

Carsharing as an example of smart mobility – comparative study Poland–Germany

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Abstract

Modern cities are focused on the implementation of the assumptions of sustainable transport development. They invest in modern solutions and intelligent technologies that improve the mobility of residents and reduce energy consumption and pollution emitted by means of transport. This article deals with issues of smart urban mobility and carsharing, in particular, as one of the examples of the implementation of sustainable transport policy. The objective of this article is a comparative analysis of the pace of development of the carsharing markets in Poland and Germany. The analysis is carried out using statistical and comparative analysis methods. In addition, for a complete presentation of the problem raised, a literature analysis is performed. The research area covers two countries, Poland and Germany, from which ten cities for each are selected for analysis. In addition, to achieve the assumed objective, we also present the basic assumptions of smart mobility and solutions used in cities, and then determine the increase in the number of cars driving in the carsharing system. In addition, the factors influencing the change in transport patterns of urban residents are analyzed, and the importance of modern communication technologies in the development of carsharing systems is emphasized. The results of the analysis can be used as a tool to support the decisions of city authorities in the field of transportation management and, in particular, the implementation of carsharing systems. They also present the dependencies of the spread of this solution in a given urban space. They indicate the largest problems that may affect the introduction of this solution as an element of the city's transportation system.

Introduction

The world economy has affected the natural environment to such an extent that we now speak of the global ecological crisis. This crisis is the result of irrational human activity in relation to the natural environment and its components (Marek-Bieniasz, 2014). As a result, there is a progressive degradation of the environment, which undermines the ecological balance and reduces the quality of people's life. The huge increase in transport over the last decades has had a significant impact on this situation. This phenomenon is visible mainly in cities and is related to the development of individual automotive

industries. With regard to the environment, such a large increase has a negative impact, as transport is high-emission, energy-intensive, and terrain-intensive. Nevertheless, there is no doubt that further development of transport is necessary and inevitable. All this necessitates changes in transportation management systems in cities. Hence, all pro-environmental activities should focus on the sustainability of transport, the priority of which will be to consider the principles of environmental protection. This approach aligns with the universally applicable direction of sustainable development, which applies to all areas of the global economy. In relation to transport, sustainable development means ensuring

transport accessibility in a safe way that would not put human health and the environment at risk.

Considering the above, the search for solutions and platforms for the sustainable development of transportation in cities, including smart mobility, is a task of great importance and embedded in their management and development strategies. One such solution is carsharing, which involves renting cars for short periods of time, such as minutes, and is an example of the sharing economy.

Considering the above, the search for solutions and levels of sustainable transport development in cities, including smart mobility, constitutes a very important task and is included in their development strategies. Carsharing, which consists in renting cars for a short time, e.g., minutes, and is an example of sharing economy, is just one of the examples thereof.

The objective of this article is an analysis of the pace of development of the carsharing markets in Poland and Germany. In addition, an attempt has been made to find an answer to the following question: does the implementation of carsharing affect the transformation of the urban transport system towards sustainable development? Statistical and comparative analysis methods are applied to explain the problem, accompanied by a literature analysis. Our selection of carsharing, as the subject of this analysis, resulted mainly from the need for the transport systems to implement the assumptions of sustainable development, which strongly emphasizes the need to reduce the index of individual motorization. This indicator determines the level of private car use by residents to travel around the city. Carsharing is one of the solutions that may affect the lowering of this index. This article presents the main trends of sustainable development of transport in cities for a comprehensive description of the analyzed issues.

Literature review

The literature on this subject describes the issue of sustainable development of transport in a comprehensive way. It is understood that the idea of sustainable development was first defined in 1987 by the World Commission on Environment and Development. The Commission adopted a definition of sustainable development as meeting the needs of both present and future generations and ensuring that they can both benefit from environmental resources (Report World, 1987). In light of the development understood in this way, in 1996, the OECD also developed a definition of sustainable

transport. According to the OECD guidelines, sustainable transport is one *that does not expose public health or ecosystems to danger and at the same time meets the needs of relocation in accordance with the principles of: the use of renewable resources below their recovery capacity and the use of non-renewable resources below the development capacity of their renewable substitutes* (OECD, 1996). Over time, the OECD definition has been modified, and currently, the sustainable development of transport means *the ability to meet the transport needs of current generations without compromising the ability of future generations to meet their own transport needs* (Richardson, 2005).

On the other hand, at the level of the member states of the European Union, actions for sustainable transport are implemented in accordance with the assumptions of the European transport policy. Mainly those indicated in the white papers on transport, which assume that the necessary action to ensure the growth of the transport sector is the promotion of smart urban mobility (He & Haasis, 2020). Particular attention should be paid to the European Commission's communication entitled *Together towards competitive and resource-efficient urban mobility*. This communication presents detailed guidelines for introducing solutions aimed at reducing the rate of individual motorization in cities and, thus, congestion (Commission Communication, 2013).

The personal motorization index represents the frequency with which urban residents use private cars to travel around. At this point, it is noteworthy that many works emphasize the need to distinguish between the fact of car ownership and car use (Hagman, 2006). In addition, there are analyses available in the literature that show that, on average, a car is used to drive around the city for an average of one hour per day, and for most of the hours, it is parked (Komornicki, 2011). Hence, the proposed measures to balance transportation development are mainly directed at reducing use rather than ownership of vehicles. European Commission documents also stress that urban development must occur while reducing greenhouse gas emissions and congestion (White Paper, 2011). It is congestion that is one of the largest transportation problems in modern cities. Hence, measures for sustainable urban transportation are commonly undertaken. These are often associated with the promotion of those forms of transportation that contribute to the demarcation of individual car use (Pędziwiatr & Sosik-Filipiak, 2021). One of them is carsharing, which relates to the sharing economy, defined in the literature

as a change in the philosophy of market participants. This change involves a shift from ownership and possession to use and enjoyment. It is associated with an agreement to pay fees for this by the users. Nowadays, a sharing economy is defined in terms of a social phenomenon (Poniatowska-Jaksch & Sobiecki, 2016). In addition, the sharing economy as a phenomenon has been highlighted in the age of the Internet (Belk, 2014).

Carsharing developed mainly on the basis of Internet technologies and was adopted as a business model consisting of sharing cars. According to the definition, it consists of the joint, organized use of the car without a need to own it (Nansubuga & Kowalkowski, 2021). It is a system for sharing the use of cars, particularly in cities. It consists in making cars available for a fee, based on a means of transport rental agreement (Schönbeck, Schwoll & Linssen-Robertz, 2018). Carsharing is the rental of vehicles that are left waiting in different parts of the city (Szwejsjer, 2018). Switzerland and the Netherlands were the first countries to introduce this system of transport, but it had a niche dimension. In addition, the development of technology and, in particular, the spread of mobile devices has also contributed to the emergence of other forms of *ridesharing* for the purpose of traveling together, and these include:

- *carpooling*, where two or more people travel in a car that belongs to one of them;

- *van pooling* involves the use of a minibus by a group of people, e.g., employees of one plant, to travel to their workplace; often, these journeys are co-financed by the employer (Kłos-Adamkiewicz & Załoga, 2017).

Therefore, transport economics defines individual mobility as the deliberate crossing of space with the use of various means of transport (Załoga, 2013). On the other hand, changes in the approach of society to the selection of the form of travel mainly result from economic reasons and an increase in ecological awareness.

Research methodology

To achieve the assumed research objective, this article details three stages of analysis regarding the research subject, which is presented in Figure 1.

The first stage of the analysis presents the assumptions of the idea of sustainable development of transport and smart mobility. The most important aspect of this concept is presented by the European institutions and the existing documents on the possibilities of smart mobility, including carsharing, have been considered.

The second stage includes an overview and analysis of the carsharing market, particularly the pace of changes in the number of vehicles used in the selected vehicle-sharing systems of Polish and German cities. A statistical analysis is utilized, and the

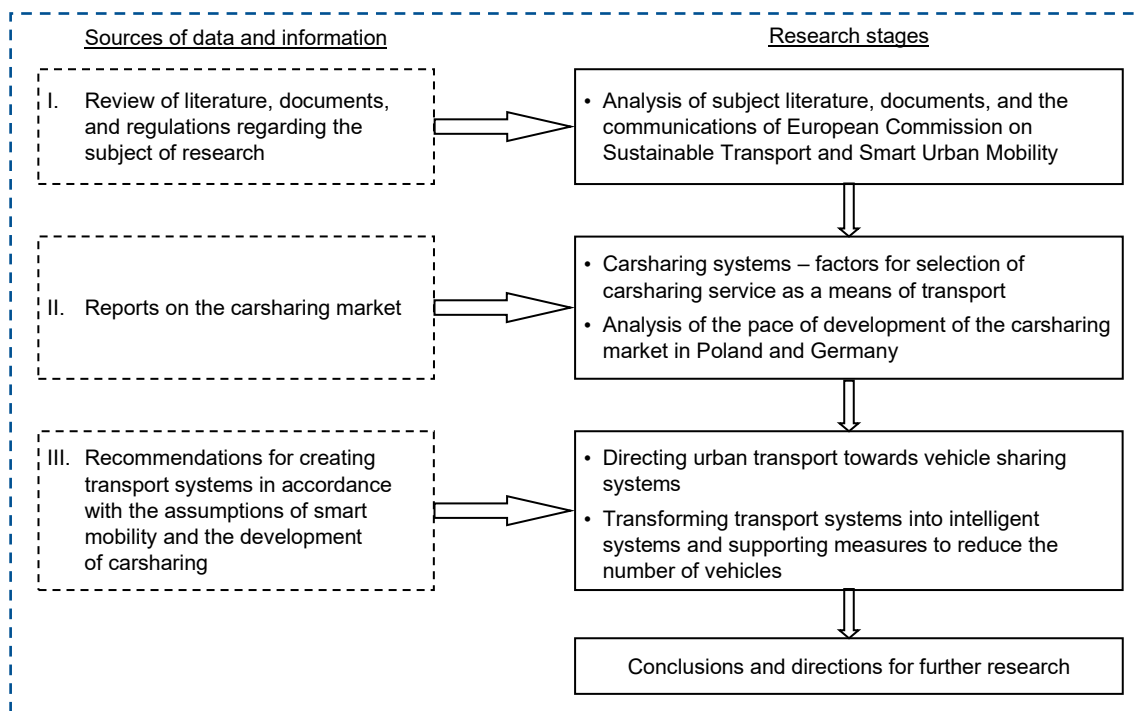


Figure 1. Research methodology scheme

increase in the number of vehicles and users over the analyzed years is compared. The operation of the carsharing system, the activities of city authorities relating to the city's transportation management system, and the promotion of alternative forms of transportation are also presented at this stage.

The third stage includes a description of recommendations that can be used as an example for the effective implementation of carsharing systems in cities and actions that limit the use of individual motorization. The research scheme adopted in this way allowed for a detailed description and analysis of the studied problem and an indication of the desired actions for the development of smart mobility. The research applied various techniques and tools for data collection and analysis. Among them were, among others, the own observation techniques, analysis of source materials, and statistical and comparative analysis. The applied methods rendered it possible to assess the solutions applied in urban transport systems and also allowed for the determination of the rate of increase in the number of vehicles moving in the carsharing systems in the analyzed cities of Poland and Germany.

Smart mobility as part of a smart city and its impact on the transport behavior of the population

Contemporary societies place high demands on the level of transport services and, thus, expect properly functioning transport systems. This results from the increasing mobility needs, which are often the result of urban sprawl and an increase in the number and distance of journeys. This leads to numerous and complex problems relating to ensuring an adequate level of mobility for the population while respecting environmental protection rules. The solution to this issue should be the development of modes of transportation that form an alternative for individual motorization, thus supporting sustainable mobility. In addition, modern societies expect a high quality of life, which requires access to public transport. This relationship is visible, especially in urban agglomerations, which are strongly involved in telematics solutions, meaning that some of them are already called smart (Firnkorn & Müller, 2015). The smart city concept implies the sustainable development of urbanized areas using modern information and communication technologies. Modern cities are introducing smart solutions, for example, in transportation, traffic management, or in the use of urban institutions. Hence, cities are adopting as a development

priority the implementation and development of the following:

- intelligent transportation systems,
- intelligent parking systems,
- intelligent delivery systems,
- smart city lighting systems, etc.

Cities' interest in these systems stems from the fact that they significantly improve operational efficiency, reduce costs, and increase safety. In urban practice, implementing smart solutions most often means implementing a central management system for the city's transportation system (Demińska et al., 2018). The goal of these measures is to achieve an optimal level of use of energy resources, through which transportation becomes more sustainable (Iwan et al., 2019). One of the solutions that is currently used as part of the smart city is carsharing. Its employment is made possible by a mobile application that allows efficient car rental and accounting for its use. On the other hand, changes in people's attitudes regarding the choice of a form of transportation are occurring in an evolutionary way. Their basis is the analysis of current transportation options and the economic evaluation of this choice. Hence, based on such analysis, ridesharing, e.g., carsharing, is often the chosen alternative to one's own car.

Based on the above, the following factors can be listed for the growth of the carsharing market and changes in the transportation behavior of urban residents:

- the high cost of owning and using a private car,
- the substitutability of the carsharing service to owning one's own car,
- availability and flexibility of carsharing service offerings,
- price competitiveness of the carsharing service relative to cab rides,
- high comfort of the ride,
- shorter transit time compared to public transportation,
- problems with parking spaces,
- increased environmental awareness of the public.

The most important factors encouraging the selection of a carsharing service as a means of transport are the high cost of owning a car, the substitutability of the carsharing service in relation to owning a car, but also taxis and public transport, and the greater environmental awareness of society. The first factor consists of cost analysis concerning owning a car, which returns a result that says it is high. According to estimates by PwC Polska, the *Total Cost of Ownership* (TCO) for a middle-class car in Poland is approximately PLN 15 000. This estimate

considers the loss of the value of the car, fuel for an average of 20 000 km, servicing, repairs, and insurance (Winiarski & Szóstakowski, 2020). The second factor is the substitutivity of the carsharing service in relation to owning a car or using taxis or public transport. It presents the price and time competitiveness of this service. Over a comparable distance, the average price for a traditional taxi ride is almost twice as high as a car ride as part of the carsharing service. For short distances, the cost of travel is slightly higher than public transport but, in return, it provides high comfort and time savings. The third factor that is gaining increasing importance, despite the lack of typical economic foundations for it, is the increase in ecological awareness of society. According to estimates, one car operating in a carsharing system can replace 4 to 12 private cars. On average (as highlighted earlier), a private car is used for one hour a day, and a car in a carsharing system for up to 10 hours (Winiarski & Szóstakowski, 2020). With regard to the fact that car transport is the main source of pollution in cities, reducing the number of cars forms a significant contribution to improving air quality. In addition, it also translates into lower parking space requirements and indirectly reduces traffic congestion (Acheampong & Siiba, 2020). This factor is becoming increasingly important when deciding on the form of mobility. The importance of the need to increase the level of use of individual vehicles is also often stressed. This is related to the fact that the comparison of CO₂ emissions per passenger-kilometer for individual modes of transportation is highest for passenger cars, in which one person travels.

The functioning of carsharing in Polish and German cities – discussion and research results

Carsharing has been known for several decades, but it was only in the second decade of the 21st century that we witnessed its widespread use. Currently, it is estimated that over 6 million users and 74 000 cars in Europe operate in the carsharing system (PwC: Carsharing, 2018). This accounts for 50% of the global market. Germany is the country with the most developed system. Currently, 243 suppliers provide carsharing services and function as a form of transport in 855 German cities and municipalities. The number of registered users of this system in 2021 was 2 874 400, an increase of 25.5% compared to the previous year (Bundesverband Carsharing, 2021). Table 1 presents the growth rate for the

Table 1. Number of cars in the carsharing system in selected German cities (based on: Statista, 2019; Bundesverband CarSharing, 2021)

City/Region	Number of cars		Growth rate [%]
	Year 2019	Year 2021	
Karlsruhe	843	969	15
Munich	1855	3130	69
Hamburg	1785	3057	71
Berlin	3166	5814	84
Stuttgart	933	886	-5
Cologne	1347	1540	14
Freiburg	318	365	15
Leipzig	496	567	14
Hanover	260	533	105
Bremen	344	457	33

number of cars operating in the carsharing systems in selected German cities.

The first city in Germany to introduce the carsharing system was Bremen in 2003. The objective of the city's authorities was to transform the transport system towards sustainability. It was assumed that this would reduce the number of passenger cars moving around the city by 2025 (Carsharing Bremen, 2010).

To develop carsharing schemes, cities have introduced a number of incentives for residents and other users. These included, among others, no fees in the paid parking zone, dedicated parking spaces, etc. The example of Bremen was followed by other German cities.

The presented data indicate that, over the analyzed years, most cities noted a significant increase in the number of cars driving relating to carsharing. However, these growth rates are uneven. There are cities such as Stuttgart, which during the last year noted a decrease in the number of rented cars but a significant increase in the number of rented mopeds and scooters. Cologne, Leipzig, Freiburg, and Karlsruhe, on the other hand, recorded significantly lower growth rates than, e.g., Hanover or Berlin. This is mainly due to the size of cities, the number of their inhabitants, and their economic and institutional significance. Despite these differences, carsharing is constantly developing in Germany. According to the Bundesverband CarSharing: Annual carsharing statistic, the number of entities offering carsharing in 2020 increased by 17% compared to 2019. Today, in German cities, carpooling is a well-known and often used solution, among other things, due to the lack of parking spaces. It should be stressed that carsharing

in urban traffic offers a promising solution but has not fully replaced private cars. On the other hand, it can significantly reduce their number, and for this reason, the interest of cities in vehicle-sharing systems is growing. This situation has been affected, albeit slightly, by the Covid-19 pandemic, which had an impact on the number of car rentals. The overall decrease in mobility has led to a significant decrease in bookings and revenues of carsharing service providers, but this has not stopped the positive upward trend.

In turn, when analyzing the situation of carsharing in Poland, it should be emphasized that its development began much later than in Germany, i.e., only in 2016. The first cities to introduce such a system were Krakow and Warsaw. Initially, a total of about 300 cars were available in the carsharing mode. The breakthrough occurred in 2017 when the number of cities offering carsharing, as well as the number of available cars, increased dramatically. This was caused by new providers of carsharing services entering the market, which systematically increased the fleet of vehicles (Car sharing market in Poland, 2019). Since 2019, carsharing has been operating in the largest cities in Poland. There are more than 4 800 cars in this system; forecasts predict that this number will grow. Some collapse in this market occurred as a result of the Covid-19 pandemic, which initially limited the demand for car rentals for a while. However, carsharing companies have promptly introduced a vehicle disinfection service to their offer so that their use is safe for health, which has influenced the growth of the number of users.

There are three leading operators in the Polish market: Traficar, Panek, and 4Mobility. The market leaders in terms of the number of cars are Panek and Traficar, which handle approximately 50-60% of all cars available in carsharing services in Poland. The rest of the market belongs to 4Mobility (Duszczyk, 2022). All operators provide their services in the free-floating system, while 4Mobility also covers the stationary system. Operators offer vehicles mainly with conventional or hybrid drives but have also introduced electric cars. Table 2 presents the growth rate of the number of cars used in the carsharing system.

The presented data indicate that the number of cars in the carsharing system in Polish cities is systematically increasing. Nevertheless, this form of transport in Poland is still at an early stage of development. It still functions to only a small extent in most of the cities; such a situation occurs, for example, in Rzeszów. However, in Szczecin, despite the

Table 2. Number of cars in the carsharing system in Polish cities (based on: Keralla Research, 2019; Mobilne Miasto, 2022)

Miasto/Region	Number of cars		Growth rate [%]
	Year 2019	Year 2021	
Warsaw	1078	1212	12
Tri-City	1021	1279	25
Krakow	499	559	12
Wrocław	463	513	11
Poznań	230	307	33
Łódź	86	306	256
Lublin	149	163	9
Katowice	101	187	85
Szczecin	30	109	263
Rzeszów	26	37	42

fact that carsharing has been operating for less than two years, it noted a very high growth rate. Despite this, only Warsaw and the Tri-City have a fleet of over a thousand vehicles. However, it should be concluded that Polish cities are interested in including carsharing in their urban transport systems. This is further confirmed by most of them, but only a few city authorities have included this new type of service in their legal solutions. The cities demonstrating the greatest interest are Łódź, Poznań, and Katowice. In these cities, facilities for carsharing were provided at the level of local law. They mainly concern preferential fees for parking in the city's paid parking zones and designating special parking spaces for them. This means that carsharing is recognized as an additional form of city mobility and an alternative to driving private cars (Global Market Insights, 2021).

Based on the analyzed cities, it should be assumed that the carsharing market in Poland and Germany is still in its developmental phase. In terms of the number of vehicles, German cities are achieving better results, but in Poland, the growth rate is also high. All this enables us to conclude that carsharing services can become a permanent part of the city transport system.

Conclusions

Modern information and communication technologies support the intensive development of intelligent mobility. They form the basis for the improvements implemented in transport systems and foster a change of thinking about individual transport by promoting ridesharing. Intelligent mobility, including extensive carsharing systems, responds to both

the demands and the main assumptions of the concept of sustainable transport development. They constitute a new, innovative mobility model that operates best in large cities and urban areas. Their implementation is consistent with the idea of sustainable transport development. In addition, they contribute to the development of the urban transport system and improve the mobility of residents.

Shared mobility benefits both cities and their residents since all forecasts demonstrate that the demand for urban mobility will rapidly increase. This is due to the growing number of people and the sprawl of cities. In such conditions, shared mobility becomes a tool that can potentially optimize car traffic. In addition, smart mobility is also altering the transport habits of society. It is conducive to reducing dependence on owning a car that is employed individually. A society that has the opportunity to use shared transport is more likely to include it in its itinerary. As a result, daily commutes around the city will be less frequently carried out by using private cars. In addition, there is one more important argument for resigning from owning a car. This is lower mobility expenses, which result from the “pay as you go” principle. Owning and maintaining a car is burdened with high fixed costs, regardless of the intensity of its use. Users of carsharing services are able to significantly reduce these costs. Shared mobility complements the existing transport system in cities. It forms another mode of travel, supplementing the city’s transport offer for residents.

Our analysis of solutions applied within the framework of smart mobility in selected cities, and the research on carsharing, demonstrated that this form of mobility develops systematically, both in Poland and Germany. The significance of carsharing in urban mobility is particularly increasing, reducing the use of individual cars and the level of pollution. This means that the promotion and use of carsharing significantly affect the change in transport behaviors of city dwellers and, thus, the transformation of the city’s transport system.

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