21. Guyader, H.; Friman, M.; Olsson, L.E. Shared Mobility: Evolving Practices for Sustainability. *Sustainability* **2021**, *13*, 12148. [\[CrossRef\]](#)
22. Burghard, U.; Dütschke, E. Who Wants Shared Mobility? Lessons from Early Adopters and Mainstream Drivers on Electric Carsharing in Germany. *Transp. Res. Part D Transp. Environ.* **2019**, *71*, 96–109. [\[CrossRef\]](#)
23. Maas, S.; Attard, M. Attitudes and Perceptions towards Shared Mobility Services: Repeated Cross-Sectional Results from a Survey among the Maltese Population. *Transp. Res. Procedia* **2020**, *45*, 955–962. [\[CrossRef\]](#)
24. Shokouhyar, S.; Shokoohyar, S.; Sobhani, A.; Gorizi, A.J. Shared Mobility in Post-COVID Era: New Challenges and Opportunities. *Sustain. Cities Soc.* **2021**, *67*, 102714. [\[CrossRef\]](#) [\[PubMed\]](#)
25. Böcker, L.; Meelen, T. Sharing for People, Planet or Profit? Analysing Motivations for Intended Sharing Economy Participation. *Environ. Innov. Soc. Transit.* **2017**, *23*, 28–39. [\[CrossRef\]](#)
26. Deloitte. The Sharing Economy: Share and Make Money: How Does Switzerland Compare? Available online: <https://www2.deloitte.com/content/dam/Deloitte/ch/Documents/consumer-business/ch-cb-shared-economy-share-and-make-money.pdf> (accessed on 15 April 2023).



27. Smith, A. Shared, Collaborative and on Demand: The New Digital Economy. Available online: <https://www.pewresearch.org/internet/2016/05/19/the-new-digital-economy/> (accessed on 15 April 2023).
28. Szymkowiak, A.; Żelichowska, E. Factors Affecting Car-Sharing and Participation in the Sharing Economy. *Ann. Univ. Mariae Curie-Skłodowska Sect. H–Oeconomia* **2019**, *53*, 99. [CrossRef]
29. Jie, F.; Standing, C.; Biermann, S.; Standing, S.; Le, T. Factors Affecting the Adoption of Shared Mobility Systems: Evidence from Australia. *Res. Transp. Bus. Manag.* **2021**, *41*, 100651. [CrossRef]
30. Nicholas, M.; Rajon Bernard, M. Success Factors for Electric Carsharing. Available online: [https://theicct.org/wp-content/uploads/2021/12/na-us-eu-ldv-electric-carsharing-factors-aug21\\_0.pdf](https://theicct.org/wp-content/uploads/2021/12/na-us-eu-ldv-electric-carsharing-factors-aug21_0.pdf) (accessed on 15 April 2023).
31. Alzahrani, S.; Alzahrani, A.; Dai, X.; Hsu, W.-C.; Tiwari, R. An Assessment of the Factors Influencing the Selection of the Best Carsharing Alternative in Portland Area Using Hierarchical Decision Modeling (HDM). In Proceedings of the 2019 Portland International Conference on Management of Engineering and Technology (PICMET), Portland, OR, USA, 25–29 August 2019; IEEE: Portland, OR, USA, 2019; pp. 1–7. [CrossRef]
32. Creswell, J. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*; Sage: Thousand Oaks, CA, USA, 2014.
33. Lubbe, W.; Ham-Baloyi, W.T.; Smit, K. The Integrative Literature Review as a Research Method: A Demonstration Review of Research on Neurodevelopmental Supportive Care in Preterm Infants. *J. Neonatal Nurs.* **2020**, *26*, 308–315. [CrossRef]
34. Doolen, J. Meta-Analysis, Systematic, and Integrative Reviews: An Overview. *Clin. Simul. Nurs.* **2017**, *13*, 28–30. [CrossRef]
35. Rycroft-Malone, J.; McCormack, B.; Hutchinson, A.M.; DeCorby, K.; Bucknall, T.K.; Kent, B.; Schultz, A.; Snelgrove-Clarke, E.; Stetler, C.B.; Titler, M.; et al. Realist Synthesis: Illustrating the Method for Implementation Research. *Implement. Sci.* **2012**, *7*, 33. [CrossRef] [PubMed]
36. Schick-Makaroff, K.; MacDonald, M.; Plummer, M.; Burgess, J.; Neander, W. What Synthesis Methodology Should I Use? A Review and Analysis of Approaches to Research Synthesis. *AIMS Public Health* **2016**, *3*, 172–215. [CrossRef] [PubMed]
37. Yigitcanlar, T.; Desouza, K.; Butler, L.; Roozkhosh, F. Contributions and risks of artificial intelligence (AI) in building smarter cities. *Energies* **2020**, *13*, 1473. [CrossRef]
38. Yigitcanlar, T.; Han, H.; Kamruzzaman, M.; Ioppolo, G.; Sabatini-Marques, J. The making of smart cities: Are Songdo, Masdar, Amsterdam, San Francisco and Brisbane the best we could build? *Land Use Policy* **2019**, *88*, 104187. [CrossRef]
39. Butler, L.; Yigitcanlar, T.; Paz, A. How Can Smart Mobility Innovations Alleviate Transportation Disadvantage? Assembling a Conceptual Framework through a Systematic Review. *Appl. Sci.* **2020**, *10*, 6306. [CrossRef]
40. Yigitcanlar, T.; Kamruzzaman, M.; Buys, L.; Ioppolo, G.; Sabatini-Marques, J.; da Costa, E.M.; Yun, J.J. Understanding ‘smart cities’: Intertwining development drivers with desired outcomes in a multidimensional framework. *Cities* **2018**, *81*, 145–160. [CrossRef]
41. Rana, R.L.; Adamashvili, N.; Tricase, C. The Impact of Blockchain Technology Adoption on Tourism Industry: A Systematic Literature Review. *Sustainability* **2022**, *14*, 7383. [CrossRef]
42. Booth, A.; Sutton, A.; Papaioannou, D. *Systematic Approaches to a Successful Literature Review*; SAGE Publications: London, UK, 2012.
43. Raddats, C.; Kowalkowski, C.; Benedettini, O.; Burton, J.; Gebauer, H. Servitization: A contemporary thematic review of four major research streams. *Ind. Mark. Manag.* **2019**, *83*, 207–223. [CrossRef]
44. Cronin, P.; Ryan, F.; Coughlan, M. Undertaking a literature review: A step-by-step approach. *Br. J. Nurs.* **2008**, *17*, 38–43. [CrossRef]
45. Boldrini, C.; Bruno, R.; Conti, M. Characterising demand and usage patterns in a large station-based car-sharing system. In *The 2nd IEEE INFOCOM Workshop on Smart Cities and Urban Computing*; IEEE: Piscataway Township, NJ, USA, 2016; pp. 1–6.
46. Boldrini, C.; Bruno, R.; Larabi, M. Weak signals in the mobility landscape: Car sharing in the European cities. *EPJ Data Sci.* **2019**, *8*, 7. [CrossRef]
47. Kim, D.; Park, Y.; Ko, J. Factors underlying vehicle ownership reduction among carsharing users: A repeated cross-sectional analysis. *Transp. Res. Part D Transp. Environ.* **2019**, *76*, 123–137. [CrossRef]
48. Perboli, G. Business models and tariff simulation in car-sharing services. *Transp. Res. Part A Policy Pract.* **2018**, *15*, 32–48. [CrossRef]
49. Schmöller, S.; Weikl, S.; Müller, J.; Bogenberger, K. Empirical analysis of free-floating carsharing usage: The Munich and Berlin case. *Transp. Res. Part C Emerg. Technol.* **2015**, *56*, 34–51. [CrossRef]
50. Perboli, G.; De Marco, A.; Perfetti, F.; Marone, M. A New Taxonomy of Smart City Projects. *Transp. Res. Procedia* **2014**, *3*, 470–478. [CrossRef]
51. Carrese, S.; D’Andreagiovanni, F.; Giacchetti, T.; Nardin, A.; Zamberlan, L. An optimization model for renting public parking slots to carsharing services. *Transp. Res. Procedia* **2020**, *45*, 499–506. [CrossRef]
52. Hu, B.; Sun, Y.; Sun, H.; Dong, X. A Contrastive Study on Travel Costs of Car-Sharing and Taxis Based on GPS Trajectory Data. *Int. J. Environ. Res. Public Health* **2020**, *17*, 9446. [CrossRef]
53. Dong, X.; Cai, Y.; Cheng, J.; Hu, B.; Sun, H. Understanding the Competitive Advantages of Car Sharing from the Travel-Cost Perspective. *Int. J. Environ. Res. Public Health* **2020**, *17*, 4666. [CrossRef] [PubMed]

54. Shaheen, S.; Cohen, A.; Martin, E. *Carsharing Parking Policy: A Review of North American Practices and San Francisco Bay Area Case Study*; Institute of Transportation Engineering: Washington, DC, USA, 2010.
55. Brinkel, N.; AlSkaif, T.; van Sark, W. The Impact of Transitioning to Shared Electric Vehicles on Grid Congestion and Management. In Proceedings of the International Conference on Smart Energy Systems and Technologies (SEST), Istanbul, Turkey, 7–9 September 2020; pp. 1–6.
56. Kortum, K.; Schönduwe, R.; Stolte, B.; Bock, B. Free-Floating Carsharing: City-Specific Growth Rates and Success Factors. *Transp. Res. Procedia* **2016**, *19*, 328–340. [\[CrossRef\]](#)
57. Dandl, F.; Bogenberger, K. Comparing Future Autonomous Electric Taxis with an Existing Free-Floating Carsharing System. *IEEE Trans. Intell. Transp. Syst.* **2019**, *20*, 2037–2047. [\[CrossRef\]](#)
58. Liao, F.; Molin, E.; Timmermans, H.; van Wee, B. Carsharing: The impact of system characteristics on its potential to replace private car trips and reduce car ownership. *Transportation* **2020**, *47*, 935–970. [\[CrossRef\]](#)
59. Cervero, R. *The Transit Metropolis: A 21st Century Perspective*. *Transportation, Land Use, and Environmental Planning*; Deakin, E., Ed.; Elsevier: Amsterdam, The Netherlands, 2020; pp. 131–149.
60. Turoń, K.; Kubik, A.; Łazarz Bogusław, B.; Czech, P.; Stanik, Z. Car-Sharing in the Context of Car Operation. *IOP Conf. Ser. Mater. Sci. Eng.* **2018**, *421*, 032027. [\[CrossRef\]](#)
61. Turoń, K. Selection of Car Models with a Classic and Alternative Drive to the Car-Sharing Services from the System's Rare Users Perspective. *Energies* **2022**, *15*, 6876. [\[CrossRef\]](#)
62. Jorge, D.; Homem de Almeida Correia, G. Carsharing system demand estimation and defined operations: A literature review. *Eur. J. Transp. Infrastruct. Res.* **2013**, *13*, 201–220.
63. Weikl, S.; Bogenberger, K. Relocation Strategies and Algorithms for Free-Floating Car Sharing Systems. *IEEE Intell. Transp. Syst. Mag.* **2013**, *5*, 100–111. [\[CrossRef\]](#)
64. Ferrero, F.; Perboli, G.; Rosano, M.; Vesco, A. Car-sharing services: An annotated review. *Sustain. Cities Soc.* **2018**, *37*, 501–518. [\[CrossRef\]](#)
65. Geum, Y.; Lee, S. Combining technology roadmap and system dynamics simulation to support scenario-planning: A case of car-sharing service. *Comput. Ind. Eng.* **2014**, *71*, 37–49. [\[CrossRef\]](#)
66. Tennøy, A.; Usterud Hanssen, J.; Visnes Øksenholt, K. Developing a tool for assessing park-and-ride facilities in a sustainable mobility perspective. *Urban Plan. Transp. Res.* **2020**, *8*, 1–23. [\[CrossRef\]](#)
67. Martin, E.; Shaheen, S. The Impact of Carsharing on Public Transit and Non-Motorized Travel: An Exploration of North American Carsharing Survey Data. *Energies* **2011**, *4*, 2094–2114. [\[CrossRef\]](#)
68. Terrien, C.; Rémi, M.; Chen, B.; Shaheen, S. Good Practices for Local Governments and Private Companies Driving Change Together in Urban Mobility: Lessons Learned from One-Way Carsharing. Available online: <https://escholarship.org/uc/item/53z3h2gt> (accessed on 13 August 2019).
69. Silvestri, A.; Foudi, S.; Galarraga, I.; Ansuategi, A. The contribution of carsharing to low carbon mobility: Complementarity and substitution with other modes. *Res. Transp. Econ.* **2020**, *85*, 100968. [\[CrossRef\]](#)
70. Tyndall, J. Free-floating carsharing and extemporaneous public transit substitution. *Res. Transp. Econ.* **2019**, *74*, 21–27. [\[CrossRef\]](#)
71. Schwabe, J. The evolution of cooperative electric carsharing in Germany and the role of intermediaries. *Environ. Innov. Soc. Transit.* **2020**, *37*, 108–119. [\[CrossRef\]](#)
72. Folkestad, C.; Hansen, N.; Fagerholt, K.; Andersson, H.; Pantuso, G. Optimal charging and repositioning of electric vehicles in a free-floating carsharing system. *Comput. Oper. Res.* **2020**, *113*, 104771. [\[CrossRef\]](#)
73. Abbasi, S.; Ko, J.; Kim, J. Carsharing station location and demand: Identification of associated factors through Heckman selection models. *J. Clean. Prod.* **2021**, *279*, 123846. [\[CrossRef\]](#)
74. Ohta, H.; Fujii, S.; Nishimura, Y.; Kozuka, M. Analysis of the Acceptance of Carsharing and Eco-Cars in Japan. *Int. J. Sustain. Transp.* **2013**, *7*, 449–467. [\[CrossRef\]](#)
75. Dowling, R.; Kent, J. Practice and public-private partnerships in sustainable transport governance: The case of car sharing in Sydney, Australia. *Transp. Policy* **2015**, *40*, 58–64. [\[CrossRef\]](#)
76. Lane, C. PhillyCarShare: First-Year Social and Mobility Impacts of Carsharing in Philadelphia, Pennsylvania. *Transp. Res. Rec.* **2005**, *1927*, 158–166. [\[CrossRef\]](#)
77. Migliore, M.; D'Orso, G.; Caminiti, D. The environmental benefits of carsharing: The case study of Palermo. *Transp. Res. Procedia* **2020**, *48*, 2127–2139. [\[CrossRef\]](#)
78. Firkorn, J.; Müller, M. What will be the environmental effects of new free-floating car-sharing systems? The case of car2go in Ulm. *Ecol. Econ.* **2011**, *70*, 1519–1528. [\[CrossRef\]](#)
79. Meijkamp, R. Changing consumer behaviour through eco-efficient services: An empirical study of car sharing in the Netherlands. *Bus. Strat. Environ.* **1998**, *7*, 234–244. [\[CrossRef\]](#)
80. Muheim, P.; Reinhardt, E. Car-Sharing: The Key to Combined Mobility. *Energy* **1999**, *5*, 58–71.
81. Migliore, M.; D'Orso, G.; Caminiti, D. The Current and Future Role of Carsharing in Palermo: Analysis of Collected Data and Results of a Customer Satisfaction Survey. In *2018 IEEE International Conference on Environment and Electrical Engineering and 2018 IEEE Industrial and Commercial Power Systems Europe (EEEIC/I&CPS Europe)*; IEEE: Palermo, Italy, 2018; pp. 1–6. [\[CrossRef\]](#)

82. Turoń, K.; Kubik, A.; Fołęga, P.; Chen, F. CO<sub>2</sub> Emissions—Evidence from Internal Combustion and Electric Engine Vehicles from Car-Sharing Systems. *Energies* **2023**, *16*, 2185. [[CrossRef](#)]
83. Schuster, T.; Byrne, J.; Cobett, J.; Schreuder, Y. Assessing the potential extent of carsharing—A new method and its applications. *Transp. Res. Rec. J. Transp.* **2005**, *1927*, 174–181. [[CrossRef](#)]

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