Mobility-as-a-Service and changes in travel preferences and travel behaviour: a systematic literature review

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Samenvatting

De verwachtingen over Mobility-as-a-Service (kortweg MaaS) zijn hooggespannen. Op velerlei terreinen zou het een positieve bijdrage kunnen leveren aan de leefomgeving en de bereikbaarheid van steden en het platteland. Maar er zijn ook nog veel vragen over MaaS waar middels kennis antwoorden op gegeven dienen te worden. Belangrijke vragen zijn: In hoeverre zijn Nederlanders bereid om MaaS te accepteren als nieuwe dienst en er ook daadwerkelijk gebruik van te gaan maken? Zijn er verschillen in de acceptatie en het potentiële gebruik van MaaS naar uiteenlopende doelgroepen?

Het KiM heeft opdracht gekregen om op zoek te gaan naar de antwoorden op deze vragen. Dit doet het KiM aan de hand van een uitgebreid onderzoeksprogramma waarin naast bestaande kennis ook nieuwe inzichten worden verzameld, onder andere met behulp van enquêtes. In de eerste verkennende fase van het onderzoek heeft het KiM een uitgebreid literatuuronderzoek uitgevoerd waarvan in deze paper de belangrijkste bevindingen worden gepresenteerd.

De inzichten uit de literatuur laten zien dat MaaS in principe voldoende toegevoegde waarde kan bieden om bepaalde groepen reizigers aan zich te binden. Daarbij lijkt het aannemelijk dat vooral jongvolwassenen die in grote steden wonen, tot de 'early adopters' van MaaS zullen behoren. Niettemin is het vooralsnog onzeker of MaaS in de dagelijkse praktijk daadwerkelijk tot gedragsverandering zal leiden en in welke mate de dienst bijvoorbeeld een alternatief biedt voor het gebruik van de privéauto.

Veel lijkt af te hangen van de manier waarop MaaS wordt vormgegeven, het precieze aanbod, de randvoorwaarden waaraan is voldaan en de toegevoegde waarde ten opzichte van huidige vervoersmogelijkheden. Het succes van MaaS hangt in ieder geval samen met de autonomie en flexibiliteit die het kan bieden. Het moet ook betrouwbaar en idealiter altijd en overal beschikbaar zijn. MaaS moet ook toegevoegde waarde bieden ten opzichte van de bestaande situatie. Vier toegevoegde waarden lijken hierbij van belang: het bieden van kostenvoordelen, meer gemak, meer keuzevrijheid en maatwerk. Op dit moment is het in ieder geval onwaarschijnlijk dat MaaS binnen enkele jaren tot forse verschuivingen in de dagelijkse mobiliteit zal leiden en tot een vermindering van bezit en gebruik van de privéauto.

1. Introduction

Integrated and seamless mobility has been a futuristic vision of mobility (in urban regions mainly) for a few years now (Preston, 2012; Schade et al., 2014). Today, Mobility-as-a-Service (MaaS) embodies that vision. MaaS is a new transport concept that integrates existing and new mobility services into one single digital platform, providing customised door-to-door transport and offering personalised trip planning and payment options. Instead of owning individual modes of transportation, or to complement individual modes of transport, customers would purchase mobility service packages (also called bundles) tailored to their individual needs, or simply pay per trip for customised travel options. Although MaaS is a relatively new concept, many studies, technical reports and business cases related to MaaS have appeared over the past couple of years. Indeed, the concept holds promise. MaaS could support a decrease in the negative externalities caused by transport and could be an efficient travel demand management tool that also improves environmental and social outcomes (Arbib & Seba, 2017; Matyas & Kamargianni, 2017). Nonetheless, much of the available scientific literature mostly pertains to defining what MaaS is and on its organisational challenges (ecosystem, technologies, integration of modes), rather than using in-depth analysis to quantify how MaaS may impact travel preferences and behaviour. Many (so-called) MaaS schemes have appeared in the past few years (see Durand et al. (2018)), but evaluations are rarely available, if done. To this day, the frequent claims about the positive contributions MaaS will make towards achieving sustainability goals rely on a scattering of limited yet insightful research findings.

Against this background, this study strives to respond to the "lack of clarity" about MaaS's impacts on travel behaviour and preferences, as stated by Wong (2017). The purpose of this research is twofold: (1) to provide a better understanding of the ways in which MaaS might impact people's travel preferences and travel behaviour (2) to establish a solid foundation for future research around MaaS, travel behaviour and preferences. These goals are achieved by analysing the first research efforts around MaaS, travel behaviour and travel preferences in a structured way. The research question that this study seeks to answer is the following:

What can current literature teach us about the expected impacts of Mobility-as-a-Service (MaaS) on people's travel preferences and travel behaviour?

Reviewing the potential impacts of MaaS on travel preferences and behaviour is relevant from research, business and policy perspectives, as it can inform various parties about the state of the research pertaining to MaaS and travel behaviour. In this sense, this review helps discern what people would value in such a new service and what might pose challenges, thereby providing a more nuanced yet realistic picture of what MaaS can achieve for travellers and society in the near future. This study can be useful to transport operators and authorities seeking to apply an attractively designed MaaS scheme. Further, researchers may be interested in the research gaps found in this review.

We restrict our research scope to Mobility-as-a-Service and impacts on travel preferences and travel behaviour. Travel behaviour refers to how people move over space, how and why they travel from point A to B, and how they use transport. In contrast, travel preferences refer to how people would prefer to move over space. We do not

comprehensively examine potential impacts on the transportation system (congestion, crowding in public transport, etc.), but rather merely as a consequence of impacts on travellers; for more details on MaaS and road congestion, see Hensher (2018), on MaaS and bus contracts, see Hensher (2017), on MaaS and land use, see Rantasila (2015).

This paper is organised as follows: in Section 2, we explain our method to select relevant studies. Next, in Section 3, we present the selected papers and their associated research methods. Section 4 provides the main outcomes of the analysis of these studies. This paper ends with a conclusion and a research agenda.

2. Method

To fulfil the goals of this study, we conduct a systematic literature review on Mobility-as-a-Service and travel preferences and behaviour. To this end, we searched in May 2018 peer-reviewed journal articles and conference papers in scientific databases with different combinations of the following keywords (or variations of these keywords): "Mobility as a Service", "travel behaviour", "travel preferences" and "modal shift". Since the amount of papers was too limited (four), we applied forward and backward snowballing techniques as described in Van Wee and Banister (2016). Kitchenham and Charters (2007) consider these techniques as useful additions to systematic database searches. We also decided to select four non-peer-reviewed studies. More details about the selection procedure can be found in Durand et al. (2018). In the final selection, we retain 14 papers and cluster them into two groups, as presented in Table 1.

Table 1: Selected studies from the systematic literature search (listed in no particular order).

Group of studies	**Year**	**Authors**	**Country/region where the study is conducted**
Research papers on MaaS pilots/linked to MaaS pilots	2016	Strömberg, Rexfelt, Karlsson and Sochor	Gothenburg (Sweden)
	2015	Sochor, Strömberg and Karlsson	
	2016	Karlsson, Sochor and Strömberg	
	2016	Sochor, Karlsson and Strömberg	
	2018	Strömberg, Karlsson and Sochor	
	2015	Smile mobility	Vienna (Austria)
	2017	Karlsson, Sochor, Aapaoja, Eckhardt, König	-
Interviews and surveys	2018	Smith, Sochor and Karlsson	West Sweden
	2018	Ho, Hensher, Mulley and Wong	Sydney (Australia)
	2017	Ratilainen	Helsinki (Finland)

	2018	Matyas and Kamargianni	London (UK)
	2017	Alonso-Gonzáles, Van Oort, Cats and Hoogendoorn	Amsterdam (The Netherlands)
	2017	Haahtela and Viitamo	Finland
	2018	Kamargianni, Matyas, Li and Muscat	London (UK)

3. Presentation of the selected papers

Before delving into the findings, the "what", we must first examine the "how": how did the selected studies draw their conclusions? Using which approach? As presented in Table 1, there are two main streams on studies on MaaS, travel behaviour and preferences.

A first stream investigated the outcomes of MaaS pilots. Most available studies on pilots focused on the 6-month Swedish MaaS pilot UbiGo, where 83 households (195 individuals) committed to monthly prepaid mobility packages that they had chosen based on their own needs. Sochor et al. (2015), Karlsson et al. (2016), Sochor et al. (2016), Strömberg et al. (2016) and Strömberg et al. (2018) provide an in-depth evaluation of how UbiGo influenced participants' travel behaviour. Another well-known pilot is the 6-month Austrian pilot Smile, where around 1,000 people used an application providing multimodal routing, integrated payment and ticketing. Results are available via a website (Smile mobility, 2015), but also in Karlsson et al. (2017) where both Smile and UbiGo are assessed on the same basis, and where extrapolated potentials of these scheme are estimated. Indeed, caution is needed as participants of these pilots are hardly representative of the population of their respective cities (Karlsson et al., 2017): see Table 2 for an overview of both pilots' sample characteristics. Yet according to Strömberg et al. (2016), a selective pilot recruitment increases the chances of success, and, consequently, creates observability (a wide audience sees that it works), showing that a modal shift towards sustainable modes is possible. Both pilots used surveys to evaluate travel behaviour changes, as well as travel diaries and interviews in the case of UbiGo.

Table 2: Overview of Smile and UbiGo pilots (Karlsson et al., 2017; Smile mobility, 2015; Strömberg et al., 2018).

	Smile	**UbiGo**
# Survey respondents	Around 170 (end-pilot survey)	164 before-pilot, 161 during-pilot, 160 end-pilot, 109 6-month follow-up
Characteristics of the sample of participants	Matched the gender and age distribution for early adopters. The average Smile user is male, aged between 20 and 40 and has a high level of education and high income.	Overrepresentation of city centre inhabitants, retired people greatly underrepresented. At least 90% of UbiGo households earned more than the gross medium income in Gothenburg.

The second stream of studies on MaaS and mode shift investigated the prospects for MaaS adoption and/or travellers' decisions within MaaS through surveys and interviews. Ho et

al. (2018), Ratilainen (2017) and Matyas and Kamargianni (2018) performed Stated Preference (SP) research to understand what types of mobility packages people would be interested in. Alonso-González et al. (2017) used the same technique to gain insights into the willingness to use various modes within a potential MaaS ecosystem. This technique is frequently used to gain insights into products and services that are not yet available (Louviere et al., 2000). The most common shortcoming of SP experiments is that they revolve around hypothetical choice situations; a choice made in such an experiment would not necessarily translate into the same choice in real life, owing to a wide variety of decision factors and circumstances that cannot be included in the experiment. Next, Kamargianni et al. (2018) used attitudinal research to gain deeper insights into intrinsic motivations for using or not using MaaS. According to Swait (1994), attitudes indirectly influence preferences, hence the relevance of attitudes for examining preferences within MaaS. Still, attitudinal research does not perfectly reflect future behaviour; it is common to see people failing to practice what they preach (Ajzen & Fishbein, 1977; J. R. Smith & Louis, 2007). Haahtela and Viitamo (2017) presented focus group results – and to a lesser extent survey results – on user preferences for MaaS products. Finally, G. Smith et al. (2018) took a different approach altogether by interviewing private stakeholders on impacts of MaaS on public transport (PT) and travellers' preferences.

Each of the survey studies include samples that are more or less representative for each metropolitan area, which is useful to bear in mind when interpreting results. Details of the representativeness of each sample are shown in Table 3 (except Haahtela and Viitamo (2017), because the paper mainly concentrated on focus groups). Overall, there is a good degree of representativeness. All studies targeted adults.

Table 3: Representativeness of samples in survey studies on MaaS.

Study	**City**	**Sample size**	**Representativeness for the city's population?**
Matyas and Kamargianni (2018)	London	1,068	Representative of the population in terms of age and gender, over-representation of full-time employed and retired people.
Kamargianni et al. (2018)	London	1,570	Representative of the population in terms of gender, age, residential zone and driving license possession. Over-representation of Caucasian British.
Ho et al. (2018)	Sydney	252	Well representative for the worker population but under-representative of retirees and housekeepers.
Alonso-González et al. (2017)	Amsterdam	797	Compared with the Dutch population: Slightly under-representative of the elderly and low-educated people, representative otherwise.
Ratilainen (2017)	Helsinki	252	Over-representation of females, older age categories and people with low-income.

4. Main outcomes

We organise the main outcomes from the systematic literature review into six themes. When needed, these insights are enriched with literature outside of MaaS.

4.1. A change in the private car ownership paradigm?

Private car use and MaaS in practice

A recurring discussion in the selected studies is private car use reduction. Pilots reveal that MaaS can trigger a decrease in private car use. 21% of the Smile pilot participants reduced the use of their private cars (Smile mobility, 2015). 44% of UbiGo participants also decreased their use of private cars during the trial (Karlsson et al., 2017). Strömberg et al. (2018) showed that the extent to which people became more positive towards the use of alternative modes, and the type of modal shift occurring, depended on pre-pilot travel behaviour, sociodemographic characteristics, and expectations of the pilot. The researchers defined four clusters:

- Car shedders (13%), i.e. people who wanted to relinquish ownership of their cars because they are expensive and inconvenient, and who wanted to reduce their environmental impact. 95% of them reduced their private car use.
- Car accessors (30%), i.e. people who wanted to gain access to a car without owning one, hesitating to purchase one for the same reason that car shedders wanted to relinquish theirs. 37% of them reduced their private car use.
- Simplifiers (22%), i.e. people who desired a smarter way of handling their use of multiple mobility services. Around 20% of them reduced their private car use.
- Economisers (35%), i.e. people who saw UbiGo as a way of saving money on PT. 53% of them reported using their private cars less during the trial.

Before the pilot, UbiGo participants were incentivised to relinquish (one of) their car(s) during the trial, receiving a financial compensation. 25% of the households chose to accept the challenge, of which 88% were single-vehicle households, and none changed their minds during the 6-month trial (Karlsson et al., 2016).

Owning versus using

In the same line, the dichotomy of owning versus using, in the sense of privately owned car versus sharing a vehicle and/or space in a vehicle, is a recurrent topic in the selected studies. In Gothenburg, 78% of UbiGo's car accessors increased their use of car sharing and 30% increased their use of car rentals (Strömberg et al., 2018). In London, 36% of the non-car-owning respondents of the Kamargianni et al. (2018) study stated they would delay purchasing a car and 40% that they would not purchase a car at all if MaaS were available. Furthermore, one in three stated that they would like to have access to a car without owning one, and one in three agreed that MaaS would help them depend less on their cars (Kamargianni et al., 2018). The researchers in London nevertheless found that half of the car owners are attached to their cars and do not like the idea of only having access to a car without owning one. Additionally, residing in the countryside or small towns could make it rather difficult to relinquish car ownership, especially when such a choice of living and commuting (daily with a private car) aligns with one's values (Haahtela & Viitamo, 2017). Cars are still widely perceived as the only transport mode that gives people sufficient autonomy and flexibility (Freudendal-Pedersen, 2009).

Using and owning may coexist. The interviewees of G. Smith et al. (2018) all believe that the diffusion of MaaS will allow for a decrease in car ownership, and more precisely that urban and suburban households will first abandon their second cars and then progressively their first cars. Karlsson et al. (2017) argue that MaaS would be a particularly good option as a replacement for second cars, or for households considering investing in a second car. The combination of shared mobility modes (car sharing, bike sharing, individual and collective demand-responsive transport, often present in MaaS schemes to provide flexibility) and public transport would therefore provide an alternative for second cars. In this perspective, what role would public transport play in MaaS?

The role of public transport

According to Hensher (2017), the MaaS era could disrupt the current role and organisation of public transport (PT). Matyas and Kamargianni (2018) and Ho et al. (2018) state that PT should be the backbone of MaaS – at least in metropolises such as London, Sydney and Vienna. In both studies, respondents were found to have a preference for mobility bundles that include public transport, especially unlimited PT. In Vienna, 48% of Smile users used PT more often (Karlsson et al., 2017). Not all PT users might switch to MaaS though: mobility bundles were not attractive to frequent public transport users in Sydney for economic reasons. Moreover, the focus group and survey participants of Haahtela and Viitamo (2017) (cities and small towns) mentioned several improvements that must be made to PT before they would consider using it (more frequently): for instance, having enough places to sit or having quiet spaces.

Pilots in urban regions found increases in public transport use among participants. 48% of respondents to Smile's post-pilot survey stated that they used public transport more often. All four clusters in UbiGo used PT more often, including up to 60% more often for the Economisers. In their survey, Kamargianni et al. (2018) found that 35% of regular car users stated that they would substitute car use for public transport if MaaS was available. One can argue that the MaaS product must have sufficient added value for this to happen though, otherwise the shift to PT would have already occurred. If such a shift does occur, this could lead to crowding in PT vehicles and at stations (Kamargianni et al., 2018). Alternatively, if MaaS with car sharing were available, 12% and 22% of regular public transport users stated they would substitute part of their PT trips with car sharing and taxi, respectively. Some of the transport professionals interviewed by G. Smith et al. (2018) believe that PT users gaining easier access to car-based services could lead to the cannibalisation of public transport modal shares. The profitability of car-based services for MaaS providers compared to PT might also contribute to this phenomenon (G. Smith et al., 2018), thereby possibly limiting MaaS's positive impact on the environment (air quality, noise, etc.) or exacerbating current issues related to private car use. Nevertheless, we also note that some of the potential decrease in PT use with MaaS might result from substitution with active modes, when distances allow: in the study of Kamargianni et al. (2018), 14% of regular PT users stated that they would substitute part of their PT use with bike sharing.

4.2. Preconditions in MaaS: the need for autonomy, flexibility and reliability

The need for autonomy and flexibility

In UbiGo, the participants revealed that they value their flexibility and autonomy. The end-pilot evaluation revealed that they had overestimated their car use (car rental and shared cars) by 30% on average, preparing "*for a need that never materialised*" (as one

participant phrased it, see Karlsson et al. (2016)). This shows the need for flexibility and autonomy in MaaS: people often want to have an option 'just in case'. In that sense, autonomy and flexibility can be deemed as preconditions for adopting MaaS. Flexibility could also perhaps explain the difference in willingness to pay (WTP) in a bundle between one-way car sharing (WTP = around $7.27 Australian dollars) versus round-trip car sharing (WTP = 0), as observed by Ho et al. (2018). Moreover, focus groups' participants of Haahtela and Viitamo (2017) often mentioned their need for the flexibility and autonomy of a private car for trip chaining (a sequence of trip segments beginning at the 'home' activity and continuing until the traveller returns 'home').
Survey and pilot participants also expressed the need for flexibility in their remarks and preferences pertaining to the design of MaaS. Matyas and Kamargianni (2018) found a preference for car sharing in terms of hours rather than days, offering more flexibility and a cheaper bundle. Smile participants appreciated the fact that the app took into account their privately owned transport modes in the trip planning, allowing for further flexibility (Smile mobility, 2015). Sochor et al. (2016) note that UbiGo participants desired a pay-per-use system based on money rather than credits (hours of car sharing and days of public transport), offering them more flexibility. The design of the service can therefore potentially enable or hinder flexibility.

Questions around reliability
As emphasised by Van Hagen and Bron (2013), reliability – with safety – is an essential prerequisite for passengers. Yet shared mobility modes raise questions in terms of reliability, as highlighted by MaaS studies that explicitly included offers with shared mobility modes. Ho et al. (2018) found that people prefer not having to book shared cars in advance, meaning they are willing to pay more for last-minute availability. With every 15-minute increase in advance booking, the researchers estimated that the willingness to pay would decrease by around $1.00 Australian dollar. Ratilainen (2017) found that what matters more to people when using DRT is the pick-up speed promise – being certain about the pick-up time, the assurance that one will be picked up on time – rather than the duration between booking and availability. Further, participants in the Haahtela and Viitamo (2017) focus groups highlighted another form of reliability: namely, they want to be provided with adequate and accurate routing when PT delays occur.

4.3. Aspects adding value in MaaS

Choice freedom
UbiGo participants enjoyed having access to the wide palette of transportation services offered on a single platform (Sochor et al., 2016), and valued the high degree of choice freedom, notably the varied car fleet they had access to. Choice freedom is therefore not only about a range of different modes (e.g. bus or electric bike), but also of vehicles (e.g. shared electric city car or shared family car). According to Spickermann et al. (2014), having a flexibly applicable "virtual fleet" that combines various vehicles and modes will be key for the groups in which private cars will be less important in future. Choice freedom can also lower entry barriers to additional services, making experimentation easier (Strömberg, 2015). UbiGo participants also stressed that car sharing sites must be situated nearby if they are to use car sharing (Sochor et al., 2015). The analysis of UbiGo's extrapolated potential by Karlsson et al. (2017) found that such a service would mainly attract households in areas where PT was readily available both in terms of routes and

frequency, and with car sharing vehicles parked less than 300 meters away (approximately). This means that even when people are willing to shift from owning a mode to accessing it, the system must allow for it. Although urban travellers expect to enjoy increasing freedom of choice in how they make trips, demand for high-level autonomy and (temporal and spatial) flexibility remains.

Convenience and value of an advanced level of integration

UbiGo users gained a new understanding of what convenience means to them thanks to the service's all-inclusiveness (Sochor et al., 2016), and this perception of all-inclusiveness was reinforced by the trust the participants had that problems would be promptly dealt with (Sochor et al., 2015). In Vienna, 55% of Smile users stated they more frequently combined different transportation modes, mainly cars and PT (26%) and bike and PT (26%) (Karlsson et al., 2017; Smile mobility, 2015). This increase in mode combination can be attributed to the Smile app's high level of integration, whereby multiple modes could be booked together within a single trip. 48% of respondents stated that their travel behaviour had changed since using the app, including using faster routes, combining different modes, and subscribing to new mobility offers. 95% of respondents were satisfied or very satisfied with such changes (Smile mobility, 2015). The focus groups of Haahtela and Viitamo (2017) also expressed high demand for integration, as well as parallel services, such as taking children to school. To sum up, it is likely that MaaS users gain multiple benefits from high levels of mobility integration.

Tailored offer

A tailor-made offer, for instance tailor-made bundles, may encourage the adoption of new travel behaviour patterns without radically changing one's habits. According to Sochor et al. (2016), the fact that subscription packages in UbiGo were personalised to fit the needs of each household played a fundamental role in changing travel behaviour. UbiGo participants declared that having a bundle made them reflect on their current travel habits. 64% of the participants stated that they had increased their use of alternative modes, especially car sharing and bus/tram, while 97% said they were satisfied with such changes (Karlsson et al., 2016). Kamargianni et al. (2015) use the term "collaborative customisation" to describe the process of dialogue between customers and providers, with the former capable of articulating their needs so that the latter can use that information to create tailor-made services or products. While many sectors refrain from engaging in this type of customisation, as it results in too many different products to produce, Kamargianni et al. (2015) argue that this is not an issue in MaaS given the non-physical nature of the service. According to the researchers, three elements are needed to design a package that fits a person's needs: individual mobility patterns, socioeconomic status, and attitudes and perceptions. However, they also note that since people are only capable of answering limited numbers of questions before becoming irritated or confused, the information collecting process and service must be smartly designed. Last but not least, such a process requires the user to accept sharing data about their preferences. The question of data privacy is therefore crucial.

4.4. The user-side design of MaaS

The design of mobility bundles

Why so much focus on mobility bundles in MaaS literature? Matyas and Kamargianni (2018) argue that MaaS could be used as a tool for altering the way people perceive travel

alternatives, rather than physically altering the alternatives, thereby potentially promoting shared mobility modes and PT, for instance. Indeed, literature on transport passes and season tickets (i.e. PT mobility packages) shows that mobility packaging significantly increases the patronage of the modes included in the package (Axhausen et al., 2000) and reduces the use of modes not included in the package (Simma & Axhausen, 2001). Bundling is frequently utilised to increase consumer acceptance and contribute to the diffusion of underutilised products or services, particularly when such products are bundled with more familiar products (Reinders et al., 2010; Sarin et al., 2003). Matyas and Kamargianni (2018) found that even though a bundle might include modes that individuals do not prefer, this does not mean that they would not purchase it. In 22% of their choice tasks, the MaaS product — i.e. a bundle of modes, discounts and extra features (e.g. luxury cabs only, floating car sharing) — offered such sufficient added value that respondents said they would actually consider purchasing it. The researchers noted that many individuals who did not previously use car and bike sharing said they would now be willing to purchase bundles containing them, and therefore perhaps be willing try these modes.

The design of the service

One reason why UbiGo allowed for changes in travel behaviour was the fact that the service was easy enough to use (Karlsson et al., 2016). When Kamargianni et al. (2018) asked people about potentially committing to a MaaS service, they discovered that the service must be carefully designed in order to attract people and lock them in. More than a half of their respondents said they would worry about running out of their subscribed amounts (of trips, kilometres, duration) in MaaS, while nearly half of the respondents also stated that subscribing to MaaS would make them feel trapped. When considering the answers per age group, Kamargianni et al. (2018) found that 52% of the respondents aged 40 and above felt uneasy about the multiple characteristics of subscription services and were nervous about committing to a MaaS subscription. This shows that in addition to the type of service provided in MaaS, the design of the service's basic elements is essential, particularly for reaching certain age groups. Further, as previously mentioned, the design of the service can potentially enable or hinder flexibility. In summary, the service's simplicity in its broader sense is key; it must be easy to navigate and understand, cancel, change plans, and so forth.

Another reason why UbiGo allowed for changes in travel behaviour was its trialability (Strömberg et al., 2016). It is the "degree to which an innovation can be experimented with on a limited basis", one of the main qualities of an innovation that allows it to spread (Rogers, 2003). Experiments are seen as "safe spaces" for people to trial behaviour without strict commitments (Laakso, 2017), potentially easing them into the travel behaviour change process (Strömberg et al., 2016).

4.5. Costs and willingness to pay

Willingness to pay and added value

Price is a preoccupation of travellers generally and hence a key aspect of MaaS. In UbiGo, households chose bundles costing on average €200, with the cheapest option €135 (Karlsson et al., 2016). MaaS could free individuals from mode-specific costs (an annual PT subscription, car costs) that potentially lock them in to specific modes. However, the forms of MaaS offering the most flexibility may not be economically feasible for everyone. The analysis of UbiGo's extrapolated potential by Karlsson et al. (2017) underlines the fact

that such a service only attracts those users for whom it is an economically feasible alternative, or who believe the service offers sufficient added value. We argue that perhaps both of these conditions must be met in order to allow for lasting changes. As already underlined by Rogers (2003), the added value is an important attribute for the rapid diffusion of an innovation. Sochor et al. (2016) argue that UbiGo's key service attributes (ease of use, choice freedom and the subsequent flexibility, tailor-made offer, convenience) add value compared to people's previous travel solutions, which could explain the willingness to pay. And developing an all-inclusive service — "*the service of the service*" (Karlsson et al., 2016) — did indeed pay off, as after using UbiGo for six months, users were found to have more a sustainable travel behaviour.

Subscription price sensitivity and incomplete comparison with car costs

All survey studies involving bundle choices found that potential users were significantly price sensitive (Ho et al., 2018; Matyas & Kamargianni, 2018; Ratilainen, 2017). The cost of a MaaS subscription compared with car costs is still unknown to this day, but it is relevant to note that car owners usually do not have the full costs overview in mind when purchasing a vehicle (Turrentine & Kurani, 2007) and often only consider the out-of-pocket costs at the point of travel (Scott & Axhausen, 2006). Consequently, travellers may be less sensitive to the long-term costs of owning vehicles than to the running costs of a MaaS subscription. Car running costs however may be more apparent in cities where, because of tolls and parking costs, owning cars is expensive, like in London for instance (The Economist, 2013). Indeed, 56% of the car-owning respondents in (Kamargianni et al., 2018) acknowledged that their cars are a major household expense. Studies indicate that people would be willing to switch to shared cars if prices and service levels are right for their needs (Haahtela & Viitamo, 2017; Kamargianni et al., 2018).

4.6. The importance of travellers' characteristics

Current travel behaviour

Current travel behaviour and attitudes towards MaaS and travelling generally may be key components for understanding if and how MaaS might change people's travel preferences and behaviour. This is shown by the segmentations done by Strömberg et al. (2018) (see section 4.1). The various segmentations applied in other studies also show that current travel behaviour must be carefully considered; for example, the answers to the attitudinal statements of Kamargianni et al. (2018) reveal the differences between car owners and non-car owners, who consequently might need to be approached differently. Ho et al. (2018) found that very frequent car users (four days per week or more) who took few or no public transport trips were among the least likely to adopt a MaaS bundle, and thus to change their travel behaviour.

Travelling and ICT skills, social inclusion

Research agrees that travellers are in general behaviourally inert (Gardner, 2009; Gärling & Axhausen, 2003). Survey studies on MaaS do not contradict this: travellers often prefer the status quo (Ho et al., 2018; Ratilainen, 2017). The study of Alonso-González et al. (2017) suggests that travelling skills (having experience with various modes, regularly engaging with mobility apps) play a role in MaaS adoption. Since MaaS is to be primarily accessed via apps, ICT skills are also likely to play a crucial role. In that sense, age might be a determinant of MaaS adoption. Studies show that young adults (the upper age limit varies per study, from 34 to 39 years old) are generally more likely to adopt MaaS than

the older generations (Alonso-González et al., 2017; Kamargianni et al., 2018). This raises questions about the access to MaaS. Karlsson et al. (2017) wrote that "voices have been raised regarding the impact of MaaS on social inclusion/exclusion", as concerns exist that MaaS might not be economically feasible for everyone and not accessible for everyone, either for geographical reasons, or because of a lack of ICT skills.

Sociodemographic and socioeconomic status, cultural aspects

Other characteristics are likely to play roles in the adoption of MaaS. Alonso-González et al. (2017) show that highly educated people are more likely to adopt MaaS. Ho et al. (2018) found via their survey that age and number of children in the household may impact MaaS subscription, which was also a main finding of the Haahtela and Viitamo (2017) focus groups. Households with at least two young children were less interested in MaaS, as was also suggested in interviews with UbiGo users (Karlsson et al., 2017).

In addition, Haahtela and Viitamo (2017) found that cultural aspects will also likely play a role in adopting MaaS, particularly with regarding how service-oriented a given culture is. The examples the researchers gave for explaining what a service-oriented culture is included: using car sharing or ride-sourcing services, ordering groceries at home, using the Internet to search for travel information, book and pay for trips.

5. Conclusion and research agenda

MaaS pilot studies provide useful insights into travel behaviour, as they work with actual changes in behaviour rather than hypothetical ones. Yet in order to be able to draw conclusions on travel preferences and travel behaviour with MaaS for a larger share of the population, it is necessary to examine the literature on MaaS outside of these projects. The mix of studies selected in this literature review shows that generally MaaS could provide enough added value to allow certain groups of travellers to consider its adoption. Young to middle-aged people residing in urban areas are likely to be the first group to switch from the more traditional mobility paradigm to MaaS. Nevertheless, we note that:

1) There remains high demand for autonomy, flexibility and reliability, prerequisites for adopting MaaS.
2) The adoption of MaaS is conditioned on how economically feasible it is for households, and whether prices can be justified by sufficient added value. This is especially true if prices are higher than a person's current mobility expenses. Such added value could be provided via attractive service designs and high levels of integration. Moreover, pilots have demonstrated that high levels of integration may allow for shifts from private car use to alternative modes.
3) Current literature only provides very limited quantified indications about who these early adopters are, and no quantification about the extent to which such shifts in travel behaviour could occur. Moreover, place of residence, socioeconomic, sociodemographic, cultural characteristics and skills are likely to play roles in adopting MaaS and subsequently potentially changing travel behaviour.

The extent to which MaaS will be adopted and instigate changes in travel behaviour in the wider population remains uncertain. Research so far shows that MaaS does not always necessarily equate with positive outcomes in terms of environmental and social sustainability. More quantitative research on travel behaviour and preferences is needed to derive measurable impacts (e.g. Vehicle Kilometres Travelled) and make more properly conclusive statements about MaaS's contribution towards achieving sustainability goals.

Three main areas of research are identified. Firstly, as mentioned above, more research about the adoption of MaaS and decisions within MaaS, especially on the quantitative side. It could focus in a first stage on urban areas, where multiple mobility services are already available. However, ultimately, it is crucial for MaaS research to focus also on groups of people who are not necessarily thought of as "early adopters", e.g. older people, as this will allow for the study of impacts on access and social inclusion. Willingness to pay and costs generally will demand special attention, as well as what exactly adds value within MaaS from a user's perspective. Further, current studies about MaaS adoption and travel behaviour usually approach respondents in an individualised manner, yet mobility choices, like car ownership, are likely decisions taken on the household level. Studies focusing on households as the unit of research are desirable.

Secondly, multiple MaaS pilots and initiatives exist, yet few findings are available to the public, partly due to commercial interests. In order to build a solid base of evidence, more MaaS pilots must be undertaken, with a systematic impact assessment available to the public. A tentative effort to build a first impact assessment framework is found in Karlsson et al. (2017).

Thirdly, there are great expectations for shared mobility modes as providers of the requisite flexibility for allowing people to switch from an ownership-based system to an access-based system, but still many doubts about their reliability, impact and synergy. More research on these topics is desired. Arguably, the integration of shared mobility modes and private modes, and public transport and shared mobility modes, is relevant in MaaS, yet research of these topics is still lacking. As for PT, it is often called the backbone of MaaS, but it too seemingly requires further study, using quantitative evidence, to determine if/when such a backbone is (always) the best option.

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