smart cities

MDPI

Article

The Problems of Scooter-Sharing in Smart Cities Based on the Example of the Silesian Region in Poland

Radosław Wolniak [1,*] and Katarzyna Turoń [2,*]

[1] Faculty of Organization and Management, Silesian University of Technology, 44-100 Gliwice, Poland
[2] Department of Road Transport, Faculty of Transport and Aviation Engineering, Silesian University of Technology, 40-019 Katowice, Poland
* Correspondence: radoslaw.wolniak@polsl.pl (R.W.); katarzyna.turon@polsl.pl (K.T.)

Highlights:

What are the main findings?

- The study identifies the lack of dedicated bike paths and poor conditions of existing paths as significant barriers to scooter-sharing adoption, especially in post-industrial regions like Silesia, where outdated transportation infrastructure adds to the challenge.
- Inadequate fleet maintenance, complex rental processes, and difficulties with app interfaces were found to contribute to user dissatisfaction and limit accessibility, particularly for users with varying levels of technological literacy or health concerns.

What is the implication of the main finding?

- The lack of dedicated bike paths and poor path conditions highlight the need for smart city initiatives to prioritize infrastructure development that supports sustainable micromobility. This could include the integration of intelligent transportation systems (ITS) and more adaptive urban planning to foster safer and more efficient scooter-sharing networks.
- The operational challenges with fleet maintenance, rental processes, and app interfaces imply that smart city strategies should focus on leveraging advanced technologies such as AI-driven fleet management, predictive maintenance, and user-friendly digital solutions to enhance service reliability, accessibility, and user satisfaction within urban mobility ecosystems.

Academic Editor: Pierluigi Siano

Received: 5 December 2024
Revised: 13 January 2025
Accepted: 15 January 2025
Published: 21 January 2025

Citation: Wolniak, R.; Turoń, K. The Problems of Scooter-Sharing in Smart Cities Based on the Example of the Silesian Region in Poland. *Smart Cities* **2025**, *8*, 16. https://doi.org/10.3390/smartcities8010016

Abstract: The rapid urbanization and pursuit of sustainability have elevated shared mobility as a cornerstone of smart cities. Among its modalities, scooter-sharing has gained popularity for its convenience and eco-friendliness, yet it faces significant adoption barriers. This study investigates the challenges to scooter-sharing systems within smart cities, focusing on the Silesian region of Poland as a case study. It aims to identify region-specific barriers and opportunities for scooter-sharing adoption in Central and Eastern Europe and to provide insights into its long-term development trends and potential challenges. Using comprehensive statistical methods, including factor analysis and regression models, this study identifies key barriers such as insufficient bike paths, poor path conditions, inadequate signage, fleet maintenance issues, and complex rental processes. External factors like adverse weather and heavy traffic, coupled with health and safety concerns, further hinder adoption, particularly among vulnerable populations. Additionally, the study explores future trends in scooter-sharing, emphasizing the role of advanced technologies, adaptive urban planning, and sustainable fleet management in ensuring long-term feasibility. Drawing on global case studies, it underscores the need for tailored infrastructural investments, advanced fleet management, and user-centric policies to align scooter-sharing systems with smart city goals of sustainability, accessibility, and improved mobility. These findings offer actionable insights for policymakers and service providers striving to integrate scooter-sharing into the evolving landscape of urban mobility.

Keywords: smart city; smart mobility; mobility management; micromobility; scooter-sharing

1. Introduction

The rapid pace of urbanization has reshaped cities worldwide, prompting new approaches to managing the challenges of population growth, transportation, and sustainability. In response, the concept of "smart cities" has emerged as a transformative framework aimed at optimizing urban resources through digital innovation, data-driven decision-making, and sustainable infrastructure. A smart city integrates technology across various domains—transportation, energy, healthcare, and environmental management—to create a safer, more efficient, and more sustainable urban environment. Key to this model is its focus on connectivity, adaptability, and enhanced quality of life for citizens through services that are responsive to their needs. Smart cities are defined by their capacity to gather real-time data, process them through advanced analytics, and implement solutions that address the complex needs of an urban population [1–3].

A core element of smart cities is the development of "shared mobility" services, which provide flexible, on-demand transportation options. Shared mobility encompasses a range of services, including car-sharing, bike-sharing, moped-sharing, and, increasingly, scooter-sharing, all of which allow people to access transportation without the financial and environmental burdens of vehicle ownership [4,5]. One key category within shared mobility is micromobility, which refers to lightweight, primarily electric or human-powered vehicles designed for short-distance travel in urban areas. This category includes bicycles (manual and electric), e-scooters, electric skateboards, and other emerging solutions such as cargo bikes. Micromobility addresses critical urban mobility challenges by providing last-mile connectivity, reducing traffic congestion, and supporting low-emission travel. These systems contribute to a broader transportation network, filling gaps in traditional public transit and making cities more navigable and accessible. Built on principles of resource efficiency, reduced congestion, and lower emissions, shared mobility services are valuable tools in the smart city ecosystem, aligning with the goal of creating user-centered urban spaces that support diverse lifestyles and reduce environmental impact [6,7].

One notable branch of shared mobility, scooter-sharing services, has seen rapid growth in recent years, especially in urban areas that prioritize low-emission, sustainable transit solutions. Scooters are compact, easy to use, and suitable for short trips, making them ideal for city landscapes. Existing studies on shared mobility have extensively examined systems like bike-sharing and car-sharing [8–24]. Almeida et al. [3] analyzed their role in promoting sustainability, while Shaheen and Cohen [4] provided a framework for understanding mobility as a service. However, research on scooter-sharing remains comparatively limited. Deveci et al. [8] addressed operational challenges such as parking, and Sobrino et al. [9] analyzed the regulatory aspects of e-scooter usage. Similarly, studies by Losapio et al. [22, 23] explored optimization strategies for e-scooter-sharing systems but focused primarily on technological solutions rather than user experiences. Furthermore, while Bozzi and Aguilera [10] discussed environmental and health impacts, their findings are primarily generalized across cities with established micromobility networks. Teixeira et al. [24] investigated barriers to bike and e-scooter shared usage but did not specifically address infrastructural and individual factors in regions like Poland. Motivated by the critical need to understand region-specific challenges in micromobility adoption, this study focuses on the Silesian region of Poland. The region's unique combination of post-industrial legacy, high population density, and growing interest in sustainable transportation provides fertile ground for exploring how scooter-sharing systems can be integrated effectively into smart city frameworks.

By focusing on less explored contexts, such as the Polish urban landscape, this paper adds depth to the existing body of research and highlights region-specific barriers and opportunities for scooter-sharing adoption.

However, scooter-sharing also introduces new logistical and operational challenges. These include infrastructure needs (such as safe and well-maintained pathways), effective parking solutions, and regulatory frameworks that support safe usage. Unlike other forms of shared mobility, scooters have specific operational requirements, such as designated lanes, proper maintenance, and safety features, that need to be addressed to ensure user convenience and safety [8–10]. Additionally, researchers like Saha et al. [15] have emphasized participatory planning as a critical factor for user engagement, while Kubik [25] demonstrated how artificial intelligence can optimize route planning in shared mobility. However, there is a lack of studies examining how these factors interact within specific regional contexts, particularly in Central and Eastern Europe. These insights inform the framework of this study, which examines how infrastructure and user-specific factors shape scooter-sharing adoption in urban environments.

According to market research presented in the Markets & Markets reports, the global electric scooter and motorcycle market was valued at USD 30.2 billion in 2021 and is projected to reach USD 104.6 billion by 2027, growing at a compound annual growth rate (CAGR) of 29.4% during the forecast period [11]. In Poland, the scooter-sharing market reflects this global expansion, showing significant growth over recent years. Data from Statista indicate that the number of shared e-scooters in Poland increased from approximately 5000 units in 2018 to over 30,000 units by the end of 2023, marking a sixfold increase [12]. This surge underscores the rising popularity and acceptance of scooter-sharing as a viable transportation option in urban Polish environments.

Focusing on the Silesian region, known in Polish as Śląsk, this area is a significant contributor to Poland's urban landscape. Silesia is located in the southern part of the country and covers an area of about 12,300 square kilometers [13]. It is one of the most densely populated regions in Poland, with a population of approximately 4.5 million people, resulting in a population density of around 366 inhabitants per square kilometer [13]. The region is highly urbanized and industrialized, featuring a network of cities such as Katowice, Gliwice, and Bytom, which form part of the Upper Silesian metropolitan area. Silesia's economy is among the strongest in Poland, with its Gross Domestic Product (GDP)—a measure of the total value of goods and services produced within the region—amounting to approximately PLN 282 billion in 2021. This accounts for around 12% of Poland's total GDP, making Silesia a pivotal economic hub. Historically reliant on coal mining, metallurgy, and heavy industry, the region is now transitioning toward innovation, technology, and sustainable development, aligning with EU decarbonization goals. The Silesian Metropolis, comprising 41 interconnected cities, experiences high levels of commuter traffic, further amplifying the demand for shared mobility solutions. As one of the largest urban agglomerations in Central and Eastern Europe, Silesia accounts for nearly 13% of Poland's industrial output, underscoring the importance of efficient, sustainable transportation in supporting its economic and social vitality. Shared mobility services, such as scooter-sharing, are emerging as critical tools for bridging gaps in last-mile connectivity and reducing congestion in this densely populated and economically vital region. Additionally, with 78% of its population residing in urban areas, the need for innovative transportation solutions in Silesia is particularly pronounced. The integration of scooter-sharing systems offers a dual opportunity to address infrastructural challenges while contributing to environmental and economic goals. By focusing on Silesia, this study not only sheds light on the unique barriers to scooter-sharing adoption in post-industrial urban contexts but also provides valuable insights for other regions undergoing similar transitions.

The dense urban fabric and significant industrial heritage of Silesia make it an ideal candidate for smart city initiatives, including the adoption of scooter-sharing services. The region has seen a notable uptake in scooter-sharing usage, aligning with its efforts to modernize transportation infrastructure and reduce environmental impact. Reports from the Mobile City Association "Micromobility Data Zone Q4 2023" indicate that Silesia has one of the highest concentrations of scooter-sharing services in Poland, with over 5000 scooters available for public use [14]. This availability provides residents with flexible transportation options that complement existing public transit systems. However, existing studies have largely overlooked the interplay between infrastructural barriers, user-specific factors, and regional planning policies, leaving a significant gap in the understanding of how these systems can be optimized for local contexts.

The research gap that this paper now intends to fill is related to the little-known understanding of what kind of barriers and problems users of smart cities face, particularly those who use scooters-sharing services in the Silesian region of Poland. With regard to shared mobility systems [15–20], there has been research on general user acceptance and operational frameworks; however, there has been limited attention paid to in-depth investigations of the unique infrastructural and operational challenges presented by scooter-sharing services in urban environments, especially in Central and Eastern Europe [21–27]. Most of the literature has tended to focus on bike-sharing schemes, often at the expense of the more nuanced dynamics of scooter-sharing that involves a different set of challenges and user experiences [28–35]. For instance, studies by Zimmermann and Palgan [34] on cargo bike-sharing and Xu and Zuo [35] on bike-sharing's impact on traffic congestion do not address scooter-sharing's unique challenges. By examining the Silesian region, this study highlights the specific barriers faced by users in Central and Eastern European cities, which differ significantly from Western urban contexts due to distinct socio-economic conditions and urban planning paradigms.

This gap is further pronounced in the context of Central and Eastern European cities, whose urban planning and transportation policies differ markedly from those in the West. Moreover, our study contributes to the existing body of knowledge by integrating individual-level factors, such as health status and physical activity, with infrastructural and operational considerations, which is a novel approach not commonly found in previous studies. Few have investigated the barriers reported by users and the interplay among individual factors, health status, and level of physical activity. Moreover, there is a need to explore how these factors collectively influence user adoption and satisfaction with scooter-sharing services in the context of smart city frameworks, particularly in regions with unique socio-economic and infrastructural conditions. This paper seeks to fill this gap by providing tailored insights and actionable recommendations based on the Silesian case study, thereby contributing new empirical data to the field of urban mobility and smart city development. While there is an increasing discourse on the contribution of micromobility to sustainable transportation within an urban context, the concrete implications for policy and urban planning are largely unexplored to date in light of user experiences. In particular, existing studies often overlook the role of user-reported obstacles, which are crucial for shaping effective urban policies and infrastructural investments. By focusing on user experiences and reported obstacles in the Silesian region, this study contributes to the body of knowledge by presenting empirical evidence on the barriers faced by scooter-sharing users, offering insights into how urban environments can better accommodate and promote such services. The work also contributes to the regional insight that enables localized strategies to enhance the effectiveness of scooter-sharing within smart cities by focusing on the Silesian region.

This paper addresses the following research questions:

- Q1—What are the main obstacles to scooter-sharing within smart cities, particularly in the Silesian region of Poland, from both the infrastructural and operational perspectives?
- Q2—In what way do infrastructural limitations—the availability, design, and condition of bike paths—determine the usage of scooter-sharing in the Silesian region?
- Q3—How does the relation of a person's individual factors, state of health, and physical activity influence the decision of a person to engage with the scooter-sharing service?
- Q4—How might the insights on user-reported obstacles within the urban context inform urban planning and policy decisions to best support and encourage scooter-sharing in smart cities?

The article is structured into six comprehensive sections to ensure a clear and systematic exploration of the topic. The Section 1 introduces the key concepts, research questions, and objectives of the study. The Section 2 delves into the theoretical background, focusing on scooter-sharing within the framework of smart cities and reviewing existing scientific studies in this domain. This provides a solid theoretical foundation for understanding the challenges and opportunities associated with scooter-sharing systems. The Section 3 outlines the methodological approach applied in this study, detailing the research design, data collection techniques, and analytical methods used to investigate the obstacles faced by scooter-sharing users in the Silesian region of Poland. The Section 4 presents the results of the study, highlighting the infrastructural, operational, and individual-level barriers identified through data analysis. These findings are thoroughly examined in the Section 5, which discusses the results in the context of existing research, providing a deeper understanding of their implications and relevance to the broader discourse on sustainable urban mobility. Finally, the Section 6 offers the conclusions, summarizing the key insights of the study while acknowledging its limitations and proposing directions for future research. This structure not only addresses the specific barriers to scooter-sharing but also provides a replicable framework for investigating micromobility challenges in other urban contexts. By structuring this article in this manner, this study provides a comprehensive exploration of the challenges of scooter-sharing within smart cities, contributing valuable empirical evidence and theoretical insights to the field.

2. Theoretical Background: Scooter-Sharing in the Context of Smart Cities

The rise of shared mobility systems has been a central theme in urban transportation research for over two decades. As cities strive to become smarter, more sustainable, and better connected, shared mobility has emerged as a key solution for addressing urban challenges such as congestion, environmental degradation, and inefficiencies in public transit. Scholars have extensively analyzed the impacts of car-sharing and bike-sharing, positioning them as foundational pillars of the shared mobility paradigm. These systems have been widely praised for their ability to reduce vehicle dependency, lower emissions, and enhance urban accessibility [36–38]. This broad body of research has consistently demonstrated the significant contribution of shared mobility to the broader goals of urban transformation, with a particular focus on sustainability and inclusivity.

Scooter-sharing, as a more recent addition to the shared mobility ecosystem, has gained significant research attention in recent years, particularly in the context of smart cities. Unlike car- and bike-sharing, scooter-sharing introduces unique operational, infrastructural, and user-experience challenges that warrant detailed exploration. Recent studies emphasize that scooter-sharing plays a pivotal role in bridging gaps in urban transportation networks, particularly by providing last-mile connectivity and enhancing accessibility to underserved areas. Scholars underline that scooter-sharing's rapid adoption has been facilitated by its suitability for short trips and its ability to complement existing public transit systems, yet its specific impacts and requirements remain underexplored compared to more established shared mobility modes.

Research on scooter-sharing systems within smart cities has focused on areas such as environmental impacts, operational efficiency, user behavior, infrastructure and urban planning, regulatory frameworks, and geographic specificity. These thematic areas are crucial for understanding the multifaceted nature of scooter-sharing and for tailoring these systems to the unique characteristics of different urban contexts.

Studies indicate that shared scooters have the potential to reduce greenhouse gas emissions by replacing short car trips, contributing to the environmental goals of smart cities [39]. However, the sustainability of these systems is often contingent on operational factors such as the durability of scooters and the use of renewable energy for charging [39–42]. Manufacturing processes, frequent battery replacements, and the relatively short lifespan of many scooters pose additional challenges [43,44]. Scholars argue that addressing these challenges requires systemic innovations in production and fleet management, emphasizing the need for policies promoting sustainable practices across the lifecycle of scooters. Experts emphasize that while scooters can reduce tailpipe emissions, the overall environmental impact depends significantly on extending their lifespan and optimizing production methods. To address these issues, researchers advocate for improving scooter durability, adopting circular economy practices like battery recycling, and integrating renewable energy into fleet management [45,46]. Such approaches are increasingly viewed as essential for aligning micromobility solutions with the broader sustainability goals of smart cities.

Efficient fleet management is crucial for ensuring the reliability and sustainability of scooter-sharing systems. Optimization models, such as dynamic rebalancing algorithms, allow operators to address spatial and temporal demand variations [44,45]. IoT technologies play a key role in monitoring scooter conditions and scheduling maintenance, while renewable energy sources are increasingly being used to power charging networks [46]. Recent advancements in predictive analytics and IoT-driven maintenance frameworks have demonstrated significant potential to reduce operational inefficiencies and enhance service quality. Studies indicate that predictive maintenance technologies and user-driven scooter redistribution incentives are emerging as critical strategies for enhancing operational efficiency and reducing costs. User incentives for redistributing scooters have also proven effective in improving fleet efficiency and reducing operational costs [47]. The integration of AI-based demand forecasting systems has further optimized fleet operations, particularly in urban areas with variable demand patterns.

User acceptance is another critical area of research. Younger populations tend to adopt scooter-sharing services more readily, often citing convenience and environmental benefits as key motivations [48]. However, concerns related to safety, such as helmet use, speed limitations, and interactions with other road users, remain significant barriers to broader adoption [49]. Researchers also highlight that the perceived lack of dedicated infrastructure exacerbates safety concerns, deterring potential users who prioritize security over convenience. Furthermore, demographic factors such as income level, gender, and educational background also influence adoption patterns, highlighting the need for inclusive policy interventions. Seasonal variations, affordability, and integration with other transport modes also influence user satisfaction and long-term engagement with scooter-sharing systems [50–53]. Findings from various studies suggest that seamless integration with multimodal transport systems significantly enhances user engagement, particularly in urban areas with well-established public transit. Innovative pricing strategies, such as dynamic pricing and subscription models, have also been identified as effective tools for increasing user retention.

The successful integration of scooter-sharing into urban environments requires adequate infrastructure. Dedicated lanes, parking zones, and clear signage significantly enhance user safety and satisfaction [54,55]. Cities with well-developed micromobility infrastructure report higher ridership, as users feel safer and encounter fewer conflicts with pedestrians and vehicles [56]. Scholars advocate for city planners to prioritize micromobility infrastructure investments to minimize friction between different types of road users. The role of public–private partnerships in financing and developing such infrastructure is increasingly recognized as a key enabler for widespread adoption. Advanced solutions, such as sensor-equipped smart infrastructure, are being explored to further enhance safety and operational efficiency [57].

Regulatory frameworks play a critical role in shaping the development of scooter-sharing systems. Inconsistent policies, such as varying speed limits and parking regulations, often hinder their adoption [57,58]. Research highlights the importance of harmonized regulations and transparent policies that balance innovation with public safety [59]. The literature suggests that regulatory harmonization, particularly in transitional regions, can significantly reduce operational challenges and foster trust between operators and users. Data-sharing agreements between operators and municipalities are also increasingly recognized as essential for effective planning and oversight [60,61]. Studies emphasize that clear and enforceable regulations, coupled with stakeholder engagement, are vital for achieving long-term sustainability and public acceptance of scooter-sharing systems.

Localized studies underscore the importance of geographic and cultural contexts in implementing scooter-sharing systems. For example, Copenhagen demonstrates how progressive urban policies and comprehensive micromobility infrastructure support the seamless integration of scooter-sharing into broader transportation networks [62,63]. Dedicated lanes and well-enforced parking regulations in the city have minimized conflicts and enhanced user experiences. By contrast, the rapid proliferation of scooters in Paris initially led to significant public backlash due to issues such as improper parking and pedestrian obstructions [64]. Regulatory interventions, including strict parking zones and operator caps, subsequently improved system reliability and public acceptance. These contrasting case studies illustrate how urban planning and governance must adapt to local contexts to optimize the benefits of scooter-sharing systems.

In Warsaw, challenges related to inadequate infrastructure and operational inefficiencies have hindered the growth of scooter-sharing systems. The lack of dedicated lanes and frequent conflicts with pedestrians have negatively impacted user perceptions [65]. These cases illustrate how differing urban dynamics necessitate tailored policy approaches to ensure the success and acceptance of scooter-sharing systems. Studies focusing on Warsaw underscore the importance of aligning micromobility initiatives with broader urban development goals, particularly in rapidly growing metropolitan areas.

While global trends in scooter-sharing provide valuable overall insights, they often fail to capture the specific nuances of implementation in connection to the local needs of transitional or post-industrial regions. Research suggests that these regions face compounded challenges, such as fragmented infrastructure, socio-economic disparities, and limited policy support, which require targeted interventions and context-specific solutions.

This study aims to address these issues by focusing on the Silesian region of Poland. By analyzing user obstacles and examining the interplay between infrastructural, operational, and cultural factors, this research contributes to a localized understanding of the barriers to scooter-sharing adoption.

Understanding how infrastructural limitations, operational inefficiencies, and user perceptions intersect in Silesia can provide valuable insights for both local policymakers and global smart city initiatives. Such insights are critical for adapting micromobility solutions to the unique needs of diverse urban landscapes, ensuring their long-term sustainability and effectiveness. By focusing on Silesia, this study bridges an important gap in the literature, offering evidence-based recommendations for enhancing scooter-sharing systems in transitional urban contexts.

3. Materials and Methods

3.1. Description of the Research

This study employed a structured survey methodology to capture detailed information on user perceptions, barriers, and specific factors that affect the utilization of scooter-sharing services. The method applied is consistent with its objectives for understanding the physical as well as operational challenges that users face within the urban environment in this region. In Figure 1, there is a summarization of the stages of this research. The questionnaire consisted of two parts dealing with the above-mentioned two aspects separately to assess scooter-sharing challenges. The first part referred to the identification of mobility obstacles that directly affected users in traveling with scooters. Among the variables were problems connected with the number of bike paths, the design of bike paths, the condition of bike paths, health and safety concerns, weather, and car traffic. The first part of the questionnaire consisted of 11 questions. The second part of the questionnaire consisted of 13 questions about Obstacles to Utilization. Among the variables examined in this part are the condition of scooter fleets, rental regulations, types of vehicles, rental costs, the registration process, the number of scooters, and battery capacity. These variables were developed in view of some preliminary observations and insight from existing research on urban mobility issues in smart city contexts. The questions were closed. We used a 5-point scale (1—very small impact; 5—very large impact). The research was carried out in the first part of 2024.

The initial set of questions underwent evaluation through the expert method (stage B2A). To determine whether a specific question should be incorporated into the survey for measuring scooter-sharing obstacles, feedback was gathered from professionals and academics specializing in smart mobility, with a particular focus on scooter-sharing. Given that these two expert groups possess varying competencies in different areas, it was essential to establish criteria for evaluating and selecting experts for participation in the survey based on their qualifications [66].

Following the main research, a pilot study was conducted in autumn 2023 with a sample of 30 people living in the Silesian region of Poland. The pilot study should resemble the full-scale survey in all aspects as far as possible. A primary purpose of the pilot study is to catch potential problems with the questionnaire. In this context, potential issues might involve checking whether participants understood the questions well and could easily give responses. This stage provided valuable feedback that pointed toward areas for improvement. In light of the information received during the pilot study, certain changes were made in the questionnaire regarding the rewording of questions for better understanding.

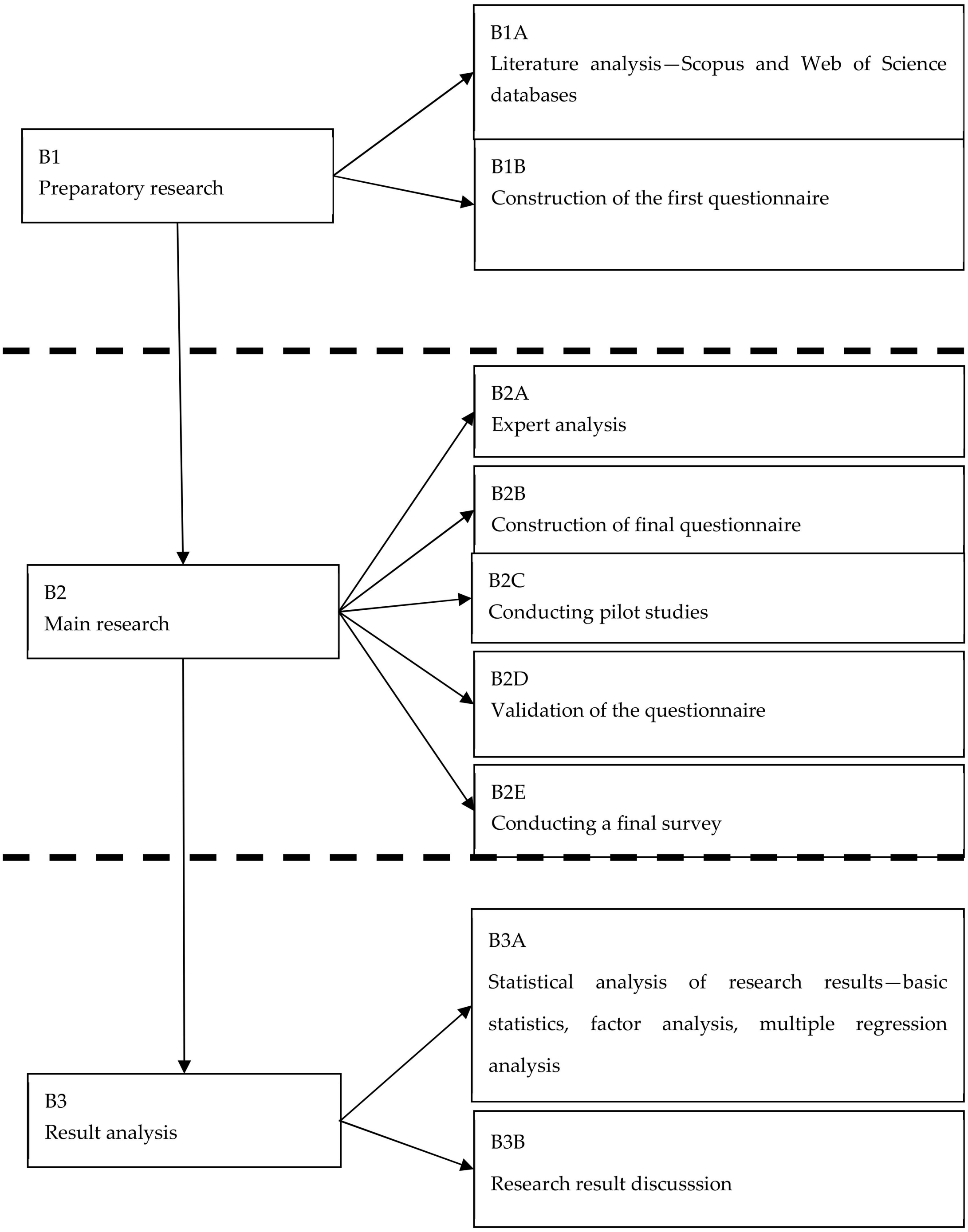

Figure 1. Stages of the research procedure.

The pilot study offered a chance to evaluate, generally, the flow and the structure of the questionnaire. In that respect, it considered the logical order of the questions and whether the length of the survey was appropriate for participants. The feedback helped identify redundancy among the questions and hinted at areas where additional questions would be necessary to capture critical aspects of utilization of scooter-sharing services.

For the purpose of this study, data were collected by a structured questionnaire disseminated via the Internet using the social network Facebook. This method was adopted because, with such a method, one may reach a very big and heterogeneous group of possible users of scooter-sharing services, in particular those familiar or potentially interested in using such services in urban areas of the Silesian region. The online survey targeted the experiences of users of scooter-sharing systems regarding barriers to mobility and obstacles to such service use.

Actual data analysis then followed, and the preparation of the raw dataset included cleaning of the data, which has always been a major aspect of making sure that the analyses performed thereafter would turn out to be accurate and reliable. Some of the main activities of data cleaning that were involved in handling the data during this period included the checking of missing values, identification of outliers, treatment, and checking on the consistency of responses.

A delete-case strategy for incomplete responses was thus adopted in case of missing responses. For example, the whole response was excluded if it was found that the respondent did not finish any substantial part of the survey—that is to say, having skipped most of the questions. This strategy was to prevent the distortion of findings based on incomplete information.

The dataset was subjected to statistical methods to identify outliers. Outliers are known to distort results, especially in methods such as regression analysis and factor analysis, where misleading conclusions about the trend of data may be drawn.

In the given study, the variables were several categorical variables, mainly dealing with the experiences of the users, either about the presence of bike paths or generally speaking about the state of the scooter fleet. This work needed to have numerical values for categorical variables. Preprocessing was carried out by controlling the categorization to maintain consistency. These were cleaned of inconsistencies, which included invalid entries and/or inconsistent response patterns, through recoding or the exclusion of problematic responses. Categorical data were sometimes recoded to dummy variables for certain statistical analyses, such as regression and factor analysis.

In this research, Cronbach's alpha (α) was applied as a reliability coefficient for the questionnaire. A Cronbach's alpha of 0.89 indicates that the items on this questionnaire are reasonably correlated to each other, and thus presumably measure the same underlying construct, which is the utilization of scooter-sharing services. In general, coefficients between 0.8 and 0.9 reflect good reliability, which indicates that items are homogeneous but heterogeneous enough to allow for fine-grained discrimination.

Therefore, a value of 0.89 suggests that the measuring instrument can consistently capture the various dimensions of the perceived obstacles to scooter-sharing. This high reliability also means that the data collected are likely to be stable and reproducible in similar settings or under repeated administrations. Therefore, stakeholders can have confidence in the conclusions drawn from this study, as the findings are based on a reliable and systematically structured measurement tool. Additionally, the reliability coefficient adds credibility to subsequent analyses such as factor analysis and regression modeling, since it indicates that the dataset is indeed representative of the users' experiences and perspectives.

To determine the sample size, the following formula was used:

$$N_{min} = \frac{N_p\left(\alpha^2 * f(1-f)\right)}{N_p * e^2 + \alpha^2 * f(1-f)} \quad (1)$$

where

N_{min}—minimum sample size;
N_P—population size from which the sample is drawn;
α—confidence level for the results, with the value of Z in the normal distribution for the assumed level of significance;
f—fraction size;
e—assumed maximum error.

In this study, the following values were adopted:

α—confidence level: 0.05;
NP—an unknown population;
f—0.5;
e—0.1.

The formula made it possible to estimate the minimum sample size necessary to ensure that the findings would be representative; meanwhile, the total population of users of scooter-sharing is unknown in the Silesian region. In utilizing the formula, the confidence level will be 95%. With such a choice of this value, the researcher attempts to ensure high representation and accuracy of their findings about the user's population. After calculation, the minimum sample was 96 questionnaires.

Our final sample size consists of 196 completed responses through online questionnaires distributed via social networking sites targeted at locals and those likely to use scooter-sharing services. This exceeds the minimum as computed with the formula (which was 96) and therefore increases the robustness of the research. In addition, through the response filtering criterion, it was ensured that only the responses by active users of scooter-sharing services were included in the results; therefore, relevant data focus on direct experiences in using these systems.

This part of the questionnaire was directed towards the operational framework of scooter-sharing systems, thus assessing barriers linked to scooter maintenance and functionality. In this regard, the variables went from general issues regarding fleet maintenance and disinfection practices of scooters to more specific ones on the usability of the rental process, including technical problems such as battery capacity, rental cost, and complexities within the application or registration system.

Data collection was carried out by a structured questionnaire addressed to users of scooter-sharing services in urban areas of the Silesian region. We conducted an online survey on Facebook platforms of various Silesian cities with the purpose of reaching an audience that is familiar and likely to use local scooter-sharing services. This distribution channel allowed us to gather 196 completed responses in an efficient manner. One question in the questionnaire concerned users' engagement in scooter-sharing services. For the next step, only the questionnaires of respondents who showed active use of scooter-sharing were selected. Through this filtering criterion, the collection of questionnaires focused on the relevant user experiences; hence, only valid questionnaires were used in the ensuing stages of data analysis.

The rating on a scale for each variable therefore provided quantitative data on the perceived importance of each obstacle. The data obtained were treated using several statistical analyses, which included central tendency, dispersion, skewness, and kurtosis. These set a base of data on user experiences and general sentiment regarding scooter-sharing infrastructure and system operations. It is from this analysis that the mean scores and identification of the primary obstacles of scooter-sharing in the region were identified [67]. We also applied factor analysis in an effort to identify and group the underlying dimensions affecting scooter-sharing challenges. After using a Varimax rotation with the Kaiser–Meyer–Olkin test and a test for matrix adequacy, two factors seemed to be important in accounting for variation in user experiences [68]. The first factor was infrastructural and safety concerns, with the variables of path availability and condition, plus associated safety concerns loading on to this factor. This second factor included personal barriers to use, including health conditions and impacts of the external environment, such as weather, which impede scooter use. These together captured more than half of the total variance, thus providing a robust model which can help in understanding the main challenges in scooter-sharing.

For this reason, multiple regression analysis might be performed to investigate in greater detail the influence of such obstacles on physical health, considering self-assessed health status and actual physical activity related to scooter use as health status indicators. Actually, this kind of analysis may help to outline how mobility and operational barriers are related to users' health outcomes, thus supporting the general objectives of promoting sustainable and health-oriented urban mobility solutions.

The survey about scooter-sharing obstacles was divided into two parts. The first part concerned the main obstacles to moving around using scooters from scooter-sharing systems—OM (Obstacles to Mobility). In this case, the following variables were taken into account:

1. OM1—Too few bike paths available for scooters;
2. OM2—Poor condition of bike paths for scooters;
3. OM3—Poorly designed bike paths for scooters;
4. OM4—Cars parked on bike paths;
5. OM5—Litter on bike paths;
6. OM6—Pedestrians on bike paths;
7. OM7—Poor signage on bike paths;
8. OM8—Safety concerns;
9. OM9—Health condition does not allow for scooter use;
10. OM10—Weather does not allow for scooter use;
11. OM11—Car traffic.

The second part concentrated on the main obstacles to using scooters from scooter-sharing systems from the perspective of the functioning of scooter-sharing systems—OU (Obstacles to Utilization). We differentiated the following variables:

12. OU1—Insufficient disinfection of the scooter fleet;
13. OU2—Poor visual condition of the scooter fleet;
14. OU3—Poor technical condition of the scooter fleet (damaged, incomplete);
15. OU4—Overly complicated rental regulations;
16. OU5—Excessive penalties for regulatory violations;
17. OU6—Too much responsibility placed on the user;
18. OU7—Inappropriate types of vehicles;
19. OU8—Rental costs;
20. OU9—Difficulties in using the application;
21. OU10—Insufficient information available in the application;
22. OU11—Complicated registration process in the system;
23. OU12—Too few scooters;
24. OU13—Insufficient battery capacity (scooter range).

As variables whose impact on the examined obstacles to using scooter-sharing was decided to be investigated, the following issues were defined:

25. V1—Assessment of health status;
26. V2—Evaluation of the level of physical activity.

3.2. The Description of Methods Used in the Data Analysis

To analyze the data, factor analysis was used with the Varimax rotation. Factor analysis is a statistical method used to identify underlying relationships between variables. It helps to reduce the dimensionality of data by grouping correlated variables into factors [68]. The goal is to explain the observed variance in the data with a smaller number of unobserved variables (factors).

Factor Model: The basic model for factor analysis can be expressed as

$$X = \Lambda F + \epsilon \tag{2}$$

where

- X is the vector of observed variables.
- Λ is the matrix of factor loadings.
- F is the vector of latent factors.
- ϵ is the vector of unique factors (error terms).

The covariance matrix of the observed variables can be expressed as

$$\Sigma = \Lambda \Phi \Lambda^T + \Psi \tag{3}$$

where

- Σ is the covariance matrix of the observed variables.
- Φ is the covariance matrix of the factors (often assumed to be the identity matrix if factors are orthogonal).
- Ψ is a diagonal matrix of unique variances (the variances of the error terms).

PCA, or principal component analysis (a part of factor analysis), is a statistical process that reduces the multidimensionality of data to lower dimensions with minimal loss of information. The objective of PCA is mainly to transform the original set of variables that are correlated into a new set of uncorrelated variables, called principal components. But now, the principal components are linear functions of the original variables taken in such a manner that the first principal component accounts for the largest variance and the second principal component is the second largest, and so on [69].

First, the data standardization process involves centering the variables by subtracting the mean and scaling them to have unit variance. This is an important step, especially when the original variables are measured on different scales. Then, PCA calculates the covariance matrix to determine how the variables relate to one another. Next comes the computation of eigenvalues and eigenvectors of this variance–covariance matrix. While eigenvalues give a ratio about the amount of variance apportioned by each principal component, eigenvectors are used to define directions that these components take in original variable space [69].

After the extraction of eigenvalues and eigenvectors, PCA arranges the principal components in order of the magnitude of their eigenvalues. This enables the researchers to identify which components explain the most variance. Only a few principal components usually remain for further analysis because they hold most of the variability. This dimensionality reduction assists in visualizing the data, reduces noise, and enhances the performance of machine learning algorithms because of the elimination of redundant features [68,69].

Variance explained is the total variance in the observed variables can be decomposed into variance explained by the factors and unique variance: $\mathrm{Var}(X) = \mathrm{Var}(\Lambda F) + \mathrm{Var}(\epsilon)$.

Varimax rotation is a statistical method applied to factor analysis with the intention of increasing the interpretability of the factors that are extracted from a dataset. The major intention of Varimax rotation is simplification of the factor structure in such a manner that the variance of the squared loadings of each factor across the observed variables is maximized. This process gives rise to a sharper distinction between the factors, making identification of which variables are most strongly associated with each factor easier.

This might also be the case when factors are extracted for the first time; their loadings could be spread across multiple variables, creating a complex and not-easy-to-interpret structure. The Varimax rotation solves this issue: it renews loadings in such a way that each variable will load highly on one or a few factors and minimally on others. Such an approach will develop a more straightforward and interpretable factor solution where the inter-relation among variables and factors would become crystal clear [68,69].

Mathematically, Varimax rotation seeks to maximize the following: the sum of the variances of the squared loadings for each factor. In so doing, it favors a solution in which some variables have high loadings on particular factors and low loadings on other variables, thereby aiding the interpretability of the underlying structure of the data. By doing so, it results in a set of orthogonal factors that are uncorrelated with one another. This may be very useful in several fields, including psychology, marketing, and social sciences, whereby knowing the distinct dimensions of a construct is critical [70–72].

The Varimax criterion can be mathematically expressed as

$$Maximize\sum_{j=1}^{k}\left(\sum_{i=1}^{p} a_{ij}^2\right)^2 \tag{4}$$

subject to the constraint that the factors remain orthogonal, which means

$$\sum_{i=1}^{p} a_{ij} * a_{ik}\, for\ j \neq k$$

where

- a_{ij} is the loading of variable i on factor j;
- p is the number of variables;
- k is the number of factors.

The Kaiser–Meyer–Olkin (KMO) test is a statistical measure used to assess the suitability of data for factor analysis. A higher KMO value indicates that the data are appropriate for factor analysis, while a lower value suggests that the data may not be suitable [68–72].

The KMO statistic is calculated using the following formula:

$$KMO = \frac{\sum_{i=1}^{p}\sum_{j=1,j\neq i}^{p} r_{ij}^2}{\sum_{i=1}^{p}\sum_{j=1,j\neq i}^{p} r_{ij}^2 + \sum_{i=1}^{p}\sum_{j=1,j\neq i}^{p} q_{ij}^2} \tag{5}$$

where

- r_{ij} represents the correlation coefficients between variables i and j.
- q_{ij} represents the partial correlation coefficients between variables i and j, which measure the correlation between two variables while controlling for the effects of other variables.

The KMO statistic ranges from 0 to 1, with interpretations as follows:

- A KMO value close to 1 (typically above 0.6) indicates that the data are suitable for factor analysis, suggesting that the variables share enough common variance.
- A KMO value below 0.5 suggests that the data may not be suitable for factor analysis, indicating that the variables do not share sufficient common variance.

In practice, the KMO test is usually conducted with Bartlett's test of sphericity, assessing the null hypothesis that the correlation matrix is an identity matrix, which implies that all variables are unrelated. A significant result for Bartlett's test combined with a high KMO value gives sufficient evidence that factor analysis will be suitable for the dataset.

In other words, the Kaiser–Meyer–Olkin test is one of the important diagnostic considerations in factor analysis that tests the sufficiency of the sample size and the strength of the intercorrelations among the variables. The computation of the KMO statistic will tell the researcher whether or not their data are appropriate to continue with, so that the results of factor analysis are meaningful and interpretable.

The scree plot by Cattell is a graphical tool in factor analysis and principal component analysis to determine how many factors or components one should be retained in a dataset. The plot displays the eigenvalues of factors in descending order, plotting value against its corresponding factor number. The graph usually contains a clear "elbow", where the eigenvalues' slope clearly flattens out, which marks the point beyond which additional factors contribute very little variance and become less meaningful. Factors that come before the elbow point are considered to be significant, since they explain most of the variance in the data, whereas factors after the elbow are often treated as noise. This visual approach makes it easier to decide on the dimensionality reduction and to avoid overfitting by selecting only the most influential factors. It will ensure that the variance retained by the components is effective in representing the structure of the data while minimizing redundancy [73].

The Mann–Whitney U test, also referred to as the Wilcoxon rank-sum test, is one of the most useful nonparametric statistical tests, which has been employed in comparing two independent groups when such data cannot fulfill normality assumptions, which is necessary for parametric tests. That determines if one group tends to have greater or lesser values than another by ranking all the observations and testing the sum of the ranks in each group. The test produces a U statistic that is then compared to a critical value or converted to a p-value in order to determine statistical significance. Unlike the t-test, the Mann–Whitney U test does not assume equal variances or a normal distribution and is, therefore, suitable for ordinal, skewed, or small-sample datasets. It is, therefore, very commonly applied in psychology, medicine, and social sciences, among other fields that evaluate the presence of differences in outcomes, preference, or behavior between two well-distinguishable populations [73].

Another method applied in the analysis of data is multiple regression analysis. Multiple regression analysis is a statistical method that is used to know the relationship between one dependent variable and two or more independent variables. This method helps the researcher to judge the effect of multiple predictors on a single outcome, and it is a very powerful tool for prediction and causal inference in many fields like social sciences, economics, and health research [72,73].

In multiple regression, the goal is to model the dependent variable Y as a linear combination of the independent variables $X_1, X_2, \ldots, X_k$. The general form of the multiple regression equation can be expressed as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k + \epsilon \quad (6)$$

where

- Y is the dependent variable (the outcome we are trying to predict).
- β_0 is the intercept of the regression line, representing the expected value of Y when all independent variables are equal to zero.
- $\beta_1, \beta_2, \ldots, \beta_k$ are the coefficients of the independent variables, indicating the change in the dependent variable Y for a one-unit change in the respective independent variable, holding all other variables constant.
- $X_1, X_2, \ldots, X_k$ are the independent variables (predictors).
- ϵ is the error term, representing the variation in Y that cannot be explained by the independent variables.

For multiple regression analysis to yield valid results, several key assumptions must be met:

1. Linearity: The relationship between the dependent and independent variables should be linear.

2. Independence: The residuals (errors) should be independent of each other.
3. Homoscedasticity: The residuals should have constant variance at all levels of the independent variables.
4. Normality: The residuals should be approximately normally distributed.

The coefficients $\beta_0, \beta_1, \ldots, \beta_k$ are estimated using the method of least squares, which minimizes the sum of the squared differences between the observed values and the values predicted by the model. The least squares criterion can be expressed as:

$$Minimize \sum_{i=1}^{n}\left(Y_i - \hat{Y}_i\right)^2 \quad (7)$$

where

- Y_i is the observed value of the dependent variable.
- $\hat{Y}_i$ is the predicted value of the dependent variable based on the regression model.
- n is the number of observations.

Multiple regression analysis is a comprehensive statistical method that enables researchers to explore the relationships between a dependent variable and multiple independent variables. By providing a framework for understanding how various factors contribute to an outcome, multiple regression serves as a valuable tool for data analysis, prediction, and decision-making across a wide range of disciplines; in our paper, the method was used to analyze relationships between scooter-sharing obstacles and the physical health of users [72,73].

4. Results

4.1. Classification of Main Obstacles to Moving Around Using Scooters from Scooter-Sharing Systems

To provide a foundational understanding of the barriers affecting scooter-sharing adoption, Table 1 presents a preliminary statistical analysis of key variables, encompassing measures of central tendency, dispersion, and distribution shape. These metrics offer valuable insights into user perceptions and experiences, forming the basis for deeper analysis of the identified obstacles.

Table 1. Basic statistics for obstacles to moving abound using scooters from scooter-sharing system.

Variable	Mean	Median	Minimum	Maximum	Standard Deviation	Skewness	Kurtosis
OM1—Too few bike paths available for scooters	3.10	3.00	1.00	5.00	1.46	−0.12	−1.34
OM2—Poor condition of bike paths for scooters	3.28	3.00	1.00	5.00	1.27	−0.28	−0.81
OM3—Poorly designed bike paths for scooters	3.24	3.00	1.00	5.00	1.28	−0.25	−0.92
OM4—Cars parked on bike paths	2.91	3.00	1.00	5.00	1.35	0.11	−1.08
OM5—Litter on bike paths	2.85	3.00	1.00	5.00	1.26	0.26	−0.83
OM6—Pedestrians on bike paths	3.65	4.00	1.00	5.00	1.34	−0.56	−0.96
OM7—Poor signage on bike paths	2.93	3.00	1.00	5.00	1.30	0.08	−0.94
OM8—Safety concerns	3.15	3.00	1.00	5.00	1.19	0.07	−0.80
OM9—Health condition does not allow for scooter use	2.32	2.00	1.00	5.00	1.34	0.64	−0.78
OM10—Weather does not allow for scooter use	3.25	3.00	1.00	5.00	1.38	−0.24	−1.15
OM11—Car traffic	3.07	3.00	1.00	5.00	1.33	−0.04	−0.99

Analysis shows that OM6 represents the highest average with 3.65; this, in fact, represents the greatest problem mentioned by the respondents because it reflects the general feeling that pedestrians are viewed as a danger to scooter users, who require separate lanes and delimitation in order to improve safety and efficiency within the usage of shared areas. Afterwards come, in order, OM2 (poor maintenance of bike paths) with 3.28 and insufficiently designed paths (OM3) with 3.24. The results above clearly show that the infrastructure is found to be very inadequate and badly maintained by users, hence being the causes that raise many problems for a safe and smooth ride. The disappearance of these two issues would radically raise user satisfaction and be important for higher diffusion of scooter-sharing systems.

Contrarily, OM8 reflects a rather low mean of 2.32, reflecting the least acute problem. This would mean that a greater proportion of users generally feel safe riding their scooters, although some minor safety concerns remain. The second is OM11, with an average of 3.10, which forms one of the major obstacles reflecting general apprehension about going through the urban traffic flow alongside big vehicles. On the other hand, OM10, scoring 3.07, shows that environmental factors, though moderate, may affect the pattern of use of scooters and require flexibility in operational strategies during inclement weather.

The results showed that infrastructural and environmental factors were strong in shaping users' experiences and decisions about scooter-sharing systems. The major complaints revolve around interference with pedestrians and the poor condition of paths, signaling the need for intervention in urban planning. Lower-rated issues of traffic and weather add to barriers that have to be overcome.

The medians in the survey data give a robust measure that describes the central tendency in respondents' perception of obstacles to scooter-sharing. For instance, a median of 3.00 for OM1, OM2, and OM3 indicates that at least half of the respondents have judged these obstacles to be at least moderately important. A consistent median indicates that users perceive the challenges posed by inadequate infrastructure. This consistency of the median score for these variables therefore reinforces the notion that these infrastructural issues are concerns that are universally felt and, as such, imply a dire need for the urban planners to address these deficiencies in order to encourage more scooter usage.

On the contrary, the median value of OM6 is 4.00, while that of OM8 is 2.00, which points to different magnitudes of perception regarding particular obstacles. The median of 4.00 for pedestrian presence suggests that many of the respondents see this as a serious problem; it is a signal to the latent dangers in using shared pathways and points to the interest in a clearer separation between pedestrians and scooter users. In contrast, the median value concerning safety issues is lower and reaches the value of 2.00, suggesting that, though related, safety is seen by most users as not being a main barrier. This discrepancy in medians is indicative of the complexity in user experiences associated with scooter-sharing systems in that, while infrastructure issues are paramount, personal perceptions on matters of safety could be relative or dependent upon individual experiences or local environments.

Standard deviation values from the survey data below provide valuable insight into the variability among the perceptions of the respondents related to obstacles in scooter-sharing systems. In this case, the rather high standard deviations of variables like OM1 and OM11, at 1.46, show a high degree of disagreement between the respondents as to the effects that these issues cause. Differences of this kind would mean that some persons treat such obstacles as very harmful; others do not think of them as grave, showing either a difference in experience or context for this user base. In contrast, the smaller standard deviations for OM8, at 1.34, and OM5, at 1.26, both indicate a higher degree of concordance among subjects on the perceived impact of those obstacles. Such variation in dispersion underlines the complexity that may exist in user experiences with scooter-sharing systems and highlights that overcoming these obstacles may need treatments that are addressed differently, as views might vary within the community.

Skewness in the survey data acts as an important indicator of how the respondents feel about these obstacles associated with scooter-sharing systems. Skewness is the measure of asymmetry in the distribution of ratings. For example, variables with a near-zero skewness, such as OM1, indicate that opinions among responders are rather symmetric around the mean value. This would be indicative of a certain consensus among those surveyed regarding the importance of this obstacle. A positive skewness, on the other hand, such as in the case of OM8, would mean that though most respondents rated safety concerns as low, a fair proportion, constituting an important minority, perceives these to be serious barriers. It is said to mean that though the majority feel fairly safe, a certain minority hold negative perceptions. Insight into such aspects is, therefore, important to the stakeholders that are interested in improving scooter-sharing systems, as the need for targeted strategy development based on concerns about vulnerability in such environments necessarily has to take into consideration active user perspectives in the planning and implementation of scooter infrastructures.

In this regard, kurtosis means the degree of "tailedness" that the distribution has regarding the respondents' perception of obstacles in view of scooter-sharing systems. This provides information about extreme values and the shape of the distribution as a whole. Thus, negative values of kurtosis, as with the variables OM2 and OM6, signify that the distribution of ratings is flatter, with fewer extreme ratings. This would imply that there is some general common viewpoint in the respondents and that few outlier opinions are far from the mean. It may indicate a situation where there is a consensus among the users about these obstacles, meaning that most have similar levels of concern about them. Conversely, if the kurtosis was positive, it would denote a more peaked distribution with more extreme values and, by extension, polarized views among the respondents. Understanding the kurtosis will, therefore, help stakeholders make out the homogeneity or heterogeneity in users' perception—quintessential for the effective handling of the challenges that come with scooter-sharing systems and enhancements reflecting broad experiences and concerns across the board.

Thus, applying factor analysis to the barriers in using scooters within a scooter-sharing system represents a higher-order statistical method to explore those latent dimensions governing user experience. Rotations such as normalized Varimax are useful in interpreting these factors because orthogonality is retained, with each factor more definitely identifying one area of influence.

Factor analysis has been carried out in order to reduce the factors' variability. Varimax rotation was performed via normalization. The Kaiser–Meyer–Olkin test result for the adequacy of the correlation matrix is 0.77, and it supports the factor analysis process in this case. The Kaiser criterion recommends retaining two factors with an eigenvalue value greater than 1. Cattell's scree plot criteria also point to retaining two factors—Figure 2 (infrastructure and safety concerns; personal usage barriers).

According to the factor analysis results, it can be noticed that the barriers to travelling using scooters from a scooter-sharing system group into two different factors. Each one of the above elements expresses another dimension of the obstacles of using scooter-sharing services and is depicted with the help of the factor loadings identified in Table 2 below. The Varimax rotation method is based on a normalized method that maximizes the variance explained by each single factor, but the factors remain orthogonal, i.e., uncorrelated.

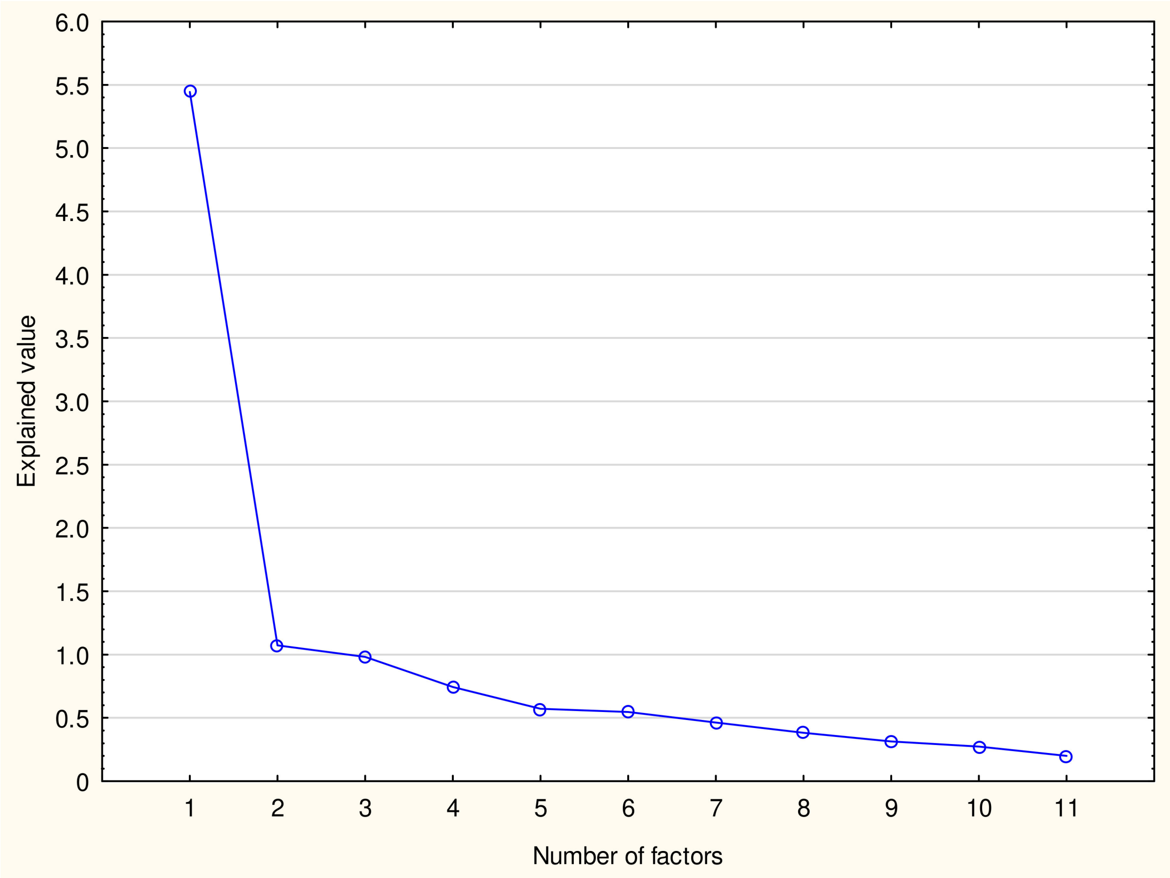

Figure 2. Cattell's scree plot for Obstacles to Mobility.

Table 2. The loadings of factors—Obstacles to Mobility.

Variables	Factor 1	Factor 2
OM1—Too few bike paths available for scooters	0.519	0.418
OM2—Poor condition of bike paths for scooters	0.557	0.562
OM3—Poorly designed bike paths for scooters	0.643	0.535
OM4—Cars parked on bike paths	0.743	0.301
OM5—Litter on bike paths	0.752	0.307
OM6—Pedestrians on bike paths	0.788	−0.065
OM7—Poor signage on bike paths	0.728	0.321
OM8—Safety concerns	0.680	0.051
OM9—Health condition does not allow for scooter use	0.132	0.797
OM10—Weather does not allow for scooter use	0.264	0.634
OM11—Car traffic	0.707	0.065
Explained value	4.312	2.206

The first factor is infrastructure and safety concerns, which is a summation of various variables outlining physical and environmental issues about the use of scooters (Figure 3). It would include such variables like the availability of bike paths (OM1), their condition (OM2), and their design (OM3). It also deals with the problem of parked cars blocking bike paths (OM4), trash (OM5), and pedestrian congestion (OM6)—all kinds of things which make them think that scooter-sharing unsafe and/or not usable. All this sums up to very bad signage, OM7, and a general low sense of safety, OM8. Another big influence concerning this aspect is car traffic (OM11), which again underlines the fact that scooter paths can be safe and accessible only where the traffic is well regulated, adequately separated, and supported by proper infrastructure to ensure the safety and convenience of scooter users.

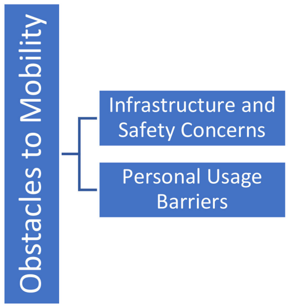

Figure 3. Identified factors of Obstacles to Mobility.

The second factor refers to the personal usage barriers, representing factors of the person that deter scooter usage. This captures the best factor of the health condition variable: it is indicative of quite a few potential users who are restricted because of bad health issues. The factor captures scooter use, influenced by weather conditions, in that such outside environmental elements restrict an individual in their ability to use a scooter. The inter-relationships among these various variables represent an extended focus on the issues experienced by scooter users and, therefore, a means through which it can be suggested that interventions targeted at infrastructural and personal barriers will tend to improve overall scooter utilization.

4.2. Classification of the Main Obstacles to Using Scooters from Scooter-Sharing Systems from the Perspective of the Functioning of Scooter-Sharing Systems

Table 3 is an overview of obstacles in using scooter-sharing systems faced by users, examined by various basic statistics. Obstacles refer to the following: the mean, median, minimum, maximum, Std. Dev., Skew, and kurtosis demonstrate the perception and experience of users.

Table 3. Basic statistics for obstacles to using scooters from scooter-sharing systems from the perspective of the functioning of scooter-sharing systems.

Variable	Mean	Median	Minimum	Maximum	Standard Deviation	Skewness	Kurtosis
OU1—Insufficient disinfection of the scooter fleet	2.40	2.00	1.00	5.00	1.34	0.55	−0.86
OU2—Poor visual condition of the scooter fleet	2.69	3.00	1.00	5.00	1.20	0.31	−0.69
OU3—Poor technical condition of the scooter fleet (damaged, incomplete)	2.90	3.00	1.00	5.00	1.22	0.11	−0.80
OU4—Overly complicated rental regulations	2.60	3.00	1.00	5.00	1.17	0.21	−0.66
OU5—Excessive penalties for regulatory violations	2.95	3.00	1.00	5.00	1.21	0.19	−0.79
OU6—Too much responsibility placed on the user	3.00	3.00	1.00	5.00	1.23	0.05	−0.89
OU7—Inappropriate types of vehicles	2.62	3.00	1.00	5.00	1.17	0.30	−0.64
OU8—Rental costs	3.25	3.00	1.00	5.00	1.31	−0.15	−1.06
OU9—Difficulties in using the application	2.39	2.00	1.00	5.00	1.13	0.36	−0.70
OU10—Insufficient information available in the application	2.44	2.00	1.00	5.00	1.08	0.41	−0.32
OU11—Complicated registration process in the system	2.37	2.00	1.00	5.00	1.19	0.43	−0.71
OU12—Too few scooters	2.61	3.00	1.00	5.00	1.16	0.34	−0.68
OU13—Insufficient battery capacity (scooter range)	2.66	3.00	1.00	5.00	1.27	0.32	−0.81

Taking OU1, which involves improper disinfection of the fleet of scooters, the average score infers a generally moderate level of concern on the part of users with regard to hygiene practices associated with the scooters. This indicates that large numbers of users may not view this as a major issue but, at the same time, a fair percentage express dissatisfaction—a potential area of concern with respect to improving health standards. OU2 has an average of 2.69, revealing that the deplorable visual condition of the fleet of scooters would reflect a little more concern among users. This score indicates that a lot of people view the scooters as not being aesthetically pleasing enough or properly maintained in a way that could affect their general user experience and potentially affect their willingness to use the service.

For OU3, the mean value is 2.90. This indicates that users are more and more concerned about the functionality and reliability of the scooters they rent. A mean value near three indicates that technical issues—like damage or incomplete components—might be a relevant barrier to user satisfaction and regular usage. For OU4, the mean score is 2.60. This evidences that users are frustrated to a moderate level. They show that some users are tolerant and can handle the regulation, but a good number perceive them as overly complicated, thus avoiding this service.

For OU5, the mean is 2.95. This suggests that users are somewhat sensitive to fines, indicating that financial consequences from their own failure to comply might be preventing users from using the service fully. The average of OU6 is 3.00; this reflects a balanced view among users. This score shows that some of the users accept this responsibility, while there is great concern about the burden it imposes on the user, which might affect the overall satisfaction with the service. OU7 has an average of 2.62, showing slight dissatisfaction with the range of vehicles. This would insinuate that users may have felt a shortfall in their needs being met, and this may not align well with their experience and frequency of use. The average score of 3.25 for OU8 signifies that users are more vocal about their concerns with pricing. This score means that expense is a determining variable in user preference and satisfaction; therefore, rental rates should be re-determined with the aim of improving user take-up and retention.

From a user experience perspective, OU9 and OU10 deal with issues relating to the challenges in making use of the application and insufficient information given to users, which have means of 2.39 and 2.44, respectively. These scores show that the application interface and the available information might be confusing for users and may hamper the effective usage of the service. The mean of OU11 was 2.37. This indicates that users felt that the problems in signing up were relatively consistent and again reinforces the idea of ease of simplification of the sign-up process as potentially increasing user engagement.

OU12, with an average of 2.61, expresses a moderate level of concern about the availability of scooters; this would tend to indicate that, for the users, the scooters are often unavailable, and this unavailability might provoke frustration and therefore limit, in general, the use of the service. The capacity of the battery is also felt to be insufficient, as was expressed in OU13, with a mean of 2.66. This reflects a high degree of concern on the part of users about the range and reliability of the scooters. Therefore, improving the performance of the batteries could go a long way in ensuring user satisfaction and user engagement with the scooter-sharing systems.

The median scores of the various barriers faced by the users of scooter-sharing systems provide important insight into the sentiment of users. Median values indicate the midpoint of the data and mean that at least half of the respondents have rated their experiences and concerns at this rating or below. As an example, the median value for the insufficient disinfection of the scooter fleet is 2.00; thus, users considered this as a high level of concern that may even affect their willingness to use the service. Likewise, the median for the visual condition of the scooters is 3.00 (OU2). This number illustrates that the fleet has generally been acceptable in terms of aesthetic appeal by its users but leaves something to be desired. This middle value brings about a division in user experiences where some may be more critical, and others find the conditions satisfactory.

Further, the median scores for various other variables exhibit interesting trends. For example, the median for technical condition is OU3 3.00, indicating that users have a mixed perception of scooter reliability, though a sufficiently large enough proportion finds it adequate. The median scores of rental costs and responsibilities placed on users are at or above 3.00; these are areas of greater concern, as many users expressed dissatisfaction. This is especially important because it shows that the cost-related and user responsibility issues are rated more negatively, which may affect the overall user experience with the use of scooter-sharing systems. Median values are a good indicator and show that improvements in these concerns are imperative for a better user experience and satisfaction.

The standard deviation values of the different barriers to scooter-sharing systems bear important information on the dispersion of user perceptions with respect to these issues. A low standard deviation reflects responses clustered around the mean, indicating a convergence of users' experiences. For example, OU1 has a standard deviation of 1.34 and reflects a relatively wide spread of opinion about insufficient disinfection, which means that though some users are seriously concerned, others may see this as no issue at all. In contrast, OU8 has a standard deviation of 1.31, indicating that perceptions of affordability vary quite strongly among users. This means that while some users find the costs to be reasonable, others can also be burdened by them, showing a likely division in user demographics or expectations. In summary, the calculation of standard deviation completes the mean and median in providing insights into the emotions of users about barriers through detailed information, not only about what users think but also how strongly they feel about these obstacles.

The values of the obstacles identified in scooter-sharing systems are useful for understanding the nature of the distribution of user perceptions with respect to these issues. A value close to zero means symmetric distribution of the variable analyzed, while positive or negative skewness shows asymmetry in the opinions of users. The skewness of OU8, for example, concerning the rental cost, is -0.15, reflecting a left-oriented skew, showing that most of the users will find the costs acceptable or lower than the average, and few people will rate the costs as too high. On the other side, OU1 is positively skewed at 0.55; this means there was a tendency for more users to rate their concerns higher in this regard, thereby being critical in reflections of hygiene standards. This asymmetry in the distribution might indicate that while there were some people who were quite insensitive about disinfection, for the majority, it would be a big issue that will impact general user engagement. Knowledge of the skewness of these variables helps us not only to identify the average concerns but also the overall sentiment and the direction, hence giving a detailed view of the user experiences within the scooter-sharing framework.

Values of kurtosis for the obstacles faced by users of scooter-sharing systems will give information on the heaviness of the tail and the peakedness of the distribution, reflecting the intensity of user sentiments regarding each issue. A kurtosis value of greater than three determines that the distribution has heavy tails with a sharper peak. It expresses that the responses of users are more concentrated towards the mean value, but with significant values of extremities on both sides. For example, OU8's kurtosis is equal to -1.06, denoting a pretty flat distribution with lighter tails; in other words, there are fewer extreme user perceptions of the costs, but their variety can denote a wider range of experiences with fewer strong opinions at the extremes. As for OU6, the kurtosis is -0.89, denoting a distribution without extreme responses. This flatter pattern of distribution would suggest that the sentiment across users is more moderate, with most submitting similar concerns rather than polarized opinions. Generally speaking, kurtosis analysis in combination with other measures of statistics reveals but does not confine central tendencies of user perceptions, including the variability and hidden intensity of these sentiments in the context of scooter-sharing systems.

Factor analysis was performed to group the factors into variables. Normalized Varimax rotation is applied further on. The Kaiser–Meyer–Olkin test result of the adequacy of the correlation matrix is 0.79 and justifies the application of factor analysis in the analyzed case. The Kaiser criterion suggests the retaining of four factors with eigenvalues greater than 1. Cattell's scree plot criterion suggests the retaining of four factors (Figure 4). The results of the factor analysis on obstacles to the use of scooters from scooter-sharing systems as perceived by the functioning of scooter-sharing systems fall into four different factors, which together explain 73% of the variance in the data. Each factor represents one single dimension of obstacles to scooter-sharing service utilization, as confirmed by the factor loadings in Table 4. Using normalized Varimax rotation, factors that provide maximum variance explained by each single factor have been extracted while maintaining orthogonality, which means that the factors would still be uncorrelated.

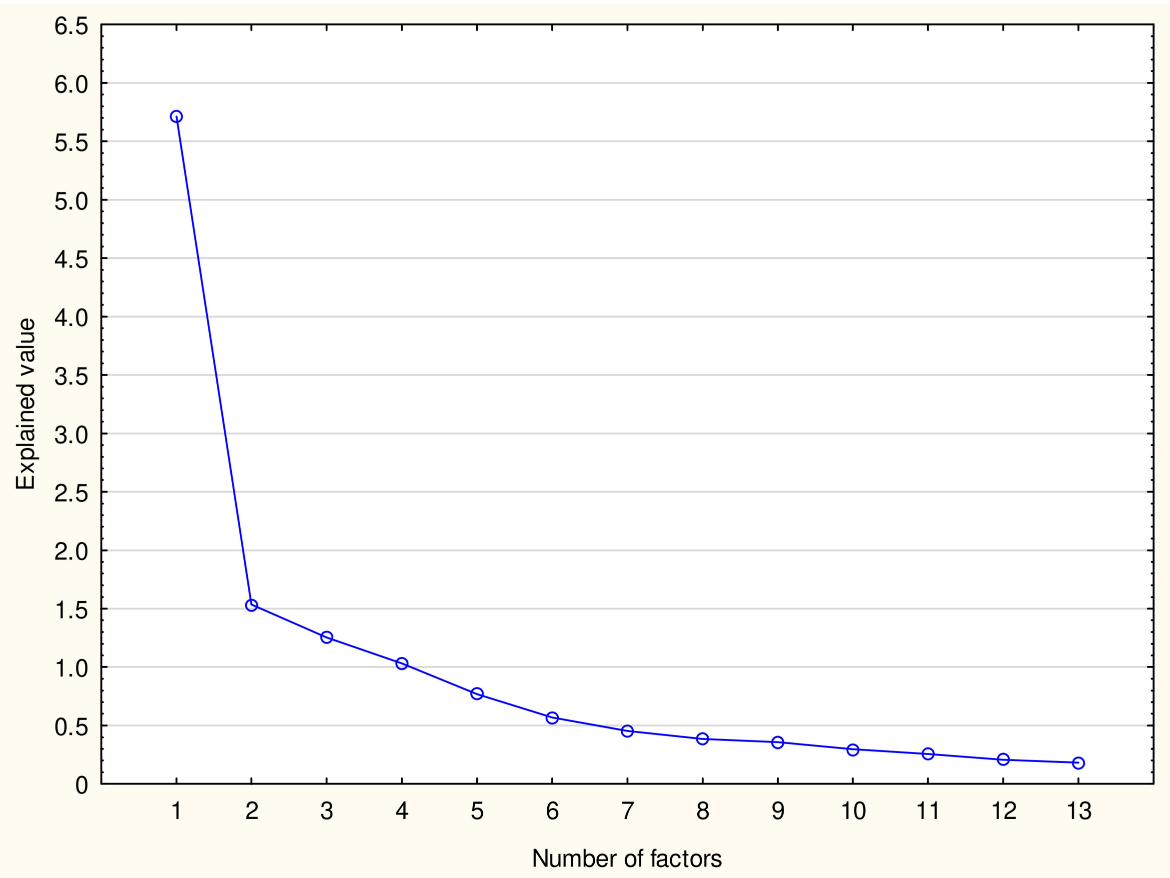

Figure 4. Cattel's scree plot of Obstacles to Utilization.

Factor 1: user experience and accessibility (Figure 5): The first factor obtained from the analysis pertains to user experience and accessibility, which plays a very vital role in determining the overall satisfaction of the users with respect to the scooter rental service (Figure 2). Highly loaded variables for difficulties in using the application (0.872), insufficient information available in the application (0.800), and a complicated registration process (0.867) indicate significant barriers that users have. Also in this factor is the variable connected with inappropriate types of vehicles (0.507). Challenges like these can lead to frustration and, therefore, may discourage people from using the service. To offer convenience, it is essential that the interface of the application be less complicated and user-friendly for a service provider. Another possibility of improving user experience involves explaining the process of renting in detail so that the users are not confused by that process (OU4). This will increase their confidence in using the scooters more often.

Table 4. The loadings of factors—Obstacles to Utilization.

Variables	Factor 1	Factor 2	Factor 3	Factor 4
OU1—Insufficient disinfection of the scooter fleet	0.111	0.776	0.082	0.105
OU2—Poor visual condition of the scooter fleet	0.193	0.862	0.130	0.072
OU3—Poor technical condition of the scooter fleet (damaged, incomplete)	0.139	0.806	0.194	0.158
OU4—Overly complicated rental regulations	0.688	0.214	0.397	0.182
OU5—Excessive penalties for regulatory violations	0.215	0.261	0.832	0.019
OU6—Too much responsibility placed on the user	0.240	0.195	0.808	0.134
OU7—Inappropriate types of vehicles	0.507	0.434	0.258	0.246
OU8—Rental costs	0.142	0.020	0.733	0.183
OU9—Difficulties in using the application	0.872	0.047	0.140	0.172
OU10—Insufficient information available in the application	0.800	0.281	0.219	0.089
OU11—Complicated registration process in the system	0.867	0.106	0.114	0.138
OU12—Too few scooters	0.280	0.092	0.068	0.819
OU13—Insufficient battery capacity (scooter range)	0.121	0.229	0.240	0.806
Explained value	0.111	0.776	0.082	0.105

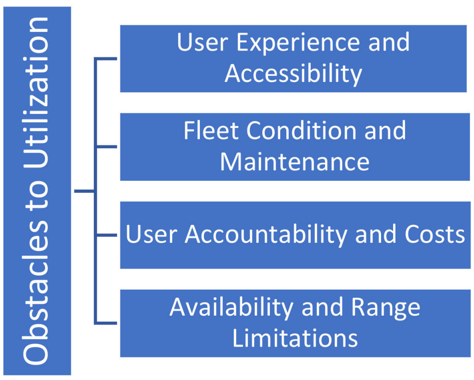

Figure 5. Identified factors of Obstacles to Utilization.

Factor 2: fleet condition and maintenance: The second factor denotes the condition and maintenance of the scooter fleet; therefore, it reflects how much operational reliability and hygiene are taken care of. Among such variables, the poor visual condition of the scooter fleet has obtained a relevance of 0.862, that of poor technical condition is 0.806, and that of insufficient disinfection is 0.776—all highlighting great concern. Unsightly and unsafe fleets will only serve to erode user trust, and if proper hygiene is not pursued, the danger to public health can be significantly heightened with the challenges of global health faced in recent years. Therefore, routine maintenance checks should be enacted by a service provider, and scooters should be cleaned and disinfected as frequently as possible. Prioritizing fleet condition and hygiene is, therefore, relevant to stimulating high levels of user trust and satisfaction among clients—a situation highly desired when trying to nurture a dependable customer base.

Factor 3: user accountability and costs: The third factor refers to a user's accountability and the costs for using the scooter rental service. High loadings on excessive penalties for regulatory violations (0.832), too much responsibility placed on the user (0.808), and concerns regarding rental costs (0.733) point out the feelings of overwhelm that users go through because of the financial and regulatory features of the service. Hence, such perceptions also make a dent in the form of apprehensions amongst users, and they may not like hiring scooters. The operator, for its part, needs to re-evaluate its fine systems to ensure that they are nondiscriminatory and well publicized. The user guidelines should also be simple to understand so that the responsibilities would also be well defined, and competitive pricing strategies may overall render the services more appealing. With reduced perceived burden, the provider is in a better position to facilitate a superior user experience, which in turn would encourage more utilization of the service.

Factor 4: availability and range limitations: The last factor identified in the analysis involves availability and range limitations, which again are core aspects for the practicality of scooter rentals. The presence of too few scooters (0.819) and the limited battery capacity (0.806) have been highlighted as issues that cause significant difficulties for users. A too-small number of scooters may readily cause availability problems during times of high demand. However, scooters with poor battery life make the distances that users can travel very small, thus limiting the attractiveness of the rental service. In this regard, the service provider needs to find ways of expanding the fleet and improving the batteries. Greater availability of scooters and better battery performance are the keys to significantly improved user satisfaction and a service that can be viable for a wider range of travel needs.

Table 5 presents the mean and standard deviation values for the identified factors in this study. The data provide insight into the average perceived importance of various obstacles related to scooter-sharing services, as well as the variability in users' responses.

Table 5. The average value of identified factors.

Factor	Mean	Standard Deviation
Infrastructure and safety concerns	2.12	1.59
Personal usage barriers	2.19	1.71
User experience and accessibility	1.68	1.40
Fleet condition and maintenance	1.84	1.51
User accountability and costs	2.09	1.67
Availability and range limitation	1.79	1.51

The mean for the factor "infrastructure and safety concerns" is 2.12, indicating that users consider this a moderate barrier in using the shared-scooter service. A high standard deviation of 1.59 would thus reflect that there is considerable variation in user perceptions about safety and infrastructure associated with the scooters, hence implying different opinions on the adequacy of infrastructure and safety measures. The second most important factor, "personal usage barriers", has an average score of 2.19, also indicating a similar level of concern. It has a large standard deviation of 1.71, which indicates that the degree in the responses of users was very divergent with regard to personal experiences or their perceptions of the challenges they themselves have to face in dealing with the service, understanding regulations, and in the responsibilities put on them.

The factor with the lowest mean score of 1.68 is "user experience and accessibility", showing that user interface and accessibility-related issues are considered less of a barrier compared to other factors by the users. For this factor, the standard deviation is 1.40, indicating a moderate variability in users' perceptions. Thus, the relatively low mean suggests that such concerns are there but less meaningful compared to either infrastructure or personal barriers of use. The factor "fleet condition and maintenance" is highly ranked at 1.84. This type of scooter condition criterion is of minor importance if taken in comparison with other ones for users. It follows that the dispersion in users' experience of fleet condition, with a standard deviation of 1.51, is highly disparate; this might reflect instances when fleet maintenance becomes especially problematic. The mean of "user accountability and costs" equals 2.09, reflecting that problems of penalties, responsibility, and rental costs are regarded as rather considerable barriers. On the other hand, it is contrasted by the fact that the standard deviation is 1.67 points, which would mean that there are quite wide variations in users' perception. However, there are respondents in the sample that rate this factor as a minor discouraging factor—meaning that others must have held a less strict or even positive view of the responsibilities and costs involved in using the scooters. The mean score given to the factor "availability and range limitations" was 1.79. it involves problems of scooter and battery availability, ranked low compared to other barriers. The standard deviation of 1.51 illustrates a moderate dispersal of opinions, assuming that as much as the availability and battery issues were great and serious for many respondents, there might be those for whom such concerns are not fundamental.

Table 6 presents the Spearman correlation coefficients between factors of obstacles to using scooter-sharing systems. Such a relation may indicate strength and direction whereby the factors may be close to one another.

Table 6. Spearman correlation between factors.

Factor	Infrastructure and Safety Concerns	Personal Usage Barriers	User Experience and Accessibility	Fleet Condition and Maintenance	User Accountability and Costs	Availability and Range Limitation
Infrastructure and safety concerns	-	0.85	0.76	0.83	0.79	0.75
Personal usage barriers	0.85	-	0.73	0.76	0.74	0.73
User experience and accessibility	0.76	0.73	-	0.81	0.84	0.83
Fleet condition and maintenance	0.83	0.76	0.81	-	0.79	0.78
User accountability and costs	0.79	0.74	0.84	0.79	-	0.80
Availability and range limitation	0.75	0.73	0.83	0.78	0.80	-

The "infrastructure and safety concerns" factor correlates with the other factors highly, ranging from 0.75 to 0.85. The concerns about infrastructure and safety will thus be strongly related to personal usage barriers, user experience, fleet condition, and user accountability. These findings also indicate that users who report issues in infrastructure and safety will also have associated challenges in other areas of the scooter-sharing experience. For example, problems with infrastructure may relate both to user concerns about the technical condition and hygiene of the fleet, as well as to regulatory aspects of the service. The "personal usage barriers" factor also correlates very highly with all other factors; these range between 0.73 and 0.85, suggesting that personal challenges faced by users tend to inter-relate with the perceptions of service infrastructure, accessibilities, the condition of the fleet, and accountability. A user having problems in accessing the service or fulfilling its requirements will probably find other issues such as technical problems of the fleet or dissatisfaction with pricing or penalties.

"User experience and accessibility" strongly correlates with all other factors, especially "user accountability and costs" at 0.84 and "availability and range limitation" at 0.83. These high correlations indicate the great importance of user interface, accessibility, and perceived user responsibility for the general impression of the scooter-sharing experience. Moreover, people who struggle with navigating this service easily might find themselves being even more inclined towards dissatisfaction for reasons such as cost, fine structures, and availability of devices. The factor of "fleet condition and maintenance" shows extremely positive associations; among them, the high ones are, especially, "user experience and accessibility" at 0.81 and "infrastructure and safety concerns" at 0.83. This would suggest that the users that are concerned about the condition and maintenance of the fleet also tend to have issues with accessibility or safety. A poorly maintained fleet not only affects the visual appeal of the scooters but may also affect the overall user experience.

"User accountability and costs" presents very high positive values when correlated with "user experience and accessibility" (0.84) and "availability and range limitation" (0.80). This would mean that the responsibility placed onto the users and cost-related concerns are directly related to questions of the applicability of an application and service availability in general. The factors will eventually affect the attitude of the users toward service involvement. "Availability and range limitation" strongly correlates with "user experience and accessibility" at 0.83 and "user accountability and costs" at 0.80. This means that the limited availability of scooters and their range affect users' experiences so much that they influence their view of service accessibility and costs related to using the scooters.

4.3. The Relations Between Obstacles to Scooter-Sharing and Metric Variables

Table 7 presents the results of the analyzed variables by gender of respondent. In this research, 82 women (52%) and 111 men (58%) participated. The Mann–Whitney U test was conducted to analyze differences between groups. This statistical test is especially fit for analyzing differences between independent groups when data are not necessarily normally distributed, and it has proven robust in this analysis. Table 5 records the p-values, bolding those variables for which there is a statistically significant difference at the $\alpha = 0.05$ level.

The analysis reveals notable gender- and age-related differences in perceptions of barriers to scooter-sharing, as detailed in Tables 7 and 8. Women expressed significantly greater concern regarding pedestrian interference on bike paths (OM6), with an average score of 4.05 compared to 3.34 for men ($p = 0.002$). This disparity suggests heightened safety and comfort concerns among female users, emphasizing the need for urban planning measures such as better pedestrian management and bike path design to enhance inclusivity. Similarly, women rated poor signage (OM7) higher than men, at 3.21 versus 2.71 ($p = 0.031$), indicating navigational challenges that could be addressed through clearer wayfinding features and urban signage improvements.

Table 7 also highlights that women's overall safety concerns (OM8) influence their attitudes toward scooter use more than men's, with a mean score of 3.42 compared to 2.94 ($p = 0.028$). This finding points to the necessity of implementing safety-focused measures such as enhanced lighting, increased surveillance, and awareness campaigns to mitigate apprehensions and foster greater female participation. Hygiene concerns (OU1) were also more pronounced among women, who rated inadequate fleet disinfection significantly higher at 2.74 compared to 2.11 for men ($p = 0.005$). This underscores the importance of hygiene protocols in building trust and attracting female users, particularly in light of heightened public health awareness post-COVID-19. Table 8 provides insights into age-based differences in perceived barriers. Younger users (18–24 years, 79% of the sample) reported distinct challenges compared to older groups (25–34 years, 12%; 36–55 years, 9%). These differences suggest that younger users may prioritize accessibility and affordability, while older users could be more influenced by safety and operational reliability. Such demographic variations highlight the need for tailored approaches to address the unique mobility requirements of different age groups. While some barriers, such as poor bike path conditions, weather constraints, and operational issues, were rated similarly across genders and age groups, the identified variations emphasize the importance of targeted interventions. Incorporating gender-sensitive and age-specific strategies into urban planning and scooter-sharing operations can create more inclusive and accessible mobility solutions. By addressing the barriers outlined in Tables 7 and 8, policymakers and service providers can improve user satisfaction and encourage broader adoption of scooter-sharing systems.

Table 7. The obstacles to using scooter-sharing in sex division.

Variables	Women (N = 83)	Men (N = 113)	*p*-Value
OM1—Too few bike paths available for scooters	3.34	2.94	0.096
OM2—Poor condition of bike paths for scooters	3.39	3.22	0.494
OM3—Poorly designed bike paths for scooters	3.48	3.06	0.063
OM4—Cars parked on bike paths	3.05	2.82	0.399
OM5—Litter on bike paths	2.95	2.79	0.452
OM6—Pedestrians on bike paths	4.05	3.34	0.002
OM7—Poor signage on bike paths	3.21	2.71	0.031
OM8—Safety concerns	3.42	2.94	0.028
OM9—Health condition does not allow for scooter use	2.33	2.32	0.994
OM10—Weather does not allow for scooter use	3.36	3.18	0.414
OM11—Car traffic	3.20	2.99	0.351
OU1—Insufficient disinfection of the scooter fleet	2.74	2.11	0.005
OU2—Poor visual condition of the scooter fleet	2.69	2.70	0.969
OU3—Poor technical condition of the scooter fleet (damaged, incomplete)	2.86	2.96	0.607
OU4—Overly complicated rental regulations	2.76	2.46	0.177
OU5—Excessive penalties for regulatory violations	3.10	2.84	0.197
OU6—Too much responsibility placed on the user	3.05	2.97	0.911
OU7—Inappropriate types of vehicles	2.73	2.52	0.296
OU8—Rental costs	3.27	3.26	0.980
OU9—Difficulties in using the application	2.51	2.29	0.289
OU10—Insufficient information available in the application	2.57	2.33	0.270
OU11—Complicated registration process in the system	2.44	2.30	0.582
OU12—Too few scooters	2.68	2.55	0.376
OU13—Insufficient battery capacity (scooter range)	2.86	2.49	0.114

Table 8. The obstacles to using scooter-sharing in age division.

Variables	18–24 Years (N = 154)	25–34 Years (N = 24)	36–55 Years (N = 18)
OM1—Too few bike paths available for scooters	3.17	2.87	2.70
OM2—Poor condition of bike paths for scooters	3.33	3.14	2.88
OM3—Poorly designed bike paths for scooters	3.29	3.14	2.71
OM4—Cars parked on bike paths	2.94	2.93	2.43
OM5—Litter on bike paths	2.88	2.71	2.71
OM6—Pedestrians on bike paths	3.72	3.29	3.29
OM7—Poor signage on bike paths	2.97	2.93	2.14
OM8—Safety concerns	3.18	3.00	3.00
OM9—Health condition does not allow for scooter use	2.34	2.57	1.43
OM10—Weather does not allow for scooter use	3.30	3.71	1.43
OM11—Car traffic	3.05	3.38	2.86
OU1—Insufficient disinfection of the scooter fleet	2.38	2.36	2.88
OU2—Poor visual condition of the scooter fleet	2.72	2.46	2.57
OU3—Poor technical condition of the scooter fleet (damaged, incomplete)	2.91	2.77	3.00
OU4—Overly complicated rental regulations	2.60	2.54	2.71
OU5—Excessive penalties for regulatory violations	2.96	2.92	2.86
OU6—Too much responsibility placed on the user	3.04	2.69	2.86
OU7—Inappropriate types of vehicles	2.61	2.62	2.71
OU8—Rental costs	3.28	3.00	3.29
OU9—Difficulties in using the application	2.35	2.58	2.86
OU10—Insufficient information available in the application	2.40	2.69	2.71
OU11—Complicated registration process in the system	2.34	2.54	2.57
OU12—Too few scooters	2.60	2.77	2.43
OU13—Insufficient battery capacity (scooter range)	2.67	2.77	2.29

Data indicate that the youngest age group, between 18 and 24 years old, perceived a number of significant barriers to shared scooter services. OM8, which relates to safety concerns, had a mean score of 3.18; though not the highest among all obstacles, it is notably high within this group. The big issue with safety is a concern for younger users, who may be more vulnerable to accidents, especially in urban environments where traffic and other hazards are rampant. This means there is a need for more safety measures, ranging from better infrastructure to better signage, and perhaps enhancements in scooter design for a safer experience. While safety is universal, the larger amount of attention paid to it by younger users demonstrates strong desires for secure and reliable mobility options. Weather conditions, OM10, were also among major obstacles for younger respondents. This was because its mean score stood at 3.30. Weather can greatly affect the usability of scooters, and the younger, perhaps more prolific, users of the service are also those most likely to encounter and be deterred by inclement weather. While this problem is underlined, it can also be a signal that the offering of the scooters needs to adapt to seasonal or even weather conditions, such as being better protected in bad weather or maintaining their operability during periods of poor weather. This may be much more relevant for younger users, who depend more on these options for urban mobility, with a view to increasing their satisfaction and regularity of use of scooter-sharing services. The mean score for car traffic (OM11) was also relatively high at 3.05, indicating that the obstacle is of major concern, especially for young users. Possible additional elements are irritation and dangers related to navigation when there is heavy car traffic. The fact that this barrier received such a high ranking underlines that an improved flow of traffic and more suitable routes would promote safe and secure scooter travel. In the meantime, against car traffic, there is a counter-argument based on creating either a scooter lane or trying not to jam the traffic, as most of the risks of riding a scooter within the intense traffic in cities are likely to decrease.

OU6 received the highest mean in this category of Obstacles to Utilization at 3.04. This would mean that operational demands to navigate the application, cope with the penalties, or manage the rent might be too much for younger ages. The complications in renting or responsibilities that come with it might deter potential users. Simplification of the user interface, reduction in penalties, and clear guidelines on usage might make the service more appealing to and more usable by this age group, raising overall satisfaction and engagement.

The mean scores given by the middle age cohort are 3.14 and 3.14 for OM2 and OM3, respectively. This reveals that they are fairly unhappy with the physical environment provided for scooter use. These scores are somewhat below the values for the youngest cohort; they still reflect major concerns about the provision of bike paths for safe and comfortable travel. Poor conditions of the paths' surface, uneven pavements, cracks, and a lack of lane markings can leave this group unable to use scooters continuously because of perceived safety risks and usability issues. For example, insufficient width, abrupt terminations, and unclear layout make navigation laborious; hence, this fact contributes to a low interest in scooter-sharing services. Another major barrier identified in this group is OM6, which had an average rating of 3.29. This concern underlines the problems of shared spaces in which there is conflict between pedestrians and scooter users. Pedestrians on bike paths may cause sudden stops, reduced traveling speed, and increased risk of collision—all factors influencing riders' feelings of insecurity. The issue also underlines the need for better segregation of the bicycle lane and pedestrian areas in order to enable smooth and safe movement of all users.

Safety concerns that further connected OM8 received a very high rating from this cohort, averaging 3.00, showing the perceived risks associated with the use of scooters. These risks may be associated with interactions with motorized traffic, poorly maintained paths, and conflicts with pedestrians, as identified earlier. This can include working professionals who use the service or people for whom it would serve the purpose of commuting day in and day out. For such users, there is little time and great need to be sure of reaching one's destination. Safety concerns, therefore, may assume more significance; safety features include improved lane demarcation, better lighting, and traffic calming in zones with mixed traffic. Financial barriers are also salient among this age bracket, as portrayed by the average score of 3.00 that OU8 expressed. Cost considerations can be very high for this age bracket since it is likely to represent people who must balance housing costs, transportation expenses, and various family-related obligations. High rents may be a perceived constraint, especially if the service is consumed frequently or along a daily journey-to-work trip. That said, this might have been improved by offering more competitive pricing models, subscription plans, or even discounts for frequent users.

In the oldest cohort, the three highest-rated obstacles to using scooter-sharing services (36–55 years) highlight key concerns related to OM6, OM8, and OU8. Such a finding may mean that older users are very sensitive to issues affecting safety, usability, and affordability and might be decisive in their acceptance of scooter-sharing services. OM6 had a mean score of 3.29. This is in contrast to the score in the youngest cohort, 18–24 years, whereby it attained the highest rank as an obstacle with a mean score of 3.72. A score of 3.29 with a ranking position lower in this age group still indicates that pedestrians on bike paths are one of the high-ranking barriers to scooter use among the older cohort. For the older age class, the incidence of pedestrians within bike paths challenges the safe and comfortable use of scooters—for instance, through the possibility of accidents or having to navigate around a usual route and hence disrupting their travel flow. For the older age class, a more cautious person, or one who can be considered as having a greater risk aversion factor, will show greater awareness of possible perils to themself from the environment. Another related concern could be the appearance of pedestrians within bike paths. What the older user values is clear, unobstructed paths for a safer and more predictable experience when using scooters.

The next most important barrier is OM8, with an average score of 3.00. This reflects a general concern about safety when using scooters: interaction with traffic, quality of infrastructure, and accidents. Older people may feel more vulnerable to injury and thus be more sensitive to issues related to safety. This individual barrier might thus be overcome not only through physical improvements in bike path design and traffic control but also through educational campaigns promoting safe riding behavior and increasing awareness for both scooter users and other road participants. The second most formidable barrier to the oldest age group is OU8, rated at 3.29, joining OM6 as the highest-rated barrier. This puts a financial emphasis on the decisions for or against the adoption of scooter-sharing services. The cost may be more difficult to justify in light of perceived risks and practical limitations, particularly for older users who actually would use their scooters in a more subsidiary or recreative manner and less for transportation. More flexible, more affordable pricing models, such as pay-as-you-go plans, senior discounts, or group pricing models, may be easier to swallow for this demographic. The results stress the necessity of earmarked strategies against the specific concerns of different age groups. Younger users appear to be influenced more by the direct quality of bike paths and require better infrastructure. Middle-aged users are more concerned about external disturbances such as traffic and weather; hence, added protection or information concerning safe usage in adverse conditions may benefit their scooter use more. The health considerations, good weather, and ease of use of the app and scooter functionality for the oldest group appear to indicate preferences for simplicity and reliability. An age-specific approach like this could contribute to more inclusive and adaptable scooter-sharing systems, offering better services to a variety of users in the urban landscape.

Table 9 shows obstacles to scooter-sharing usage according to the size of the population in the place of residence of the respondent. The above split shows that citizens from smaller towns (less than 50,000 residents)/medium-sized cities (up to 500,000 citizens) experience obstacles differently than citizens of large urban centers.

OM1 concerned respondents most in cities with more than 500,000 residents at an average of 3.80. This is significantly higher compared to those from smaller towns and cities, which means that demands for infrastructure where people use scooters are very high in large cities. This would suggest not only more scooter riders but also a more complete urban setting in which the competition for specific lanes and paths is highly acute. By comparison, infrastructure concerns are extant but not quite as clearly demarcated in towns of less than 50,000 inhabitants, presumably because of lower densities of traffic and fewer competitive users.

OM2 and OM3 also become important barriers but with nuanced variations across city sizes. Surprisingly, those most concerned about the poor condition and poor design of bike paths are residents of smaller towns—3.60 and 3.70, correspondingly—which would mean that while large cities might struggle with quantity, smaller towns face problems of quality and suitability in the existing paths. Mid-sized cities, which are those with 50,001 to 100,000 residents, also show a high level of concern for the infrastructure challenges; hence, there is generally a need for improvement in the quality of bike paths in less populated areas.

Table 9. The obstacles to using scooter-sharing in place of living (city size) division.

Variables	Under 50,000 Citizens (N = 41)	50,001–100,000 Citizens (N = 45)	100,001–500,000 Citizens (N = 105)	Above 500,000 Citizens (N = 5)
OM1—Too few bike paths available for scooters	3.26	3.23	3.09	3.80
OM2—Poor condition of bike paths for scooters	3.60	3.24	3.26	3.00
OM3—Poorly designed bike paths for scooters	3.70	3.38	3.15	3.50
OM4—Cars parked on bike paths	2.90	2.90	2.79	3.50
OM5—Litter on bike paths	2.85	3.19	2.68	3.25
OM6—Pedestrians on bike paths	3.85	4.05	3.53	4.00
OM7—Poor signage on bike paths	3.14	3.29	2.86	2.75
OM8—Safety concerns	3.05	3.67	3.17	3.25
OM9—Health condition does not allow for scooter use	2.55	2.24	2.32	2.75
OM10—Weather does not allow for scooter use	3.20	3.14	3.33	3.50
OM11—Car traffic	3.10	3.60	3.03	3.25
OU1—Insufficient disinfection of the scooter fleet	2.45	2.64	2.34	2.60
OU2—Poor visual condition of the scooter fleet	2.55	2.81	2.70	2.75
OU3—Poor technical condition of the scooter fleet (damaged, incomplete)	3.10	2.95	2.92	2.75
OU4—Overly complicated rental regulations	2.65	2.67	2.52	2.50
OU5—Excessive penalties for regulatory violations	3.10	3.00	3.00	2.25
OU6—Too much responsibility placed on the user	2.95	3.19	3.00	2.75
OU7—Inappropriate types of vehicles	2.75	2.81	2.51	2.50
OU8—Rental costs	3.35	3.33	3.22	3.00
OU9—Difficulties in using the application	2.65	2.71	2.24	2.00
OU10—Insufficient information available in the application	2.65	2.48	2.48	2.25
OU11—Complicated registration process in the system	2.70	2.71	2.14	2.00
OU12—Too few scooters	2.50	2.48	2.63	2.00
OU13—Insufficient battery capacity (scooter range)	2.30	2.81	2.65	3.00

Among the issues that are faced most by almost all city sizes is OM6. Residents of mid-sized cities, with 50,001 to 100,000 citizens, rate this obstacle the highest at 4.05, meaning that in such urban cities, congestion on paths shared with pedestrians is a very critical issue. These results suggest that in cities where infrastructure expansion may lag, the conflict between pedestrians and users of scooters is high, calling for better-separated pathways or more awareness efforts in alleviating crowding.

Looking at some of the operational obstacles, some may be discerned. Smaller cities give an average of 3.10 in the case of OU3 compared to the larger cities, whose respondents claim preoccupation with the technical condition of scooters at 2.75. This may point to a difference in service quality or maintenance standards outside the major urban centers. OU8 was another concern named across the board for all city sizes, with larger cities showing somewhat less concern at a mean of 3.00 compared to smaller cities at 3.35. This may be indicative of the high cost of living in large cities where scooter rental can be considered an option with relatively moderate expenses compared to other options.

Again, it is clear from the mean value of 2.00 for OU9 and OU11 that the technology-related barriers reported for larger cities are considerably lower compared to smaller towns, probably indicating that residents in major urban centers are more accustomed to digital interactions or that the functionality of apps is optimized for these regions. Smaller-town residents are more concerned with these technological aspects, which could indicate that in these areas, increased support, education, or simplification of apps would result in an improved user experience and higher adoption rates.

OM9, for example, is rated with a mean of 2.75 for residents of the largest cities, while OM10-related constraints are rated with a mean of 3.50. This might reflect both challenges due to urban air quality and more pronounced seasonal variations in larger cities. Consequently, in major cities, external factors can have a greater impact on the desire to use scooter-sharing—which then may be less appealing in adverse weather.

Furthermore, the analysis shows that city size is one of the main factors influencing the profile of perceived barriers to scooter-sharing. Large cities are truly in greater need of more bike paths, while smaller cities seem to be more concerned about the maintenance and design of such paths. Application usability and other more technological and operation-related challenges, such as the maintenance of scooters, also seem to be more problematic in small towns. This may provide further hints that tailored scooter-sharing service strategies—considering the size of a city—may bring better user satisfaction and more effectively deal with most locally relevant barriers, supporting its wider adoption in diverse urban contexts.

4.4. The Multidimensional Model of Relationships Between Scooter-Sharing Obstacles and the Physical Health of Users

In the next step of the analysis, a multiple regression analysis was performed on the variables at hand. Of course, the models should include variables that are highly correlated with the dependent variable while maintaining low or negligible correlation among the independent variables themselves. To attain these regression models, the backward stepwise multiple regression method was applied. These models allow investigation of the dependence of one dependent variable on several independent variables (explanatory). In multiple regression analysis, a prediction of the dependent variable is possible by making use of information provided by the independent variables.

The following table outlines those variables that achieved a significance level of $\alpha = 0.01$, while those cells that are blank were not part of the model. Also included in Table 10 is the constant or intercept of the regression equation along with the R value, which is indicative of the excellence of fit of the model to the empirical data. It also includes R^2, adjusted R^2, and the standard error of estimation concerning the variable at issue. Table 8 shows the output of multiple regression analysis regarding the relation of barriers to scooter-sharing—named as OM1-OM11 and OU1-OU13—to the physical health of users, named as V1-V2.

Table 10. The multidimensional model of relationships between scooter-sharing obstacles and physical health of users.

Obstacles	Variables	
	V1—Assessment of Health Status	V2—Evaluation of the Level of Physical Activity
OM1—Too few bike paths available for scooters		
OM2—Poor condition of bike paths for scooters		
OM3—Poorly designed bike paths for scooters		
OM4—Cars parked on bike paths	0.326	
OM5—Litter on bike paths	−0.229	
OM6—Pedestrians on bike paths		
OM7—Poor signage on bike paths		
OM8—Safety concerns		
OM9—Health condition does not allow for scooter use	0.185	
OM10—Weather does not allow for scooter use		
OM11—Car traffic		
OU1—Insufficient disinfection of the scooter fleet		
OU2—Poor visual condition of the scooter fleet		
OU3—Poor technical condition of the scooter fleet (damaged, incomplete)		
OU4—Overly complicated rental regulations		
OU5—Excessive penalties for regulatory violations		
OU6—Too much responsibility placed on the user		0.295
OU7—Inappropriate types of vehicles	−0.27	
OU8—Rental costs		−0.229
OU9—Difficulties in using the application		
OU10—Insufficient information available in the application		
OU11—Complicated registration process in the system		
OU12—Too few scooters		
OU13—Insufficient battery capacity (scooter range)		−0.193
Intercept	4.63	4.862
R	0.429	0.385
R^2	0.184	0.148
Adjusted R^2	0.156	0.061
Standard error of estimation	0.9439	0.858

The multiple regression analysis reveals key barriers to scooter-sharing adoption and their impact on users' physical health, offering potential intervention points to improve both systems and public health. By examining relationships between obstacles (OM1–OM11 and OU1–OU13) and health indicators (V1—health status assessment; V2—physical activity evaluation), this study highlights critical factors affecting scooter usage in urban contexts, particularly for active transportation and sustainable mobility.

The results, summarized in Table 10, identify significant associations between barriers and physical health outcomes. OM4 (cars parked on bike paths) shows a positive correlation (0.326) with health status (V1), suggesting that obstructed bike paths diminish accessibility, discouraging scooter use and reducing physical activity. Similarly, OM5 (litter on bike paths) negatively correlates with health status (−0.229), indicating that poor environmental conditions deter users. OM9 (health conditions preventing scooter use), with a correlation of 0.185, highlights how pre-existing health issues reduce scooter adoption, exacerbating disparities in access to active transportation.

Operational challenges also contribute significantly. OU6 (excessive responsibility on users) shows a positive correlation (0.295) with physical activity (V2), indicating that operational burdens discourage engagement with scooter-sharing systems. OU7 (inadequate vehicle types) negatively correlates (−0.27) with physical activity, reflecting the importance of vehicle suitability in promoting usage. Economic barriers, such as OU8 (rental costs), demonstrate a negative correlation (−0.229) with physical activity, emphasizing affordability as a determinant of user engagement. Similarly, OU13 (low battery capacity) correlates negatively (−0.193) with physical activity, illustrating how technical limitations constrain user satisfaction and willingness to engage.

The regression model reveals moderate relationships, with R-values of 0.429 and 0.385, and explains 18.4% and 14.8% of the variance in V1 and V2, respectively. Adjusted R^2 values (0.156 and 0.061) further support the model's fit while accounting for predictors.

These findings underline the importance of addressing infrastructure and operational barriers to enhance scooter-sharing systems. Interventions targeting path obstructions, vehicle suitability, and economic accessibility could simultaneously improve physical health outcomes and promote sustainable urban mobility. Future research should focus on longitudinal studies to evaluate the long-term efficacy of proposed solutions and expand the understanding of these dynamics in diverse urban contexts.

5. Discussion

This study investigates the critical barriers to integrating scooter-sharing systems into smart cities, focusing on the Silesian region of Poland. Through statistical analysis, key obstacles were identified in infrastructure, operations, and external factors, providing insights for urban planners, policymakers, and service providers.

5.1. Infrastructural Barriers

The lack of dedicated bike paths (OM1) and poor conditions of existing paths (OM2, OM3) significantly deter micromobility adoption, consistent with Behrend et al. [74]. Post-industrial regions like Silesia face unique challenges due to outdated transportation systems, unlike cities such as Amsterdam and Copenhagen, where advanced cycling infrastructure fosters high adoption rates [63,75–78]. Addressing these issues requires targeted investments, predictive maintenance, and collaboration between public and private stakeholders [75–78]. Additionally, obstructions like parked cars (OM4) and pedestrian interference (OM6) further impede usability, highlighting the need for Intelligent Transportation Systems (ITSs) and dedicated lanes [79].

5.2. Operational Challenges

Inadequate fleet maintenance (OU1, OU2, OU3) and hygiene concerns exacerbate user dissatisfaction, particularly during health crises like COVID-19 [80,81]. Predictive maintenance technologies and stringent hygiene protocols, supported by public–private partnerships, can address these issues [82]. Complex rental processes (OU4) and application interfaces (OU9, OU10) further deter users, especially in regions with varying levels of technological literacy. Simplified interfaces, biometric authentication, and multilingual support can improve accessibility and broaden the user base [82,83].

Limited scooter availability (OU12) and battery inefficiency (OU13) also hinder service reliability. IoT-enabled sensors and AI-driven fleet management can optimize operations, while advancements in battery technology and renewable energy integration can support sustainability goals [84–89].

5.3. External and Individual Factors

Adverse weather (OM10) and traffic conditions (OM11) deter usage, particularly in regions like Silesia. Dynamic pricing models and weather-adaptive route suggestions can mitigate these challenges, supported by collaborations with meteorological agencies [83]. Health-related barriers (OM9) underline the need for adaptive designs catering to users with limited mobility, as well as public health campaigns to promote micromobility's benefits [83].

Safety concerns (OM8), especially among vulnerable populations, necessitate measures like helmet mandates, speed limits, and dedicated pathways, similar to successful implementations in cities like Paris and Melbourne [90–92]. Public awareness campaigns [87] and training programs can further improve safety and user confidence.

5.4. Comparative Insights

Comparisons with other European cities reveal best practices and opportunities for improvement. In Copenhagen and Amsterdam, extensive bike lanes and clear signage drive adoption [63] while Paris demonstrates the importance of strict regulations and incentives [64,90]. Berlin's legal frameworks ensure operational consistency, and Helsinki and Stockholm's dynamic pricing models and public transport integration improve access [93–100].

Silesia's sustainability objectives align with those in Oslo and Copenhagen [95], where renewable energy systems and durable fleet designs address environmental challenges [100–103].

To overcome the barriers identified, Silesia must adopt a context-sensitive, phased approach, integrating infrastructural investments, operational innovations, and adaptive policies. Collaborative efforts with stakeholders, pilot programs, and continuous monitoring will ensure sustainable and scalable improvements. Drawing from global best practices, tailored solutions in Silesia can position scooter-sharing as a reliable, inclusive, and sustainable urban mobility option, advancing smart city objectives and user satisfaction.

6. Conclusions

This study identifies key barriers to scooter-sharing adoption in the Silesian region, focusing on infrastructural and operational challenges. By analyzing user-reported obstacles, the research highlights the significant impact of inadequate bike path availability (OM1), poor design (OM2, OM3), and operational issues such as insufficient fleet maintenance (OU1, OU2) and complex rental processes (OU4). The findings underscore the need for tailored urban planning strategies, infrastructure investments, and operational enhancements to improve safety and usability. These barriers are further exacerbated by external factors like adverse weather (OM10) and traffic conditions (OM11), as well as individual health and activity levels (OM9), which influence user engagement.

To address the challenges identified in this study, several recommendations are proposed from various analytical standpoints. From an infrastructural advancement standpoint, it is essential to expand and maintain dedicated bike paths (OM1), improve their design (OM2, OM3), and implement proper signage systems (OM7) to enhance safety and usability. These measures directly address user concerns about accessibility and risk mitigation. Moreover, investments in predictive maintenance and IoT-enabled monitoring technologies can ensure the long-term functionality and reliability of the infrastructure.

From an operational optimization perspective, service providers must prioritize fleet reliability through AI-driven predictive maintenance systems (OU1, OU2) to reduce service disruptions and increase user trust. Simplifying rental processes (OU4) and incorporating multilingual interfaces can enhance accessibility across diverse demographic groups. The integration of renewable energy-based charging solutions further aligns operational practices with broader sustainability objectives and environmental goals.

From a user-centric engagement framework, strategies that address safety concerns (OM8) are paramount. Public awareness campaigns focusing on safe riding practices and helmet use can bolster user confidence and adoption. Adaptive pricing models and flexible policies tailored to adverse weather conditions (OM10) or high-traffic scenarios (OM11) can further incentivize participation, fostering satisfaction and loyalty among users.

From a policy and collaborative dynamics perspective, the successful implementation of these recommendations hinges on robust partnerships among local authorities, technology developers, and urban planners. Such collaborations can facilitate funding for pilot programs and promote the deployment of innovative, context-specific technologies. Public–private partnerships are particularly essential for fostering scalable and sustainable solutions, ensuring the effective integration of micromobility systems within urban mobility ecosystems and advancing the broader objectives of smart city development.

As a preliminary study, this research is limited by the sample size of 196 respondents, which may not fully represent the diverse demographics of the Silesian region. Furthermore, the focus on a single post-industrial area restricts the generalizability of the findings to other urban contexts. Future research should consider a larger, more diverse sample and extend to other regions to validate and expand upon these findings.

Future studies should explore the longitudinal effects of infrastructure and policy changes on user behavior. Comparative analyses with other Central and Eastern European cities could reveal shared challenges and best practices, enriching the discourse on micromobility in diverse urban contexts. Additionally, integrating user-centered urban planning strategies with insights into operational efficiency could provide a holistic framework for enhancing scooter-sharing systems. These efforts will inform scalable solutions, contributing to the broader goals of sustainable urban mobility and smart city development.

This study provides actionable insights for addressing the unique challenges faced by scooter-sharing systems in transitional urban environments like Silesia. By implementing the recommended strategies and continuing to build on this research, policymakers and stakeholders can promote the effective integration of micromobility services into sustainable urban transport systems.

Author Contributions: Conceptualization, K.T. and R.W.; literature review, K.T. and R.W.; methodology, K.T. and R.W.; validation, K.T. and R.W.; formal analysis, K.T. and R.W.; investigation, K.T. and R.W.; writing—original draft preparation, K.T.; writing—review and editing, R.W.; funding acquisition, R.W. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: Data are contained within the article.

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

References

1. Narain, S. Integrating Smart City Technologies for Enhanced Urban Sustainability. *J. Sust. Sol.* **2024**, *1*, 13–17. [CrossRef]

2. Jacques, E.; Neuenfeldt Júnior, A.; De Paris, S.; Francescatto, M.; Siluk, J. Smart Cities and Innovative Urban Management: Perspectives of Integrated Technological Solutions in Urban Environments. *Heliyon* **2024**, *10*, e27850. [CrossRef] [PubMed]
3. Almeida, F.; Guimarães, C.M.; Amorim, V. Exploring the Differences and Similarities between Smart Cities and Sustainable Cities through an Integrative Review. *Sustainability* **2024**, *16*, 8890. [CrossRef]
4. Shaheen, S.; Cohen, A. Shared Mobility: An Overview of Definitions, Current Practices, and Its Relationship to Mobility on Demand and Mobility as a Service. In *International Encyclopedia of Transportation*; Elsevier: Amsterdam, The Netherlands, 2021; pp. 155–159. [CrossRef]
5. Bıyık, C.; Abareshi, A.; Paz, A.; Ruiz, R.A.; Battarra, R.; Rogers, C.D.F.; Lizarraga, C. Smart Mobility Adoption: A Review of the Literature. *J. Open Innov. Technol. Mark. Complex.* **2021**, *7*, 146. [CrossRef]
6. Razmjoo, A.; Gandomi, A.H.; Pazhoohesh, M.; Mirjalili, S.; Rezaei, M. The Key Role of Clean Energy and Technology in Smart Cities Development. *Energy Strategy Rev.* **2022**, *44*, 100943. [CrossRef]
7. Okonta, D.E.; Vukovic, V. Smart Cities Software Applications for Sustainability and Resilience. *Heliyon* **2024**, *10*, e32654. [CrossRef]
8. Deveci, M.; Gokasar, I.; Pamucar, D.; Chen, Y.; Coffman, D. Sustainable E-Scooter Parking Operation in Urban Areas Using Fuzzy Dombi Based RAFSI Model. *Sustain. Cities Soc.* **2023**, *91*, 104426. [CrossRef]
9. Sobrino, N.; Gonzalez, J.N.; Vassallo, J.M.; Baeza, M.D.L.A. Regulation of Shared Electric Kick Scooters in Urban Areas: Key Drivers from Expert Stakeholders. *Transp. Policy* **2023**, *134*, 1–18. [CrossRef]
10. Bozzi, A.D.; Aguilera, A. Shared E-Scooters: A Review of Uses, Health and Environmental Impacts, and Policy Implications of a New Micro-Mobility Service. *Sustainability* **2021**, *13*, 8676. [CrossRef]
11. MarketsandMarkets. Electric Scooter and Motorcycle Market by Vehicle Type (E-Scooter/Moped, E-Motorcycle), Battery Type (Sealed Lead Acid, Lithium-ion), Distance Covered, Technology, Voltage—Global Forecast to 2027. 2022. Available online: https://www.marketsandmarkets.com/Market-Reports/electric-scooter-market-30570739.html (accessed on 10 November 2024).
12. Statista. Shared Mobility in Poland. 2023. Available online: https://www.statista.com/topics/6579/shared-mobility-in-poland// (accessed on 10 November 2024).
13. Central Statistical Office of Poland (GUS). Statistical Yearbook of the Silesian Voivodeship. 2022. Available online: https://katowice.stat.gov.pl/en/publications/statistical-yearbook/ (accessed on 10 November 2024).
14. Mobile City Association icromobility Data Zone Q4 2023. Available online: https://mobilne-miasto.org/en/micromobility-data-zone-q4-2023/ (accessed on 10 November 2024).
15. Saha, A.; Görçün, Ö.F.; Pamucar, D.; Arya, L.; Simic, V. Evaluation of shared micro-mobility systems for sustainable cities by using a consensus-based Fermatean fuzzy multiple objective optimization and full multiplicative form. *Eng. Appl. Artif. Intell.* **2024**, *134*, 108662. [CrossRef]
16. Yu, J.; McKinley, G. Synthetic Participatory Planning of Shared Automated Electric Mobility Systems. *Sustainability* **2024**, *16*, 5618. [CrossRef]
17. Schofield, M.; Wang, N.; Ho, S.-S. Rebalancing Shared Mobility Systems by User Incentive Schemes: State-Action Representation Design and Analysis. In Proceedings of the ACM Symposium on Applied Computing, Avila, Spain, 8–12 April 2024; pp. 1045–1047.
18. Wei, S.; Zhang, Y.; Zhou, Z.; Zhang, T.; Xu, K.; Wei, S.; Zhang, Y.; Zhou, Z.; Zhang, T.; Xu, K. FedSM: A Practical Federated Shared Mobility System. *Proc. VLDB Endow.* **2024**, *17*, 4445–4448. [CrossRef]
19. Anttila, M.; Besker, T.; Svenson, P. Gender Aspects of Shared Mobility Services from a System of Systems Perspective. In Proceedings of the 2024 19th Annual System of Systems Engineering Conference, SoSE 2024, Tacoma, WA, USA, 23–26 June 2024; pp. 30–35.
20. Turoń, K.; Tóth, J. Innovations in Shared Mobility—Review of Scientific Works. *Smart Cities* **2023**, *6*, 1545–1559. [CrossRef]
21. Popova, Y.; Zagulova, D. Aspects of E-Scooter Sharing in the Smart City. *Informatics* **2022**, *9*, 36. [CrossRef]
22. Losapio, G.; Minutoli, F.; Mascardi, V.; Ferrando, A. Smart balancing of E-scooter sharing systems via deep reinforcement learning: A preliminary study. *Intell. Artif.* **2022**, *16*, 49–67. [CrossRef]
23. Losapio, G.; Minutoli, F.; Mascardi, V.; Ferrando, A. Smart balancing of E-scooter sharing systems via deep reinforcement learning. *CEUR Workshop Proc.* **2021**, *2963*, 83–97.
24. Filipe Teixeira, J.; Diogo, V.; Bernát, A.; Vaiciukynaite, E.; Stefania Sanna, V. Barriers to bike and e-scooter sharing usage: An analysis of non-users from five European capital cities. *Case Stud. Transp. Policy* **2023**, *13*, 101045. [CrossRef]
25. Kubik, A. The Use of Artificial Intelligence in the Assessment of User Routes in Shared Mobility Systems in Smart Cities. *Smart Cities* **2023**, *6*, 1858–1878. [CrossRef]
26. Trzeciak, M.; Jonek-Kowalska, I. Monitoring and control in program management as effectiveness drivers in polish energy sector. Diagnosis and Directions of Improvement. *Energies* **2021**, *14*, 4661. [CrossRef]
27. Li, A.; Zhao, P.; Liu, X.; Axhausen, K.W.; Qu, X. Comprehensive comparison of e-scooter sharing mobility: Evidence from 30 European cities. *Transp. Res. Part D Transp. Environ.* **2022**, *105*, 103229. [CrossRef]

28. Jonek-Kowalska, I.; Wolniak, R. *Smart Cities in Poland: Towards Sustainability and a Better Quality of Life?* Taylor & Francis: New York, NY, USA, 2023; ISBN 1000935396.
29. Jonek-Kowalska, I.; Wolniak, R. Sharing Economies' Initiatives in Municipal Authorities' Perspective: Research Evidence from Poland in the Context of Smart Cities' Development. *Sustainability* **2022**, *14*, 2064. [CrossRef]
30. Kubik, A.; Turoń, K.; Folęga, P.; Chen, F. CO2 Emissions—Evidence from Internal Combustion and Electric Engine Vehicles from Car-Sharing Systems. *Energies* **2023**, *16*, 2185. [CrossRef]
31. Wolniak, R. European Union Smart Mobility-Aspects Connected with Bike Road System's Extension and Dissemination. *Smart Cities* **2023**, *6*, 1009–1042. [CrossRef]
32. Wolniak, R. Analysis of the Bicycle Roads System as an Element of a Smart Mobility on the Example of Poland Provinces. *Smart Cities* **2023**, *6*, 368–391. [CrossRef]
33. Mahajan, S.; Argota Sánchez-Vaquerizo, J. Global comparison of urban bike-sharing accessibility across 40 cities. *Sci. Rep.* **2024**, *14*, 20493. [CrossRef]
34. Zimmermann, K.; Palgan, Y.V. Upscaling cargo bike sharing in cities: A comparative case study. *J. Clean. Prod.* **2024**, *477*, 143774. [CrossRef]
35. Xu, X.; Zuo, W. Does bike-sharing reduce traffic congestion? Evidence from three mega-cities in China. *PLoS ONE* **2024**, *19*, e0306317. [CrossRef]
36. Turoń, K.; Kubik, A.; Łazarz Bogusław, B.; Czech, P.; Stanik, Z. Car-Sharing in the Context of Car Operation. *IOP Conf. Ser. Mater. Sci. Eng.* **2018**, *421*, 032027. [CrossRef]
37. Mouratidis, K.; Peters, S.; Van Wee, B. Transportation Technologies, Sharing Economy, and Teleactivities: Implications for Built Environment and Travel. *Transp. Res. Part D Transp. Environ.* **2021**, *92*, 102716. [CrossRef]
38. Czech, P.; Turoń, K.; Urbańczyk, R. Bike-Sharing as an Element of Integrated Urban Transport System. In *Advanced Solutions of Transport Systems for Growing Mobility*; Sierpiński, G., Ed.; Advances in Intelligent Systems and Computing; Springer International Publishing: Cham, Switzerland, 2018; Volume 631, pp. 103–111. [CrossRef]
39. Gebhardt, L.; Ehrenberger, S.; Wolf, C.; Cyganski, R. Can Shared E-Scooters Reduce CO2 Emissions by Substituting Car Trips in Germany? *Transp. Res. Part D Transp. Environ.* **2022**, *109*, 103328. [CrossRef]
40. Hollingsworth, J.; Copeland, B.; Johnson, J.X. Are E-Scooters Polluters? The Environmental Impacts of Shared Dockless Electric Scooters. *Environ. Res. Lett.* **2019**, *14*, 084031. [CrossRef]
41. Neves, A.; Ferreira, H.; Lopes, F.J.; Godina, R. Environmental Assessment of Electric Scooters: Unveiling Research Gaps, Analyzing Factors, and Charting Pathways for Sustainable Micromobility. *Procedia Comput. Sci.* **2024**, *232*, 1400–1411. [CrossRef]
42. Reis, A.F.; Baptista, P.; Moura, F. How to Promote the Environmental Sustainability of Shared E-Scooters: A Life-Cycle Analysis Based on a Case Study from Lisbon, Portugal. *J. Urban Mobil.* **2023**, *3*, 100044. [CrossRef]
43. Unal, S.; Biyik, H. Driving Performance Enhancement Using Fuel Cell in E-Scooters. *Int. J. Hydrogen Energy* **2024**, *67*, 1206–1217. [CrossRef]
44. Yue, J.; Long, Y.; Wang, S.; Liang, H. Optimization of Shared Electric Scooter Deployment Stations Based on Distance Tolerance. *ISPRS Int. J. Geo-Inf.* **2024**, *13*, 147. [CrossRef]
45. Carrese, S.; D'Andreagiovanni, F.; Giacchetti, T.; Nardin, A.; Zamberlan, L. A Beautiful Fleet: Optimal Repositioning in E-Scooter Sharing Systems for Urban Decorum. *Transp. Res. Procedia* **2021**, *52*, 581–588. [CrossRef]
46. Vanus, J.; Bilik, P. Research on Micro-Mobility with a Focus on Electric Scooters within Smart Cities. *World Electr. Veh. J.* **2022**, *13*, 176. [CrossRef]
47. Mitropoulos, L.; Stavropoulou, E.; Tzouras, P.; Karolemeas, C.; Kepaptsoglou, K. E-Scooter Micromobility Systems: Review of Attributes and Impacts. *Transp. Res. Interdiscip. Perspect.* **2023**, *21*, 100888. [CrossRef]
48. Abouelela, M.; Al Haddad, C.; Antoniou, C. Are Young Users Willing to Shift from Carsharing to Scooter–Sharing? *Transp. Res. Part D Transp. Environ.* **2021**, *95*, 102821. [CrossRef]
49. Hermawan, K.; Le, D.-T. Examining Factors Influencing the Use of Shared Electric Scooters. *Sustainability* **2022**, *14*, 15066. [CrossRef]
50. Ecer, F.; Küçükönder, H.; Kayapınar Kaya, S.; Faruk Görçün, Ö. Sustainability Performance Analysis of Micro-Mobility Solutions in Urban Transportation with a Novel IVFNN-Delphi-LOPCOW-CoCoSo Framework. *Transp. Res. Part A Policy Pract.* **2023**, *172*, 103667. [CrossRef]
51. Hensher, D.A.; Wei, E.; Liu, W.; Balbontin, C. Profiling Future Passenger Transport Initiatives to Identify the Growing Role of Active and Micro-Mobility Modes. *Transp. Res. Part A Policy Pract.* **2024**, *187*, 104172. [CrossRef]
52. Guo, Y.; Zhang, Y. Understanding Factors Influencing Shared E-Scooter Usage and Its Impact on Auto Mode Substitution. *Transp. Res. Part D Transp. Environ.* **2021**, *99*, 102991. [CrossRef]
53. Ren, X.; Rasouli, S.; Timmermans, H.J.P.; Kemperman, A.D.A.M. Long-Term Mobility Choice Considering Availability Effects of Shared and New Mobility Services. *Transp. Res. Part D Transp. Environ.* **2024**, *133*, 104274. [CrossRef]

54. Gibson, H.; Curl, A.; Thompson, L. Blurred Boundaries: E-Scooter Riders' and Pedestrians' Experiences of Sharing Space. *Mobilities* **2022**, *17*, 69–84. [CrossRef]
55. Askari, S.; Javadinasr, M.; Peiravian, F.; Khan, N.A.; Auld, J.; Mohammadian, A.K. Loyalty toward Shared E-Scooter: Exploring the Role of Service Quality, Satisfaction, and Environmental Consciousness. *Travel Behav. Soc.* **2024**, *37*, 100856. [CrossRef]
56. Zhang, C.; Du, B.; Zheng, Z.; Shen, J. Space Sharing between Pedestrians and Micro-Mobility Vehicles: A Systematic Review. *Transp. Res. Part D Transp. Environ.* **2023**, *116*, 103629. [CrossRef]
57. Zeng, F.; Pang, C.; Tang, H. Sensors on Internet of Things Systems for the Sustainable Development of Smart Cities: A Systematic Literature Review. *Sensors* **2024**, *24*, 2074. [CrossRef]
58. Meng, S.; Brown, A.; Klein, N.; Thigpen, C.; Haydu, B.; Stout, N. *Shared Scooter Parking: The Role of Parking Density and Land Use in Compliance and Demand*; University of Oregon: Eugene, OR, USA, 2024. [CrossRef]
59. Gallo, M.; Marinelli, M. Sustainable Mobility: A Review of Possible Actions and Policies. *Sustainability* **2020**, *12*, 7499. [CrossRef]
60. Turoń, K.; Kubik, A. Open Innovation in the Shared Mobility Market. *J. Open Innov. Technol. Mark. Complex.* **2021**, *7*, 212. [CrossRef]
61. Yun, J.J.; Zhao, X.; Jung, K.; Yigitcanlar, T. The Culture for Open Innovation Dynamics. *Sustainability* **2020**, *12*, 5076. [CrossRef]
62. Available online: https://www.tier.app/he/blog/micro-mobility-unleash-huge-potential-copenhagen (accessed on 16 November 2024).
63. Impact of Parking Restrictions on E-Scooter Usage in Copenhagen. Available online: https://www.kk.dk/sites/default/files/agenda/c5d39137-acf1-44dc-a043-5de1d6d18542/fb70ea0f-7d4c-42d0-b7e6-96831ce5f61a-bilag-7_0.pdf (accessed on 16 November 2024).
64. Paris Set to Ban Rented E-Scooters After an Overwhelming 90% Vote for Their Removal. Available online: https://www.cnbc.com/2023/04/03/paris-bans-rented-e-scooters-after-an-overwhelming-90percent-vote-for-their-removal.html (accessed on 16 November 2024).
65. Turoń, K.; Kubik, A.; Folęga, P.; Chen, F. Perception of Shared Electric Scooters: A Case Study from Poland. *Sustainability* **2023**, *15*, 12596. [CrossRef]
66. Allison, P.D. *Multiple Regression: A Primer*; Sage Publication: Thousand Oaks, CA, USA, 1998.
67. Freedman, D. *Statistics*; Viva Book: New Delhi, Delhi, 2011.
68. Timothy, B. *Confirmatory Factor Analysis for Applied Research*, 2nd ed.; Guilford Publications: New York, NY, USA, 2015.
69. Mulak, S.A. *Foundations of Factor Analysis*; Taylor and Francis: New York, NY, USA, 2009.
70. Pett, M.A.; Lackey, N.R.; Sullivan, J.J. *Making Sense of Factor Analysis: The Use of Factor Analysis for Instrument Development in Health Care Research*; Sage: Thousand Oaks, CA, USA, 2003.
71. Kim, J.O. *Introduction to Factor Analysis: What It Is and How to Do It*; Sage Publication: Thousand Oaks, CA, USA, 1978; p. 13.
72. Gaurav, K. *Multiple Regression Analysis: Key To Social Science Research*; GRIN Verlag: Munich, Germany, 2011.
73. Lütkepohl, H. *New Introduction to Multiple Time Series Analysis*; Springer: Berlin/Heidelberg, Germany, 2006.
74. Behrendt, F.; Heinen, E.; Brand, C.; Cairns, S.; Anable, J.; Azzouz, L.; Glachant, C. Conceptualising Micromobility: The Multi-Dimensional and Socio-Technical Perspective. *Transp. Sci. Technol.* 2023; *preprint*. [CrossRef]
75. Amsterdam Smart City. 2024. Available online: https://amsterdamsmartcity.com/ (accessed on 7 January 2025).
76. Zero-Emission Mobility in Amsterdam Implementation Agenda 2023–2026. 2023. Available online: https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://assets.amsterdam.nl/publish/pages/867636/zero-emission_implementation_agenda_2023-2026.pdf&ved=2ahUKEwjDgtLMiOOKAxXSHRAIHbyBG6wQFnoECB0QAQ&usg=AOVaw317uqMHScQLUDn5JvdeBJF (accessed on 7 January 2025).
77. Pessler, V. Organization of Bike-Sharing in Amsterdam and Berlin. 2022. Available online: http://essay.utwente.nl/93481/1/93481_Pessler-Valeria.pdf (accessed on 7 January 2025).
78. Jonek-Kowalska, I. Assessing the energy security of European countries in the resource and economic context. *Oeconomia Copernic.* **2022**, *13*, 301–334. [CrossRef]
79. Lu, Y.; Zhang, L.; Corcoran, J. How Weather and Built Environment Factors Influence E-Scooter Ridership: Understanding Non-Linear and Time Varying Effects. *J. Cycl. Micromobility Res.* **2024**, *2*, 100036. [CrossRef]
80. Štefancová, V.; Kalašová, A.; Čulík, K.; Mazanec, J.; Vojtek, M.; Mašek, J. Research on the Impact of COVID-19 on Micromobility Using Statistical Methods. *Appl. Sci.* **2022**, *12*, 8128. [CrossRef]
81. Pourfalatoun, S.; Miller, E.E. Effects of the COVID-19 Pandemic on Use and Perception of Shared e-Scooters. *Transp. Res. Interdiscip. Perspect.* **2023**, *22*, 100925. [CrossRef]
82. Weiss, A.; Pollock, S.; Kattan, L. Scooting into Place: How Comfort on Different Infrastructure Types Influences Shared E-Scooter Trip Making. *J. Cycl. Micromobility Res.* **2024**, *2*, 100047. [CrossRef]
83. Cohen, A.; Shaheen, S. *Planning for Shared Mobility*; University of California: Berkeley, CA, USA, 2018. [CrossRef]
84. Stecuła, K.; Wolniak, R.; Grebski, W.W. AI-Driven Urban Energy Solutions—From Individuals to Society: A Review. *Energies* **2023**, *16*, 7988. [CrossRef]

85. Skubis, I.; Wolniak, R.; Grebski, W.W. AI and Human-Centric Approach in Smart Cities Management: Case Studies from Silesian and Lesser Poland Voivodships. *Sustainability* **2024**, *16*, 8279. [CrossRef]
86. McDougall, S.; Reppa, I.; Kulik, J.; Taylor, A. What Makes Icons Appealing? The Role of Processing Fluency in Predicting Icon Appeal in Different Task Contexts. *Appl. Ergon.* **2016**, *55*, 156–172. [CrossRef] [PubMed]
87. Okyere, I.O.; Atanga, R.A.; Okine, B.A. Customer Retention Management Strategies in Freight Transport Service Industry in Ghana. *Arch. Bus. Res.* **2016**, *4*, 6. [CrossRef]
88. Wolniak, R.; Stecuła, K. Artificial Intelligence in Smart Cities—Applications, Barriers, and Future Directions: A Review. *Smart Cities* **2024**, *7*, 1346–1389. [CrossRef]
89. Jonek-Kowalska, I. Housing Infrastructure as a Determinant of Quality of Life in Selected Polish Smart Cities. *Smart Cities* **2022**, *5*, 924–946. [CrossRef]
90. Christoforou, Z.; Gioldasis, C.; de Bortoli, A.; Seidowsky, R. Who is using e-scooters and how? Evidence from Paris. *Transp. Res. Part D Transp. Environ.* **2021**, *92*, 102708. [CrossRef]
91. Latinopoulos, C.; Patrier, A.; Sivakumar, A. Planning for e-scooter use in metropolitan cities: A case study for Paris. *Transp. Res. Part D Transp. Environ.* **2021**, *100*, 103037. [CrossRef]
92. Banning Shared E-Scooters in Melbourne Could Hinder the Growth of Circular Business Models Across Australia. Available online: https://pursuit.unimelb.edu.au/articles/what-banning-shared-e-scooters-tells-us-about-australias-circular-economy (accessed on 20 November 2024).
93. Wolniak, R.; Jonek-Kowalska, I. The creative services sector in Polish cities. *J. Open Innov. Technol. Mark. Complex.* **2022**, *8*, 17. [CrossRef]
94. Giordano, R. The Micromobility Sharing Schemes' Innovation. A Multi-Level Perspective Analysis on the City of Copenhagen. Available online: https://research-api.cbs.dk/ws/portalfiles/portal/60699639/800977_Master_Thesis.pdf (accessed on 7 January 2025).
95. Trafic, S. E-Scooter Safety. Experience from Denmark. 2022. Available online: https://etsc.eu/wp-content/uploads/Denmark.pdf (accessed on 7 January 2025).
96. Catch Me If You Can! How European Cities Are Regulating Shared Micromobility. 2023. Available online: https://www.polisnetwork.eu/wp-content/uploads/2023/11/SHARED-MICROMOBILITY-REPORT.pdf (accessed on 7 January 2025).
97. Wortmann, C.; Syré, A.M.; Grahle, A.; Göhlich, D. Analysis of Electric Moped Scooter Sharing in Berlin: A Technical, Economic and Environmental Perspective. *World Electr. Veh. J.* **2021**, *12*, 96. [CrossRef]
98. Oostendorp, R.; Hardinghaus, M. Shared vs. private e-scooters: Same vehicle—Different mode? Empirical evidence on e-scooter usage in Germany. *Transp. Res. Procedia* **2023**, *72*, 2173–2180. [CrossRef]
99. Mladenović, M.; Dibaj, S.; Lopatnicov, D. Evaluation of Electric Scooter Deployment in the City of Helsinki A Perspective on Sociotechnical Transitions Dynamics and Adaptive Governance, Spatial Planning and Transportation Engineering, Department of Built Environment, School of Engineering Aalto University. 2022. Available online: https://www.aalto.fi/sites/g/files/flghsv161/files/2022-11/Evaluation%20of%20electric%20scooter%20deployment%20in%20the%20City%20of%20Helsinki%20-%20Final%20Report.pdf (accessed on 7 January 2025).
100. Guo, Z.; Liu, J.; Zhao, P.; Li, A.; Liu, X. Spatiotemporal heterogeneity of the shared e-scooter–public transport relationships in Stockholm and Helsinki. *Transp. Res. Part D Transp. Environ.* **2023**, *122*, 103880. [CrossRef]
101. Shared E-Scooters in Oslo. 2023. Available online: https://trid.trb.org/view/1686345 (accessed on 7 January 2025).
102. Wincent, B.B. Shared E-Scooter U Sage Patterns Analysis of App and Trip Data, KTH Royal Institute of Technology 2024. Available online: https://kth.diva-portal.org/smash/get/diva2:1840203/SUMMARY01.pdf (accessed on 7 January 2025).
103. Mouratidis, K. Bike-sharing, car-sharing, e-scooters, and Uber: Who are the shared mobility users and where do they live? *Sustain. Cities Soc.* **2022**, *86*, 104161. [CrossRef]