EPiC Series in Computing

Volume 93, 2023, Pages 68–81

Proceedings of Society 5.0 Conference 2023

Analysing Barriers in the Business Ecosystem of European MaaS Providers: An Actor-Network Approach

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Abstract

As new Mobility as a Service (MaaS) platforms are being established in Europe, researchers and practitioners seek evidence on the barriers experienced by the MaaS providers in their evolving business ecosystem. This paper conceptualises the MaaS business ecosystem using a Systematic Literature Review (SLR) combined with Actor-Network Theory (ANT) by constructing an actor-network of key actors. This actor-network, along with the identified MaaS business ecosystem barriers, is then used for Multiple Case Study Research, interviewing 18 European MaaS experts. The cross-case analysis revealed how MaaS providers problematise, interest, enrol and mobilise their business ecosystems. Furthermore, the paper outlines and amends key barriers in the areas of (1) technology and data, (2) social and cultural, and (3) policy and regulation. Researchers and practitioners can use the findings of this study to formulate policies, create best practices or conduct further research on the development of MaaS.

1 Introduction

In the transportation industry, digitalisation enables new concepts like MaaS. Since the early introduction of MaaS by Hietanen (2014), mobility services are gaining traction and becoming relevant for enterprises and consumers. In this context, companies are searching for information and studies on how business ecosystems like the MaaS business ecosystem are developing.

At the same time, in academia, researchers started to formulate and conceptualise MaaS and its business ecosystem by conducting studies and analysing the market. In the MaaS research domain, there is an academic debate going on how to conceptualise the MaaS business ecosystem (Giesecke et

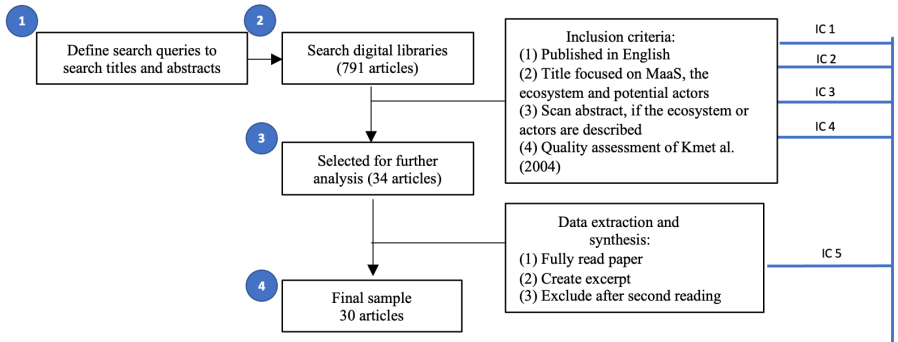
al., 2016; Jittrapirom et al., 2017). This debate is caused by a need for a structured approach to conceptualising the emerging MaaS ecosystem, causing confusion for researchers and practitioners.

In addition, a theoretical foundation to conceptualise the MaaS business ecosystem is missing (Smith & Hensher, 2020). Further, pilots and case studies of MaaS reveal barriers in the ecosystem of the actors (Arias-Molinares & García-Palomares, 2020; Ghazy et al., 2021). In this context, barriers prevent the development and diffusion of MaaS platforms (Butler et al., 2021; Smith et al., 2019).

Thus, uncovering barriers holistically would facilitate and govern the development of MaaS platforms (Kamargianni & Matyas, 2017; Wong et al., 2020). More practitioners' research underpinned by a theoretical framework is needed to materialise the concept and to understand the barriers experienced by the actors in the MaaS business ecosystem. As a result, the aim of this paper is at a managerial level to holistically investigate the barriers that MaaS providers are facing so that researchers and practitioners can take action to overcome them.

2 Systematic Literature Review on MaaS Actors and Barriers

A Systematic Literature Review (SLR) was conducted, which uncovered the actor-network of the MaaS business ecosystem (**Section 2.1**), revealed barriers of the actors in the MaaS business ecosystem (**Section 2.2**), and identified the research gap (**Section 2.3**). For the SLR, the guide of Okoli (2015) was followed. The process, including the search terms, digital libraries searched, inclusion criteria (IC1-IC3) and quality assessment (IC4) of Kmet et al. (2004), is shown in **Figure 1**.



Search terms and digital libraries (date of research: 01/30/2023)

Digital Library	Search Query	No. of results
Google Scholar:	"Mobility as a Service" AND ("actor" OR "business ecosystem" OR "ecosystem" OR "network")	438
IEEE Xplore:	(("Document Title":Mobility as a Service) AND (("Abstract":"actor") OR ("Abstract":"business ecosystem") OR ("Abstract":"ecosystem") OR ("Abstract":"network")))	193
Scopus	"Mobility as a Service" AND ("actor" OR "business ecosystem" OR "ecosystem" OR "network")	69
EBSCO	"Mobility as a Service" AND AB ("actor" OR "business ecosystem" OR "ecosystem" OR "network")	58
Web of Science:	TI="Mobility as a Service" AND AB=("actor" OR "business ecosystem" OR "ecosystem" OR "network")	33
Total		**791**

Filtering based on inclusion criteria and data extraction and synthesis	
Total number of articles found in digital libraries	791
Total number of articles after cleaning of duplicate results	652
IC1: Published in English	632
IC2: Title focused on MaaS, the ecosystem and potential actors	296
IC3: Scan abstract, if the ecosystem or actors are described	72
IC4: Quality Assessment of Kmet et al. (2004), Cut-Off Score: 0.80	34
Final Sample	30

Figure 1: Systematic Literature Review on MaaS Business Ecosystem Actors and Barriers

2.1 The MaaS Business Ecosystem Actor-Network

As a result of the SLR, key actors and their relationships in the MaaS business ecosystem have been identified in the SLR. To conceptualise the MaaS business ecosystem, ANT and the conceptual understanding of Kamargianni and Matyas (2017) in combination with the syntax of Alexander and Silvis (2014) helped to develop the first MaaS business ecosystem actor-network (see **Figure 2**). The identified key actors are as follows:

The **MaaS Provider** is the focal actor of the MaaS business ecosystem. The MaaS provider is in the middle of the ecosystem and integrates public and private operators managing both demand and supply by offering mobility services to customers and dispatching mobility services to different transport operators (Arias-Molinares & García-Palomares, 2020; Pham et al., 2021). Next, the **Mobility Service Providers (MSPs)** offer mobility services and provide the MaaS provider access to their data using APIs (Kamargianni & Matyas, 2017). By selling their capacity and offering their service and data, transport operators can expand their markets (Arias-Molinares & García-Palomares, 2020). **Digital Service Providers (DSPs)** enable technology solutions, applications and services to the transport operator and the MaaS provider (Eckhardt, 2020). They consist of the actors: aggregators, integrators, brokers, dynamic multi-service journey planners, ticketing and payment solutions providers and technology and IT providers. **Regulatory Organisations** are responsible for defining policies, rules and regulations which need to be considered by other actors in the ecosystem, but most importantly by the MaaS provider (Kamargianni & Matyas, 2017). Such organisations can be local authorities, the government & legislation, international organisations, and unions. **Customers & Users** are core actors consuming the mobility services provided by the business ecosystem through booking the services or by having subscription plans (Mulley & Nelson, 2020). The users can be either private users like residents, visitors/tourists or corporate customers (Polydoropoulou et al., 2020). Finally, the **Wider Business Ecosystem** consists of the actors who influence the ecosystem from a distance: ICT infrastructure, OEMs and resellers, insurance companies, entertainment firms, investors & funding agencies, universities, and research institutes, and the MaaS champion.

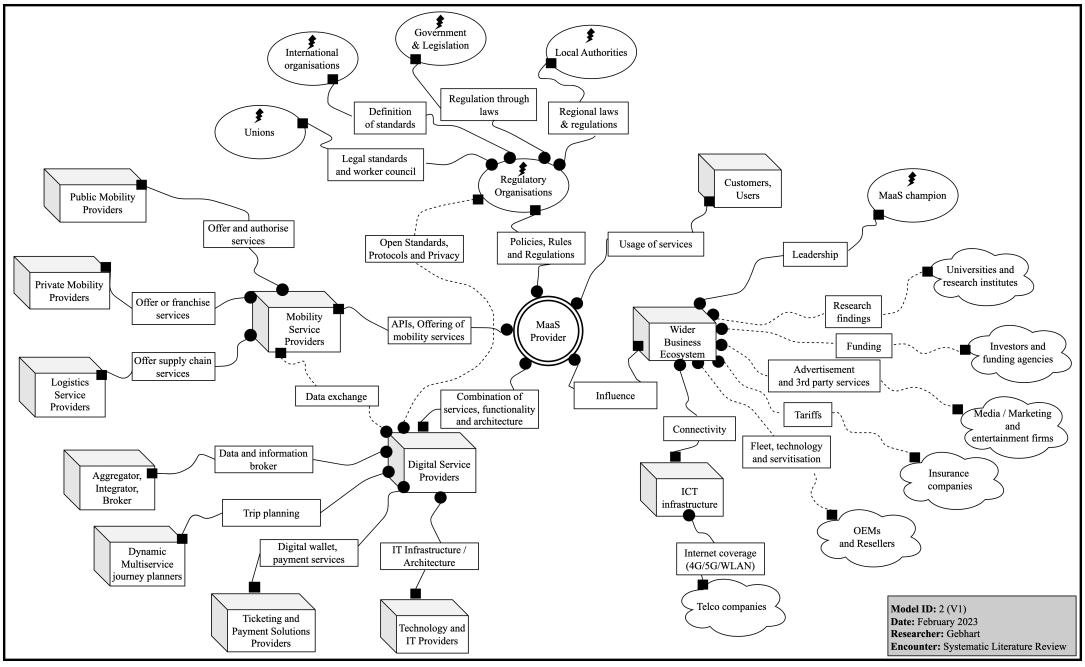


Figure 2: The MaaS Business Ecosystem Actor-Network

2.2 Identified Barriers in the MaaS Business Ecosystem

The second part of the SLR revealed barriers of the identified actors in the MaaS business ecosystem. The technical, sociological, and economic themes for designing MaaS services of Christiaanse (2019) served as an initial classification for the emerging barriers. To further identify barriers to managing and developing a MaaS platform, the papers from the SLR have been coded in these key themes: ***Technology and Data (TD)***, ***Social and Cultural (SD)*** and ***Policy and Regulation (PR).*** Each of those *Themes* has multiple *Sub-Themes* underneath, introduced in the following paragraphs and summarised in **Table 1.**

Technology and Data (TD) describes barriers emerging in the thematic area of platform tech and data (Cottrill, 2020; Gace & Babic, 2020; Ghazy et al., 2021). The theme is consisting out of four subthemes (TD1) data security and privacy, (TD2) lack of openness of data and standardisation / data silos and interoperability, (TD3) modernisation of ICT infrastructure / internet coverage / real-time information available and (TD4) unclear or no platform architectures existing.

Social and Cultural (SD) describes social and cultural barriers in the MaaS business ecosystem (Alyavina et al., 2022; Karlsson, 2020; Toyama, 2022). It consists of six subthemes (SD1) acceptance of users, travel behaviour and lack of user trust, (SD2) competition, losing monopoly position, control and influence, (SD3) difficulties for users related to technologies, (SD4) missing collaboration, (SD5) missing leadership and vision and (SD6) skills and knowledge gaps.

Policy and Regulation (PR) outlines policy and regulatory barriers experienced by the MaaS provider in their business ecosystem (Mulley & Nelson, 2020; Murati, 2020; Tabascio & Brail, 2022). It consists of three subthemes (PR1) demand estimation, creation of business models and tailoring of services, (PR2) legal issues, bureaucracy, and institutional barriers and (PR3) poor governance framework, policy, and regulation challenges.

Table 1: Identified Barriers in the MaaS Business Ecosystem

Themes	Sub-Themes
Technology and Data (TD)	*(TD1) Data security and privacy*
	(TD2) Lack of openness of metadata and standardisation: data silos and interoperability
	(TD3) Modernisation of ICT infrastructure, internet coverage and real-time information available
	(TD4) Unclear / no platform architectures existing
Social and Cultural (SC)	*(SC1) Acceptance of users, travel behaviour, lack of user trust*
	(SC2) Competition, losing a monopoly position, control, and influence
	(SC3) Difficulties for users related to technologies
	(SC4) Missing collaboration
	(SC5) Missing leadership, vision, and directions into which to develop
	(SC6) Skills and knowledge gaps
Policy and Regulation (PR)	*(PR1) Demand estimation, creation of business models, tailoring of services*
	(PR2) Legal issues, bureaucracy, and institutional barriers
	(PR3) Poor governance framework policy and regulation challenges

2.3 Summary and Research Gap

Through systematically identifying actors in the MaaS ecosystem, actors' relationships and experienced barriers were extracted. As a result, the actor-network of the MaaS business ecosystem, in combination with the extracted barriers in the network, now serves as the theoretical and conceptual basis for further empirical research.

In addition, the SLR has shown a need to incorporate empirical evidence and data from recent MaaS pilot projects. This gap is underpinned by Haavisto (2020), who states that "we have to recognise that transport research lacks both similar empirical studies, and lacks operationalised conceptual frameworks from philosophy and sociology of technology" (Haavisto, 2020, p. 857).

Consequently, Arias-Molinares and García-Palomares (2020) conclude that the "main challenges lying ahead are to promote new MaaS pilots to gain more data and develop more research" (Arias-Molinares & García-Palomares, 2020, p. 262). In particular, Guyader et al. (2021) emphasise that "more case studies on the interplay between institutional logics in MaaS initiatives from other markets are a valuable contribution to the discussion" (Guyader et al., 2021, p. 17).

Therefore, ANT, in combination with the findings of the SLR on the actors in the MaaS business ecosystem, led to the conceptualisation of the first MaaS business ecosystem actor-network. This artefact will now serve as a basis for a qualitative exploration of the barriers experienced in European MaaS implementations. The research approach of this study is depicted in **Figure 3.**

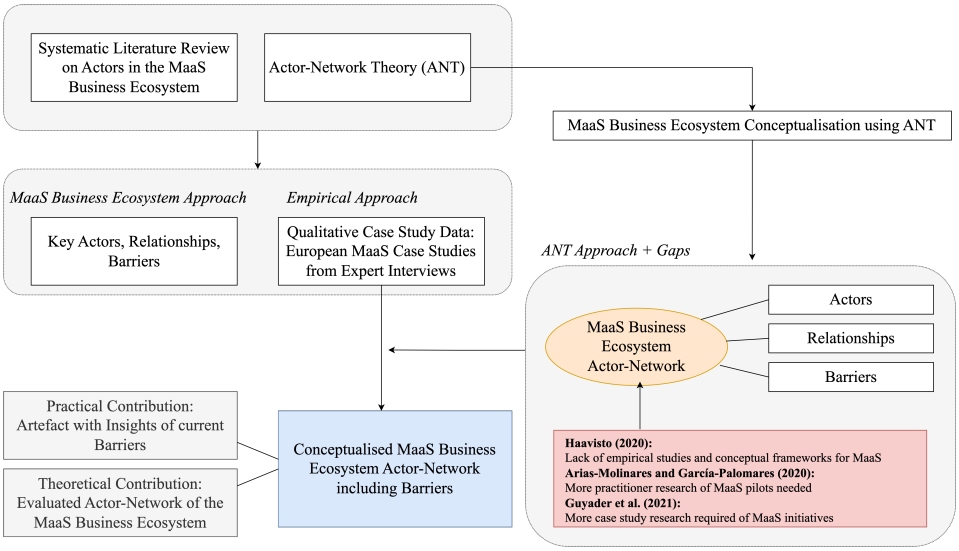


Figure 3: Research Gap and ANT Approach

3 Analysing Barriers of European MaaS Providers

The SLR has shown a lack of empirical evidence and data on the barriers experienced by MaaS pilots. Therefore, this study aims to answer the following research question: **How can barriers in the business ecosystem of MaaS providers be identified and understood?**

To answer the research question, primary qualitative data was obtained through expert interviews and analysed through cross-case analysis using thematic coding (*see* **Section 3.1**). These patterns were then applied to the translation steps of ANT (Problematisation, Interessement, Enrolment and Mobilisation) to identify matches and gaps in application to this study (*see* **Section 3.2**).

3.1 Research Methodology and Design

For researching the barriers of the MaaS business ecosystem in their applied environment, Design Science Research (DSR) of Hevner (2007), in combination with Multiple Case Study Research of Yin (2018), has been adopted as the research methodology. This study was conducted as part of a larger research thesis with related research questions, and the process is depicted in **Figure 4**.

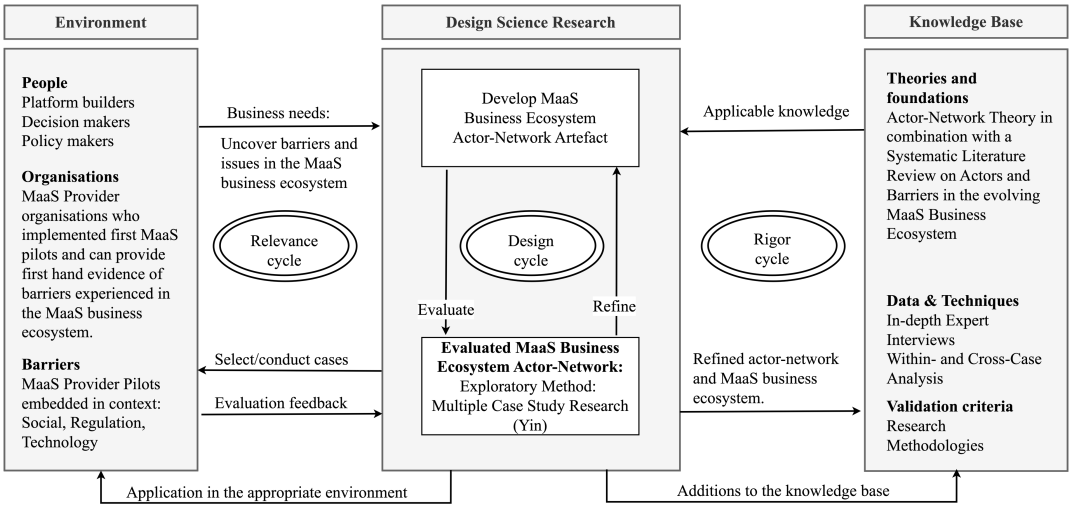


Figure 4: Research Design of this paper adapted from Hevner (2007) and Yin (2018)

The cases have been selected as homogenous in the criteria but heterogenous in their context. That means the case had to be a MaaS provider or advisor in a Public-Private Partnership (PPP) located in Europe. In total, 18 experts (N=18) were interviewed with managerial and topic experience (*I1-I18, see* **Table 2**). All interviews were conducted as one-to-one virtual meetings, and each interview lasted between 42-79 minutes. Questions were based on the research question and were asked in an in-depth semi-structured interview guide split into three parts to capture the aspects of their experience. The interviews were recorded and manually transcribed using oTranscribe. Then the interviews were coded deductively with NVivo using thematic codes from the SLR (see **Table 1**). All coded barriers were evaluated, and conclusions were drawn based on the interview data.

Table 2: Overview of Interviewees including their Roles and MaaS Case Origin

IDs	***Interviewee Role***	***MaaS Case Origin***
I1	Managing Director	Germany
I2	Partner Project Leader	Switzerland
I3	MaaS Project Lead	
I4	MaaS Policy Coordinator	Finland
I5	MaaS Co-Founder	Scotland
I6	MaaS Project Advisor	Lithuania
I7	MaaS Consultant	Germany
I8	MaaS Chief Revenue Officer	England
I9	Product Owner MaaS	Germany
I10	MaaS Project Lead	England
I11	Head of Digital Channels	Hungary
I12	Mobility Director	Spain
I13	Business Development Manager	Netherlands
I14	MaaS Product Owner	Czech Republic
I15	Head of Product Management	Wales
I16	Senior Innovation Officer	England
I17	MaaS Project Officer	Scotland
I18	Lead MaaS Consultant	England

3.2 Summarising Evidence of Cross-Case Actor-Networks

This section describes how the selected cases are building their business ecosystem. The four translation moments of ANT are used to summarise the evidence: 'Problematisation', 'Interessement', 'Enrolment' and 'Mobilisation'. In the context of this paper, 'Problematisation' compares the context and goals of the cases, 'Interessement' describes how other actors were interested in joining the individual actor-networks, 'Enrolment' shows the integration strategies, while 'Mobilisation' highlights the network effects.

Regarding **Problematisation**, the context and background of the individual cases differed, while they all shared similar goals. The main goal of the cases involved creating a platform and developing strategies to bring more people to the public transport system, triggering a mindset change for citizens (I1, I6, I11, I15). Most cases have started with pilots collecting evidence and experiences before continuing with a larger-scale solution (I10, I16). In these pilots, it was found that more cooperation is required in a PPP to ensure that they do not just work independently from each other (I15, I18). This PPP aimed to deliver integrated, collaborative MaaS for the regions by replacing existing apps to achieve the societal goals of a local region (I8, I18). To realise this, several cases formed alliances in regional transport partnerships, working together with local MSPs and local authorities. As the different cities started at different points in time with different contexts, the maturity levels of their solutions varied. In some cases, the pilot was being prepared, in others it was completed, and the first rollout was planned, while in some cases there was already an operational platform with many daily users. All the cases interviewed were funded by the cities or by public money coming through funds. However, the goal of these MaaS platforms was not "making money but using it as a steering instrument for mobility in cities and agglomerations" (I2). In terms of implementation, there was a 50/50 split between cases with commercial DSPs and cases with custom development.

Concerning **Interessement**, the strategies to get other actors interested in joining the actor-networks of the individual cases varied. Activities of the cases to grow their network had been to map out their existing ecosystem in the region, reaching out to the different actors and introducing them to their manifesto and business case (I17, I18). For example, I11 stated, "we know almost all companies, and we do have contacts" (I11). Most of the time, the actors meet at industry events and thus exchange regularly (I3, I9). For most cases, a tendering procedure had to be established, including transport-related criteria such as a comprehensive mobility mix and other requirements, including the interface, size, and growth strategy (I1, I9). While some cases had issues persuading or contacting larger MSPs, it had been the other way around for others with a prominent name. For example, they created a continuous interest expressions procedure in which they invited all the MSPs to express their interest in being part of the case (I1, I9). For those who had issues persuading other MSPs, their strategy had been to show the interested actor the solution's potential, including the benefits and value the other actor would get by joining (I14). Besides that, active partner management was conducted by most of the participating cases (I3, I9, I17). As mentioned in the previous subsection, some cooperated with a DSP to release their MaaS platform. The benefit of working with a DSP was that they could use their existing actor-network. To achieve the wished mobility mix and the critical mass for the cases, the cases used their neutral position of power to create working groups or enact a committee or board where they gathered with interested MSPs to discuss different ideas (I6, I10). In these board meetings, challenges and strategies were discussed, including commercial, technical and policy topics.

The **Enrolment** phases of the individual cases can be summarised into three significant steps, (1) the initial expansion and procedures, (2) the prioritisation and funnelling and (3) readiness & depth of integration. First, for the integration, there had been an initial expansion and establishment of procedures by the different cases. The initial expansion of the individual actor networks started by reaching out to new actors and having an initial conversation about how they see themselves as part of the network (I16, I18). Other cases tendered a concession to require the integration if they want to

operate in the city (I1). As different partners were evaluated, one critical consideration was whether the partnership was commercially attractive. A key factor was whether their APIs were ready to be integrated and whether they already had agreements in place. (I13, I16). This initial expansion resulted in a list of promising partners for which two types of contracts were created. The first type of contract was a Letter of Intent (LOI) to evaluate the potential partnership, while the second included details about the commercial model (I2, I18). If an agreement were reached, the new actor would be handed over to the platform provider, the city, or a DSP (I18).

Depending on the maturity levels of the individual cases, the **Mobilisation** of the network has been observed in different forms. While in some cases, no, or minimal mobilisation happened, others report network pull effects. This effect increases as the cases become more visible to the public. One example is that one of the cases became more visible once the app was launched and received good ratings (I1). Another case reported that the platform's success had been noticed, and potential partners heard through an informal exchange like word of mouth about the platform, requesting integration into the platform (I3, I11). When growing the network I9 reported that whenever the platform launched new providers or stations, they saw a significant increase in usage and engagement of the platform. Another critical factor was the platform's branding, influenced by spokespersons or so-called MaaS champions. They helped establish trust in the regional transport partnerships and pushed the MaaS business ecosystem forward. MaaS champions were advocating for MaaS and were crucial in attracting other stakeholders into the network. Further, they were the key to success as they were decision-makers and helped to trigger organisational, cultural, and behavioural changes (I9, I12, I18).

4 Discussion of Cross-Case Actor-Network Barriers

In each of the previously introduced ANT translation moments, barriers were experienced by the MaaS providers. This chapter discusses the findings by amending the barriers from the SLR (*see* **Table 2**) with insights from the academic literature. For that, in the following paragraphs, the barriers from the themes (*TD1-TD4*, *SC1-SC6* and *PR1-PR3*) are introduced and discussed:

When building a MaaS solution, *(TD1) Data security and privacy* are of paramount importance. MaaS services are built to share personal travel information (Cottrill, 2020). To ensure data privacy, the participating companies have established strict rules and regulations, following the General Data Protection Regulation (GDPR) (I1, I2, I7, I8). Before the MaaS implementation, extensive workshops were held between all parties to ensure that all necessary precautions were taken. As most parties involved were public companies, they were held to higher standards with the GDPR as a basis (I7, I9). One reason is that the MaaS provider acts as an integrator.

Concerning *(TD2) Lack of openness of metadata and standardisation: data silos and interoperability,* the findings revealed that some more traditional operators still need to get their APIs ready or open for external consumption (I10). In addition, the integration process is described as unique for each operator, requiring a significant amount of effort and cooperation between the operators and the MaaS provider (I11, I12, I14, I17). Thus, to ensure a successful implementation of MaaS, it is crucial to support the standardisation and openness of data. These findings align with the research report of Gace and Babic (2020), who highlight data-related challenges as the openness and standardisation of data as necessary factors for the MaaS development. In addition, the findings align with Polydoropoulou et al. (2020), who identified the lack of data and APIs as significant barriers, demanding a thorough case-specific analysis.

(TD3) Modernisation of ICT infrastructure, internet coverage and real-time information available represents barriers experienced concerning outdated IT infrastructure, IT systems, internet connectivity and real-time information. Early in the academic literature Kamargianni and Goulding (2018) highlight the need for functioning ICT infrastructure in cities. This starts from mobile network

coverage and download speeds but extends to smart ticketing and mobility services. This is in line with the findings of I4, who sees the need for more physical infrastructure supporting new mobility services. However, it is also criticised on the company side that small companies do not have the infrastructure in place and need to invest much money to modernise their infrastructure (I1, I12). Overall, a mixed picture of readiness is observed by I18, who divides the factor readiness into behavioural, business, and technical readiness. Here, I18 clarifies that a split exists between legacy public transport providers and new mobility providers. For I2, it had been a significant issue to identify the technically ready MSPs. Considering real-time information, Ghazy et al. (2021) introduce a data layer built on top of the infrastructure layer. Though, these layers are far away from reality. Evidence shows that real-time data would be ideal in most cases but requires a significant modernisation in the backends of participating actors (I2, I3, I5, I11, I13).

(TD4) Unclear / no platform architectures existing emphasises unclear or missing IT platform architectures. In its academic context, Smith and Hensher (2020) describe this barrier in the context of its technocratic nature with platform architectures. The findings of this paper revealed that it is indeed a challenge how MaaS platforms and the technology are being architected. I8 mentions an underestimation of the number of edge cases, indicating the complexity of MaaS. This complexity is also recognised by Reyes García et al. (2020), who outlined that the number of MaaS providers is caused by a lack of common architecture that facilitates the complex integration of all actors involved in the MaaS ecosystem. According to I6, defining a MaaS platform and creating a consistent user experience was one of the main aspects. The architecture had not been up to the standard where they wanted it to be (I10). In the academic literature, *Zhou et al. (2023)* contend that because of the complexity, a connection with enterprise architecture modelling would help to address resilience concerns for MaaS reliability. While this cannot be proven with the case studies, it is evident that better modelling would help. I5 highlights that creating consistency across different MaaS solutions can be substantial. In this context, it is also evident that for many actors in the MaaS ecosystem, it is not their "bread and butter" to architect and further develop such platforms (I10). I11 recognises a shift from traditional architecture towards a more cloud-based approach for MaaS.

(SC1) Acceptance of users, travel behaviour and lack of user trust showcase the barriers to user acceptance, the required behaviour changes in travel behaviour and the lack of user trust. Evidence from the case studies reveals that there has been a low acceptance and demand, particularly in the pilot phases (I2, I7). Significantly, the demand for subscription-based services was far below expectations and disappointing (I2). The reason was that the app and solution did not incorporate all MSPs. As a result, having a critical mass of MSPs in the platform is essential for the users' acceptance (I7). While this critical mass is a new factor, the literature reports that MaaS has to offer a higher level of multimodal integration to trigger noticeable changes in the users' travel behaviours (Karlsson, 2020). Alonso-González et al. (2017) recognise that more services can reduce those initial barriers. Further, it was observed that people in the region "were not ready for that model yet, and it came across as quite expensive" (I10). This readiness has been also discussed in the academic literature. For example, in the work of Kamargianni and Goulding (2018), they construct a MaaS index for the city's readiness and include citizen familiarity and willingness as a factor. The price factor mentioned by I10 is also an important aspect, as the results of Toyama (2022) show that the price value significantly impacts the intention to use MaaS.

(SC2) Competition, losing a monopoly position, control, and influence are social barriers addressing the fear of competition, of losing monopoly position or power of control and influence. In the literature, this barrier was recognised early on as a prerequisite for cooperation, as the regional and local actors are permeated by both formal and informal institutions (Karlsson et al., 2017). The findings show that competition is still a major barrier for MaaS. The study participants stressed that, in their experience, there is commercial competition between market participants because transport companies are afraid of losing customers (I2, I6, I13). However, smaller MaaS platforms report that they feel the other players do not need them and therefore do not see them as competition (I14).

Regarding competition, the results show that transport companies tend to keep certain information about their bus routes in their own app because they fear losing users of their own app. In literature, Alyavina et al. (2022) findings show that the fear of loss of control over their own brand is the reason for such behaviour. It turns out that the participating companies are mainly afraid of cannibalising their own app (I5, I7). They might also target other audiences and pay commissions, losing control and power over their own app and mobile offering (I7, I11).

(SC3) Difficulties for users related to technologies barrier describes that it is difficult for users to understand and effectively use the MaaS technologies due to missing know-how or other factors like age. The paper of Arias-Molinares and García-Palomares (2020) shows that with the options through MaaS increasing, users find it challenging to navigate through all the information sources, applications, tickets and journey planners. While MaaS tries to counter these effects by providing a unified experience, it is evident that some user groups still have issues using the technology. This is supported by the findings of this work, as participants describe that a general understanding of MaaS is often not the problem but rather a technical understanding of the concept (I1, I7). This leads to barriers to adoption as some people will never use an app, and others use apps all the time (I8). This is a contrast to the findings of Alonso-González et al. (2017), who see user readiness as the main factor. MaaS providers try to lower this barrier by providing users with a single login for all services. For example, if a user had already registered for a previous non-integrated offering, they can be hinted that they can use the same login procedures to use the MaaS platform (I1).

(SC4) Missing collaboration is about barriers to collaboration between the different actors in the MaaS business ecosystem. In literature, Smith et al. (2019) argued that the innovation process of MaaS will go hand in hand with increased inter-organisational collaboration and that barriers will originate from this process, making it difficult for public providers to collaborate with private actors. This has also been found by the findings of this study, which show that collaboration and cooperation in the MaaS ecosystem are hampered for several reasons. One factor observed is that no culture of collaboration or cooperation exists, also caused by missing know-how on developing solutions together (I4). One reason for this is outlined by Karlsson et al. (2020), who explain that the MaaS business ecosystem lacks a culture of collaboration and assumed roles and responsibilities. Also, informal factors such as organisational cultures and new collaboration and partnerships are established among actors who have not worked together previously. Another factor observed has been that some stakeholders do not talk to each other, which also led to an unwillingness to give their budget for the benefit of others (I13). In this context, it was also reported that it is not easy to get in touch with some actors (I14). Sometimes it was even politically sensitive to talk directly to the companies (I15). This is in line with the findings of Arias-Molinares and García-Palomares (2020), who argue that conflicting goals of private/public organisations can create barriers to collaboration.

(SC5) Missing leadership, vision and directions into which to develop is a barrier which emerged by a lack of a future vision and leadership among the MaaS business ecosystem actors. Guyader et al. (2021) recognise that leadership involvement to manage and resolve tensions in MaaS ecosystems is vital. This study's findings indicate a lack of leadership across the cases. Namely, a lack of clear accountability and leadership at the city, regional and state level are observed (I8). Evidence shows that taking over leadership roles can be dangerous (I12). One reason for that was that decision-making in public sector organisations had been reported as slow and involved an uphill battle against traditional mindsets and forms of organisation (I15). Further, it has been reported that many people are involved in decision-making. This highlights the need for a person to be committed to making MaaS a success in the region. Scholars have also recognised this, introducing the term MaaS champion. This actor provides strong leadership, linking short-term innovation and developing long-term sustainability visions linked to societal transitions (Mulley & Nelson, 2020; Smith & Hensher, 2020). However, not all participants observed a lack of MaaS champions. For example, I18 reports that “the political and senior leadership side has helped to bring other stakeholders along that journey and convince them that this is the right thing for us to be doing” (I18). Such findings are confirmed by

Kandanaarachchi et al. (2022), who report from the Sydney MaaS trial that having a MaaS champion and the right mix of partners has been a crucial factor for success.

(SC6) Skills and knowledge gaps describe the barriers that the MaaS provider lacks skills or has knowledge gaps required to build a MaaS platform. In literature, Crozet and Coldefy (2021) stress that the MaaS provider has to acquire new skills and position themselves as a trusted third party. These missing skills are also represented in the empirical data collected by this paper. For example, participants describe a lack of resources and skills to develop and implement a successful MaaS platform (I2, I4, I5, I12). Here, it is pointed out that the MaaS provider does not have the necessary resources to develop the MaaS offering properly, including financial resources and technical know-how. In this context, significant knowledge gaps exist as some MaaS providers have no vision and lag in digitalisation and technology (I10). Examples of such skills include app development and technical know-how to develop interfaces and backends.

(PR1) Demand estimation, creation of business models and tailoring of services describe the barriers experienced when estimating the demand, creating business models, and tailoring the mobility services. Evidence showed that establishing a MaaS model in some markets can be challenging as there are not enough large cities to generate a sufficient customer base (I3, I4). Further, it is indicated that many Public Transport Operators (PTOs) do not understand what their customers need, while they are good at understanding how transportation works (I8). Here, it is unclear which part of MaaS is the most important for the customer, just the multimodal journey planning or potentially other topics (I15). Besides the demand estimation, creating business models was a barrier in the cases. In the context of a MaaS platform, a business model refers to the design of an approach that enables all participating actors to profit from the creation of mobility services. In the literature, Mulley and Nelson (2020) recognise that the business model discussion is still early. Here, Mulley and Nelson (2020) emphasise that a business plan must understand the cost and establish value. The empirical findings show that many MaaS providers struggle to establish a business plan (I1, I2, I7, I14). Some providers even consider a business model utopia in the short and mid-term (I2). One business model issue has been tailoring mobility services. Here, the tailoring of services refers to the adoption of mobility services to the users' needs by bundling those services and creating subscriptions. Evidence shows that the cases reported regulatory challenges to create such an offering because no cross-subsidisation of public transport fares could be done (I2, I12).

(PR2) Legal issues, bureaucracy, and institutional barriers are barriers caused by legal issues slow decisions due to bureaucracy and institutional barriers. Legal issues can emerge through the complex legal requirements required to make MaaS a reality. These could span from local and national to international laws, rules and regulations. Kamargianni and Matyas (2017) highlighted the need for a MaaS provider to have legal agreements and frameworks in place. The findings of this paper outline that the public MaaS providers are bound by municipal law and that everything they do needs to have a direct link to the city for which they operate (I1, I11). They are also influenced by international laws influencing their selection process of service providers. For example, I1 indicated that because of the European Schrems II ruling, their project had been delayed, because they had to make sure that their DSP was following this rule. Further, Murati (2020) indicate that under EU law there is no harmonised legal basis for multimodal passenger transport in EU law. This is in line with the findings of this study. The cases revealed that their digital regulatory framework was unclear, resulting in ambiguities in how the company structure should be set up to comply with legal requirements (I12).

(PR3) Poor governance framework policy and regulation challenges address the lack of poor governance frameworks and missing policies or regulations. The lack of such frameworks poses challenges to the MaaS provider and their business ecosystem. In literature, Karlsson et al. (2017) recognise the importance of such frameworks on different levels. In practice, different governance, policy, and regulations barriers were observed within the cases. Here, insufficient governance frameworks, limited licensing options and different regulatory regimes in different cities were causing

barriers to develop a MaaS platform (I2, I6, I16). In this context, Tabascio and Brail (2022) express the need for governments to understand the local and regional implications better. While some cities had the power to control licensing and the number of providers and vehicles, other cities' power was very limited to control the mobility options (I3, I14, I18). This shows that consistent regulation for MaaS is hard to achieve. With inconsistent regulations across Europe and little regulative power, it is hard for the MaaS providers to establish a clear framework and regulation (I14, I18).

5 Conclusion

The objective of this paper was to answer the research question**: How can barriers in the business ecosystem of MaaS providers be identified and understood?** The contribution to theory and practice, along with some reflections for future research, are summarised below.

The outlined research gaps of missing empirical evidence and data on MaaS platforms by Haavisto (2020), Arias-Molinares and García-Palomares (2020) and Guyader et al. (2021) have been amended by providing interpretive evidence from 18 MaaS experts. Through conceptualising the MaaS business ecosystem with ANT using an SLR on actors and barriers, main actors and three barrier themes (*TD, SC, PR*) with 13 sub-themes (*TD1-TD4, SC1-SC6, PR1-PR3*) were identified. This conceptualisation, in combination with the cross-case analysis of the barriers, contributes to practice serving as a fundament for more case-specific analysis to help practitioners to formulate new policies and regulations for MaaS.

Currently, many MaaS implementations are happening in Europe, and this study investigated cases focusing on urban MaaS. Future studies may seek to (1) research and compare the findings with other MaaS implementations, (2) uncover barriers in the context of rural MaaS implementations, or (3) generate best practice frameworks to overcome these barriers.

Overall, the blossoming of MaaS platforms and the emergence of pilots are increasingly essential for future mobility. Looking at the future, the concept of MaaS can support cities and citizens to develop and transform into sustainable mobility systems. This paper laid the foundation for more case-specific analysis to help academics and practitioners build effective policies to let MaaS thrive. By tackling those barriers with new technology and policies, it is evident that the MaaS business ecosystem will continue to grow and mature over the next few years.

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