



Article

Study of the Demand for Ecological Means of Transport in Micromobility: A Case of Bikesharing in Szczecin, Poland

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Abstract: The need for urban societies to move continues to grow with the intensity of their various activities. One of the challenges in micromobility in cities based on bike, scooter, or public scooter systems is determining the potential yet realistic demand for such services. This article aims to present the level of demand for eco-friendly non-motorized transport systems and identify the motivations driving users of public transport to choose these eco-friendly Personal Mobility Devices (PMD). The authors propose a methodology based on the integration of four components: a case study, an analysis of participatory budget projects, a metadata analysis of bikesharing (BSS) in Szczecin, and a meta plan. They utilized a case study method and conducted a survey based on a custom questionnaire. An analysis of participatory budget projects and data from the operation of bikesharing in Szczecin was performed using statistical methods. Applying the heuristic tool meta plan, they outlined the directions for the development and support of bikesharing as an example of micromobility in Szczecin. The research identified connections between the socio-demographic structure of respondents and attributes of bike communication. This study highlighted periods of intensive system use and locations with the highest exploitation. It showed that the demand for BSS depends on weather conditions, traveler convenience, the density and coherence of bike infrastructure with important locations for residents, transfer connections, and safety. The presented research results can assist planners and authorities in Szczecin and other cities in expanding bikesharing.

Keywords: micromobility; bikesharing; participating budget; non-motorized transport; public transport; meta plan; passenger transport



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1. Introduction

Shared micro-mobility is not just a trend but also an alternative to an effective means of urban transportation. Observations confirm that urban public transport undergoes continuous transformations, and these changes are not always beneficial for city residents, often stemming from alterations in road infrastructure, spatial planning, and ongoing repairs. Such phenomena discourage city dwellers from using public transport, as evidenced by the increasing number of cars, with the highest car ownership rate in Europe reported in 2023—687 cars per 1000 inhabitants, according to the European Statistical Office Eurostat [1]. Carsharing is also gaining popularity, with the number of car rental companies continually increasing [2–4]. However, both forms of urban travel have a negative impact on the environment, contribute to congestion, and shape the quality of life in cities. Non-motorized forms of transportation, such as bikesharing, scooters, and electric scooters, present an alternative way of moving around the city. This form of transport is known as micromobility, utilizing small, light, and emission-free Personal Mobility Devices (PMDs) [5]. These devices enable residents to cover short distances, typically the first or last segment of a planned journey, including individuals with disabilities who use these devices to improve their mobility [6,7]. Micro-mobility is defined differently in various literature, often as the

shared use of bicycles, scooters, motorcycles, and other low-speed transportation modes according to needs [8–10]. The National League of Cities (NLC) identifies micro-mobility as the mass sharing of bicycles and scooters in urban areas. However, the U.S. Department of Transportation refers to this form of transport as microtransit [11].

The evolving micromobility becomes an increasingly important part of urban residents' mobility each year, and studying user needs is crucial for its development direction. In Polish cities, this can be based on gathering information about projects from the Participatory Budget (PB). Such projects have been implemented since 2011 in small cities—with populations ranging from 5000 to 20,000 inhabitants medium-sized cities with populations in two ranges: 20,000–50,000 and 50,000–100,000, as well as large cities with populations of 100,000–200,000 and above 200,000 [12–14]. The specificity of the issue requires the application of appropriate tools, methods, and methodologies that would outline social needs significantly, including in this area. Updating information related to the needs of Personal Mobility Devices is also an indicator of the development direction and policies pursued by city authorities. The aim of the article is to determine the scale of needs for the functioning of a bikesharing system (BSS) as an element of micromobility in a medium-sized city in Poland.

For the purpose of achieving the goal, the following tasks have been defined:

1. Identification of the level of interest in the bike rental system in Poland;
2. Evaluation of the socio-demographic structure in the context of using bicycles as a means of transport;
3. Quantitative analysis of urban bike rental in terms of time and urban space;
4. Assessment of social involvement in the expansion of cycling infrastructure in Szczecin;
5. Determination of the current situation of bikesharing in Szczecin, its weaknesses, and directions for development.

The article has the following structure: In Section 2, a literature review and several key points regarding the demand for ecological micromobility among city residents are presented. In Section 3, research methodology related to the studied area, in this case, the city of Szczecin, and the proposed approach to the analyzed problem of ecological micro-mobility, especially bikesharing, are presented. In Section 4, the results of the implementation of the proposed approach to determine the level of residents' needs in Szczecin regarding shared micromobility are presented. This is based on the analysis of applications submitted to the Participatory Budget and a survey conducted using an author's questionnaire. Surveys were conducted from 2019 to 2021. The research also included metadata from the city's bikesharing system. Section 5 is dedicated to discussing the results. The final conclusions are included in Section 6. The research results have many implications for business practice. This relates to managing the city's transportation system, energy savings, and decarbonization policy. This also includes the creation of new business models that respond to the challenges of contemporary society and are in line with the principles of sustainable development.

The conducted research has allowed us to conclude that the analyzed problem is not homogeneous. Despite the significant interest of researchers, this issue has not been considered so far using the proposed configuration of methods and data. The proposed methodology allows for obtaining data from multiple sources and a more reliable assessment of them. There is, therefore, a research gap to be filled. It can be stated that the added value of the article lies in its multi-aspect approach to the problem of demand for ecological means of transportation in the city, using bikesharing as an example.

2. Literature Review

The 21st century is characterized not only by the progress of digitization and technology but also by the growing need for mobility over various distances. Residents of small, medium, and large cities travel for daily chores, healthcare appointments, and recreational purposes. Means of transportation include cars, buses, trams, and sometimes trolleybuses or subways. There are also alternative options, such as non-motorized and

shared transportation, that supporting micromobility. These include bicycles, scooters, and electric scooters [15]. While users may have their means of transportation, city authorities, guided by the concept of sustainable development, increasingly provide rental systems for residents, including bicycles, scooters, and electric scooters.

Research on residents' mobility and micro-mobility needs employs various methods and methodologies [16]. Blad and others proposed a methodology based on multi-criteria analysis (MCA) and multi-actor multi-criteria, consisting of five criteria measuring location suitability—potential demand in a given location, hub implementation costs (regional shared mobility center), generalized travel costs to and from the center, connection to the environment, and social impact measured by nine attributes [17]. Other researchers emphasize that location modeling techniques can be grouped into three categories: “mathematical algorithms”, “multi-criteria decision-making”, and “GIS” [18].

2.1. Shared Mobility and Micromobility

Shared mobility is a category of transportation that has gained a new dimension in recent years, not only in Poland but as a global phenomenon of sharing various goods and services. It falls between public transport and individual transport [19]. Shared mobility is most commonly discussed in the context of urban travel using specially designated shared vehicles, ranging from bicycles, electric scooters, and scooters to cars, accessible to the general public [20–22]. Shared mobility services have a long history; for example, the first known shared bicycle system was established in 1965 in Amsterdam [23], and the first shared car system emerged much earlier, in 1948 in Zurich [24,25]. While public bikesharing systems have existed for almost half a century, their rapid growth in both prevalence and popularity worldwide occurred in the last decade [26,27]. Bikesharing programs serve to showcase and promote environmentally friendly aspects of mobility in cities and can contribute to achieving specific goals related to mobility, health, and reducing dependence on fossil fuels [28,29].

2.2. Bikesharing System

Bikesharing is a form of urban transportation that offers temporary rental, with a deposit and a specified fee, for various bicycle types such as single bikes, tandem bikes, rickshaws, rollerblades, and scooters. The system provides an efficient way to shift part of the city's traffic from cars to bicycles. Shared mobility services can be a source of savings, reducing daily transportation costs, providing convenience, and limiting vehicle ownership [30,31]. A properly functioning BSS consists of several elements. The system includes owners, users, regulations, rental services, operations, system infrastructure, and support. The first group comprises local government institutions and networks of public operators, such as Clearchannel (SmartBike). In Paris, the city owns the Vefib system, but JCDecaux covers the costs of purchasing and maintaining bicycles in exchange for advertising rights. In Warsaw, the Veturilo system is owned by the Nextbike GZM company, while the Call-a-Bike system in Germany operates thanks to Deutsche Bahn [32]. The second group, users, mainly consists of city residents commuting to work and school daily. This also includes tourists who, by visiting cities like Szczecin, gain access to an affordable and independent means of transportation. Students and individuals using bikes for commuting to Park and Ride (P&R) facilities and important public transport hubs, such as train stations, bus stops, tram stops, or metro stations, are also significant user groups. The legal aspect, part of the BSS, involves key legal acts applicable in Poland concerning bicycle traffic and infrastructure, such as the Vienna Convention on Road Traffic of 1968 [33] and the Road Traffic Act of 20 June 1997 [34]. Rental services, both commercial and public, form another critical element of the BSS. Commercial services operate based on straightforward principles, with a customer service office often serving as a bicycle warehouse and repair point. In the case of public rentals, they consist of customer service offices, bicycle parking areas with racks and bicycles, stations with docking points, bike vending machines, specialized services, and a website. Crucial for the BSS is its

infrastructure, designed to facilitate bike traffic and enhance cyclist safety. For the system to function smoothly, its infrastructure should meet five requirements: coherence, directness, attractiveness, convenience, and safety. Another system element is organization, which encompasses all activities from conceptualization and design to implementation. The last component is supported, provided by programs such as CIVITAS II, which gave rise to the CARAVEL project, focusing on “Traveling toward new mobility” and aiming to increase the efficiency of public transport with environmental considerations [35].

The justification for creating such systems seems evident and stems from several fundamental premises highlighted by researchers in this field, summarizing the benefits of bike usage, such as flexible mobility, emission reduction, physical activity benefits, alleviating traffic congestion and fuel consumption, individual financial savings, and support for multimodal transport connections for various purposes [36].

The demand for bike rentals is a multi-faceted research area covering different factors influencing usage patterns and operational strategies. Hua presents empirical research results on the operation of bike rentals during the COVID-19 pandemic, shedding light on the impact of external events on demand [37]. Additionally, Guo identifies the connection between public bike usage and the built environment, emphasizing the significance of infrastructure and urban design on demand variability [38]. Shen contributes to understanding bike rentals as a sustainable transport option, highlighting bikesharing’s potential to reduce car usage [39].

Studies conducted by researchers [40] focus on optimization models and predicting demand for BSS, addressing the need for efficient supply and spatial regression models to meet demand effectively. Lin emphasizes the importance of understanding the spatiotemporal distribution of demand to increase the operational efficiency of the BSS [41]. Others [42] compare the effectiveness of various repositioning strategies based on predicted demand patterns, contributing to the development of effective operational strategies. Additionally, Lainjo and Yu tackle challenges related to demand forecasting and allocation strategies, offering valuable insights into improving the planning and allocation of shared bike systems [43]. Zhou underlines the importance of factors influencing bike rental demand, including weather, air quality, spatial location, and historical travel data [44].

Recognizing the need for comprehensive demand and supply management strategies [45], the impact of pricing and coordination strategies on the supply chain of city bikes has also been investigated [46], based on multiple linear regression models, and [47] delves into the influence of the built environment, spatial interactions, and social factors on the use of city bikes, providing a holistic understanding of the determinants of station-based bike demand.

In summary, demand for bike rentals is influenced by numerous factors, including external events, the built environment, optimization models, weather, and pricing strategies. Understanding these factors is crucial for developing effective operational and planning strategies to meet the demand for bikesharing systems.

Continuing with the review of studies on bikesharing demand in cities, the authors did not come across a multidimensional comparison of demand based on survey research among residents, metadata from the rental system, and reports of PB projects. They believe that this article can be a valuable addition to their knowledge in this area.

2.3. *Bikesharing in Poland*

Cycling in Polish cities, much like worldwide, aims to reduce car traffic, traffic jams, and improve transport accessibility, aligning with the promotion of low-emission transport initiatives [48]. It is the most energy-efficient mode of transportation. Through bike-sharing, it becomes widely accessible, cost-effective, and requires minimal space. The primary energy consumption (MJ) per passenger-kilometer for a bicycle is 0.06, compared to 0.16 MJ/pkm for pedestrian traffic. In comparison to trams (0.52 MJ/pkm) and, of course, personal cars (2.45 MJ/pkm), bicycles are notably more energy-efficient [49].

The popularity of public bike systems in Polish cities is growing steadily, drawing attention from researchers and becoming the subject of various inquiries. Bicycles are increasingly incorporated into government strategies and feature in various local government documents such as transportation plans, e.g., the Sustainable Public Transport Development Plan (PZRPTZ), city budgets, local spatial development plans (MPZP), and sustainable urban mobility plans (SUMP). In the case of the SUMP for Poznań, there is advocacy for bicycles to become the second most popular mode of transport [50]. Similarly, in the Mobility Plan of the Lublin Functional Area for the years 2017–2025, priority is emphasized on the widespread use of bicycles in urban transport [51].

In 2021, the operation of public bicycles was declared in 86 cities in Poland. In the case of 70 cities, the initiative was financially supported by the municipality, while in 17 cities, it was funded from another source. The situation changed quite dynamically, as in 2022, commercial operators providing bicycles appeared in four major cities [52]. A comparison of public bicycle systems managed by municipalities according to provinces in 2022 is presented in Figure 1. It is evident how significantly Mazovian Voivodeship deviates from the others, reaching a level of over 6000 bicycles.

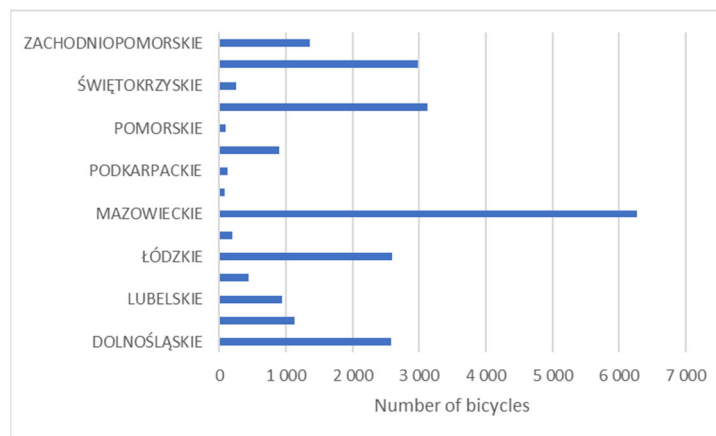


Figure 1. The number of bicycles in bicycle systems in individual voivodeships in Poland. Source: Own elaboration based on GUS data [53] (accessed: 5 January 2024).

The number of bicycles available in selected cities across Poland is presented in Figure 2.

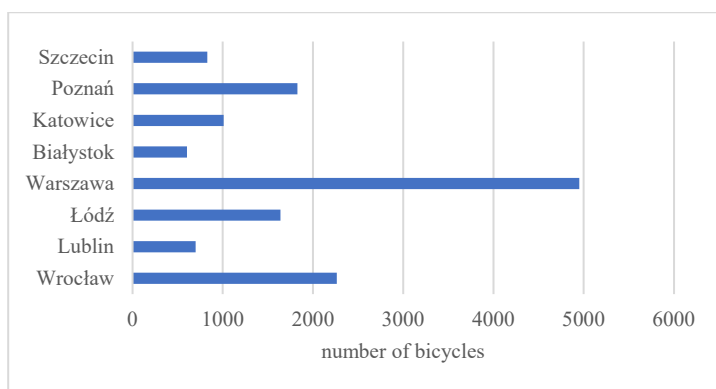


Figure 2. The number of bicycles in bicycle systems in individual cities in Poland in 2022. Source: Own elaboration based on GUS data [53] (accessed: 5 January 2024).

In terms of the number of bicycles, the order is noticeable: Warsaw—4951 units, Wrocław—2265 units, Poznań—1829 units. Szczecin ranks 6th with 830 bicycles. Similarly, the number of rentals for public bicycles is depicted in Figure 3.

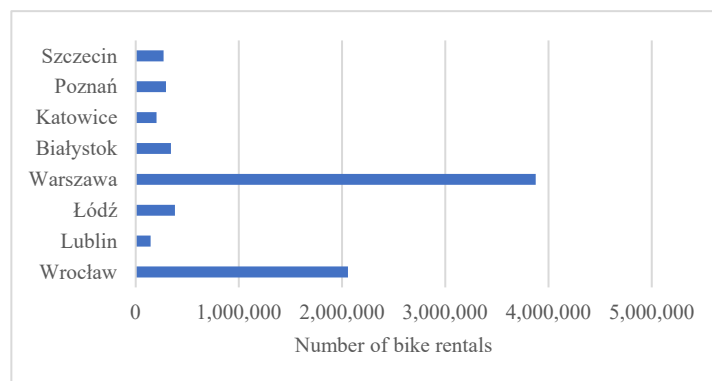


Figure 3. The number of bicycle rentals in bicycle systems in selected cities in Poland in 2022. Source: Own elaboration based on GUS data [53] (accessed: 5 January 2024).

A comparison of the number of bicycle paths is presented in Figure 4.

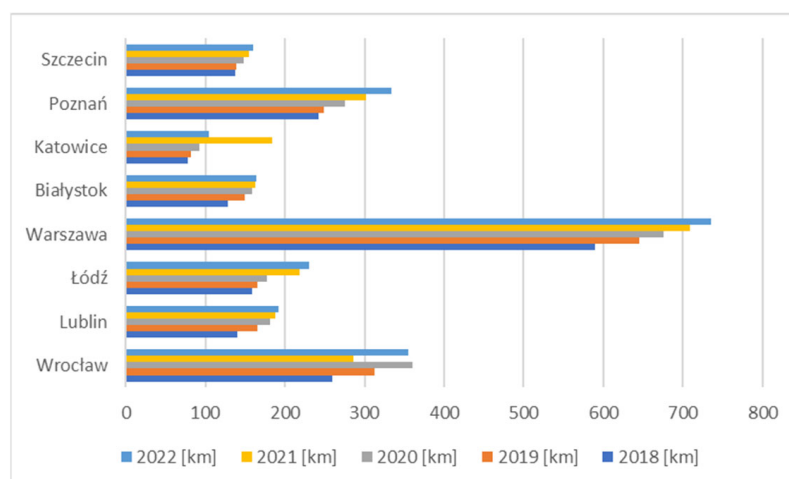


Figure 4. Comparison of bicycle paths in selected cities in Poland from 2018 to 2022. Source: Own elaboration based on GUS data [53] (accessed: 5 January 2024).

In most cities, there is a systematic regression in the expansion of bicycle paths. As in previous comparisons, Warsaw has the most extensive network of roads. The least number of bicycle paths is observed in Katowice. This may result from the reclassification of roads into other forms of urban or bicycle infrastructure, such as traffic-calmed zones.

Summarizing the above comparisons and the pace of development of non-motorized shared transportation, specifically city bike systems, in selected Polish cities, it should be noted that the potential for sustainable mobility is not fully recognized by legislators and city authorities. There is still a lack of monitoring and demand management for city bikes and optimal station planning to promote synergy between micromobility and public transportation. Additionally, systematic efforts are crucial for regulations and infrastructure solutions ensuring the safety of using city bikes and other shared vehicles. According to the Polish Ecological Club, Mazovian District (PKEOM), the foundation of urban systems should be conventional and electric bikes, complemented by cargo bikes. Furthermore, the widespread adoption of shared bikes still requires attention and the resolution of issues, including accessibility for older individuals who may face challenges in using applications for active mobility needs [54].

3. Research Methodology

3.1. Study Area

Szczecin is the largest city in north-western Poland, situated in one of the countries bordering the Baltic Sea. It is home to approximately 401,990 residents [55]. Positioned near the Polish–German border at the mouth of the Oder River, its coordinates are 14°33′10″ E longitude and 53°25′44″ N latitude [56]. The city covers an area of 300.55 km², with 1202.8 km² occupied by water bodies. Its distinctive feature is its location on both sides of the Oder River, posing frequent transportation challenges for both residents and urban planners of city infrastructure. The public transportation network and city bike stations are depicted in Figures 5 and 6.

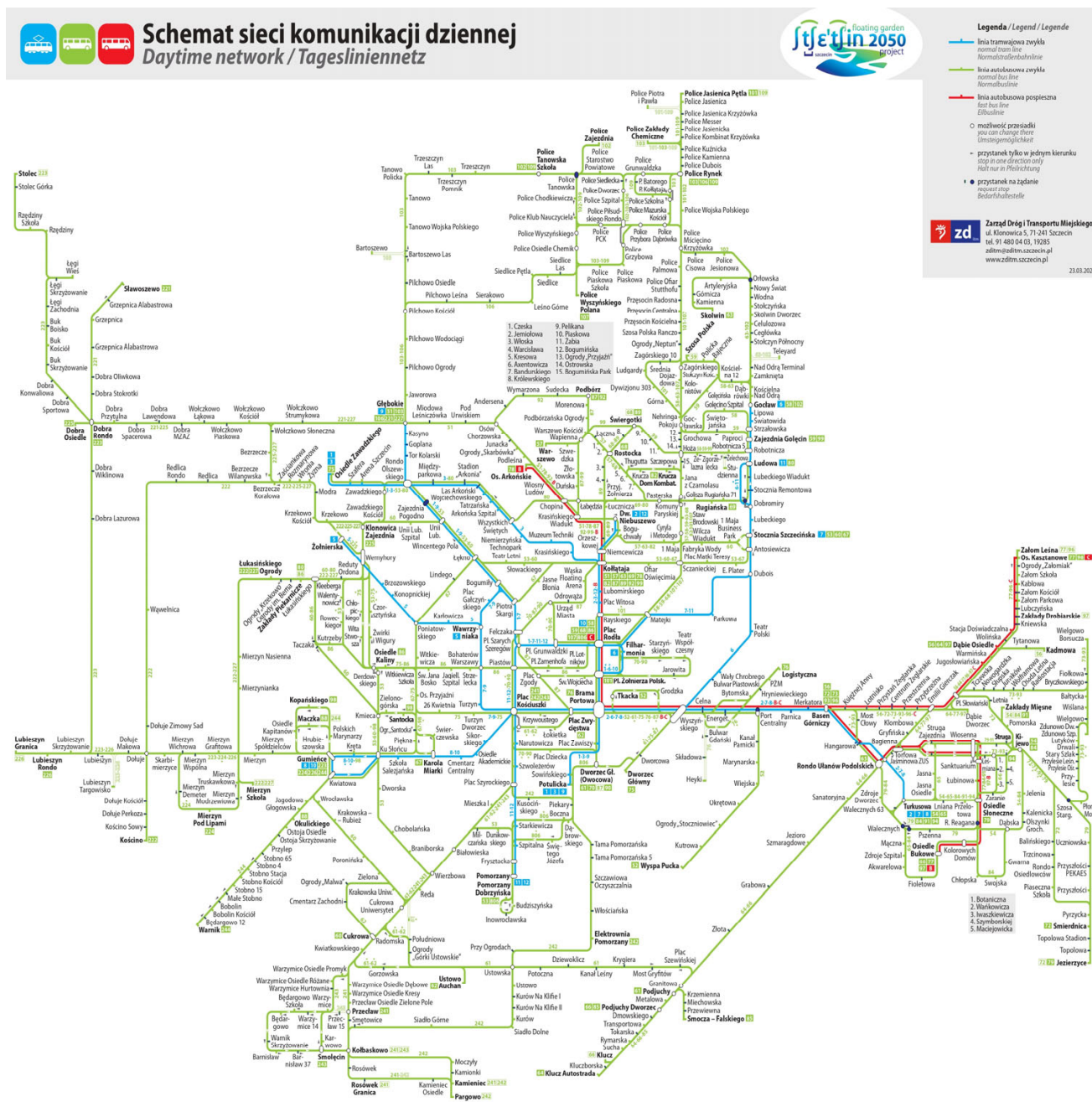


Figure 5. Diagram of the daily communication network. Source: [57] (accessed: 27 January 2024).

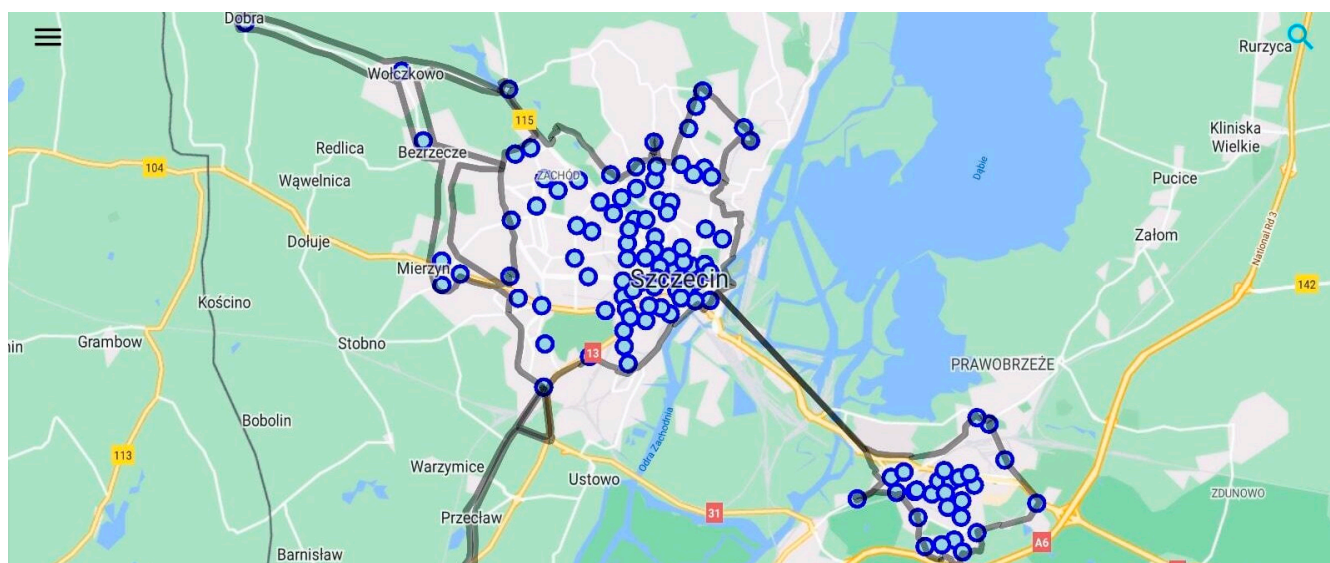


Figure 6. City bike parking zones Source: Own elaboration based on [58] (accessed: 27 January 2024).

Within Szczecin, Road and Urban Transport Management (ZDiTM) operates as a separate organizational unit. It is a municipal budgetary entity responsible, among other things, for the broad organization and management of public transport [59]. ZDiTM issues contracts to operators, companies holding permits for passenger transport services, who have entered into agreements with the public collective transport organizer, ZDiTM, to provide public transport services on the specified communication line, encompassing both bus and tram services, as shown in Figure 7.

As part of their operations, transportation is arranged on numerous lines [60]:

- Regular daytime tram lines: 1, 2, 5, 6, 7, 8, 9, 10, 11, and 12;
- Regular daytime bus lines: 51, 52, 53, 54, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 72, 73, 75, 76, 77, 78, 79, 80, 82, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 96, 97, 98, 99, 101, 102, 103, 106, 107, 109, 221, 222, 223, 224, 225, 226, 227, 241, 242, 243, and 244;
- Regular daytime on-demand bus lines: 904 and 908;
- Regular daytime express bus lines: B and C;
- Regular daytime substitute bus lines: 806;
- Night bus lines: 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, and 536.

3.2. City Bike in Szczecin

The idea of introducing city bikes in Szczecin under the name “Szczeciński Rower Miejski” (SRM) emerged in 2014 with the development of cycling infrastructure in Szczecin. It was also a result of citizens’ participation in deciding on a portion of the budget in 2014 through the Citizens’ Budget (PB). The project underwent a citizens’ vote and garnered the highest number of votes (2728), securing the top position among nearly 300 proposals submitted to the Szczeciński Budżet Obywatelski (SBO) in 2014. Following a competitive tender process, the company BikeU was selected to implement the project with a value of PLN 2.69 million (PLN 575,000 from the SBO, the rest from self-financing, Nieruchomości i Opłaty Lokalne—NiOL). NiOL is the entity responsible for project implementation and ongoing operations [61].

In 2018, the length of cycling paths in Szczecin was 137.3 km and progressively increased to 139.3 km in 2019, 148.6 km in 2020, 154.9 km in 2021, and 160 km in 2022 [55]. The number of SRM stations from 2018 to 2020 was 87 [62].

In 2018, the SRM season started with a delay on March 6 instead of March 1. During the winter break, damage to locks occurred, and even after repairs, there were issues with unlocking bikes at old stations. On April 10, the station on 26 Kwietnia Street was

dismantled due to the construction of a bike path in the area, and it was reactivated on October 24. Unfortunately, in 2018, the number of rentals did not exceed 500,000. The highest number of rentals was in May—86,000. June followed slightly lower with 78,000, and April with 72,000 rentals. In the remaining months, bikes were less popular, considering that they were inactive during the winter months from November to March. In May, 50 new Bike_S bikes were purchased. After their acquisition, the fleet was supplemented with vehicles that, after four years of SRM operation, were worn out or lost.

From 1 March 2019, a total of 586 bikes were introduced on the streets of Szczecin, all of which underwent a thorough inspection during the winter break. Damaged parts were replaced, gears and brakes were adjusted, and the necessary parts were lubricated. In the city center, 368 bikes were stationed, and 217 were available on the right bank. It was announced that the 2019 season might be the last in the current formula. Participation in the Citizens' Budget 2019 and the corresponding number of votes allowed Szczeciński Rower Miejski to transition to fourth-generation bikes. The number of rentals in various months, such as November, July, or September, noticeably decreased. This is especially evident in November, with a total of just under 20,000 rentals. The best month of the season was undoubtedly June, with 69,258 rentals, followed by April with 59,324 rentals, and July with 55,665 rentals. The 2019 season concluded with 410,000 rentals, 80,000 less compared to the previous year. This could be attributed to the emergence of alternative forms of transportation such as electric scooters, although their presence did not significantly affect the popularity of Bike_S.

Repaired and repainted bikes allocated to 87 stations began the seventh season on the streets of Szczecin in 2020. Users had access to 350 bikes on the left bank and 170 on the right bank. Due to the COVID-19 pandemic, Bike_S bicycles were out of use from April 1 to 6 May 2020. All bikes transported back to the stations underwent disinfection of the most frequently touched elements, such as handles, saddles, steering wheels, and keypad terminals for stations. On 21 May 2020, 63 new bikes joined the Bike_S-SRM fleet. The supplier was the company Nextbike, in collaboration with NiOL since 2016. This year, there was the least interest in city bikes due to the epidemic threat. The situation related to the coronavirus left a significant mark on the final monthly results, causing the lowest interest in the history of Bike_S. Excluding April, which had no bikes on the streets of Szczecin, November and March performed the worst, with the number of rentals being 11,000 and 17,000, respectively. Surprisingly, the highest number of rentals occurred during the holiday season, especially in July. The epidemic likely compelled Szczecin residents to stay in the city during this time, positively influencing the utilization of city bikes.

The 2020 season concluded with 217,508 bike rentals. Compared to previous seasons, the result was unsatisfactory and significantly differed from those of previous seasons. One of the main reasons was the threat associated with the coronavirus epidemic, which forced bikes off the streets of Szczecin for five weeks. The implemented lockdown and restrictions also contributed to the situation. Despite the inconveniences, the transition to the next generation of bikes was announced, concluding the current stage of Bike_S with 3 million trips since 2014. These years were marked by numerous problems that NiOL had to confront. Failures and station and bike vandalisms were the main factors causing trouble for residents and operators who had to deal with emerging obstacles. Nevertheless, NiOL always made every effort to mitigate the consequences of events and provide an alternative means of transportation for the residents of Szczecin, such as city bikes. According to Bike_S statistics, Szczeciński Rower Miejski was most frequently rented between 3:00 PM and 4:00 PM on weekdays. This suggests that city bikes were primarily used as an alternative to both public and individual transportation.

In 2021, Szczeciński Rowery Miejskie was not available to Szczecin residents due to preparations for the transition to the fourth generation of bikes. Tender procedures were carried out, not always according to the planned schedule of the project.

BikeS fourth generation started operating on 1 March 2022. Registration is possible exclusively through the Roovee mobile application, available for free download from

<http://www.bikes-srm.pl> as well as from Google Play, the App Store, and the App Gallery. The application is available in four languages: Polish, German, English, and Ukrainian. The application enables, among other things, initiating the starting fee (PLN 20), topping up the account, purchasing a subscription, locating parking zones and available bikes, reserving a bike, and, above all, renting a bike by scanning the QR code from the electronic lock. A total of 800 bikes equipped with GPS and autonomous locks await future users. The system operates year-round, not just from March to November as in previous editions of the bike. Ordinary bike docks have replaced the former docking stations, and their number has increased from 87 to 99. The system operates on new principles, and a re-registration is necessary for individuals who were previously registered in the rental and wish to use it again [63].

3.3. Participating Budget

Local authorities and municipalities, understanding the need for residents' mobility, particularly in the context of bikesharing, strive to fulfill these needs. However, due to limited city or municipality budgets, they cannot always financially support initiatives related to this area. In such cases, participating in a citizens' budget (PB) project competition, also known as participatory budgeting, can be a good solution. It is planned for a specific year, and, to gain social support, this process should be designed as a regular mechanism for citizens' co-decision on initiatives within the city or municipality, especially those related to micromobility. In Poland, participatory projects between 2011 and 2019 were created by local governments solely based on the general statutory competencies of a given local government unit [64,65].

In 2013, the highest number of such projects was reported in Łódź—903, Gdańsk—421, Szczecin—304, nearly the same in Zielona Góra—302, and Radom—277. The number of proposals could be influenced by various factors, including the size of the city, the amount of the citizens' budget, the territorial division of the city, and the specified circle of entities allowed to submit applications to the PB. However, regardless of all differentiating factors, it can be stated that residents are actively engaged in submitting proposals to citizens' budgets already in the first year or first years of the budgets' operation [66].

Most frequently, in such projects related to micromobility, residents considered the construction or renovation of pedestrian paths. On the PB list, following investments in roads, parking spaces, and especially in the largest cities, cycling paths were included, significantly improving and encouraging the use of shared micromobility. In the category of urban furniture, PB included bike racks alongside benches, trash bins, and lamps. Not all proposed solutions by residents are accepted, contributing to the examination of the justification for implementing a particular solution. Since 2018, all cities with county rights, i.e., 66 cities, have been obligated to implement PB projects. Only two cities from this group deviated from this obligation in 2021–2022. There are also smaller, non-legally obligated cities that decide to engage in this type of social participation, thus gaining partial insights into the infrastructure, transport, and recreational needs of residents [67].

Residents of Szczecin have been regularly participating in the competition for projects from the Szczeciński Budżet Obywatelski (SBO) since 2013. In Szczecin, 226 projects were submitted only in the last year [68]. Details are presented using a histogram, in Figure 7.

In terms of allocated funds, SBO is present in the central areas of cities with over 200 thousand inhabitants. Warsaw is the clear leader in this ranking, which is not surprising considering its population size. Following closely are Krakow and Wrocław. On the other hand, residents of Radom, Częstochowa, and Gdynia have the smallest budget at their disposal. When comparing the largest cities in Poland in terms of the PB amount per capita, Katowice takes the lead in this ranking, with 70.7 PLN per capita. Warsaw is in the second position, allocating an average of 54.5 PLN per resident. Among the 14 cities with over 200 thousand inhabitants, Szczecin ranks tenth with an amount of 43.6 PLN. Right behind are Lublin (42.2 PLN) and Gdańsk (42 PLN) [68].

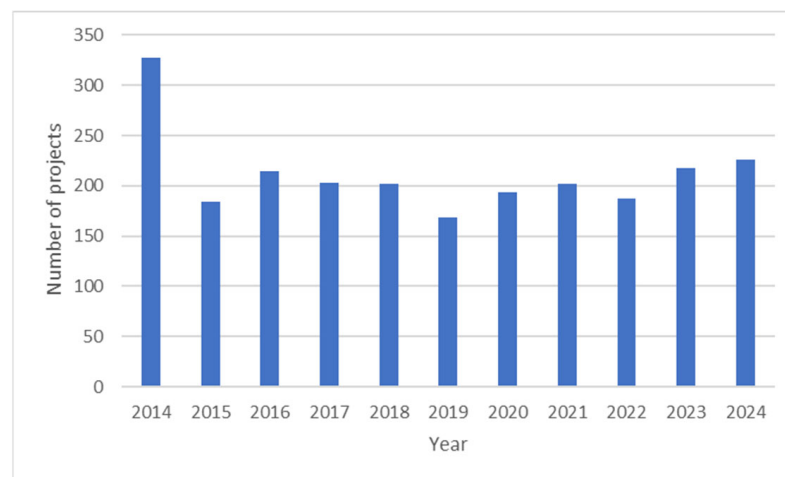


Figure 7. The number of submitted citizens' projects in Szczecin in editions from 2014 to 2024. Source: Own elaboration based on [68] (accessed: 28 January 2024).

Thus far, through SBO, various aspects of bikesharing have been financed, including the establishment of Szczeciński Rower Miejski along with its expansion, the construction and extension of bike paths, and cycling roads. The rules and procedures for participating in social consultations within SBO are preceded by the announcement of the relevant resolution for the given year in the Official Journal of the West Pomeranian Voivodeship [69–72].

3.4. Methods

The applied research procedure is presented in Figure 8.

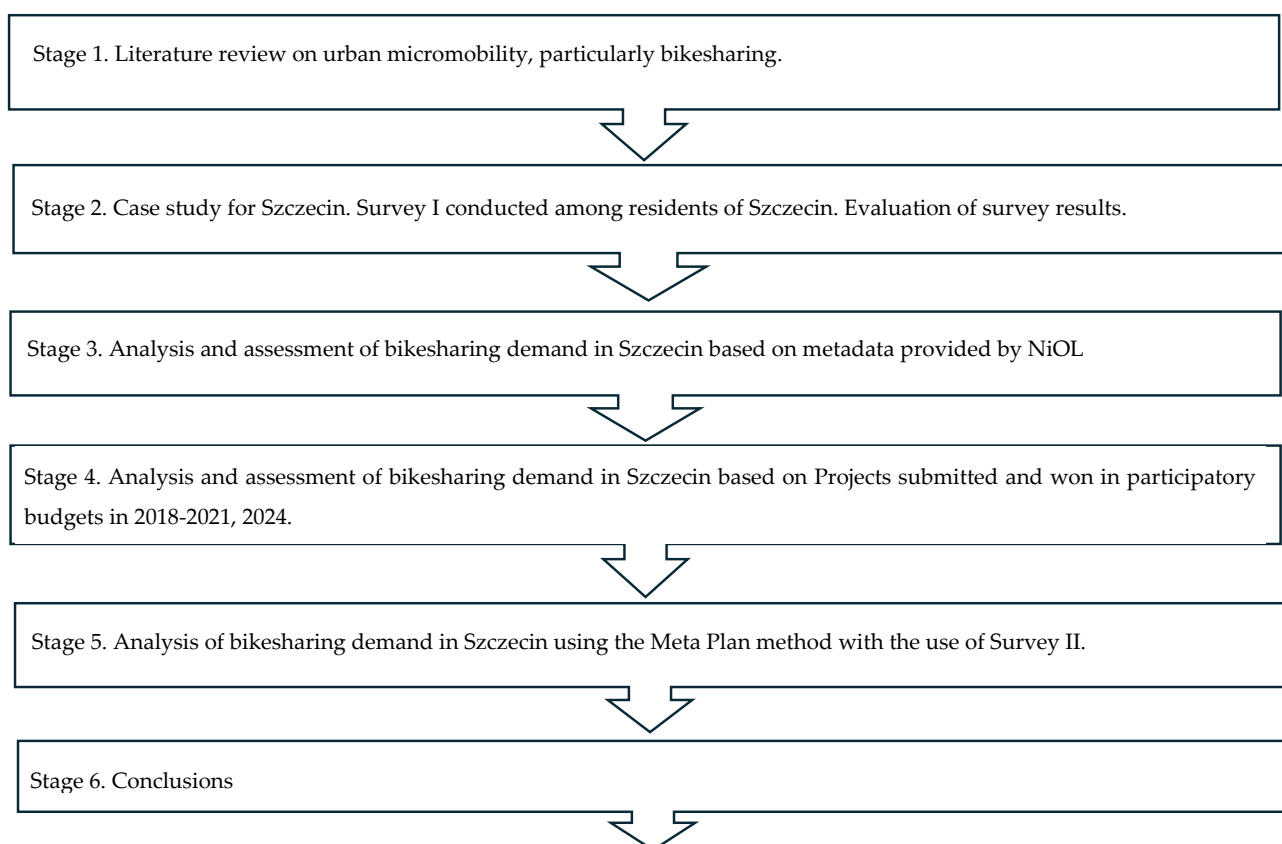


Figure 8. Research methodology. Source: Own elaboration.

In the first stage, a review of the literature available in the Web of Science and Scopus databases was conducted on the topic of urban micro-mobility from the perspective of eco-sharing, particularly bikesharing.

In the second stage, an analysis of the transportation needs of Szczecin residents in the field of micromobility and other available means of transportation was carried out using the case study method.

Unpublished research based on a proprietary survey questionnaire titled “Quality of life from the perspective of residents of a medium-sized city using various means of transportation” was utilized for this purpose. Treated as primary research, the survey was made available to Szczecin residents through the Google browser from 17 May 2019, to 1 April 2021. A total of 322 respondents, aged 16 to 80, participated in this study. Out of the nine questions in the survey, four were utilized, specifically in the section related to bicycles, covering their availability, frequency of use, safety assessment, and the impact on respondents’ lives.

To determine user preferences, a six-element metric was employed, characterizing respondents based on gender, age, occupational activity and industry, education level, and place of residence [73]. A non-random, random sample method was used for this study [74].

To assess the results, correspondence analysis, Kruskal–Wallis analysis of variance, and dependency tests were used.

In the third stage, an analysis of bikesharing in Szczecin was conducted for the years 2018–2020 based on data provided by the NiOL company. The level of bike rentals was evaluated using variance tests.

To evaluate the level of social involvement in the expansion of cycling infrastructure in stage 4, and thus obtain information on the level of interest in bikesharing in Szczecin, the authors analyzed and assessed the qualitative and quantitative aspects of projects submitted and won in Szczecin’s participatory budgets in the years 2018–2021 and 2024.

In the fifth stage, to determine the current situation of bikesharing in Szczecin, its weaknesses, and directions for development, a brief survey II was conducted among SRM users on 11–12 December 2023. It consisted of two metric questions: “In which age group do you belong?” and “What is your occupational activity?” Additional questions included: “How often do you ride a bike?” and “What factors influence your decision to ride a bike?”. A total of 345 respondents aged 15 to 80 participated in this study.

During this stage, a meta plan [75] was also developed for the issue: “Too little interest in bikesharing among Szczecin residents”. The meta plan involved gathering input and insights from participants to address and discuss potential solutions or improvements related to the identified problem.

The research discussed in the article exhibits characteristics of both quantitative and qualitative research. The quantitative aspect pertains to identifying the level of interest in bikesharing in Poland, particularly in Szczecin. The qualitative research focuses on determining the social involvement in the expansion of cycling infrastructure and the weaknesses of bikesharing in Szczecin, along with its directions for development. Conducting research using both quantitative and qualitative methods allows it to be treated as a form of methodological triangulation.

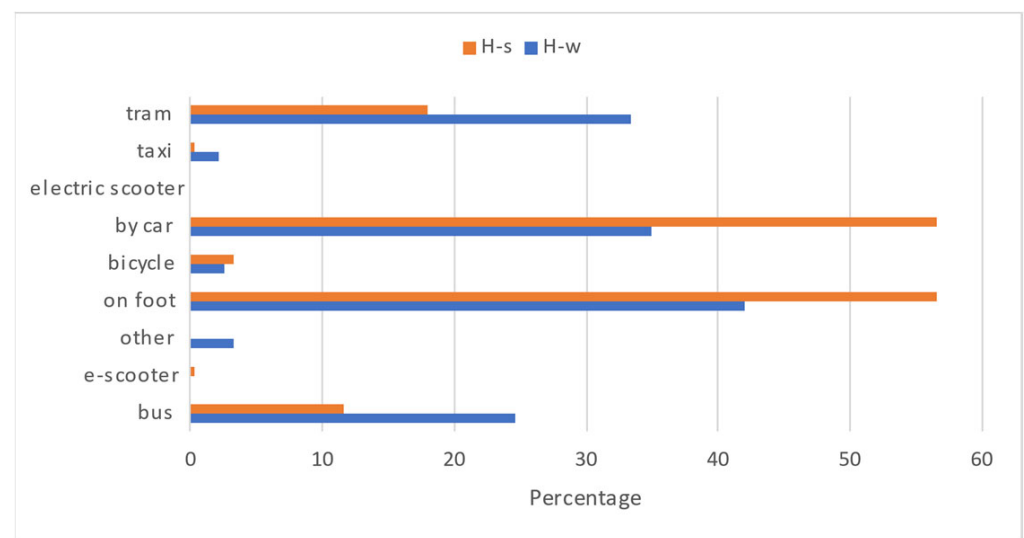
4. Results

4.1. Case Study for Szczecin in the Scope of Micromobility

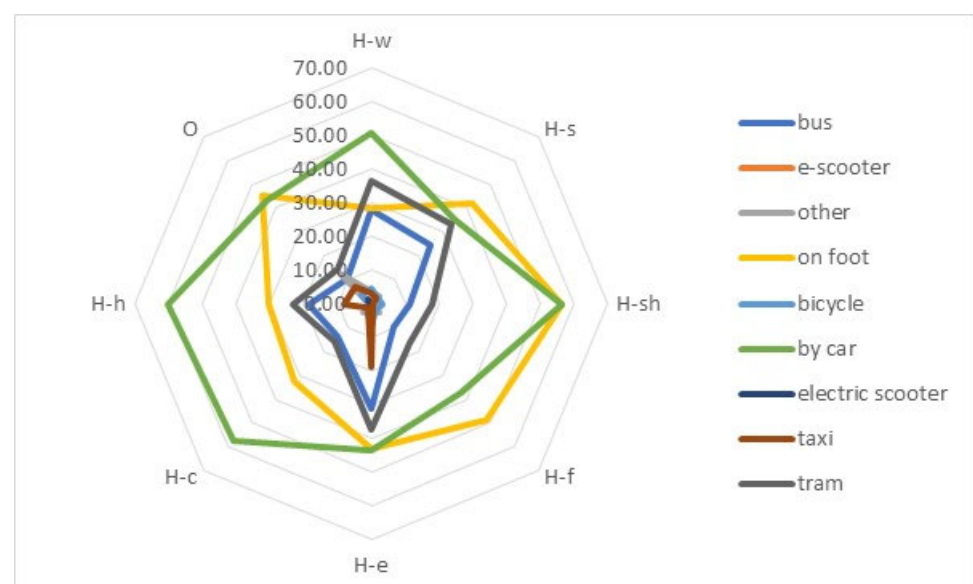
Based on respondents’ answers to questions regarding the frequency of bike usage, bike availability, safety of biking, and the impact of biking on their lives, connections between the characteristics of the chosen mode of transportation, in this case, a bike, and the characteristics of the respondents were identified. When asked about the type of transportation chosen by Szczecin residents for commuting to various places (Table 1) the role of bikes is relatively small. For example, 4.35% of respondents declared commuting to work by bike and 2.5% for commuting to school, as shown in Figure 9.

Table 1. Travel directions suggested to the respondents and their abbreviations.

Travel Directions	Abbreviations Used
Home–work	H-w
Home–school	H-s
Home–shopping	H-sh
Home–fitness	H-f
Home–entertainment	H-e
Home–cemetery	H-c
Home–hospital	H-h
Other than mentioned	O

**Figure 9.** Percentage of users declaring commuting to work or school by a specific means of transportation.

Overall, across all directions, the dominant modes of transportation are cars and walking [76], as illustrated in Figure 10, where the percentage of respondents choosing a specific means of transportation for the respective commuting direction is presented.

**Figure 10.** Percentage of users declaring the choice of means of transportation in different directions.

The utilization of the three micromobility options considered in the survey is depicted in accordance with the graph presented in Figure 11.

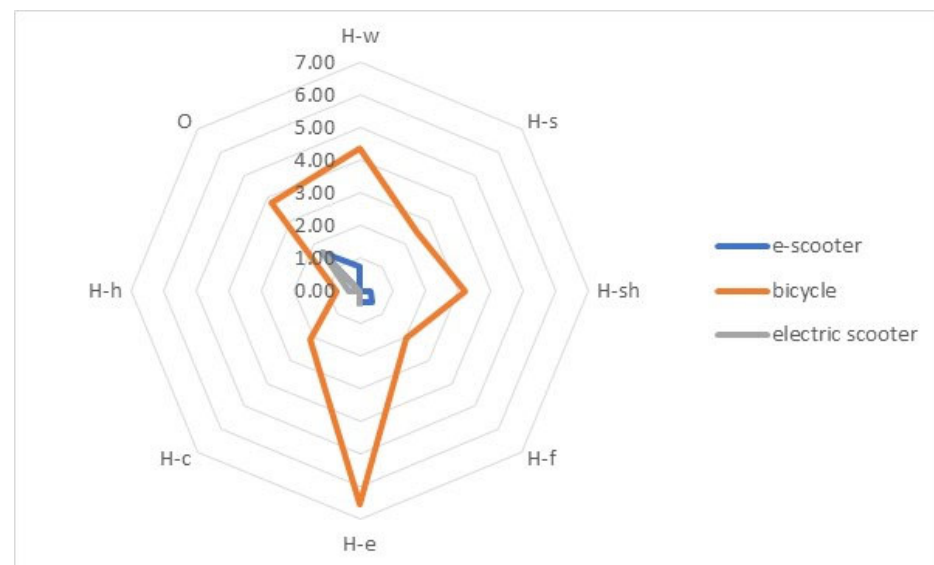


Figure 11. Percentage of users declaring the choice of an eco-friendly means of transportation in different directions.

Only the bicycle was noticeably declared by respondents. The predominant use of bicycles is on the home-entertainment route (H-e). The declaration of the frequency of using a specific means of transportation for micromobility by Szczecin residents is presented in Figure 12.

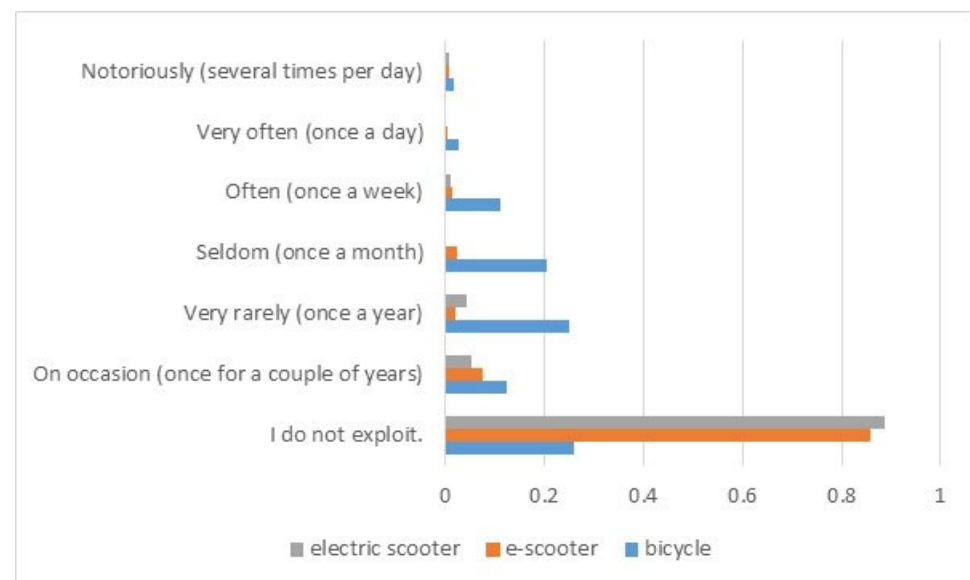


Figure 12. Percentage of residents declaring the frequency of choosing a micromobility means.

For scooters and electric scooters, the response “I do not use” clearly dominates, reaching almost 90%. Regarding bicycles, declarations of non-use and infrequent use also prevail, but they are distributed more evenly, not exceeding 25%.

Socio-Demographic Structure of Respondents in the Context of Bicycle Travel

The following analyses demonstrate the demand for bicycles as an urban means of transportation by linking age categories, occupations, residence, and education with various aspects of biking: frequency of use, availability, and safety.

A chi-square independence test revealed a dependence between the frequency of bike usage and the respondent's age (test statistic value of 59.25 with a critical value of 50.99). However, the strength of the dependence is not substantial, with a Cramer's V coefficient of 0.18. Correspondence analysis allows for the association of age categories with the frequency of bike usage, as depicted in Figure 13.

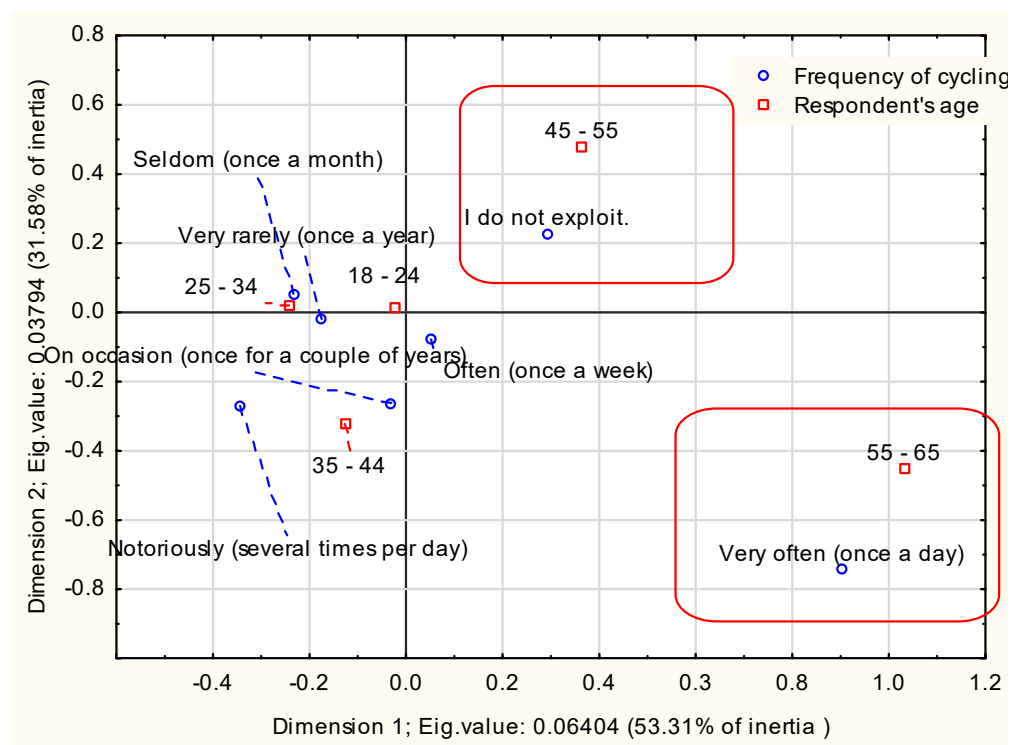


Figure 13. Two-dimensional chart of profiles for the categories “frequency of bicycle usage” and “age”.

The presented arrangement of the two variables explains almost 85% of the inertia of all observed variables, enabling the analysis of the co-occurrence of individual categories. Two distinct groups can be clearly identified:

- Very frequent users, whose percentage is highest in the age group from 55 to 65 years.
- Non-users of bicycles, whose percentage is highest in the age group from 45 to 55 years.

In other cases, associations are highly diverse. A chi-square independence test revealed a dependence between the characteristics of “frequency of bicycle usage” and “the degree of impact of cycling in the city on the respondent’s life” (test statistic value of 156 with a critical value of 50.99). The strength of the dependence is moderate, with a Cramer’s V coefficient of 0.29. Correspondence analysis allows for the association of impact categories with the frequency of bicycle usage, as depicted in Figure 14.

Consistent use of a bicycle is associated with a declaration of a strong impact (Group I). Frequent and very frequent use of a bicycle is linked to a strong and very strong impact (Group II). On the other hand, the declaration of little or no impact is associated with infrequent bicycle use. These associations confirm the coherence of respondents’ opinions in the analyzed survey.

A chi-square independence test revealed a dependence between the frequency of bicycle usage and the assessment of biking safety (test statistic value of 79 with a critical value of 50.99). However, the strength of the dependence is not substantial, with a Cramer’s V coefficient of 0.19. Correspondence analysis allows for the association of safety assessment categories with the frequency of bicycle usage, as depicted in Figure 15.

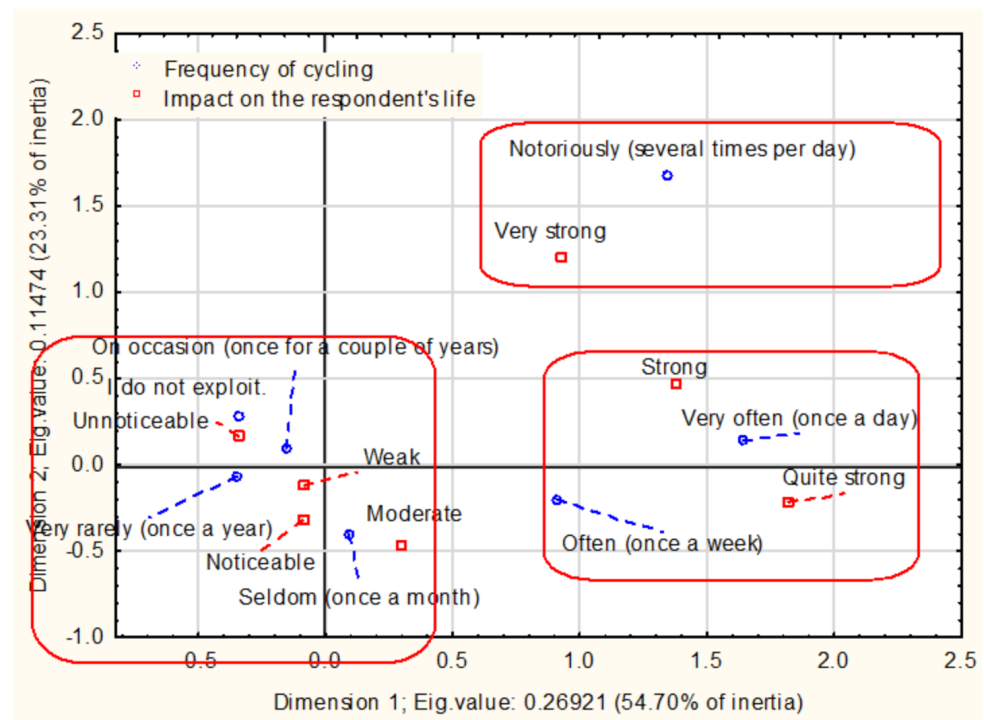


Figure 14. Two-dimensional chart of profiles for the categories “frequency of bicycle usage” and “impact of cycling on life”.

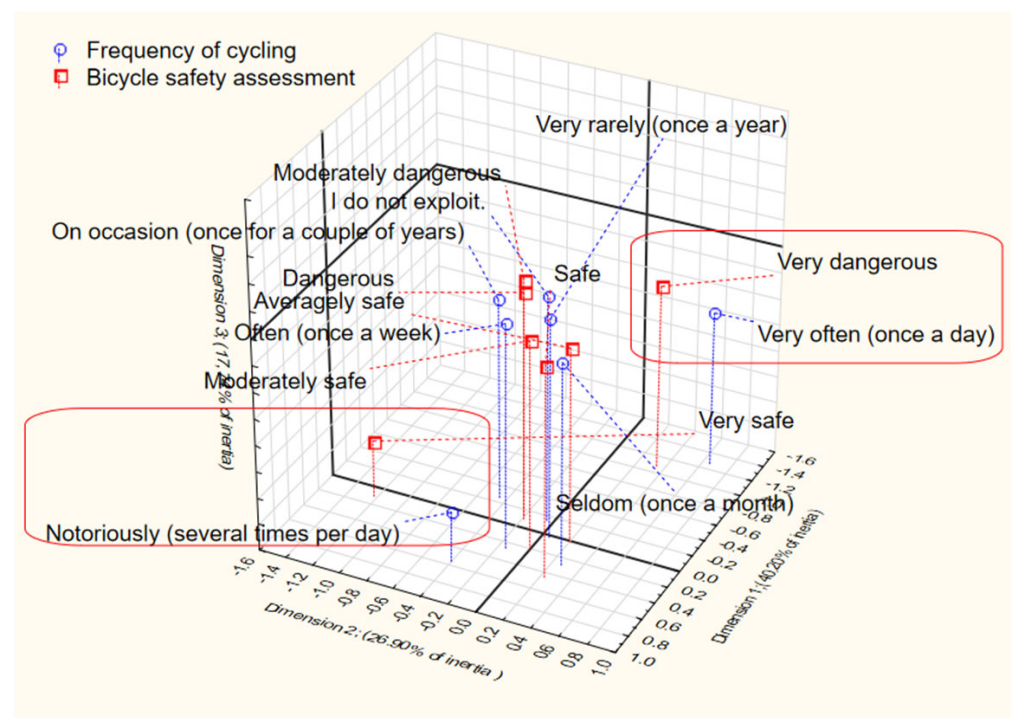


Figure 15. Three-dimensional chart of profiles for the categories “frequency of bicycle usage” and “assessment of bicycle safety”.

In the presented associations, two groups stand out:

Habitual users who perceive biking as very safe.

Those who bike very frequently (once a day) and assess biking in a completely different manner—as very unsafe.

This indicates an awareness of the actual conditions of cycling in Szczecin. A chi-square independence test revealed a dependence between the assessment of bicycle safety and the respondent's type of occupational activity (test statistic value of 38.5 with a critical value of 36.4). However, the strength of the dependence is not substantial, with a Cramer's V coefficient of 0.17. Correspondence analysis allows for the association of safety assessment categories with the frequency of bicycle usage. For the two dominant groups in the survey, students and professionally active individuals, the chart of associations is as follows, as presented in Figure 16.

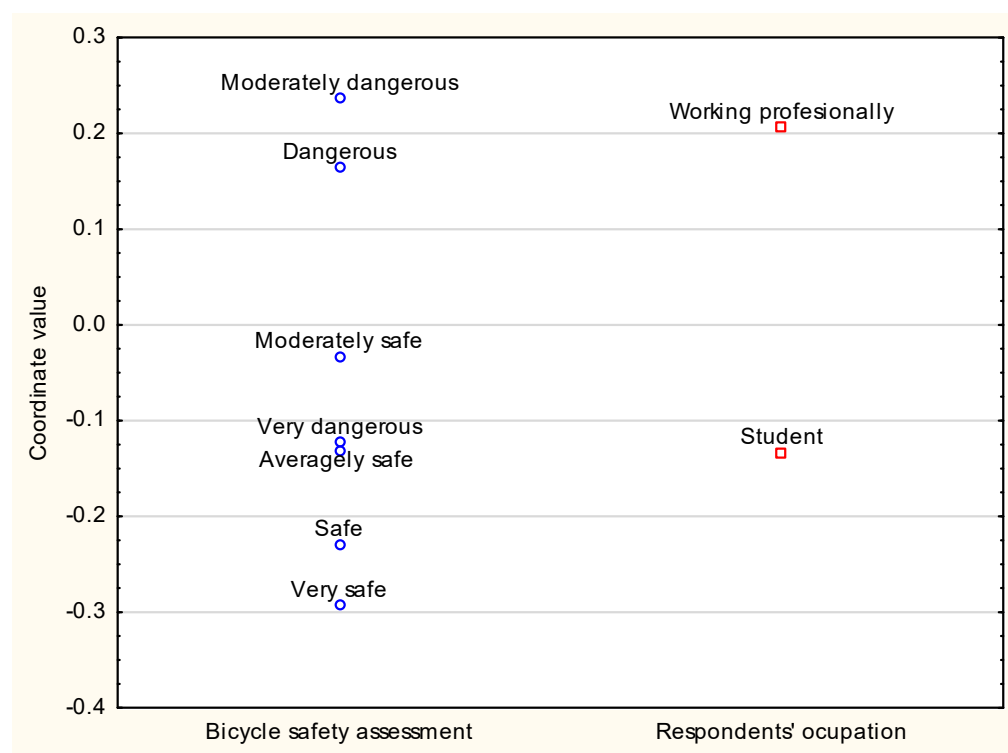


Figure 16. One-dimensional chart of profiles for the categories “assessment of bicycle safety” and “occupation”.

Professionally active individuals assess biking as unsafe, while among students, the prevailing opinion is that biking is a safe means of transportation. Although the student category is strongly associated with the assessment that biking is extremely unsafe.

A chi-square independence test revealed a dependence between the assessment of bicycle safety and the respondent's place of residence (test statistic value of 28.7 with a critical value of 28.4). However, the strength of the dependence is not substantial, with a Cramer's V coefficient of 0.17. Correspondence analysis allows for the association of safety assessment categories with the respondent's place of residence, as presented in Figure 17.

In this case, individuals from outside Szczecin clearly formed groups with different assessments of the safety of cycling in Szczecin. People from the vicinity of Szczecin have moderate opinions about the safety of cycling. Those from more distant areas within the West Pomeranian Voivodeship rate the safety of cycling very poorly. On the other hand, individuals from farther regions of Poland perceive cycling in Szczecin as very safe. However, the opinions of Szczecin residents regarding the safety of cycling are extremely diverse.

A chi-square independence test revealed a dependence between the assessment of bicycle availability and the respondent's age (test statistic value of 125.5 with a critical value of 50.99). The strength of the dependence is moderate, with a Cramer's V coefficient of 0.25. Correspondence analysis allows for the association of availability categories with the age of respondents, as depicted in Figure 18.

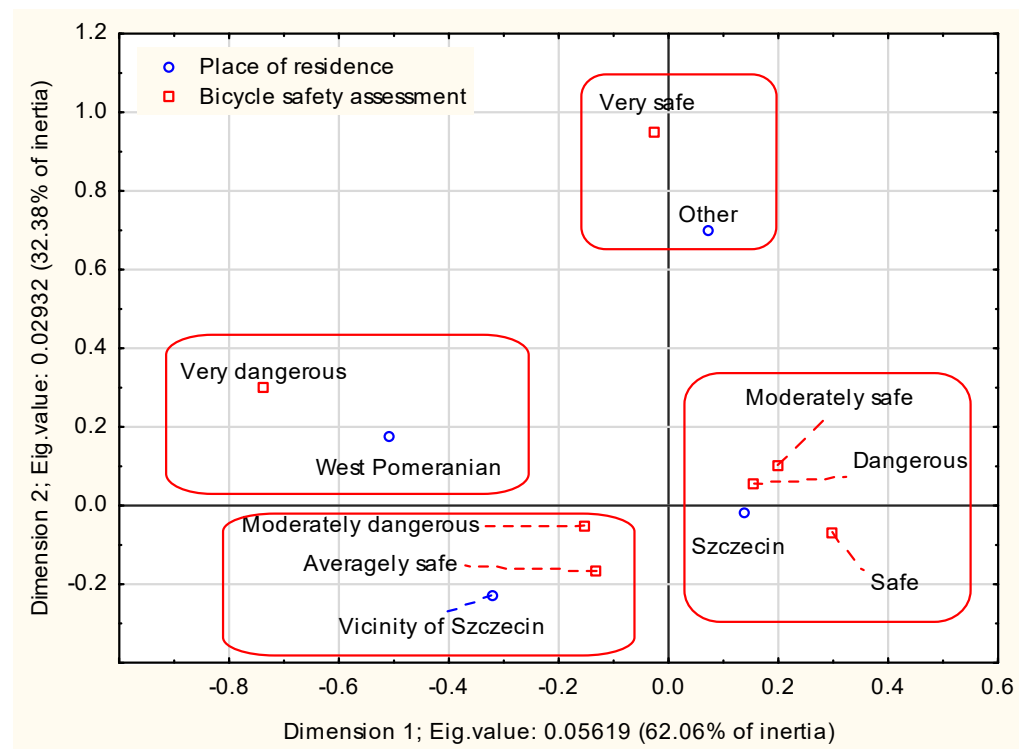


Figure 17. Two-dimensional chart of profiles for the categories “assessment of bicycle safety” and “place of residence”.

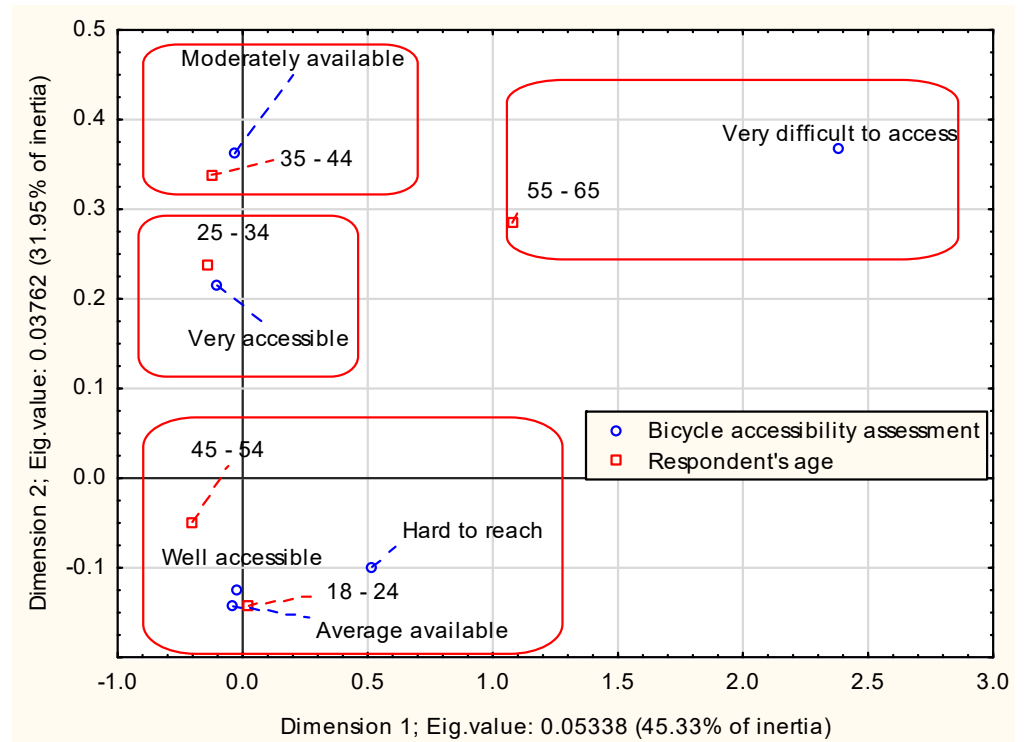


Figure 18. Two-dimensional chart of profiles for the categories “assessment of bicycle availability” and “age”.

Within the age group of 55 to 65 years, opinions prevail that the bicycle is a very difficult means of transportation to access. In the age group of 25 to 34 years, opinions

prevail that the bicycle is very accessible. In the age group of 35 to 44 years, opinions prevail that the bicycle is moderately accessible. However, the age groups 45–54 and 18–24 have diverse opinions about the availability of bicycles in Szczecin.

A chi-square independence test revealed a dependence between the assessment of bicycle availability and the respondent's education level (test statistic value of 172.5 with a critical value of 28.9). The strength of the dependence is substantial, with a Cramer's V coefficient of 0.42. Correspondence analysis allows for the association of availability categories with the two most numerous groups of respondents with higher and medium education, as depicted in Figure 19.

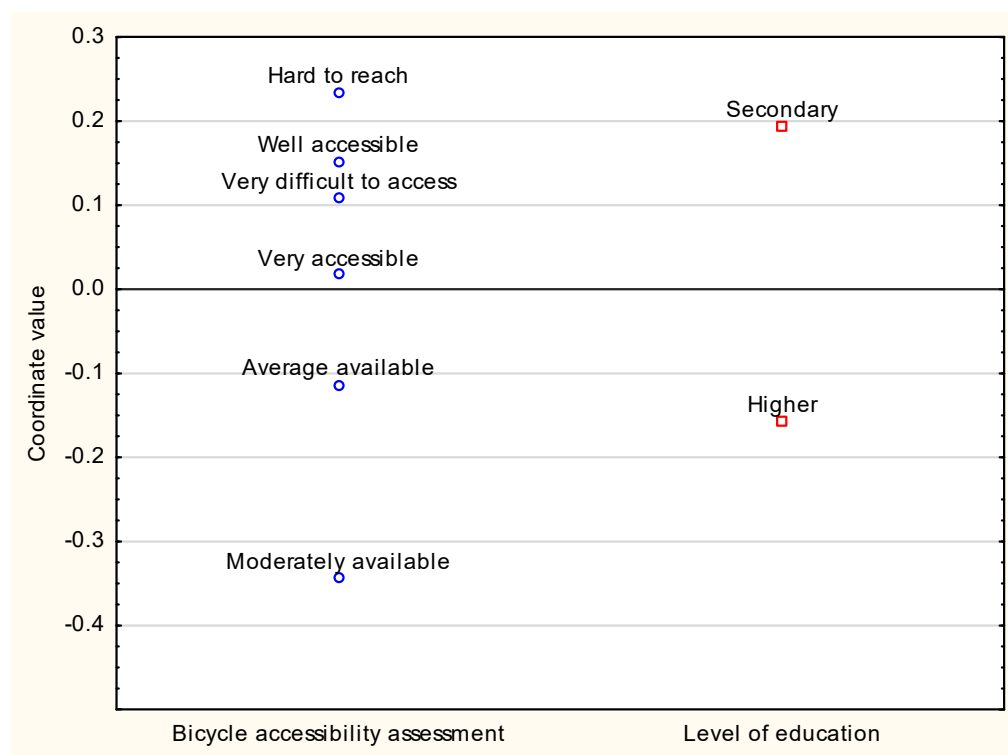


Figure 19. One-dimensional chart of profiles for the categories “assessment of bicycle availability” and “education”.

Among the two dominant groups with medium and higher education, it can be observed that respondents with higher education rate the availability of bicycles as average. Meanwhile, the group with medium education declares extreme opinions: very accessible and at the same time very difficult to access.

4.2. Meta-Analysis of Bike Rental Data for the Years 2018–2020

The main indicator of the intensity of using city bikes is the number of rentals. Below (Figure 20) are comparisons and statistics related to the period 2018–2020. In 2021, the operation of city bikes in Szczecin was suspended.

Over the years 2018–2020, noticeable seasonal fluctuations in the number of bike rentals can be observed. Additionally, there is a clear decline in the number of city bike rentals. Particularly low values in 2020 are associated with the COVID-19 pandemic, during which the operation of city bikes was significantly restricted. However, earlier data already suggested a decrease in interest in city bikes, as depicted in Figure 21.

While the years 2014–2018 do not significantly differ in terms of the average daily number of rentals, 2019 already has a significantly lower average, and this trend deepens in 2020. The absolute annual number of rentals has been systematically decreasing since 2016, as shown in Figure 22.

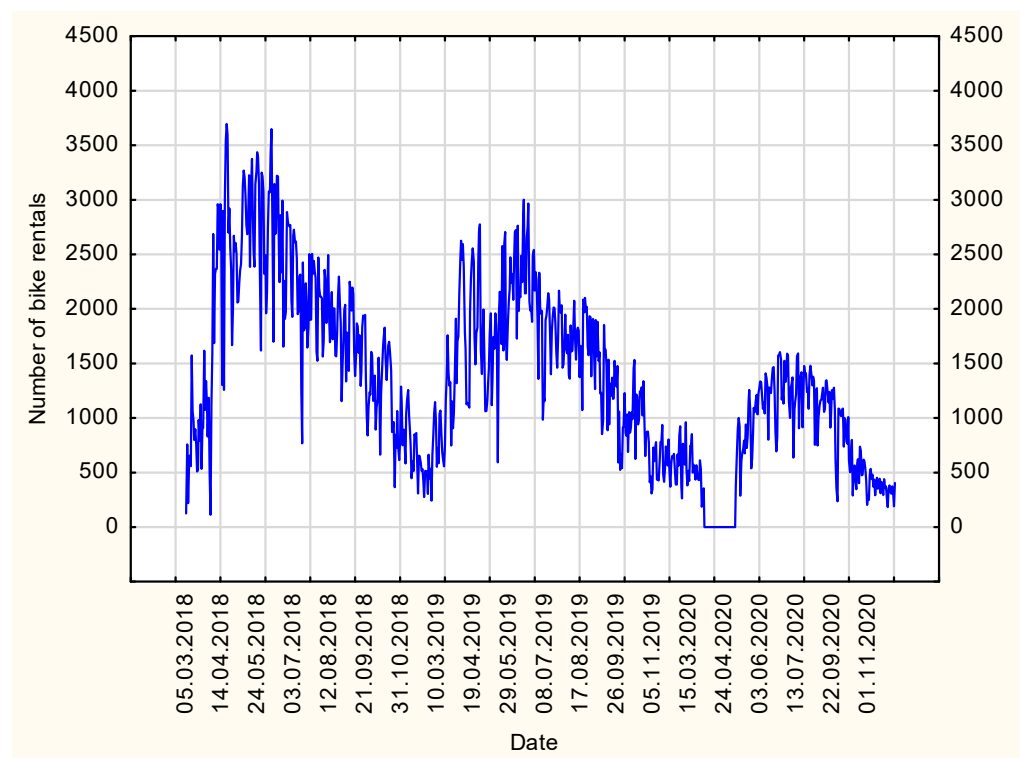


Figure 20. Time series of the number of bike rentals in the years 2018–2020. Source: Own elaboration based on: [62].

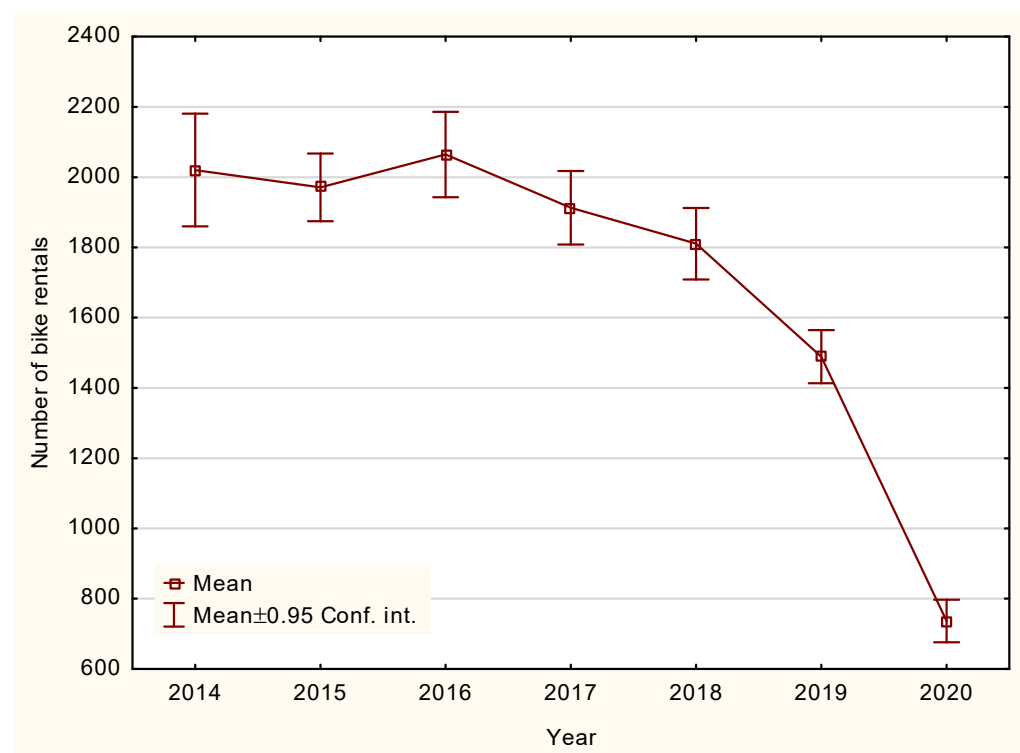


Figure 21. Dynamics of changes in the average daily number of rentals in the years 2014–2020. Source: Own elaboration based on: [62].

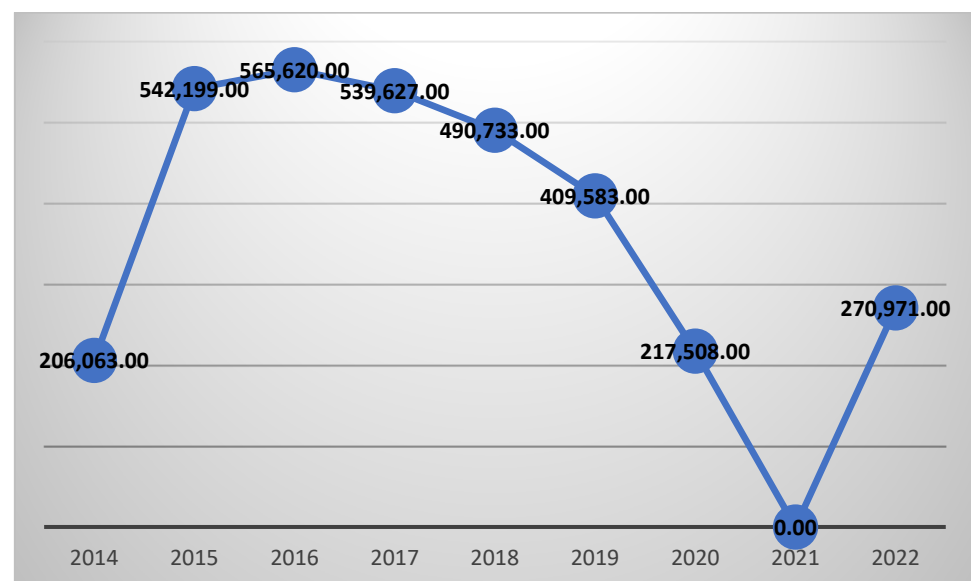


Figure 22. Dynamics of changes in the annual number of rentals in the years 2014–2022. Source: Own elaboration based on: [55,62].

The distribution of the number of rentals in individual months was as follows, as depicted in Figure 23.

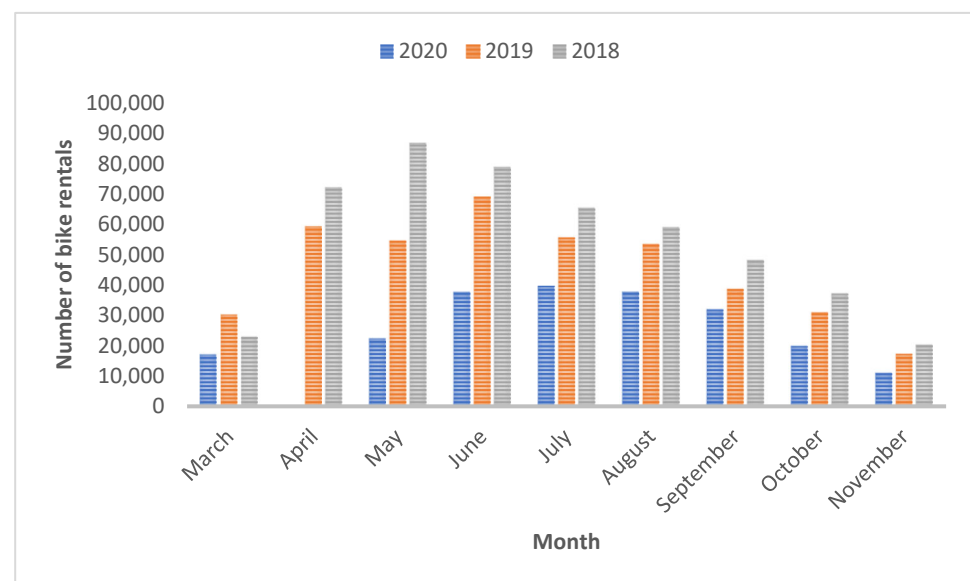


Figure 23. Number of rentals in individual months of city bike operation. Source: Own elaboration based on: [62].

Another measure of demand for bikesharing services is the average daily number of bikes on the streets. Details for each month and the years 2018–2020 are presented in Table 2.

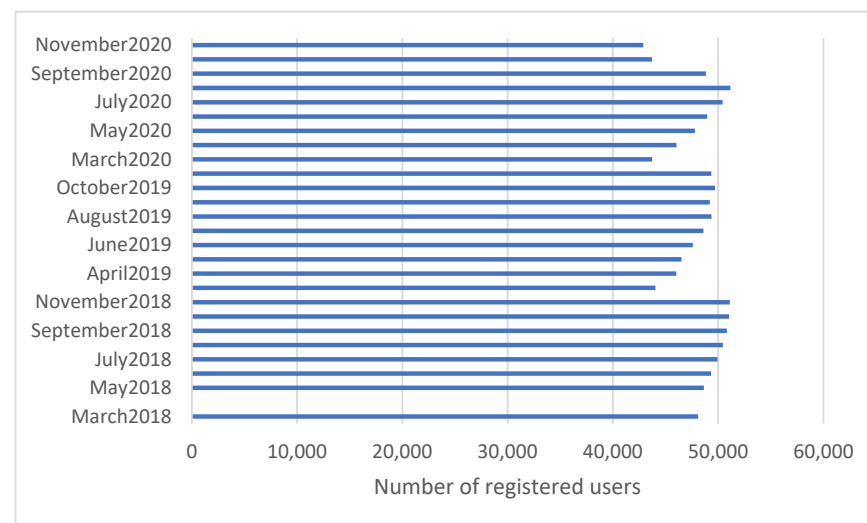
Despite the significantly varied number of rentals in individual years, the average number of city bikes (SRM) cycling on the streets of Szczecin continues to grow: in 2018, it was 525 bikes, in 2019—547 bikes, and in 2020, it reached 568 bikes.

Another indicator of SRM popularity is the number of registered users, which remained at a similar level between 40,000 and 50,000 during the examined period, as shown in Figure 24.

Table 2. Average number of bikes daily on the streets in individual months in the years 2018–2020.

Month	2018	2019	2020
March	599	636	522
April	580	593	-
May	547	577	588
June	515	573	611
July	517	544	588
August	443	515	576
September	-	505	560
October	474	481	547
November	503	501	555

Source: Own elaboration based on: [62].

**Figure 24.** Number of users in individual months of city bike operation. Source: Own elaboration based on [62].

To assess the periodicity of changes in SRM usage, the daily number of rentals was analyzed in two aspects: monthly and weekly.

The daily number of rentals is also highly variable in individual months. Data from the month of April are significantly disrupted because the city bike system did not operate in this month in 2020, and the data underestimate the average. A similar situation occurred in May when the bike service started, but there were significant restrictions. In the years 2018–2019, the situation unfolded as depicted in Figure 25.

Kruskal–Wallis tests indicated a significant difference between the number of rentals in individual months. Fisher’s Least Significant Difference tests allow the identification of the following groups, as shown in Table 3.

Table 3. Systematized results of the Fisher’s test for month.

Month	Average Number of Rentals	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
11	626.833			****				
3	914.500				****			
10	1099.919					****		
9	1447.633						****	
8	1813.903	****						
7	1952.532	****						
4	2190.050		****					
5	2281.790		****					
6	2468.617							****

Source: Own elaboration based on [62]. (****) means belonging to a given group.

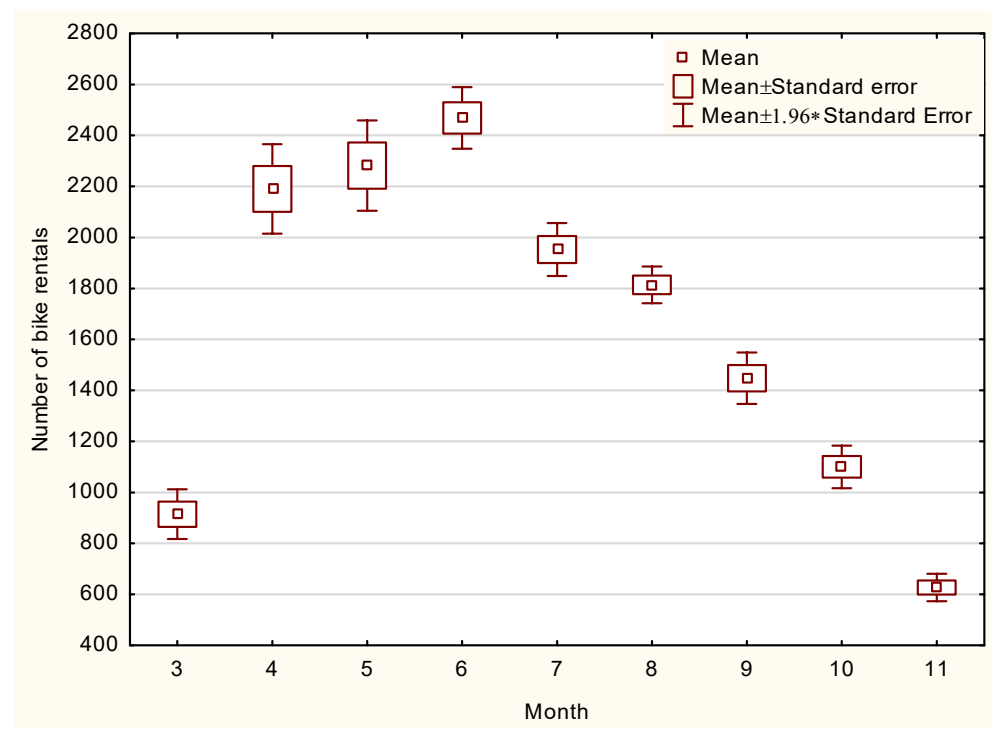


Figure 25. Variation in the daily number of rentals in individual months of the years 2018–2019. Source: Own elaboration based on [62].

The highest number of rentals occurred in June, while the lowest was in November. In July and August, there was a significant decrease compared to June—the holiday season. During the months of April to May, the number of rentals was notably higher than in the vacation months of July and August. It can be inferred that city bikes are used more for commuting to school and work than for recreational or shopping purposes. This is also evident in the diagram below, where a lower number of rentals is observed on Saturdays and Sundays. Additionally, a significantly lower number of rentals is noticeable in the autumn and winter months, indicating the significant impact of weather conditions, which in Szczecin during this period, especially do not favor cycling, as shown in Figure 26.

Multiple comparison tests (Fisher's LSD test) indicate significant differences between the number of rentals on Saturdays and Sundays compared to the other days of the week, as presented in Table 4.

Data on rentals at individual SRM stations allows us to identify stations with the highest number of rentals. The 20 most popular stations are presented in Figure 27.

Table 4. Systematized results of the Fisher's test for day of week.

Day of the Week	Average Daily Number of Rentals	Group 1	Group 2
Sunday	1391.597		****
Saturday	1461.256		****
Thursday	1697.603	****	
Monday	1700.885	****	
Tuesday	1756.641	****	
Wednesday	1759.282	****	
Friday	1769.101	****	

Source: Own elaboration based on [62]. (****) means belonging to a given group.

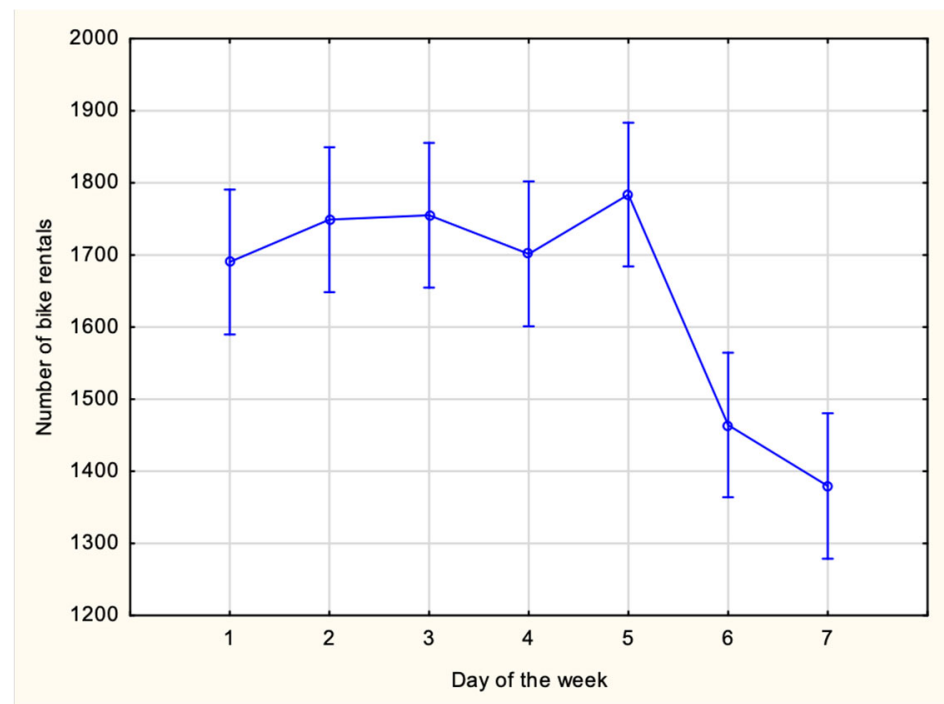


Figure 26. Average daily number of rentals on individual days of the week with a 0.95 confidence interval. Source: Own elaboration based on [62].

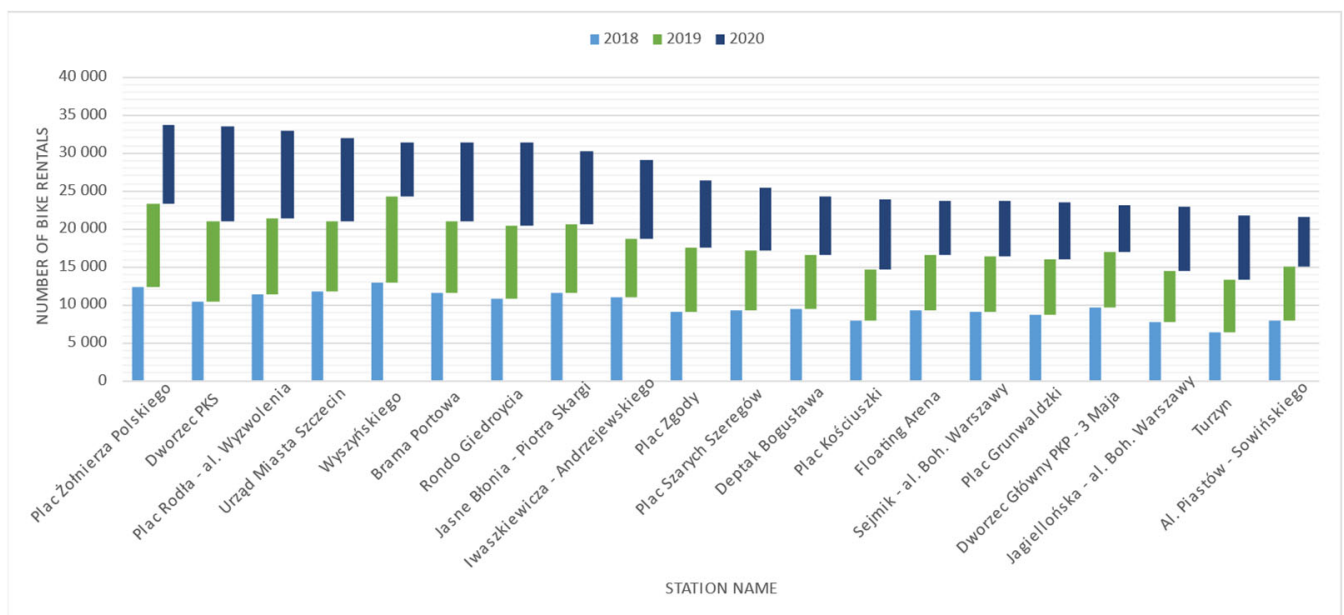


Figure 27. Number of rentals at individual stations. Source: Own elaboration based on [62].

Nineteen out of the 20 most popular city bike stations are located in the left-bank part of Szczecin, with only one in the right-bank part. The map below illustrates the distribution of these stations in the left-bank part, which constitutes the central area of Szczecin with municipal and provincial offices, universities, cultural centers, the main railway and bus station, dormitories, etc. (Figure 28).

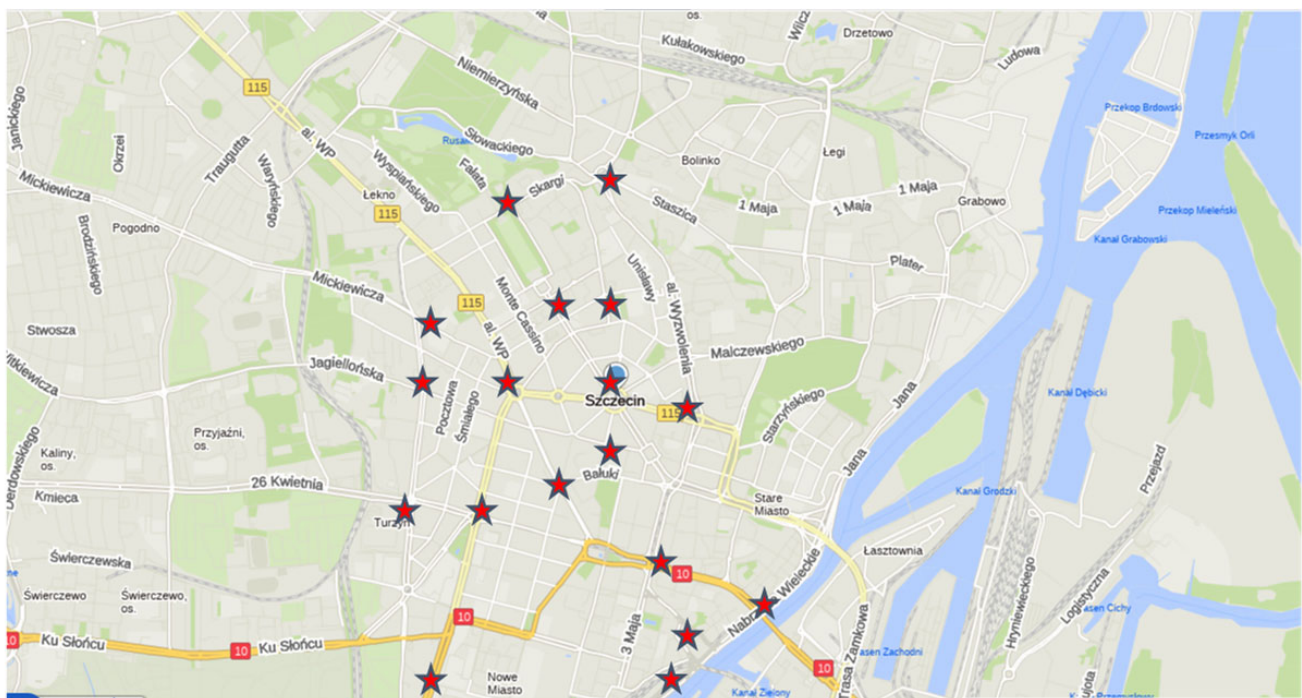


Figure 28. Distribution of the most popular SRM stations in the center of Szczecin. Source: Own elaboration based on [62].

All of these most popular SRM stations are located near crucial points, such as:
 Intersections of tram and bus lines
 Transfer centers
 Offices
 Railway stations
 Dormitories

The choice of mobility method, considering factors such as availability, travel time, and the number of transfers, is influenced by the specific organization of urban space in Szczecin, including the topography, rivers, street and road network, and bridges.

4.3. Analysis of the Szczecin Participatory Budget (SBO)

In the years 2018–2021, residents of Szczecin actively participated in submitting projects for implementation within the framework of the SBO. Each year, the funds allocated for the implementation of selected projects have been increasing, from 8 million PLN in 2018 to 17.2 million PLN in 2024. Details are presented in Table 5.

Table 5. Basic data on SBO projects in the years 2018–2024.

Year	Funds	Number of Projects	Number of Votes Cast
2018	$8.00 \cdot 10^6$	113	75,047
2019	$9.00 \cdot 10^6$	110	61,727
2020	$1.27 \cdot 10^7$	122	141,415
2021	$1.46 \cdot 10^7$	113	134,607
2022	$1.67 \cdot 10^7$	114	122,181
2023	$1.75 \cdot 10^7$	153	134,630
2024	$1.72 \cdot 10^7$	124	51,131

Source: Own elaboration based on: [77] (accessed: 29 January).

Part of these projects was related to the broadly understood cycling infrastructure and involved bikesharing stations, cycling paths, and other related initiatives. Details are provided in Table 6.

Table 6. Data on cycling projects in SBO.

Year	Number of Bicycle Projects	Percentage of Bicycle Projects	Number of Votes Cast for Bicycle Projects	Percentage of Votes Cast for Bicycle Projects
2018	23	20.35	12,048	16.05
2019	12	10.91	7148	11.58
2020	2	1.64	1247	0.88
2021	7	6.19	8656	6.43
2022	9	7.89	9487	7.76
2023	12	7.84	8288	6.16
2024	16	12.90	2429	4.75

Source: Own elaboration based on: [77] (accessed: 29 January).

On average, 9.8% of all projects and 7.7% of all votes are related to cycling infrastructure. Some of these projects are closely connected to bikesharing. Between 2018 and 2021, there were a total of 14 such projects, constituting only 1.65% of all voted projects.

During this period, only five cycling projects were selected for implementation. In 2019, the project “Pedestrian-roller-skating-cycling route around Lake Goplana—an extension of the existing route around the Arkonka bathing area” was chosen as a citywide project with a budget of PLN 3,156,500. It received 2854 votes and was accepted for implementation as the winner.

In 2020, a district project was chosen: “Pumptrack—a universal cycling track in Wielgowo” with a budget of PLN 253,000. It received 940 votes [77].

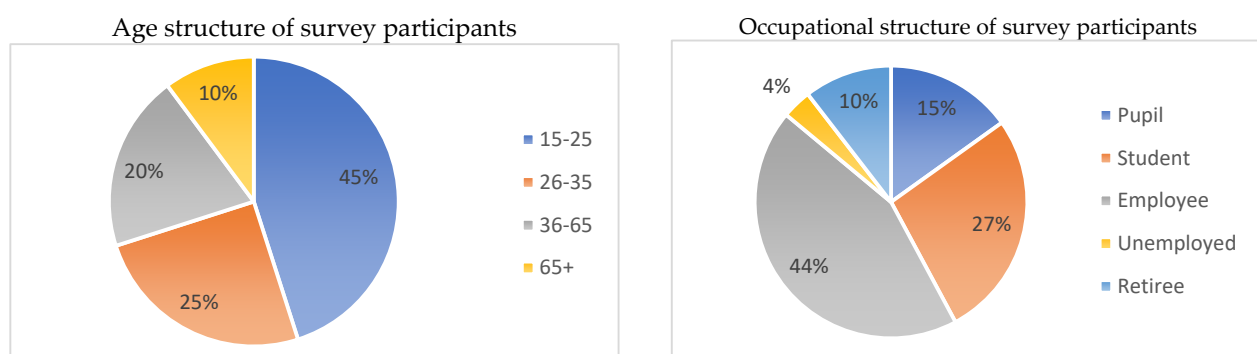
In 2021, three district projects were selected:

- “Consistent cycling routes for Szczecin—Szczaniecka” (budget—PLN 330,000; number of votes—724)
- “Jezioro Słoneczne, Gumieńce—improvement of recreational and cycling infrastructure. Construction of the missing section of the roller-cycling path around Lake Słoneczne, construction of a skatepark at Taczak” (budget—PLN 580,000; number of votes—2600);
- “Consistent cycling routes for Szczecin—Matejki” (budget—PLN 231,000; number of votes—839) [78].

4.4. Meta Plan for Bikesharing in Szczecin

After conducting the previously discussed analyses, the authors decided to utilize another method. The meta plan was developed based on all previously conducted research, and additionally, specifically for its needs, a survey was conducted among 345 respondents aged 15 to 80 years old. The survey results are presented in Figure 29.

The developed meta plan takes into account the observations and conclusions from the previous analyses and helps formulate final conclusions in the analysis of the needs of Szczecin residents regarding the use of bikesharing, partially addressing the question of why there is too little interest in bikesharing in Szczecin. Details are presented in Figure 30.

**Figure 29.** Cont.

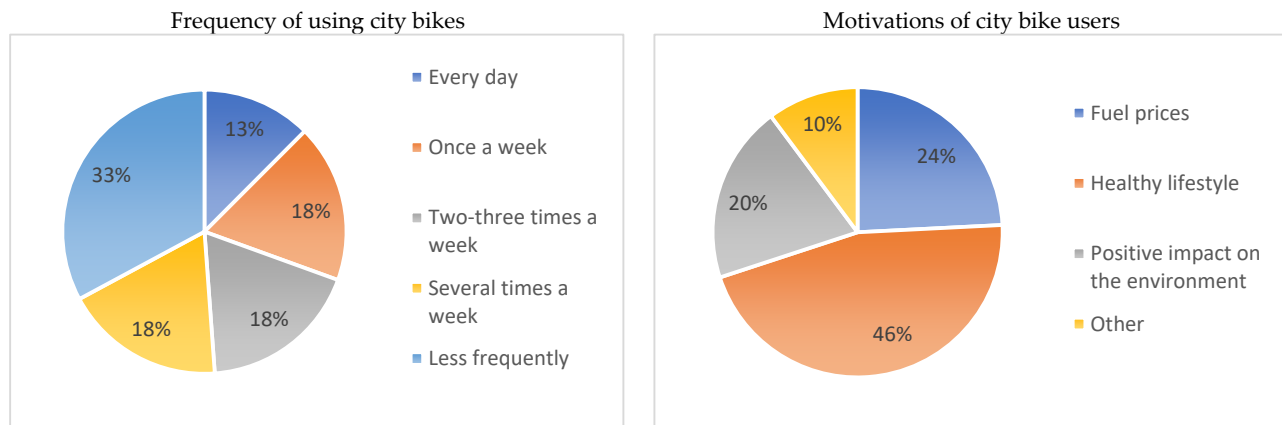


Figure 29. Survey Results for meta plan. Source: Own elaboration.

Insufficient interest in bikesharing among residents of Szczecin	
<p>How is it?</p> <p>100 stations and 800 bikes</p> <ul style="list-style-type: none"> • Increase in ride costs by 0.04 PLN from March 2023 • Main users aged 15–25 • 44% of users are working individuals • The main motivation for using bikesharing is a healthy lifestyle. • Easy bike operation. • The quality of the bike bell signal is audible and of good quality. • The bike is durable and resistant to wear, has a comfortable seat, is equipped with an adequate number of reflectors and lights, has a luggage rack or basket, and has effective brakes. • Competitive price compared to other Personal Mobility Devices (PMDs). 	<p>How it should be:</p> <ul style="list-style-type: none"> • SRM adapted to weather conditions and the environment. • An expanded and cohesive network of bike lanes in the city. • Campaigns promoting RM as a competitive, health-promoting, and environmentally friendly means of transportation. • An expanded network of RM stations. • Educational programs highlighting the benefits of using RM. • An attractive pricing policy for renting RM. • Simple bike rental process. • Comfortable and safe bikes for users. • Systemic or quantitative prevention of bike shortages at stations. • Well-maintained bikes in terms of hygiene, mechanics, and aesthetics.
<p>Why it's not as it should be:</p> <ul style="list-style-type: none"> • Lack of travel comfort. • Insufficient safety in moving around the city. • Deficient bike infrastructure. • Unfavorable weather conditions. • Lack of awareness of the benefits. • Unavailability of bike stations in the vicinity. • Preferences for other means of transportation. • Health limitations of potential users. • Insufficient number of bikes. • Fear of poor technical condition of vehicles. • Lack of proper communication about the benefits and ease of using RM. • Using personal bikes, more tailored to the individual needs of the traveler. • Fear of using shared bikes due to hygiene issues. 	
<p>Conclusions, what needs to be changed:</p> <ul style="list-style-type: none"> • Improve the linear infrastructure of RM. • Enhance the coherence of the bike network. • Introduce seasonal promotions in the winter. • Implement promotional activities for less active user groups. • Placement of bike stations at key points in the city, large housing estates, and educational centers. • Implement educational programs in schools to raise awareness of the benefits of bikesharing. • Increase the number of available bikes. • Regular technical inspections of bikes. • Discounts for regular users. • Ensure comfortable seats and efficient gear shifting. 	

Figure 30. Meta plan for bikesharing in Szczecin. Source: Own elaboration.

5. Discussion

To investigate the demand for ecological individual means of transport, one of the Polish cities where BSS has been operating since 2014 was chosen. The main reason for creating the system was the societal need expressed in the voting during the Civic Budget. Since then, there has been a systematic development of the system, which has already found its place in the city's transportation system. It constitutes an important element, positively influencing the capacity and mobility of the residents.

A case study based on survey research and metadata concerning Bike_SSRM confirms the findings that entertainment, despite the passage of time, still seems to be a key motivation for bike users in Szczecin, as well as in cities like London [79]. The demand for bikes in Szczecin is also influenced by unfavorable weather conditions, similar to New York and London [80,81], where demand drops during adverse weather. Respondents, especially those active professionally, confirm that the bike is an important alternative means of transportation in the city, and they assess its availability positively. However, when it comes to assessing its safety, they are not as enthusiastic as younger, learning individuals, as confirmed by other studies [82].

A significant factor influencing the utilization of BSS is comfort and convenience. Users are much more willing to use bikes, which is also confirmed by other researchers, especially during warmer months [83]. Unfavorable weather conditions discourage bicycle travel [84].

The utilization of city bikes in Szczecin is noticeably lower on weekends and during the holiday period, as confirmed by research in other cities [85,86]. Researchers analyzing the demand for electric bikes [87] have shown that factors such as weekends, summer months, and the proximity of recreational centers and bike paths influence more frequent use of bikesharing systems. In Szczecin, as in many other cities, bikesharing systems are based on non-electrically powered vehicles. On the other hand, many authors confirm the relationship between bikesharing demand and the proximity of businesses and workplaces to bikesharing stations [88]. Gervini and Khanal suggest that urban infrastructure and the spatial distribution of bike stations are key factors in meeting the demand for city bikes [89]. This situation is also evident in Szczecin, as demonstrated by the authors.

The significant decrease in demand for city bikes in Szczecin during COVID-19 is also confirmed by research [90], especially in the initial months of the pandemic. However, the situation in Szczecin in the later months of 2020 unfolded differently than in many American and European cities, such as Budapest [91] or Kosice [92], where there was an increase in the number of rentals to pre-pandemic levels. In Szczecin, the decline was continuous, and the main reason, as presumed by the authors, could be the COVID-19 pandemic. SRM was unavailable to users in April, which undoubtedly influenced rental statistics. Additionally, Bike_SSRM was being prepared for a change in operator and system formula to a dockless system, so there was no investment in new bikes or existing stations.

Verification of the demand for BSS in Szczecin based on submitted SBO projects confirms the community's interest in this non-motorized individual form of transportation. Each year, Szczecin residents systematically submit needs related to BSS in various elements of bike infrastructure and the bikes themselves. Despite the globally recognized initiative of participatory budgeting [93,94], there are few cases of using this form of societal co-decision to assess its interest in BSS.

6. Conclusions

The research methodology proposed by the authors, based on case studies, surveys, SRM and BO metadata, and the meta-plan method, allows for a more thorough assessment of the demand among Szczecin residents for the environmentally friendly means of transportation that is the bicycle.

The goal set forth in the article was achieved through the implementation of specific tasks using methods chosen by the authors.

The identification of the level of interest in the bicycle rental system in Poland was conducted based on literature analysis and data from the Central Statistical Office (GUS). This level, viewed through the prism of the number of bicycles and rentals as well as the length of bike paths, continues to increase steadily.

The survey results in Szczecin unequivocally demonstrated significant correlations between various socio-demographic groups and different aspects of cycling, such as safety, accessibility, frequency, and others. Bikesharing stands out as dominant compared to other ecological means of transportation. Information obtained from professionally active respondents indicates a need for using bikesharing systems with limited trust in safety. The issue of bikesharing system accessibility is still evolving, which may indicate the dynamic development of the area under investigation.

The quantitative analysis of bikesharing system (BSS) rentals revealed specific locations and periods of intense BSS usage. This provides valuable guidance for city authorities and public transportation organizers in building new models, especially concerning the distribution of bike paths, the placement of additional BSS stations, and the quantity of available bikes at each station.

The analysis of participatory budgets (BO) allowed for the assessment of social interest and approval for BSS development. The percentage of engaged residents ranges from 5% to 16% of the total population. This indicates that the public bike system serves as a reinforcing element of sustainable mobility in the city.

The applied meta-plan method allowed the authors to identify new aspects and supplement the previously mentioned uses of BSS in Szczecin, which are influenced by several important factors. These factors include:

- Still insufficiently developed linear and point infrastructure for bicycles.
- High burden on the city's linear infrastructure, and consequently, also on the bicycle infrastructure, due to urban development investments carried out simultaneously, which also affects the emergence of congestion and adversely impacts the safety of cyclists.

The research presented in the article allows us to conclude that the social demand for bikesharing in Szczecin is shaped by a complex interplay of factors, including urban infrastructure, efficiency, proximity to businesses and employment centers, and the COVID-19 pandemic. Understanding and addressing these factors is necessary and essential for effectively meeting the demand for bikesharing and promoting micromobility through the use of shared non-motorized transportation.

The research results have many implications for business practice. This relates to managing the city's transportation system, energy savings, and decarbonization policies, and also includes the creation of new business models that respond to the challenges of contemporary society and align with the principles of sustainable development.

The proposed methodology integrates science, represented by researchers, with urban data analysis. It can assist planners and officials in Szczecin and other cities in expanding or initiating exploration of areas for future BSS station locations. Through BO analysis and individual meta-plan development, it allows for the identification of tasks necessary for implementation.

The proposed methodology is not without flaws. It does not consider the participation of older people and those with disabilities in BSS. In the future, it would be necessary to examine this area and seek solutions beneficial to all urban subsystems (pedestrian, bicycle, individual, and public transportation), taking into account all stakeholders involved.

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Abbreviations

PMD	Personal Mobility Device
NCL	National League of Cities
DBS	Dockless Bicycles Stations
PB	Participatory Budget or Citizens' Budget
SBO	Participatory Budget in Szczecin (Szczeciński Budżet Obywatelski)
P&R	Park and Ride
pkm	passenger-kilometer
SUMP	Sustainable Urban Mobility Plans
SRM, Bike_S	Szczecin City Bike (Szczeciński Rower Miejski)
GUS	Statistics Poland (Główny Urząd Statystyczny)
ZDiTM	Road and Public Transport Authority in Szczecin
SDP	Sustainable Development Principles
NiOL	Nieruchomości i opłaty Lokalne
BSS	Bikesharing system

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