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Is Mobility as a Service an effective solution to achieve smart mobility?

A multiple case study of European MaaS aggregators.

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ABSTRACT

Mobility as a Service is a new concept that has raised enormous expectations since its launch, as it seemed to be the ultimate solution to transition to a smarter and more sustainable urban mobility. However, a few years after its conception, MaaS aggregators have collided with operational reality and many challenges and critical aspects have arisen. This explorative research provides a multiple case study of European MaaS aggregators, integrated with a sample of stakeholders involved in the MaaS ecosystem, and attempts to comprehend whether these solutions can effectively help the transition to smart mobility. Qualitative data were collected through semi-structured interviews and then analysed through the thematic analysis method. The key findings are: (1) MaaS aggregators are not an effective solution in the short term, as they are in a delicate transitional phase where user numbers are still too low to have a significant impact; (2) in the long term, if MaaS aggregators manage to find effective answers to the various critical aspects presented in this research, they have the potential, as also demonstrated by some studies, to be an effective support for the achievement of smart mobility; (3) MaaS alone it's not the ultimate solution to smart mobility, however if its positive growth continues, it will certainly play an important future role in it.

Keywords: *MaaS, MaaS Aggregators, Smart mobility*

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1. INTRODUCTION

This initial chapter first presents the general context to which the phenomenon investigated in this research belongs. Immediately afterwards, the purpose of the work, the research questions that guided this study, and the author's contribution to the literature are explained. To conclude, the structure of the research is illustrated briefly.

1.1 General Background

Smart cities are efficient interconnected urban environments designed with two key aims: reduction of cities' environmental impact and improvement of the overall quality of life of its inhabitants (Bibri & Krogstie, 2017). The smart city model has become more and more important in the last fifteen years as testified by the increased attention of academia on this issue. Thanks to the extensive systematic literature review conducted by Cocchia (2014), in which the author has analysed 705 papers, it has been possible to grasp the significant increase of published research on this topic since 2007. The reason behind this increase in interest is that this innovative way of conceiving the city seems to be the solution for the development of a sustainable future.

As forecast by the United Nations by 2050 about 66% of the world's population will live permanently in cities. This new distribution involves important social and environmental challenges and requires us to implement effective solutions. The growth of cities without a substantial change would be catastrophic for our planet. Indeed, already at the current rate cities are responsible for the usage of approximately 70% of the world's resources (United Nations, 2015).

The dimension of the smart city model on which the focus is higher for the improvement of the quality of life of citizens and reduction of the environmental impact of cities is the smart mobility. As demonstrated also by Dameri et al. (2017), of the 42 smart city projects analysed in their research, nearly half are oriented to the achievement of smart mobility.

The importance of reaching a new sustainable and intelligent mobility is due to the enormous negative externalities it currently generates. Indeed, the transport sector is one of the main pollutants, accounting for 25% of greenhouse gas emissions in the world, and furthermore, 70% of these emissions are produced by urban mobility (García-Ayllón & Kyriakidis, 2022). Therefore, it is fundamental to point out that this number is set to grow, in fact, urban passenger mobility demand is increasing sharply and by 2050 it could be 38% higher than in 2010 (United Nations, 2017).

Mobility has always been one of the most complex and critical aspects of any city, it becomes smart mobility when the citizen can access an intelligent system of modes of transportation that, through the adoption of information and communication technologies (ICTs), can use information in real-time. Thanks to this system it would be possible to achieve the two key aims of a smart city cited before. People can save time and money, and improve their trips, and at the same time, help the city to reduce greenhouse gas emissions (Zapolskyte et al., 2022).

One of the most studied and promising solutions for the development of a successful smart mobility are the Mobility as a Service (MaaS) aggregators. These digital platform ecosystems, offering multimodal sustainable transport modes, propose themselves as an answer to the social-environmental challenges that our cities have and in the future will have to face (Ydersbond et al., 2020). The central nodes of these ecosystems are the MaaS providers that own the platforms through which the transport providers offer their services (see figure 1).

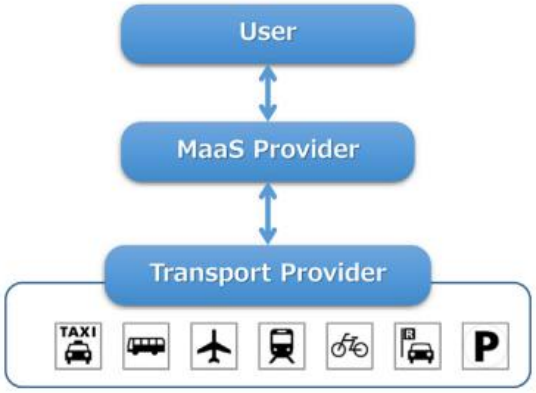

Figure 1: MaaS model – (Sakai, 2019)

These integrated platforms propose a bundle of transportation options, both public and private, offering a tailored service to the end-user that could replace the private car for all, or at least most, of his travels (Ydersbond et al., 2020).

1.2 Research purpose

It is now clear that cities should be radically transformed to reduce their negative environmental impact on the planet. As it is presented in more detail in the literature review, since urban transport is one of the most critical aspects, achieving sustainable and Smart mobility is therefore essential. This research is focused on what appears to be one of the most promising solutions for reaching this important goal: Mobility as a Service (MaaS). The concept of Mobility as a Service has aroused great interest since its presentation in 2014 during the Intelligent Transportation System (ITS) Europe Congress. Since that day, the literature on this subject has grown enormously. Indeed, MaaS

aggregators seemed to have the potential to revolutionise urban mobility helping to achieve the socio-environmental goals of the cities (Arias-Molinares & Garcià-Palomares, 2020). However, in the following years, various challenges and difficulties arose during the implementation phase, and the literature agreed that MaaS could achieve the final goal of smart mobility only if these issues can be resolved (Zhao et al., 2020). With this exploratory research, the author wants to verify whether the high expectations initially placed on this solution were justified by understanding if MaaS aggregators can be an effective solution to achieve sustainable smart mobility.

1.3 Delimitations

This research is limited to the European continent, indeed it would be impossible for the author, considering time constraints, to conduct an accurate study of MaaS aggregators worldwide. Furthermore, the researcher will investigate MaaS only from the perspective of MaaS aggregators, thus excluding MaaS operators that do not provide a multimodal mobility service. Finally, no attempt will be made to define MaaS, for it has already been extensively discussed in literature. The primary focus of this research will be on studying MaaS from an operational point of view.

1.4 Research questions

The formulation of the research questions is a critical factor in any research. Research questions influence the choice of the methodology and, in particular, have an impact on the data collection phase. Even though the nature of this research is explorative the researcher decided to formulate well-defined research questions to avoid loss of focus on the chosen issue. The development of too open-ended questions could have led to the collection of too much data that would be useless for research purposes, for this reason, the risk of not carrying out a clear study was high (Bell et al., 2018).

To formulate and refine the research questions of this work the author adopted the “what, why, and how” framework elaborated by Watson (1994).

What?	Why?
What puzzles/intrigues me! What do I want to know more about/ understand better? What are my key research questions?	Why will this be of enough interest to others to be published as a thesis, book, paper, guide to practitioners or policy makers? Can the research be justified as a 'contribution to knowledge'?
How – conceptually?	How – practically?
What models, concepts and theories can I draw on/develop to answer my research questions! How can these be brought together into a basic conceptual framework to guide my investigation?	What investigative styles and techniques shall I use to apply my conceptual framework (both to gather material and analyse it)? How shall I gain and maintain access to information sources?

Figure 2: "what, why and how" framework - *(Watson, 1994)*

Following the matrix above (see figure 2) and, considering the research purpose, the author elaborated the following research question:

RQ: *Can Mobility as a Service (MaaS) aggregators help implement the smart mobility model?*

To provide an answer as complete as possible to the main research question the researcher developed the following sub-questions:

SQ1: *What is the current state of development and market adoption of MaaS aggregators in Europe?*

SQ2: *What are the implementation challenges that MaaS aggregators are facing?*

SQ3: *What is hampering the adoption of MaaS aggregators now and what could be integrated in the future?*

The author in answering the research questions wants to make his small contribution to the literature by providing research that combines the relevant academic literature with primary data gathered from interviews. In achieving the purpose of this research, several aspects of MaaS aggregators were investigated. First, the author deepened the study on the implementation challenges that MaaS aggregators are facing. Then, on their actual stage of development and market response, the factors that are hampering their adoption and the future trends that these solutions should be able to integrate to be more effective, the literature was found to be scarce or outdated and, therefore, the researcher hopes with this work to help fill these research gaps.

1.5 Research structure

This research is structured into six chapters:

1. Introduction
2. Literature review
3. Methodology
4. Empirical findings
5. Data analysis
6. Conclusions

The introduction chapter provides a general presentation of this study. This chapter explains the general background, the purpose of this research, its delimitations, the contributions the author intends to make and the research questions that oriented this work.

The literature review chapter follows a funnel approach. It starts by presenting the smart city model to which the smart mobility dimension belongs and then, increasingly narrowing the exploration of the theory on the focus of this research, addresses the specific concepts on which the Mobility as a Service and MaaS aggregators are based. Therefore, the research gaps identified, and the theoretical framework are outlined at the end of the chapter.

The methodology chapter presents and explains the choices concerning the nature and structure of this research and the different techniques and methods used to collect both primary and secondary data and to analyse the first ones.

The empirical findings chapter includes all summaries of the literal transcripts from the semi-structured interviews, organised by company.

The data analysis chapter is organised into four sections in which the data from the interviews are presented and compared with the literature review. In the first one, the structure and functioning of the MaaS aggregators interviewed are analysed and a twofold categorisation of them is performed. The other three sections discuss the aggregated themes that emerged from the coding process. Finally, the last section illustrates the revised theoretical framework elaborated at the end of the analysis process.

The conclusions chapter, using the key results of this study, presents the answers to the research questions. In addition, the potential implications that the results of this research may have, research limitations and future research proposals are discussed at the end of the chapter.

2. LITERATURE REVIEW

This chapter includes all the theoretical concepts on which this research is based. Conducting an in-depth literature review is essential to have an accurate knowledge of the phenomenon under study and of the context in which it occurs (Bell et al., 2018). This chapter is structured as a funnel (see figure 3), it begins with the general context and then gets incrementally tighter addressing the specific concepts on which the Mobility as a Service (MaaS) and MaaS aggregators are built. It is divided into six sections. In the first section, the smart city paradigm is presented in brief, this part was necessary to understand the background in which the MaaS concept was born. In the second section, the focus is on one of the main dimensions of the smart city model, the smart mobility. In the third section, the MaaS model is carefully defined. In the fourth section is illustrated the Digital business ecosystem (DBE) concept as it is the structure of MaaS aggregators. Finally, in the last two sections, the research gaps identified after the literature review and the theoretical framework that will be used during this research are presented.

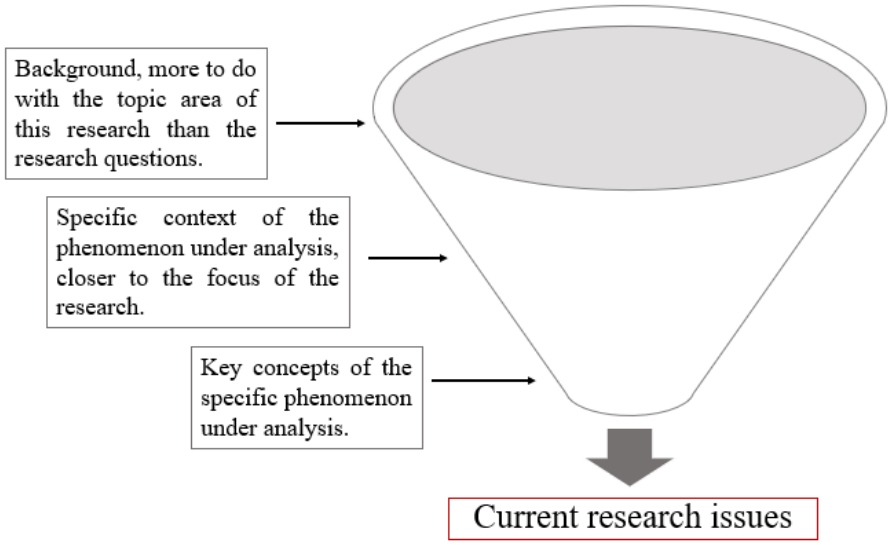

Figure 3: Literature review funnel – *(produced by the author)*

2.1 Smart city paradigm

The concept of smart city was first coined between the 80s and 90s, but it has become extremely popular only in the last decade (Cocchia, 2014). Several projects have been implemented or are under development in many cities around the world, and even if they have different characteristics and approaches, they share the same goal. Every project aims to make the city a more sustainable place for its inhabitants using the latest technologies (Dameri, 2013). Cities are transforming into

“Smart” cities thanks to the implementation of Information and Communication technology (ICT) in different aspects of the urban system, indeed as outlined by Neirotti et al. (2014), the adoption of the smart city model entails an intelligent urban development to achieve sustainable growth.

This aspect is crucial because the global population is increasing and, as a consequence, cities will become increasingly bigger. As forecasted by the United Nations (2016) now about 55% of the global population lives in urban contexts and by 2030 the percentage will grow up to 66%. With this estimated growth cities will have to deal with new challenges, such as: traffic congestion, parking allocation, saturated transport networks, pollution, waste management etc. (Camero & Alba, 2019). To address these issues, cities need to implement a variety of new smart solutions to meet citizens' needs efficiently, while limiting negative externalities as much as possible (Albino et al., 2015). In this scenario, the concept of smart city has been seen as an all-encompassing strategy to solve the new socio-environmental issues of cities (Zhao et al., 2021).

The literature about the smart city concept is wide and fragmented and a clear definition of this model lacks (Keshavarzi, Yildirim, & Arefi, 2021). The concept of smart city is defined in several different ways and the word “Smart” is often substituted by other terms such as: digital, sustainable, and intelligent.

Although the terminology is heterogeneous and there are various definitions which differ slightly from each other, it was possible to identify a common element between all the definitions, the use of Information and communication technology (ICT) to provide high-quality services to the smart inhabitants (Dameri, 2013). Basically, the smart city model consists of increasing the efficiency of cities with an intelligent management of urban systems based on the use of ICT and other types of technology (Bibri & Krogstie, 2017).

The ICT in its various shapes (infrastructures, applications, data analytics capabilities, and services) is the central focus of every smart city project. The ICT evolution and the urban growth should be directly proportional to achieve a strategic sustainable development of the cities. Without ICT it would be impossible to face the urgent and complex challenges that the ever-growing cities have to deal with. In fact, many cities have already implemented smart solutions that are based on ICT to increase the levels of sustainability and liveability (Bibri & Krogstie, 2017). Thus, the only way to make urban living more sustainable, limiting as much as possible the impact of the cities on the environment, is the implementation of an integrated computerized urban society (ibid).

Given the above and, taking into consideration the nature of this work the researcher believes that the following definition, coined in the ISO (2018, p. 1-95) report, is the most suitable, cities can be

defined as “Smart” if they: “Provide better services for citizens; provide a better life environment where smart policies, practices and technology are put to the service of citizens; achieve their sustainability and environmental goals in a more innovative way; Identify the need for smart infrastructure; facilitate innovation and growth; and build a dynamic and innovative economy ready for the challenges of tomorrow”. This definition considers almost all key points of the smart city model, it contains all the actions and general objectives of an ideal smart city. Therefore, it stresses another important concept, the fact that technology is essential but always with the final aim of improving people's quality of life. The ICT must be at the service of citizens and must be used to reach the socio-environmental objectives of the cities (Batty, et al., 2012).

However, there is one element that is missing, the social nature of this phenomenon. As explained by Neirotti et al. (2014) every city is a complex urban ecosystem composed of several actors: citizens, local authorities, and firms from various sectors. In this perspective, the ecosystems can be seen as “intelligent communities” where the collaboration between the actors can be facilitated by technology (Appio, Lima, & Paroutis, 2019). To conclude, the development and implementation of new technologies must be complementary to the needs of the ecosystem (Neirotti et al., 2014). ICT or other technologies alone cannot transform cities (Attour & Burger-Helmchen, 2015).

2.1.1 Smart city dimensions

After having defined the concept of smart city, is useful to delve into the characteristics of the model. Several authors have researched this topic, the most cited work is Giffinger & Gudrun (2010), the two researchers conceptualised six dimensions on which the Smart city model is based (see figure 4).

1. Smart Environment:

Every smart city must reduce its ecological footprint. This dimension includes different aspects of the city environment: sustainable resource management, environmental protection and reduction of pollution (Staffans & Horelli, 2014).

There are several fields in which the adoption of the technology (Internet of things or Internet of Data) can make the management of the city environment “smart”. For example, cities can apply technology to the waste cycle (collection, disposal, and recycling) thus handling the waste generated by people, firms, and city services in a smart way (Neirotti et al., 2014). Alternatively, they could adopt smart solutions to manage sustainably the environmental resources and related infrastructure. However, whatever the “smart” solution or field to which it is applied the key

element to streamline services is the use and sharing of real-time data (Appio, Lima, & Paroutis, 2019).

2. Smart People:

This dimension emphasises the importance of human and social capital for smart cities' growth. Human capital is the set of skills and competencies of a group of people (i.e., inhabitants of the city), while social capital can be defined as the network of relationships of social institutions (Appio, Lima, & Paroutis, 2019). These two factors are interconnected and their development it's important to foster economic growth (ibid). In this dimension, technology is an important tool that facilitates the learning and working of people. Therefore, ICT is also a tool that can increase citizens' participation in the life of smart cities. This factor is fundamental, in fact, smart cities aim to improve the lives of their citizens by creating a sustainable, inclusive and dynamic community (Al Sharif & Pokharel, 2022).

3. Smart Economy:

The concept of smart Economy is intended as the new collaborative business environment that is growing thanks to the development of a multitude of innovative solutions that are trying to solve the challenges of Smart cities (Appio, Lima, & Paroutis, 2019). Smart cities are characterised by a dynamic context that fosters knowledge sharing and attracts new talents, technologies, and ideas. Indeed, smart cities are creating several hubs (Research centres, Innovation parks etc.), based on the collaboration between the public and private sectors, in which new projects that can create both economic and social value are developed (ibid).

4. Smart Governance:

In the innovative context of smart cities, the role of the public authorities is crucial. The various Governance entities (GEs), as explained by Appio et al. (2019, p. 8) must: "certify data quality and integrity, coordinate various stakeholders (including citizens) throughout and the value chains and generate both internal and external awareness about smart city initiatives". Government entities (GEs) assume a central role in the urban ecosystem, and they can succeed in their new complex task thanks to the extensive use of ICT (Appio, Lima, & Paroutis, 2019).

5. Smart Living:

Smart Living more than a dimension can be considered as the final objective that smart cities may achieve with the correct implementation of the other dimensions. Indeed, smart living presupposes a generalised improvement of the well-being of the citizen. Smart living comprises two main factors:

quality of life and sustainability (OECD Statistics and Data Directorate, 2017). All the smart solutions should help improve one of these spheres.

To conclude this brief presentation of the different layers of the smart city model the analysis of the smart mobility dimension lacks. It's important to carefully define smart mobility because is the general boundary of this research and within and for this specific context the MaaS solution was invented. Considering the focus of this research and, for what has been said so far, this last dimension will be explained in detail in the next section.

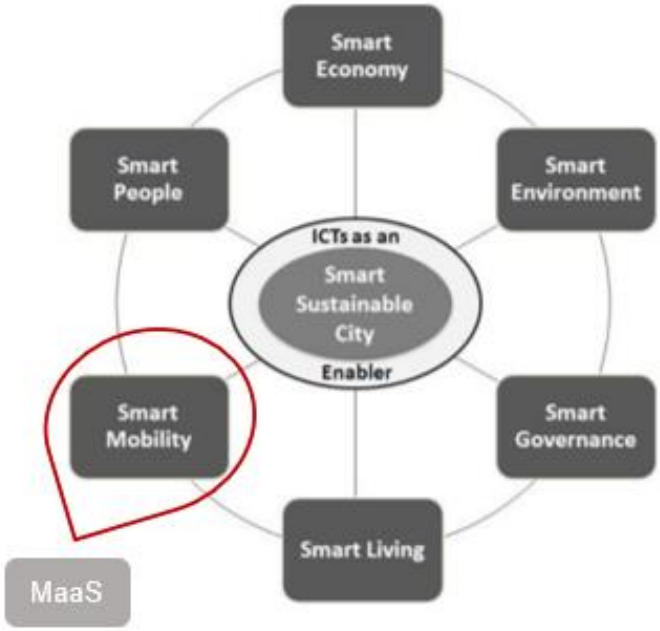

Figure 4: The six dimensions of smart city - Adapted by the author from *(Ibrahim, El-Zaart, & Adams, 2017)*

2.2 Smart mobility

Smart mobility is probably the most studied dimension of the smart city model. Just to provide a figure, is interesting to mention the research of Dameri et al. (2017) in which of 42 ICT enabled smart city projects analysed nearly half (18) were focused on smart mobility. The actual trend for all the cities worldwide is to develop and implement smart solutions to improve transport network efficiency, trying to achieve an ever-increasing integration (Albino, Berardi, & Dangelico, 2015).

As in the case of the smart city model, a clear and unique definition of this concept lacks. In general, smart mobility can be defined as an integrated, intelligent transportation system (ITS), of people and goods, that through the intensive adoption of different technologies, will make urban mobility more efficient, safe, and sustainable (Munhoz, et al., 2020). In its work, Ertico (2019, p. 6)

clearly explained the concept of ITS, which are: “systems in which information and communication technologies (ICT) are applied in the field of road transport, including infrastructure, vehicles and users, and in traffic management and mobility management, as well as for interfaces with other modes of transport”.

Intelligent transportation systems thus presuppose two factors:

- The digitalization of the urban infrastructures, using short-range and long-range communication technologies, to obtain real-time information about traffic congestion, accidents, parking situation, pollution levels, etc. (Appio, Lima, & Paroutis, 2019). Through the collection and monitoring of data in real-time cities authorities can manage efficiently the mobility infrastructure, reducing the travel time and the impact on the environment of the users (Munhoz, et al., 2020).
- The implementation of ICT to achieve a multi-modular world, as will be explained in detail in the next paragraph, in which smart cities will offer different interconnected mobility alternatives such as carsharing, bike-sharing, ridesharing, public transportation etc. (Groth, 2019).

The long-term vision is to create an urban ecosystem in which it will no longer be necessary to own a car (Appio, Lima, & Paroutis, 2019). To disincentivize the use of ones own motorized vehicles it is necessary to increase the quality and availability of public transportation and offer new capillary modes of travel (ibid). In this scenario, citizens could choose from the various mobility proposals the one most appropriate to their needs (Bıyık, et al., 2021). Keeping in mind that, as stated in the section above, the final aim of any project should be the improvement of the well-being of the citizen, in fact through the implementation of the smart mobility model citizen could experience a: “convenient, safe, active, balanced, and secure lifestyle because they could pick from many interlinked transit options” (ibid, p. 6).

However, vehicles for the transportation of people and goods will obviously continue to circulate, but through a smart mobility network in which there will be a vehicle-to-vehicle (V2V), vehicle-to-urban infrastructures (V2I) and urban infrastructures-to-vehicle communication (I2V) there won’t be the actual chaotic urban mobility (Ertico, 2019). Connectivity will allow to effectively manage the different aspects of city traffic, making mobility safer and sustainable. First, by providing safety-based services to drivers, such as blind spot monitoring, navigation systems, cooperative automated cruise control and eco-driving (ibid). Second, by providing real-time services on the status of urban infrastructures, such as: street parking management, park & ride information,

dynamic traffic information and smart routing services (ibid). Combing these two types of services city authorities can reduce traffic congestion, limit negative externalities, and at the same time improve the mobility experience of the citizen (Bıyık, et al., 2021).

As in the other five layers of the Smart city model, the role of the technology is crucial, both for optimizing traffic management and improving the quality of urban transportation. This research is interested in on how the urban transportation is changing and, in particular, is focused on Mobility as a service (MaaS) as it's one of the most promising solutions to tackle the challenges of urban mobility (Moura, 2018).

2.2.1 Smart mobility objectives

The actual urban mobility of the cities is a complex and intricate system of which a multitude of actors are part, after decades of substantial stagnation where the car was considered the indispensable element of the system, we are now experiencing a period of great change (Arthur D. Little, 2018).

This transformation is essential for the future smart cities and their sustainable vision, transport is one of the main pollutants, accounting for 25% of greenhouse gas emissions in the world, and going into greater detail, 70% of these emissions are produced by urban mobility (García-Ayllón & Kyriakidis, 2022). This number is set to grow, in fact, urban passenger mobility demand is increasing sharply and by 2050 it would be 38% higher than in 2010 (United Nations, 2017).

Smart mobility, as explained in the previous section, seems to be the solution. As stated by Gabrys: "Smart mobility is generally an approach that aids in the reduction of poisonous fumes expelled into the atmosphere by vehicles and human congestion. Equally, smart mobility aids in raising the quality of transportation in a manner that is environmentally friendly" (Bıyık, et al., 2021, p. 2). Analysing the above definition, two macro-objectives of smart mobility can be identified. The first one is making urban mobility sustainable through the reduction of air pollution, traffic congestion and improvement of the use of resources etc. (Bıyık, et al., 2021). The second one is building a new "smart" mobility system that will be accessible to everyone, safe, comfortable, and tailored to the needs of each user (ibid).

2.3 Mobility as a service (MaaS) background

The Mobility as a service model (MaaS) aroused enormous interest during the 2014 Intelligent Transportation System (ITS) Europe Congress and since that day many solutions have been

developed and tested in several cities around the world (Butler, Yigitcanlar, & Paz, 2021). This concept was born out of the urgent need for future smart cities to adopt new mobility solutions that could be viable alternatives to car ownership. It has begun the so-called "servicing" era in which more and more people are moving beyond the concept of "ownership" to embrace the philosophy of "usership" (Arias-Molinares & Garcià-Palomares, 2020).

This new attitude to the consumption of the people, pooled with an ever-increasing connectivity encouraged the development of a new economic system known as the "Sharing economy" (Bai & Velamuri, 2021). To have a deeper understanding of the concept it's really useful to analyse the definition reported in the study of Puschmann & Alt (2016), they describe this model as a: "collaborative consumption made by the activities of sharing, exchanging, and rental of resources without owning the goods" (p. 95). The entire system is based on the key concept of using and sharing of products and services among others.

This new economic system is the strategy on which smart cities rely for the achievement of sustainable city life. One of the areas where the concept of sharing economy is having most success is personal urban mobility. An interesting definition of shared mobility is provided by Shaheen & Chan (2016, p. 573), in their work they describe it as: "the shared use of a motor vehicle, bicycle, or other mode, that enables travellers to gain short-term access to transportation modes on an as-needed basis". Many people aren't interested anymore in owning each mode of transportation, with the associated costs and risks, and they just want to purchase the service needed (Arias-Molinares & Garcià-Palomares, 2020). The sharing mobility model is composed of three main macro-areas: sharing of a vehicle, sharing of a passenger ride and the sharing of a delivery ride (Shaheen & Chan, 2016).

The growing adoption of this new attitude, on which MaaS solution bases its roots, depends on three main elements (Novikova, 2017):

- cost savings
- convenience of locations, use, and access for the end-users
- environmental awareness

These three factors perfectly summarise the essence of MaaS and outline the purpose of the existence of this new mobility solution.

2.3.1 MaaS model

In the context analysed above Mobility as a Service (MaaS) could play a fundamental role in the radical transformation of the urban mobility system, MaaS solutions can facilitate the shift to a more sustainable way of moving offering several transport services easily accessible on the personal devices of the citizen (Lopez-Carreiro et al., 2020).

Just as in the case of the smart city concept first and then smart mobility, there is no clear and commonly accepted definition of MaaS. In general, the most comprehensive definition, which also incorporates some of the concepts explained in the previous section, is the one of Arthur D. Little (2018) according to which: "MaaS aims to provide consumers with integrated, flexible, efficient and user-oriented mobility services. It implies a shift away from the personal ownership of individual motorised transportation modes, and non-integrated means of transportation towards the use of integrated multimodal mobility solutions consumed as services. This shift is enabled by combining transportation services from public and private transportation providers through an "integrated mobility platform" that creates and manages the journey and integrates planning and payment (based on mobility packages tailored to the needs of each customer segment) on a one-stop-shop principle" (p. 59).

The digital platform, owned by the MaaS aggregator, should allow the end-user to control every factor of their trip, providing real-time traffic information, proposing immediate alternatives to solve unforeseen problems and finally giving the possibility to book and pay for the various transport alternatives used without ever leaving the same digital interface, as it is shown by figure 5 (Alyavina, Nikitas, & Njoya, 2021).

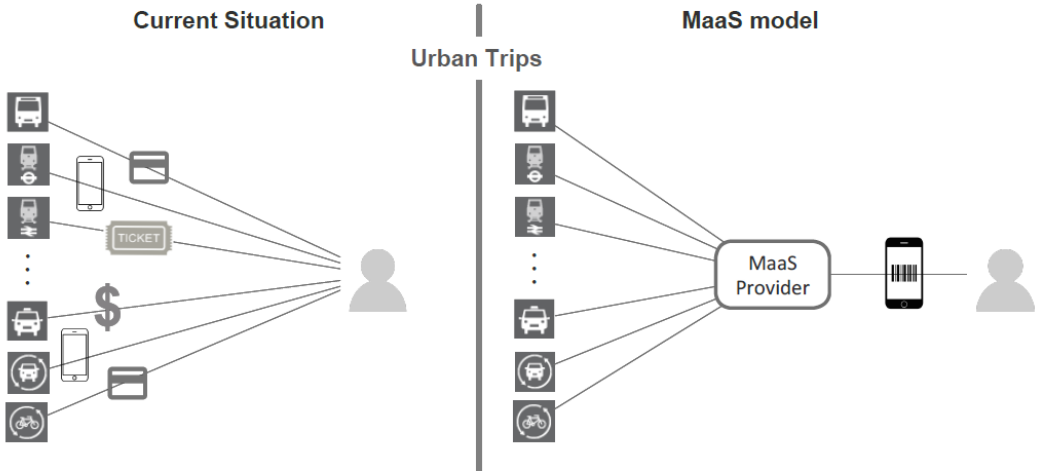

Figure 5: MaaS model operation - (Kamargianni & Matyas, 2017)

The platform can be considered as the central hub of a complex ecosystem and the MaaS aggregator is responsible both for the demand and supply side of the value chain. From a demand point of view, through the collection of real-time data from the different stakeholders of the ecosystem the MaaS operator is responsible for providing a "flexible, personalised on-demand service" (Atkins, 2015). The service of the MaaS aggregators should be the most convenient, fastest, and safest way to travel for the end-user. While, moving to the supply side, the MaaS provider must coordinate the various transport service providers assigning the daily trips required by the end-users and ensuring the quality of service (Kamargianni et al., 2019).

For a deeper analysis of the MaaS model, the graph proposed by the consultancy firm Arthur D. Little (2018) it's extremely valuable. In the graph are highlighted several factors on which the different MaaS solutions are built (see figure 6).

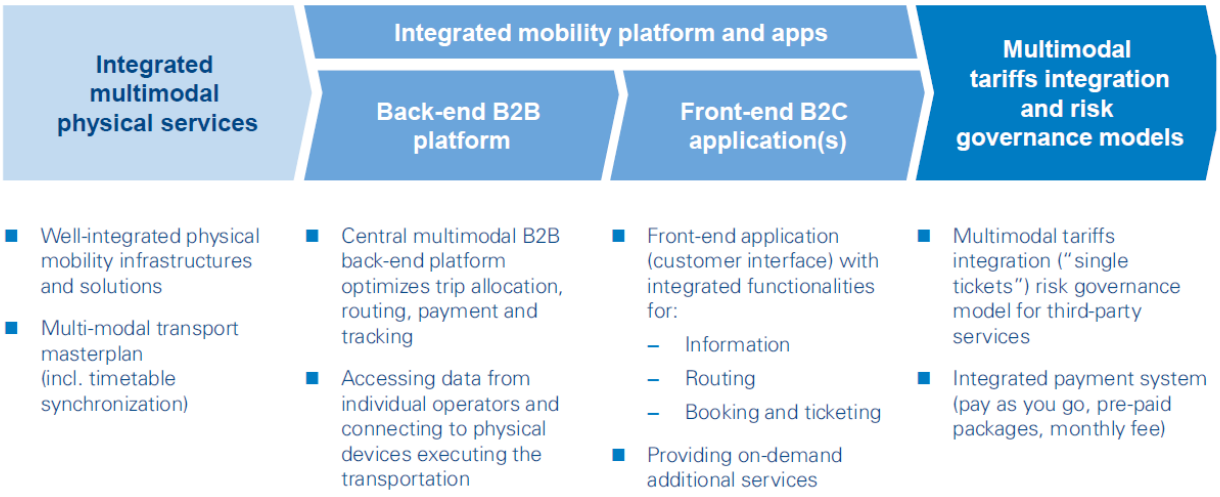

Figure 6: Key factors of the MaaS model - *(Arthur D. Little, 2018)*

All the key elements presented in the graph can be grouped in two macro-areas: integration and multimodality.

Integration is the core concept of the model, MaaS is based on a user-friendly single digital platform easily accessible by all the actors of the ecosystem (both end-users and providers). The platform, thanks to the extensive use of ICT, offers several integrated functionalities, such as routing, booking, ticketing and finally payment (Alyavina, Nikitas, & Njoya, 2021). The integrated payment system for the mobility services represents the true advantage of the MaaS operators as it provides different payment types to fully adapt to the individual needs of each customer. The payment methods vary from the classic "pay as you go" or "pre-paid packages" to personalised

bundled mobility packages tailored to the needs of each customer (Arthur D. Little, 2018; Arias-Molinares & Garcià-Palomares, 2020).

Another important functionality is the intermodal journey planning, the MaaS provider offers the optimal journey for each user providing multimodal mobility based on: taxi, ride-hailing, car-sharing or car rental, ride-sharing, carpool, bike-sharing and other micro mobility options, such as e-scooters, and walking (Alyavina, Nikitas, & Njoya, 2021). This service is made possible by the collection of real-time data on all available transport modes in the city (both public and private) and from the urban mobility infrastructure which provides information on the traffic situation (ibid).

Once the key components of the MaaS concept are outlined, to complete the analysis of the MaaS model it's now important to deepen the structure of the ecosystems centred around the digital platforms of the MaaS aggregators. These ecosystems are composed of many different actors, with different needs and ambitions, essential for the functioning of the platform itself (Arias-Molinares & Garcià-Palomares, 2020).

As presented by Alyavina et al. (2021), the main actors of the MaaS aggregators ecosystems are five:

1. **a MaaS provider**, that must facilitate the cooperation with all the actors involved to generate the final service for the end-users;
2. **transport Service Providers**, who offer their physical products on the platform, sharing their data with the MaaS operator to offer an increasingly customer-oriented service;
3. **technology providers**, who offer MaaS Operator their capabilities and technological solutions. These companies are essential for the operation of the platform, which is the heart of each MaaS operator, and enable the MaaS aggregators to provide services such as: journey planning, ticketing, payment etc.;
4. **public authorities**, that must facilitate and regulate the development of this new market.
5. **customers**, using the integrated service offered by the platform.

2.3.2 MaaS categorization

For the scope of this research, it's essential to define some criteria to categorize MaaS solutions. The various providers can be subdivided by the type of business model and by the level of service integration.

For the first categorization, Alyavina et al. (2021) propose three business models based on which actor assumes the role of MaaS provider (see figure 7):

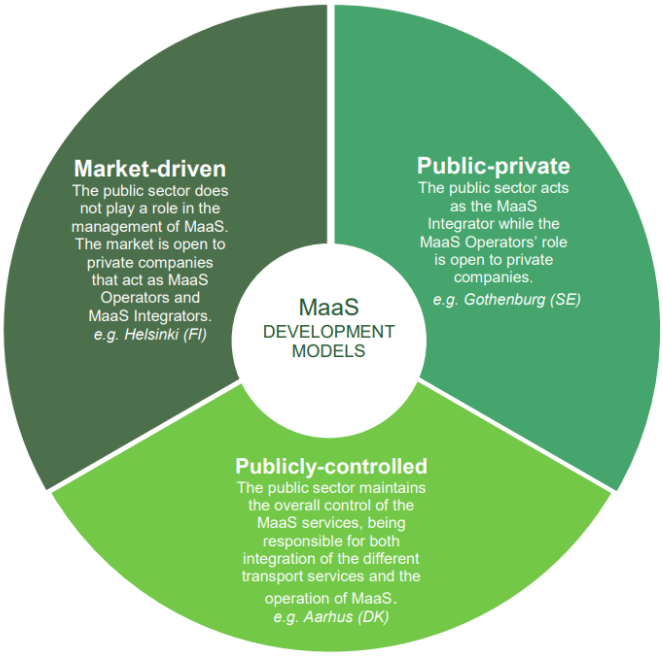

Figure 7: MaaS Development Models - *(Valdani, Vicari & Associati, 2019)*

1. **Commercial model (or market-driven)**, in this model the platform is owned by a private company that coordinates the different stakeholders of the ecosystem and guarantees the integrated service provided to the end customer. Generally, the private company is a transport service provider or a technology provider;

2. **Public controlled model**, in this case, the key role is assumed by a public authority (municipality, public transport provider etc.). The public authority must be able to procure all mobility services offered by private operators to make its solution as attractive as possible to the end-users;

3. **Public & Private Partnership model**, where there is a partnership between the public authority and the private firm. The public authority, often a public transport operator, is responsible for the procurement of various mobility services to be included in the ecosystem, while the private actor develops and manages the platform on which these services will be integrated.

The second way of categorisation, proposed by Sochor et al. (2018), depends on the level of integration of service provided by each platform. The following graph gives an immediate visual representation of the scale (see figure 8).

Figure 8: MaaS categorization based on the level of integration - *(Sochor et al., 2018)*

The scale has four steps, where step zero includes all the transport service providers that operate alone without integration. Climbing the ladder, level one represents the integration of information. All the companies that provide the end-user with a multimodal travel planning service are part of this category. Typically, they are big firms such as Google or Moovit, with a large customer base, that offer their services for free, earning from advertisement. These companies collect data from the transport service providers and help the users find the most suitable trip. The transport providers grant their data for free because they can have access to an enormous number of potential customers (Sochor et al., 2018). These companies aren't responsible for the quality of the service whose information they provide on their platform, they just facilitate the users in their daily trips (ibid).

Moving forward, level two integrates the booking and payment phases to the travel planner service already offered by the level one firms. At this level, the user isn't only able to find the best trip but can also book and pay for all the transport modes necessary for his travel on the same platform (Sochor et al., 2018). MaaS aggregators of level two are responsible for the payment phase but, as tier one operators, are not liable for the transport service provided via their platform. The source of income for operators are the brokerage commissions, indeed users aren't willing to pay a monthly subscription or extra costs for the service offered by level two MaaS providers (ibid).

Continuing with the analysis, level three firms achieved the so-called integration of the service offer, at this level the MaaS aggregators no longer act as mere brokers but, on the contrary, they propose themselves as an alternative to car ownership. Indeed, level three MaaS operators offer comprehensive bundled mobility services that can satisfy the needs of every single user or entire families. The customers are willing to pay a monthly subscription both because the MaaS

aggregator is the guarantor of the entire service and because they wouldn't be able to obtain the same complete service addressing the individual transport providers on their own. To keep a high quality of the service MaaS operators can't standardize their service, they must create an ecosystem composed of the best transport providers of each mode of the selected city (Sochor et al., 2018). The future aim is to have the same platform accessible in several cities with the same subscription.

Finally, level four includes the integration of societal goals, in this level the public authorities must cooperate with the MaaS providers to achieve the socio-environmental goals of smart mobility. Public actors could pursue this task by developing a framework of incentives, applicable through the MaaS providers' platforms, to influence the mobility choices of the citizen. To this day it seems that no MaaS aggregator has reached this last level and this research wants to understand what obstacles need to be overcome to make this happen (Sochor et al., 2018).

2.3.3 MaaS implementation challenges

It has been widely acknowledged that MaaS has the potential to be an effective solution for improving city mobility and there are several studies on how it can help reduce its negative externalities by reducing CO2 emissions (Cole, 2018; Zhao et al., 2020).

However, for MaaS to have a high impact and help achieve more sustainable urban mobility, there are several challenges that MaaS aggregators will have to overcome.

The first group of factors that could hamper the implementation of these solutions concerns end-users. MaaS belongs to the category of sustainable innovations and, as stated by Sopjani et al. (2019), for the success of solutions where users are considered core stakeholders it is fundamental to consider the habits and needs people. Within this category, there are two major challenges. Firstly, MaaS aggregators must be able to make potential customers perceive the benefits of their service compared to the means of transport used by the average person. People evaluate new services according to various functionalities, the most important of which are: ease and experience of use, cost-effectiveness, price-worthiness, and flexibility (Sochor, 2021). Second, they must succeed in the arduous task of changing the mindsets and travel habits of citizen (Sopjani et al., 2019). Taking the car as an example, car ownership gives several perceived benefits such as the feeling of freedom, social validity, and flexibility (ibid). MaaS providers should be able to communicate their unique characteristics to trigger this cultural change.

The second group contains the challenges of managing an ecosystem as complex as that of MaaS platforms. MaaS aggregators are having difficulty integrating the services of the different players in

the ecosystem needed to provide the multimodal experience to customers. As evidenced by the study of Hasselwander & Bigotte (2021) that involved 50 experts in the field, from a technical point of view this is caused by the absence of common Application Programming Interfaces (APIs) or other key technologies for integration, and the lack of open data or the unwillingness of the mobility providers to share data. While, from an organisational point of view, there is a need to increase the degree of cooperation. Some stakeholders are unwilling to cooperate and do not agree with the role of brokers of MaaS aggregators (ibid).

The third group of challenges concerns the regulations and policies of public actors. The role of public authorities is of fundamental importance for the development of MaaS, indeed, there is no certainty that technological development and new mobility services alone will succeed in the difficult task of influencing people's travel habits towards a more sustainable form of mobility (Crozet, Santos, & Coldefy, 2019).

The regulation of urban mobility is often fragmented and does not foresee specific categories for the new mobility services. As stated by Sochor, (2021, p.10): “Many policies and regulations may need to be tweaked or reworked to allow for such services to emerge at scale”. A regulatory update is crucial for new modes of urban mobility, for example only when: “MaaS is identified by city authorities as a type of sustainable transport mode with the same policy for government subsidy or tax reduction as other public transport modes, MaaS can be implemented in a city where subsidy and tax reduction is offered to those who commute by public transport” (Li & Voege, 2017, p.103). In addition, in several European cities, employees who decide to travel to work by public transport receive free subscriptions from the companies or tax reductions from the government. Without a clear framework for MaaS, employees who choose to use this sustainable mode of transport instead of public transport will not be guaranteed the same benefits (Li & Voege, 2017).

Therefore, there is also an urgent need for new policies that regulate and incentivise collaborative relationships between the various mobility service providers that decide to join the MaaS platform ecosystems (Hasselwander & Bigotte, 2021). Public authorities have different regulatory instruments that would facilitate the transition from the car ownership model to the usership model. Among the possible measures, they could introduce a congestion tax on the circulation of cars in the city or create reserved lanes for car-sharing vehicles (Crozet, Santos, & Coldefy, 2019). Finally, understanding the role that public transport companies should play in the development of this solution is crucial. Should they be the MaaS providers, or should they just invest in and collaborate with private MaaS platforms? (ibid).

The last key challenge for MaaS aggregators is to succeed in developing business models that are financially sustainable in the long term (Zhao et al., 2021). The business models of new mobility services providers face serious challenges. A lot of new MaaS providers have gone bankrupt and those who remain in business are hardly profitable (Crozet, Santos, & Coldefy, 2019). It is extremely difficult to find successful B2C business models and many MaaS providers whose ecosystems seemed to revolutionise urban mobility are having funding problems (ibid). The result is that players such as Whim or Moovel are seeking, and increasingly need, the support and funding of public transport authorities (ibid). A solution might be to be able to design suitable mobility packages and offerings that are increasingly responsive to user needs and have unique functionalities that users are willing to pay for (Hasselwander & Bigotte, 2021). Finally, MaaS cannot be a solution that alone can meet all the daily mobility demands of a city, the costs and investments involved would be enormous (Crozet, Santos, & Coldefy, 2019). The issue of cost is also one of the biggest barriers that are preventing these new mobility solutions to scale up. Certainly, MaaS is useful and can play a key role in the future urban mobility, but there is a need to understand the cases where multimodality has unique benefits compared to the use of a single mode of transport (ibid).

To conclude, for MaaS solutions to increase their effectiveness there must be alignment between the user, business, and societal perspectives (Sochor, 2021).

2.4 Digital platform ecosystem in MaaS aggregators

The digital platform ecosystem (DPE) is a new concept that incorporates the two related elements of digital platform and ecosystem, for the authors of this model the DPE comprises: “a platform owner that implements governance mechanisms to facilitate value creating mechanisms on a digital platform between the platform owner and an ecosystem of autonomous complementors and consumers” (Hein, et al., 2020, p. 4). In this paradigm, the final service of the digital platform is totally based on the independent providers of the ecosystem, without which the platform would lose interest in the eyes of end-users, but at the same time, it’s fundamental to point out that the digital platform is the only one able to provide the final service sought by citizen (ibid). There is therefore a strong interdependence between the various players in the ecosystem and the digital platform. The platform ecosystem assumes the so-called “hub and spoke” form, where a multitude of companies are connected to the central platform through ICT and other technologies that facilitate the exchange of data and services (Jacobides, Cennamo, & Gawer, 2018). All the companies cooperating in the creation of the final service are called complementors.

To continue the analysis of the model, it is useful to deepen the two key concepts of digital platform and ecosystem.

The first part of the definition above highlights the central role of the digital platform and its owner. According to Tan et al. (2015, p. 249), a digital platform can be defined as: “a commercial network of suppliers, producers, intermediaries, customers and producers of complementary products and services termed complementors that are held together through formal contracting and/or mutual dependency”. The main task of the platform owner is to manage the complex ecosystem of complementors participating in the co-creation of the final service through appropriate governance structures (Asadullah, Faik, & Kankanhalli, 2018). The platform owner sets the rules for managing the interactions between the actors of the supply and demand side of the ecosystems (Hein, et al., 2020). However, the digital platform also has two other duties, in fact, the platform providers take the roles of “facilitators” and “guarantee”. They help with the collection and sharing of data, but they also monitor, control, and optimise the services for end-users (Kohtamäki et al., 2019). This solution has become so popular because simplifies and optimises the customer experience allowing, at the same time, a reduction of transaction costs, including distribution, search, contracting, and monitoring costs (Asadullah, Faik, & Kankanhalli, 2018).

The second key element that must be briefly explained is the ecosystem concept. The ecosystem is formed around the digital platform and is basically an innovative way of organizing economic activities (Jacobides et al., 2019). The ecosystem organisational form allows the coordination of a multitude of autonomous firms offering complementary products or services necessary for the creation of the final product or service that attracts the customer (ibid).

It has been explained what an ecosystem does, now it is necessary to give a definition of what it is. There is no single definition of this concept and according to Jacobides et al. (2018), one of the leading experts in the field, in the academic literature could be identified three broad categories of ecosystems: the business ecosystem, the innovation ecosystem and the platform ecosystem. The model under analysis enables the formation of a platform ecosystem that is composed of all the stakeholders that make the digital platform service attractive to the end-users (ibid). In this view, the ecosystem could be defined as a: “set of actors that contribute to the focal offer’s user value proposition” (Kapoor, 2018, p. 2). The contribution to the focal offer could be both upstream and downstream of the value chain. In the case of the MaaS aggregators, the several transport service providers contribute to the upstream phase while technology providers, with their capabilities, are present in all stages of the process leading to the "production" of the final service (i.e., booking, payment, travel planning, data collection and elaboration) (ibid).

The DPE model described above perfectly reflects the characteristics of the structure of the MaaS aggregators. They are based on a digital platform, which regulates and coordinates an ecosystem of several stakeholders that provide different services to the platform. The core providers are the transport operators that supply all the transport modes that will be integrated by the platform to offer the customer the optimal journey. It's important to point out the strong interdependencies between the MaaS operators and the transport providers, indeed without the physical transport providers' vehicles, the digital platform would become a mere journey planner (such as Google maps) while these latter without contributing to the platform would lose three main advantages. First, they would lose the opportunity to enter a new market that, in a near future, could be worth multi-trillion thanks to the transition from mobility ownership to mobility usage. Second, they would lose a possible increase in market share in the short term. Third, they would not have access to the platform's capacity to manage demand flows. Indeed, MaaS aggregators, gathering the data in real-time can avoid overloads for each transport provider improving the quality of their service and thus customer satisfaction (Kamargianni & Matyas, 2017).

The MaaS digital platform, in addition to providing an integrated mobility service, must also consider the socio-environmental objectives of the city. As explained by Kohtamäki et al. (2019, p. 389): "the platform business models may be aligned with sustainability arguments by reducing energy consumption and waste by effectively using economies of scope". Regardless, the achievement of societal goals doesn't only depend on MaaS aggregators, indeed cooperation with public authorities is crucial for the achievement of sustainable mobility.

To complete the analysis of this model there is one last factor to be analysed, the fundamental role of technology. Indeed, MaaS digital platform ecosystems are completely reliant on the extensive use of the latest technologies.

Digital technologies are making possible the redesign and optimisation of entire industries, the urban mobility field is undergoing a huge transformation, and MaaS aggregators should help to achieve the smart mobility paradigm (Jacobides et al., 2019).

Going into detail, MaaS operators employ Information and communication technologies (ICT) to coordinate and manage the complex ecosystem of providers and customers and big data and cloud computing to store, analyse and use the enormous flow of real-time data coming from customers, transport providers, and urban infrastructures (Kamargianni & Matyas, 2017).

Using these technologies and through an intelligent data collection, the orchestrator of the ecosystem (i.e. the MaaS operator) can optimize the journey planning considering the real-time

situation of the city and, by combining various modes of transport offered by its providers, is then able to propose the optimal trip to the customer (Arthur D. Little, 2018). By continuing to collect data from its customers, the digital platform will then be able to provide a mobility service that will be increasingly aligned with the needs, expectations, and travel habits of each of its users (ibid). To conclude, MaaS aggregators seem to have realised that: "Mobility can now be seen as an information service with physical transportation products, rather than a transportation product with additional services" (Florence School of Regulation, 2016, p. 85).

2.5 Research gaps

The review of the current academic literature on the subject matter of this research enabled the author to gain a deeper understanding of the context and characteristics of the solution being researched. The academic literature has extensively studied the smart mobility paradigm and MaaS, as it seems to be one of its most promising solutions. Several pieces of research on this solution have been carried out in the last 8 years, many of which focused on giving a definition of MaaS or identifying the core elements of this solution. Furthermore, there are also some research papers on the major challenges MaaS aggregators are facing.

However, despite the academic effort, at the end of the literature review process, two areas where literature is scarce or outdated were identified:

- The current state of development of MaaS aggregators and the response of the European market to these innovative solutions;
- The future trends that the MaaS aggregators could integrate to be increasingly effective and competitive and the missing factors that are hampering a greater adoption of this solution.

Given the inductive nature of this work the researcher, through the collection of qualitative data, aims to contribute to the literature also by deepening the study of the issues mentioned above.

These two topics are of absolute interest to answer the research questions. Since the purpose of this research is to understand if MaaS aggregators can be an effective solution to help achieve smart and sustainable mobility it is crucial to comprehend the current level of development, the response of the European market, what will be implemented in the future and on what there is a need to focus more to achieve greater success.

2.6 Theoretical framework

The theoretical framework produced by the author (see figure 9) is a comprehensive overview of the key concepts presented in the literature review chapter. This summary scheme was used as a guide during the primary data collection phase and as a starting point during the data analysis stage.

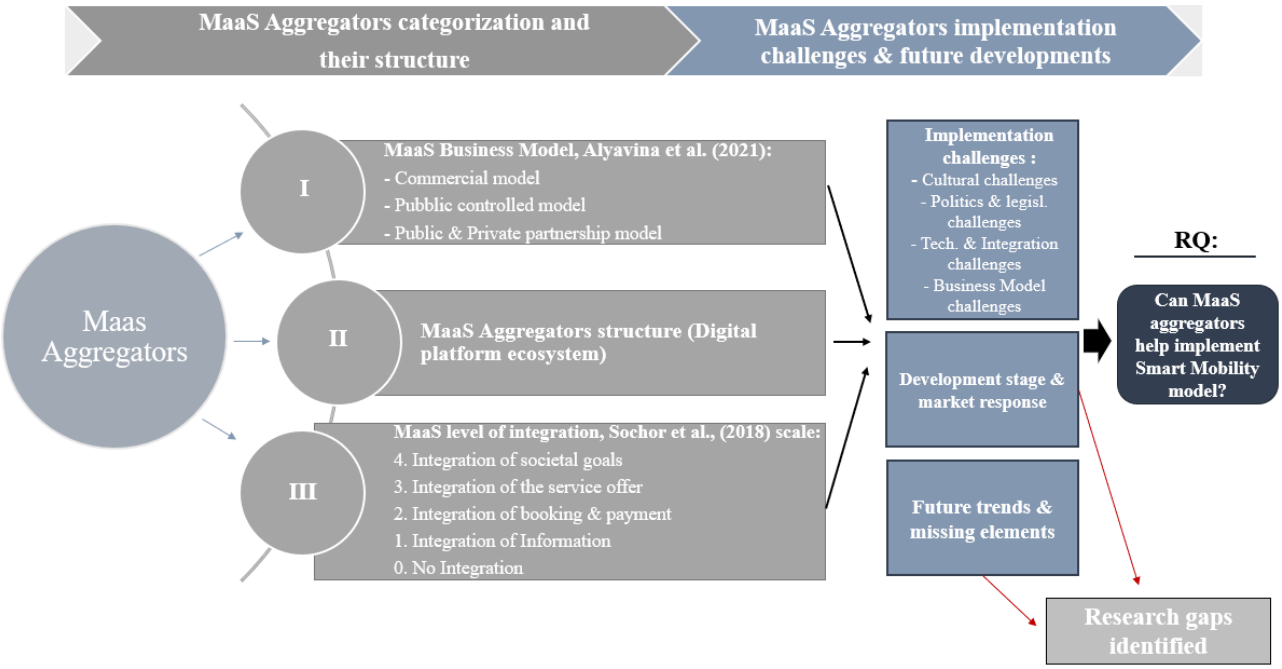

Figure 9: Theoretical framework - *(produced by the author)*

This work has two primary areas of interest that are strictly interconnected. The first one has the purpose of gaining a better understanding of the MaaS aggregators through the points of view of the interviewed managers. During this stage, the researcher deepened his knowledge of their functioning and structure. The companies were then categorised according to two criteria:

- The nature of the MaaS operator, according to the categorisation proposed by Alyavina et al. (2021) there are three business models based on which actor assumes the role of MaaS provider (see I, figure 9).
- The level of integration of the service provided by the platform, based on the scale ideated by Sochor et al. (2018), (see III, figure 9).

The categorisation phase is of fundamental importance as it acts as a bridge to the second primary area of research. Indeed, it is essential to categorise the MaaS aggregators before analysing the different themes of the second research area.

The second area of interest has three macro themes of analysis:

- The actual level of development of MaaS solutions in Europe and the analysis of market responses to current operational MaaS aggregators. Indeed, to comprehend the current situation of this solution it is essential to examine these two factors, taking also into consideration the categorisation carried out in the first phase;
- The recognition of the implementation challenges that MaaS aggregators will have to overcome to achieve their socio-environmental objectives and, thus be able to play an effective role in the implementation of the smart mobility paradigm. There is a strong correlation between the two elements since, as explained during this chapter, smart mobility is: "an approach that aids in the reduction of poisonous fumes expelled into the atmosphere by vehicles and human congestion. Equally, smart mobility aids in raising the quality of transportation in a manner that is environmentally friendly" (Bıyık, et al., 2021, p. 2). The insights into the functioning of the platform ecosystems of the selected sample European MaaS aggregators and their categorization were also useful to understand if MaaS aggregators of different categories have divergent or convergent challenges and whether there is any category that has an advantage over the challenges that have emerged;
- The exploration of future trends that MaaS aggregators should seek to integrate into their model to continue to be innovative and offer an increasingly comprehensive service to their customers and, the analysis of the missing elements that are hampering the adoption of these solutions and thus preventing them from having a larger impact on urban mobility.

As will be explained in detail in the next chapter (see 3.3.1), the primary data collection phase was structured into two stages. In the first one, the focus was on the selected sample of Europen MaaS aggregators while, in the second one, were interviewed representatives of various stakeholders from the MaaS world. This choice was made to deepen the knowledge of the phenomenon under analysis and, in particular, to investigate the second area of interest in detail, obtaining interesting points of view from a dual perspective. In this way, the author got to know the direct points of view of the MaaS aggregators and the internal points of view of the actors belonging to the five categories of the MaaS ecosystems presented by Alyavina et al., (2021).

3. METHODOLOGY

This chapter presents and explains the choices concerning the nature and structure of this research and the different techniques and methods used to collect and analyse the empirical data. It is divided into six sections. The first one presents the research strategy and the set of underlying epistemological positions. The second outlines the choice of the research design and why other structures were discarded. In the third and fourth sections are illustrated the methods used for the data collection process and the sampling criteria. The fifth explains the different steps of the approach used to analyse the data. Finally, in the last section, is displayed how this research met the quality criteria of Guba & Lincoln (1994).

3.1 Research strategy

In business research, research strategy is defined as the general approach that each researcher takes in carrying out their project (Bell et al., 2018). There are three types of strategies: quantitative, qualitative, and mixed strategy.

The choice of the suitable research strategy starts with the research methods necessary to conduct the data collection phase (Bell et al., 2018). As we shall see in detail below, the researcher chose a qualitative strategy given the decision of conducting semi-structured interviews.

However, there are two other factors which the researcher considered to develop an appropriate qualitative research strategy:

- Role of theory in the research
- Philosophical assumptions (Epistemological & Ontological)

The role of theory, according to Bell et al. (2018), is intended both as a way of understanding a phenomenon and as a way of relating theory to research. There are three approaches: inductive, deductive, and abductive.

Qualitative research, such as this one, is generally based on an inductive approach, whereby the key findings are used to contribute to the academia by building new theories (Bell et al., 2018). Following this method, the author wants to integrate the literature on the subject through the primary data obtained from the two samples interviewed.

Going on, the philosophical assumptions are the set of underlying assumptions about reality made by the researcher, even though they may seem abstract concepts, it is necessary to make them

explicit and ensure that they are consistent with the choice of research design and research methods to be sure to carry out solid research with valid conclusions (Bell et al., 2018).

For what concerns Ontology, since this research aims to investigate MaaS aggregators and their digital platform ecosystems, the author adopted the constructionism position. According to this way of perceiving reality, the social phenomenon under study exists thanks to the interaction of all the actors involved (Bell et al., 2018). Indeed, the ecosystems are constantly evolving structures that only manage to create value through the actions of their actors, without which, the ecosystem would have no sense of existence.
The choice of the Epistemological position is closely linked to the ontological approach embraced (Bell et al., 2018). Following the above, the researcher adopted the interpretivism position. This research is interested in understanding the points of view of managers working either in MaaS aggregators or in companies that are part of the MaaS ecosystem by collecting qualitative data on this mobility solution.

3.2 Research design

Research design represents the backbone of every academic research, it provides a framework for the collection and analysis of all the data necessary to answer the main research question and sub questions (Bell et al., 2018).

In business and management research there are five types of research design, each having its characteristics and its own advantages and disadvantages:

- Experimental design
- Longitudinal design
- Cross-sectional design
- Comparative design
- Case study

Considering the research strategy adopted and the purpose of this work, the multiple case study was chosen as the design for this research. The multiple case study belongs to the broad category of case study design and its main feature is that allows the research to not be limited to a single and unique case (Bell et al., 2018).

Therefore, the author decided to also adopt a comparative approach. In this way, it was possible to gain a deeper understanding of the phenomenon under study in the various contexts. The researcher analysing the selected sample of European MaaS aggregators was able to study their ecosystems

and, afterwards, by comparing them was able to figure out their similarities and differences in the level of development, market response and implementation challenges.

This structure is consistent with the author's intention of providing an analysis of the different MaaS aggregators present in Europe to answer the main research question. Through this method the researcher could study the same innovation in purposefully different and unique contexts to give a generalized explanation of the state of the art of platforms that are based on the theoretical concepts presented in the second chapter (Goffin et al., 2019).
To ensure the clarity and quality of this research, as also stated by Goffin et al. (2019), the author needs to specify why he discarded the other types of research design.
The researcher excluded the other common and solid designs because they are not consistent in at least one of the different dimensions of the methodology of this research, in fact: experimental design is generally used for confirmatory research, longitudinal design requires to study the sample at various points in time, and cross-sectional design involves studying subjects at a single point in time to analyse the variations in the population (Bell et al., 2018).

3.3 Research methods

Research methods are the tools through which data is collected to answer the defined research questions. The data collection phase is the fundamental point of every research project (Bell et al., 2018). For this work, the researcher collected both primary and secondary qualitative data. In the following sections the methods used and the rationale behind these choices are explained.

3.3.1 Primary Data Collection

Primary qualitative data were collected to answer the research questions presented in the first chapter for several reasons. First, the researcher chose this type of data to increase the quality and credibility of this work. Then only by collecting this type of data the alignment between the research problem and research questions could be ensured. Lastly, adopting the thematic analysis method it was fundamental to be familiar with the data collected (Bell et al., 2018).

Therefore, the researcher adopted semi-structured interviews as the method for this qualitative research because having a well-defined research problem and research questions, this method seemed the best choice. With the semi-structured interviews, it was possible to trace a useful path to study the chosen phenomenon, gathering unique insights from the managers' points of view. In addition, thanks to the detailed interview guide, the researcher could obtain comparable answers to provide a comprehensive overview of the actual situation of the MaaS in Europe.

Unstructured interviews were discarded because this method, even if can lead to the discovery of unique insights, didn't suit the characteristics and the purpose of this work. This research has a well-defined research problem that renders these types of interviews less effective. Therefore, the researcher adopted a comparative design for which it was essential to obtain comparable answers from the interviews.

The primary data were gathered by interviewing a sample of European MaaS aggregators that have managed to build a transport services ecosystem accessible through a single platform. In addition, to enrich the research, stakeholders belonging to the categories presented by Alyavina et al. (2021) were interviewed. The interviews with the second sample were useful in providing an alternative point of view on the topics covered in this study.

The collected data were useful to deepen the knowledge about the structures and the operation of MaaS aggregators and to get valuable insights into the current state of development and market response, the implementation challenges they will have to overcome to be an effective solution for smart mobility, the missing factors that are hampering the adoption these solutions and the future trends they will have to integrate to be even more effective.

3.3.2 Secondary Data Collection

Secondary qualitative data were collected for the elaboration of an extensive literature review (see chapter 2). The literature review is the crucial phase of every business research as it has multiple purposes (Bell et al., 2018). First, it allows the researcher to gain a comprehensive view of the field that will be investigated, deepening the knowledge of the key concepts and theories that will be used during the research process. Second, the information collected enables the definition of the methodology and the refinement of the research questions. Finally, through the elaboration of a theoretical framework (figure 9), it provides the guide for the primary data collection phase and the starting point of the subsequent analysis process (ibid).

The collected data were useful to understand the broad and specific context in which MaaS aggregators operate and why they were created. Therefore, they were also fundamental to understand in depth all the theoretical concepts behind the innovation under study.

The researcher gathered the data from the following authoritative database: Scopus, Science Direct, Springer Link, Google scholar, Luiss university library and Gothenburg university library.

To limit the research and to find only relevant literature for this work the following keywords were used: *Mobility as a Service, MaaS aggregators, MaaS operators, MaaS challenges, MaaS business*

model, MaaS model, Smart mobility, Smart city, urban mobility, future trends in mobility, digital platform, Ecosystems and platform ecosystem.

3.3.3 Interview guides

Since the researcher choose the semi-structured interview method, as explained in the section before, two detailed interview guides were elaborated before starting the two rounds of interviews. Given the design of this research, this level of structure was necessary to ensure a certain degree of comparability between the chosen cases (Bell et al., 2018). Therefore, this choice was also consistent with the fact that the researcher had a clear idea of how the gathered data would be analysed since he used the theoretical framework (see figure 9) as a guide for the data analysis process (ibid).

The first guide (see Appendix A) was produced to interview the selected sample of European MaaS aggregators, while the second guide was elaborated for the sample of stakeholders belonging to one of the categories proposed by Alyavina et al. (2021) (see Appendix B).

As was already explained in the theoretical framework paragraph (see 2.6), this research has two primary areas of interest. The questions of the first interview guide were oriented to analyse both the areas while the ones of the second interview guide were focused on gathering the points of view and opinions of the company representatives interviewed on the second area of interest of this research.

3.3.4 Interviews set up

The interviews were all conducted on online meeting platforms chosen by the interviewees according to their preferences. No face-to-face interviews were conducted both for security reasons due to the Covid 19 pandemic and because, given the objective of this research, managers located in various European countries were interviewed. Before the start of each interview, the author requested permission to record the audio of the meeting and to use the information gathered within this research. Therefore, it was also asked whether the respondents preferred to remain anonymous or not. It was explained that the recordings would not be disclosed and that they would be only used to allow the author to make literal transcriptions. This choice prevented the author from taking notes during the meetings, thus allowing him to concentrate fully on the interviews. Therefore, considering the lack of experience of the researcher, to optimally conduct interviews, the ten principles developed by Kvale (1996) were followed.

3.4 Sampling

The sampling process can be divided into two macro-categories: probability and non-probability sampling. Considering the characteristics and the research design of this work, a type of non-probability sampling was used to select the companies to be interviewed. Among the non-probability sampling, the author adopted purposive sampling.

Going into detail, as identified by Patton (1990), there are various types of purposive sampling, for the author the most suitable is criterion sampling.

The author adopted this method because he wanted to select the sample strategically, by following criteria that keep the research objectives in mind and enable the research questions to be answered effectively (Bell et al., 2018).

For this research, two different samples were constructed to obtain different points of view and make a more complete analysis. The first sample consists of the MaaS aggregators selected to be part of the multiple case study, while the second sample consists of the companies belonging to the five categories of actors of the MaaS ecosystem elaborated by Alyavina et al. (2021).

The companies in the first group were selected according to the following criteria, they must be:

- MaaS platforms that have achieved at least service integration (level two of Sochor scale);
- MaaS aggregators that have reached the implementation phase;
- MaaS aggregators operating in one or more European countries.

Once the companies were selected, the interviewees were chosen according to the following criteria:

- They must have worked for at least two years in the company;
- They must have worked with the MaaS solution.

In this way, the researcher tried to obtain a sample with sufficient experience and expertise.

Company:	Interviewee:	Job title:	Date & length of interview:	Platform used:
MaaS Global	Sohail Rashid	MaaS Expansion Manager	07/04/22 - 30 min	Google Meet
CityMapper	Samy Zerrouki	(ex-) Product Manager, Shareholder	05/04/22 - 45 min	Google Meet
Yumuv (SBB)	Isabel Götz	Manager for Research & Innovation	13/04/22 - 30 min	Microsoft Teams
Yumuv (VBZ)	Patrick Bösch	Project Manager	26/04/22 - 35 min	Microsoft Teams
Upstream	Gernot Hörhager	Project Manager	14/04/22 - 30 min	Microsoft Teams

Figure 10: Sampling table group one – *(produced by the author)*

For the second group, the firms were selected according to the following criteria:

- They must belong to the categories presented in the literature review (see 2.3.1);
- They must operate in one or more European countries.

Company:	Interviewee:	Job title:	Date & length of interview:	Platform used:
Tier	Alex Sprey	Senior Manager Strategic Parterships	07/04/22 - 30 min	Google Meet
Lynk & Co	Michael Zorez	Product Manager	11/04/22 - 36 min	Microsoft Teams
Hertz	Anders Tarnell	Head of marketing (SE and DK)	12/04/22 - 35 min	Microsoft Teams
Rise	Steven Sarasini	Senior Researcher	25/04/22 - 45 min	Microsoft Teams

Figure 11: Sampling table group two – *(produced by the author)*

3.5 Data analysis

To carry out a reliable and rigorous analysis the thematic analysis method was adopted for this work. The main objective of this method is to identify all the recurrent patterns in the collected data useful for answering the research questions (Maguire & Delahunt, 2017). The analysis process was conducted by following the established "six-phase framework" (see figure 12), this guide provided by Clarke & Braun (2013) is a useful tool for conducting a systematic and comprehensive analysis.

Step 1: Become familiar with the data, Step 2: Generate initial codes, Step 3: Search for themes,	Step 4: Review themes, Step 5: Define themes, Step 6: Write-up.

Figure 12: Six steps framework - (Maguire & Delahunt, 2017)

The first step is immediately subsequent to the data collection phase. At the end of the interviews, the author made literal transcriptions using the online word software. In this way, any possible personal contamination was avoided. After this initial phase, the transcripts were read and initial notes were made on some similar answers (such as more collaboration with mobility providers, congestion tax, new sources of revenue, etc.) and possible second-order concepts.

In the second step, the first-order concepts were individuated directly from the data collected, no predetermined codes were selected. The researcher did not use any qualitative data analytic software to study the data and analysed the transcripts by hand. The data were coded keeping in mind the purpose of this work and the research questions, so were selected only the codes that are useful for answering the questions presented in the first section (see section 1.4).

During the third step, the researcher individuated nine recurrent patterns (second-order concepts or themes) in the answers of the respondents. All the themes describe a specific aspect of the MaaS model and were of fundamental importance in answering the research question.

In this fourth step, the researcher reviewed the selected themes and checked whether the first-order concepts in each pattern were coherent and if were useful in answering the research question. Then in the fifth step, also relying on the areas of interest identified in the theoretical framework, the second-order themes were grouped into three aggregate themes. While the last step consisted of writing this research paper.

3.6 Research quality

The quality of a business research can be assessed by several criteria. According to Bell et al. (2018), the three main factors to be considered in the evaluation of business research are reliability, replicability, and validity.

Business research shall be defined:

1. Reliable, when the measures used for the research generate stable and consistent results over time.
2. Replicable, when it's possible for other authors, following the same methodology, to repeat the research obtaining comparable results.
3. Valid, when the measures chosen by the author are suitable to study the phenomenon, leading to correct and accurate conclusions (Bell et al., 2018).

Over the years it has been realised that these criteria are not suitable for all types of research and that especially the concepts of reliability and validity are only appropriate for evaluating quantitative research. Indeed, both factors would be limitative in the evaluation of qualitative research as they are based on the judgement of research measurement (Bell et al., 2018).

One alternative to develop a suitable framework to evaluate qualitative research is to adapt the criteria explained above, according to this solution the revised criteria are internal/external validity and internal/external reliability (Bell et al., 2018). The second alternative, proposed by Guba & Lincoln (1994), is based on two new primary criteria: trustworthiness and authenticity. The two alternatives are both valid but, according to Johnson et al. (2006), it's of paramount importance to follow quality criteria that are logically consistent with the philosophical assumptions of the research. Following this approach, the first alternative was discarded as reliability and validity criteria are based on a positivist epistemology position while this work, as explained in detail in the "research strategy" section, follows an interpretivism view. The second alternative rejects this position and for this reason was adopted for this qualitative research (Bell et al., 2018).

3.6.1 Trustworthiness & Authenticity

In this section how this research has conformed to this criterion will be set out. Trustworthiness is grounded on the assessment of four elements:

1. **Credibility:** the research must be conducted according to good practice and must present a concordance between the interviews and the research findings. To meet this criterion a careful literature review of the phenomenon under analysis and of the general and specific context in which occurs was carried out. Therefore, all the respondents were selected following specific criteria and always bearing in mind the purpose of this research. While, to ensure a full correspondence between the interviews and the transcripts, the author, with the permission of the interviewees, recorded the interviews. Using the online word software, the literal transcripts were processed and then used to carry out the coding process. Finally, to ensure the transparency and reliability of this research, the empirical findings of the interviews obtained by summarising the literal transcripts were sent to all the interviewees who requested it for confirmation.
2. **Transferability:** the final findings can be applied to other realities, contexts, or environments other than the one analysed, in short, whether or not the results are generalizable. This is one of the main problems of qualitative research, indeed this type of research usually studies small groups making difficult the transferability of the findings. However, since this research analyses an innovative solution, the researcher tried to increase the level of transferability by selecting firms, belonging to the same field, with different and unique characteristics.
3. **Dependability:** all the stages of the research process should be tracked. To respect this criterion, as proposed by Bell et al., (2018), an "auditing" approach has been used. In this research all stages of the work were carefully explained, starting with the formulation of the research questions, the choice of methodology and ending with the analysis of the collected data.
4. **Confirmability:** the research must be objective and unbiased by the author. The researcher remained neutral throughout this work and during the data collection and analysis phase adhered exclusively and scrupulously to the opinions provided by the respondents. Indeed, interview transcripts were transcribed in a literal manner via the online word software to avoid personal contamination.

Finally, the second alternative primary criterion elaborated by Guba & Lincoln (1994) is authenticity. To meet this criterion, the researcher tried to represent as complete a picture as possible of the world of MaaS in Europe by interviewing representatives of several companies.

Thanks to this approach, the results of this research are grounded in different points of view, opinions, and ideas of the interviewees through which the researcher has deepened his knowledge of the phenomenon under study and its context (Bell et al., 2018).

4. EMPIRICAL FINDINGS

This chapter presents the findings derived from the literal transcripts of the semi-structured interviews with the managers of the two selected samples (see figures 10 and 11). The findings are grouped by company and at the beginning of each paragraph there is a brief explanation of the background of each firm for information purposes.

4.1 MaaS Global (Whim)

MaaS Global is the world's first MaaS operator, and with their app "Whim" they offer a true integrated multimodal experience providing all urban transport services available on the market. The users can plan, book, and pay for their trips on the platform and monthly and annual subscriptions are also offered. Whim is currently operational in several cities: Vienna, Antwerp, Helsinki, Turku, Tokyo, Switzerland (nationwide) and Birmingham.

4.1.1 Interview sum up

The interview started with some icebreaker questions to learn more about the background of the interviewee and his role in the company. Sohail Rashid is an entrepreneur that founded different companies in the telematics industry, after having liquidated his shares, he joined MaaS Global in March 2018. He is the manager responsible for the expansion of Whim and he is running the development of MaaS Global in Asia as it's an expert in the middle east market.

After this brief presentation, the focus of the interview moved on to the first area of interest in this research (see figure 9). MaaS Global is the company that launched a MaaS solution called Whim. It is a platform, in the form of an app, that is the centre of a complex ecosystem of stakeholders, such as micro-mobility providers, car rental companies, public transport authorities, and taxi companies, that is now available in different European countries and Japan. MaaS Global was the first company to launch this new service and according to Sohail their value proposition is simple, they want to demonstrate to people that:

"You can get the same kind of services as owning a car without owning a car".

Changing the mindset and the behaviour of the people isn't a simple mission, many people love their cars, but they don't realize the amount of time and money that lose every day, especially in the chaotic traffic of big cities. The main idea is to provide customers with an ideal garage full of different options which the users can access immediately according to their needs at the time. Whim will take care of all the trips of the user, from the starting point to the arrival.

MaaS Global offers a lot of different packages. Customers can choose, depending on their needs, between a variety of subscription packages and the classic pay-as-you-go option. For example, if a customer wants to get access only to public transport and bike-sharing, with unlimited rides only for the first one, he can buy the specific package for €50 a month.

Then for the unlimited subscribers the platform, with the same cost that the customer pays to own a car, provides unlimited travel with all the transport modes available. This final solution is really promising and innovative because replaces all the unique features of the private car and it's not limited to the city. Indeed, in the bundle is also included the car rental service for trips outside the city.

Even if there are doubts regarding the sustainability of this MaaS business model in the long term, Sohail is confident of Whim's success and supported his point of view by explaining the revenue model of the company.

The first source of income for Whim is the commissions on the rides of the various transport providers, except for the public transport. The last one doesn't give commission because they are already subsidising their service and cities, as a rule, don't give any margins to private companies.

The second part of the revenue model is based on the subscription. Whim is applying the same strategy as some mobility companies. These firms provide equal data plans to everybody, knowing that some people will use fewer data and some people will use more data, making money on the users that habitually use less data than those paid for. Equally Whim believes that applying this concept, and having a critical mass of subscribers, will be able to be profitable.

The market before the Covid Pandemic was responding generally well to Whim's offer, there was an upward trend, and the company was gaining subscribers. MaaS Global was expanding but in many cities, such as Singapore, the launch was stopped by the sanitary emergency. However, even if the response is positive, customers are growing more slowly than forecast.

According to Sohail, it's quite normal, Whim isn't like Uber that can just spend billions of dollars to acquire customers and give subsidised rights. That's not how MaaS global is operating, that's not their intent. The firm wants to go into cities, set up joint ventures, and then collaborate with local partners to develop the business, they don't want to spend billions of dollars to acquire customers. Following this policy, directly quoting him:

"It's gonna take a while we get adoption from customers and then from users. It's a slower growth rate, but when people come on board and sign up, they stay".

Then the interviewer shifted the focus of the conversation to the second area of interest of this research, starting with the analysis of the actual development of this solution and of the different implementation challenges that MaaS aggregators should have to overcome to help implement the smart mobility in cities.

In Europe, right now, Whim is the main player. The platform isn't anymore an early age stage start-up, however even if the technology is mature enough the market adoption is still far away. The other providers don't have the technology base that Whim has. This competitive advantage was developed over the years, indeed MaaS Global raised so far about 65 million euros and 60% of these funds were invested in developing our product.

Achieving the market adoption is a challenge, in the next few rounds of financing Whim is expecting to raise more money and the company will spend more on marketing to expand in more cities and subsidise the service and get more people on board.

According to Sohail, there is also a variety of other challenges that MaaS aggregators must overcome to be effective.

The first one is increasing the degree of collaboration with cities. Public authorities are essential for the MaaS operators as they give authorisations to provide their services and, in some cases, also manage public transport. Cities authorities must take the initiative and should facilitate alternative ways of mobility. For example, they could impose strict limits on the movement of cars in the city or they could invest more in public transport (which is the backbone of urban mobility) to encourage its use.

The second one is finding ways to improve the cooperation with some transport providers. Going into detail, while taxi companies are very eager to connect with the MaaS platforms because they know they can offer them more rides, micro-mobility providers are less inclined. They are often not willing to integrate within MaaS ecosystems because they think that these platforms will take away their customers. They fail to grasp the opportunities and benefits we could gain from cooperation. According to Sohail, this is a crucial point because:

"Without the transport service providers we can't work, we can't do anything".

The last challenge is the expansion of the actual range of subscription packages. The interviewee highlighted the necessity to be creative and different from the competitors offering special services to the customers that may entice them to join the MaaS ecosystem. For example, in Japan, Whim is offering a bundle including some attractions that are available in Tokyo. This solution represents also another source of revenue as the company is also able to gain extra money from commissions.

Going on with the interview, to be able to reach the final stage (integration of the societal goals) of the Sochor scale (see figure 8) and the aspired smart green mobility, there must be an alignment of objectives between MaaS operators and the national environmental agencies. Whim has all the metrics necessary for these agencies to develop a framework of incentives or limitations.

Indeed, the platform keeps track of the carbon footprint of each user, the usage habits (duration, preferred transport modes, etc.), the positive impact on the environment through certain user behaviours, etc.

The role of public authorities is of paramount importance, MaaS aggregators such as Whim, want to get rid of a million cars in the next couple of years but they are not going to do that if car manufacturing companies keep offering up more and more cars. There must be introduced a moratorium on the number of cars circulating in the cities as was done in Singapore. Implementing such a regulation would provide an incentive to citizens to try more sustainable transport solutions, realising how important their impact on the planet is.

Finally, the interview concluded with a brief overview of the future trends that the MaaS should be able to integrate. For the interviewee, it's a matter of completeness of service. In the future MaaS aggregators should be able to connect all the different transport modes, including air journeys, not limiting to the boundaries of each city.

4.2 Citymapper

Citymapper is a MaaS aggregator founded in 2011 in London, its multimodal mobility platform is used by more than 50 million people in 80 cities around the world. In addition to the traditional services Citymapper also offers subscription packages that bundles different modes of transport for the users.

4.2.1 Interview sum up

The interview started with some icebreaker questions to know more about the background of the interviewee and his role in the company. Samy Zerrouki joined Citymapper in 2018 and for two years was responsible for the operational side of the platform. Therefore, he was also the product manager of Citymapper pass. He isn't working for the company anymore, but he is a shareholder.

After this brief presentation, the focus of the interview moved on to the first area of interest in this research (see figure 9). Citymapper is structured as a platform ecosystem, the firm is in the centre and all the actors are placed around having connections of various kinds. The company is organised

into several autonomous teams that follow the various services offered by and through the platform. Citymapper has both public providers and private providers and offers a wide range of mobility services from buses, and trams to bicycles, scooters, etc.

These services are essential for the achievement of the value proposition of the firm, indeed Citymapper wants to help navigate its users in the complex environment of cities, offering a user-friendly tool that brings together the different mobility services in cities. Although the platform is getting a good response from the market in terms of usage in the various European cities where it is present, it is still not profitable. Indeed, Citymapper is struggling in finding the right business model. Two years ago, the firm has launched the Citymapper pass, a new smart travel card that offers its subscribers various mobility services. Then, it started to offer Citymapper plus, a premium version of the platform with advanced features. Both the solutions have not met expectations and are not bringing in the expected revenues. According to Samy, the main motivation behind these results is that:

"When your customers are used to using a product which is free for such a long time it then becomes difficult to make them pay. Unless there is something competitive, a really competitive new feature, but it's not the case, I don't think the different premium features that we are offering are convincing our customers".

The best exit for City Mapper would be to be acquired by a bigger company like Uber or Google Maps. Now, it is not sustainable in the long term for Citymapper to provide this type of service, but maybe a bigger company could.

Then the interviewer shifted the focus of the conversation to the second area of interest of this research, starting with the analysis of the actual development of this solution and of the different implementation challenges that MaaS aggregators should have to overcome to help implement the smart mobility in cities.

Describing the actual situation of the MaaS aggregators it's a tough task, the European market is divided and there is also great competition. In northern Europe, this solution is more advanced while in central and southern Europe is far behind. However, the interviewee does not yet believe there is an ideal MaaS that has all the elements theorised. The main problem is again that the MaaS aggregators, in most cases, are not managing to make money with their services.

The technology is mature enough, in Paris, for example, the MaaS operator when a user takes the metro, not only suggests the time and the line to be taken, but it also tells you which wagon to sit in so that you can get off quickly at your destination. Considering that, the critical element, the main

challenge for the present and the future, is finding a successful fare system both for the company and the users. It is not as simple as it may seem, the main problem is finding the ones sustainable (profitable) for the MaaS provider and convenient for the customers within the several possible options. Quoting the interviewee directly:

"Maybe a fare system can be the distance to have a unified fare".

According to Samy, there is also a variety of other challenges that the MaaS operators must overcome to be an effective solution.

The first one is increasing the integration and collaboration with the public sector. There are different aspects in which the degree of collaboration must be increased. Public companies, if they decide to become part of the ecosystem of a MaaS platform, should share all their data to facilitate service improvement. Then, in cities where public transport companies are far behind in technology, cities should stop competing with MaaS aggregators. If the public cares about the user, it should enter a strong partnership with the private sector. The perfect example is London, where, 10 years ago, TFL (the local public transport provider) favoured the adoption of Citymapper, recognising its best features. Finally, public authorities should facilitate the transition to a new type of mobility by implementing a system of incentives, they could be tax cuts, to reward the green behaviours. Other possible solutions could be the congestion tax for the use of private cars or the implementation of special lanes for carpooling, car sharing, and any other sustainable mode of transport.

The second challenge is offering this solution on a scale. The scalability is difficult to achieve with the actual numbers. Therefore, in Europe, there is also a huge problem of cultural and legislative differences. There is an urgent need for unified legislation, the role of the European Union will be extremely important.

Finally, there is the cultural barrier. Many people are still attached to the concept of car ownership. Some love the freedom that a car gives you, they treat their vehicles as a second home. Others are still attached to the notion that having a nice car gives social validity. Finally, in many suburbs of cities, due to infrastructure problems, they are still the only viable alternative. The role of the public authority is also crucial here.

Going on with the interview, the focus shifted to all the factors that are missing to reach the majority of the citizen.

The first one is the improvement of marketing campaigns. MaaS aggregators need to make their services known and highlight the benefits that both they and the environment could gain from using their platforms. The second one is the improvement of the User experience (UX). Interfaces should

be made as user-friendly as possible for all generations. In the case of Citymapper, the technology is starting to become less effective as they didn't make big improvements in the last five years.

Finally, the last area of improvement is the value proposition. MaaS aggregators should offer some bundles for families. A subscription similar to Netflix that can be shared among family members, and which takes into account the needs of different users. Ideally, MaaS would substitute the car that is used for all the needs of the whole family.

After having analysed in-depth the specific context in which the MaaS aggregators operate and their actual situation, a brief overview of the future trends of the sector was done.

According to Samy, the next trend would be the creation of a unique European MaaS that would allow the user to travel with every mode of transport everywhere, from planes to public transport. It's not an easy task, the main problem is the resistance of the operators. They do not yet have the common vision necessary to find an agreement on data, tariffs, etc.

The interview ended with a suggestion of the interviewee:

"I would change the name (MaaS). It doesn't speak to the users. If I had a magic band, I would create a name which speaks to final users and not only to politicians, scholars, and experts of the sector".

4.3 Yumuv

Yumuv is the first regional MaaS operator that offers subscriptions packages. It's a project launched in 2020 which was born from the collaboration of Swiss Federal Railways (SBB CFF FFS) and public transport operators (PTOs) in Zurich (VBZ), Basel (BVB), and Bern (BERNMOBIL).

4.3.1 Interview sum up (VBZ)

The interview started with some icebreaker questions to learn more about the background of the interviewee and his role in the company. Patrick Bösch is a project manager responsible for product development at VBZ, the public transport company in Zurich. In the last years, he worked on several big projects on mobility such as Zuri mobility and Yumuv.

After this brief presentation, the focus of the interview moved on to the first area of interest in this research (see figure 9). Yumuv is structured as a digital platform ecosystem, the core platform partners are the Swiss Federal Railways (SBB) and the public transport operators of the cities involved: BVB (Basel), Bernmobil (Bern), and VBZ (Zurich). SBB, which has invested the most

resources and funds in the platform, is leading the project. The ecosystem then consists of the various mobility providers whose services have been integrated into the platform (car sharing, e scooters, bike-sharing, and cargo bikes), Trafi, the technology partner that enabled the development of the platform, and the ETH Zurich as scientific monitoring.

The project is a clear success, but the market response wasn't as good as forecast. There are different reasons explaining why the numbers did not meet expectations.

First, the social-economic situation of the cities caused by the Covid 19 pandemic.

Second, is the difficulty of explaining this innovative solution to customers. Yumuv presents two new concepts that are far away from the solutions to which users are used: the payment for different mobility services through one solution with one app and the bundle approach. Explaining these concepts clearly and quickly is an extremely difficult task.

Then the interviewer shifted the focus of the conversation to the second area of interest of this research, starting with the analysis of the actual development of this solution in Europe and of the different implementation challenges that MaaS aggregators should have to overcome to help implement the smart mobility in cities (see figure 9).

According to Patrick, keeping in mind the Gartner hype cycle, the MaaS solution has passed the peak of inflated expectations and is at a more or less advanced point of the next downward phase. Ever since the launch of this solution, enormous expectations have been created, and it seemed that MaaS could solve all the problems of urban mobility. but now that the platforms are operational, numerous problems and challenges have arisen. Developing and operating an ecosystem of different actors is a daunting task, funds, and expertise are needed.

There are also a variety of other challenges that the MaaS aggregators must overcome to be an effective solution.

The main one is the change of mindset of the whole mobility sector. They should imagine themselves as an enormous ecosystem where the aim isn’t anymore to lock customers into their services or products. Mobility players must understand that customers move from one solution to another and that this does not mean losing customers. Quoting directly the interviewee, the real question is:

“Have players an interest in such an ecosystem?”.

The second challenge is the leveling of technology, the will to cooperate is not enough. Common interfaces (APIs) are needed for integration and collaboration. During the development of Yumuv,

the interviewee learnt a very valuable lesson, not all operators have the same level of technical capabilities.

The last one is to educate people about this innovation. Many people, even if they unconsciously already do it, do not know what multimodal mobility is.

Going on with the interview the attention has shifted to how the MaaS aggregators and the public authorities should cooperate to reach smart urban mobility and on the role of the public sector.

Every city has different characteristics, structures, and needs. So, it is difficult to find an unambiguous solution. Three questions need to be answered:

- Do the public authorities have to provide MaaS solutions or are it something they have to monitor?
- Should it be something hybrid, with a private actor, that the public sector should subsidise or help in building this infrastructure?
- Should these solutions be left to the private market to develop without intervention?

However, according to Patrick, the public side has a huge interest in MaaS platforms. If the aim is to reduce the number of cars on the road and make mobility more sustainable public agencies should directly invest or encourage, through incentives, the development of this solution. Cars have unique characteristics, such as flexibility, and availability, which can only be replaced by a complex, fully developed ecosystem of various means of transport.

Finally, the interview concluded with a brief overview of what is missing from the actual MaaS aggregators to reach the majority of people and of which future trends the MaaS sector should be able to integrate to be more effective.

As well as improving the platform more and more to offer the most seamless service possible, we also need to work on the connection between the digital platform and the physical reality. people need to see multimodality. Therefore, it is important to build hubs where the user can find all the means of transport offered by the platform. it is also a question of publicity and brand awareness.

To conclude, it will be interesting to understand the positioning of Uber. The firm is entering the market of MaaS with the introduction of bike-sharing and e-scooters. Will Uber integrate other solutions?.

4.3.2 Interview sum up (SBB)

The interview started with some icebreaker questions to learn more about the background of the interviewee and her role in the company. Isabel Götz joined the Swiss Federal Railways (SBB) three years ago and she is now the manager of the Research & Innovation network of the company. She followed Yumuv project since its launch in 2020 and she collaborated in the development of all areas of the project. Therefore, she was responsible for the management of the connections to the cities, Zurich, Bern & Basel, in which the platform is operating.

After this brief presentation, the focus of the interview moved on to the first area of interest in this research (see figure 9). During this interview, the structure and organisation of Yumuv were not analysed as the necessary data had already been collected during the interview with Patrick Bösch.

The value proposition of the company is to provide an easy-to-use mobility solution to the customers that gives access to various micro-mobility services and public transport. Yumuv is a public-owned platform, and the final aim is to complete and improve the experience of using public transport, covering also the first and last mile with other modes of transport. Since the platform has been operational for a year, its impact is limited, but still, the results are positive.

Even with the pandemic, we had a lot of customers but when the smart working became a constant the number of users started to drop as there were no longer any commuters using the service to get from their homes to the offices. Overall, as Isabel said:

"After an evaluation, we can say that it was a successful product and the project has been successfully implemented".

The numbers started to drop as there were no longer any commuters using the service to get from their homes to the offices. Then, the interviewer shifted the focus of the conversation to the second area of interest of this research, starting with the analysis of the actual development of this solution and of the different implementation challenges that MaaS aggregators should have to overcome to help implement the smart mobility in cities.

According to the interviewee, it's difficult to describe the actual European situation, the sector can certainly improve even more. This solution needs the commitment of different forces.

First, the public authorities (municipalities, governments, etc.) should favour MaaS operators by publicising them to citizens and introducing incentives and clearer regulations. The role of the public side it's crucial, to leave a significant impact MaaS needs to be financed and supported.

However, to push for more cooperation from the public authorities, as the interviewee said, what is missing is more numbers and more facts to provide reliable evaluations.

Second, the actors in the MaaS ecosystem must cooperate to push the development of these platforms even further, keeping in mind their social responsibility.

According to Isabel, there is also a variety of other challenges that the MaaS aggregators must overcome to be an effective solution.

The first one is finding actors who want to really collaborate with the platform. It is not obvious, and in the case of Yumuv, this process was facilitated by the reliability that the public transport companies owning this project provided. With that support, the platform was able to create the necessary links with the software provider to get access to key data that have made it possible to create the backbone of this solution.

Second, developing a solution that is in line with the different strategies of the cities, indeed it's important to point out that each city has different characteristics and needs.

Third, is a marketing problem. The main issue is that people don't know this solution, they must be informed about the presence of the service and its operation. Even in the case of Yumuv if there had been the possibility to invest more in marketing the user numbers would have been different.

The last challenge is finding the economic and skill resources to develop effectively the MaaS solution.

Going on with the interview, the focus shifted to all the factors that are missing to reach the majority of the citizen. There need to be a lot of incentives, both for the end-user and the MaaS providers. For the customers, to facilitate the transition from the ownership of private cars to the usership model. Citizen needs to see some benefit, there is a need to provide an added value in comparison to a car. Quoting the interviewee directly:

"That needs to be implemented first to make it more attractive. Otherwise, people don't see the benefit of using it. It's not just oh, I'm going to save the world. I'm going to make it greener, so I'm taking the bicycle in the end. Comfort and the own wallet have a higher priority".

While, for MaaS aggregators, the aim is to facilitate the development of this solution (tax cuts, offices, etc.).

To conclude, after having analysed in-depth the specific context in which the MaaS aggregators operate and their actual situation, a brief overview of the future trends of the sector was done. In the

future, MaaS operators should extend their services and their coverage. The extension of the services is necessary to provide more complete packages that can be perfect substitutes for cars. While, the increase coverage to rural areas is very important to attract commuters to the MaaS aggregators.

4.4 Upstream

Upstream was founded in 2016 jointly by the public transportation operator, Wiener Linien, and the city infrastructure company, Wiener Stadtwerke. Given the focus on mobility, Wiener Linien holds the majority share in the company (51%). Upstream is a public MaaS platform that allows for planning, payment, and access to mobility services.

4.4.1 Interview sum up

The interview started with some icebreaker questions to learn more about the background of the interviewee and his role in the company. Gernot Hörhager is a project manager working in the Research & Development department of Upstream and is responsible for the on-demand services. He also worked in the Data Science department. With his team, they collected and analysed users' mobility data to help the city of Vienna optimise its services.

After this brief presentation, the focus of the interview moved on to the first area of interest in this research (see figure 9). Upstream mobility is a subsidiary of Winer Linen, a public transport company, and Wiener Stadtwerke, a public infrastructure company. The focus of the company is to improve urban mobility. This company is unique in Europe, operating both B2C and B2B.

Indeed, since its platform has an open interface, all mobility apps can have access to it and use it to offer their services. Thus, Upstream is not limited to operating in Vienna with its app (WienMobil) but also offers its platform to interested public transport companies, facilitating their transition to smart, multimodal urban mobility. For example, Hamburger Hochbahn, a public operator of bus and heavy rail, has created its MaaS solution called "Switch" using Upstream Mobility technology.

Upstream mobility's integrated platform in Vienna, offers multimodal transport to its users thanks to the ecosystem of mobility providers that are linked to the platform. Among the providers, there are bike sharing, car sharing, public transport, taxi, and car rental companies. The platform has reached a deep level of integration as it offers on its app: routing, booking, and ticketing services. However, it currently offers "pay as you go" as the only payment option. Except in the case of Vienna, where a bundle between public transport and bike-sharing is offered, it is currently not

possible for the company to offer other payment options. In the case of Vienna, it was only possible because the public transport company also owns a bike-sharing company. In other cities in which the Upstream mobility platform is operating, platform operators should make agreements with other mobility providers to add subscriptions or other forms of payment.

According to Gernot, it is difficult to assess with certainty the market response to their MaaS solution. Due to the Covid 19 pandemic, the economic and social situation of the last two years has been difficult, however where the platform is active and fully integrated with the city, such as in Vienna and Hamburg, users' response is positive. The distinctive element and the main advantage of the company is its ownership. Being a public company is a guarantee on the management and respect for the privacy of user data. This represents an advantage for cities and more generally for public transport operators who want to open to this new solution.

Then the interviewer shifted the focus of the conversation to the second area of interest of this research, starting with the analysis of the actual development of this solution in Europe and of the different implementation challenges that MaaS aggregators should have to overcome to help implement the smart mobility in cities.

At present, there are several multimodal mobility platforms in Europe, at different levels of development, but in five years, the interviewee believes that these platforms will not be able to limit themselves to offering only current mobility services. These platforms will have to be integrated with the city, thus enabling the achievement of the smart city paradigm. Among the new functionalities, for example, they will have to be able to provide all relevant information on charging columns for electric cars, while also allowing booking and payment.

The interviewee believes that there are two main challenges that MaaS aggregators must overcome to be an effective solution.

First, succeed in changing the mindset, and thus the policies, of city authorities. Indeed, MaaS is not a solution born to make a profit, private MaaS aggregators are having so much difficulty in finding a sustainable business model in the long term so, it must be the cities that invest in these platforms. It would also be a strategic choice for public authorities to reduce emissions and achieve smart and sustainable mobility.

Cooperation between public authorities and MaaS aggregators is also a political issue. It is closely dependent on the different political actors and their long-term vision of the city's development. Furthermore, there is no one-size-fits-all solution as each city has unique characteristics with its strengths and weaknesses. Directly quoting Gernot, this is due to the fact that:

"All our customers have a specific application because they have different needs, different regulations, for example for the payment process".

Second, succeed in changing the mindset of users. For this purpose, the role of public authorities, municipalities, or government agencies, is extremely important. They should introduce a system of incentives and/or limitations to facilitate the transition.

The interview ended with the suggestion of the interviewee, it would be perfect to have a mobility app in which are integrated data science and machine learning services. He wishes to have:

"An app that knows me better than myself and that is thinking for me".

4.5 Tier

Tier is a European micro mobility provider founded in 2018, it plays a key role in the ongoing transformation of urban mobility by helping cities reduce emissions and car congestion. The company currently operates in 100 cities and has helped to avoid more than 15 million car journeys.

4.5.1 Interview sum up

The interview started with some icebreaker questions to learn more about the background of the interviewee and his role in the company. Alexander Sprey joined Tier in November 2020 and now is the Senior Manager of strategic partnerships. He is leading the strategic partnerships team and oversees Tier's global Mobility as a Service (MaaS) strategy. His team is finding new ways to connect the services of Tier, which are the E scooters, and E-bikes, that are provided in almost 200 cities now in Europe, with other modes of transport, especially public transport. The final aim is to offer citizens an experience that is as integrated and seamless as possible to make it easier to leave their private cars behind.

After this brief presentation, the focus of the interview moved on to the first area of interest in this research (see figure 9). According to Alexander, MaaS and its providers, could potentially be the future of urban mobility. The interviewee used the conditional tense because these solutions can be effective but under certain conditions, quoting him directly:

"It very much depends on how it's set up and to what extent or better how far the integration will go".

Now, the development of this solution is at a good stage, but we are still far from the final goal. Supposing a scale from zero to five we are at level two. The sector has taken several steps forward

in recent years but certainly is not enough to make the transition from car ownership to usership happen. To have a significant impact on the way people move around and on the CO2 emissions and the other negative externalities there is much more needed from various points of view.

Further analysing this topic, Alexander identified in the proliferation of a lot of different mobility service providers, some successful others less successful, in several European cities a positive and hopeful signal. In fact, without this variety of alternatives, there wouldn't be anything to connect and integrate on a single application or different applications. In parallel, there is also a general opening toward the necessity to cooperate to integrate different modes of transport to facilitate the mobility experience of the end-users. Even some operators, for example, some Tier's competitors, that not too long ago were closed to external collaboration, are now opening to this new model. Finally, they are appreciating the benefits of these operations.

The second critical element identified during the interview is the scalability of MaaS solutions. Using his words:

"I think that what we haven't been able to demonstrate yet is achieving this (referring to MaaS) at scale, is that what we need to have a powerful impact, right?".

Continuing the analysis of the actual situation of MaaS aggregators was also highlighted the fact that some of them so far have not really been able to grow at the same pace as the actors of their ecosystems. The perfect example are some micro-mobility operators such as Tier and Bolt that are expanding their range of services and are expanding into more and more cities with their platforms.

Then the interviewer, after having analysed the actual development of the MaaS in Europe, shifted the focus of the conversation to the different implementation challenges that MaaS aggregator should have to overcome to help implement smart mobility in cities.

According to Alexander, there are a variety of challenges, the main one is the need for closer collaboration between all the different actors involved in this solution. More cooperation is needed especially with the public transport because directly quoting the interviewee:

" It will remain the backbone of urban mobility and, there is no MaaS, no successful or no full complete MaaS without public transport".

There must be the willingness of public transport operators to find new ways to collaborate, and in that direction the role of city authorities is fundamental. It is also very important to mention public authorities because they are responsible for the provision of the legal framework that regulates urban mobility. They play a key role in the success of the MaaS model, in fact for an effective

MaaS service isn't sufficient the development of an easy-to-use app and the successful integration of the various modes of transport. Of course, digital integration is an essential step but, to reach a complete MaaS aggregator, is also necessary the integration at a physical level. Cities should improve parking infrastructures, implement even more new mobility hubs close to public transport stations and invest in bike and micro-mobility lanes to make users' experience safer and smoother. Then cities should also provide a framework to facilitate the data sharing between the different urban mobility providers.

Alexander concluded the analysis of the first challenge by reiterating that also the degree of cooperation with other stakeholders should increase if we want to make this solution successful.

The second main challenge identified during the interview belongs to a commercial level. The different MaaS aggregators operating in Europe right now have managed to integrate different mobility service providers but, except few exceptions such as Whim, they offer only a "pay as you go" payment option, meaning that the user must pay per trip for every single transport mode used. As the technology integration isn't anymore a barrier to the implementation of this solution, finding a way to combine these offers into a single convincing commercial offering it's now the real current and future challenge. According to Alexander, many possible options can be considered: monthly fees, unique daily tickets, and single trip tickets (that cover all the modes of transport used in the journey). Finding a business model that is sustainable in the long term and that actually makes the MaaS platforms operate profitably and at scale, it's a critical challenge to be tackled. One solution could be the B2B because employee’s mobility is a huge market on which it seems easier to build a sustainable business model, but B2C still remains a critical factor.

The third challenge consists in finding a way to make MaaS platforms more accessible for families but also for people with disability.

Going on with the interview the attention has shifted to how MaaS aggregators and public authorities should cooperate to reach smart urban mobility. To address the socio-environmental challenges and, to foster sustainable mobility, a system of incentives via the MaaS app that rewards the green behaviours it's not sufficient. If the real common aim is to foster the shift from ownership of the car to usership there is an urgent need to radically change or adjust the public policies at a European level to make cars financially much more unattractive. To have a better understanding of this concept, Alexander made an example, in Germany now you can have a public parking space for your car for just €20 per year. With this policy, the government is basically incentivizing people to keep owning a private car because they are subsidising a public space. The price is too little compared to all the negative externalities linked to cars. Therefore, also we must consider the

possible “loss of income”, the parking spaces could be used in a much more environmentally friendly way. Definitely, according to Alexander:

“There are still few steps that need to be taken before we look at the level four of the Sochor scale, there is a lot that needs to happen”.

Also, in this case, the role of city authorities is of paramount importance. To have sustainable smart mobility there is also the need for investments on the infrastructural level. To facilitate the transition European cities, need to implement low-speed zones, more bike lanes, and improve the service of the public transport.

After having analysed in-depth the specific context in which the MaaS aggregators operate and their actual situation, a brief overview of the future trends of the sector was done. The interviewee thinks that new technologies such as autonomous driving will surely bring more opportunities and benefits but at the same time, he strongly believes that, right now, we already have sufficient modes of transport in cities to convince citizens to change their routines. According to Alexander, instead of thinking to integrate new solutions, the MaaS sector should think:

"How can we make it as attractive as possible so that people think this is enough for me to leave my private car behind?”.

The interview ended with a suggestion:

“Humans weren’t born with cars, they came in the XX century, and we adjusted our city infrastructure. I don't see a reason why we can adjust our city infrastructure again to a new model that we envision for ourselves in the future, right? It's an investment, it requires time and effort. But it's possible”.

4.6 Lynk & Co

Lynk & Co is an automotive company, owned by Geely Automobile Holdings, founded in Sweden in 2016. The firm has a unique business model, it offers monthly or annual memberships that gives customers access to cars that can be shared with other drivers. On average, a car isn’t moving for 96% of the time but users pay it 100% of the time, this proposition lets the cars make money for the users when they are not using it.

4.6.1 Interview sum up

The interview started with some icebreaker questions to know more about the background of the interviewee and his role in the company. Michael Zorez works in the mobility sector since 2014, he had a consulting company that collaborated with small and medium-sized companies in the areas of EVs, charging, and renewable energy. Last year he joined Lynk & Co and he works as product manager in the connectivity department of the company. He is responsible for the whole infotainment system of the company's cars, from the navigation to the mobility services.

After this brief presentation, the focus of the interview moved on to the first area of interest in this research (see figure 9). According to Michael, the future of this sector lies in a more pragmatic approach to mobility. MaaS aggregators must develop and follow a clear final goal, quoting him directly:

"Is the goal to provide more customer value to make it easier for people to move around and remove obstacles? Or is the goal only to make money?".

Although it's difficult to assess as the situation is different from market to market in Europe, if we consider the first objective the interviewee believes that there have been positive developments even though this solution may be not achievable today or in the foreseeable future in some European regions. Taking into example the Lynk & Co case, the MaaS solution they are offering is catching on in every market where it has been marketed.

Generally, aggregators are managing to make it easier for people to find mobility services, but something is still missing. The current focus on quantity, on making available different transport modes throughout the city, should shift to the quality of these services. Therefore, MaaS aggregators must also be able to develop a business model that is sustainable over time. There has been progress with the introduction of subscriptions but unless you don't sell a real "product" it can be quite difficult to make that work from a financial perspective.

This is a critical point, and the respondent expressed several concerns on this issue. The easiest way to find other sources of income should be to include advertising on the platform, but this would penalise the user experience for customers. Another possible solution should be to identify the users' needs, for example, access to events or restaurants, correlated with the mobility services, and then offer packages combining these services with the company's offerings, trying to add value to the customer could be a winning strategy.

Then the interviewer, after having analysed the actual situation of MaaS, shifted the focus of the conversation to the different challenges that the MaaS sector should have to overcome to help implement smart mobility in cities (see figure 9).

The first and main challenge currently, also for Lynk & Co, is to get the system more stable and reliable. MaaS is a new service and once users have been persuaded to use the platform the providers cannot afford customers to have problems during usage. As Michael said:

"If people decide to use the MaaS solution and then they encounter issues in the app, then they will probably try it once, but not a second time".

Then directly linked to the first point, the platform should be as user-friendly as possible to ensure an easy and immediate experience. These days customers are used to a certain degree of technology, they are used to control their smart tv or certain items in the house through voice control and they expect the same level of technology in everything. If MaaS aggregators can offer a good product customers will continue to use their services and will advertise the platform, in fact satisfied users are the best form of advertising.

The second challenge is the achievement of the scale. The mission of helping to achieve smart and sustainable mobility is not feasible now. There are several good initiatives but their impact on the reduction of emissions and vehicles on the road is still limited. According to Michael, this factor is also what is hampering the cooperation with public authorities. From a government level, MaaS operators are still considered a bunch of start-ups. In many cases, they do not yet have the numbers or the reliability to push the public sector into greater cooperation.

Finally, there is the mindset barrier. People do not willingly change their routines and many people do not like to change at all. For this reason, MaaS aggregators must be able to make their services as attractive as possible to facilitate change. Therefore, they should make the entry barrier as low as possible.

Going on with the interview, the focus shifted to all the factors that are missing to reach the majority of the citizen.

First, MaaS operators need to increase their coverage in cities. They cannot be limited to central districts. For the majority of the population, it is not a viable solution to move from their homes to their offices. In some neighbourhoods, public transport or the car is still the only convenient solution for users. Many people who would benefit and be interested in MaaS solutions may not be able to access it.

Second, an active role for public authorities. They should nudge the citizen toward more sustainable mobility facilitating the change. Governments should start educational campaigns to raise awareness of their negative impact on the planet and in parallel should discourage car ownership. If the ownership will remain attractive many people will continue to buy vehicles to move around instead of paying to use them when needed. The regulation should be modified to support the development of the new mobility services. Quoting the interviewee directly:

"Drive the change towards a more sustainable mobility could have a much bigger effect than just offering money to buy certain vehicles".

After having analysed in-depth the specific context in which the MaaS aggregators operate and their actual situation, a brief overview of the future trends of the sector was done. In the future MaaS providers in order not to lose so many potential customers and to make their services more attractive, they will not be limited to covering cities. The interview ended with a suggestion of the interviewee, if he had a magic band he would:

"Plant the seed of understanding in every person on the planet, because if people don't understand why they should do something, they are not likely to do it".

4.7 Hertz

Hertz is a worldwide leader in car rental and leasing services founded in 1918. The company over the years, developed and expanded its portfolio of rental car brands, which now includes a broad range of varied offerings, both on and off airport, at approximately 10,300 locations across the globe.

4.7.1 Interview sum up

The interview started with some icebreaker questions to learn more about the background of the interviewee and his role in the company. Anders Tarnell joined Hertz almost twenty years ago, he is now the head of marketing for Sweden and Denmark. Therefore, Hertz in Sweden has a long history of experimental mobility projects and the interviewee also contributed to different projects between Volvo Cars and Hertz about peer-to-peer solutions and other mobility initiatives.

After this brief presentation, the focus of the interview moved on to the first area of interest in this research (see figure 9). According to Anders, the MaaS platforms are good initiatives that in the future will probably help the citizen in their daily lives but at the moment they aren't mature yet. The problem is from a customer perspective, the platforms are still too complicated. MaaS is a

feasible solution, the travel industry has a long history of partnership, brokerage, and commissions. It's been working in this manner for many years.

Although it's feasible the interviewee has some concerns about the profitability of the business model of MaaS aggregators in the long term. He made a comparison with the car rental industry, where some big companies are working as aggregators that thanks to the superiority of their distribution platforms and the strength of their brand manage to make money through commissions paid by rental companies that exploit their technology. The case is very similar to those of the MaaS operators, both do not have the means, and exploit their technological superiority. It is a very risky business, and you always must make sure that your technology has unique functionalities.

According to Anders, in the long run, the firms that are most likely to succeed are the large public transport players (train, bus, or metro). They have the strength, structure, and data to be able to offer multimodal platforms effectively. Therefore, they already have a large customer base that will be more inclined to use these new services. These state-owned companies should take the lead, they should open up to this new solution by actively influencing the market.

Still talking about big companies, Uber is another serious possibility. It has all the key elements: Funds, technology, and brand awareness. Quoting the interviewee directly:

"It's going to be interesting to discover their proposal, and their business model, I mean, how much money will they take from the user? Or car rental companies (and other mobility providers) for instance?".

Then the interviewer shifted the focus of the conversation to the second area of interest of this research, starting with the analysis of the actual development of this solution and of the different implementation challenges that MaaS aggregators should have to overcome to help implement the smart mobility in cities (see figure 9). The development of MaaS is at a good stage. there are some interesting initiatives from the EU level, but the problem is that there is a misalignment between Nordic countries, which started to develop these solutions some years ago, and the rest of Europe.

To further develop and be an effective solution for smart mobility there are several challenges.

The first one is increasing the level of collaboration by overcoming the resistance of some operators. This solution functions thanks to the platforms but only exists because of the ecosystem of providers that gravitate around them. You must be good at making the potential benefits clearly understood. As Anders said:

"If something happens in the society, I think we cannot be against it. We need to be a part of that".

Hertz has realised this and instead of fighting innovations, it continuously collaborates on different projects, for example with VOI (a Swedish micro-mobility operator) to understand how to be part of and exploit the change.

The second challenge for MaaS aggregators is to deliver a solution that offers what users require while, at the same time, being able to find the funds to invest in marketing and thus make this solution known to the mainstream public, not just have the early adopters, and to acquire the average consumer.

Going on with the interview the attention shifted to how the MaaS operators and the public authorities should cooperate to reach smart urban mobility.

The role of public authorities in the success of MaaS is crucial. This solution is catching on, every year we get closer and closer to the final goal so the European governments should support it both by doing more from a regulatory point of view and by introducing stricter restrictions. In addition, to control the emissions of cars, an important step would be to introduce a sort of carbon tax for people, to set a sort of personal annual limit which, if exceeded, leads to fines. Certainly, it is a process that takes time, you could start with more permissive levels which could then be lowered from year to year based on the responses of the citizens. The important thing is to create the structure.

According to Anders, this top-down approach is also what is missing for the MaaS solution to be adopted by the majority of citizens. There is a need for this government pressure to push people to change their behaviour and habits. Quoting him directly:

"To make sure and enforce people to abandon their car. That's where we're going to end up".

As also mentioned during the first part of the interview, another factor that could favour the adoption of this solution would be the entry of the big mobility players into this sector.

However, MaaS aggregators should also do more. They should pull together as an industry to push for these changes. In many cases, they are still small and medium-sized companies, and in this way, they would have more "bargaining power".

After having analysed in-depth the specific context in which the MaaS aggregators operate and their actual situation, a brief overview of the future trends of the sector was done.

The future of the transport industry, in general, is very uncertain and extremely volatile. During the pandemic many experts of the car rental industry and travel industry thought that industry numbers would fall and never return to 2019 levels. But this year, in March and April, Hertz Sweden had the

highest reservations ever in its history, and it is not a local phenomenon, as the same positive trend is present throughout Europe. Considering the climate crisis, the focus of governments on controlling emissions, will most likely be a short-term phenomenon, but the interviewee cannot say for sure.

The interview ended with a suggestion from Anders, he proposed to conduct a pilot study of one year, during which five hundred volunteers live with a maximum carbon budget to spend. Quoting him directly:

"It would be interesting to see how that will affect their lives and their choices".

4.8 Rise

RISE is the Swedish research institute for innovation. It collaborates with companies, universities, and the public sector to develop a sustainable society.

4.8.1 Interview sum up

The interview started with some icebreaker questions to learn more about the background of the interviewee and his role in the institute. Steven Sarasini joined the Research Institutes of Sweden (Rise) in 2014. He is a senior researcher currently focused on the sustainable mobility as a service (MaaS) solution. In the past, he has worked on different projects ranging from sustainable innovation to circular business and electromobility.

After this brief presentation, the focus of the interview moved on to the first area of interest in this research (see figure 9).

According to Steven first is important to make a distinction between the different types of MaaS solutions using the Sochor scale. The solutions currently on the market can be defined as MaaS aggregators (platforms) from the second level onwards (see figure 8). Whim for example is a level three platform that integrates different services by offering bundles and other forms of payment. Platforms of this type, such as also Citymapper, are not able to achieve the user-centric approach required by this type of service. MaaS aggregators need and want to have in-depth knowledge of the users and their needs but, according to the respondent, the current structure is not suitable for this aim. Platforms are great for the technical aspect, (connecting different transport providers around the cities, routing, etc.) but they miss the support service dimension.

A critical point for the further development of this type of solution is finding a business model that can be sustainable in the long term. MaaS aggregators of levels two and three can be profitable if they can reach a relevant number of users in each city where they operate. The margins for MaaS platforms on the trips of the various transport providers are low and to start making money the volume should be high.

In addition, they must find alternative sources of revenue. An alternative would be to implement the Facebook model and then start placing advertisements on applications, but again it would be possible only with hundreds of thousands of users. Another viable opportunity would be to start monetising the collected big data or linking the mobility services with the new housing complex instead of building new car parks. However, according to the interviewee, the most interesting opportunity would be to explore new segments. MaaS aggregators have more chance to be profitable entering the B2B segment, offering this form of sustainable mobility to companies for their employees. For example, they could offer to each company a flat monthly fee for all employees, thus gaining access to large groups of new customers. This would also be a great opportunity to encourage people towards a form of sustainable mobility. Concluding the reflection on this topic, according to Steven, there are many potential opportunities to be explored. MaaS aggregators could be profitable but, now, many are not.

Then the interviewer shifted the focus of the conversation to the second area of interest of this research, starting with the analysis of the actual development of this solution in Europe and of the different implementation challenges that MaaS aggregators should have to overcome to help implement the smart mobility in cities (see figure 9).

Steven started to study MaaS shortly after the 2014 conference that started the hype about this solution. Since that day many projects have been started and several MaaS operators have emerged in Europe. However, now most of the sector is at an “early” stage with some exceptions that are in the “growth” phase, and, from a business perspective, there are still many hypotheses untested or unfalsifiable. There are still doubts about the readiness of the market for this concept and there are still no examples of large companies that have managed to run major marketing campaigns on this solution.

According to the interviewee, there are two main challenges that MaaS aggregators must overcome to help achieve the smart mobility paradigm.

The first one regards changing the behaviour and the mindset of the users. For a part of the population, the services offered by MaaS operators are indeed convenient but, for the remaining

part, for various reasons, car ownership is still indispensable. It is an extremely difficult task to change the minds of this segment of the population. there is a need to educate people on how this technology works, its advantages, benefits, etc. Steven doesn't believe that people are ready for level three MaaS yet. Adopting this technology implies a totally new and digital lifestyle that requires the development of certain skills.

The second challenge regards the ecosystem side of MaaS. To make this solution work, there needs to be a certain degree of cooperation between the different mobility providers in the city. Typically, the most established private actors, such as big car-sharing companies, are more difficult to get on board. It is a time-consuming process, for example in Gothenburg a pilot study was launched in 2014 and only a few months ago the public transport company gave permission for third-party ticket sales.

More generally, challenges can be said to lie both upstream and downstream in the value chain.

The role of public authorities in the further development of MaaS is crucial. In the public sector, there are various authorities present in the MaaS ecosystem, city authorities, governmental authorities, and public transport companies. The task of the public sector would be to enable and facilitate innovation and above all to push it forward. According to Steven, public transport companies are too slow and too bureaucratic and are slowing down and, in some cases, blocking the market. Thinking about the final environmental goals, they should always support MaaS operators by enabling ticket sales (with some type of condition) and integrating with their platforms. Indeed, in this way, MaaS operators will have more customers and it would speed up the transition from private cars to more sustainable means of transport. Therefore, they should also leave the management of the transportation system to MaaS providers to exploit the data collected in real-time.

Finally, European legislators are wondering whether public transport companies should also be MaaS aggregators, according to Steven:

"I don't think that that's particularly useful, because I think the market should design them".

Every city has a different context, in some, they could probably take on the role of provider but, in others, they should leave this role to the private sector. From a regulatory perspective, it's important to create an "even playing field" so if a country gives tax benefits if you have a company car then it should be the same with mobility services, such as in Belgium. One could even go further by giving tax benefits to employees who live close to their workplace and decide to use sustainable mobility services. There is a lot that can be done from a tax perspective. On the other hand, from the point of

view of incentives, the respondent believes that alternative forms of transport such as MaaS should be promoted alongside public transport.

Going on with the interview, the focus shifted to all the factors that are missing to reach the majority of the citizen. First, in most cases, there is a lack of understanding of the service design process. Providers have spent and continue to invest a lot of money to develop the technology and then, at the end of the process, with the remaining funds they try to find a market for this technology. The research for the right market is crucial and, as it is a new technology, investment is needed to make it known to most people. Linking directly to this theme, Steven said:

"I sometimes feel up that MaaS it's a solution searching for a problem rather than a solution which is built on like empirical knowledge of what people want".

Second, MaaS aggregators should also be able to offer their services in the suburbs as there are many users potentially interested in the service there. Unfortunately, there is a coverage problem, there is a high density of transport only in central areas.

The interview ended with a brief overview of the future trends. In the next 20 to 30 years, as soon as we would have low-cost electric autonomous vehicles, there will be enormous pressure on public transport and city traffic congestion. If the long-term aim is really to reduce private cars there will be the need for an adequate response from public transport companies and MaaS operators. MaaS is a niche market between public transport and the automotive industry, if it wants to survive it will have to be able to cooperate with both sides.

5. DATA ANALYSIS

In this chapter an analysis and comparison are performed between the empirical findings and the previous literature review chapter. In addition, key findings are presented to integrate the identified areas where the theory is poor or outdated. To conclude, the revised theoretical framework that was developed at the end of the analysis process is explained in the last section.

The theoretical framework was used as a starting point for the analysis process and, as explained in its reference section (see section 2.6), this research is divided into two parts. The first area served the author to deepen his knowledge of MaaS aggregators, their structures and operation. Furthermore, thanks to the data obtained, a categorisation was carried out based on the Sochor (2018) scale and on the business model categories proposed by Alyavina et al. (2021). As also stated by Steven Sarasini (Rise) during the interview conducted for this research, it is essential to bring order to the world of MaaS platforms before proceeding with the analysis of these solutions and the context in which they operate in detail. The dual categorisation of MaaS aggregators, used to compare them within the themes that emerged from the coding process, served this purpose.

To carry out the analysis of the second area of interest, the author, therefore, adopted thematic analysis as it is a rigorous method that allows a reliable and linear analysis of the primary data collected (Bell et al., 2018). As explained in more detail in the methodology, the researcher decided to use the "six-phase framework" to conduct the thematic analysis, as this approach enables to perform a clear and systematic study (Maguire & Delahunt, 2017).

During the final phase of the coding process, the researcher created the coding table (see Appendix C) and a data structure to give the reader an immediate visual representation of the analysis process (see figure 13).

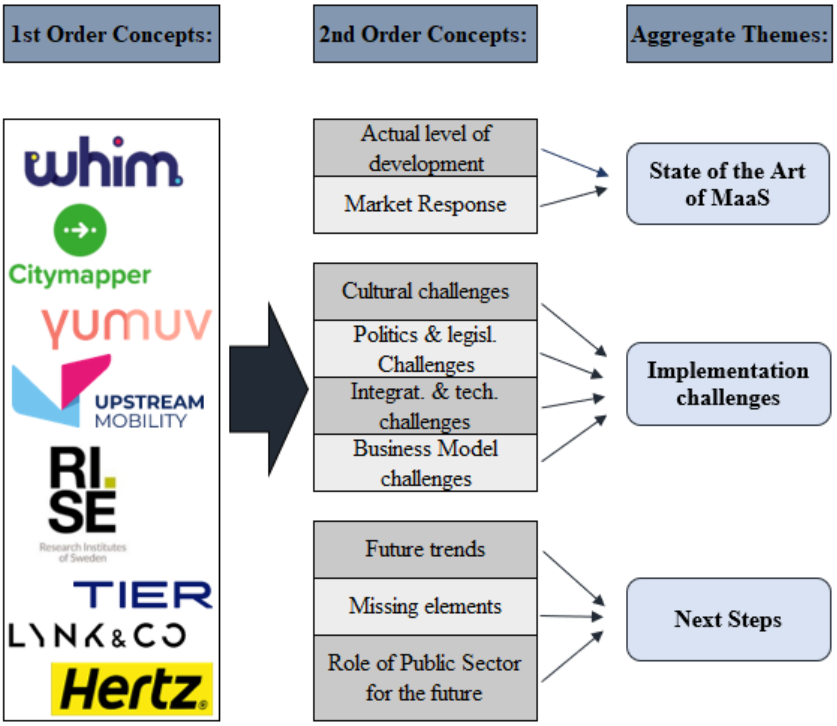

Figure 13: Data structure – *(produced by the author)*

In the following sections the aggregated themes obtained will be discussed in detail.

5.1 MaaS aggregators structure & final categorization

In this research, the Digital Platform Ecosystem was identified as the basic structure of MaaS aggregators, and the definition that best encapsulates this concept is the one formulated by Hein et al., (2020). According to the authors, the Digital platform ecosystem (DPE) comprises: "a platform owner that implements governance mechanisms to facilitate value-creating mechanisms on a digital platform between the platform owner and an ecosystem of autonomous complementors and consumers" (Hein, et al., 2020, p. 4).

Based on the data collected during the interviews with the four MaaS aggregators of the first sample, it is possible to state that all these MaaS solutions are congruent with the characteristics of the identified model.

As Sohail Rashid said, Whim is a platform that is the centre of a complex ecosystem of stakeholders, such as micro-mobility providers, car rental companies, public transport authorities, and taxi companies, that is now available in different European countries and Japan. Also, Samy Zerrouki described Citymapper as a platform ecosystem in which the firm is the centre around which all the actors are placed with connections of various kinds. Finally, Patrick Bösch, defined

Yumuv as a digital platform in which the core platform partners are the Swiss Federal Railways (SBB) and the public transport operators of the cities involved: BVB (Basel), Bernmobil (Bern), and VBZ (Zurich).

Continuing the comparison with the theoretical concepts, in all the companies under study, the MaaS providers assume the so-called “hub and spoke” form, in which the platforms are the central hub of a complex ecosystem and the MaaS operators are responsible both for the demand and supply side of the value chain (Kamargianni et al., 2019).

Therefore, MaaS aggregators of all respondents present complex ecosystems whose actors fall into the five categories proposed by Alyavina et al., (2021). In the case of the MaaS model, several transport service providers contribute to the upstream phase while technology providers, with their capabilities, are present in all stages of the process leading to the "production" of the final service (i.e., booking, payment, travel planning, data collection, and elaboration) (Kapoor, 2018).

It is interesting to highlight the case of Yumuv, in which the ETH Zurich is part of the ecosystem for scientific monitoring. The presence of an academic partner, with a prominent role, within the MaaS ecosystem was not found in the other companies interviewed.

Concerning the role of the company in the ecosystem, the only case that differs from the others is Upstream. The Austrian company, as Gernot Hörhager said, is not only a MaaS operator in Vienna (with WienMobil) but also a technology supplier. In fact, it also offers its open platform to interested public transport companies, facilitating their transition to smart, multimodal urban mobility. The most relevant example is Hamburger Hochbahn, a public transport operator, that created its MaaS solution called “Switch” using Upstream technology.

Going on with the analysis, although these MaaS aggregators have structures based on the same theoretical concepts, they have different business models. As presented by Alyavina et al., (2021) MaaS companies fall into three categories: commercial model, public controlled model, and the public & private partnership model.

In the group of MaaS aggregators under analysis 50% of the companies fall into the “commercial Model” category and the other 50% into the “public controlled model”.

Whim, held by MaaS Global, and Citymapper belong to the first category. They are private companies that coordinate the different stakeholders of the ecosystem and guarantee the integrated service provided to the end customer (Alyavina et al., 2021). While Yumuv and Upstream fall into the second category, in both cases the platforms are held by public authorities. However, they are cases of particular interest because arise from the joint efforts of various public stakeholders. In

particular, as Patrick Bösch explained, the platform of Yumuv is the result of a partnership between several public transport companies. The project is led by SBB, which has invested the most resources and funds in the platform, and it is the first case of a MaaS regional operator. By having the presence of the different public transport companies of the cities where the project operates there has been an alignment of vision between the various operators desired by Sami Zerrouki (Citymapper). Although, as Gernot Hörhager (Upstream) pointed out, it is extremely difficult to develop a single solution that considers the different characteristics of each city.

After analysing the structure of the sample of MaaS aggregators and their business model according to which actor took on the role of MaaS operator, we move on to an assessment of the level of service integration currently achieved.

The MaaS topology, devised by (Sochor et al., 2018), is an effective tool for achieving this aim. This approach is based on a scale ranging from 0 to 4, where level 0 represents the lack of integration and level 4 the integration of societal goals (see figure 8).

All MaaS aggregators interviewed reached level two on this scale. This stage consists of the integration of the booking and payment phases to the travel planner service already offered by the level one firms (Sochor, et al., 2018).

As stated by Gernot (Upstream), their platform has reached this deep level of integration as it offers on its app: routing, booking, and ticketing services. The same can be said of the other MaaS aggregators (Whim, Citymapper, and Yumuv) that allow users to find the desired trip and also book and pay for all the transport modes necessary for their travel on their platforms.

Level three consists of the integration of the service offer, at this stage MaaS aggregators no longer act as mere brokers but offer comprehensive bundled mobility services that can satisfy the needs of every single user or of entire families. The customers are willing to pay a monthly subscription both because the MaaS operator is the guarantor of the entire service and because they wouldn't be able to obtain the same complete service addressing the individual transport providers on their own (Sochor et al., 2018).

According to the data collected, only Whim, Citymapper, and Yumuv have reached this level. MaaS Global (Whim) offers a lot of different packages. Customers can choose, depending on their needs, between a variety of subscription packages. For example, if a customer wants to get access only to public transport and bike-sharing, with unlimited rides only for the first one, he can buy the specific package for €50 a month. Also, Citymapper has launched two years ago a smart travel card, called

Citymapper pass, that offers its subscribers a bundle of mobility services. However, the bundles offered by these two companies are still limited to their home cities of Helsinki and London.

Even though these MaaS aggregators are operating in several cities, we are still far from the ultimate goal of having a single platform accessible in several cities with the same subscription (Sochor et al., 2018). The only case that seems to have come close to this goal, albeit on a regional level, is Yumuv where during its pilot study year the same bundle was available in Basel, Bern, and Zurich.

Finally, to give an immediate visualisation of the categorisation carried out, the summary diagram below has been produced.

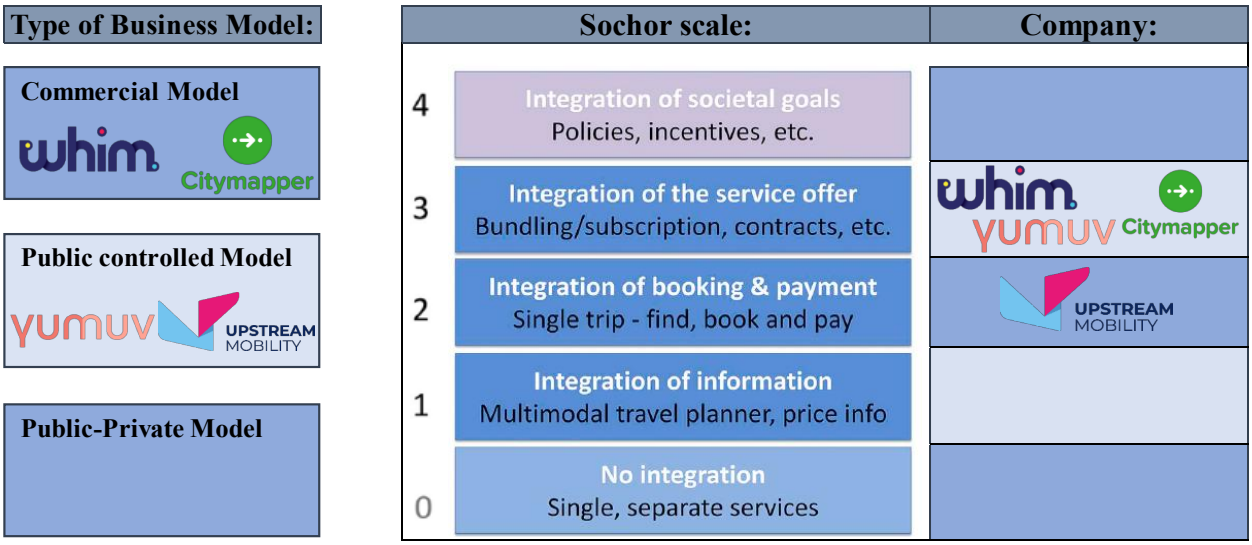

Figure 14: Categorization table – *(produced by the author)*

5.2 State of the art of MaaS

In this section, using the data collected, is presented an investigation into the current state of development of MaaS in Europe and the responses MaaS aggregators are getting from the market.

According to several respondents, describing the current state of development of MaaS aggregators in Europe is a difficult task. Gernot Hörhager (Upstream) believes that this is because, at present, there are several multimodal mobility platforms in Europe, at different levels of development. While, Samy Zerrouki (Citymapper) believes it depends, as also confirmed by Michael Zorez (Lynk & Co), on important differences between the various markets. There is no single European market as legislative and cultural differences are still significant.

However, as stated by the Anders Tarnell (Hertz) and Michael Zorez (Lynk & Co), the general development of MaaS is at a good stage, since the 2014 ITS Europe Congress many solutions have

been developed and tested in several cities around Europe. Alexander Sprey (Tier) identified in this proliferation of a lot of different mobility service providers, some successful and others less successful, a positive and hopeful signal. Although he also pointed out that some MaaS aggregators so far have not really been able to grow at the same pace as the actors of their ecosystems, such as the micro-mobility providers.

Continuing with the analysis of the European context, interviews with Samy Zerrouki (Citymapper) and Anders Tarnell (Hertz), it emerged that there is a misalignment between Nordic countries, which started to develop and test MaaS solutions some years ago, and the rest of Europe. It is no coincidence that Whim, the first MaaS operator, is Finnish.

According to Steven Sarasini (Rise), based on the business life cycle, most of the MaaS aggregators are at an "early" stage with some exceptions that are in the "growth" phase. Therefore, it's important to highlight that from a business perspective, as will also be presented in the next section, there are still many hypotheses untested or unfalsifiable. One of the exceptions mentioned by Steven Sarasini (Rise) is Whim, which as also stated by Sohail Rashid (Whim), isn't anymore an early age stage start-up. They developed a competitive advantage over the years, indeed MaaS Global raised so far about 65 million euros and 60% of these funds were invested in developing our product. However, even if the technology is mature enough the market adoption is still far away.

Patrick Bösch (Yumuv) instead used the Gartner hype cycle to give an assessment of the current state of this solution. MaaS has passed the "peak of inflated expectations" and is at a more or less advanced point of the next downward phase. Indeed, since the launch of this solution, enormous expectations have been created, and this is compatible with the emergence and proliferation of different MaaS solutions around Europe. It seemed that MaaS could solve all the problems of urban mobility. But now that the platforms are operational and numerous problems and challenges have arisen, the phase of high expectations and the resulting technological development is over and has given way to a delicate settling-in phase on which the future of this solution depends.

However, what all respondents agree on is that even though several important steps forward have been made in recent years the road to market adoption and smart mobility is still long.

It is now time to analyse the reactions that the interviewed MaaS aggregators are getting from the market. As presented by various experts Mobility as a Service (MaaS) could play a fundamental role in the radical transformation of the urban mobility system, MaaS solutions can facilitate the shift to a more sustainable way of moving offering several transport services easily accessible on the personal devices of the citizen (Lopez-Carreiro et al., 2020). Therefore, as stated by Arias-

Molinares & Garcià-Palomares (2020), it has begun the so-called “servicing” era in which more and more people are moving beyond the concept of “ownership” to embrace the philosophy of “usership” that is at the base of the MaaS model. The aim of this section is to understand whether the theorised expectations are in line with the current situation MaaS aggregators are experiencing.

Regarding the current market response, all MaaS aggregators interviewed (Whim, Citymapper, Yumuv, and Upstream), regardless of their business model and level of service integration, provided broadly similar data.

The first factor to be highlighted before continuing the analysis is the difficult socio-economic situation caused by the Covid 19 pandemic over the last two years. Restrictions on people's mobility have inevitably impacted the use of MaaS aggregators.

In the case of Yumuv, as stated by Isabel Götz and Patrick Bösch, when the smart working became a constant the number of users started to drop as there were no longer any commuters using the service to get from their homes to the offices. While, Sohail Rashid pointed out that Whim was expanding in several cities, such as Singapore, before the health emergency caused a forced stop.

In general, the user response from MaaS aggregators is positive. The market before the Covid Pandemic was responding generally well to Whim's offer, there was an upward trend, and the company was gaining subscribers and the same positive results, in the cities where the platforms are fully operational, were found by Citymapper, Yumuv, and Upstream.

Although two constants of fundamental importance have emerged. Firstly, the results, although positive, were below the forecasts made. As claimed by Patrick Bösch Yumuv’s first year is a clear success, but the market response wasn't as good as the forecast for various factors that will be addressed in the next section. Sohail Rashid also confirmed that even if the response is generally positive, customers are growing more slowly than Whim’s forecast. However, the respondent is not worried as he believes that: “it's gonna take a while we get adoption from customers and then from users. It's a slower growth rate, but when people come on board and sign up, they stay”.

The second element is the lack of financial sustainability. Samy Zerrouki emphasised that although Citymapper is getting a good response from the market in terms of usage in the various European cities where it is present, it is still not profitable. Data were confirmed in part by Gernot Hörhager who nevertheless believes that Upstream, and in general MaaS solutions, was not created with the intention of making a profit. In this case, it is significant to highlight that this difference in perspective may be due to the fact that Citymapper is a private company while Upstream is a public company born from the collaboration of two public authorities.

5.3 Implementation challenges

In this section, to provide an overview of the current situation, a comparison between the collected data and the literature review has been made, taking into consideration the different nature and characteristics of the MaaS aggregators analysed.

The actual urban mobility of the cities is a complex and intricate system of which a multitude of actors are part and, after decades of substantial stagnation where the car was considered the indispensable element of the system, there is now a period of great change (Arthur D. Little, 2018).

This transformation is essential for the future of smart cities and their sustainable vision. The transport sector is one of the main pollutants, accounting for approximately 25% of greenhouse gas emissions in the world, and going into greater detail, 70% of these emissions are produced by urban mobility (García-Ayllón & Kyriakidis, 2022). Therefore, this number is set to grow, urban passenger mobility demand is increasing sharply and by 2050 it would be 38% higher than 2010 (United Nations, 2017). Considering the concerning statistics above, achieving smart mobility is crucial. The first aim of smart mobility is to make urban journeys more sustainable through the reduction of air pollution, the reduction of traffic congestion, the improvement of the use of resources, etc. (Bıyık, et al., 2021). As presented in the literature review, it has been widely acknowledged that MaaS has the potential to be an effective solution for improving city mobility and there are several studies on how it can help reduce its negative externalities by reducing CO2 emissions and car traffic (Cole, 2018; Zhao et al., 2020).

However, to make this solution an effective tool to help achieve the goals of Smart mobility there are several challenges that MaaS aggregators will have to overcome.

5.3.1 Cultural challenges

The first group of challenges identified in the coding process relates to user culture. MaaS belongs to the category of sustainable innovations and, as stated by Sopjani et al., (2019), for the success of solutions where users are considered core stakeholders it is fundamental to consider and influence people's habits and needs. On this first challenge, there is an alignment of all MaaS aggregators.

According to Sohail Rashid (Whim), managing to change the mindset and the behaviour of the people isn't a simple mission, many people love their cars, but they don't realize the amount of time and money that lose every day, especially in the chaotic traffic of big cities. While, Samy Zerrouki (Citymapper) identified as reasons for people's attachment to the car-ownership concept, as the freedom and the social validity that owning a car gives you.

Michael Zorez (Lynk & Co) and Steven Sarasini (Rise) also agree on the difficulty of changing the mindset of users. The former underlined the fact that people do not willingly change their routines and many people do not like to change at all. While the latter believes that users aren't ready yet for adopting a technology that implies a totally new and digital lifestyle.

The views presented so far are congruent with what can be found in the theory. Indeed, according to (Sopjani et al., 2019), car ownership gives several perceived benefits such as the feeling of freedom, social validity, and flexibility. Therefore, the authors also pointed out that to succeed in the difficult task of changing people's habits and culture MaaS aggregators should be able to communicate their unique characteristics to trigger this cultural change (ibid).

Communication and education are also the second critical challenge identified by the majority of respondents.

Isabel Götz (Yumuv) pointed out the fact that many citizens don't know about this solution and so there is an urgent need to inform them about the presence of MaaS and its operation. Many people, even if they unconsciously already do it, do not know what multimodal mobility is. This factor was also confirmed by Patrick Bösch (Yumuv) and Steven Sarasini (Rise) that stressed the need to educate people about this innovation. In particular, as we argued before, to win the competition from cars there is the need to educate people on how this technology works, its advantages, benefits, etc. About this issue, it is interesting to report the proposal of Michael Zorez (Lynk & Co) that stresses the importance of public actors, as we will see in detail in the next section, the respondent thinks that municipalities or national governments should start educational campaigns to raise awareness of the negative impact on the planet of personal mobility to discourage car ownership.

To conclude, Patrick Bösch (Yumuv) gave an interesting point of view that wasn't presented in the literature review chapter. Indeed, according to him the change of mindset not only concerns the users but also the whole mobility sector. The various players should start imagining themselves as an enormous ecosystem where the aim isn't anymore to lock customers into their services or products.

5.3.2 Politics and legislation challenges

The second group encompasses the political and legislative challenges. As seen in the literature review, this category is strictly interconnected with the challenges of the first group. Indeed, the role of public authorities is of paramount importance for the development of MaaS, there is no certainty

that new mobility services alone will succeed in the difficult task of influencing people's travel habits towards a more sustainable form of mobility (Crozet, Santos, & Coldefy, 2019). As also stated by Anders Tarnell (Hertz) there is a need for government pressure to push people to change their behaviour and habits.

All MaaS aggregators (Whim, Citymapper, Yumuv, and Upstream), regardless of the categories identified in the first section, identified the need for green policies and incentives of various kinds from the public sector as a key element for the development of MaaS aggregators.

Different regulatory instruments would facilitate the transition from the car ownership model to the usership model. Among the possible measures, public authorities could introduce a congestion tax on the circulation of cars in the city or develop reserved lanes for car-sharing vehicles (Crozet, Santos, & Coldefy, 2019). Samy Zerrouki (Citymapper), reiterated the importance of these two instruments. In particular, he believes that the implementation of special lanes for carpooling, car sharing, and any other sustainable mode of transport could be a truly effective solution.

During the interviews, other measures were also addressed. Sohail Rashid (Whim) stated that is necessary to introduce a moratorium on the number of cars circulating in the European cities as was done in Singapore. The interviewee, thanks to his experience in the field, is convinced that the implementation of such a regulation would provide an incentive to citizens to try more sustainable transport solutions, they would realise how important their impact on the planet is. While, Anders Tarnell (Hertz), believes that a carbon tax should be implemented in parallel with measures to control car emissions. This instrument would consist of the introduction of a personal annual limit of emissions which, if exceeded, leads to fines. It is a complex and time-consuming process that takes time, but governments could start with more permissive levels which could then be lowered from year to year based on the responses of the citizens. As pointed out by the interviewee the important thing is to create the structure.

Going on with the analysis, as stated by the majority of respondents, in addition to policies to limit car use a system of incentives should also be introduced. Samy Zerrouki (Citymapper) and Gernot Hörhager (Upstream) have argued that public authorities should facilitate the transition to a new type of mobility by implementing a system of incentives, for example, they could be tax cuts, to reward the green behaviours. While Isabel Götz (Yumuv) noted that the incentives shouldn’t be only for the end-user but also for the MaaS providers. For the latter, the aim is to facilitate the development of this solution by providing tax cuts, free offices, etc.

However, to be able to introduce an effective incentive system there needs to be a change at the regulatory level. The urgency of changing the legal framework that regulates urban mobility has also been remarked by Alexander Sprey (Tier) and Michael Zorez (Lynk & Co).

Indeed, as shown in the literature review, the regulation of urban mobility is often fragmented and does not foresee specific categories for the new mobility services such as MaaS. As stated by Sochor, (2021): “Many policies and regulations may need to be tweaked or reworked to allow for such services to emerge at scale”. For example, in several European cities, employees who decide to travel to work by public transport receive free subscriptions from the companies or tax reductions from the government. Without a clear framework for MaaS, employees who choose to use this sustainable mode of transport instead of public transport will not be guaranteed the same benefits (Li & Voege, 2017).

As stated by Steven Sarasini (Rise), it's important to create an "even playing field" so if a government gives tax benefits if a citizen has a company car then it should be the same with mobility services, such as in Belgium. He also suggested granting tax benefits to employees who live close to their workplace and decide to use sustainable mobility services. There is a lot that can be done from a tax perspective. The same can be said of government subsidies, if they are given for public transport (which is the backbone of urban mobility), they should also be given for other forms of sustainable urban mobility.

To conclude, referring back to the previous section, where it emerged that there is no single market in Europe because of the cultural and legislative differences. It is interesting to point out, as argued by Samy Zerrouki (Citymapper), that there is an urgent need for unified legislation and, for this aim, the role of the European Union will be extremely important. Therefore, there is also an urgent need for new policies that regulate and incentivise collaborative relationships between the various mobility service providers that decide to join the MaaS ecosystems (Hasselwander & Bigotte, 2021).

5.3.3 Technology and integration challenges

The third category of challenges covers the areas of technology and integration. The four biggest challenges that emerged during the interviews were: the integration from a technical point of view, data sharing, the lack of collaboration, and the need to increase coverage.

Managing an ecosystem as complex as that of MaaS platforms isn’t an easy task, as confirmed by all respondents. MaaS aggregators are having difficulty integrating the services of the different

players in the ecosystem needed to provide a multimodal experience to customers (Hasselwander & Bigotte, 2021).

Although the technology has now reached an appropriate level of maturity as explained by Samy Zerrouki (Citymapper) and Sohail Rashid (Whim), not all operators have the same level of technology. Precisely about this factor Patrick Bösh (Yumuv) pointed out that there is an urgent need for technological levelling, the will to cooperate is not enough. The interviewee then has specified that, as confirmed by the research of Hasselwander & Bigotte (2021), this misalignment is due to the lack of APIs or other key technologies necessary for integration.

Moving on, Hasselwander & Bigotte (2021) identified in the lack of open data and in the unwillingness of the mobility providers to share data another critical issue. On this topic, which emerged in the interviews with all MaaS aggregators, responses varied.

The collection and use of data is a key component of MaaS platforms, as also reiterated by Samy Zerrouki (Citymapper). However, on this issue, MaaS aggregators controlled by public authorities (Yumuv and Upstream) did not have the difficulties encountered by private MaaS aggregators (Whim and Citymapper). According to Gernot Hörhager (Upstream), being a publicly owned company is a key advantage. Public ownership is a guarantee of proper data management and respect for the privacy of user data. This factor represents an incentive for cities and more generally for mobility operators who want to open to this new solution. Another key element, as also evidenced by (Hasselwander & Bigotte, 2021), for the growth of MaaS aggregators is to increase the level of collaboration with public actors and other mobility providers.

On this issue, all the experts interviewed, albeit with different perspectives, agreed with the theory. The respondents of privately-owned companies, such as Whim and Citymapper, highlighted the need for greater cooperation from public actors, referring in particular to municipalities and public transport operators. Sohail Rashid (Whim) emphasised the importance of the public authorities explaining that they are essential for the MaaS operators as they give the authorisation to provide their services and they also manage public transport, which is the backbone of urban mobility. Moving on to the second group of respondents, Alexander Sprey (Tier) confirmed that there is a need for greater willingness to cooperate on the part of public transport operators, who, also helped by city authorities, should push for new ways of collaborating with MaaS aggregators.

While agreeing with the topic emerged, Isabel Götz (Yumuv) claimed that to push for more cooperation from the public authorities, MaaS aggregators lack more numbers and more facts to provide reliable evaluations. Also according to Michael Zorez (Lynk & Co) MaaS solutions, in

many cases, do not yet have the numbers or the reliability to push the public sector into greater cooperation. From a government level, MaaS aggregators are still considered a bunch of start-ups.

Also concerning the mobility service providers, the need to increase the degree of cooperation by overcoming the resistance of some operators has emerged during the majority of interviews. MaaS platform is based on an ecosystem of actors providing mobility services and as stated by Sohail Rashid (Whim) without partner companies, MaaS aggregators would have no way to exist. Anders Tarnell (Hertz) reinforced this statement by explaining that this solution functions thanks to the platforms but only exists because of the ecosystem of providers that gravitate around them.

Sohail Rashid (Whim) considers that micro-mobility operators are the companies least likely to cooperate. They are often not willing to integrate within MaaS ecosystems because they think that these platforms will take away their customers. This evidence was also confirmed by Alexander Sprey (Tier), manager of one of the world's largest micro-mobility providers, according to which some micro-mobility providers were until recently closed to external collaboration. However, they are now opening up as they have finally realized the opportunities and benefits they could gain from cooperation.

Integrating various services is not an easy process and Isabella Götz (Yumuv) mentioned the social responsibility of the various actors and hopes for a change. To conclude, it is interesting to note that also on this issue publicly owned MaaS aggregators have been facilitated. This process was easier thanks to the reliability that the public transport companies owning the MaaS aggregators.

The last critical challenge, which emerged during the interviews is to succeed to increase the level of coverage in the city and surrounding areas. Overcoming this challenge is of paramount importance if the MaaS aggregators want to acquire commuters as customers.

5.3.4 Business Model challenges

The last category encapsulates all the challenges that MaaS aggregators will have to overcome to develop a business model that is financially sustainable in the long term (Zhao et al., 2021). As presented in the literature review a lot of new MaaS operators have gone bankrupt and those who remain in business are hardly profitable (Crozet, Santos, & Coldefy, 2019). Samy Zerrouki (Citymapper) confirmed what was found in the literature explaining that in most cases, MaaS providers are not managing to make money with their services. As confirmed by Alexander Sprey (Tier), finding a way to combine these offers into a single convincing commercial offering is now the real current and future challenge.

About this crucial issue, the MaaS aggregators interviewed have conflicting opinions. Sohail Rashid is positive about the profitability of his company as he believes in Whim's revenue model and, as we will see later, thinks that subscription packages are the solution. Samy Zerrouki, on the other hand, firmly believes that the only way out for Citymapper is to be acquired by a larger company, like Uber or Google, that can make the necessary investments. Indeed, actually, it is not sustainable in the long term for Citymapper to provide this type of service. The company in the last year has tried to launch new services, such as Citymapper pass and plus, but these solutions have not met expectations and are not bringing in the expected revenues. The last point of view is the one of Gernot Hörhager (Upstream), according to the interviewee MaaS is not a solution born to make a profit. He then argued that given the fact that private MaaS aggregators are having so much difficulty in finding a sustainable business model in the long term it should be the cities to invest in these platforms.

The experts of the second group of interviewees all showed serious doubts about the possible financial sustainability of the business model of MaaS aggregators. According to Alexander Sprey (Tier) finding a business model that is financially sustainable in the long term and that makes MaaS aggregators operate profitably and at scale, it's a critical challenge to be tackled. Anders Tarnell (Hertz), as well as expressing his concerns on the subject, also made an interesting comparison with the car rental industry where some big companies work as aggregators and manage to make money through commissions paid by rental companies that exploit their technology. The case is very similar to those of MaaS aggregators, both do not have the means, and exploit their technological superiority. But, as he stressed, it is a very risky business, and aggregators always must make sure that their technology has unique functionalities. Steven Sarasini (Rise) believes that MaaS operators of levels two and three could be profitable only if they can reach a relevant number of users in each city where they operate. The margins for MaaS platforms on the trips of the various transport providers are low and to start making money the volume should be necessarily high.

Several possible solutions for overcoming this challenge emerged from the interviews.

According to Alexander Sprey (Tier) and Steven Sarasini (Rise) and as confirmed by Crozet et al. (2019) the B2C is a complex segment where it is extremely difficult to find successful business models. According to both respondents, MaaS aggregators would have more chance to be profitable by entering the B2B segment, offering this form of sustainable mobility to companies for their employees. For example, as proposed by Steven Sarasini (Rise), they could offer to each company a flat monthly fee for all employees, thus gaining access to large groups of new customers. This

would also be a great opportunity to encourage people towards a form of sustainable mobility. However, as already presented in the section 5.3.2, this requires a change at the regulatory level.

Going on, Hasselwander & Bigotte (2021) in their study pointed out that the offering of mobility packages that are increasingly responsive to user needs and have unique functionalities that users are willing to pay for could be an effective solution.

Third-level (Sochor scale) MaaS aggregators are already offering such solutions to their users. Sohail Rashid (Whim) is convinced that it is the right path and for him the real challenge is the expansion of the actual range of subscription packages. The interviewee highlighted the necessity to be creative and different from the competitors offering special services to the customers that may entice them to join the MaaS ecosystem. For example, in Japan, Whim is offering a bundle including some attractions that are available in Tokyo. Michael Zorez (Lynk & Co) agrees with this solution and thinks that identifying the needs of the users correlated with the mobility service and then offering packages combining these services with the company's bundles could be the winning strategy.

While, Samy Zerrouki (Citymapper) and Alexander Sprey (Tier) have underlined the absolute necessity of offering some bundles for families. The former hypothesised a subscription similar to Netflix that can be shared among family members, and which takes into account the needs of different users. Ideally, MaaS would substitute the car that is used for all the needs of the whole family.

Another solution that emerged could be to include advertising on the MaaS applications, implementing the Facebook model. But as pointed out by Michael Zorez (Lynk & Co) this would penalise the user experience for customers. In addition, Steven Sarasini (Rise) highlighted that it would be possible only with hundreds of thousands of users. To conclude, other viable opportunities could be to start monetising the collected big data or linking the mobility services with the new housing complex instead of building new car parks.

5.4 Next Steps

In this section it have been identified all the elements that will have to be solved or clarified in the future to increase the diffusion and impact of MaaS aggregators. Then, as emerged in the literature review and, as already partially mentioned in the section 5.3.2, the role of the public sector is crucial for the future development of this solution. In this section, the aim is to understand what

kind of role it should play in the future. Finally, an overview of future trends of the MaaS sector has been provided.

The majority of respondents identified the lack of effective marketing campaigns as a critical element. Samy Zerrouki believes that Citymapper needs to improve its marketing campaigns to make its services known and to highlight the benefits that both the users and the environment could gain from using their platforms. Isabel Götz (Yumuv) also emphasised that investing more in campaigns could be an important factor in the development of the solution, indeed she believes that with more funding and therefore the possibility of a more extensive marketing campaign, Yumuv's numbers would have been different. Anders Tarnell (Hertz) also noted that being able to find the funds to invest in marketing is a crucial step. It is fundamental to make this solution known to the mainstream public, MaaS aggregators cannot be limited to having the early adopters, they also must reach the average consumers. On the issue of funding, Sohail Rashid (Whim) pointed out that that the lack of funds is a present but normal problem. In fact, MaaS Global, as well as the other MaaS aggregators, have spent significant sums of money on developing the technology and now have to raise capital to launch major marketing campaigns to expand in more cities and subsidise the service and get more people on board.

However, Steven Sarasini (Rise) disagreed with the previous statement and provided an alternative point of view. According to the senior researcher, there is a lack of understanding of the service design process. Companies, in most cases, have spent and continue to invest a lot of money to develop the technology and then, at the end of the process, with the remaining funds they try to find a market for this technology. To conclude the analysis of this first factor, it is interesting to report Steven Sarasini's (Rise) concerns, quoting the interviewee directly: “I sometimes feel up that MaaS is a solution searching for a problem rather than a solution which is built on like empirical knowledge of what people want”.

The research for the right market is crucial and, as it is a new solution, investment is needed to make it known to most people. This directly relates to the need for clear communication on the unique functioning and benefits of MaaS presented in the literature review and in the first part of this section (Sopjani et al., 2019).

About this issue, Patrick Bösch (Yumuv) thinks that one possible solution is to show the customers multimodality. MaaS aggregators need to work on the connection between the digital platform and the physical reality by building hubs where the user can find all the means of transport offered by the platform.

The third missing factor that emerged during the interviews was the provision of an even simpler and more immediate user experience (UX). It must be taken into account that not all people have the same technological skills and therefore if MaaS aggregators want to reach a wider audience, interfaces should be made as user-friendly as possible for all generations. Furthermore, according to Michael Zorez (Lynk & Co) this could also be a partial solution to the absence of large marketing campaigns. Indeed, if customers would be satisfied with the user experience of the service, they would advertise MaaS platforms to their acquaintances, satisfied users are the best form of advertising.

Another critical element identified during the interviews is the scalability of MaaS aggregators. Michael Zorez (Lynk & Co) and Alexander Sprey (Tier) believe that this element is what is missing to have a powerful impact.

To conclude, several respondents remarked on the possible future role of Uber. The ride-hailing giant has made several investments in recent years to expand its offer of mobility services. The firm, with the introduction of bike sharing and e-scooters, has become the central broker of a MaaS ecosystem. As pointed out by Anders Tarnell (Hertz), Uber has all the necessary elements analysed above: funds, technology, and brand awareness. It will be interesting to understand the future positioning of the company and their next moves.

It is now time to analyse the role that public authorities should play to continue the effective development of MaaS and MaaS aggregators. First of all, it's crucial to reiterate that, as confirmed by all interviewees and as partially introduced in the section 5.3.2, an active role of public sector is crucial for the future of this solution.

Based on this assumption, the aim in this section is to clarify what kind of role they should play in the future. As seen in the literature review, there are doubts about this issue and experts are questioning one matter in particular: Should cities, and therefore public transport companies, be the MaaS operators? or, should they just invest in and collaborate with private MaaS aggregators? (Crozet, Santos, & Coldefy, 2019).

As was to be expected, the views of MaaS aggregators on this issue are mixed. Private MaaS aggregators have aligned in stating that the role of the public sector is simply to facilitate the transition and encourage the use of sustainable forms of mobility. While, with regard to public MaaS aggregators, no uniformity of thought emerged.

Samy Zerrouki (Citymapper) believes that, in many cities where public transport companies are far behind in technology, they should stop competing with MaaS operators. If these public actors care

about users, they should enter strong partnerships with the private sector. The perfect example is London, where, 10 years ago, TFL (the local public transport provider) favoured the adoption of Citymapper, recognising its best features. While, Sohail Rashid (Whim) argued that the main task of cities authorities is to facilitate alternative ways of mobility. Furthermore, if the aim is to achieve smart and green mobility, they should actively cooperate with MaaS aggregators by setting common targets. Taking into example his company, Whim has all the metrics necessary for the national environmental agencies to develop a framework of incentives or limitations.

Integrating the perspective of the experts in the second group of interviews, it is interesting to report the opinion of Steven Sarasini (Rise). The respondent agrees with Samy Zerrouki (Citymapper) and he also added that public transport companies are too slow and too bureaucratic and are slowing down or, in some cases, blocking the mobility market. Therefore, thinking about the issue of the environmental goals highlighted by Sohail Rashid (Whim), he stated that public transport companies should also support MaaS aggregators by enabling ticket sales (with some type of condition) and integrating with their platforms. Indeed, in this way, MaaS operators will have more customers, and this would speed up the transition from private cars to more sustainable means of transport. Finally, on the questions raised in the literature review he believes that, in most cases, public transport companies should not become MaaS operators themselves and should let the market design these solutions.

Turning to the point of view of public MaaS aggregators, Gernot Hörhager (Upstream) believes that public authorities should invest in and manage MaaS solutions. Indeed, MaaS is not a solution born to make a profit and private MaaS aggregators are having so much difficulty in finding a sustainable business model as emerged in the previous paragraph. According to the interviewee it would also be a strategic choice for public authorities to reduce emissions and achieve smart and sustainable mobility. Anders Tarnell (Hertz) agrees with this opinion as he believes that, in the long run, the firms that are most likely to succeed are the large public transport players. They have the strength, structure, and data to be able to offer multimodal platforms effectively. Therefore, they already have a large customer base that, knowing the company, will be more inclined to use these new services. The state-owned companies should take the lead, they should open to this new solution by actively influencing the market.

However, not all respondents have such a strong opinion. Patrick Bösh (Yumuv) argued that given the fact that every city has different characteristics, structures, and needs it is difficult to find an unambiguous solution. Certainly, the public side has a huge interest in MaaS platforms, but they do not necessarily have to manage this service themselves. Indeed, if the final aim is to reduce the

number of cars on the road and make mobility more sustainable public agencies could directly invest or encourage, through incentives, the development of this solution.

Finally, Alexander Sprey (Tier) claimed that the public sector should focus more on infrastructure investments. Indeed, to achieve a sustainable smart mobility, cities should improve parking infrastructures, implement new mobility hubs close to public transport stations and invest in bike and micro-mobility lanes to make the users' experience increasingly safe and smooth.

The last topic of this section is the analysis of future trends of the MaaS sector. As argued by Anders Tarnell (Hertz) the future of this sector and of the transport industry, in general, is very uncertain and extremely volatile. Suffice it to note that during the pandemic many experts of the car rental industry and travel industry claimed that industry numbers would fall and never return to 2019 levels. But this year, in March and April, Hertz Sweden had the highest reservations ever in its history, and the same positive trend is present throughout Europe.

However, according to Sohail Rashid (Whim) in the future MaaS aggregators should be able to connect all the different transport modes, including air journeys, not limiting to the boundaries of each city.

Even in the opinion of Samy Zerrouki (Citymapper) the extension of the service to all types of mobility is a crucial element. Furthermore, he also identified in the creation of a unique European MaaS operator a second future trend. Combining these two factors it would be developed a platform that would allow the user to travel with every mode of transport everywhere, from planes to public transport.

Moving on, Gernot Hörhager (Upstream) stated that, in the future, data science and machine learning technologies should have to be integrated into mobility apps to develop a service that increasingly takes into account the specific needs of each customer. This would provide a technology that can adapt and actively improve the lives of its users.

To conclude it is of absolute importance to report what emerged from the interview with Steven Sarasini (Rise). According to the senior researcher in the next 20 to 30 years, as soon as low-cost electric autonomous vehicles will be launched, there will be enormous pressure on public transport and city traffic congestion. If the long-term aim is really to reduce private cars there will be the need for an adequate response from public transport companies and MaaS operators. MaaS is a niche market between public transport and the automotive industry, if it wants to survive it will have to be able to cooperate with both sides.

5.5 Revised Theoretical framework

This section explains the new theoretical framework elaborated at the end of the analysis process. The first framework produced in the literature review chapter, used as a starting point for the analysis, was revisited and modified through the integration of empirical findings.

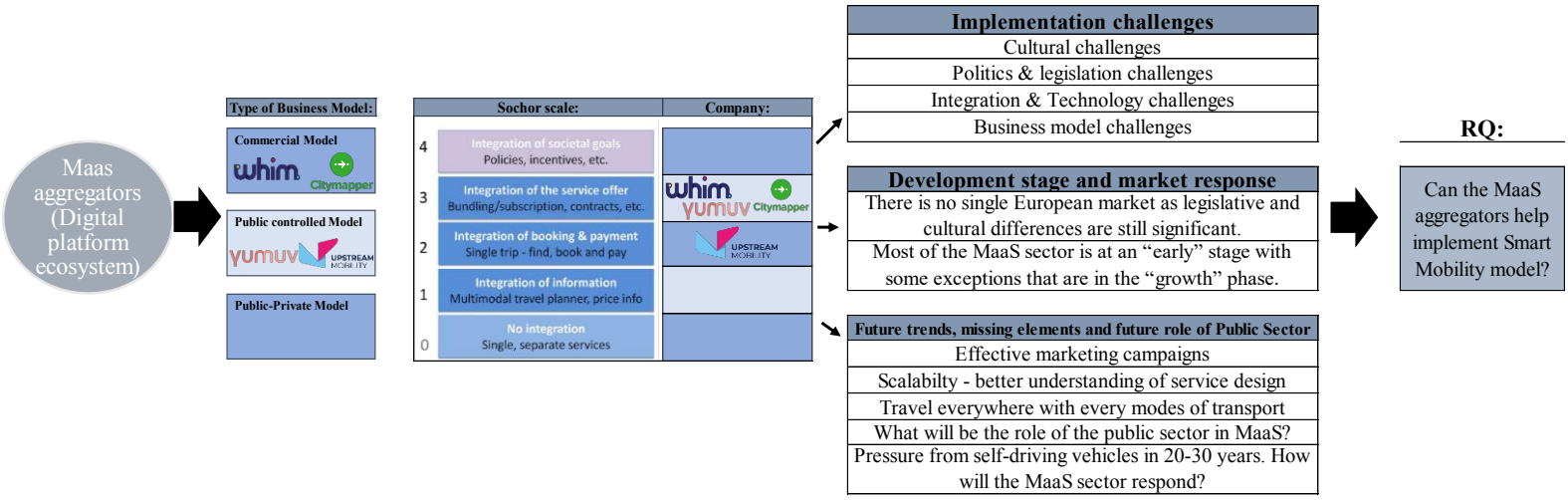

Figure 15: Revised Theoretical Framework – *(Produced by the author)*

Concerning the first area of interest of this research, in the first section of the data analysis, the structure of the MaaS aggregators interviewed was first analysed by comparing the theory and data collected. In this research, the Digital platform ecosystem (DPE) was identified as the basic structure of MaaS aggregators. According to Hein et al. (2020), the DPE comprises: "a platform owner that implements governance mechanisms to facilitate value-creating mechanisms on a digital platform between the platform owner and an ecosystem of autonomous complementors and consumers". As evidenced by the responses of the managers of Whim, Citymapper, Upstream, and Yumuv their companies adopt this structure.

Going on with the analysis, a double categorisation was made using the types of business models identified by Alyavina et al., (2021) and the MaaS topology, devised by Sochor et al. (2018).

Although the MaaS aggregators interviewed have structures based on the same theoretical concepts, they have different business models. In the group of MaaS aggregators under analysis 50% of the companies fall into the "commercial model" category and the other 50% into the "public controlled model". As regards the level of integration, all MaaS aggregators offer their customers bundles or other forms of payment alternative to pay-as-you-go and thus, except Upstream, fall within level three of the Sochor scale (integration of the service offered).

To conclude the first part, a final scheme was drawn up (see figure 14) and included in the revised theoretical framework.

With regard to the second area of interest, the three themes identified in the first theoretical framework also emerged from the coding process of the collected data. The various themes were analysed considering the categorisation carried out previously and integrating the points of view of the actors in the second set of interviews.

The first theme contains the implementation challenges that MaaS aggregators are facing and will have to solve to continue their development. Comparing the literature review with the empirical findings, it is possible to state that there is a general congruence between theory and the data collected. Several challenges are identical for MaaS aggregators irrespective of the level of service integration or the type of business model, but on some issues, such as data management or collaboration between different stakeholders, an advantage for publicly owned MaaS aggregators has emerged. About the other two themes, identified as research gaps, using empirical findings, data were provided to supplement the theory on the subject. Therefore, considering the purpose of this study and to answer the research questions, the empirical findings collected were extremely useful.

The second theme (Development stage & market response) remained unchanged while the third one (Future trends & missing elements) of the old theoretical framework was completed with a new second-order concept (Future role of Public sector) that emerged from the coding process and which was also partially addressed in the literature review. In several interviews, the importance of the public sector for MaaS aggregators was emphasised and different points of view were presented on what role public authorities should play in the future.

Finally, the revised theoretical framework summarised the key points that emerged from the data analysis process.

6. CONCLUSIONS

In this research an in-depth knowledge of MaaS and European MaaS providers was developed. The final purpose of this work, as summarised in the main research question, was to understand whether MaaS aggregators can satisfy the enormous expectations by being an effective solution for help achieving smart mobility. In this final chapter, the main conclusions to which the author arrived at the end of the research process are presented. The conclusions, based on a summary of the most important results, are divided according to the research questions. In addition, in the third and fourth sections practical and theoretical implications and the research limitation emerged are explained. Finally, in the last section the research areas concerning MaaS that would be of interest to study in the future are discussed. Considering that MaaS is a continuously developing and expanding solution, several areas could be explored.

6.1 Sub Research questions

In this section, the author answered the three research sub-questions presented in the first chapter. These questions were a key guide during the research as they allowed the author to collect data to answer the main research question.

6.1.1 Sub Research question one

The first research question aims to provide an overview of the current European scenario. By integrating the points of view of the two groups of interviewees, the author was able to understand the current state of MaaS development in Europe and the responses that MaaS aggregators are getting from the market.

The research question answered in this section is as follows:

What is the current state of development and market adoption of MaaS aggregators in Europe?

Regarding the current state of MaaS development in Europe, several respondents stated that giving a precise answer to this question is difficult for several reasons. First, because in Europe there are many MaaS aggregators at different levels of development. Secondly, because of major cultural and legislative differences that are impeding the development of a single European market. Based on these premises, several pieces of information emerged that were important for the purpose of this research.

While the latter factor is currently a barrier or obstacle to the expansion of MaaS aggregators, the former also has positive implications. As also mentioned by Alexander Sprey (Tier), the proliferation of a lot of different mobility service providers, some successful and others less successful, is a positive and hopeful signal for the future. Moreover, competition will lead to the constant improvement of these solutions.

Based on the opinions of the interviewees, it is possible to assert that a good level of MaaS development has been achieved in Europe. Although, it is crucial to point out that there is a strong misalignment between the more advanced northern European countries, which started to develop and test MaaS solutions some years ago, and the rest of Europe. To be more precise in identifying the current state of development Steven Sarasini (Rise) and Patrick Bösch (Yumuv) used respectively the business life cycle and the Gartner hype cycle scales.

According to the first respondent, most of the MaaS aggregators are at an "early" stage of development with some exceptions, such as Whim, that are in the "growth" phase. Therefore, it's important to highlight that from a business perspective there are still many hypotheses untested or unfalsifiable. While, the second interviewee believes that MaaS has passed the "peak of inflated expectations" of the Gartner hype cycle and is at a more or less advanced point of the next downward phase. Since the launch of this solution, it seemed that MaaS could solve all the problems of urban mobility and for this reason, enormous expectations have been created, and this is compatible with the emergence and proliferation of different MaaS solutions around Europe mentioned above. But, now that the platforms are operational and numerous problems and challenges have arisen, the phase of high expectations is over and has given way to a delicate settling-in phase on which the future of this solution depends.

Before examining the responses that MaaS aggregators are getting from the market, it is important to point out that the results were negatively affected by the difficult socio-economic situation caused by the Covid 19 pandemic over the last two years. Restrictions on people's mobility have inevitably limited the use of MaaS platforms.

Despite this difficult scenario, all MaaS aggregators interviewed, regardless of their business model and level of integration, provided broadly similar positive data. Even though the results are encouraging, they are below the forecasts made by the firms. As also argued by Sohail Rashid (Whim) customers are growing more slowly than expected. However, the interviewee reiterated that there is one extremely positive fact, new customers hardly ever leave the service once they have tried it.

To conclude, in a nutshell, it can be said that there are encouraging signs of both MaaS development and market adoption. MaaS aggregators are in a delicate phase of transition and their future depends on a multitude of factors. Therefore, due to the actual small numbers the impact this solution is having in the transition towards smart and sustainable mobility is still limited.

6.1.2 Sub Research question two

As mentioned in the previous section, MaaS aggregators are at a delicate stage in their development process, in this section are presented the main challenges that MaaS aggregators will have to overcome to continue their growth path and to help achieve smart mobility.

The research question answered in this section is as follows:

What are the implementation challenges that MaaS aggregators are facing?

Four categories of challenges emerged from the comparison of literature and empirical findings.
The first group of challenges relates to customers and companies' culture. MaaS belongs to the category of sustainable innovations and, as stated by Sopjani et al. (2019), for the success of solutions where users are considered core stakeholders it is fundamental to consider and influence people's habits and needs. The first major challenge of this category is to succeed in changing the mindset and the behaviour of the people. It is a difficult task because, as the interviews revealed, many people are habitual, do not like change and are attached to the car ownership concept. In addition, according to Steven Sarasini (Rise) many users aren't ready yet for adopting a technology that implies a totally new and digital lifestyle. The second critical challenge for MaaS aggregators is to be able to communicate their unique benefits to trigger this cultural change and to educate users about this solution. To win the competition from cars there is the need to educate people on how this technology works, its advantages, benefits, etc. Many people, even if they are already unconsciously doing it, do not know what multimodal mobility is. To conclude, the cultural change not only concerns the users but also the whole mobility sector. The various mobility players should start imagining themselves as dots of an enormous ecosystem where the aim isn't to lock customers into their services or products anymore.

The second category of challenges is strictly interconnected with the previous factors and concerns the political-legislative sphere. The intervention of public authorities is crucial for the full development of MaaS. As has also emerged from theory, there is no certainty that new forms of sustainable mobility, such as MaaS, will succeed on their own in completing the transition from the car ownership model to the usership model. There is a need for a system of limitations and

incentives. The first to enforce a decrease in the use of private cars in the city, possible solutions would be the introduction of a congestion tax or a moratorium on cars on the road. While, the incentives, on the other hand, should be aimed at citizens and companies to facilitate the transition to sustainable forms of mobility.

The third category of challenges comprises the technological and organisational challenges that the governance of such complex ecosystems involving a multitude of different actors poses. Starting with the technical challenges, the need for technological alignment between the various mobility operators emerged. The lack of common APIs and other tools hinders the full integration of the various services. Another key challenge is the sharing of user data between MaaS platforms and providers. On this issue, it is important to note that publicly owned MaaS aggregators have encountered less resistance. Public ownership is in fact a guarantee for companies on the proper treatment of data and on compliance with privacy regulations. The other major challenge for MaaS aggregators is to achieve a greater degree of collaboration by overcoming the resistance of some companies, such as the micro-mobility service providers. Also on this issue, publicly owned MaaS aggregators appear to have a clear advantage over privately-owned companies. These challenges are crucial because MaaS works because of the platform but only exists thanks to the ecosystem of providers around it.

Finally, the last category of challenges that emerged from the analysis process brings together all the challenges to which MaaS aggregators will have to find an answer to develop a business model that is financially sustainable in the long term. This is a vital issue, in fact many MaaS operators have failed and the remaining ones hardly manage to be profitable, as in the case of Citymapper. As things stand at this moment, several interviewees showed serious doubts about the possible financial sustainability of MaaS solutions unless significant numbers are achieved. However, some interesting solutions emerged, such as the expansion of bundling and the entrance into the B2B segment. This segment is less critical than the B2C one and, for many experts, could make MaaS aggregators profitable.

6.1.3 Sub Research question three

This section presents the missing factors that are preventing MaaS aggregators from achieving larger market adoption and thus a greater impact and, provides an overview of possible future trends concerning MaaS.

The research question answered in this section is as follows:

What is hampering the adoption of MaaS aggregators now and what could be integrated in the future?

During the analysis process, several factors emerged which are hampering MaaS aggregators from having a greater impact on urban mobility. The first is the shortage of funds to run marketing campaigns to advertise and incentivise citizens to start using MaaS. The lack of funding, in many cases, is caused by a poor understanding of the service design process. MaaS aggregators have invested heavily in the development of the technology and, it was only at the end of the process that they started to search for a market for their mobility services. In this way, it looks more like a solution that seeks a problem to be solved rather than a measure designed on the knowledge of what people actually need.

Directly related to this first issue is the necessity to build physical hubs that could connect digital platforms with physical reality. It must be considered that not all people are equally educated and possess the same technological skills. This solution would render the concept of multimodality more immediate and less abstract, promoting at the same time MaaS in cities.

Addressing the second part of the question, it is important to emphasise that the future of MaaS is uncertain and extremely volatile. Possible future trends are the extension of the range of services offered, integrating all available modes of transport and, the breaking down of city boundaries. Thus, developing a platform that could take you everywhere and by any means. Furthermore, to develop a service that is increasingly tailored to the mobility needs of users, machine learning and data science technologies would be integrated into mobility apps.

In conclusion, given the numerous challenges presented in this research, it will be of vital importance to clarify what kind of role the public sector will play in the future. Both the literature and the interviewees have contrasting views on this question. One part believes that, given the financial problems of MaaS aggregators, public transport authorities as is occurring in some cases should become MaaS aggregators. While some others, considering their excessive slowness and bureaucracy argue that they should limit themselves to collaborating and incentivising the use of MaaS.

6.2 Main Research question

In this section, the purpose of this research is finally achieved by providing an answer to the following main research question:

Can Mobility as a Service (MaaS) aggregators help implement the smart mobility model?

The answer to this question depends on a multitude of diverse factors. Clearly in recent years, many steps have been made in the development of MaaS. There are now several MaaS aggregators that with their platforms operate in different European countries. The responses these solutions are receiving from the market are also generally positive, although it must be underlined that the numbers of users and subscribers in many cities are still relatively small. Moreover, even though growth is on an upward trend, it is not reaching forecasts. These results are probably due to some factors that emerged during the course of this research.
First, is the scarcity of funds to run large marketing campaigns to incentivise the use of these solutions. This lack of resources for many providers is caused by an incomplete comprehension of the service design process. Many MaaS aggregators after having focused and having invested in the development of the technology are, only now, looking for a market for their service. Another important factor is the need to educate citizens on the function and unique benefits of MaaS. MaaS aggregators will have to succeed in the daunting task of transforming the mindset and mobility behaviour of citizens that have for decades been based on the car ownership model.

To overcome this arduous challenge the public authorities' role is crucial, they should facilitate and support the transition. There is a necessity for infrastructural investments to transform cities' layouts that have been built for cars by making them more suitable for new forms of sustainable mobility. In addition, a system of incentives to make the use of MaaS more attractive to citizens and limitations, such as congestion tax or carbon tax, to make the use of private cars increasingly unattractive should be introduced. At the same time, there should also be a shift in the attitude of the mobility providers. They should start conceiving urban mobility as an immense ecosystem where the goal is no longer to lock customers into a single mode of transport. For the success of MaaS solutions, which are at the centre of this ecosystem, there is a need to achieve a greater degree of collaboration, indeed MaaS aggregators work thanks to their platforms but only exist because of the ecosystem of providers that rotate around them.

Among the various challenges, the most significant for the future of MaaS aggregators is being able to develop a business model that is financially sustainable in the long term. Many new MaaS providers have already gone bankrupt, and the remaining ones are struggling to be profitable. On this issue, it will be necessary to clarify what kind of role public transport authorities will take on in the future. Indeed, they have the necessary funds, structure, and customer base to be successful MaaS aggregators. Some public transport operators have begun to pursue this approach and, as this

research has shown, they also seem to have an advantage over private MaaS aggregators on some sensitive challenges such as data sharing and collaboration.

In conclusion, considering what has been discussed so far, the answer to the research question is definitely no in the short term. MaaS aggregators are in a delicate transitional phase, where user numbers are still too low to have a significant impact, in which the enormous expectations aroused at the launch of this solution have given place to several implementation problems and challenges. However, in the medium to long term, the response is different. Indeed, if MaaS aggregators manage to find effective answers to the various critical aspects presented in this research, they have the potential, as demonstrated by some studies, to be an effective support for the achievement of smart mobility and its important socio-environmental objectives. They will certainly not be the solution that alone will transform urban mobility but if MaaS aggregators continue their growth path extending the coverage of their services, offering a way of moving increasingly tailored to the needs of users and, considering a possible more active role of public authorities, they will be able to play an important role in the future smart city mobility.

6.3 Implications

This section explains how the results of this research could be relevant for new MaaS aggregators, public transport authorities, and literature.

Concerning new MaaS aggregators, this research may help them to comprehend which areas they need to focus on more to continue their growth path. Indeed, the most important implementation challenges and the currently missing factors that need to be tackled with to achieve greater market adoption were investigated. In addition, many new MaaS providers have gone bankrupt by not being able to develop a business model that is financially sustainable over time, from the interviews conducted potential solutions that could be tested to solve this crucial issue emerged.

In addition, time has revealed that there is broad uncertainty about what type of role public transport authorities should take in MaaS. This research hopes to contribute to the decision-making process of public transport authorities by presenting a clear picture of the current situation of MaaS aggregators in Europe and, considering that some public actors have already undertaken the launch of MaaS platforms, by providing important insights into two of these solutions.

In conclusion, this study contributed to the literature by exploring whether MaaS aggregators can be a solution to help achieve smart mobility. By investigating various aspects of MaaS aggregators, the reasons were explained for which in the short term they are not an effective solution and as in the

medium to long term they may eventually become to have an important role in future smart mobility.

6.4 Future Research

Mobility as a Service is an ongoing digital innovation that is currently continuing its growth path. For this reason, it is expected further research on this topic which will go in parallel with MaaS development.

There are several areas where further research would be useful. First, the author believes that it would be worthwhile to conduct the same research in a couple of years to analyse whether and how MaaS aggregators have managed to overcome the implementation challenges that have emerged and whether they have continued their growth.

Furthermore, as the results of this study showed, the crucial challenge is to be able to develop a business model that is financially sustainable in the long term. It is necessary future research delves into this issue and tests the various hypotheses that currently exist and proposes new ones.

To conclude, another critical element presented in this empirical study is the scarcity of funds to run marketing campaigns. As it has been explained in this research, in many cases, this is due to a lack of complete interpretation of the service design process, which has induced many MaaS aggregators to invest mainly in the development of the technology, leading them to seek a market for their service only at the end of this development process. In the future, to prevent new MaaS aggregators from making the same errors, it would be useful to analyse the proper application of the service design process in the development of MaaS aggregators, identifying possible success cases that could be replicated by new operators.

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APPENDIX A

Interview guide – European MaaS providers	
Area of interest:	***Questions:***
Initial introduction:	Brief presentation of the pourpose of this research.
Icebreaker:	Please tell me a bit about your current position in the company.
	How long have you been working in this sector?
MaaS platform ecosystem and it's operation:	How is the ecosystem of your platform structured? Who are the main actors?
	What is your company's value proposition? How is the market reacting? *(if the answer is positive, what are the main factors of success?)*
Challenges, barriers and future developments of MaaS aggregators:	How would you describe the development stage of MaaS aggregators in Europe?
	What are the current and future challenges that the MaaS aggregators must overcome to help achieve smart mobility in cities? *(Both from demand and supply side)*
	How would you cooperate with public authorities to achieve the societal goals (level 4 of Sochor scale)? *(What do you think is the best way?)*
	In your opinion, What is missing from the actual MaaS model to reach the majority of citizens?
	What are the future trends that this solution should be able to integrate?
End of the interview:	If you could have unlimited powers, what would you change about the MaaS model?

APPENDIX B

Interview guide – Actors of the MaaS ecosystem	
Area of interest:	***Questions:***
Initial introduction:	Brief presentation of the pourpose of this research.
Icebreaker:	Please tell me a bit about your current position in the company.
	How long have you been working in this sector?
MaaS platform ecosystem:	What do you think about MaaS aggregators?
Challenges, barriers and future developments of MaaS aggregators:	How would you describe the development stage of MaaS aggregators in Europe?
	What are the current and future challenges that the MaaS aggregators must overcome to help achieve smart mobility in cities? *(Both from demand and supply side)*
	How do you think cooperatation with public authorities to achieve the societal goals (level 4 of Sochor scale) should take place? *(What do you think is the best way?)*
	In your opinion, What is missing from the actual MaaS model to reach the majority of citizens?
	What are the future trends that this solution should be able to integrate?
End of the interview:	If you could have unlimited powers, what would you change about the MaaS model?

APPENDIX C

Company interviewed:


1st Order Concepts:	2nd Order concepts:	Aggregate Themes:
Northen Europe more advanced than central and southern Europe	**Actual level of Development**	**State of the art of MaaS**
Different levels of development and great competition		
Technology is mature enough but the market adoption is still far		
Proliferation of a lot of different MaaS providers		
MaaS passed the peak of inflated expectations and is in downward phase (Gartner hype cycle)		
Good development but still far away from the final goal		
MaaS apps haven't really been able to grow at the same pace as the actors of their ecosystems		
MaaS is a niche market between public transport and the automotive industry		
The market before pandemic was responding generally well	**Market Response**	
Customers are growing more slowly than forecast		
Low growth rate but if people sign up they stay		
Changing the mindset of people it's hard	**Cultural challenges**	**Implementation Challenges**
People attached to the concept of ownership		
Car gives social validity and freedom		
Educate customers on this solutions		
Changing the mindset of mobility operators		
More investment in public trasport	**Politics & Legislation challenges**	
Moratorium on circulating cars in cities		
Congestion tax		
Special lanes for sustainable modes of transport		
Clearer unified regulation		
Incentives for users and MaaS providers		
System of incentives and/or limitations to facilitate the transition		
Increse degree of collaboration with Municipalities & Public transport operators	**Integration & Technology challenges**	
More cooperation with mobility providers		
Micro-mobility providers less inclened to cooperate		
Technology levelling between operators		
MaaS solutions should extend their services and coverage		
Can the Business Model be profitable?	**Business Model challenges**	
Extend the range of subscription packages		
New sources of revenue		
Struggling in finding the right Business Model		
MaaS not limiting to the boundaries of cities	**Future trends**	**Next steps**
Unique European MaaS		
Integrate data science and machine learning		
Future very uncertain and extreamly volatile		
Funds for marketing	**Missing elements**	
Brand awareness		
Connection between digital platform and physical reality		
Lack of understanding of service design		
Offering MaaS on a scale		
What role should the public sector play?	**Role of Public Sector for the future**	
Public transport companies should stop compete on MaaS		
Role of public sector crucial for the future of MaaS		
Investments in city infrastructure		
Cities authorities must take the initiative		