Acta Sci. Pol., Administratio Locorum 24(1) 2025, 23–38.
https://czasopisma.uwm.edu.pl/index.php/aspal plISSN 1644-0749 eISSN 2450-0771 DOI: 10.31648/aspal.10660

ORIGINAL PAPER
Received: 03.10.2024 Accepted: 24.11.2024

MOBILITY-AS-A-SERVICE AS A DIRECTION FOR URBAN MOBILITY: A SYSTEMATIC LITERATURE REVIEW

Beata Chmiel[1]✉, Patryk Wierzbowski[2]✉

[1] ORCID: 0000-0002-0408-8690
[2] ORCID: 0000-0003-0059-6994
[1,2] University of Gdansk, Faculty of Economics, Department of Logistics
Armii Krajowej street, 119/121, 81-824 Sopot, **Poland**

ABSTRACT

Motives: Urban development is associated with the emergence of problems such as pollution, traffic congestion, and suburbanisation. Effective transportation and mobility policies can play an important role in mitigating these problems.
Aim: This article explores the issue of shaping urban mobility through Mobility-as-a-Service (MaaS). The key elements relevant to the implementation of MaaS by city authorities were identified based on a systematic literature review and the PRISMA methodology. Different approaches to defining MaaS and methods for measuring its effectiveness were examined in detail. Challenges and issues related to the implementation of the concept were also analysed.
Results: The results showed that the successful implementation of MaaS requires a high level of digitalisation and collaboration between the public and private sectors. The absence of these elements can hinder the implementation and development of MaaS. The present findings also highlighted that current research on MaaS neglects issues related to public participation in the implementation process, which may lead to lower user acceptance and reduced interest from private companies.

Keywords: Mobility-as-a-Service, urban mobility, policy-making, PRISMA method

INTRODUCTION

It is estimated that by the middle of the 21st century, 68% of the global population would live in cities (UN, 2023). Rapid urban growth will generate further challenges, such as pollution, transport congestion or the process of suburbanisation. Urban challenges create the need to implement sustainable urban mobility (SUM), with the primary goal of reducing carbon emissions through the use of low-carbon modes of transport (Banister, 2011). The urban transport system is the result of cooperation between various stakeholders and actors, the actions taken by urban authorities, and the transport policies in place. However, the number of actors creating this system and the limited capacity for infrastructure development can reduce its efficiency.

Public transport (PT) is the most desirable way to develop urban mobility because of its relatively low environmental impact and the fact that it minimises the occurrence of transport congestion (McLeod et al., 2017). Nevertheless, with urban sprawl and the emergence of metropolitan areas, private car usage is increasing. Urban authorities are therefore

✉beata.chmiel@ug.edu.pl, ✉patryk.wierzbowski@ug.edu.pl

taking steps to make PT and alternative methods of traveling within the city more attractive (Berrebi et al., 2021). An example of such actions are urban mobility development strategies or Sustainable Urban Mobility Plans (SUMPs). A relatively recent urban mobility concept is Mobility-as-a-Service (MaaS), the main goal of which is to improve PT in the city, i.e., to mitigate the negative effects of urban transport development.

The main objective is to provide guidance for municipal authorities on initiating the implementation of the MaaS concept. This primary objective is broken down into three specific goals: Objective 1: Identify all components of the MaaS concept. Objective 2: Identify potential opportunities and challenges in implementing MaaS. Objective 3: Determine whether the MaaS measurement tools (metrics/indicators) identified in the study are related to the opportunities and challenges in MaaS implementation. The results will help identify actions city authorities can take to begin implementing MaaS. The article examines the city as a living environment where residents rely on the transportation system and its available modes to meet their needs. By addressing issues related to the local development of cities and urban agglomerations, the functioning of their transportation systems, and the organization of urban space, the article aligns well with the aims and scope of research published in the journal.

The article is divided into three parts. The first part presents the literature review on urban challenges with a focus on mobility, urban transport integration and the concept of MaaS and its relation to transport integration. The methods used are then described. The third section presents the results, which are divided according to the specific objectives into: the analysis and synthesis of MaaS definitions, the identification of challenges and potential of the MaaS concept, ways to measure MaaS implementation, and proposals for the urban authorities. Finally, discussion, the main conclusions and limitations of the analysis are presented.

LITERATURE REVIEW

Urban challenges in terms of mobility development

The prevailing mode of transportation in cities is the private car (Lu et al., 2021). Therefore, tacking action to decrease the number of cars in urban areas in favor of micromobility, carsharing and PT is crucial (Fan & Harper, 2022). The importance of fostering diverse forms of urban mobility was first highlighted in the Green Paper "Towards a new urban mobility" (Commission of the European Communities, 2007).

Navigating cities poses challenges for individuals with disabilities, the elderly, and women, who often carry luggage (Loukaitou-Sideris, 2020). Barriers to accessibility in both public and private transportation include inadequately adapted vehicle interiors for wheelchair users, a lack of ramps and designated seating in vehicles, high fare costs, and safety concerns during travel or transfers (Remillard et al., 2022). Digital exclusion presents a challenge for the elderly, leading to underutilization of shared services, micromobility, or urban bicycle systems (Mubarak & Suomi, 2022). Mobility development strategies and the design of transportation infrastructure and vehicles should consider the perspectives of marginalized individuals (Karner et al., 2020). However, improvements in infrastructure alone are insufficient to address safety concerns during travel and transfers, as these issues primarily stem from social factors (Tiznado-Aitken et al., 2024).

In many cities, disparities in infrastructure accessibility exist between motorised and non-motorised transport users due to "car-centric" urban development (Bertolini, 2020). Narrow pavements and bicycle lanes contribute to conflicts between users, while streets and parking spaces account for nearly 50% of transport infrastructure (Gössling et al., 2016). Walking and PT is often perceived as options for individuals with lower incomes, highlighting social inequalities in urban space distribution between affluent and poorer residents (Guzman et al., 2021). Effective

✉beata.chmiel@ug.edu.pl, ✉patryk.wierzbowski@ug.edu.pl

measures to mitigate these disparities include implementing urban policies and strategies to reduce parking spaces and increase parking fees (Guzman et al., 2020). Additionally, the adoption of new technologies, including ICT (Information and Communication Technology), may shift user transportation behaviour toward PT or multimodal travel, consequently altering space utilization patterns. City authorities should focus their efforts on improving the quality and accessibility of PT, as well as using tools that encourage people to give up traveling by private car.

Integration of urban transport

Improving the urban mobility system should focus on changing private car users' behaviour and providing new travel options. These efforts include transport integration, a process in which the transportation system within a city or region is restructured to promote multimodality through collaboration between public entities and private operators (Maretić & Abramović, 2021). Transport integration may encompass various components: physical integration, network integration, information integration, fare integration, institutional integration.

The lowest level of integration is physical integration, while the highest is institutional integration. Full transport integration implies integration at all levels. However, achieving integration at each level faces certain barriers. At level 1, these barriers are mainly technical and financial, as upgrading or building new infrastructure is often expensive. Moreover, outdated infrastructure leads to inefficiencies in the overall system and congestion (Wang et al., 2018). At level 2, various systems including ICT systems and GPS, are utilized to support the prioritization of PT and the analysis of passenger flows (Kunicina et al., 2014). The subsequent level involves the integration of passenger information, which should be user-friendly and standardised across the city. At level 4, integration encompasses the unification of PT fares and tickets, which is particularly important in agglomerations where multiple fares are often present, potentially confusing users (Bashynska, 2020). Institutional integration represents the most comprehensive dimension, involving legal empowerment and cooperation among various actors.

The reorientation of urban policies and strategies toward integration and multimodality is primarily driven by the necessity to implement SUM (Carlan et al., 2014). Users themselves are also driving change by forming informal car-sharing and carpooling groups. To implement SUM, systemic actions are necessary. It is therefore important to foster public-private cooperation for the development of a diversified transport offering, thereby reducing costs and increasing the network's capacity (Doina, 2013). Municipal authorities play a crucial role in this process, as they have the authority to initiate change (May, 2013). Additionally, local authorities are responsible for implementing policies and strategies.

Mobility-as-a-Service as a holistic vision of urban mobility

Adopting a systemic perspective facilitates the establishment of cooperation among stakeholders, thereby enhancing effectiveness. Helsinki was the first city to approach mobility systematically by implementing MaaS concept, integrating public and private transport within a mobile app, and providing various payment packages (Hietanen & Sahala, 2014). MaaS represent a concept that offers a systemic approach to urban mobility, emphasizing sustainability, cost-effectiveness, and the provision of high-quality travel experiences for user (König et al., 2016). This quality entails enabling users to plan their journeys, purchasing tickets and tracking vehicle location in real-time, and fully integrating the transportation network and modes, including micro- and shared mobility options. According to the Sakai (2019) approach, MaaS is all modes of transport except private cars. MaaS can thus be regarded as the ultimate stage in transport integration (Zhao et al., 2021), described in the figure as full service integration, representing the highest, fifth level (see: Fig. 1). The lack of integration is therefore the lowest level one highlighted in the figure.

✉beata.chmiel@ug.edu.pl, ✉patryk.wierzbowski@ug.edu.pl

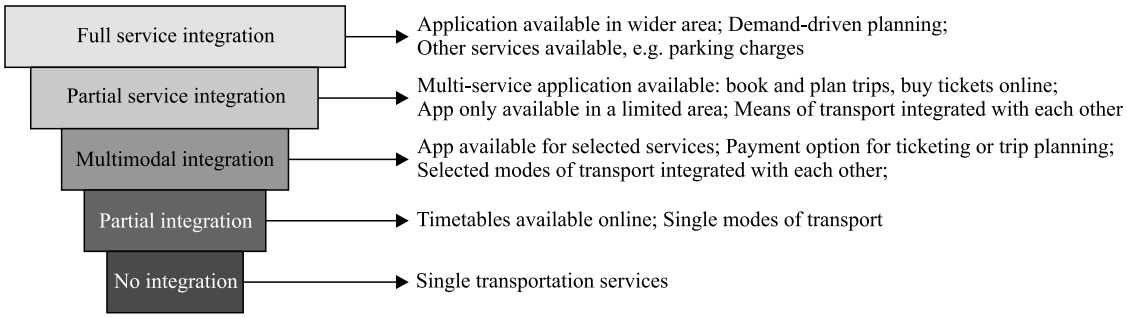

Fig. 1. Level of MaaS integration
Source: own elaboration based on Zhao et al., 2021.

MaaS encompasses a wide range of services primarily targeting users who either do not wish to or cannot use a private car (Mulley & Kronsell, 2018). Integrating services into a single mobile app facilitates city navigation and encourages more private car users to transition to PT. MaaS aligns with transportation policies, with a primary focus on fostering new transportation behaviour and promoting SUM. In the future, the concept will evolve towards MaaS 3.0, or Sustainable MaaS, incorporating decision-support systems to support and achieve sustainability goals (Vitetta, 2022). An important element in the development of MaaS 3.0 will be green marketing and the increasing environmental awareness of stakeholders (Rey-Moreno et al., 2023). MaaS can be implemented regardless of geographical area or scale, but cities are generally best prepared in terms of infrastructure and available transport options to adopt the concept (Eckhardt et al., 2017). It is important to note that cities are characterized by higher levels of social capital, which is a key aspect of promoting the use of MaaS. While investment funding may pose challenges for smaller cities, it cannot be considered a key barrier, given the potential for external funding.

Therefore, the role of municipalities is pivotal in the implementation of MaaS. However, it should be emphasized that many city authorities are not taking steps to implement MaaS but are instead focusing on measures to improve the quality of PT (Hensher & Hietanen, 2023). While these actions are necessary, they are often insufficient due to financial constraints. This poses a significant challenge, which is why MaaS concept has not been widely adopted. It is noteworthy that cities must demonstrate a certain level of commitment to MaaS implementation (Sarasini et al., 2017). Urban authorities must be prepared to assume a proactive role in relation to other actors.

MATERIALS AND METHODS

In this paper, the Systematic Literature Review (SLR) method was employed following the five-step literature review procedure outlined by Denyer & Tranfield (2009). The SLR conducted in accordance with this procedure aims to provide decisions regarding the databases selected by the authors, the keywords, the search periods, and the number of publications retrieved. Thus, it also allows to assessment of the validity of the conducted research and the accuracy of the review. Furthermore, it enables the reliability and applicability of the findings to be evaluated.

Step 1. included a preliminary literature review, allowed the formulation of three research questions. The study proposed the following questions: RQ1: Does the MaaS concept refer to the integration of urban transport and the use of new technologies, or should it be expanded to include other components? RQ2: What challenges and barriers do different MaaS actors face? RQ3: What are the ways to measure the implementation of MaaS?

Step 2. takes into account search engines for scientific publications. Based on the preliminary research, the topic of the study and the research questions, the following search terms were used: Mobility as a Service

✉beata.chmiel@ug.edu.pl, ✉patryk.wierzbowski@ug.edu.pl

AND deifnition OR meaning, Mobility as a Service AND measure* OR index OR evaluation, Mobility as a Service AND develop* AND urban. The search terms were combined with the corresponding Boolean operators (Atkinson & Cipriani, 2018), allowing the authors to construct predefined logical conditions according to which publications were searched. It was decided to choose three databases of scientific articles: EBSCOhost, Web of Science, and Wiley. These databases were chosen due to their ability to search for publications according to the established search logic, their availability in academic institutions and because they are used in other related studies.

In step 3. additional conditions and search criteria for publications were defined: articles published in English, full-text articles in open access. The restriction to open-access publications was due to their accessibility for authors and the facilitation of research replication by other researchers. A timeframe was not specified.

In step 4. the publications were analysed in detail using the PRISMA methodology (Mańkowski et al., 2022) (see: Fig. 2).

The PRISMA methodology used to present the SLR results is designed to provide a detailed presentation of the publications utilized.

In step 5. the analysis of the full-text publications was summarised, and the results were synthesized (see: Results section). The ways of defining and measuring MaaS are presented in the form of tables (see: table 1 and table 3), while challenges and threats are depicted in the form of graphs using the free Cmap tool, illustrating the network of relationships between the three groups of actors: users, local authorities, and operators (see: Figures 3 and 4).

RESULTS

Identification of the MaaS components

The MaaS concept can be conceptualised differently depending on the research perspective and adopted scope. Sixteen definitions of MaaS in the literature were identified from the period 2016–2023.

The overarching goal of MaaS is to achieve the SUM objectives, based on four components: well-developed infrastructure, the use of modern technologies, the availability of a broad package of services, and the cooperation of various actors. A well-developed infrastructure network can encourage desired transport behaviors, such as using environmentally friendly modes of transport (Giesecke

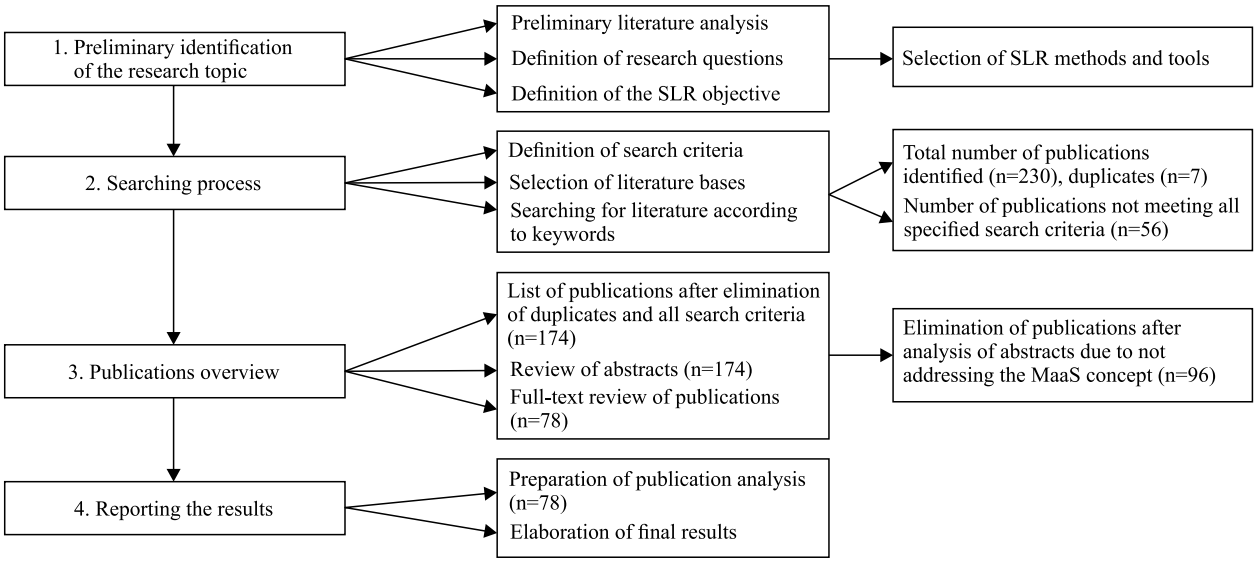

Fig. 2. PRISMA research procedure
Source: own elaboration based on Mańkowski et al. (2022) and Denyer & Tranfield (2009).

✉beata.chmiel@ug.edu.pl, ✉patryk.wierzbowski@ug.edu.pl

Table 1. The most common definitions of MaaS

Authors	Definition
Alyavina et al. (2020); Gao & Zhu (2022)	Integration of multimodal transport alternatives available on demand in a single mobile application.
Butler et al. (2021); Calderón & Miller (2020); Castellanos et al. (2022); Wright et al. (2020)	A transport system that serves as an alternative to driving a private car, offering an innovative, user-centered service that integrates multiple modes of transport with shared and on-demand options, effectively meeting users' transportation needs.
Cisterna et al. (2021); Hesselgren et al. (2022); Smith et al. (2018)	A user-oriented mobility distribution model that combines several modes of transport into a single integrated plan available as a subscription, accessible via a digital platform or mobile app with a single interface.
Esztergár-Kiss et al. (2020); Xi et al. (2023); Russo (2022)	A new mobility concept that integrates, manages and distributes different mobility options – such as PT, ridesharing, cars or bicycles and taxis – using smart digital technologies, often in the form of service packages.
Giesecke et al. (2016); Kraus et al. (2023); Rindone (2022)	A new mobility concept designed to promote sustainable transport development by increasing the use of environmentally friendly transport modes and implementing effective mobility strategies.
Lyons (2020)	A new function of intermediation in the mobility ecosystem that aims to provide end-users of the transport system with more convenient (and potentially more flexible and cost-competitive) access to transport modes with a single digital platform.

Source: own elaboration based on SLR.

et al., 2016; Rindone, 2022). Furthermore, a well-maintained infrastructure is necessary to promote active mobility, which positively impacts users' health by increasing their levels of physical activity. The use of modern technology can help create facilities for people with special needs. Integration helps promote the use of multiple modes of transport within a single journey (Cisterna et al., 2021; Hesselgren et al., 2020). The integration of transport modes is facilitated at interchange hubs, which are often located on the outskirts of cities (Lyons, 2020).

The most comprehensive definitions were presented by, among others, Butler et al. (2021), Cisterna et al. (2021), and Smith et al. (2018), as they incorporate a user needs-based approach and the integration of various modes of transport. However, they lack elements related to the sustainable development of transport. This aspect was emphasized in the definitions provided by Giesecke et al. (2016) and Russo (2022). According to their perspective, MaaS can only be implemented through the adoption of appropriate policies and strategies. These definitions, while highlighting key components of MaaS, completely omit the integration of different modes of transport, the use of mobile applications, and innovation. In contrast, Lyons (2020) pointed to specific benefits for users from using MaaS, such as lower costs and a higher level of flexibility, suggesting that these are the most critical factors from the user perspective. However, the definition lacks references to the benefits for city authorities and operators.

The researchers did not limit the definition of MaaS to integration, suggesting an evolving approach in which integration is only one element. An important aspect of MaaS is the collaboration between actors and the development of a business model. Therefore, participatory processes involving stakeholders should be a key element in implementing the concept. MaaS components are indicators that a certain level of maturity has been reached in a city and can be seen as milestones in the implementation of the concept. It can thus be concluded that system flexibility increases with the achievement of successive levels of MaaS, influencing the attainment of SUM objectives.

✉beata.chmiel@ug.edu.pl, ✉patryk.wierzbowski@ug.edu.pl

MaaS challenges and future developments

As part of the literature analysis, we defined the challenges encountered by actors implementing MaaS concepts. In Fig. 3 also takes into account the various perspectives on the perception of potential risks in the implementation of MaaS.

In terms of challenges, several areas and perspectives were highlighted. Funding barriers may associated with infrastructure development needs or transport platform services (Kayikci & Kabadurmus, 2022; Leung et al., 2023). Underutilization of data results in a technology gap (Bokolo, 2023), and there is also a lack of mobile application-based payment solutions. Difficult internet access can also be a barrier. Additionally, there is a need to align physical infrastructure with the technological layer to support MaaS services. A lack of appropriately trained staff is another identified issue.

Another significant barrier is the lack of development of a unified business model (Leung et al., 2023). This issue is crucial from the point of view of the interests of the various actors involved in the implementation of MaaS-based solutions (Papaioannou et al., 2022). The difficulties in achieving this may relate to the pricing of services and the subsequent allocation of revenues among the various actors (Karlsson et al., 2020). The organisational and technological gap between public and private actors (Nikitas et al., 2017) and the lack of adequate competences on the part of PT operators to enable efficient cooperation, as evidenced by the fact that none of the MaaS pilot implementations were initiated by local authorities may become another significant barrier to implementing MaaS.

Furthermore, there are social risks associated with the development of MaaS. These include concerns that MaaS solutions may not be applicable to smaller cities (Butler et al., 2020). Not all users will be able to easily take advantage of MaaS solutions due to lack of confidence in the electronic payment system (Karlsson et al., 2020). MaaS implementation may also exclude the elderly or the digitally poor individuals (Pangbourne et al., 2020). Additionally, it may be

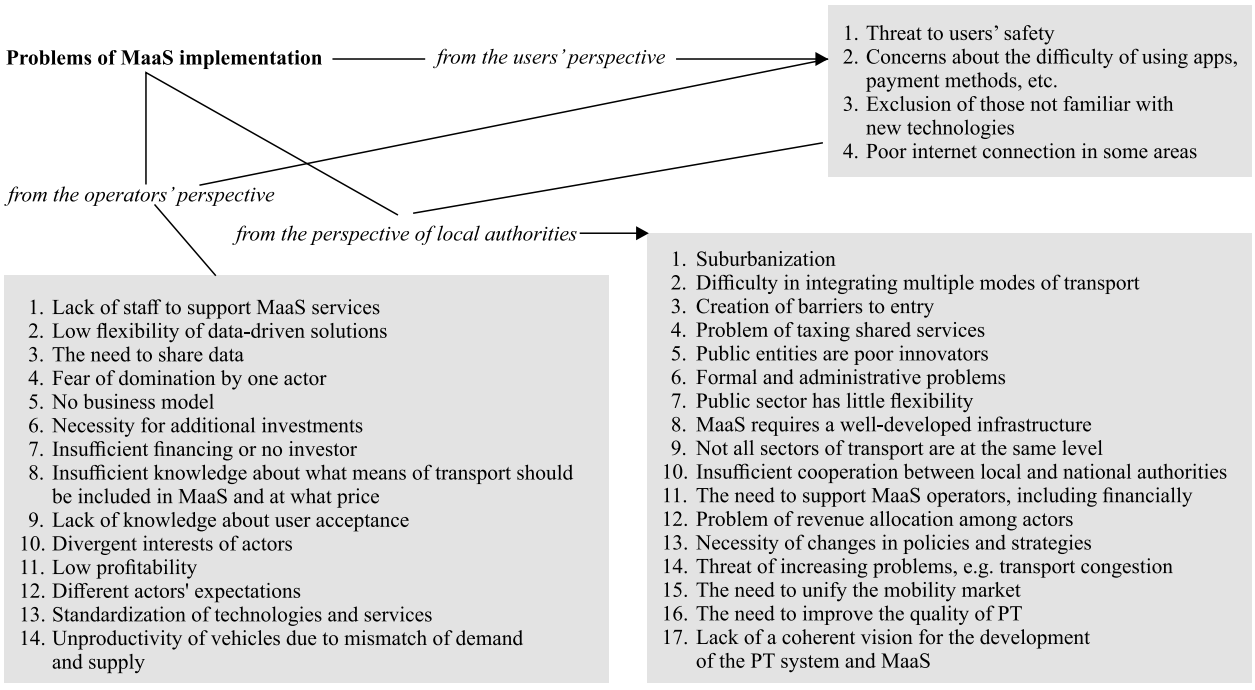

Fig. 3. Implementation problems for concrete MaaS actors
Source: own elaboration based on SLR.

✉beata.chmiel@ug.edu.pl, ✉patryk.wierzbowski@ug.edu.pl

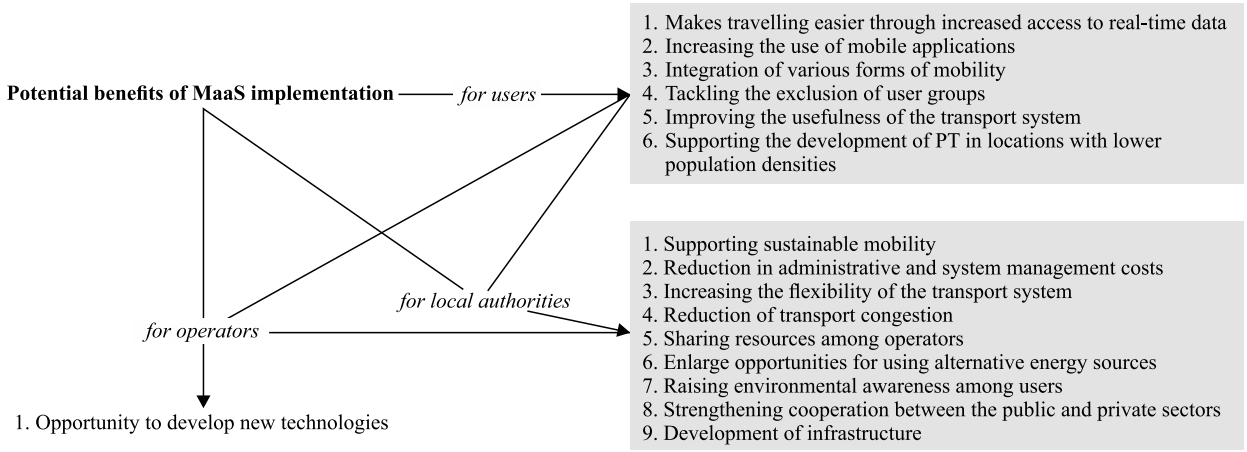

Fig. 4. Potential benefits for concrete MaaS actors
Source: own elaboration based on SLR.

important to adequately secure the data collected by apps or to integrate different services (Jittrapirom et al., 2018). The lack of willingness to share data in real time on the part of transport system users may also be an issue (Rindone, 2022).

Figure 4 summarizes the identified potential benefits associated with the implementation of MaaS, grouped from the perspective of users, service providers and local authorities.

By sharing the resources of different operators, a comprehensive passenger service can be implemented (Butler et al., 2020). The MaaS concept allows all innovative transport solutions to be combined and implemented simultaneously, while contributing to the promotion of SUM. MaaS is an opportunity to develop e-mobility, which may also contribute to a reduction in the number of cars and thus reduce congestion (Russo, 2022). In this way, the implementation of the MaaS concept can positively impact the reduction of greenhouse gas and carbon dioxide emissions, contributing to improved air quality.

This also includes the integrating the implementation or development of MaaS into strategies related to the digitization of cities (İnaç et al., 2021), which may prove to be a suitable response to the increasing interest of users in new forms of mobility (Karlsson et al., 2020) and a high propensity to embrace new technologies, with a particular interest observed among young people. The MaaS concept necessitates the development of tools for monitoring and adaptation to market changes (Jittrapirom et al., 2018). Collecting and utilizing real-time data can streamline travel for users (Gonzalez-Feliu et al., 2018) and also attract IT companies that will find opportunities to offer their services in a city.

MaaS can enhance cooperation between the public and private sectors (Cooper et al., 2019). MaaS-based solutions can bolster traditional PT, especially in areas with poor access to PT, such suburban areas (Delponte & Costa, 2022). It should be emphasized that the authors are aware of the risk that MaaS solutions may compete with existing PT. Therefore, the proposed concept should be implemented in a way that ensures the MaaS service package complements, rather than competes with, existing public transportation by integrating it as a fundamental component.

MaaS addresses challenges in mobility policy-making, including those related to the appropriate highest possible level of integration of transport services (Russo & Rindone, 2023). Suburbanisation triggers the need to develop and implement flexible intermodal transport (Leung et al., 2023) and integrate the metropolitan area (Delponte & Costa, 2022). The flexibility and customization of solutions implemented through the application or development of the MaaS concept can serve as a tool to address social marginalisation. This may involve the inclusion of marginalized individuals.

✉beata.chmiel@ug.edu.pl, ✉patryk.wierzbowski@ug.edu.pl

Approaches to measuring MaaS implementation

The implementation of MaaS relies heavily on establishing robust cooperation among stakeholders, with local authorities playing a pivotal role in initiating this process (Maas, 2021). Researchers investigating the acceptance level of MaaS typically rely on survey results and statistical analysis as the basic building blocks for creating indexes (see: Table 2).

The identified indices can be divided into three groups: those assessing the level of acceptance of MaaS services (Hoerler et al., 2020; Matowicki et al., 2022; Zijlstra et al., 2020), those focusing of MaaS attributes (Dadashzadeh et al., 2022; Farahmand et al., 2021), and those pertaining to specific types of MaaS services (He & Csiszár, 2020; Kamargianni et al., 2016; Narayanan & Antoniou, 2023).

Hoerler et al. (2020) research revealed that regular PT users show higher acceptance of MaaS. Notably, factors such as flexibility, lower pricing, and independence were identified as potential incentives for the utilization of integrated mobility services. In contrast, Zijlstra et al. (2020) highlighted age as a critical factor, with individuals aged over 75 exhibiting negative attitudes toward MaaS across all dimensions. This observation was also supported by Matowicki et al. (2022). Moreover, being a student or government employee was associated with more favourable attitudes toward MaaS. Dadashzadeh et al. (2022) analysed the inclusiveness of MaaS at the service level. They used three sub-indexes:

Table 2. Approaches to the measurement of MaaS

Authors	Year	Name of index	Objective	Variables
Dadashzadeh et al.	2022	MaaS Inclusion Index: MaaSINI	Examine the possibility of providing MaaS services to group with special needs.	physical availability of transport services; price and payment options; data collection; inclusive design
Farahmand et al.	2021	-	Examine what attributes lead to prefer one alternative over another.	car ownership; commuting costs and frequency; place of parking; mobility packages
He & Csiszár	2020	Quality index of MaaS services	Group and analyse MaaS services that are in a similar phase of development.	passenger service features; fare structure; real-time information; data sharing; transfer possibility, vehicle interior design
Hoerler et al.	2020	-	Measuring acceptance for specific MaaS solutions.	shared mobility usage; leisure travel on weekdays and weekends; place of residence
Kamargianni et al.	2016	MaaS integration index	Permits a comparison of the different mobility integration systems.	number of means of transport per ticket; trip planning and booking; presence or not of packages; payment options
Matowicki et al.	2022	User Behavior Model	Comparison of participants with high readiness to use MaaS with those who are undecided.	Not described accurately.
Narayanan & Antoniou	2023	Mode choice model for bike-, car- and ridesharing	There is a need for a model that is able to capture this phenomenon.	Not described accurately.
Zijlstra et al.	2020	Latent Demand for MaaS Index (LDMI)	Allows to identify who has the highest probability of adopting MaaS in the near future.	online booking and payment; tech optimism; openness to new forms of travel; multimodality; openness to paying for information

Source: own elaboration based on SLR.

✉beata.chmiel@ug.edu.pl, ✉patryk.wierzbowski@ug.edu.pl

(1) Accessible Transport Index, calculated as the product of accessibility and type of disability, (2) Accessible Data Index, calculated as the product of information on a specific facility and given weight, and (3) Accessible Platform Index, calculated as the product of a specific inclusive platform criterion and given weight. The sum of these indexes yields the MaaSINI, which enables testing the inclusiveness of a platform. On the other hand, Farahmand et al. (2021) conducted stated choice experiment, targeting Dutch employees, which involved hypothetical mobility packages. The results revealed that price is a crucial determinant of mode choice with the most significant price being 140 EUR per month for each package. Those who use their own car for commuting are more inclined to opt for car- and e-bikesharing. This suggests that individuals who use their own car may be less willing to switch transportation modes. On the other hand, Narayanan & Antoniou (2023) analysed transportation behaviour. The results show that as the travel distance increases, the propensity to use bikesharing decreases in favour of carsharing. However, with shorter travel time, the propensity to use shared transportation increases. He & Csiszár (2020) presented an index of MaaS service quality. The results indicate that private operators score higher in the MaaS transition phase.

It is important to highlight some drawbacks of the presented indexes. Firstly, the basic methodology employed by some studies, may consider only limited elements (Narayanan & Antoniou, 2023; Zijlstra et al., 2020). While fragmented analyses may be useful for specific purposes, they might not capture the full complexity of the MaaS phenomenon. However, the problem often lies in the limited geographic scope of such analyses. This limitation is typically due to constraints such as data availability and cost. Additionally, studies conducted between 2020 and 2023 should acknowledge the COVID-19 pandemic as a potential confounding factor. It's also worth noting that users may still not fully grasp the concept of MaaS (Farahmand et al., 2021), which could impact their responses.

DISCUSSION

MaaS represented the preferred direction for mobility development, often synonymous with full integration (Zhao et al., 2021). In the article, these elements are incorporated as integrations at the fifth (or highest) level. However, it is important to highlight the evolution of the MaaS approach, which is shifting away from a narrow view of MaaS as full integration to include other components (e.g. the effective collaboration of stakeholders, development of infrastructure, and use of modern technologies). The aim of MaaS implementation should be to achieve SUM goals, in line with the Rindone (2022) approach. This approach is appropriate considering the future development of MaaS towards MaaS 3.0 (Rey-Moreno et al., 2023). Initially, the MaaS concept focused on eliminating the use of private cars in the city (Sakai, 2019), but private cars should be considered one of the alternatives. City authorities should work towards making parking policies more effective to discourage car use.

Local authorities play a pivotal role. However, the lack of coherent vision for urban mobility development, and inconsistent definitions of MaaS pose significant barriers. Therefore, there is a pressing need to develop a comprehensive framework for defining MaaS, encompassing: a broad range of services, integration, infrastructure development, modern technologies, and sustainability considerations. Research by He & Csiszár (2020) suggests that the availability of diverse services on a MaaS platform correlates with increased user adoption. However, operators often face uncertainty regarding the business model and encounter challenges related to profitability (Karlsson et al., 2020; Kayikci & Kabadurmus, 2022; Leung et al., 2023). Urban mobility planning requires municipal authorities to take deliberate action in cooperation with stakeholders and actors. Hence, from the local authority's point of view, the most important aspect of MaaS remains the final stage, i.e., establishing cooperation and developing a business model that is distinct from the competition. It is also the only activity that does not require a large financial outlay.

✉beata.chmiel@ug.edu.pl, ✉patryk.wierzbowski@ug.edu.pl

Thus, it can be concluded that research on the MaaS concept focuses on analysing user needs, while neglecting the operators' perspective, as confirmed by the analysed MaaS indices. The inclusion of operators in the MaaS implementation process was emphasized in Leung et al. (2023) study, which has been confirmed by the conducted research. In MaaS definitions, actors are mentioned but not specifically identified. This may imply difficulties in implementing and developing the concept.

CONCLUSION AND LIMITATIONS

The analysis of the components of MaaS illustrates how urban authorities should approach the implementation of the concept. MaaS implementation should be reflected in the urban mobility development strategy. The creation of urban policies and regulations to encourage private operators and IT companies to implement technologies and services in the city is an extremely important part of MaaS development.

The potential benefits suggest that implementing MaaS can support the development of PT in the city, particularly by addressing the needs of people with reduced mobility and those at risk of exclusion. However, it is crucial to accurately identify their needs and expectations from transport services. To this end, surveys are invaluable in capturing users' subjective perspectives and subsequently adjusting the transport offer accordingly. Nevertheless, the identified barriers indicate that implementing MaaS involves incurring additional costs, conducting participatory processes, educating users and operators, and developing a business model that can be replicated by various operators. This process requires close collaboration with experts and researchers.

In order to implement the concept, it is necessary to gather resources, primarily information and human resources. The MaaS implementation process is faster in cities with well-developed infrastructure and well-educated citizens. Stakeholders, not just MaaS actors, should be involved in the process from the outset. This approach will build awareness of the concept among residents and encourage them to use such solutions in the future. Social participation was not mentioned in any MaaS definitions, and indicators related to it were not included in any MaaS index.

The development of urban transport depends on the actions taken by various actors, particularly the municipal authorities, who are responsible for shaping transport policies. One of their key tasks is to oversee the transport system and guide it toward a sustainable development path. Therefore, the MaaS concept aligns with the aspirations of city authorities. For these measures to be effective, municipal authorities need to collaborate with public and private operators as well as the IT industry. This collaboration is essential to developing a business model based on cooperation rather than competition. MaaS services should be supervised by local authorities in terms of the proposed mobility packages, user fees charged, the security of user data, the distribution of profits among actors, and the achievement of SUM objectives.

Inclusiveness stands out as a crucial attribute of MaaS services, reflecting its user-centered nature (Cisterna et al., 2021; Giesecke et al., 2016; Hesselgren et al., 2020). Concerns raised by users often revolve around the security of mobile app usage and potential exclusion of segments such as the elderly or individuals lacking internet access (Jittrapirom et al., 2018). Despite these concerns, the positive impacts of MaaS implementation are anticipated to be experienced most significantly by users and local authorities. As such, the potential advantages of MaaS adoption underscore its potential to address various mobility challenges and enhance overall transportation experiences for individuals and communities alike.

It's important to acknowledge the limitations of the analysis presented. Firstly, the exclusion of grey literature means that valuable insights from practical implementations of MaaS may have been missed, focusing primarily on theoretical aspects. Secondly, the search was restricted to three databases chosen based on availability, which could limit the breadth of the analysis. Expanding the search to include more databases could yield a greater number of publications and enrich the analysis. Thirdly, due to the comprehensive nature of the analysis covering

✉beata.chmiel@ug.edu.pl, ✉patryk.wierzbowski@ug.edu.pl

three main areas the presentation of results had to be synthesized, potentially overlooking nuanced details.

However, these limitations provide opportunities for discussion and serve as a basis for further research in the field. Therefore, further research should focus on identifying MaaS indicators and factors that could accelerate the implementation of this concept in cities. Knowledge of the challenges and barriers can help business model researchers assist city authorities and operators in developing a suitable model for MaaS services.

Consequently, there is a notable gap in existing research concerning operators' perspectives, warranting further investigation into the economic viability and business models associated with MaaS implementation. Closing this gap will contribute to a more comprehensive understanding of the challenges and opportunities within the MaaS ecosystem. The analysis presented highlights the need to include the perspectives of operators and municipalities in the implementation and development of MaaS and emphasizes the importance of public participation in this process. These components are often neglected in MaaS studies, so future research should focus on incorporating them into the indices used to measure MaaS.

Author contributions: The authors have approved the final version of the article. The authors have contributed to this work as follows: B.Ch. and P.W. developed the concept and designed the study, B.Ch. collected the data, P.W. analyzed and interpreted the data, B.Ch. drafted the article, P.W. revised the article critically for important intellectual content.

Funding: This research was undertaken as part of the Projects for the Development of Young Researchers at the Faculty of Economics, University of Gdańsk project and was fully funded by a grant (539-E070-B104-24).

REFERENCES

Alyavina, E., Nikitas, A., & Tchouamou, N. E. (2020). Mobility as a service and sustainable travel behaviour: A thematic analysis study. *Transportation Research Part F: Traffic Psychology and Behaviour*, *73*, 362–381. https://doi.org/10.1016/j.trf.2020.07.004

Atkinson, L. Z., & Cipriani, A. (2018). How to carry out a literature search for a systematic review: a practical guide. *BJPsych Advances*, *24*(2), 74–82. https://doi.org/10.1192/bja.2017.3

Banister, D. (2011). Cities, mobility and climate change. *Journal of Transport Geography*, *19*(6), 1538–1546. https://doi.org/10.1016/j.jtrangeo.2011.03.009

Bashynska, I. (2020). Improving the Tariff Policy of Urban Passenger Transport Based on International Experience. *TEM Journal*, *9*(4), 1588–1596. https://doi.org/10.18421/TEM94-34

Berrebi, S. J., Joshi, S., & Watkins, K. E. (2021). On bus ridership and frequency. *Transportation Research Part A: Policy and Practice*, *148*, 140–154. https://doi.org/10.1016/j.tra.2021.03.005

Bertolini, L. (2020). From "streets for traffic" to "streets for people": can street experiments transform urban mobility? *Transport Reviews*, *40*(6), 734–753. https://doi.org/10.1080/01441647.2020.1761907

Bokolo, A. (2023). Data enabling digital ecosystem for sustainable shared electric mobility-as-a-service in smart cities-an innovative business model perspective. *Research in Transportation Business and Management*, *51*, Article 101043. https://doi.org/10.1016/j.rtbm.2023.101043

Butler, L., Yigitcanlar, T., & Paz, A. (2020). How can smart mobility innovations alleviate transportation disadvantage? Assembling a conceptual framework through a systematic review. *Applied Sciences (Switzerland)*, *10*(18). https://doi.org/10.3390/APP10186306

Butler, L., Yigitcanlar, T., & Paz, A. (2021). Barriers and risks of Mobility-as-a-Service (MaaS) adoption in cities: A systematic review of the literature. *Cities*, *109*, Article 103036. https://doi.org/10.1016/J.CITIES.2020.103036

Calderón, F., & Miller, E. (2020). A literature review of mobility services: definitions, modelling state-of-the-art, and key considerations for a conceptual modelling framework. *Transport Reviews*, *40*(3), 312–332. https://doi.org/10.1080/01441647.2019.1704916

Calle, C. A., Campillay, C. M., Araya, G. F., Ojeda, I. A., Rivera, B. C., Dubó, A. P., & López, T. A. (2022). Access

✉beata.chmiel@ug.edu.pl, ✉patryk.wierzbowski@ug.edu.pl

to public transportation for people with disabilities in Chile: a case study regarding the experience of drivers. *Disability & Society*, *37*(6), 1038–1053. https://doi.org/10.1080/09687599.2020.1867067

Carlan, V., Rosca, E., & Rosca, M. A. (2014). Urban and per-urban passenger transport integration through hub-and-spoke-network. *Theoretical and Empirical Researches in Urban Management*, *9*(1), 74–84.

Castellanos, S., Grant-Muller, S., & Wright, K. (2022). Technology, transport, and the sharing economy: towards a working taxonomy for shared mobility. *Transport Reviews*, *42*(3), 318–336. https://doi.org/10.1080/01441647.2021.1968976

Cisterna, C., Giorgione, G., & Viti, F. (2021). Explorative analysis of potential MaaS customers: An agent-based scenario. *Procedia Computer Science*, *184*, 629–634. https://doi.org/10.1016/j.procs.2021.03.078

Commission of the European Communities. (2007). COM(2007) 551 final: Green Paper – Towards a new culture for urban mobility. In *Green Paper – Towards a new culture for urban mobility*.

Cooper, P., Tryfonas, T., Crick, T., & Marsh, A. (2019). Electric Vehicle Mobility-as-a-Service: Exploring the "Tri-Opt" of Novel Private Transport Business Models. *Journal of Urban Technology*, *26*(1), 35–56. https://doi.org/10.1080/10630732.2018.1553096

Dadashzadeh, N., Woods, L., Ouelhadj, D., Thomopoulos, N., Kamargianni, M., & Antoniou, C. (2022). Mobility as a Service Inclusion Index (MaaSINI): Evaluation of inclusivity in MaaS systems and policy recommendations. *Transport Policy*, *127*, 191–202. https://doi.org/10.1016/j.tranpol.2022.09.006

Delponte, I., & Costa, V. (2022). Metropolitan MaaS and DRT Schemes: Are They Paving the Way Towards a More Inclusive and Resilient Urban Environment? In *Studies in Health Technology and Informatics* (pp. 304–311). https://doi.org/10.3233/SHTI220853

Denyer, D., & Tranfield, D. (2009). Producing a Systematic Review. In *The SAGE Handbook of Organizational Research Methods* (pp. 671–689). SAGE Publications Inc.

Doina, C. (2013). Indicators for the performance and for the effort in transport. *Constanta Maritime University's Annals*, *18*, 261–264.

Eckhardt, J., Sochor, J., Aapaoja, A., & Nykänen, L. (2017). MaaS service combinations for different geographical areas. *ITS World Congress 2017 Montreal*, 1–11.

Esztergár-Kiss, D., Kerényi, T., Mátrai, T., & Aba, A. (2020). Exploring the MaaS market with systematic analysis. *European Transport Research Review*, *12*(67), 1–16. https://doi.org/10.1186/s12544-020-00465-z

Fan, Z., & Harper, C. D. (2022). Congestion and environmental impacts of short car trip replacement with micromobility modes. *Transportation Research Part D: Transport and Environment*, *103*(103173), 1–17. https://doi.org/10.1016/j.trd.2022.103173

Farahmand, Z. H., Gkiotsalitis, K., & Geurs, K. T. (2021). Mobility-as-a-Service as a transport demand management tool: A case study among employees in the Netherlands. *Case Studies on Transport Policy*, *9*(4), 1615–1629. https://doi.org/10.1016/j.cstp.2021.09.001

Freudendal-Pedersen, M. (2020). Sustainable urban futures from transportation and planning to networked urban mobilities. *Transportation Research Part D: Transport and Environment*, *82*, Article 102310. https://doi.org/10.1016/J.TRD.2020.102310

Gao, Y., & Zhu, J. (2022). Characteristics, Impacts and Trends of Urban Transportation. *Encyclopedia*, *2*, 1168–1182. https://doi.org/10.3390/encyclopedia2020078

Giesecke, R., Surakka, T., & Hakonen, M. (2016). Conceptualising Mobility as a Service. A User Centric View on Key Issues of Mobility Services. *2016 11th International Conference on Ecological Vehicles and Renewable Energies, EVER 2016*, 1–12. https://doi.org/10.1109/EVER.2016.7476443

Gonzalez-Feliu, J., Pronello, C., & Grau, J. M. S. (2018). Multi-Stakeholder Collaboration In Urban Transport: State-Of-The-Art And Research Opportunities. *Transport*, *33*(4), 1079–1094. https://doi.org/10.3846/transport.2018.6810

Gössling, S., Schröder, M., Späth, P., & Freytag, T. (2016). Urban Space Distribution and Sustainable Transport. *Transport Reviews*, *36*(5), 659–679. https://doi.org/10.1080/01441647.2016.1147101

Guzman, L. A., Arellana, J., & Alvarez, V. (2020). Confronting congestion in urban areas: Developing Sustainable Mobility Plans for public and private organizations in Bogotá. *Transportation Research Part A: Policy and Practice*, *134*, 321–335. https://doi.org/10.1016/J.TRA.2020.02.019

Guzman, L. A., Oviedo, D., Arellana, J., & Cantillo-García, V. (2021). Buying a car and the street: Transport justice and urban space distribution. *Transportation Research Part D: Transport and Environment*, *95*, Article 102860. https://doi.org/10.1016/J.TRD.2021.102860

✉beata.chmiel@ug.edu.pl, ✉patryk.wierzbowski@ug.edu.pl

He, Y., & Csiszár, C. (2020). Quality assessment method for mobility as a service. *Promet – Traffic – Traffico*, *32*(5), 611–624. https://doi.org/10.7307/ptt.v32i5.3374

Hensher, D. A., & Hietanen, S. (2023). Mobility as a feature (MaaF): rethinking the focus of the second generation of mobility as a service (MaaS). *Transport Reviews*, *43*(3), 325–329. https://doi.org/10.1080/01441647.2022.2159122

Hesselgren, M., Sjöman, M., & Pernestål, A. (2020). Understanding user practices in mobility service systems: Results from studying large scale corporate MaaS in practice. *Travel Behaviour and Society*, *21*, 318–327. https://doi.org/10.1016/j.tbs.2018.12.005

Hietanen, S., & Sahala, S. (2014). Mobility as a Service. Can it be even better than owning a car? *Forum Virium Helsinki*, 1–56.

Hoerler, R., Stünzi, A., Patt, A., & Del Duce, A. (2020). What are the factors and needs promoting mobility-as-a-service? Findings from the Swiss Household Energy Demand Survey (SHEDS). *European Transport Research Review*, *12*(1). https://doi.org/10.1186/s12544-020-00412-y

İnaç, H., Oztemel, E., & Aydin, M. E. (2021). Smartness and Strategic Priority Assessment in Transition to Mobility 4.0 for Smart Cities. *Journal of Intelligent Systems: Theory and Applications*, *4*(2), 113–126. https://doi.org/10.38016/jista.933005

Jittrapirom, P., Marchau, V., van der Heijden, R., & Meurs, H. (2018). Dynamic adaptive policymaking for implementing Mobility-as-a Service (MaaS). *Research in Transportation Business & Management*, *27*, 46–55. https://doi.org/10.1016/j.rtbm.2018.07.001

Kamargianni, M., Li, W., Matyas, M., & Schäfer, A. (2016). A Critical Review of New Mobility Services for Urban Transport. *Transportation Research Procedia*, *14*(0), 3294–3303. https://doi.org/10.1016/j.trpro.2016.05.277

Kan, Z., Tang, L., Kwan, M. P., Ren, C., Liu, D., & Li, Q. (2019). Traffic congestion analysis at the turn level using Taxis' GPS trajectory data. *Computers, Environment and Urban Systems*, *74*, 229–243. https://doi.org/10.1016/J.COMPENVURBSYS.2018.11.007

Karlsson, I. C. M., Mukhtar-Landgren, D., Smith, G., Koglin, T., Kronsell, A., Lund, E., Sarasini, S., & Sochor, J. (2020a). Development and implementation of Mobility-as-a-Service – A qualitative study of barriers and enabling factors. *Transportation Research Part A: Policy and Practice*, *131*, 283–295. https://doi.org/10.1016/j.tra.2019.09.028

Karner, A., London, J., Rowangould, D., & Manaugh, K. (2020). From Transportation Equity to Transportation Justice: Within, Through, and Beyond the State. *Journal of Planning Literature*, *35*(4), 440–459. https://doi.org/10.1177/0885412220927691

Kayikci, Y., & Kabadurmus, O. (2022). Barriers to the adoption of the mobility-as-a-service concept: The case of Istanbul, a large emerging metropolis. *Transport Policy*, *129*, 219–236. https://doi.org/10.1016/j.tranpol.2022.10.015

König, D., Eckhardt, J., Aapaoja, A., Sochor, J., & Karlsson, M. (2016). *Business and operator models for MaaS: MAASiFiE Deliverable Nr 3*. Conference of European Directors of Roads (CEDR).

Kraus, L., Proof, H., & Jeppe, A. (2023). Estimation of joint value in mobility as a service ecosystems under different orchestrator settings. *European Transport Research Review*, *15*(1), 1–16. https://doi.org/10.1186/s12544-023-00594-1

Kunicina, N., Galkina, A., Zabasta, A., Patlins, A., & Kondratjevs, K. (2014). Traffic Route Modelling and Assignment with Intelligent Transport System. *Electrical, Control and Communication Engineering*, *7*(1), 34–40. https://doi.org/10.1515/ecce-2014-0021

Lamanna, M., Klinger, C. A., Liu, A., & Mirza, R. M. (2020). The Association between Public Transportation and Social Isolation in Older Adults: A Scoping Review of the Literature. *Canadian Journal on Aging / La Revue Canadienne Du Vieillissement*, *39*(3), 393–405. https://doi.org/10.1017/S0714980819000345

Leung, A., Burke, M., & Scott, P. (2023). Tourism MaaS – The case for regional cities. *Research in Transportation Business and Management*, *49*, Article 101017. https://doi.org/10.1016/j.rtbm.2023.101017

Li, Y., & Voege, T. (2017). Mobility as a Service (MaaS): Challenges of Implementation and Policy Required. *Journal of Transportation Technologies*, *7*(2), 95–106. https://doi.org/10.4236/jtts.2017.72007

Loukaitou-Sideris, A. (2020). A gendered view of mobility and transport: Next steps and future directions. *Engendering Cities: Designing Sustainable Urban Spaces for All*, 19–37. https://doi.org/10.4324/9781351200912-2/GENDERED-VIEW-MOBILITY-TRANSPORT-ANASTASIA-LOUKAITOU-SIDERIS

Lu, J., Li, B., Li, H., & Al-Barakani, A. (2021). Expansion of city scale, traffic modes, traffic congestion, and air pollution. *Cities*, *108*, Article 102974. https://doi.org/10.1016/J.CITIES.2020.102974

✉beata.chmiel@ug.edu.pl, ✉patryk.wierzbowski@ug.edu.pl

Lyons, G. (2020). Walking as a service – Does it have legs? *Transportation Research Part A: Policy and Practice*, *137*, 271–284. https://doi.org/10.1016/j.tra.2020.05.015

Maas, B. (2021). Conjoint analysis of mobility plans in the city of Dresden. *European Transport Research Review*, *13*(1). https://doi.org/10.1186/s12544-021-00478-2

Mańkowski, C., Szmelter-Jarosz, A., & Jezierski, A. (2022). Managing Supply Chains During the Covid-19 Pandemic. *Central European Management Journal*, *30*(4), 90–119.

Maretić, B., & Abramović, B. (2021). The spatial reorganization of an integration transport point: a case study of the city of Šibenik. *Transport Problems*, *4*(4), 15–22. https://doi.org/10.21307/TP-2021-056

Matowicki, M., Amorim, M., Kern, M., Pecherkova, P., Motzer, N., & Pribyl, O. (2022). Understanding the potential of MaaS – An European survey on attitudes. *Travel Behaviour and Society*, *27*, 204–215. https://doi.org/10.1016/J.TBS.2022.01.009

May, A. D. (2013). Urban Transport and Sustainability: The Key Challenges. *International Journal of Sustainable Transportation*, *7*(3), 170–185. https://doi.org/10.1080/15568318.2013.710136

McLeod, S., Scheurer, J., & Curtis, C. (2017). Urban Public Transport. Planning Principles and Emerging Practice. *Journal of Planning Literature*, *32*(3), 223–239. https://doi.org/10.1177/0885412217693570

Mubarak, F., & Suomi, R. (2022). Elderly Forgotten? Digital Exclusion in the Information Age and the Rising Grey Digital Divide. *INQUIRY, 59*. https://doi.org/10.1177/00469580221096272

Mulley, C., & Kronsell, A. (2018). Workshop 7 report: The "uberisation" of public transport and mobility as a service (MaaS): Implications for future mainstream public transport. *Research in Transportation Economics*, *69*, 568–572. https://doi.org/10.1016/J.RETREC.2018.08.007

Narayanan, S., & Antoniou, C. (2023). Shared mobility services towards Mobility as a Service (MaaS): What, who and when? *Transportation Research Part A: Policy and Practice*, *168*(November 2022), 1–15. https://doi.org/10.1016/j.tra.2023.103581

Nikitas, A., Kougias, I., Alyavina, E., & Njoya Tchouamou, E. (2017). How Can Autonomous and Connected Vehicles, Electromobility, BRT, Hyperloop, Shared Use Mobility and Mobility-As-A-Service Shape Transport Futures for the Context of Smart Cities? *Urban Science*, *1*(4), 36. https://doi.org/10.3390/urbansci1040036

Pangbourne, K., Mladenović, M. N., Stead, D., & Milakis, D. (2020). Questioning mobility as a service: Unanticipated implications for society and governance. *Transportation Research Part A: Policy and Practice*, *131*, 35–49. https://doi.org/10.1016/j.tra.2019.09.033

Papaioannou, G., Polydoropoulou, A., Tsirimpa, A., & Pagoni, I. (2022). Assessing the Potential of "Mobility as a Service" in Passenger Maritime Transport. *Frontiers in Future Transportation*, *2*, 1–11. https://doi.org/10.3389/ffutr.2021.710311

Remillard, E. T., Campbell, M. L., Koon, L. M., & Rogers, W. A. (2022). Transportation challenges for persons aging with mobility disability: Qualitative insights and policy implications. *Disability and Health Journal*, *15*(1), Article 101209. https://doi.org/10.1016/J.DHJO.2021.101209

Rey-Moreno, M., Periáñez-Cristóbal, R., & Calvo-Mora, A. (2023). Reflections on Sustainable Urban Mobility, Mobility as a Service (MaaS) and Adoption Models. *International Journal of Environmental Research and Public Health*, *20*(1). https://doi.org/10.3390/ijerph20010274

Rindone, C. (2022). Sustainable Mobility as a Service: Supply Analysis and Test Cases. *Information (Switzerland)*, *13*(7), 1–15. https://doi.org/10.3390/info13070351

Russo, F. (2022). Sustainable Mobility as a Service: Dynamic Models for Agenda 2030 Policies. *Information (Switzerland)*, *13*(355). https://doi.org/10.3390/info13080355

Russo, F., & Rindone, C. (2023). Smart City for Sustainable Development: Applied Processes from SUMP to MaaS at European Level. *Applied Sciences (Switzerland)*, *13*(3), 1–18. https://doi.org/10.3390/app13031773

Sakai, K. (2019). MaaS trends and policy-level initiatives in the EU. *IATSS Research*, *43*(4), 207–209. https://doi.org/10.1016/j.iatssr.2019.11.001

Sarasini, S., Sochor, J., & Arby, H. (2017). What characterises a sustainable MaaS business model? *1st International Conference on Mobility as a Service (ICOMaaS)*, 1–15.

Smith, G., Sochor, J., & Karlsson I. (2018). Mobility as a Service: Development scenarios and implications for public transport. *Research in Transportation Economics*, *69*, 592–599. https://doi.org/10.1016/J.RETREC.2018.04.001

Tiznado-Aitken, I., Guerrero, B. T. E., & Sagaris, L. (2024). Uncovering gender-based violence and harassment in public transport: Lessons for spatial

✉beata.chmiel@ug.edu.pl, ✉patryk.wierzbowski@ug.edu.pl

and transport justice. *Journal of Transport Geography*, *114*, Article 103766. https://doi.org/10.1016/J.JTRANGEO.2023.103766

Vitetta, A. (2022). Sustainable Mobility as a Service: Framework and Transport System Models. *Information (Switzerland)*, *13*, 346. https://doi.org/10.3390/info13070346

Wang, L., Xue, X., Zhao, Z., & Wang, Z. (2018). The impacts of transportation infrastructure on sustainable development: Emerging trends and challenges. *International Journal of Environmental Research and Public Health*, *15*(6). https://doi.org/10.3390/ijerph15061172

Wang, P., Chen, X., Zheng, Y., Cheng, L., Wang, Y., & Lei, D. (2021). Providing real-time bus crowding information for passengers: A novel policy to promote high-frequency transit performance. *Transportation Research Part A: Policy and Practice*, *148*, 316–329. https://doi.org/10.1016/J.TRA.2021.04.007

Wright, S., Nelson, J., & Cottrill, C. (2020). MaaS for the suburban market: Incorporating carpooling in the mix. *Transportation Research Part A: Policy and Practice*, *131*, 206–218. https://doi.org/10.1016/J.TRA.2019.09.034

Xi, H., Tang, Y., Waller, S., & Shalaby, A. (2023). Modeling, equilibrium, and demand management for mobility and delivery services in Mobility-as-a-Service ecosystems. *Computer-Aided Civil and Infrastructure Engineering*, *38*(11), 1403–1423. https://doi.org/10.1111/mice.12958

Zhao, X., Andruetto, C., Vaddadi, B., & Pernestål, A. (2021). Potential values of maas impacts in future scenarios. *Journal of Urban Mobility*, *1*, Article 100005. https://doi.org/10.1016/J.URBMOB.2021.100005

Zijlstra, T., Durand, A., Hoogendoorn-Lanser, S., & Harms, L. (2020). Early adopters of Mobility-as-a-Service in the Netherlands. *Transport Policy*, *97*, 197–209. https://doi.org/10.1016/j.tranpol.2020.07.019

✉beata.chmiel@ug.edu.pl, ✉patryk.wierzbowski@ug.edu.pl