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Key barriers in MaaS development and implementation: Lessons learned from testing Corporate MaaS (CMaaS)

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ABSTRACT

To reach the full potential of Mobility as a Service (MaaS), especially its projected positive environmental impacts, the barriers to development and implementation processes must be identified. However, studies identifying such MaaS barriers are rare. Following an interdisciplinary approach, this paper aims to bridge this gap by adding knowledge on barriers to MaaS development and implementation using four perspectives (service design, business model, user travel attitude and behavior, and system impacts). Following a systems thinking approach, the barriers are investigated at three levels (individual, organizational and societal) to show their relationships. This paper investigates a specific type of MaaS, namely Corporate Mobility as a Service (CMaaS). The results obtained by investigating a large-scale CMaaS pilot provide implications of general barriers to MaaS development and implementation. The findings presented in this paper provide knowledge and guidance to MaaS stakeholders.

1. Introduction

Urban planners and local authorities face many challenges brought by growing and aging populations, increased urbanization, traffic congestion, and increased air pollution. Mobility as a Service (MaaS) is anticipated to have the potential to help authorities improve transport services and mitigate some of the difficulties that the transport sector faces (Sochor et al., 2016; Jittrapirom et al., 2018; Pangbourne et al., 2020). MaaS is a complex sociotechnical system that includes multimodal mobility, multiple stakeholders and multiple objectives (Markard et al., 2012). MaaS brings public and private sectors together to provide end-to-end customer travel solutions that deliver multimodal transport choices in seamless planning and payment systems (Heikkilä, 2014). There is a strong body of studies showing how MaaS could help reduce private car usage and emissions (Cole, 2018; Hoadley, 2017) as well as improve transport accessibility and travel experience (European Commission, 2016; Hensher, 2017). Outcomes from field surveys and MaaS trials have shown that MaaS can provide solutions to make people's travel more efficient and more sustainable (Kamargianni et al., 2018; Sochor et al., 2016; Strömberg et al., 2016, 2018).

However, the potential benefits of MaaS can be realized only if the requirements of involved actors are satisfied, the needs and expectations of users are met, and the existing barriers are identified and overcome (Polydoropoulou et al., 2018). Jittrapirom et al. (2018) have specifically pointed out that the potential of MaaS depends on various aspects, such as user acceptance, business models, scalability, data privacy and security, but that these aspects contain uncertainties and could induce barriers for MaaS development and implementation. In order to implement complex sociotechnical systems like MaaS, barriers from technical, economic, political, and social aspects need to be identified (Sovacool et al., 2011). This means that there is a need to identify barriers for developing and implementing MaaS and that knowledge about these barriers is important in order to:

- support necessary integration between public and private transport services for enabling MaaS.
- help citizens utilize MaaS for more efficient and accessible travel.
- support MaaS providers and operators in developing sustainable business models.
- support authorities in MaaS-related policymaking.

Only a few studies have attempted to reveal barriers that hinder MaaS from providing sustainable transport solutions. Smith et al., (2018) discussed institutional barriers that could influence MaaS development at the macro and meso levels. Polydoropoulou et al. (2018) found that the lack of data from the key MaaS stakeholders and end users could induce technical barriers for setting application programming interfaces. They also identified social barriers to changing potential users' travel behavior, since they have a strong reliance on private cars. Gras (2018) identified barriers in preventing authorization to implement a MaaS service on end users in São Paulo. Zöschinger (2019) discussed the design barriers in setting up a MaaS framework at a municipal level in Munich. These studies have indeed called attention to the fact that barriers in MaaS development and implementation need to be addressed, but they primarily focused on one

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perspective. Moreover, none of these studies specifically investigated how barriers could relate to and influence each other.

The involvement of professionals from different disciplines is required for the development and implementation of MaaS (Pangbourne et al., 2020). Each discipline, for example service designers, operation engineers, company managers, landscape architects, and scholars, should have specific involvement and tasks (Giesecke et al., 2016). Thus, identifying MaaS barriers also requires the involvement of different disciplines and consideration of different perspectives for broader and deeper identification (Casadó et al., 2020). It is also essential to look at the interrelationships of the barriers due to the systemic nature of MaaS. As Mattsson and Jenelius (2015) highlighted, interdisciplinary collaborations between authorities, operators and scholars are needed when building a reliable transport system. Taking a systems thinking approach can help one understand the causes of the barriers, improve the engagement of multiple disciplines, reconcile objectives, address needs of stakeholders, and enhance solutions in different contexts (Lu et al., 2018).

This paper acknowledges the importance of an interdisciplinary approach and applies it to identify barriers to MaaS development and implementation by considering four perspectives, namely service design (SD), business model (BM), user travel attitude and behavior (TrA&B), and system impacts (SI). The paper further investigates how these barriers relate to each other by applying these perspectives at three levels (individual, organizational and societal) following a systems thinking approach. The variant of MaaS studied in this paper is referred to as Corporate Mobility as a Service (CMaaS). The following two research questions are addressed:

1: What barriers to the development and implementation of CMaaS can be identified by investigating a real CMaaS pilot using the four perspectives?
2: How do the barriers relate to each other in the system across the three levels (individual, organizational, societal) of the real CMaaS pilot?

CMaaS fulfils what is commonly viewed as the main characteristics of MaaS: integrating several transport modes through use of ICT, providing a “one-stop-shop” for mobility; and requiring some kind of registration or subscription (Jittrapirom et al., 2017). CMaaS is mainly under the context of a company and enables mobility both within and to and from a worksite for employees (Hesselgren et al., 2019). CMaaS uses a business-to-employee model instead of a general business-to-consumer model. The knowledge acquired from CMaaS barriers can therefore be used to identify barriers in general MaaS. The systemic overlook of how the barriers relate to each other can also provide guidance to decision-makers in implementing MaaS in general.

The paper is structured in the following five sections. Section 2 presents the methodology that is applied in this paper. Section 3 describes barriers identified under the above-mentioned four perspectives by empirically analyzing a real CMaaS pilot. Section 4 describes how the barriers relate to each other based on the results of Section 3 and discusses the findings. Section 5 concludes the paper.

2. Methods for identifying MaaS barriers

MaaS systems have a general systemic nature with multiple development conditions, decision-making processes, operation contexts and stakeholder actions (Senge, 2006; Markard et al., 2012). In order to implement MaaS successfully and obtain the potential benefits, various disciplines and perspectives need to be considered within the whole system (Casadó et al., 2020; Pangbourne et al., 2020). Sochor et al. (2015b) emphasized three perspectives to be considered, the user perspective, the commercial perspective and the societal perspective. These three perspectives engage multiple disciplines and are crucial at phases of MaaS implementation, operation and post-evaluation. However, they do not address the development phase of MaaS. Service design is commonly used in this phase, and this perspective can provide a holistic view of a service system (Hesselgren et al., 2019).

To identify and understand the barriers of CMaaS interdisciplinarily, this paper adopts four perspectives that are unique and important in different phases of CMaaS development and implementation. The four perspectives are service design (SD), business model (BM), user travel attitude and behavior (TrA&B), and system impacts (SI). The four perspectives are crucial in specific phases of CMaaS development and implementation. They also support and give inputs to each other in the system as a whole. The following section further explains the four perspectives and the commonly used methods.

2.1. The four perspectives and their methods

2.1.1. SD perspective

Service design looks into the CMaaS system and takes into consideration the fact that MaaS development depends on company needs and technologies, as well as users' daily practices and societal goals and regulations. It is an inherently holistic activity, since many different aspects must be brought together to design services that fulfil conflicting needs. Service design is involved in the initial stages of the CMaaS development process to gather user insights and identify issues, as well as during the development process to concretize and finalize a service with all its touchpoints.

Service design methods are co-creative, user-centered and iterative (Stickdorn et al., 2018). Methodologies that are used in the service design perspective are usually qualitative, based on interviews, workshops and observations. As Gürdür and Sopjani (2018) discussed, service design requires an understanding of individual behavior and organizational actions to design intelligent transport systems. Service design investigates the system usefulness for individuals, organization and society.

2.1.2. BM perspective

The building of sustainable business models is crucial for a company implementing CMaaS systems. The business model perspective focuses on the value proposition, value capture, and value creation in order to understand the value that the service will provide (Bowman and Ambrosini, 2000). Understanding possible value propositions can provide information to support service design in developing the service system. Understanding how value is captured gives guidelines for adjusting the business model for the service system to provide the company economic benefits and meet sustainable goals. Understanding value creation may indicate uptake, and how the users and the company will benefit from the services.

Methods such as qualitative interviews and workshops are most commonly used to research the business model perspective (Polydoropoulou et al., 2020). Foss and Saebi (2017) discussed the importance of business models for the organization and for macromanagement. Sarasini and Linder (2018) discussed the importance of understanding business model innovations from public and private stakeholders' perspectives in order to capture values of MaaS and assess system usefulness for involved organizations.

2.1.3. TrA&B perspective

User acceptance is essential in order to successfully implement CMaaS for the employees of the corporation. Information about (i) travel attitudes towards CMaaS in commuting to/from and within work; and (ii) travel behavior using CMaaS in commuting to/from and within work is important to know. Examining employees' TrA&B can facilitate an understanding of how well the service is implemented and accepted at the individual level. This knowledge can support service design in making adjustments to increase service quality and efficiency. The knowledge can also help organizations improve cost-benefit control and enhance long-term development of services. Furthermore, the TrA&B perspective can provide information that can be fed into the system impacts on how employees interact, influence and promote the CMaaS to reach its full potential while enabling sustainable travel.

In this perspective, the most commonly used methodologies are quantitative data-driven analysis based on travel surveys (Jahanshahi et al., 2015), transport cards (Pelletier et al., 2011) and mobile phone data (Wang et al., 2018). Understanding users' travel attitudes and behavior through MaaS pilots and experiments is necessary since this perspective

evaluates and explores system usefulness for individuals (Sochor et al., 2015a; Miramontes et al., 2017; Kamargianni et al., 2018; Varela et al., 2018).

2.1.4. SI perspective

CMaaS is a complex and dynamic socio-technical system that consists of a range of interdependent parts. For a company that offers a CMaaS service, the system impact evaluation could be an important follow-up tool for understanding the possible effects of upscaling. This perspective accumulates information from the service users, service operators, and society (city/region scale) and assesses the impacts. The system impact perspective sets up a modelling platform for the system as a whole and evaluates the impacts both within and beyond the system.

From the system impact perspective, a combination of data-driven quantitative and qualitative analysis of interviews and workshops is required to measure the impacts (Aapaoja, 2017). Modelling and simulations are also needed given the complexity of measuring the accumulated impacts at the system level (Kamargianni and Matyas, 2017). This perspective connects system usefulness for individuals with the impacts on organizations and society (Karlsson et al., 2019).

2.2. Relationships between the three levels and four perspectives

Karlsson et al. (2017) have pointed out that, apart from having different perspectives for successful development and implementation of MaaS, it is important to take a systemic approach by viewing the system from different levels. They propose that individuals, organizations and society are the three crucial levels to be considered in MaaS systems. In our view, there is a clear connection between the perspectives (user, commercial, societal) described by Sochor et al. (2015b) and the levels (individual, organizational, societal) from Karlsson et al. (2017). First, from a user perspective, the main agent is MaaS end users, which mainly reflect the change of travel behavior at an individual level. Second, in the commercial perspective, the main agents are the service providers and operators, which mainly reflect the change of business models and transitions at an organizational level. Third, in the societal perspective, the main agent is the city and region, which mainly reflects how MaaS systematically influences the city or region in terms of social welfare, ecology and environment at a societal level.

Similarly, there are connections among the four perspectives used in this paper and the three levels individual, organizational and societal. The connections are formed because these four perspectives focus on different phases of the CMaaS. As illustrated in Fig. 1, SD mainly focuses on the development phase but has extensions throughout the process, BM is mainly applicable in the implementation phase, TrA&B is mainly considered in the operation phase, and SI is mainly relevant in the follow-up phase.

SD thus connects to all three levels since it considers the users' needs, the company's capabilities and society's requirements. BM connects to the organizational level since it reflects the company's business model change in providing and operating a CMaaS. TrA&B connects to the individual level since it reflects user changes in work-related travel due to access to a CMaaS. SI connects to the societal level since it reflects what impacts the CMaaS could have on the users, company and city/region that extends beyond the company. Understanding the relationships of the three levels and four perspectives at different phases of CMaaS development and implementation is imperative to identifying the barriers of CMaaS and checking how the barriers could relate to each other. Fig. 1 shows the chronological order of how each perspective is active in a certain phase of CMaaS. It also captures the systematic nature of the CMaaS and shows the necessity of considering different disciplines when identifying the barriers.

3. Barriers identified from the four perspectives

3.1. The CMaaS case

This paper serves to study a real CMaaS case deployed at a company in Sweden. The CMaaS was launched in 2018 and is still in use. There were approximately 15,000 employees in the company at the time of launch. The employees were located in more than 70 different buildings spread out over a radius of five kilometers. The company initially wanted to improve employee efficiency while at work and reduce the use of private cars in order to potentially decrease the number of parking spaces and reduce commuting-related congestion. The company set the overall goal of providing an accessible, attractive, effective and sustainable transport solution for its employees to/from and within work. In this CMaaS, mobility services were both provided and operated by the company.

As illustrated in Fig. 2, the services included 3 internal taxis, 14 small shuttle buses and 40 shared e-bikes within the company area, as well as 6 commuter buses for commuting to and from the city. Walking and regular bikes were not considered in this CMaaS, as they do not require booking or timetables. Walking was not a practical mode to travel within the work area, while e-bikes were believed to be more attractive than regular

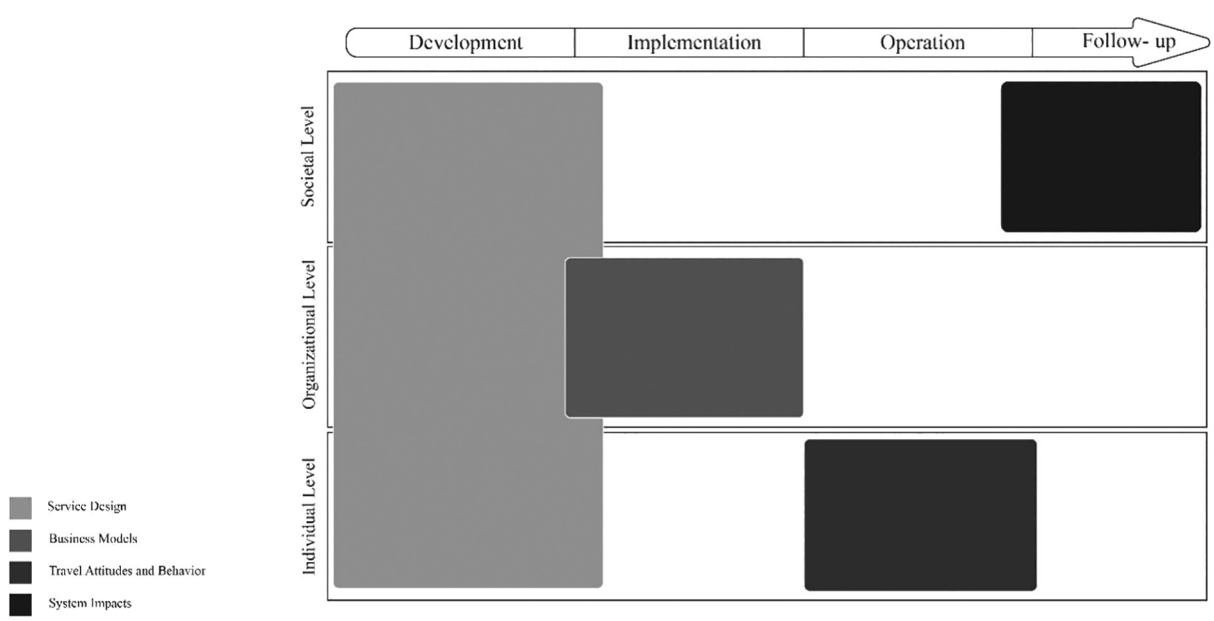

Fig. 1. Relationships of the three levels and four perspectives at different phases of CMaaS development and implementation.

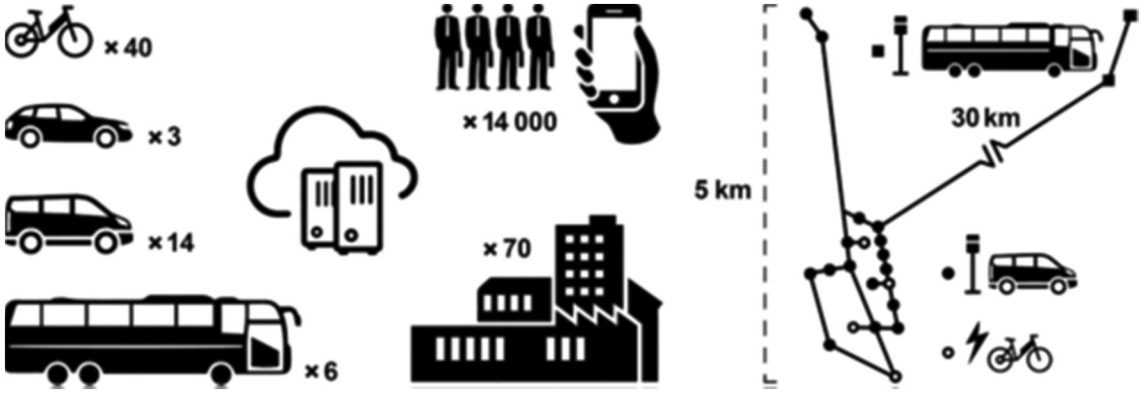

Fig. 2. The CMaaS services provided by a company in Sweden.
(Source: Hesselgren et al. (2019).)

bikes. However, the service application offered options to find one's way by foot or by private bike on the map.

Three-wave surveys were conducted before the launch, 6 months after the launch, and one year after launch. The surveys consisted of questions on demographics, daily travel behavior, perceptions and attitudes towards the CMaaS services. The first survey mainly incorporated the service design perspective in the development phase. The second survey mainly aimed to capture the changes in users' travel attitudes and behaviors. The third survey mainly aimed to understand the system impacts of the CMaaS. Selection of the employees was controlled by the HR department due to company policy. The process followed a stratified selection to include different genders, ages and work positions. The surveys were distributed via internal email to about 2000 employees on each occasion, and 435, 355, 422 responses were collected respectively. Among the respondents, the distribution of gender and age was rather balanced, while white-collar workers had a response rate about double that of blue-collar workers. Survey analysis results can be found in Varela et al. (2018), Hesselgren et al. (2019) and Vaddadi et al. (2020). One main finding to be noted here is that, after one year of use, the provided CMaaS services accounted for 44% of the trips conducted within work. Respondents showed high expectations for the services and the satisfaction rate was 75% for those who experienced the services. Furthermore, 21% of respondents claimed they may shift from private car use to CMaaS services if good incentives were provided by the company. This could contribute to reducing CO_2 emissions.

Apart from the many benefits of the CMaaS in establishing a more sustainable work-related mobility system, the researchers of the four perspectives also identified a number of barriers to the development and implementation of the CMaaS. The subsections below describe the main barriers found in designing the service, investigating potential business models, understanding the users' travel attitudes and behaviors, and evaluating the system impacts.

3.2. Barriers identified from the SD perspective

Service design drives innovation through the use of an iterative learning process. Co-design and service design methods based on Sanders and Stappers (2008) and Stickdorn et al. (2018) were applied in the design phase of the CMaaS. Insights from users and organizational units were used to guide the process. 77 interviews with employees were conducted in four iterative rounds. The users' lifestyles, travel needs and attitudes, as well as policies and the employers' responsibilities, were found to be important (Hesselgren et al., 2019). Most importantly, the service design perspective identified a need to widen the development project's scope. This was also pointed out by several employees during interviews, as many believed that the current service was only a small step in the right direction. Five main barriers were found from this perspective:

1) **SD1**: The company was not able to view and develop CMaaS as a complex sociotechnical system.
2) **SD2**: There were conflicts for employees in the use of CMaaS while at the same time following company policies and norms.
3) **SD3**: The departments within the company did not make an integrated effort in developing CMaaS.
4) **SD4**: The CMaaS could not be connected to public transport due to taxation issues.
5) **SD5**: There was no planning function in the service platform to assist users in planning their workday travel beforehand.

The first main barrier was that the CMaaS was not understood as a sociotechnical system by the company. The development of the service failed to involve several corporate functions. R&D and HR in particular could have supplied resources and capabilities if they had been involved or assigned ownership of the development. The second barrier was strongly related to the first, i.e. because the development project was run by a small operative unit, the focus was mostly on measurable outputs and cost efficiency. This, in turn, resulted in the CMaaS not being integrated with larger surrounding contexts. The barriers of organizational understanding and contextual integration made it hard to counter the barrier of it not being possible to connect the service to public transport due to taxation. The lack of a planning function in the service platform made the service system unappealing to users, as many wanted to plan trips beforehand. Also, the user group for the CMaaS was limited since using CMaaS sometimes conflicted with the company's workplace policies and cultural norms, such as being efficient.

3.3. Barriers identified from the BM perspective

The business model analytical framework in this specific CMaaS case was based on Bowman and Ambrosini (2000) and Foss and Saebi (2017). Ten semi-structured interviews were conducted to understand the company's initiatives and goals, as well as how the operations and management team planned and ran the service. The focus of the service system was on relevant value propositions, and the development of a travel planning and booking application for the CMaaS had been the predominant focus instead of developing the operations management system. In a deeper study based on the interviews, Lindblad and Nygårds (2018) found that the business model for the service system was only included in the development to a limited extent. This was mainly because the CMaaS system was primarily developed for the specific requirements of this specific workplace context and location. Scale-up potential and transferability to other workplaces and locations were therefore limited. For this, the CMaaS needed to optimize vehicle utilization, an area where the company lacked expertise, as well as to be able to capture benefits of the services. Three main barriers were found from this perspective:

1) **BM1**: The company was not able to capture value from the CMaaS because integration with different departments was lacking.
2) **BM2**: The company's inability to handle the complexity of the CMaaS severely limited value creation.

3) **BM3**: The company's inability to create a suitably flexible service made the value proposition weak.

The barriers to developing and operating CMaaS in this specific case related to the tension between solving the specific problems at this workplace and finding a suitable business model to develop a service that could be scaled up and transferred to other workplaces. First of all, there was a barrier to the company being able to create an attractive value proposition because the operations management system limited the development of a suitably flexible service. Secondly, there was a barrier to the company capturing value since the financial and operational indicators could not be acquired because integration with other departments was lacking. Thirdly, CMaaS management was assigned to a small, operative unit. This was a barrier to value creation because the unit lacked the capabilities and resources needed to develop a system complex enough to optimize for broad coverage and high usage.

3.4. Barriers identified from the TrA&B perspective

In the specific CMaaS case, a survey was conducted 6 months after launch and 355 responses were collected. Varela et al. (2018) applied a latent class and latent variable model and a conceptual framework based on Krueger et al. (2018) to the data set to understand the user attitudes towards the CMaaS. Varela et al. (2018) found that users could be classified into (Aapaoja, 2017) car-oriented (75%) and (Auvinen and Tuominen, 2014) shared mobility-oriented (25%). Furthermore, it showed the necessity of giving consideration to the demographic factors of the users, spatial factors of the context and design factors of the service in a new mobility service system. An ongoing positive trend of reduction in private car ownership was detected in the car-oriented group. Around 50% of both categories showed a willingness to use car sharing. It was also found that access to adequate information to plan trips and check for disruptions was important for shared mobility-oriented users. Users in both categories put a high value on the possibility of accommodating irregular schedules. Three main barriers were identified from this perspective:

1) **TrA&B1**: Requirements between users and the service provider were unsynchronized.
2) **TrA&B2**: The flexibility and accessibility of the provided CMaaS were limited.
3) **TrA&B3**: Incentives and time for users to change travel attitudes and behavior were lacking.

The developed and implemented CMaaS could not produce a significant shift from the use of private car to combined mobility services due to these identified barriers. First of all, the users' need for information access and real-time updates in CMaaS was much higher than the service could provide for. The barrier of limited flexibility and accessibility made it hard for users to maximize the utility of their choice. Secondly, changing users' travel attitudes and behavior and getting high user acceptance did not happen quickly since users needed to experience the services, evaluate the cost-benefit ratio and then adapt to more dynamic mobility patterns. The barrier of users not being given any incentives and enough time to change travel attitudes and behavior made it hard to achieve large adoption. Thirdly, mobility services provided in the corporate context also needed time to update and evolve, while users expected a mature CMaaS at once. This barrier of unsynchronized requirements between users and service providers made it difficult to popularize the services.

3.5. Barriers identified from the SI perspective

Vaddadi et al. (2020) proposed a framework for evaluating the system impacts of CMaaS based on Karlsson et al. (2019) and a selection of KPIs (Vaddadi et al., 2020). Applying the framework to the data collected one year after the launch of the CMaaS, different levels (individual, company and societal) and dimensions (environmental, economic and social) influenced each other to show the system impacts of CMaaS implementation. For example, the scalability of CMaaS had a positive influence on employees' perception of the provided mobility services' accessibility. The potential decrease in private car use could have a positive influence on the overall adoption of MaaS at a societal level. The SI perspective identified relationships between how the individuals perceived the service, how the company operated the service and how society made decisions to scale up the service. However, it was challenging to capture all the relationships between positive and negative impacts due to lack of information at a certain level. For example, employee satisfaction with the CMaaS could be influential in making the CMaaS profitable, not only through improvement to the employees' productivity but also through promoting the CMaaS as a commercial product to other companies. However, this link was unclear in this case since the company paid for all services and the financial data regarding the cost of services provided was confidential. The difficulties in measuring the system impacts made it difficult to follow up the service and improve the implementation. Three main barriers were found from this perspective:

1) **SI1**: Impacts on user travel beyond the company context could not be investigated since the service was not linked to travel outside the company.
2) **SI2**: Impacts on business potential values were underrated and made it difficult to scale up or promote the services to other companies.
3) **SI3**: Impacts on society were vague and made it difficult for the city to acknowledge the services.

The barriers identified through this perspective were closely linked to barriers identified from the other three perspectives. First of all, there was a barrier to acquiring knowledge of users' travel attitudes and behavior beyond the company's geographical boundaries because the departments within the company were not integrated in the operation of the CMaaS. The CMaaS was not integrated with public transport and the municipality outside the company. Secondly, due to the limited geographical boundaries of the company and the limited expertise in operating the CMaaS as a complex system, there was a barrier to scaling up the service or transferring it to other companies. Thirdly, there was a barrier to society outside of the company's geographical boundaries acknowledging the potential of the CMaaS since the CMaaS was limited to the company's context. This barrier made it difficult to follow up the CMaaS since impact evaluation is not only essential for further development of the service system but is also necessary in order to implement the service system on a larger scale for wider potential benefits in sustainable mobility.

4. Discussion

The barriers that have been identified by considering the service system from each perspective are connected to different phases of CMaaS development and implementation. Through different phases, the usefulness of the service system was addressed at the individual, the organizational and the societal level. Considering service systems at these three levels is not only important for taking an interdisciplinary and integrative approach in service design (Manzini and Vezzoli, 2003). It is also important for defining beneficiaries of the value creation process as a whole through these three levels (Lepak et al., 2007). Connections among these three levels embody the systemic nature of CMaaS as a sociotechnical system and enable a systemic evaluation of the barriers. Following what has been emphasized in Section 2 of methods, the discussion here in Section 4 begins by demonstrating how the barriers found in Section 3 can be mapped out to the individual, the organization and the societal level. Furthermore, the suggested framework for mapping barriers, the relationships of the barriers within the system, as well as the degree to which these findings may be transferable to MaaS in general are discussed.

4.1. Mapping barriers to the three levels

The results in Fig. 3 show the identified barriers grouped into the individual, organizational and/or societal level. When analyzing the service system from an SD perspective, the identified barriers appeared at all levels. This indicates the importance of taking a holistic approach when developing the CMaaS system. When considering the service system from a BM

perspective, the identified barriers were at the organizational level, while most barriers were connected to the individual level when looking at the service system from a TrA&B perspective. When the service system was analyzed from a SI perspective, the identified barriers were mainly connected to the societal level.

It was also found that some of the barriers spanned across all three levels. SD1and SI2 can be regarded as barriers on both the organizational level and the societal level. SD2 is a barrier that links both the individual level and the organizational level. TrA&B1 and SI1 are two barriers that can be mapped to all three levels.

This mapping not only shows how the barriers found through the interdisciplinary approach cover all three levels, but also gives rise to some speculations. Are there patterns showing how the barriers relate to each other? Could there be hierarchical relationships among the identified barriers? These speculations spurred us to further examine how the barriers were interrelated to hinder the development and implementation of the system. The main influential relationships among the barriers within the CMaaS system were therefore investigated by conducting a joint work of the authors, each representing a different discipline and following a systems thinking approach (Goldman and Gorham, 2006; Lu et al., 2018).

4.2. Checking the main influential barriers

In our analysis, the three barriers SD1, TrA&B1, and SD3 were identified as the most influential barriers likely causing or influencing other barriers. Fig. 4 illustrates the results of the main influential relationships among the barriers.

SD1 may likely have caused SD3 (the lack of integration of other departments in the development), which could have limited the scope of the CMaaS development. This, in turn, limited the value creation of the CMaaS (barrier BM2), since the company was incapable of handling the complexity of the system at the organizational level. Secondly, the limited scope of the CMaaS that originated from SD1 made it difficult to provide a level of flexible and accessible services that fulfil the travel needs of the employees (barrier TrA&B2) at the individual level. Although users can get some information on routing by foot or bike via the CMaaS application, walking was not well considered, while e-bikes were partially accessible at certain areas. The possibility of shaping the employees' travel behavior by encouraging the use of all modal options beyond the current CMaaS was therefore limited. Thirdly, due to SD1, the scope of the services was limited, making it difficult to measure the impacts of the service at the societal level. This could have resulted in the city not being able to acknowledge the potential benefits that CMaaS may bring to the city (barrier SI3). This could hinder the city from developing a more comprehensive MaaS system by integrating the CMaaS and promoting more sustainable mobility solutions.

The second influential barrier TrA&B1 (user perception of the service provider's inability to meet their requirements for the services) was a barrier that had influences at all three levels. First, the organization did not address the norms and policies that made the service inadequate for some users. The unsynchronized requirements between users and the service

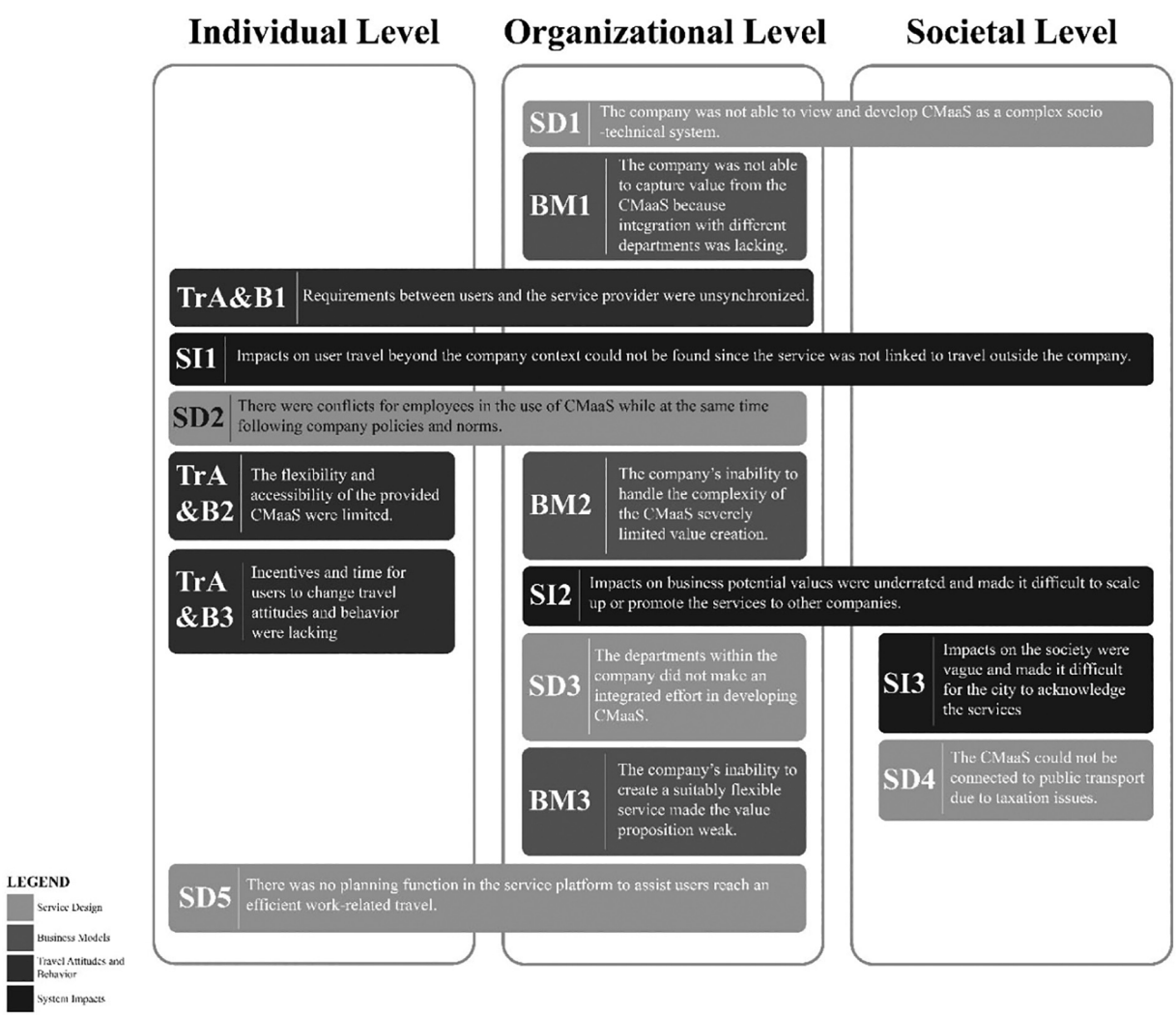

Fig. 3. Barriers that can be connected to the individual, organizational and system levels.

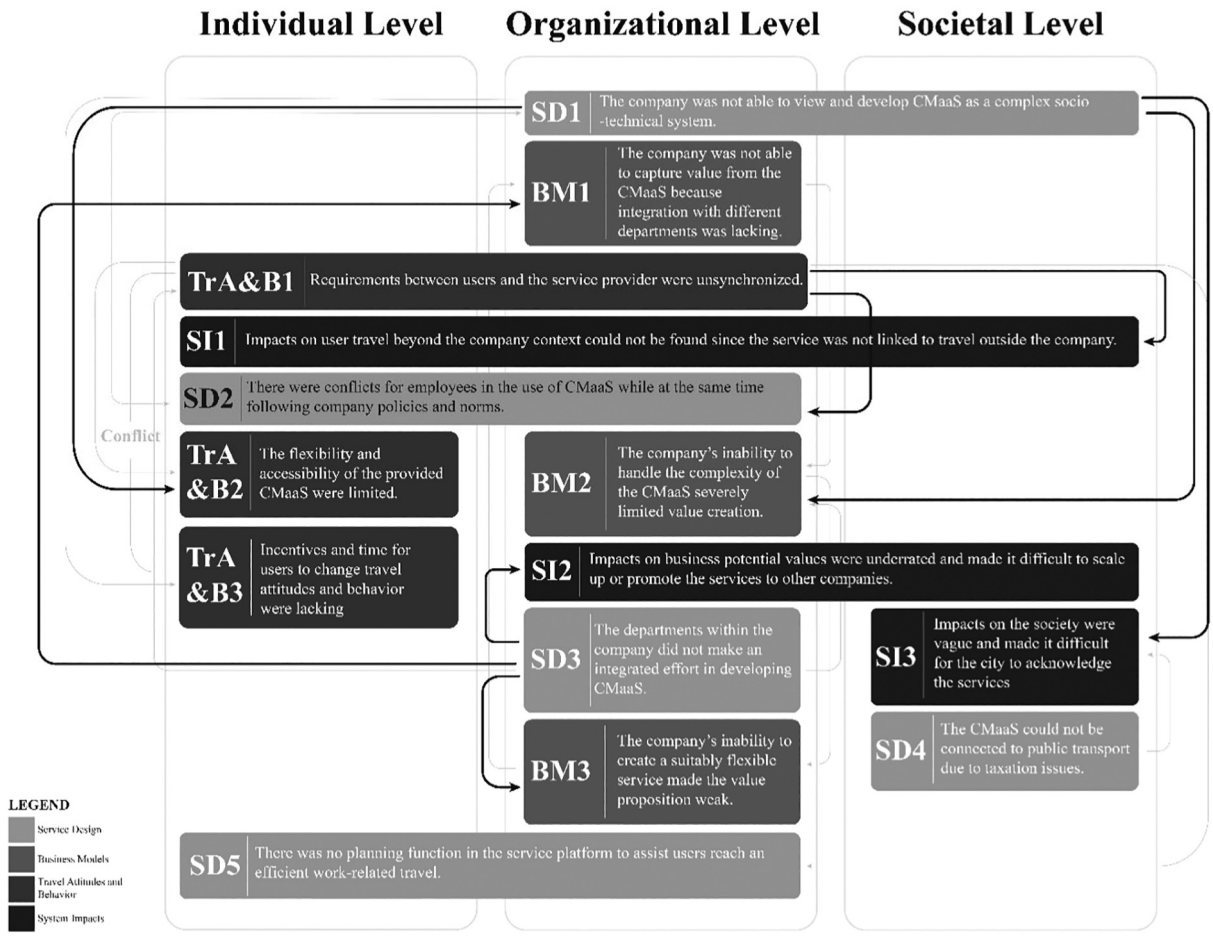

Fig. 4. Relationships among barriers at the individual, organizational and societal levels.

provider likely triggered conflicts for employees in using CMaaS while at the same time following company policies and norms (barrier SD2) respectively at the individual and organizational level. Secondly, the lack of synchronization in TrA&B1 made it more difficult to check the impacts on users' travel beyond the company context (barrier SI1) at the societal level.

The third influential barrier SD3 (lack of effort in integrating departments in the development of the CMaaS) was a barrier that had influences at the organizational and societal levels. First, the weak connection and cooperation described in SD3 caused certain problems for the company in identifying business values through application and development of business models that suited the CMaaS (barrier BM1) at the organizational level. Secondly, the barrier SD3 made the company unable to create benefits either internally or externally (barrier BM3) at the organizational level. Thirdly, SD3 may have also triggered the problem that the impacts of business potential values were underrated and the services could not be promoted to a larger scale at the societal level (barrier SI2). Because the company did not have a systematic plan for a continued development of the CMaaS, focus was mainly put on efficient daily operation. However, the operative department did not have the capabilities to continue the evolvement and optimization of the CMaaS without involving other departments in the process. Without integrated efforts to achieve a clear business and societal goal from the CMaaS, the service system will probably face bottlenecks that hold up implementation and further development.

In addition to the hierarchy of relationships identified above, there were also relationships between barriers within a single level. Within the individual level, TrA&B2 and TrA&B3 conflicted with each other. The users expected access to a mature service system from the beginning but ignored the fact that it took time to change their own travel attitudes and behavior. Within the organizational level, BM1, BM2 and BM3 likely formed influences in a loop. First, if the inability to develop a value proposition had negative influences on value creation, it could have further negative effects on capturing value from CMaaS. Then if the benefits of the services could not be well captured, the company would not be able to have a proper value proposition. Within the societal level, SD4 may cause difficulties in SI3. Since the CMaaS could not connect to public transport due to taxation issues, the impacts CMaaS may have on sustainable travel could be limited.

The connections and relations among the barriers could be complex and extensive. Although Fig. 4 shows the main influential ones, it emphasizes the importance of considering the relations of barriers systemically. It also sets a direction for the future analysis to fully investigate the barriers and identify the relationships.

4.3. Lessons learned

The interdisciplinary cooperation of the project team brought insights from various perspectives into understanding how CMaaS implementation could succeed at different levels. The integrated approach conducted by the researchers combined methods and involved actors at different levels, which captured vital aspects of CMaaS development and implementation. The work conducted in this project brings information about Corporate MaaS, and is especially useful for companies that are willing to address the travel needs of their employees. The knowledge of the barriers identified in this paper could be applied to MaaS that are operated in other contexts. Incentives and strategies are needed for individuals to change travel attitudes and behavior, for companies to adopt and implement CMaaS, and for society to benefit from the potential offered by MaaS.

The studied CMaaS system was targeted for use by white-collar workers. This was mainly because that white-collar workers usually had higher

travel needs within work, while the travel needs of blue-collar workers during work hours were limited. This could be regarded as insufficiently inclusive, especially in the long-term. As Loorbach (2007) stressed, building and/or changing complex sociotechnical systems require continuous experimentation and learning, which is a central premise in the sustainability transitions field. In order for the development and implementation of CMaaS to be continually successful in the long term, competencies and capabilities must be developed and expanded.

A company may therefore need to review the system's social inclusiveness in order to further develop CMaaS as a complex sociotechnical system. A company needs to set goals that integrate the requirements from the individual, organizational and societal levels to fulfil the employees' travel needs and the company's business and societal goals. Such integrated goals can contribute to achieving better synchronization with other transport options beyond a company's geographical boundaries. Integrating CMaaS systems with other MaaS systems can also support the establishment of long-term sustainable and beneficial transport solutions.

In addition to cross-functional integration between departments, integration with the society outside the company is also needed to develop and operate CMaaS. In the case studied in this paper, barriers such as conflicting workplace norms, generous parking rules, and taxation hindered the CMaaS from being integrated with the public transport system, which is in line with Hesselgren et al. (2019). Some barriers may be case-specific, but one general conclusion is that, in order to promote sustainable mobility solutions, CMaaS should address all work-related travel needs.

CMaaS may be a limited, sandboxed version of MaaS, but it could share some specific responsibilities within a larger MaaS system and enable accessible, flexible and customized mobility services. Following the development of MaaS, different types of MaaS may therefore be needed to meet complex travel needs in specific contexts. It is important that these systems coexist, cooperate, and function coherently within the ecosystems and that they are continuously developed to reform future transport systems.

5. Conclusions

To unravel the potentials of MaaS, there is a need to identify barriers to its development and implementation. It is important that the examination of such barriers is interdisciplinary and systemic. This is not only in line with what scholars currently suggest, as mentioned in Section 2, but also brings different approaches together and contributes to the current knowledge of barriers to MaaS.

Applying an interdisciplinary approach, this paper considers four perspectives (service design, business model, user travel attitude and behavior, and system impacts) to identify barriers to the development and implementation of MaaS. The 14 barriers identified by investigating a large-scale CMaaS pilot provide implications of general barriers to MaaS development and implementation. To further investigate how the barriers could possibly influence the system, a systems thinking approach was used. By mapping the barriers to three levels (individual, organizational and societal), a hierarchy of the barriers and some main influential relationships within the system were identified. This paper contributes by providing knowledge and guidance to MaaS stakeholders with two main takeaways:

1) It is necessary to not only identify barriers interdisciplinarily and systemically, but also capture possible relationships between the barriers during development and implementation. Some perceived barriers may be merely symptoms of larger, underlying issues.
2) In order to design, develop and implement well-functioning service systems, it is important to view MaaS as a complex sociotechnical system. It is essential to integrate the needs of different stakeholders, including the needs of the end users, and enable evaluation of system impacts.

This study also contributes by showing why it is necessary to involve multiple disciplines and stakeholders in identifying barriers and enabling good implementation of MaaS systems. This paper investigates CMaaS, but similar challenges are likely present in the development of MaaS systems on larger city or regional scales.

The paper encourages further discussions and continuous investigations of barriers within MaaS systems, whereby other perspectives could be added. Further analysis is also needed to fully understand MaaS barriers and to investigate possible relationships between the barriers. Finally, it is important to enhance MaaS development through continuous trials and experiments. Understanding how MaaS systems evolve over time and capturing these dynamic changes are necessary for MaaS to reach its potential benefits.

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CRediT authorship contribution statement

Xiaoyun Zhao: Writing (original manuscript preparation), coordination of the work, conceptualization, methodology, users' travel behavior and attitude perspective, writing (review and editing)

Bhavana Vaddadi: System impact perspective, visualization, methodology, writing (review and editing)

Martin Sjöman: Service design perspective, methodology, writing (review and editing)

Mia Hesselgren: Service design perspective, Business model perspective, methodology, writing (review and editing)

Anna Pernestål: Methodology, writing (review and editing), funding acquisition.

Declaration of competing interest

The authors state that there is no conflict of interest.

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