Ministry of Infrastructure
and Water Management

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

Anne Durand, Lucas Harms, Sascha Hoogendoorn-Lanser, Toon Zijlstra

KiM Netherlands Institute for Transport Policy Analysis

Contents

Summary

Mobility-as-a-Service in 2018: high expectations and fragmented insights
Integrated and seamless mobility has been a futuristic vision of mobility (in urban regions mainly) for a few years already. Today, **Mobility-as-a-Service** (MaaS) embodies that vision. It 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 them, customers would purchase mobility service packages tailored to their individual needs, or simply pay per trip. 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, expectations are high. It is frequently mentioned that MaaS will improve the travelling experience, reduce travellers' costs and efficiently manage travel demand while improving environmental and social outcomes. Such frequent claims rely on a scattering of limited yet insightful research findings.

Explorative and systematic literature reviews on MaaS, travel behaviour and preferences
In times when many see in MaaS a tool for instigating more sustainable travel behaviour patterns among the population, it is relevant to establish **what we currently know, based on scientific literature, about MaaS's potential impacts on travel preferences and travel behaviour**. Two complementary pathways are used to reach this goal. First, we conducted an explorative literature review based on relevant research on travel preferences and behaviour *outside of* MaaS. Indeed, there is already a considerable amount of studies that provide relevant insights to understand the potential impact of MaaS on travellers. Second, we conducted a systematic literature review *focused exclusively on* MaaS, travel preferences and travel behaviour. This systematic review provides structured knowledge about the state-of-the-art research on MaaS and travel behaviour and preferences. The main insights gained from these reviews are summarised below.

Uncertainties around changes in travel behaviour
Generally, the reviewed studies show that MaaS has the potential to reach certain travellers, to support decreases in private car use and to instigate different travel patterns among these travellers. However, the **impact magnitude**, the **timeline** and **direction** of these changes remain relatively uncertain and require more quantitative results, whether on the individual level (travel behaviour, travel preferences) or societal level (e.g. social and environmental sustainability). Nevertheless, it is unlikely that a drastic shift from the private car ownership paradigm to the MaaS paradigm will occur within a few years.

Current literature can however inform us about the preconditions for adopting MaaS and for subsequent changes in travel behaviour patterns, while also providing qualitative indications of potential users and impacts.

Preconditions for adoption of MaaS
Studies consistently agree that it is particularly challenging to change travel behaviour when no trigger exists for doing so, especially for habitual trips. This indicates that as a first step MaaS may have more potential for **incidental trips**; however, to allow such trips to occur even incidentally, individuals must actually *start* using MaaS. The adoption of MaaS, conditioning a subsequent potential change in travel behaviour, is likely to require a combination of multiple aspects. First, it is important that **MaaS adds enough value for travellers**. MaaS pilots show that choice freedom, tailor-made offers and increases in travel convenience – notably through high levels of integration – can positively impact MaaS adoption. The need for such "tailor-made all-inclusiveness" is especially valid if the asking price is higher than what travellers are used to. This leads to the second point about **costs:** to provide travellers with a viable, lasting alternative, adopting the service must be economically feasible. In that sense, customising the type of offer to the user will likely play a

key role. Adopting the service must also be **perceived** as economically feasible; for example, the price structure of MaaS could be an obstacle, especially for car owners. Consequently, the latter might need to be introduced to MaaS in a different manner than non-car-owners. Third, it is crucial that **MaaS does not require travellers to compromise (too much)** on their autonomy, flexibility and reliability demands. Being able to combine modes during a trip is deemed a key strength of MaaS. Shared mobility modes in particular (car sharing, bike sharing, individual and collective demand-responsive transport) can provide flexibility and choice freedom in access-based systems such as MaaS, yet their finite and flexible nature raises questions about reliability. Fourth, a particularly crucial point is **a smart design of the MaaS user interface**, rendering it accessible for everyone.

Preconditions for MaaS's potential to challenge travel behaviour patterns
In order to have a chance to instigate new travel behaviour patterns, it is likely that the MaaS user interface (e.g. a smartphone application) needs to include **behavioural change support systems** features. There are four of these: customisation to the user, information and feedback, commitment, and an appealing and simple design. However, these features may not be **sufficient** conditions for influencing travel behaviour. The value-adding aspects of MaaS – more convenience, choice freedom, etc. – can also potentially influence travel behaviour. In essence, such aspects arise from a high degree of mobility integration. MaaS's levels of integration are currently defined as (1) information integration, (2) ticketing and payment integration, (3) service integration, and (4) integration of societal goals. Research reveals that a comprehensive approach combining multiple levels of integration is more likely **to encourage passengers to use the integrated modes** than solely a lower level of integration. Further, mobility packages could be used to influence travel behaviour patterns. Generally, MaaS studies regard bundles as having the potential to alter the way people perceive travel alternatives rather than physically altering alternatives, thereby **potentially promoting the use more sustainable modes**, and notably shared mobility modes. The latter have proven to be effective for **decreasing car use** and, to a lesser extent, car ownership. Effects on congestion, PT use, cycling and walking vary across modes or lack quantified analysis.

Potential MaaS users
Generally, young to middle-aged people residing in urban areas are likely to be the first group to switch to MaaS from a more traditional mobility paradigm. Current literature only provides **very limited quantified indications** about who these travellers are, and no quantification about the extent to which such shifts in travel behaviour could occur. The extent to which MaaS will be adopted and instigate changes in travel behaviour among the wider population remains uncertain. Skills, values (like a low sense of ownership), age and place of residence, and other socioeconomic, sociodemographic and cultural characteristics are likely to play roles in the adoption of MaaS and potential subsequent changes in travel behaviour.

Impacts of MaaS
This study names a few impacts that MaaS could have. In particular, we note that the question of who MaaS will reach raises questions that only a few studies have addressed: namely, MaaS's impact on (perceived) **access to transport** and **social inclusion**. In addition to this, MaaS could impact a wide range of dimensions through the changes in travel behaviour it could trigger, including **environmental sustainability** (e.g. air pollution, noise pollution) and **the transport system** generally (e.g. capacity optimisation, passenger demand). However, at such a preliminary stage in this new type of paradigm, only rough qualitative indications about the types of impacts exist, and the extent and direction of such impacts remain uncertain. Perhaps one of the most illustrative examples of this uncertainty is MaaS's impact on sustainability via car use: while MaaS's access-based paradigm may compel decreases in private car use, it may also provide access to motorised vehicles to people who previously did not have such access.

Research agenda
Three main areas of research were identified. Firstly, more research about the adoption of MaaS and decisions within MaaS, especially on the quantitative side, is needed in order to be able to make more conclusive statements about MaaS adoption and travel behaviour changes. Secondly, in order to build a solid base of evidence, more MaaS pilots with a systematic impact assessment available to the general public must be undertaken. 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.

1 Introduction

Integrated and seamless mobility has been a futuristic vision of mobility (in urban regions mainly) for a few years now (Loose, 2010; Motta et al., 2013; Preston, 2012; Schade et al., 2014). Today, Mobility-as-a-Service (MaaS)[1] 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[2] tailored to their individual needs, or simply pay per trip for customised travel options.

1.1 Problem statement

Although MaaS is a relatively new concept, many studies, technical reports, opinion pieces and business cases related to MaaS have appeared over the past couple of years. Indeed, numerous promises and challenges emerge with the concept. According to Matyas and Kamargianni (2017), MaaS, when carefully designed, promises to be inclusive of all population groups in society and be an efficient travel demand management tool for assisting the shift towards more sustainable travel. The design question is therefore important (Karlsson et al., 2016) and intrinsically linked to potential MaaS users. In fact, MaaS is described in literature as a user-centric paradigm (Giesecke et al., 2016; Jittrapirom et al., 2017).

Scientific literature pertaining to MaaS is growing fast. According to G. Smith et al. (2018), “the term has rapidly gone from nowhere to nearly everywhere in the personal transport sector” since 2014. In June 2017, Utriainen and Pöllänen (2017) searched “Mobility as a Service” in a large scientific database (Scopus) and found 37 peer-reviewed journal and conference papers mentioning the term in either their titles, abstracts or keywords. By June 2018 this number had more than doubled to 76 citations. Nonetheless, much of this available literature focuses on 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, as already emphasised by Matyas and Kamargianni (2017). Although multiple pilots and schemes have been initiated around the world in recent years (see section 2.4), empirical knowledge of MaaS’s expected impacts on people’s travel preferences and travel behaviour remains limited, as highlighted by Ho et al. (2017). Consequently, the frequent claims about the positive contributions MaaS will make towards achieving sustainability goals rely on a scattering of limited yet insightful research findings.

1.2 Goal, research question and relevance of the study

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 therefore to provide a better understanding of the ways in which MaaS might impact people’s travel preferences and travel behaviour. 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?

[1] Also called Transportation-as-a-Service (TaaS) in the United States (Wong, 2017).
[2] “Bundle” and “package” will be used interchangeably in this study; for a definition, see section 2.1.

Reviewing the potential impacts of MaaS on travel preferences and behaviour is relevant from the 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, the 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.

1.3 Approach

We use a two-step approach to reach our objective. First, we provide an explorative literature review on research topics not directly focused on MaaS, but which are particularly relevant for MaaS. Second, we conduct a systematic literature review of studies focused on MaaS and travel behaviour.

1.3.1 Explorative literature review of MaaS-related topics

The core characteristics of MaaS, as defined by Jittrapirom et al. (2017), have already benefitted from research examining the impacts on travel preferences and travel behaviour. Although not directly focused on MaaS, such research is undeniably relevant to better understand the potential impact of Mobility-as-a-Service on travel behaviour and preferences. These nine core characteristics (presented in no particular hierarchical order) are:

1. The integration of transport modes, including shared mobility modes[3] (see definition in section 2.3) and more traditional modes,
2. The tariff option (i.e. pay-as-you-go and mobility packages),
3. A single platform, where users can plan, book, pay and get tickets for their trips,
4. Multiple actors (customers, providers, platform owners, authorities, etc.),
5. The use of technologies (smartphones, Internet networks, ICT, etc.),
6. Demand orientation,
7. Registration requirement, to facilitate the use of the service and allow for customisation,
8. Personalisation to the needs of the user,
9. Customisation, enabling the user to modify the offered option based on their preferences.

How might each of these core characteristics influence travel behaviour and travel preferences? The characteristics can be translated into relevant research themes pertaining to travel preferences and travel behaviour. Based on the list of Jittrapirom et al. (2017), we selected three relevant research themes relating to MaaS and travel preferences/behaviour; Appendix A details the complete selection procedure. The three chosen research themes are:

- Mobility integration, travel behaviour and travel preferences,
- ICT, particularly smartphone applications, and travel behaviour,
- Shared mobility modes, travel behaviour and travel preferences

After providing background information on travel behaviour inertia, we successively explore these themes with literature that does necessarily pertain to MaaS yet is highly pertinent for MaaS. This literature review is meant to be explorative, meaning that, in order to keep our research efforts manageable, no systematic paper selection criteria will be applied.

[3] Following the terminology defined in Shaheen et al. (2015), modes like bike sharing, car sharing and on-demand modes are grouped under the term of shared mobility modes.

1.3.2 Systematic literature review of MaaS and travel behaviour

At the time of writing, early 2018, there is a growing body of relevant studies on Mobility-as-a-Service and travel behaviour and preferences (notions of travel preferences and behaviour, and especially their connections, are defined in section 1.4.1). We conduct a systematic literature review on Mobility-as-a-Service and travel preferences and behaviour. The selection procedure is described in Appendix B. In the final selection, we retain 14 papers and cluster them into two groups.

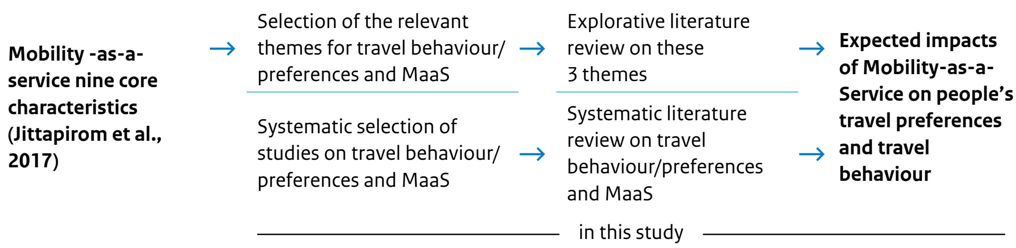
- First, there are studies based on MaaS pilots: UbiGo (Karlsson et al. (2016); Sochor et al. (2015); Sochor et al. (2016); Strömberg et al. (2016); Strömberg et al. (2018); and Smile (Smile mobility, 2015)). The study of Karlsson et al. (2017) was also selected, as it provided in-depth analysis of both pilots.
- Second, there are studies that investigated the prospects for people to adopt MaaS and/or travellers' decisions in MaaS through surveys and interviews (Alonso-González et al. (2017); Ho et al. (2017); Haahtela and Viitamo (2017); Kamargianni et al. (2018); Matyas and Kamargianni (2018); Ratilainen (2017); G. Smith et al. (2018)).

This systematic review allows us to devise a list of aspects that play or could play a role in the adoption of MaaS and/or in changes in travel behaviour.

1.3.3 Schematic overview

The results from the explorative literature review will be used to give context to the findings of the systematic literature review. This approach is depicted in Figure 1.

Figure 1 The study's two-step approach.



1.4 Definitions and scope

Below we provide definitions for a few key terms that are used frequently and define the scope of our research.

1.4.1 Travel behaviour, travel preferences and their connection

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. In this sense, travel behaviour is usually more constrained than travel preferences (Kattiyapornpong & Miller, 2007). Intuitively, travel preferences can be understood as somehow influencing travel behaviour. More formally, Chowdhury (2014) showed how the preferences of public transport users influenced their travel behaviour through control beliefs[4], under the constraints of resources (e.g. time, money, skills). Although we acknowledge that the preferences–behaviour relationship is not unidirectional, i.e. behaviour can also potentially influence preferences (Kroesen et al., 2017) through exposure (Serenko & Bontis, 2011), this connection remains outside the scope of our study.

[4] Personal control beliefs reflect the beliefs of an individual regarding the extent to which they are able to influence or control outcomes.

1.4.2 The sharing economy and consumer-to-consumer initiatives

The rise of MaaS is often associated with the emergence of the sharing economy, at least outside academia. However, the sharing economy has a contested definition (Acquier et al., 2017): while some argue that it only includes consumer-to-consumer (C2C) interactions (Frenken & Schor, 2017), others accept a broader definition, including business-to-customer initiatives (Stephany, 2015) or both for-profit and non-profit dimensions (Muñoz & Cohen, 2017). All definitions contain C2C initiatives, like carpooling or hitchhiking, which have been associated with the sharing economy for more than a decade now (Benkler, 2004). Although Holmberg et al. (2016) incorporate peer-to-peer services in their definition of MaaS, there is, to the best of our knowledge, no MaaS scheme where consumer-to-consumer initiatives are included, nor empirical studies where such initiatives are considered (yet). To avoid any ambiguity, we leave the notion of the sharing economy, and in particular C2C initiatives, outside the scope of our study. Note however that we do not imply that MaaS and consumer-to-consumer initiatives are incompatible.

1.4.3 Scope

We restrict our research scope to Mobility-as-a-Service and impacts on potential users (preferences, behaviour). 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, see Hensher (2018) (MaaS and road congestion), Hensher (2017) (MaaS and bus contracts), Rantasila (2015) (MaaS and land use). Similarly, considerations on sustainability[5] will not be thoroughly addressed; see Giesecke et al. (2016) and Akyelken et al. (2018). We exclude from our scope considerations on business models (see Aapaoja et al. (2017) and Sarasini et al. (2017)), institutional conditions (see Mukhtar-Landgren et al. (2016)), information services, car market perspectives, freight, and mathematical modelling. Modes such as Hyperloop or drones are excluded from the scope of this study, as are Autonomous Vehicles (AVs), because MaaS must also be considered in the absence of AVs (Hensher, 2018); see Kamargianni et al. (2018) for MaaS scenarios for the AV era.

1.5 Structure of the report

Our report is divided in five sections. This section – Section 1 – is the introduction. Section 2 provides a definition of MaaS. Sections 3 and 4 follow the approach described in Figure 1, first with the explorative literature review and second with the systematic literature review. Section 5 is the conclusion, summarising the main findings and providing recommendations for future research directions for MaaS and travel behaviour and preferences.

[5] Definitions of sustainability vary in literature. It is usually considered as encompassing social, economic and environmental dimensions. Note though that in transport studies, sustainability is often considered from the environmental perspective only, i.e. minimising car travel or the emission of air pollutants. Unsustainable transport is generally equated with car use (Sunio & Schmöcker, 2017).

2 Defining MaaS

Multiple MaaS initiatives have emerged around the world in recent years since the early description by Hietanen (2014): MaaS is “a mobility distribution model in which a customer’s major transportation needs are met over one interface and are offered by a service provider”. As presented in section 1.3.1, Jittrapirom et al. (2017) defined nine core characteristics of MaaS, providing insights into MaaS’s components. However, according to Sochor et al. (2017), the lack of characterisation of MaaS embracing its complexity – and notably the connection between all components – can render governing the transition towards a MaaS-based transport system challenging. In this section we begin by introducing the notion of integration for defining MaaS. Based on this, we present the topology defined by Sochor et al. (2017) to describe MaaS. Next, a definition of shared mobility modes is provided, followed by a presentation of MaaS schemes.

2.1 MaaS and forms of integration

Mobility-as-a-Service is frequently described in terms of integration (Hietanen (2014), Kamargianni et al. (2015), Kamargianni et al. (2016), König et al. (2016), Sochor et al. (2017), and Jittrapirom et al. (2017)). In fact, as explained in section 1.3.1, we will use literature on mobility integration in section 3.2 to explore the potential impacts of MaaS on travel behaviour. For now, we simply note that according to two MaaS literature reviews, MaaS can comprise the following types of integration: payment, ticketing, bundles, information and service [6] (Kamargianni et al., 2016; Sochor et al., 2017). Payment and ticketing integration are briefly described in section 2.4 and further defined in section 3.2, along with information and service integration. What is new compared to the traditional concept of mobility integration is bundle integration.

What is a bundle? When a user buys a mobility package or bundle in the context of MaaS, they pre-purchase predefined sets of credits on a fixed basis for a combination of modes. These credits could be in time, distance or money units, with pre-determined service level agreements. Packages would have a fixed price, and they could also include extra services such as grocery delivery, the guarantee of a stable Internet connection and silent spaces in public transport, free snacks, etc. (Hietanen, 2014).

2.2 A topology for MaaS and “MaaS schemes”

Sochor et al. (2017) proposed a topology of MaaS, as shown in Figure 2, which they argue can facilitate discussions about MaaS, notably “comparisons of” different schemes, as well as understanding the potential effects of MaaS. This topology can recall traditional definitions of mobility integration (see section 3.2.1). We will use this scale in the remainder of this study. Note that a similar topology was applied in the White Paper for the Dutch Ministry of Infrastructure and Water Management (MuConsult, 2017). The levels in Figure 2 are not necessarily dependent on each other, as UbiGo reached Level 3 without fully completing Level 1, for example. Additionally, some issues of interpretation can always arise, and some schemes may only achieve partial integration of a given level. In Figure 2, societal goals refer to the integration of wider goals such as congestion mitigation and urban planning (see section 3.2 on mobility integration).

[6] Information and service integration are also sometimes referred to as ICT and organisational integration in literature.

Nowadays many mobility initiatives are labelled as MaaS, yet such initiatives only provide travel information and no option to book or pay for any ticket: this is Level 1 of integration. In the remainder of this study we use the term “MaaS schemes” to denote initiatives that reached at least Level 2 of the typology in Figure 2. In such initiatives, users can at least book their tickets or pay for them via a single platform, where information is most of the time also provided. Multiple initiatives at this stage are frequently mentioned by the scientific community as MaaS initiatives (see Kamargianni et al. (2016), König et al. (2016) and Sochor et al. (2017), amongst others). Note that this distinction is meant to help keep our research efforts manageable and focused on initiatives with more advanced levels of integration.

Figure 2 Proposed topology of Mobility-as-a-Service including levels (left) and examples (right) (from Sochor et al. (2017)).

4	**Integration of societal goals** Policies, incentives, etc.	
3	**Integration of the service offer** Bundling/subscription, contracts, etc.	UbiGo whim
2	**Integration of booking & payments** Single trip – find, book and pay	GVH Hannovermobil smile simply mobile moovit
1	**Integration of information** Multimodal travel planner, price information	Qixxit Google Transport for London lyft
0	**No integration**	Hertz sunfleet

Before presenting MaaS schemes and classifying them according to the typology presented in Figure 2, we provide a definition of shared mobility modes, as these are often present in MaaS schemes.

2.3 Shared mobility modes

Bike and car sharing are often included within MaaS schemes (see section 2.4). **Bike sharing systems** allow users to pay to borrow shared bicycles for a short term from an unattended bike sharing station and then return them to another bike sharing station. Lately, free-floating (or one-way) bike sharing systems have appeared, whereby users can pick up and drop off borrowed bikes at locations of their choice; however, a (paying or free) subscription is often needed to access the system. Examples of bike sharing include the PT-bike (in the Netherlands), Citi Bikes (New York), Santander Cycles (London), and free-floating bikes, such as Flickbike, Gobike, oBike and Mobike. **Car sharing** works similarly: once subscribed to a service, people may borrow cars on a short-term basis (ranging from a few minutes to a few days). There is a difference between one-way shared cars and return-to-base shared cars (i.e. round trip). Examples of car sharing include Greenwheels (in the Netherlands), car2go (26 cities in the world), Zipcar and GoGet (Australia), and cambio CarSharing (Germany and Belgium). Demand-responsive forms of transport are sometimes offered within MaaS schemes or will soon be (see section 2.4); they exist mainly in two forms. First, **collective demand-responsive transport** (often abbreviated as DRT) services are door-to-door or stop-to-stop services that provide casual, on-demand transport. They can also be called flexible micro transport services (FMTS) or microtransit, as they are seen as flexible on-demand public transport services, i.e. public transport services that do not operate according to a schedule. Examples of DRT systems in the Netherlands include the Opstapper, Buurtbus, and Brengflex. ViaVan in Amsterdam is fully commercial, as are Lyft Line in the USA, Citymapper Smart Ride in London, and UberPOOL in multiple countries. Second, there is individual demand-responsive transport, frequently called ride hailing or **ride-sourcing**[7]. Companies offering such services are often referred to as Transportation Network Companies (TNC's). Ride-sourcing matches supply and demand by allowing travellers to use a smartphone application to request individual car rides in real-time from potential suppliers. Examples of ride-sourcing services include Uber, Lyft and Didi Chuxing. Ride-sourcing is not yet integrated in any MaaS scheme, although there are signs of initiatives in this direction (e.g. MaaS Alliance (2017)).

2.4 Presentation of MaaS schemes

Multiple schemes have reached Level 2, although ticketing and payment are not necessarily integrated yet. Payment integration only means that while a well-developed integrated platform may be available, the associated journey planner does not display combinations of options, such as car sharing + train, for example. Tickets must be booked and paid for separately, which for example is the case for moovel in Germany, myCicero in Italy, Tuup in Finland, NaviGoGo in Scotland and iDPASS in France. Ticketing integration only means that separate fees must be paid to the various services, although the traveller has a single ticket (e.g. smart card) for accessing all the various services. Often, partial payment integration is provided through subscriptions and pay-per-use systems, as is the case for Hannovermobil in Germany, and EMMA in France.

B2B (Business to Business) is one of the earliest examples of a full Level 2 integration scheme: originating in the Netherlands, employers provide employees with customisable business cards offering access to public transport (PT) in the country, bike sharing and sometimes additional services. However, this scheme provides only partial Level 1 integration, as no dedicated trip planner is yet available.

The Austrian pilot project Smile is a well-known MaaS scheme with Level 2 integration. This scheme not only served as an example of cooperation between (large) transport providers, but also between other parties, such as software engineers and environmental protection groups. The Smile app provided multimodal routing (capable of combining private vehicles, PT and shared mobility modes within the same trip), integrated payment and ticketing. As a follow-up to Smile, an improved trip planner was developed (Beam-Beta), and together they gave birth to the WienMobil Lab app, operational since 2017.

To date three Level 3 schemes have been designed. The first, SHIFT, developed in Los Angeles (USA), was never operational: it would have integrated a variety of services, including bike sharing, car sharing, taxi, DRT, and a valet service, and was unique in that it would have owned the bus, car and bike fleets. The second scheme, UbiGo, was a Swedish pilot in which households chose prepaid bundles based on their own needs; they would therefore plan their trips while taking into account the chosen bundle. When the subscription ran out, because for instance someone had used all the available car rental days, it was still possible to make trips using all modes, but they would be billed for them afterwards. A relaunch in Stockholm is planned in 2018 (UbiGo, 2017). The third and final scheme is Whim, a Finnish MaaS initiative, which has been operational since 2016. At the time of writing, users can choose between two types of bundles, in addition to pay-as-you-go: "Whim Urban", costing €49 per month and offering unlimited urban public transport use and discounted taxi prices, and "Whim Unlimited", costing €499 per month and presenting itself as a "*Modern alternative for owning a car. At the price of owning a car you get unlimited access to public transport, taxi or a* [shared] *car according to your daily need.*" (MaaS Global, 2018).

Table 1 summarises MaaS initiatives around the world and the type of integration. Note that this overview is not comprehensive, and that many initiatives are currently being developed or are deemed highly likely to emerge in the coming years in Asia and Oceania (ARK Invest, 2017; L.E.K., n.d.; MaaS Global, 2016).

[7] This mode of transport is also sometimes called ride sharing, but this is inaccurate (Frenken & Schor, 2017).

Table 1 Overview of MaaS initiatives and description of the type of mobility integration.

Name of the initiative	Place	Status	Modes	Type of mobility integration
moovel	Hamburg and Stuttgart, Germany	Operational (2015-)	Car sharing, taxi, urban PT, regional PT.	Level 2 (partial, payment integration).
myCicero	Italy	Operational (2015-)	Urban PT, regional PT, international PT, parking, permit for urban congestion charging zones.	Level 2 (partial, payment integration).
NaviGoGo	Dundee and North East Fife region, Scotland, UK	Operational (2017-)	Car sharing, taxi, urban PT, regional PT.	Level 2 (partial, payment integration).
iDPASS	France	Operational (2017-)	Car renting, taxi, valet parking.	Level 2 (partial, payment integration).
Tuup	Turku region, Finland	Operational (2016-)	Car sharing, bike sharing, taxi, urban PT, DRT.	Level 2 (partial, payment integration, ticketing integration to come in 2018).
Hannovermobil	Hannover, Germany	Operational (2014-)	Car sharing, taxi, urban PT, regional PT.	Level 2.
EMMA (TaM)	Montpellier, France	Operational (2014-)	Bike sharing, car sharing, urban PT, parking.	Level 2.
Business travellers cards: NS Business Card, MobilityMixx, Radiuz Total Mobility, etc.	The Netherlands	Operational (national coverage of these cards since 2013)	(Car sharing, parking, tank filling, electric car loading, taxi, car rental), bike sharing, urban PT, regional PT.	Level 2 (Business to Business), partial Level 1.
Smile	Vienna, Austria	Pilot (2014-2015)	Bike sharing, car sharing, taxi, urban PT, regional PT, parking.	Level 2.
WienMobil Lab	Vienna, Austria	Operational (2017-)	Bike sharing, car sharing, taxi, urban PT, parking.	Level 2.
SHIFT	Las Vegas, USA	Planned (2013-2015)	Bike sharing, car sharing, taxi, collective DRT, valet parking.	Level 3.
UbiGo	Gothenburg, Sweden	Pilot (2013-2014), version 2.0 in preparation	Bike sharing, car sharing, car renting, taxi, urban PT.	Level 3.
Whim	Helsinki, Finland	Operational (2016-)	Bike sharing (car sharing to come), car renting, taxi, urban PT, regional PT.	Level 3.

These schemes are not necessarily developed and driven by the same types of stakeholders. For example, moovel was initiated and is fully owned by an industrial group, Daimler AG (Daimler AG, n.d.). Smile was initiated by the infrastructure manager of the city of Vienna and was essentially a collaboration between Vienna's PT provider and Austria's train operator (Smile mobility, 2015). NaviGoGo emerged as part of a project that included Scottish governmental entities, ICT and mobility companies, and transport operators (Pick&Mix, 2017). The influence of the types of stakeholders on the success of MaaS is still unclear though. More research is needed in this area, but this is beyond the scope of our study.

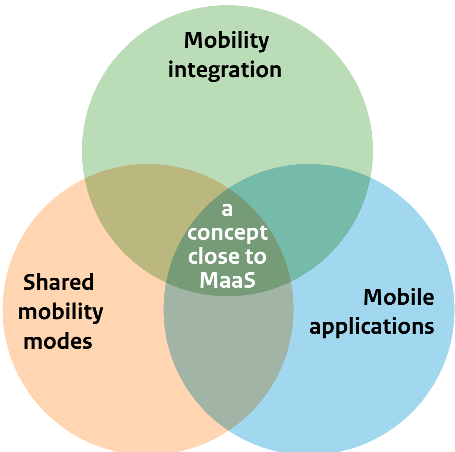
3 Lessons learnt on influencing travel preferences and behaviour

In this explorative literature review we examine how MaaS might change travel preferences and behaviour, according to pertinent research into travel preferences and travel behaviour conducted outside of MaaS. Based on Jittrapirom et al. (2017), three relevant themes were selected (see section 1.3.1 or, for more details, Appendix A) and will be discussed in successive sections:

- Mobility integration, travel behaviour and preferences,
- ICT, particularly smartphone applications, and travel behaviour,
- Shared mobility modes, travel behaviour and preferences.

As these three themes are based on the core characteristics of MaaS as defined by Jittrapirom et al. (2017), a concept close to MaaS arguably lies at their intersection, as depicted in Figure 3. Further, the overlaps that exist between these themes will also be explored in this section.

Figure 3 The three themes discussed in this explorative literature review and their intersections.



Before delving into the literature pertaining to these themes, we first provide background information on travel behaviour inertia and owning versus using. Each section ends with a reflection on the impacts for Mobility-as-a-Service.

3.1 The challenge of changing travel behaviour

This section describes why changing travel behaviour is challenging. Opportunities to challenge travel behaviour are also highlighted.

3.1.1 Travel behaviour inertia

It has commonly been noted that travel behaviour tends to repeat itself not only on a daily basis, but also on a weekly and perhaps even yearly basis (Pendyala et al., 2001). A stream of studies based on motivational models (see Theory of Planned Behaviour by Ajzen (1991)) suggests that travellers' behaviour is the result of a deliberation process (Bamberg et al., 2003; Bamberg & Schmidt, 2003), yet such models neglect the repetitive nature of travel behaviour decisions (Gardner, 2009), which led to another stream of studies arguing that habits dominate behavioural outcomes in stable contexts (Aarts et al., 1998; Gardner, 2009; Gärling & Axhausen, 2003; Gärling et al., 2001; Verplanken et al., 1997). The habit approach implies that there is little to no deliberation in the travel behaviour. In such cases, appeals to reason are ineffective (Gärling & Axhausen, 2003). Chorus and Dellaert (2012) found that even travellers who actively consider alternative travel options for each trip exhibit travel inertia if they dislike risk and if the quality of the travel alternatives is only revealed upon use. According to Bovy and Stern (1990), inertia is characterised by "certain thresholds that need to be crossed before changing routine behaviour" (p. 32), "factors [...] which encourage keeping the status quo and oppose behavioural change" (p. 110). Van Exel and Rietveld (2009) showed that car drivers in Amsterdam substantially overestimate public transport travel time. However, informing such travellers of the travel time they can gain when using public transport may not convince them to switch modes. Indeed, they might find justifications for their existing behaviour (Tertoolen et al., 1998). Travel decisions are not necessarily rational anyway: symbolic and affective factors (Steg, 2005) and emotions (De Vos & Witlox, 2017; KiM, 2017) also play roles in travel behaviour, even more so than instrumental factors in some instances (e.g. leisure trips; see Anable and Gatersleben (2005)). Note that research has shown that a mode shift behaviour is more likely for leisure trips than work trips (Vedagiri & Arasan, 2009).

3.1.2 Questioning ownership?

Mobility in the 20th century was characterised by the arrival and reign of the car (Goodall et al., 2017). In the Netherlands, the car scores particularly well on independence and flexibility, aspects in which public transport often lags behind (KiM, 2017). This is also true elsewhere in Europe (Woods & Masthoff, 2017). Research shows that relinquishing one's car can be difficult, because people are often attached to their own cars (Paundra et al., 2017; Steg, 2005), regarding them as "a place for me-time" and to "zone out" (Kent, 2015). Laakso (2017) gave free bus passes to people who had relinquished their cars in a small city in Finland: the study's participants reported that they needed to plan more in advance than previously or restructure routines (e.g. grocery shopping, dropping off children). But more than functional considerations, emotions and feelings played a crucial role in building a new routine. Freudendal-Pedersen (2009) states that cars are widely perceived as the only transport mode that gives people the autonomy and flexibility required to live a modern life. Here, autonomy means being independent from others and having control over one's way of moving. Flexibility means being able to adapt to one's varying needs independent from time and space constraints.

Concurrently, more and more people acknowledge that cars negatively impact sustainability (Banister, 2008). Arbib and Seba (2017) predict the end of individual car ownership. However, Banister (2008) argues that this could prove difficult to achieve and might potentially contravene notions of freedom and choice. Additionally, Spickermann et al. (2014) stress that while the emotional attachment to cars is likely to dissolve among a large portion of the population in future, older generations may find it more difficult to relinquish the traditional ownership model and generally may be more hesitant to embrace innovative services.

A trend running in parallel is the growing demand for non-ownership services (Moeller & Wittkowski, 2010), also called access-based consumption (Bardhi & Eckhardt, 2012). In this perspective, and also due to the single platform concept, MaaS is often associated with Spotify (The Economist, 2016) and Netflix (König et al., 2017). According to Bardhi and Eckhardt (2012), access-based consumption is gaining value because it "enables consumers' freedom of lifestyles and flexible identity projects". Moeller and Wittkowski (2010) found that the demand for non-ownership of service is positively influenced by "trend orientation" and "convenience orientation" factors. However, it is negatively influenced by the "possession importance" factor.

3.1.3 Windows of opportunity

Relatively recently the focus in research on travel behaviour change has shifted towards key or life events that trigger changes in travel behaviour (Lanzendorf, 2003). Such events are "windows of opportunity" (Schäfer et al., 2012) allowing for de-routinisation, i.e. when individuals are able to examine the routine nature of their own behaviour (Spaargaren, 1997). Studies have shown that individuals are indeed more susceptible to interventions when a major change to the infrastructure of their neighbourhoods had occurred, when they had recently relocated residence or workplace (Thøgersen, 2012; Verplanken & Roy, 2016), upon the birth of a child (Berveling et al., 2017) or upon selling one's car (Laakso, 2017). Note that studies on windows of opportunity all focus on the impact that a certain key event had on car ownership or car use, and the subsequent consequences for active modes and public transport use. According to Redman et al. (2013), tactics to entice car users to PT, coupled with interruptions in habitual behaviour, can successfully instigate mode change, as long as PT services have attributes that are perceived to be at least equally as appealing as travel by car.

3.1.4 What does this mean for Mobility-as-a-Service?

Experts believe that on the individual level, MaaS's greatest impact will be on the use of private cars (Karlsson et al., 2017), in line with attention to lifestyles and mobility without owning a car. Moreover, many see in MaaS a tool for instigating more sustainable travel behaviour patterns among the population, and in particular for breaking private car dependence (Jittrapirom et al., 2017). Nevertheless, the literature highlights complex psychological processes behind travel behaviour and a dominance of travel behaviour inertia. The latter is relatively common among travellers, especially for work-related trips and habitual trips, yet recent research suggests windows of opportunity exist during which people are more likely to challenge their travel habits, although not all windows of opportunities may provide equal opportunities for adopting MaaS. Consequently, despite travel behaviour inertia, MaaS implemented with the goal of reducing dependence on private cars might have potential.

3.2 Mobility integration, travel behaviour and preferences

In this section, we first define mobility integration and then present impacts on travel behaviour and travel preferences. The last section highlights implications for MaaS.

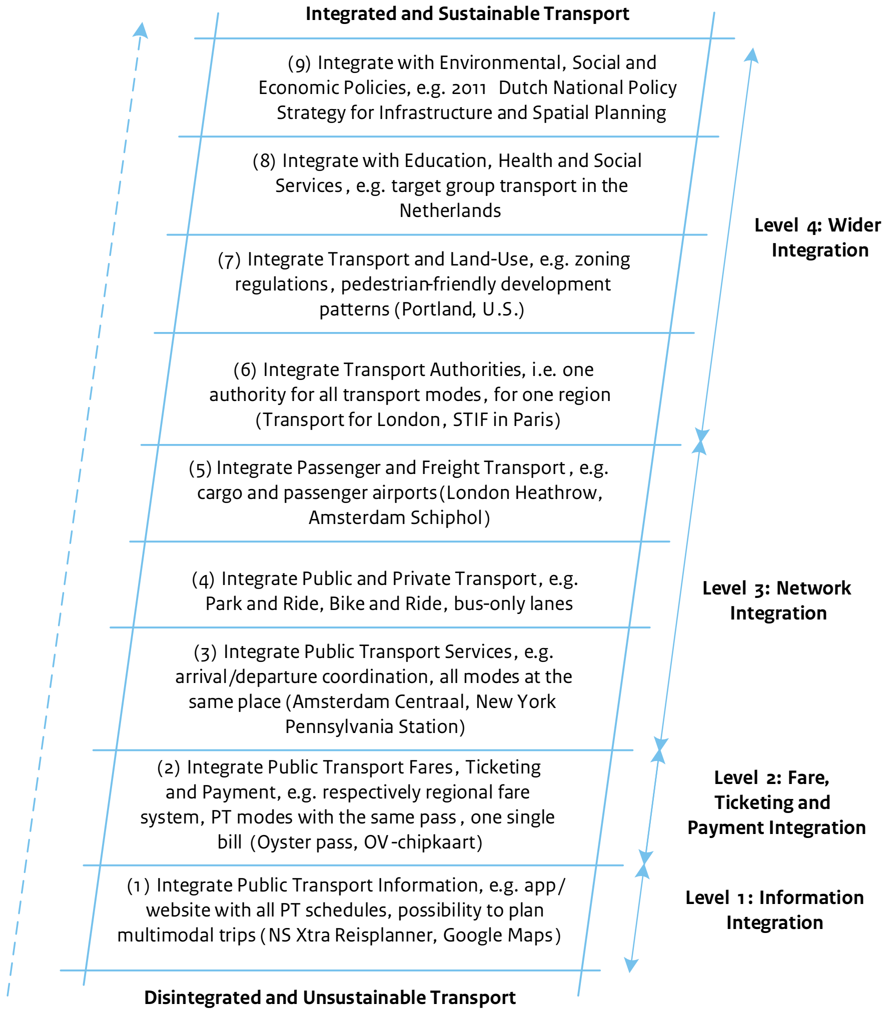
3.2.1 Definition of mobility integration, as traditionally understood

Mobility or transport[8] integration is not new. Despite the lack of a clear definition of this notion (Preston, 2010), it has been a focal point and guiding principle for the development of several transport policies in numerous countries (Potter & Skinner, 2000), focusing on public transport integration and PT/private

[8] Most studies defining integration in transport research refer to *transport* integration, yet studies on MaaS use mobility integration (see Kamargianni et al. (2016) and E. Lund (2016)). This is probably due to the direct connection with "Mobility-as-a-Service", and the fact that mobility is nowadays used with the broad meaning of "the ability to move freely or be easily moved" (Cambridge Dictionary, n.d.). Meanwhile, "transport" has become more of a word of reference in everyday language for "motorised mobility", as reflected by the definition provided by the Cambridge Dictionary (n.d.): "a system of vehicles, such as buses, trains, aircraft, etc. for getting from one place to another". According to Sochor et al. (2017), offering mobility rather than transport is central in MaaS. Therefore, we will continue using the term *mobility* integration in this study, but use *transport* integration when referring to studies using this term.

modes integration. NEA and partners (2003) distinguish between information integration, fare and ticket integration, network integration and wider integration. In an attempt to describe the concept in its full complexity, Potter and Skinner (2000) used a scale, and Hull (2005) used rungs of an integration ladder; this latter description was then re-used and adapted by Preston (2010). We re-adapted this integration ladder based on Preston (2010), Hull (2005), and NEA and partners (2003), as shown in Figure 4. The integration ladder is organised in approximate ascending order of organisational difficulty; it is not necessary to have fully completed one rung in order to access the following one. Note that sustainability is often agreed to be the highest rung of the integration ladder (George, 2001; Potter & Skinner, 2000; Preston, 2010). Commonly cited objectives for transport integration are the efficient use of resources, improved accessibility, environmental protection, and increased safety (Preston, 2010). According to Potter and Skinner (2000), 'lower' understandings of integration are unable to deliver complete solutions to challenges of a high order of magnitude; only a comprehensive approach stands a chance of successfully tackling such challenges.

Figure 4 The integration ladder and its rungs; corresponding mobility integration levels (adapted from Preston (2010), Hull (2005), and NEA and partners (2003)).



3.2.2 Mobility integration, travel behaviour and preferences

Research suggests that a higher level of integration in transport is more appealing to travellers than lower levels. We use the 4-Level description of NEA and partners (2003) to describe the effects of mobility integration on travel preferences and travel behaviour.

Level 1. At present, PT information is frequently sought for routine trips and non-routine trips, and there is growing demand for information beyond just arrival and departure times, such as crowding levels and disruptions (Chorus et al., 2006; Matsumoto & Hidaka, 2015). By displaying multiple options in real-time, such information systems (or ATISs, Advanced Traveller Information Systems) have the potential to make users rethink their travel habits (Chorus et al., 2006; Kenyon & Lyons, 2003; Tang & Thakuriah, 2011) and to allow for reductions in actual and perceived waiting times (Watkins et al., 2011). Recent studies using rigorous statistical analyses show that improved information can lead to increases in patronage (Brakewood et al., 2015; Tang & Thakuriah, 2012). However, Pronello et al. (2017), and Skoglund and Karlsson (2012), found that improved travel information does not necessarily significantly promote changes in travel behaviour away from the use of private cars, even when the trip planner can display time savings with PT compared to private cars (Skoglund & Karlsson, 2012). ATISs may add enough value to compel more frequent use of public transport, but not enough to lead to a significant decrease in car use, unless there is an explicit intention to do so (Pronello et al., 2017; Skoglund & Karlsson, 2012) (see section 3.1.1 on travel behaviour inertia and section 3.3 on apps and travel behaviour). Note that literature reviews reveal a generally low willingness to pay for information provided via information systems, especially for PT information (Chorus et al., 2006; Pronello et al., 2017). There are currently plenty of systems providing information for free, but people may be willing to pay if the system is perceived to add sufficient value and functions faultlessly (Pronello et al., 2017; Zografos et al., 2012). Today however most travellers view information integration as a basic prerequisite and care more about higher integration levels (Chowdhury et al., 2018).

Level 2. Fare integration is usually achieved via a fare scheme valid in all PT modes, such as a (zonal) flat fare or distance-based fare. Ticket and payment integration can be achieved via a single ticket valid for a journey across multiple modes, and is nowadays frequently achieved via smart card technology. Fare, ticketing and payment integration proved beneficial in terms of PT patronage in multiple European cities, leading to more convenience, more freedom of choice in transport mode, occasional reductions in travel costs, and increases in patronage (Abrate et al., 2009; Blythe & Holm, 2002; NEA and partners, 2003). A recent study also supports the premise that ticketing integration via smart cards can successfully increase the use of the modes accessible via smart cards (AECOM, 2011).

Level 3. Network integration has also delivered positive outcomes in terms of patronage, especially when combined with fare and ticketing integration, as in Madrid (Matas, 2004) or Vienna and Manchester (NEA and partners, 2003). In Vienna, ticketing integration triggered a restructuring of the network, which in turn led to increased patronage and substantial improvements for passengers in terms of travel times. There, only a limited number of passengers saw their amount of transfers increase due to network integration. Indeed, a major drawback of network integration is transferring, and hence potential increases in waiting times (Chowdhury et al., 2018; NEA and partners, 2003). Buehler (2011) explained that the reason why PT patronage, cycling and walking is higher in Germany than in the USA is partly due to the better integration of PT services in Germany.

Level 4. In terms of wider integration, the integration of land-use, transport and environmental policy has garnered attention in recent decades (Candel, 2017; Geerlings & Stead, 2003; Newman & Kenworthy, 1996). A few studies mentioning impacts on travellers can be mentioned here. A study in Japan demonstrated that integrated land-use and transport strategies led to CO_2 reduction and user benefits (in terms of generalised travel costs) (Doi & Kii, 2012). Transit-oriented development has been shown to promote public transport use (H. Lund, 2006), as well as cycling and walking, thereby promoting physical activity (Langlois et al., 2016). Although policies integrating transport and land-use/environmental/ social aspects are often part of regional or national strategies and visions (see examples in rungs 8 and 9 of Figure 4), implementation remains difficult, and impact assessments of such integration on travellers remain limited (Candel, 2017; Preston, 2010).

3.2.3 What does this mean for MaaS?

Attractiveness for potential users. Research on mobility integration has primarily focused on PT integration and PT/private modes integration. Studies show that a higher level of integration is more appealing to travellers than lower levels. There are numerous benefits of integration from the traveller's side: a higher level of convenience, more freedom of mode choice, and potentially cheaper and shorter journeys. Since mobility integration is a key aspect of MaaS, and since MaaS is also defined with an integration ladder (see section 2.2), we can assume that MaaS initiatives with high integration levels are likely to be more attractive to users than initiatives with lower integration levels, as Kamargianni et al. (2016) already highlighted. Nevertheless, we note that mobility integration evolved over the span of multiple decades, hinting at long development and implementation times, probably owing to the diversity of actors involved. Technology may shorten these time periods, but high integration levels as standards within MaaS might not occur in the short term.

Mobility integration and shared mobility modes. Experts deem the combining of various modes of transport as MaaS's most relevant impact on individuals (Karlsson et al., 2017). These various modes include shared mobility modes. Initial signs of integration between shared mobility modes and PT have emerged. Payment and ticketing integration exists in the Netherlands with the PT-bikes, whereby bikes can be rented at stations with a PT pass (Martens, 2007), without requiring a separate subscription. Moreover, PT-bikes have also recently incorporated information integration via the national train company's trip planning app, which shows the number of available PT-bikes at any given station. Ticketing integration is becoming increasingly common between PT companies and car and bike sharing companies, as exhibited by the cooperation between STIB (PT and bike sharing operator in Brussels, Belgium) and Cambio (a car sharing company) (Loose, 2010), and between SBB (Swiss train operator) and Mobility Car sharing. Consequently, in the context of MaaS, there would also be shared mobility modes in the integration ladder. Rung 3 for instance would become "*Integrate PT and shared mobility modes services*". Arguably, the more modes, the more challenging it is to implement "seamless transfers". To date however research on mobility integration and shared mobility modes remains scarce.

3.3 Changing travel behaviour through mobile applications

In this section we first discuss how mobile applications might lead to changes in travel behaviour. Next, we shed light on key features in mobile apps aiming to promote more sustainable travel patterns, as recently supported in a literature review. The final section highlights implications for MaaS.

3.3.1 Mobile applications and sustainable travel behaviour?

ICT is expected to play an increasingly important role in shaping travel behaviour (Gössling, 2017), and mobile devices and apps in particular will be of central importance, thanks to their widespread adoption and pervasive use (Lathia et al. 2013). Mobile applications that impact travel behaviour include apps providing information about travel (including convenience information, such as parking, congestion, crowdedness in PT, etc.), planning, routing, access to shared mobility modes, booking, payment, price comparison of travel alternatives, safety and health advice, and social media apps (Gössling, 2017). Gössling (2017) indicates that apps can use persuasion to support mode change towards "sustainable transport choices". Technologies to promote sustainable mobility were coined Behaviour Change Support Systems (BCSS) by Oinas-Kukkonen (2010), and defined as "information systems designed to form, alter, or reinforce attitudes, behaviours or an act of complying without using deception, coercion or inducements". An example of such a system is a multimodal, real-time information and navigation application. However, as indicated in section 3.2.2, the contribution of such apps to a modal shift away from private cars remains unclear. Further, shared mobility modes (that often require the use of an app) may generally lead to reductions in private car use, but may not necessarily lead to more sustainable travel patterns (see section 3.4). Notably, there is an entire category of applications that makes using private cars more attractive and hence may not serve sustainability goals (Gössling, 2017). When zooming in on the effectiveness of BCSSs for changing travel behaviour in particular, virtually no definitive conclusions can be drawn due to a lack of methodological robustness (Sunio & Schmöcker, 2017). Consequently, as suggested by Andersson et al. (2018) and Sunio and Schmöcker (2017), mobile applications that aim to instigate more sustainable travel patterns must be more grounded in travel behaviour change theory if they are to effectively promote change.

3.3.2 Key features in mobile apps to support travel behaviour change

To investigate the key features that smartphone application technologies need to promote sustainable mobility, Andersson et al. (2018) conducted a literature review of behaviour change and ICT in the fields of transport, health, energy and climate, and grounding findings in behavioural change theories.

First, Andersson et al. (2018) found that customisation to the user is crucial to promote mode change, as the literature review of Chorus et al. (2006) already underlined. According to the diffusion of innovations theory, a product must be adapted to the user, and not vice versa (Rogers, 2003). Stopka (2014) demonstrated that travellers do indeed have a significant interest in personalised advice, and that this is an integral part of the seamlessness of the door-to-door travel experience. Second, Andersson et al. (2018) found that information and feedback are important for encouraging individuals to perform the desired behaviour. Third, they found that engaging users is a key issue in terms of changing behaviour via apps, which reminds us of travel behaviour inertia. In that sense, continuous improvement[9] and gamification could play important roles. Fourth, an appealing and simple design is key to holding the interest of users. One of the qualities that allows an innovation to spread is how simple it is to use, without the need to learn (Rogers, 2003). That which is simpler to understand is adopted more rapidly than that which requires new skills and comprehension.

3.3.3 What does this mean for MaaS?

Mobility-as-a-Service is to be primarily accessed on the passenger side via an application on a smartphone or tablet. The rise of MaaS concurs with the recent growing interest in the way apps could trigger changes in travel behaviour. Research suggests that four aspects of apps are crucial to promoting sustainable mobility: customisation to the user, information and feedback, engaging the user, and an appealing and simple design. Although to date there is no definitive conclusion about the effectiveness of behaviour change support systems, taking into account these four features – and generally travel behaviour theory, as briefly introduced in section 3.1 – in designs of MaaS applications could help attract users, lock them in and promote alternative travel behaviour patterns.

3.4 Shared mobility modes, travel behaviour and preferences

In this section, we highlight insights into shared mobility modes from the literature. Each subsequent section addresses one mode and is articulated as follows: we first describe the typical socioeconomic and sociodemographic characteristics of users and also the trip characteristics, and then we present the findings for how each mode impacts PT use, walking, cycling, car ownership and car use. The final section highlights implications for MaaS.

3.4.1 Car sharing

Car sharing users and trips. Research shows that the people more likely to participate in car sharing are young and highly educated adults with moderate to high incomes who live in urban areas and in households with limited car ownership (Becker et al., 2017; Clewlow, 2016b; Kang et al., 2016; KiM, 2015; Le Vine & Polak, 2017). According to Bardhi and Eckhardt (2012), car sharing often attracts people who have a low sense of ownership and a utilitarian view of mobility. Visiting friends or family, shopping (including shopping for heavy items), recreation and business trips are most frequently mentioned as trip

[9] A key aspect to spreading an innovation, according to the diffusion of innovations theory (Rogers, 2003).

purposes; most users appear to rent cars for incidental mobility needs (Baptista et al., 2014; KiM, 2015; Le Vine & Polak, 2017).

Price structures. Research reveals that many car owners do not have the full costs overview in mind when purchasing vehicles (Turrentine & Kurani, 2007). Moreover, many drivers 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 car sharing subscription.

Car sharing and PT use/walking/biking. Car sharing schemes can enable shifts towards other modes. While station-based car sharing triggers a shift away from private vehicles and toward public transportation or walking/cycling (Shaheen et al., 2009; Sioui et al., 2013), the impact of free-floating car sharing is less clear. Becker et al. (2017) found that free-floating car sharing can fill a gap in public transport (modal integration effect), but that in many cases it reduces PT use and walking/cycling (substitution effect) in favour of car trips. This was partly confirmed by Martin and Shaheen (2016), who found that a majority of car2go members used taxis and PT less frequently (although the integration/substitution effects vary per city), but walked more frequently.

Car sharing, private car use and car ownership. Several studies have indicated that car sharing reduces vehicle ownership rates per capita among car sharing members, as summarised in Baptista et al. (2014) and Shaheen et al. (2012). Martin and Shaheen (2011) note that the decrease in privately owned vehicles is also accompanied by an average decline in VKT/VMT (Vehicle Kilometres Travelled/Vehicle Miles Travelled) of between 27 and 43% per year. Reducing private car use is less likely to occur among suburban car sharing members than urban ones (Clewlow, 2016a) and among individuals with high education levels and/or high incomes (Le Vine & Polak, 2017). Martin et al. (2010) found that between 9 and 13 privately owned vehicles were taken off the road per (station-based) car-sharing vehicle, which includes both the suppression and shedding effects. Car sharing's suppression effect is the effect that car sharing has on suppressing the members' need to personal vehicles, while the shedding effect is the effect that allows car sharing members to sell or discard their personal vehicles. Examples of these effects can be found in recent studies examining free-floating car sharing. According to Martin and Shaheen (2016), who studied the impact of car2go in five North American cities, the suppression effect was larger than the shedding effect (7-10% and 2-5%, respectively). Similarly, Le Vine and Polak (2017) found the suppression effect in some 30% of free-floating car sharing members in London, compared to just 4% for the shedding effect, although shedding is more likely than suppressing among low-income households. In the Netherlands, Suiker and van den Elshout (2013) found that 4% of car2go members in Amsterdam had reconsidered owning cars.

3.4.2 Bike sharing

All insights provided in this section derive from studies on station-based bike sharing. To the best of our knowledge, insights into how free-floating schemes impact travel behaviour remain lacking as of mid-2018, and the same applies for bike sharing's impact on car ownership.

Bike sharing users and trips. Bike sharing users are younger, have higher incomes, higher education levels and are more likely to work full- or part-time than the average population (Fishman, 2016; Ricci, 2015). Bike sharing users do not necessarily have lower car ownership rates than non-users (Fishman et al., 2013). The main reasons for using bike sharing are convenience (close to work, to home, fast, short routes, getting around more easily), followed by saving money (Fishman, 2016). Users usually praise the time saved compared to other modes that are subject to congestion or delay (Sener et al., 2009). Shared bicycles are typically used for short-duration trips, while trip purpose depends on the type of user, notably long-term users (more work-related purposes) or casual users (more leisure-related purposes) (Fishman, 2016).

Bike sharing and PT use/walking/biking. Research reveals that most people who switch to shared bikes come from walking and PT, not from cars; for example, Bullock et al. (2017) found that in Dublin 77% of the total had switched from walking, 16% from bus/tram, and the remainder from taxis. As with car sharing, modal integration and modal substitution effects exist. According to Yang et al. (2018), modal integration can decrease the average user travel times and increase urban public transport network efficiency, as shared bikes are used for first and last miles. Studies have shown that bike sharing and PT integration provide users with considerable incentive to use bike sharing, potentially resulting in car use reduction (Bachand-Marleau et al., 2011; Martens, 2007). But substitution also exists: in Lyon (France), 50% of bike sharing trips replaced PT trips (DeMaio, 2009). According to Martin and Shaheen (2014), in cities with high population densities and high public transport network densities, bike sharing decreases PT use in dense and central urban locations (as recently confirmed by Campbell and Brakewood (2017)), and increases PT use in suburban areas/city peripheries.

Bike sharing and private car use. Research universally shows that bike sharing systems reduce car travel (Fishman et al., 2014; Martin & Shaheen, 2014; Shaheen et al., 2013). Nevertheless, shifting away from private cars remains limited and highly context-dependent. Fishman et al. (2014) estimate a car substitution rate of 2% among users in London (U.K.), which contrasts with rates of 19%, 19% and 21% among users in Minneapolis/St. Paul (U.S.), and Melbourne and Brisbane (Australia), respectively. Fishman et al. (2014) explained such differences as due to lower numbers of car commuting trips in cities with low substitution rates. The impact of bike sharing systems on road congestion is unclear (Fishman, 2016).

3.4.3 Ride-sourcing

Most of the available studies on ride-sourcing derive from California (U.S.); several studies have analysed data collected there in 2015 among adults aged 18 to 50 (Alemi et al., 2017; Alemi, Circella, Mokhtarian, et al., 2018; Alemi, Circella, & Sperling, 2018; Circella et al., 2018).

Ride-sourcing users and trips. The rate of adopting ride-sourcing is significantly higher among people who are young adults, highly educated, work full time, have higher incomes (Alemi et al., 2017; Clewlow & Mishra, 2017b), reside in urban areas, are childless (Alemi et al., 2017), have low rates of car ownership, and already undertake multimodal trips (Alemi, Circella, & Sperling, 2018). Moreover, Alemi et al. (2017) found positive correlations between ride-sourcing adoption and the frequent use of smartphones for daily travel and social media, shopping online, and previous bike sharing and/or car sharing use. Although ride-sourcing is primarily used incidentally (Alemi, Circella, Mokhtarian, et al., 2018), ride-sourcing trips can account for 15% of all trips within San Francisco on an average weekday (SFCTA, 2017). Among ride-sourcing users, the most-cited reasons for using such services are convenience, reliability, short travel times, avoiding drunk driving, and not having to park (Alemi, Circella, & Sperling, 2018; Clewlow & Mishra, 2017b; Rayle et al., 2016).

Ride sourcing and PT use/walking/biking. Both modal integration and modal substitution with PT exist. According to Clewlow and Mishra (2017b), the extent to which one is more prevalent than the other depends on the demographics of the user and the availability and type of PT. APTA (2016) and Alemi, Circella, and Sperling (2018) suggest that a complementary effect is at work, since a majority of ride-sourcing trips are made between 22:00 and 4:00, when public transport services are limited, and owning to “to not drink and drive” being frequently cited as a main reason for using ride-sourcing. A study recently demonstrated that ride-sourcing has significant potential to complement PT as a feeder system, while reducing total VKT (Stiglic et al., 2018). Ride-sourcing has however been shown to compete with PT in urban and suburban settings, as well as in the context of trips to/from airports (Alemi, Circella, & Sperling, 2018; Rayle et al., 2016; Schaller, 2017). Regarding walking and biking, more than 40% of the frequent ride-sourcing users in a Californian survey reported a decrease, and less than 10% an increase in these active modes (Circella et al., 2018).

Ride-sourcing, private car use and car ownership. Studies consistently find a correlation between ride-sourcing adoption and reductions in private car driving: 26% of users in seven major U.S. cities reported that they drove less after adopting on-demand ride services (Clewlow & Mishra, 2017b), with this share increasing to 40% for San Francisco only (Rayle et al., 2016), and 70% for frequent[10] users in California (Alemi, Circella, & Sperling, 2018). More than 90% of Rayle et al. (2016) survey respondents stated that they did not change the number of vehicles they owned after joining a ride-sourcing scheme (some even increased their vehicle ownership), while that figure was 91% in the Clewlow and Mishra (2017a) study. The more frequently a person used ride-sourcing, the more likely they were to have shed a vehicle (Clewlow & Mishra, 2017a). Impacts on congestion remain unclear (Jin et al., 2018). Note that ride-sourcing could induce trips: in the Rayle et al. (2016) study, 8% of respondents would not have made their trip had ride-sourcing not existed.

Ride-sourcing and other shared mobility modes. Alemi et al. (2017) found a positive correlation between ride-sourcing adoption and previous use of bike sharing and/or car sharing. However, frequent car sharing use negatively correlates with ride-sourcing, indicating potential competition (Alemi, Circella, Mokhtarian, et al., 2018). Research reveals the impact of combining ride-sourcing and car sharing: 57% of the individuals who adopted both services are carless and reside in highly urbanised neighbourhoods, compared to 37% for non-adopters, while 33% are carless and reside in PT-accessible neighbourhoods, compared to 19% for non-adopters (Clewlow, 2016b). The American Public Transportation Association's term "supersharers" denotes people who used some combination of bike sharing, car sharing and ride-sourcing for commuting, errands and recreational trips within the past three months (APTA, 2016). Nevertheless, Clewlow and Mishra (2017b) found that such users still have on average higher rates of car ownership than PT-only users. Supersharers remain a small group though.

3.4.4 Demand-responsive transport

DRT users. Initially, the growth of DRT around the world was fostered by policies aiming to ensure the provision of transport services for people with impairments, resulting in DRT and disabilities often being associated (Aldaihani et al., 2004; de Jong et al., 2011; Enoch et al., 2004). However, owing to technological improvements, DRT is increasingly used for new applications. Cervero (1997) highlighted the potential of DRT in settings combining spatial dispersion and low dependency on city centres. DRT services are increasingly used in rural areas, where they have proved to be most effective in both meeting demand (Laws, 2009) and justifying public investments (Davison et al., 2012). Mulley and Nelson (2009) posited that areas in urban and peri-urban settings might also benefit from DRT services, notably when there is insufficient demand for a viable fixed-route service. We will refer to this type of DRT as *coverage-oriented* DRT services. According to the literature review of Jain et al. (2017), eight characteristics are likely to impact the use of a DRT service: being aged 15-24, or 55 and above; being female; not being in the workforce; not possessing a driving licence; low household income and vehicle ownership rates; being a single-person household; and not having a train station in one's neighbourhood. Further, there is a higher share of people with mobility impairments among coverage-oriented DRT users than among the general population (TCRP, 2004; Wang et al., 2014). Jain et al. (2017) found that such services are frequently used for shopping and social purposes. DRT's high adaptability (Laws, 2009) also renders it relevant in high-density areas (Davison et al., 2012). We refer to this type of DRT as *urban* DRT services[11]. According to Santi et al. (2014), more than 95% of taxi trips in New York City could be shared without incurring more than five minutes delay, and various urban network structures around the world show similar potential (Tachet et al., 2017). A stated preference study conducted in Chicago (in the context of commuting trips) revealed that the 18-34 and 51-69 age groups are more likely to adopt urban DRT, as are the high-income respondents (Frei et al., 2017). Another stated preference study conducted in Amsterdam (pertaining to leisure trips) revealed that among car owners, it

[10] Alemi, Circella, and Sperling (2018) define "frequent" as at least once a month.

[11] We do not imply that DRT cannot be used for coverage purposes and in densely populated areas. We make the distinction here for the sake of clarity.

is the highly educated, working individuals aged 50 or younger who are more likely to include urban DRT in their mobility choices (Alonso-González et al., 2017). This study also revealed that more multimodal individuals are more prone to engage in urban DRT use, in line with the OECD ITF (2017) study.

*DRT and travel behavi*our. Coverage-oriented DRT is designed, and often subsidised, to substitute and complement public transport, where/for whom other alternatives are limited (rural areas, people with impairments, etc.). Moreover, literature on urban DRT remains relatively limited. Studies suggest that urban DRT use may reduce walking, biking and PT use, but the complementary/substitution effects, notably with PT, are as yet unknown and could depend on the design of the DRT service (Alonso-González et al., 2017; Frei et al., 2017; Gunay et al., 2016; Jokinen et al., 2017).

3.4.5 What does this mean for MaaS?

Changes in travel behaviour. Studies show that small car suppression and shedding effects do exist, which is encouraging in the context of MaaS. Effects on VKT, PT use, cycling and walking vary across modes and often depend on built environment characteristics. Table 2 provides an overview of the effects of shared mobility modes on travel behaviour. Note however the unequal degree of knowledge about the various modes (e.g. we know more about bike sharing than urban DRT; consequently, more uncertainties exist about the effects of urban DRT). Moreover, even when multiple studies are available, standard methodologies for assessing impacts on travel behaviour do not necessarily exist (e.g. for bike sharing, see Fishman (2016)).

Table 2 Overview of the effects of shared mobility modes on travel behaviour.

	Impact on…				
	PT use	Active modes (walking, cycling)	Private car use	Car ownership	VKT (Vehicle Kilometres Travelled)
Car sharing (station-based)	(+)	(+)	(-)	(-) mostly for urban dwellers, suppression and shedding effects depending on household income	(-)
Car sharing (free-floating)	(+)/(-)	(-)/(+)			(+)
Bike sharing	(+) in suburban areas of densely populated cities / (-) in city centres with high population and PT network densities	(+) for cycling / (-) for walking	(-)	(?)	(+)/(-)
Ride sourcing	(+)/(-)	(-)	(-)	(-) for frequent users	(?) (potentially (+))
Ride sourcing + car sharing	(?)	(?)	(-)	(-) stronger effect than ride sourcing or car sharing alone	(?)
Coverage-oriented DRT	In these cases, DRT is designed to substitute and complement public transport. Other alternatives may be limited for users (no PT available, mobility impairment, etc.).				
Urban DRT	(?) (potentially (-))	(-) (based on 1 study)	(-) potentially	(?)	(?)

(+): Increase in general
(-): Decrease in general
(?): Impact still unclear or unknown
(+)/(-): Sometimes increase, sometimes decrease.
The table does not provide any quantification, just an indication of the trend direction in general.
For nuances, the reader can refer to the above sections and cited references.

Users' profiles and the question of access to transport. By design, shared mobility modes are usually situated in areas with high population densities, where they are more commercially viable (Agatz et al., 2012). A (potentially unintended) pre-selection of users already occurs, owing to the fact that these shared mobility modes are usually available in cities and not in more remote places. Moreover, the profiles of typical users are relatively comparable across these modes (car and bike sharing, ride-sourcing, urban DRT): often younger people with higher incomes and education levels who are more likely to be employed than the average population. A strong focus on these modes in MaaS and a potential subsequent substitution effect with PT could raise the question of who will truly benefit from MaaS, especially when public subsidies are involved (with shared mobility modes or PT). Further, as noted by Jin et al. (2018) regarding ride-sourcing, the question of the 'digital divide' remains relevant for a service like MaaS. This term originally referred to unequal access to ICT and the skills required to use it (Selwyn, 2004), but today has also expanded to include the unequal access to smartphones and mobile data (Jin et al., 2018). Shared mobility modes can require such technology and MaaS would also likely require it. However, smartphone (and mobile data) use is arguably not easy for everyone, even in countries with high smartphone penetration rates, and hence a sharp digital divide remains (Poushter, 2017). New technologies pertaining to mobility have the potential to give people more possibilities, yet also to exclude and immobilise those who have limited access to them. Additionally, other barriers to using shared mobility modes exist, notably among people with low incomes or minorities (see Namazu et al. (2018) for car sharing, Fishman (2016) for bike sharing); it is unlikely that these barriers would simply disappear when such modes are integrated in MaaS, and therefore they will also need to be addressed.

Price structure. Note that the price structure of MaaS is comparable to the price structure of car sharing memberships (pay-as-you-go and pre-defined plans), which may deter some car owners in a similar way as car sharing's price structure does, even when maintaining the status quo is not the cheapest option.

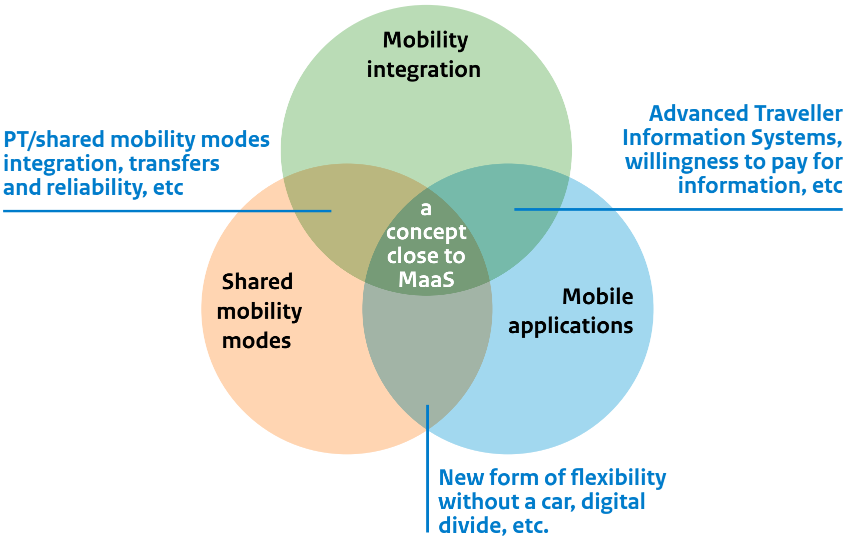
Types of trips. The types of trip purposes with shared mobility modes usually depend on how frequently such modes are used, with infrequent users tending to make more casual (e.g. leisure) rather than time-critical trips. Nevertheless, a majority of shared mobility modes members use these services on an incidental basis, which suggests that: (1) MaaS including shared mobility modes may initially only be used for casual and incidental trips, and that (2) a heavy focus on commuting trips in the initial stages may only attract people with the innovators' profile, as well as some early adopters.

Reliability with shared mobility modes. As emphasised by Van Hagen and Bron (2013), reliability – and safety – is an essential prerequisite for passengers. Shared mobility modes introduce new meanings of reliability, which differ from the usual meaning of reliability in conventional public transport, because of the uncertainties about local availability that are inherent to the flexible and finite (scarce) nature of such services. Lamberton and Rose (2012) define product scarcity as "the likelihood that a product or product-related resource will be unavailable when a consumer desires access", and they demonstrated that a perceived risk of product scarcity due to competition for the shared product could be a key inhibitor to participating in a commercial sharing program. Fricker and Gast (2016) demonstrated that even a low probability of unavailability of shared bikes may deter use, especially for individuals that rely on them daily. Additionally, Weckström et al. (2017) found that long response times and unavailability of vehicles were the main reasons why higher income groups discontinued their use of Kutsuplus, an urban DRT service. In addition to the unguaranteed availability upon departure, other aspects could affect the reliability of shared mobility modes and therefore potentially MaaS, including the anxiety of returning a shared vehicle on time (ter Berg & Schothorst, 2015) and transfers within schedule-free modes, or from a schedule-free mode to a schedule-bound mode (and vice versa). Such uncertainties about reliability could have consequences for MaaS's adoption and use.

3.5 Conclusion

Based on the nine core characteristics of MaaS as described by Jittrapirom et al. (2017), we have selected and discussed three relevant themes. Where these three themes intersect – as depicted in Figure 5, an annotated version of Figure 3 –, coupled with an understanding of the MaaS concept and travel behaviour theory, provides some insights and discussion points about Mobility-as-a-Service and its potential for instigating changes in travel preferences and travel behaviour, as summarised below.

Figure 5 The three themes and their intersections as discussed and addressed in this explorative literature review.



Our explorative literature review indicates that the large-scale adoption and use of MaaS may remain relatively unlikely in the short term and unclear over the longer term. However, MaaS seemingly has potential for reaching specific population groups, particularly young and tech-savvy urban individuals. It may also hold promise to instigate changes in travel behaviour and preferences among them, potentially in a more sustainable direction. Nonetheless, it is crucial to take various aspects into account when pursuing a widespread adoption of MaaS and change in travel patterns. First, research on mobility integration reveals how challenging the integration process is. A higher level of integration is more attractive to travellers; however, developing and successfully implementing such integration is a long-term and complex process. Second, no definitive conclusions have yet been reached about the impact of mobile applications that aim to support changes in travel behaviour (so-called Behavioural Change Support Systems). Research reveals that four app features in particular are necessary conditions, yet they may not be sufficient. Third, although research on shared mobility modes sheds light on the existence of suppression and shedding effects with cars, it pertains only to specific user profiles. In the vast majority of cases, using such modes remains incidental and must not be automatically associated with more sustainable travel patterns. Integrating these modes within MaaS has the potential to provide an advanced level of flexibility, but it also raises questions about the reliability of such modes and, more generally, problems associated with social inclusion.

4 Systematic literature review of the potential impact of MaaS on travel preferences and behaviour

In this section we present a literature review of the potential impact of MaaS on travellers' preferences and behaviour. Our focus is on studies specifically pertaining to MaaS and travel behaviour/preferences. In the selected studies, we found six common themes pertaining to MaaS, travel behaviour and preferences. This section is therefore structured as follows:

- *Introduction*: Presentation of the selected papers and the associated research methods.
- *Theme* 1: A change in the private car ownership paradigm?
- *Theme* 2: Preconditions in MaaS: the need for autonomy, flexibility and reliability
- *Theme* 3: Aspects adding value in MaaS
- *Theme* 4: The user-side design of MaaS
- *Theme* 5: Costs and willingness to pay
- *Theme* 6: Travellers' characteristics

4.1 Presentation of the selected papers and the associated research methods

In this section we start by presenting 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? Here we provide some insights into the representativeness of the studies' samples, as well as information about research methods that can be important to bear in mind when reading and interpreting the results (e.g. limitations of certain research methods).

4.1.1 Selection of relevant papers

We apply a systematic selection based on a few keywords and criteria, as detailed in Appendix B. In our final selection, we retain 14 papers that can be clustered into two groups, as presented in Table 3. The type of study and research methods are also briefly presented in Table 3. Note that in the systematic literature review (section 4.2 to 4.7) we use a few other references for illustration purposes or to provide a definition.

Table 3 Results from the systematic literature search conducted in May 2018 on Mobility-as-a-Service and its potential impacts on travel preferences and behaviour.

Group of studies	Year	Authors	Type of study and research methods	Country/region where the study is conducted
Research papers on MaaS pilots/ linked to MaaS pilots	2016	Strömberg, Rexfelt, Karlsson and Sochor	Comparative analysis of two cases studies (one is UbiGo) in light of Rogers' diffusion of innovations theory.	Gothenburg (Sweden)
	2015	Sochor, Strömberg and Karlsson	Evaluations of MaaS pilots (qualitative and quantitative: surveys, interviews and travel diaries for a few days (UbiGo)).	
	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*	In-depth evaluations of UbiGo and Smile	-
Interviews and surveys	2018	Smith, Sochor and Karlsson	Development of MaaS scenarios through interviews with professionals.	West Sweden
	2017	Ho, Hensher, Mulley and Wong	Survey research: Stated Preference experiment on MaaS monthly bundles.	Sydney (Australia)
	2017	Ratilainen*		Helsinki (Finland)
	2018	Matyas and Kamargianni		London (UK)
	2017	Alonso-Gonzáles, Van Oort, Cats and Hoogendoorn	Survey research: Stated Preference experiment on mode choice.	Amsterdam (The Netherlands)
	2017	Haahtela and Viitamo	Evaluation of the potential of MaaS through a survey and focus groups.	Finland
	2018	Kamargianni, Matyas, Li and Muscat*	Survey research: Evaluation of the potential of MaaS through attitudinal research.	London (UK)

*These studies are neither journal articles nor conference papers; see explanation in Appendix B.

4.1.2 Research methods

Overview of methods. Pilot and survey research are often used to make quantitative statements about the impacts of MaaS on travel preferences and travel behaviour. Survey research was either used as a complement, as in the case of evaluating UbiGo, or as a main method for gathering information about MaaS, and was occasionally preceded by a more quantitative approach, such as Haahtela and Viitamo (2017) using focus groups to assist in the survey's design. When used as a main method for acquiring information about MaaS, attitude research and stated preference (SP) research are often used. G. Smith et al. (2018) took a different approach than the rest of the selected studies: they conducted interviews with private stakeholders, in which PT and MaaS were discussed. They then performed a structured analysis of the interview transcripts and identified three scenarios for the future developments of MaaS.

Pilots. Evaluations of pilots typically used various methods, as presented in Table 3. Additionally, these pilots differed in multiple aspects, as shown in Table 4. Both pilots primarily targeted young or middle-aged urban dwellers. Moreover, the participants agreed to sign up for such trials and seemingly genuinely enjoyed the possibility of trying a new service (Sochor et al., 2016). The participants were not particularly deterred by prices, especially in the case of UbiGo, which worked with monthly bundles (see section 4.6 for bundles' prices). Karlsson et al. (2017) found that UbiGo was particularly more attractive for households of more than one person situated in the city centre of Gothenburg, where car sharing and PT provision are good. Based on data from Sochor et al. (2015) and Karlsson et al. (2016), at least 90% of UbiGo households seemingly earned more than the gross medium income in Gothenburg. All told, the pilots' results may not apply to the entire population of these respective cities and countries, generally. There is however a benefit to having such a select group of participants: it creates observability. According to Strömberg et al. (2016), selective pilot recruitment increases the chances of success, and, consequently, creates observability (a wide audience can see that it works) – showing that a sustainable modal shift is possible.

Table 4 Overview of Smile and UbiGo pilots (Karlsson et al., 2017; Smile mobility, 2015; Strömberg et al., 2018).

	Smile	**UbiGo**
Type of MaaS pilot*	Level 2	Level 3
Pilot duration	6 months (from November 2014)	6 months (from November 2013)
Amount of pilot participants	Over 1,000	195 people in 83 households
Amount of 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.

* See section 2.2.

Attitudinal research. An attitude is a group of opinions, values and dispositions to act associated with a particular concept. Attitudes can be measured by showing respondents statements pertaining to a particular concept and asking them to evaluate the extent to which they agree with the statement. According to Swait (1994), attitudes indirectly influence preferences, hence the relevance of attitudes for examining preferences within MaaS. Kamargianni et al. (2018) used attitudinal statements to gain deeper insights into intrinsic motivations for using or not using MaaS.

Stated preferences studies. Stated Preference (SP) techniques are frequently used to gather information about products and services that are not yet available (Louviere et al., 2000). In discrete choice SP, respondents are asked to choose between different hypothetical alternatives defined by a set of attributes (e.g. travel time and price) that usually have two to three levels (e.g. €10, €25, €40 for the price attribute). The researcher controls the experiment process. In Ho et al. (2017), Matyas and Kamargianni (2018), and Ratilainen (2017), respondents chose their favourite mobility bundle from a given selection, with the aim being to understand which types of bundles might appeal to potential users in Sydney, London and Helsinki, respectively. Note that the first two studies used so-called context-aware experiments, in which researchers strive to make the choice situations the respondents face as realistic as possible by using data about the respondents' actual travel behaviour. Although requiring extra effort in terms of data collection, it is a growing trend in SP experiments (Cherchi & Hensher, 2015); see Matyas and Kamargianni (2017) for an explanation on context-aware experiments.

In Alonso-González et al. (2017), respondents were asked to choose between different modes that may coexist in an urban MaaS scheme, so as to establish the modal consideration set (also called "modal portfolio") for residents of Amsterdam.

Shortcomings of SP and attitudinal research. 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. Moreover, even when respondents choose a certain bundle with modes they have not used before, will they actually use them? Matyas and Kamargianni (2018) found that 64% of their respondents answered positively to the statement, "I would be willing to try transport modes I previously didn't use if my MaaS plan included them". Although this looks encouraging for modes like bike sharing, car sharing and DRT, it could still be that while respondents express excitement at the idea of MaaS, they might be more hesitant in reality to change their travel habits and adopt modes they previously did not use. Further, the potential for hypothetical bias in SP experiments always exists: it could be that respondents misunderstand the hypothetical product or service explained to them. Attitudinal research also does not perfectly reflect future behaviour; it is common to see people failing to practice what they preach (J. R. Smith & Louis, 2007) and multiple studies in the past have reported low or inconsistent correspondence between attitudinal and behavioural entities (Ajzen & Fishbein, 1977).

Representativeness of samples. Each of the survey studies include samples that are more or less representative for each metropolitan area, which can be useful to bear in mind when interpreting the results. Details of the representativeness of each sample are shown in Table 5; overall, there is a good degree of representativeness. All studies targeted people aged 18 or above.

Table 5 Representativeness of samples in survey studies on MaaS (excluding evaluations of pilots).

Study*	City (and metropolitan area)	Sample size	Representativeness?
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. (2017)	Sydney	252	Well representative for the worker population but under-representative of retirees and housekeepers.
Alonso-González et al. (2017)	Amsterdam	797	Slightly under-representative of the elderly and low-educated people (compared with the Dutch population), representative otherwise.
Ratilainen (2017)	Helsinki	252	Over-representation of females, older age categories and people with low-income.

*Haahtela and Viitamo (2017) is not included here because the paper mainly focused on focus groups and the complementarity between focus groups and survey.

4.2 A change in the private car ownership paradigm?

4.2.1 Private car use and MaaS in practice

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

- Car shedders (13%), i.e. people who wanted to relinquish ownership of their cars because they were 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.

Note that 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).

4.2.2 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 also a recurrent topic in the selected studies. In London, 67% of non-car owners believe there is no need to own cars, regardless of their age or area of the city they live in (Kamargianni et al., 2018). Moreover, 36% of the non-car-owning participants stated they would delay purchasing a car and 40% that they would not purchase a car at all if MaaS were available. In UbiGo, 78% of the car accessors increased their use of car sharing and 30% increased their use of car rentals (Strömberg et al., 2018). Regarding car owners in London, 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, while one-fourth of car owners stated that they would even be willing to sell their cars for unlimited access to car sharing (Kamargianni et al., 2018). The researchers nevertheless noted that half of the car owners were attached to their cars and did not like the idea of only having access to a car without owning one; around half of the car-owning respondents in London disagreed with the statement, “MaaS would help me depend less on my car”. 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). In light of our previous discussion on car ownership in section 3.1, such findings are not very surprising: cars are widely perceived as the only transport mode that gives people sufficient autonomy and flexibility (Freudendal-Pedersen, 2009).

Note though that the dichotomy of owning versus using presents gradations, hybrid forms where using and owning may coexist. The interviewees of G. Smith et al. (2018), private stakeholders, 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. In their analysis of the extrapolated potential of UbiGo, Karlsson et al. (2017) argue that such a service 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 and public transport would therefore provide an alternative for second cars. In this perspective, what role would public transport play in MaaS?

4.2.3 The role of public transport

According to Hensher (2017), the MaaS era could disrupt the current role and organisation of public transport. Matyas and Kamargianni (2018) and Ho et al. (2017) state that PT should be the backbone of MaaS – at least in metropolises such as London, Sydney and Vienna. Both studies found that respondents have a preference for mobility bundles that include public transport, especially unlimited public transport. In Vienna, 48% of Smile users used PT more often (Karlsson et al., 2017). Note though that not all public transport users might switch to MaaS: 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 as well as small towns) mentioned several improvements that must be made to public transport before they would consider switching (more frequently) to buses and trains. A first major improvement would be having enough places to sit, while other suggestions for improvement included being able to work during commutes, with quiet spaces, power sockets and Internet connections. 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, while all groups in UbiGo used public transport 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, although one can argue that the MaaS product must have sufficient added value – otherwise, the shift to PT would have already occurred. If such a shift does take place, 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 public transport trips with car sharing and taxi[12], 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 providers compared to public transport 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. 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: some of the potential decrease in PT use with MaaS might result from substitution with active modes, when distances allow.

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

4.3.1 The need for autonomy and flexibility

In UbiGo, the participants revealed that they value their flexibility and autonomy, even when using their private cars less frequently. 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)), which 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. (2017). Moreover, Haahtela and Viitamo (2017) noted that people in focus groups often mentioned their need for the flexibility and

[12] The researchers also indicate that respondents are in favour of using taxi as a shared option (i.e. DRT), but no quantitative information is available on this topic.

autonomy of a private car for trip chaining[13], whether it be for work (meetings in diverse locations) or private purposes (picking up children at school, grocery shopping after work, etc.).

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.

4.3.2 New meanings of reliability

As previously discussed in section 3.4.5, reliability is a prerequisite for passengers, yet shared mobility modes introduce new meanings of reliability. MaaS studies that explicitly included offers with shared mobility modes show that discussions about reliability are indeed topical in the context of MaaS. Ho et al. (2017) 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, as part of the service in MaaS, 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.

4.4 Aspects adding value in MaaS

4.4.1 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 services, making experimentation easier and contributing to the creation of new mental models (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 if 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.

[13] By trip chaining, we refer to a sequence of trip segments beginning at the ‘home’ activity and continuing until the traveller returns ‘home’ (Primerano et al., 2008), for instance home > work > restaurant > home.

4.4.2 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 any problem would be promptly dealth with (Sochor et al., 2015). In Vienna, 55% of Smile users stated they more frequently combined different transportation modes, mainly cars and public transport (26%) and bike and public transport (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 (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.

4.4.3 Tailored offer

Literature on smartphone apps and travel behaviour shows that to have a chance at instigating changes in travel behaviour, it is crucial for the service to be tailored to the user (see section 3.3.2). This is confirmed in MaaS. 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).

Ho et al. (2017) noted that when respondents were offered the choice of creating mobility package themselves, they often replicated their current travel patterns, something which the researchers had already been partly capable of doing thanks to a detailed questionnaire completed prior to the SP survey. Similarly, Matyas and Kamargianni (2018) found that frequent taxi users tended to prefer more taxi in their plans, PT Travelcard owners preferred plans with PT Travelcards, and (private or shared) bicycle users plans that included bike sharing. 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 customised 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 tailor-made offer requires the user to accept sharing data about their preferences. The question of data privacy is therefore crucial.

Note that the customised or tailor-made offer discussed in this section is part of, but not equal to, the "customisation to the user" feature detailed in section 3.3.2. Indeed, the latter also refers to the customisation of the application interface, for example, as discussed in section 4.5.2 below.

4.5 The user-side design of MaaS

4.5.1 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, and 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.

4.5.2 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), which accords with the importance of simplicity in ICT systems that aim to change travel behaviour (see section 3.3.2). 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, transfer unused credits to the next month, change plans, and so forth.

Another reason why UbiGo allowed for changes in travel behaviour was its trialability[14] aspect (Strömberg et al., 2016). According to Laakso (2017), experiments are considered as "safe spaces" for people to trial behaviour without strict commitments, and this could potentially ease people into the travel behaviour change process, thereby creating observability for local policy and the public (Strömberg et al., 2016).

4.6 Costs and willingness to pay

4.6.1 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

[14] Trialability, the "degree to which an innovation can be experimented with on a limited basis", is in fact also one of the main qualities of an innovation that allows it to spread (Rogers, 2003).

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. Sochor et al. (2016) argue that the pilot's key service attributes (ease of use, choice freedom and the subsequent flexibility, tailor-made offer, convenience) add value[15] compared to people's previous travel solutions, which could explain the willingness to pay (Rogers, 2003). 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 the users were found to have more sustainable travel preferences and behaviour.

4.6.2 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., 2017; Matyas & Kamargianni, 2018; Ratilainen, 2017), which accords with the discussion in section 3.4.1 on fixed and running costs in subscription systems versus private cars. Although there are significant fixed costs related to owning a car, the variable costs of driving additional kilometres are relatively low, hence car owners often find using their own cars cheaper. 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).

4.7 The importance of travellers' characteristics

4.7.1 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 4.2.1). 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 introduced to MaaS differently. Ho et al. (2017) 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.

4.7.2 Travelling and ICT skills, social inclusion

As previously mentioned in section 3.1.1, travellers are in general behaviourally inert. Survey studies suggest that travellers indeed often prefer the status quo (Ho et al., 2017; Ratilainen, 2017). Moreover, ride-sourcing and urban DRT studies reveal that the more multimodal an individual is, the more likely they are to adopt these modes. However, travelling skills[16] not only play a role in shared mobility modes adoption, but seemingly also in MaaS adoption generally, as shown by Alonso-González et al. (2017). This suggests that a lack of experience with the various modes could be an obstacle to using MaaS. In this respect, the trialability aspect could play a major role as noted by Strömberg et al. (2016). It is also worth noting that Alonso-González et al. (2017) consider MaaS-prone behaviour as the behaviour of someone engaging in mobility app usage on a weekly basis. On the user side, MaaS is to be primarily accessed via apps, hence the crucial role of ICT skills. In that sense, age is likely to play a role in the adoption of MaaS. Studies show that young adults[17] are generally more likely to adopt MaaS than the older generations

[15] The added value or the relative benefit is an important attribute for the rapid diffusion of an innovation, according to Rogers (2003).

[16] Defined here as being familiar with using multiple modes, and in particular non-privately owned modes such as public transport.

[17] The upper age limit of "young adult" varies per study, from 34 to 39 years old.

(Alonso-González et al., 2017; Kamargianni et al., 2018), which brings us back to discussions about the digital divide, access to MaaS generally, and inclusion, as noted in section 3.4.5. Karlsson et al. (2017) emphasise 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 everywhere, due to potential commercial interests.

4.7.3 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. (2017) 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). These findings, as well as the finding that young adults are more likely to adopt MaaS generally, are confirmed by a recent study on the future implementation of MaaS that used a structured expert opinion collection technique (Jittrapirom et al., 2018).

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. Moreover, they noted that Finland has a less developed service-oriented culture than Austria or Switzerland (where part of their research was also conducted), which they posited as explanation for why the Finnish commuters they surveyed were perhaps not yet fully ready to engage in MaaS.

4.8 Conclusion

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 provides a balanced overview of the current state of research on MaaS and travel behaviour. Studies show that generally MaaS could provide enough added value to allow certain groups of travellers to consider adopting this service. 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 It must be economically feasible for people/households, and prices must be justified by sufficient added value, especially if they 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, age and place of residence, and other socioeconomic, sociodemographic, cultural characte-ristics and skills, are likely to play roles in adopting MaaS and subsequently potentially changing travel behaviour.

Generally, the extent to which MaaS will be adopted and instigate changes in travel behaviour in the wider population also remains uncertain and requires more attention, notably to quantify the extent of such changes. The positive contribution of MaaS towards achieving sustainability goals is consequently still unclear. Table 6 summarises the aspects that are likely to play roles in adopting MaaS and changing travel behaviour among travellers, and shows the types of studies that highlight the importance of each aspect.

Table 6 List of aspects playing a role in the adoption of MaaS and potential changes in travel behaviour, according to the literature.

Type of aspect	Aspect	PR[1]	SIR[2]
Trip-specific aspect	Convenience of the trip with MaaS	x	x
	Choice freedom within MaaS	x	x
	Flexibility	x	x
	Autonomy		x
	Reliability of shared mobility modes		x
Service-specific aspect	Ease-of-use	x	x
	Customisability of the service (tailored to one's needs)	x	x
	Trialability	x	
	High level of integration, including product bundling	x	x
Costs aspect	Costs, willingness to pay	x	x
Travellers' characteristics	Sociodemographic, socioeconomic and cultural characteristics	x	x
	Past and current travel behaviour, travelling skills	x	x

Categories are defined as presented in Table 2. 1: Pilots research, 2: Survey and interview research.

5 Conclusion and agenda for further research

5.1 Conclusion

In times when many see in MaaS a tool for instigating more sustainable travel behaviour patterns among the population, it is relevant to establish what we currently know, based on scientific literature, about MaaS's potential impacts on travel preferences and travel behaviour. Two pathways are used to reach this goal: an explorative literature review based on relevant research on travel preferences and behaviour conducted *outside of* MaaS, and a systematic literature review *focused exclusively on* MaaS, travel preferences and travel behaviour.

Generally, the reviewed studies show that MaaS has the potential to reach certain travellers, to support decreases in private car use and to instigate different travel patterns among these travellers. However, the impact magnitude and direction of these changes remain relatively uncertain and require more quantitative results, whether on the individual level (travel behaviour, travel preferences) or societal level (e.g. social and environmental sustainability). The exact size of the group of travellers that will initially be impacted also remains unclear, as is the timeline for wider adoption among the population. Indeed, it is unlikely that a drastic shift from the private car ownership paradigm to the MaaS paradigm will occur within a few years.

Current literature can however inform us about the preconditions for adopting MaaS and for subsequent changes in travel behaviour patterns, while also providing qualitative indications of potential users and impacts.

5.1.1 Preconditions for adoption of MaaS and subsequent changes in travel behaviour

Studies consistently agree that it is particularly challenging to change travel behaviour when no trigger exists for doing so, especially for habitual trips. This indicates that as a first step, MaaS may have more potential for incidental trips. However, to allow such for trips to occur, individuals must actually *start* using MaaS. Beside the obvious precondition of the physical existence and availability of MaaS, the adoption of MaaS, conditioning a subsequent potential change in travel behaviour, is likely to require a combination of multiple aspects. First, it is important that MaaS adds enough value for travellers. MaaS pilots show that choice freedom, tailor-made offers and increases in travel convenience – notably through high levels of integration – can positively impact MaaS adoption. The need for such "tailor-made all-inclusiveness" is especially valid if the asking price is higher than what travellers are used to. This leads to the second point about costs**:** to provide travellers with a viable, lasting alternative, adopting the service must be economically feasible. In that sense, customising the type of offer to the user will likely play a key role. Adopting the service must also be perceived as economically feasible; for example, the price structure of MaaS could be an obstacle, especially for car owners. Consequently, the latter might need to be introduced to MaaS in a different manner than non-car-owners. Third, it is crucial that MaaS does not require travellers to compromise (too much) on their autonomy, flexibility and reliability demands. Being able to combine modes during a trip is deemed a key strength of MaaS. Shared mobility modes in particular can provide flexibility and choice freedom in access-based systems such as MaaS, yet their finite and flexible nature raises questions about reliability. Fourth, a particularly important point is a smart design of the MaaS user interface, rendering it accessible for everyone.

5.1.2 Preconditions for MaaS's potential to challenge travel behaviour patterns

A smart design of the user interface is one feature of behavioural change support systems. In order to have a chance to instigate new travel behaviour patterns, it is likely that the MaaS user interface (e.g. a smartphone application) needs to include all of these features, i.e. customisation to the user, information and feedback, commitment, and an appealing and simple design. However, these features may not be sufficient conditions for influencing travel behaviour. The value-adding aspects of MaaS – more convenience, choice freedom, etc. – can also potentially influence travel behaviour. In essence, such aspects arise from a high degree of mobility integration. MaaS's levels of integration are currently defined as (1) information integration, (2) ticketing and payment integration, (3) service integration, and (4) integration of societal goals. Research reveals that a comprehensive approach combining multiple levels of integration is more likely to encourage passengers to use the integrated modes than solely a lower level of integration. Further, mobility packages could be used to influence travel behaviour patterns. Generally, MaaS studies regard mobility packages as having the potential to alter the way people perceive travel alternatives rather than physically altering alternatives, thereby potentially promoting the use more sustainable modes, and notably shared mobility modes. The latter have proven to be effective for decreasing car use and, to a lesser extent, car ownership. Effects on congestion, PT use, cycling and walking vary across modes or lack quantified analysis.

5.1.3 Potential MaaS users

Generally, young to middle-aged people residing in urban areas are likely to be the first group to switch to MaaS from a more traditional mobility paradigm. Current literature only provides very limited quantified indications about who these travellers are, and no quantification about the extent to which such shifts in travel behaviour could occur. The extent to which MaaS will be adopted and instigate changes in travel behaviour among the wider population remains uncertain. Skills, values (like a low sense of ownership), age and place of residence, and other socioeconomic, sociodemographic and cultural characteristics are likely to play roles in the adoption of MaaS and potential subsequent changes in travel behaviour.

5.1.4 Impacts of MaaS

This study named a few impacts that MaaS could have. In particular, we note that the question of who MaaS will reach raises questions that only a few studies have addressed: namely, MaaS's impact on (perceived) access to transport and social inclusion. Shared mobility modes could provide a good starting point for examining these questions. In addition to impacts on social sustainability, MaaS could impact a wide range of dimensions through the changes in travel behaviour it could trigger, including environmental sustainability (e.g. air pollution, noise pollution) and the transport system generally (e.g. capacity optimisation, passenger demand). However, at such a preliminary stage in this new type of paradigm, only rough qualitative indications about the types of impacts exist, and the extent and direction of such impacts remain uncertain. Perhaps one of the most illustrative examples of this uncertainty is MaaS's impact on sustainability via car use: while MaaS's access-based paradigm may compel decreases in private car use, it may also provide access to motorised vehicles to people who previously did not have such access. In order to make conclusive statements about such effects, more research about MaaS adoption and travel behaviour within MaaS is required, especially on the quantitative side.

5.2 MaaS research agenda

Both literature reviews identified a number of points for future research. Although there are currently few MaaS-related studies available, the subject is topical, as shown by the fact that the vast majority of relevant studies were published in 2016, 2017 or 2018.

MaaS adoption and travel behaviour change. A wide range of impacts must be researched generally, including of MaaS's impact on health, sustainability, the transport system, land use, etc. Many people quickly express excitement about such potential impacts, but what we need first is more research about the adoption of MaaS and decisions within MaaS, especially on the quantitative side. Only then can the impacts be derived in terms of measurable goals (e.g. Vehicle Kilometres Travelled). Quantitative research could occur in a first stage in urban areas, where multiple mobility services are already available, but research on MaaS is also relevant for non-urban areas. Ultimately, it is crucial for MaaS research to also focus on groups of people who are not necessarily thought of as "early adopters", as this will allow for the study of impacts on access and social inclusion. Moreover, research on MaaS packages, incentives (rewards when users display certain behaviour), the need for privacy and how to transition from ownership models to access-based models could also provide valuable insights. By privacy, we mean both the willingness to share data to the MaaS operator for enhanced personalisation and the willingness to share a ride. Perhaps one of the most delicate points is the willingness to pay and costs generally, which will demand special attention and more research on what exactly adds value within MaaS from a user's perspective. At the core, how can mobility be a service for travellers? What would truly add value to travel generally? Do people recognise the added value of MaaS, and if not (how) can that be changed? Further, we note that current studies about MaaS adoption and travel behaviour usually approach respondents in a very 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 would be desirable. Additionally, it could be relevant to explore other user segmentations than the traditional car users (or car owners)/PT users, in order to better understand MaaS adoption and choices within MaaS. Segmentations based on sociological analysis or lifestyles could be applied, for example.

MaaS pilots. 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 general public. A tentative effort to build a first impact assessment framework is found in Karlsson et al. (2017). Such pilots could have a geographical basis (e.g. pilots in certain regions), but also on a certain situational basis, such as for example examining how MaaS could substitute a second car in households that are hesitating to shed their second cars.

Shared mobility modes and public transport. 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. However, doubts persist about the reliability of such modes (e.g. availability, transfers), their impact (congestion, modal split) and their synergy. More research on these topics is desired, bearing in mind that an unequal degree of knowledge about these modes exists: for instance, we do not yet know much about urban DRT. 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.

Literature

Aapaoja, A., Eckhardt, J., & Nykänen, L. (2017). *Business models for MaaS*. Paper presented at the 1st International Conference on Mobility as a Service (ICoMaaS), Tampere, Finland.

Aarts, H., Verplanken, B., & van Knippenberg, A. (1998). Predicting Behavior From Actions in the Past: Repeated Decision-Making or a Matter of Habit? *Journal of Applied Social Psychology, 28*(15), 1355-1374. doi:10.1111/j.1559-1816.1998.tb01681.x

Abrate, G., Piacenza, M., & Vannoni, D. (2009). The impact of Integrated Tariff Systems on public transport demand: Evidence from Italy. *Regional Science and Urban Economics, 39*(2), 120-127. doi:10.1016/j.regsciurbeco.2008.05.014

Acquier, A., Daudigeos, T., & Pinkse, J. (2017). Promises and paradoxes of the sharing economy: An organizing framework. *Technological Forecasting and Social Change, 125*, 1-10. doi:10.1016/j.techfore.2017.07.006

AECOM. (2011). Study on Public Transport Smartcards - Final Report. European Commission Directorate-General for Mobility and Transport.

Agatz, N., Erera, A., Savelsbergh, M., & Wang, X. (2012). Optimization for dynamic ride-sharing: A review. *European Journal of Operational Research, 223*(2), 295-303. doi:10.1016/j.ejor.2012.05.028

Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes, 50*(2), 179-211. doi:10.1016/0749-5978(91)90020-T

Ajzen, I., & Fishbein, M. (1977). Attitude-Behaviour Relations: A Theoretical Analysis and Review of Empirical Research. *Psychological Bulletin, 84*(5), 888-918.

Akyelken, N., Banister, D., & Givoni, M. (2018). The Sustainability of Shared Mobility in London: The Dilemma for Governance. *Sustainability, 10*(2). doi:10.3390/su10020420

Aldaihani, M. M., Quadrifoglio, L., Dessouky, M. M., & Hall, R. (2004). Network design for a grid hybrid transit service. *Transportation Research Part A: Policy and Practice, 38*(7), 511-530. doi:10.1016/j.tra.2004.05.001

Alemi, F., Circella, G., Handy, S., & Mokhtarian, P. (2017). *What Influences Travelers to Use Uber? Exploring the Factors Affecting the Adoption o On-Demand Ride Services*. Paper presented at the 96th Annual Meeting of the Transportation Research Board (TRB), Washington D.C., United States.

Alemi, F., Circella, G., Mokhtarian, P., & Handy, S. (2018). *On-demand Ride Services in California: Investigating the Factors Affecting the Frequency of use of Uber/Lyft*. Paper presented at the 97th Annual Meeting of the Transportation Research Board (TRB), Washington D.C., United States.

Alemi, F., Circella, G., & Sperling, D. (2018). *Adoption of Uber and Lyft, Factors Limiting and/or Encouraging Their Use and Impacts on Other Travel Modes among Millennials and Gen Xers in California*. Paper presented at the 97th Annual Meeting of the Transportation Research Board (TRB), Washington D.C., United States.

Alonso-González, M., Van Oort, N., Cats, O., & Hoogendoorn, S. (2017). *Urban Demand Responsive Transport in the Mobility as a Service ecosystem: its role and potential market share*. Paper presented at the International Conference Series on Competition and Ownership in Land Passenger Transport (Thredbo 15), Stockholm, Sweden.

Anable, J., & Gatersleben, B. (2005). All work and no play? The role of instrumental and affective factors in work and leisure journeys by different travel modes. *Transportation Research Part A: Policy and Practice, 39*(2), 163-181. doi:10.1016/j.tra.2004.09.008

Andersson, A., Winslott Hiselius, L., & Adell, E. (2018). Promoting sustainable travel behaviour through the use of smartphone applications: A review and development of a conceptual model. *Travel Behaviour and Society, 11*, 52-61. doi:10.1016/j.tbs.2017.12.008

APTA. (2016). Shared Mobility and the Transformation of Public Transit, American Public Transportation Association.

Arbib, J., & Seba, T. (2017). Rethinking Transportation 2020-2030: The Disruption of Transportation and the Collapse of the Internal-Combustion Vehicle and Oil Industries. *RethinkX*.

ARK Invest. (2017). China's Booming Autonomous Car Opportunity Retrieved from https://ark-invest.com/research/chinese-mobility-as-a-service. Accessed on July 19th, 2018

Axhausen, K. W., Simma, A., & Golob, T. (2000). *Pre-commitment and usage. Season tickets, car and travel.* Paper presented at the RSA World Congress, Lugano, Switzerland.

Bachand-Marleau, J., Larsen, J., & Ed-Geneidy, M. (2011). Much-Anticipated Marriage of Cycling and Transit: How Will It Work? *Transportation Research Record: Journal of the Transportation Research Board, 2247*. doi:10.3141/2247-13

Bamberg, S., Ajzen, I., & Schmidt, P. (2003). Choice of travel mode in the theory of planned behavior: The roles of past behavior, habit, and reasoned action. *Basic and applied social psychology, 25*(3), 175-187. doi:10.1207/S15324834BASP2503_01

Bamberg, S., & Schmidt, P. (2003). Incentives, morality, or habit? Predicting students' car use for university routes with the models of Ajzen, Schwartz, and Triandis. *Environment and behavior, 35*(2), 264-285. doi:10.1177/0013916502250134

Banister, D. (2008). The sustainable mobility paradigm. *Transport Policy, 15*(2), 73-80. doi:10.1016/j.tranpol.2007.10.005

Baptista, P., Melo, S., & Rolim, C. (2014). Energy, Environmental and Mobility Impacts of Car-sharing Systems. Empirical Results from Lisbon, Portugal. *Procedia - Social and Behavioral Sciences, 111*, 28-37. doi:10.1016/j.sbspro.2014.01.035

Bardhi, F., & Eckhardt, G. (2012). Access-Based Consumption: The Case of Car Sharing. *Journal of Consumer Research, 39*. doi:10.1086/666376

Becker, H., Ciari, F., & Axhausen, K. W. (2017). Comparing car-sharing schemes in Switzerland: User groups and usage patterns. *Transportation Research Part A: Policy and Practice, 97*, 17-29. doi:10.1016/j.tra.2017.01.004

Benkler, Y. (2004). Sharing Nicely: On Shareable Goods and the Emergence of Sharing as a Modality of Economic Production. *The Yale Law Journal, 114*(2), 273-358.

Berveling, J., Olde Kalter, M.-J., & Harms, L. (2017). *Baby on board. How life events impact mobility.* Paper presented at the European Transport Conference (ETC), Barcelona.

Blythe, P., & Holm, C. (2002). ADEPT III: Piloting Combi-cards for Public Transport Ticketing in Finland. *Traffic Engineering and Control, 43*(1), 16-20.

Bovy, P. H. L., & Stern, E. (1990). *Route choice. Wayfinding in transport networks*: Kluwer Academic Publishers.

Brakewood, C., Macfarlane, G. S., & Watkins, K. (2015). The impact of real-time information on bus ridership in New York City. *Transportation Research Part C: Emerging Technologies, 53*, 59-75. doi:10.1016/j.trc.2015.01.021

Buehler, R. (2011). Determinants of transport mode choice: a comparison of Germany and the USA. *Journal of Transport Geography, 19*(4), 644-657. doi:10.1016/j.jtrangeo.2010.07.005

Bullock, C., Brereton, F., & Bailey, S. (2017). The economic contribution of public bike-share to the sustainability and efficient functioning of cities. *Sustainable Cities and Society, 28*, 76-87. doi:10.1016/j.scs.2016.08.024

Cambridge Dictionary. (n.d.). Online Cambridge Dictionary. Retrieved from https://dictionary.cambridge.org/. Accessed on June 11th 2018.

Campbell, K. B., & Brakewood, C. (2017). Sharing riders: How bikesharing impacts bus ridership in New York City. *Transportation Research Part A: Policy and Practice, 100*, 264-282. doi:10.1016/j.tra.2017.04.017

Candel, J. (2017). Holy Grail or inflated expactations? The success and failure of integrated policy strategies. *Policy Studies, 38*(6), 519-552. doi:10.1080/01442872.2017.1337090

Cervero, R. (1997). *Paratransit in America: Redefining mass transportation*: Greenwood Publishing Group.

Cherchi, E., & Hensher, D. A. (2015). *Stated preference surveys and experimental design: an audit of the journey so far and future research perspectives* Paper presented at the Travel Survey Methods Conference, Leura, Australia.

Chorus, C., & Dellaert, B. (2012). Travel Choice Inertia: The Joint Role of Risk Aversion and Learning. *Journal of Transport Economics and Policy (JTEP)*, 139-155.

Chorus, C., Molin, E. J. E., & Van Wee, B. (2006). Use and Effects of Advanced Traveller Information Services (ATIS): A Review of the Literature. *Transport Reviews, 26*(2), 127-149. doi:10.1080/01441640500333677

Chowdhury, S. (2014). An investigation of public transport users' willingness to select routes with transfers *PhD thesis, The University of Auckland*.

Chowdhury, S., & Ceder, A. (2016). Users' willingness to ride and integrated public-transport service: A literature review. *Transport Policy, 48*, 183-195. doi:10.1016/j.tranpol.2016.03.007

Chowdhury, S., Hadas, Y., Gonzalez, V. A., & Schot, B. (2018). Public transport users' and policy makers' perceptions of integrated public transport systems. *Transport Policy, 61*, 75-83. doi:10.1016/j.tranpol.2017.10.001

Circella, G., Alemi, F., Tiedeman, K., Handy, S., & Mokhtarian, P. (2018). The Adoption of Shared Mobility in California and Its Relationship with Other Components of Travel Behaviour. Report for the National Center for Sustainable Transportation Research.

Clewlow, R. (2016a). Carsharing and sustainable travel behavior: Results from the San Francisco Bay Area. *Transport Policy, 51*, 158-164. doi:10.1016/j.tranpol.2016.01.013

Clewlow, R. (2016b). *Shared-use mobility in the United States: Current adoption and potential impacts on travel behaviour*. Paper presented at the 95th Annual Meeting of the Transportation Research Board (TRB), Washington D.C., United States.

Clewlow, R., & Mishra, G. S. (2017a). *Disruptive Transportation: The Adoption, Utilization and Impacts of Ride-Hailing in the United States*. Retrieved from

Clewlow, R., & Mishra, G. S. (2017b). *Shared Mobility: Current Adoption, Use and Potential Impacts on Travel Behaviour*. Paper presented at the 96th Annual Meeting of the Transportation Research Board (TRB), Washington D.C., United States.

Daimler AG. (n.d.). By app from A to B. moovel simplifies urban mobility. Retrieved from https://www.daimler.com/products/services/mobility-services/moovel/.

Davison, L., Enoch, M., Ryley, T., Quddus, M., & Wang, C. (2012). Identifying potential market niches for Demand Responsive Transport. *Research in Transportation Business & Management, 3*, 50-61. doi:10.1016/j.rtbm.2012.04.007

de Jong, W., Vogels, J., van Wijk, K., & Cazemier, O. (2011). The key factors for providing successful public transport in low-density areas in The Netherlands. *Research in Transportation Business & Management, 2*, 65-73. doi:10.1016/j.rtbm.2011.07.002

De Vos, J., & Witlox, F. (2017). Travel satisfaction revisited. On the pivotal role of travel satisfaction in conceptualising a travel behaviour process. *Transportation Research Part A: Policy and Practice*, 106, 364-373. doi:10.1016/j.tra.2017.10.009

DeMaio, P. (2009). Bike-sharing: History, Impacts, Models of Provision, and Future. *Journal of Public Transportation, 12*(4), 41-56. doi:10.5038/2375-0901.12.4.3

Doi, K., & Kii, M. (2012). Looking at sustainable urban mobility through a cross-assessment model within the framework of land-use and transport integration. *IATSS Research, 35*(2), 62-70. doi:10.1016/j.iatssr.2012.02.004

Enoch, M., Potter, S., Parkhurst, G., & Smith, M. (2004). INTERMODE: Innovations in Demand-Responsive Transport. Report for the Department for Transport and Greate Manchester Passenger Transport Executive. London: Department for Transport.

Fishman, E. (2016). Bikeshare: A Review of Recent Literature. *Transport Reviews, 36*(1), 92-113. doi:10.1080/01441647.2015.1033036

Fishman, E., Washington, S., & Haworth, N. (2013). Bike Share: A Synthesis of the Literature. *Transport Reviews: A Transnational Transdisciplinary Journal*. doi:10.1080/01441647.2013.775612

Fishman, E., Washington, S., & Haworth, N. (2014). Bike share's impact on car use: Evidence from the United States, Great Britain, and Australia. *Transportation Research Part D: Transport and Environment, 31*, 13-20. doi:10.1016/j.trd.2014.05.013

Frei, C., Hyland, M., & Mahmassani, H. S. (2017). Flexing service schedules: Assessing the potential for demand-adaptive hybrid transit via a stated preference approach. *Transportation Research Part C: Emerging Technologies, 76*, 71-89. doi:10.1016/j.trc.2016.12.017

Frenken, K., & Schor, J. (2017). Putting the sharing economy into perspective. *Environmental Innovation and Societal Transitions, 23*, 3-10. doi:10.1016/j.eist.2017.01.003

Freudendal-Pedersen, M. (2009). *Mobility in Daily Life, Between Freedom and Unfreedom*: Ashgate Publishing.

Fricker, C., & Gast, N. (2016). Incentives and redistribution in homogeneous bike-sharing systems with stations of finite capacity. *EURO Journal on Transportation and Logistics, 5*(3), 261-291. doi:10.1007/s13676-014-0053-5

Gardner, B. (2009). Modelling motivation and habit in stable travel mode contexts. *Transportation Research Part F: Traffic Psychology and Behaviour, 12*(1), 68-76. doi:10.1016/j.trf.2008.08.001

Gärling, T., & Axhausen, K. W. (2003). Introduction: habitual travel choice. *Transportation, 30*(1), 1-11. doi:10.1023/a:1021230223001

Gärling, T., Fujii, S., & Boe, O. (2001). Empirical tests of a model of determinants of script-based driving choice. *Transportation Research Part F: Traffic Psychology and Behaviour, 4*(2), 89-102. doi:10.1016/S1369-8478(01)00016-X

Geerlings, H., & Stead, D. (2003). The integration of land use planning, transport and environment in European policy and research. *Transport Policy, 10*(3), 187-196. doi:10.1016/S0967-070X(03)00020-9

George, C. (2001). Sustainability appraisal for sustainable development: integrating everything from jobs to climate change. *Impact Assessment and Project Appraisal, 19*(2), 95-106. doi:10.3152/147154601781767104

Giesecke, R., Surakka, T., & Hakonen, M. (2016). *Conceptualising Mobility as a Service. A user centric view on key issues of mobility services.* Paper presented at the Eleventh International Conference on Ecological Vehicles and Renewable Energies (EVER).

Goodall, W., Dovey Fishman, T., Bornstein, J., & Bonthron, B. (2017). The rise of Mobility as a Service. *Deloitte Review*.

Gössling, S. (2017). ICT and transport behaviour: A conceptual review. *International journal of sustainable transportation, 12*(3), 153-164. doi:10.1080/15568318.2017.1338318

Gunay, B., Akgol, K., Andreasson, I., & Terzi, S. (2016). Estimation of Modal Shift Potential for a New Form of Dial-A-Ride Service. *Journal of Public Transportation, 19*(2), 75-88. doi:10.5038/2375-0901.19.2.5

Haahtela, T., & Viitamo, E. (2017). *Searching for the potential of MaaS in commuting - comparison of survey and focus group methods and results.* Paper presented at the 1st International Conference on Mobility-as-a-Service, Tampere, Finland.

Hensher, D. A. (2017). Future bus transport contracts under a mobility as a service (MaaS) regime in the digital age: Are they likely to change? *Transportation Research Part A: Policy and Practice, 98*, 86-96. doi:10.1016/j.tra.2017.02.006

Hensher, D. A. (2018). Tackling road congestion – What might it look like in the future under a collaborative and connected mobility model? *Transport Policy*. doi:10.1016/j.tranpol.2018.02.007

Hietanen, S. (2014). 'Mobility as a Service' - the new transport model? *ITS & Transport Management Supplement. Eurotransport.*, 12(2), 2-4.

Ho, C., Hensher, D. A., Mulley, C., & Wong, Y. (2017). *Prospects for switching out of conventional transport services to mobility as a service subcription plans - A stated choice study*. Paper presented at the International Conference Series on Competition and Ownership in Land Passenger Transport (Thredbo 15). Stockholm, Sweden.

Hull, A. (2005). Integrated transport planning in the UK: From concept to reality. *Journal of Transport Geography, 13*, 318-328. doi:10.1016/j.jtrangeo.2004.12.002

Jain, S., Ronald, N., Thompson, R., & Winter, S. (2017). Predicting susceptibility to use demand responsive transport using demographic and trip characteristics of the population. *Travel Behaviour and Society, 6*, 44-56. doi:10.1016/j.tbs.2016.06.001

Jin, S. T., Kong, H., Wu, R., & Sui, D. Z. (2018). Ridesourcing, the sharing economy, and the future of cities. *Cities, 76*, 96-104. doi:10.1016/j.cities.2018.01.012

Jittrapirom, P., Caiati, V., Feneri, A.-M., Ebrahimigharehbaghi, S., Alonso-González, M., & Narayan, J. (2017). Mobility as a Service: A Critical Review of Defintions, Assessements of Schemes and Key Challenges. *Urban Planning, 2*(2), 13-25. doi:10.17645/up.v2i2.931

Jittrapirom, P., Marchau, V., van der Heijden, R., & Meurs, H. (2018). Future implementation of Mobility as a Service (MaaS): Results of an international Delphi study. *Working Paper of the SCRIPT project. Available at Radboud Repository.*

Jokinen, J.-P., Sihvola, T., & Mladenovic, M. N. (2017). Policy lessons from the flexible transport service pilot Kutsuplus in the Helsinki Capital Region. *Transport Policy*. doi:10.1016/j.tranpol.2017.12.004

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

Kamargianni, M., Matyas, M., & Li, W. (2018). Londoners' attitudes towards car-ownership and Mobility-as-a-Service: Impact assessment and opportunities that lie ahead. MaaSLab - UCL Energy Institute Report, Prepared for Transport for London.

Kamargianni, M., Matyas, M., Li, W., & Schäfer, A. (2015). Feasibility Study for "Mobility as a Service" concept in London. MaaSLab - UCL Energy Institute Report.

Kang, J., Hwang, K., & Park, S. (2016). Finding Factors that Influence Carsharing Usage in Seoul. *Sustainability, 8*. doi:10.3390/su8080709

Karlsson, I. C. M., Sochor, J., Aapaoja, A., Eckhardt, J., & König, D. (2017). Deliverable 4: Impact Assessement *MAASiFiE project funded by CEDR*.

Karlsson, I. C. M., Sochor, J., & Strömberg, H. (2016). Developing the 'Service' in Mobility as a Service: Experiences from a Field Trial of an Innovative Travel Brokerage. *Transportation Research Procedia, 14*, 3265-3273. doi:10.1016/j.trpro.2016.05.273

Kattiyapornpong, U., & Miller, K. (2007). *Differences within and between travel preference, planned travel and choice behaviour of Australians travelling to Asians and overseas destinations.* Paper presented at the Council of Australasian University and Hospitality Education: Tourism: Past achievements, future challenges, Sydney University of Technology, Australia.

Kent, J. L. (2015). Still Feeling the Car – The Role of Comfort in Sustaining Private Car Use. *Mobilities, 10*(5), 726-747. doi:10.1080/17450101.2014.944400

Kenyon, S., & Lyons, G. (2003). The value of integrated multimodal traveller information and its potential contribution to modal change. *Transportation Research Part F: Traffic Psychology and Behaviour, 6*(1), 1-21. doi:10.1016/S1369-8478(02)00035-9

KiM. (2015). Carsharing in the Netherlands: Trends, user characteristics and mobility effects [Netherlands Institute for Transport Policy Analysis].

KiM. (2017). Trends in perception of mobility (in Dutch) [Netherlands Institute for Transport Policy Anlaysis].

Kitchenham, B., & Charters, S. (2007). Guidelines for performing Systematic Literature Reviews in Software Engineering. EBSE Technical Report.

König, D., Eckhardt, J., Aapaoja, A., Sochor, J., & Karlsson, I. C. M. (2016). Deliverable 3: Business and operator models for MaaS. *MAASiFiE project funded by CEDR*.

König, D., Piri, E., Karlsson, I. C. M., Sochor, J., & Heino, I. (2017). Deliverable 5: Technology for MaaS. MAASiFiE project funded by CEDR.

Kroesen, M., Handy, S., & Chorus, C. (2017). Do attitudes cause behavior or vice versa? An alternative conceptualization of the attitude-behavior relationship in travel behavior modeling. *Transportation Research Part A: Policy and Practice, 101*, 190-202. doi:10.1016/j.tra.2017.05.013

L.E.K. (n.d.). Development of Mobility-as-a-Service (MaaS) Pilots for New Zealand Transport Agency. Retrieved from https://www.lek.com/insights/development-mobility-service-maas-pilots-new-zealand-transport-agency-0. Accessed on July 19th, 2018

Laakso, S. (2017). Giving up cars – The impact of a mobility experiment on carbon emissions and everyday routines. *Journal of Cleaner Production, 169*, 135-142. doi:10.1016/j.jclepro.2017.03.035

Lamberton, C. P., & Rose, R. L. (2012). When is ours better than mine? A framework for understanding and altering participation in commercial sharing systems. *Journal of Marketing, 76*(4), 109-125. doi:10.1509/jm.10.0368

Langlois, M., Wasfi, R. A., Ross, N. A., & El-Geneidy, A. M. (2016). Can transit-oriented developments help achieve the recommended weekly level of physical activity? *Journal of Transport & Health, 3*(2), 181-190. doi:10.1016/j.jth.2016.02.006

Lanzendorf, M. (2003). *Mobility biographies. A new perspective for understanding travel behaviour*. Paper presented at the 10th International Conference on Travel Behaviour Research, Lucerne, Switzerland.

Laws, R. (2009). Evaluating publicly-funded DRT schemes in England and Wales. *PhD Thesis, Loughborough University*.

Le Vine, S., & Polak, J. (2017). The impact of free-floating carsharing on car ownership: Early-stage findings from London. *Transport Policy*. doi:10.1016/j.tranpol.2017.02.004

Loose, W. (2010). The State of European Car-Sharing. Energy-efficient mobility through car-sharing, funded by the programme Intelligent Energy Europe.

Louviere, J., Hensher, D. A., & Swait, J. (2000). *Stated Choice Methods: Analysis and Applications*: Cambridge University Press.

Lund, E. (2016). Feasibility study MaaS-A business case for EC2B.

Lund, H. (2006). Reasons for Living in a Transit-Oriented Development, and Associated Transit Use. *Journal of the American Planning Association, 72*(3), 357-366. doi:10.1080/01944360608976757

MaaS Alliance. (2017). MaaS Alliance partners with Uber to support shared mobility. Retrieved from https://maas-alliance.eu/maas-alliance-partners-uber-support-shared-mobility/. Accessed on February 12th, 2018

MaaS Global. (2016). MaaS Global expanding to Asia with its all-in mobility app Whim. Retrieved from http://maas.global/maas-global-expanding-to-asia-with-its-all-in-mobility-app-whim/. Accessed on July 19th, 2018

MaaS Global. (2018). Whim Helsinki - Find your plan. Retrieved from https://whimapp.com/monthly-plans/. Accessed on February 22nd, 2018.

Martens, K. (2007). Promoting bike-and-ride: The Dutch experience. *Transportation Research Part A: Policy and Practice, 41*(4), 326-338. doi:10.1016/j.tra.2006.09.010

Martin, E. W., & Shaheen, S. A. (2011). Greenhouse Gas Emission Impacts of Carsharing in North America. *IEEE transactions on intelligent transportation systems, 12*(6), 2011. doi:10.1109/TITS.2011.2158539

Martin, E. W., & Shaheen, S. A. (2014). Evaluating public transit modal shift dynamics in response to bikesharing: a tale of two U.S. cities. *Journal of Transport Geography, 41*, 315-324. doi:10.1016/j.jtrangeo.2014.06.026

Martin, E. W., & Shaheen, S. A. (2016). Impacts of Car2Go on vehicle ownership, modal shift, vehicle miles traveled and greenhouse gas emissions: an analysis of five North American Cities. *Working paper of the Transportation Sustainability Research Center at UC Berkeley*.

Martin, E. W., Shaheen, S. A., & Lidicker, J. (2010). Impact of Carsharing on Household Vehicle Holdings. *Transportation Research Record: Journal of the Transportation Research Board, 2143*, 150-158. doi:10.3141/2143-19

Matas, A. (2004). Demand and Revenue Implications of an Integrated Public Transport Policy: The Case of Madrid. *Transport Reviews, 24*(2), 195-217. doi:10.1080/0144164032000107223

Matsumoto, T., & Hidaka, K. (2015). Evaluation the effect of mobile information services for public transportation through the empirical research on commuter trains. *Technology in Society, 43*, 144-158. doi:10.1016/j.techsoc.2015.08.001

Matyas, M., & Kamargianni, M. (2017). *Stated Preference Design for exploring Demand for "Mobility as a Service" Plans*. Paper presented at the 5th International Choice Modelling Conference, Cape Town, South Africa.

Matyas, M., & Kamargianni, M. (2018). The potential of Mobility as a Service bundles as a mobility management tool. *Transportation, Published online on August 6th 2018*. doi:10.1007/s11116-018-9913-4

Moeller, S., & Wittkowski, K. (2010). The burdens of ownership: reasons for preferring renting. *Managing Service Quality: An International Journal, 20*(2), 176-191. doi:10.1108/09604521011027598

Motta, G., Ferrara, A., Sacco, D., You, L., & Cugola, G. (2013). Integrated Mobility: A Research in Progress. *Journal of Software Engineering and Applications, 6*, 97-101. doi:10.4236/jsea.2013.63b021

MuConsult. (2017). White Paper Mobility as a Service in the Netherlands (in Dutch).

Mukhtar-Landgren, D., Karlsson, I. C. M., Koglin, T., Kronsell, A., Lund, E., Sarasini, S., . . . Wendle, B. (2016). Institutional conditions for integrated mobility services (IMS): Towards a framework for analysis. K2 Working Papers.

Mulley, C., & Nelson, J. D. (2009). Flexible transport services: A new market opportunity for public transport. *Research in Transportation Economics, 25*(1), 39-45. doi:10.1016/j.retrec.2009.08.008

Muñoz, P., & Cohen, B. (2017). Mapping out the sharing economy: A configurational approach to sharing business modeling. *Technological Forecasting and Social Change, 125*, 21-37. doi:10.1016/j.techfore.2017.03.035

Namazu, M., MacKenzie, D., Zerriffi, H., & Dowlatabadi, H. (2018). Is carsharing for everyone? Understanding the diffusion of carsharing services. *Transport Policy, 63*, 189-199. doi:10.1016/j.tranpol.2017.12.012
NEA and partners. (2003). Integration and regulatory structures in public transport. Study commissioned by the European Commission, DG TREN.
Newman, P. W. G., & Kenworthy, J. R. (1996). The land use—transport connection: An overview. *Land Use Policy, 13*(1), 1-22. doi:10.1016/0264-8377(95)00027-5
OECD ITF. (2017). Shared Mobility Simulations for Helsinki. Case-Specific Policy Analysis.
Oinas-Kukkonen, H. (2010). *Behavior change support systems: A research model and agenda.* Paper presented at the 5th International Conference on Persuasive Technology, Copenhagen, Denmark.
Paundra, J., Rook, L., van Dalen, J., & Ketter, W. (2017). Preferences for car sharing services: Effects of instrumental attributes and psychological ownership. *Journal of Environmental Psychology, 53*, 121-130. doi:10.1016/j.jenvp.2017.07.003
Pendyala, R., Parashar, A., & Muthyalagari, G. (2001). *Measuring day-to day variability in travel characteristics using GPS data.* Paper presented at the 79th Annual Meeting of the Transportation Research Board (TRB), Washington D.C., United States.
Pick&Mix. (2017). The consortium - Pick&Mix project. Retrieved from http://www.pickandmixproject.com/about/. Accessed on July 19th, 2018
Potter, S., & Skinner, M. (2000). On transport integration: a contribution to better understanding. *Futures, 32*, 275-287. doi:10.1016/S0016-3287(99)00097-X.
Poushter, J. (2017). Smartphones are common in advanced economies, but digital divide remains. Pew Research Center. Retrieved from http://www.pewresearch.org/fact-tank/2017/04/21/smartphones-are-common-in-advanced-economies-but-digital-divides-remain/. Accessed on June 11th, 2018.
Preston, J. (2010). What's so funny about peace, love and transport integration? *Research in Transportation Economics, 29*(1), 329-338. doi:10.1016/j.retrec.2010.07.042
Preston, J. (2012). Integration for Seamless Transport. Discussion Paper at the International Transport Forum (ITF).
Primerano, F., Taylor, M. A. P., Pitaksringkarn, L., & Tisato, P. (2008). Defining and understanding trip chaining behaviour. *Transportation, 35*(1), 55-72. doi:10.1007/s11116-007-9134-8
Pronello, C., Duboz, A., & Rappazzo, V. (2017). Towards Smarter Urban Mobility: Willingness to Pay for an Advanced Traveller Information System in Lyon. *Sustainability, 9*(10), 1690. doi:10.3390/su9101690
Rantasila, K. (2015, 23-25 Nov. 2015). *The impact of Mobility as a Service concept to land use in Finnish context.* Paper presented at the International Conference on Sustainable Mobility Applications, Renewables and Technology (SMART), Kuwait.
Ratilainen, H. (2017). Exploring Consumer Preferences for MaaS Subscription Packages using a Stated Choice Experiment. *Master Thesis, Delft University of Technology*.
Rayle, L., Dai, D., Chan, N., Cervero, R., & Shaheen, S. A. (2016). Just a better taxi? A survey-based comparison of taxis, transit, and ridesourcing services in San Francisco. *Transport Policy, 45*, 168-178. doi:10.1016/j.tranpol.2015.10.004
Redman, L., Friman, M., Gärling, T., & Hartig, T. (2013). Quality attributes of public transport that attract car users: A research review. *Transport Policy, 25*, 119-127. doi:10.1016/j.tranpol.2012.11.005
Reinders, M., Frambach, R., & Schoormans, J. (2010). Using Product Bundling to Facilitate the Adoption Process of Radical Innovations. *Journal of Product innovation Management, 27*(7), 1127-1140. doi:10.1111/j.1540-5885.2010.00775.x
Ricci, M. (2015). Bike sharing: A review of evidence on impacts and processes of implementation and operation. *Research in Transportation Business & Management, 15*, 28-38. doi:10.1016/j.rtbm.2015.03.003
Rogers, E. M. (2003). *Diffusion of innovations* (Fifth ed.): Simon and Schuster.

Santi, P., Resta, G., Szell, M., Sobolevsky, S., Strogatz, S. H., & Ratti, C. (2014). Quantifying the benefits of vehicle pooling with shareability networks. *Proceedings of the National Academy of Sciences, 111*(37), 13290-13249.

Sarasini, S., Sochor, J., & Arby, H. (2017). *What characterises a sustainable MaaS business model?* Paper presented at the 1st International Conference on Mobility-as-a-Service, Tampere, Finland.

Sarin, S., Sego, T., & Chanvarasuth, N. (2003). Strategic use of bundling for reducing consumers' perceived risk associated with the purchase of new high-tech products. *Journal of Marketing Theory and Practice, 11*(3), 71-83. doi:10.1080/10696679.2003.11658502

Schade, W., Krail, M., & Kühn, A. (2014). *New mobility concepts: myth or emerging reality?* Paper presented at the 5th Transport Research Arena (TRA), Paris, France.

Schäfer, M., Jaeger-Erben, M., & Bamberg, S. (2012). Life Events as Windows of Opportunities for Changing Towards Sustainable Consumption Patterns? *Journal of Consumer Policy, 35*, 65-84. doi:10.1007/s10603-011-9181-6

Schaller, B. (2017). Unsustainable? The Growth of App-Based Ride Services and Traffic, Travel and the Future of New York City. Schaller Consulting Report.

Scott, D. M., & Axhausen, K. W. (2006). Household Mobility Tool Ownership: Modeling Interactions between Cars and Season Tickets. *Transportation, 33*(4), 311-328. doi:10.1007/s11116-005-0328-7

Selwyn, N. (2004). Reconsidering political and popular understandings of the digital divide. *New media & society, 6*(3), 341-362.

Sener, I. N., Eluru, N., & Bhat, C. R. (2009). An analysis of bicycle route choice preferences in Texas, US. *Transportation, 36*(5), 511-539. doi:10.1007/s11116-009-9201-4

Serenko, A., & Bontis, N. (2011). What's familiar is excellent: The impact of exposure effect on perceived journal quality. *Journal of Informetrics, 5*(1), 219-223. doi:10.1016/j.joi.2010.07.005

SFCTA. (2017). TNCs Today: A Profile of San Francisco Transportation Network Company Activity. San Francisco County Transportation Authority. Retrieved from https://www.sfcta.org/tncstoday. Accessed on June 4th, 2018.

Shaheen, S. A., Chan, N., Bansal, A., & Cohen, A. P. (2015). Shared Mobility White Paper: Definitions, Industry Developments and Early Understanding. UC Berkeley Transportation Sustainability Research Center and Caltrans.

Shaheen, S. A., Cohen, A. P., & Chung, M. S. (2009). North American Carsharing. *Transportation Research Record: Journal of the Transportation Research Board, 2110*, 35-44. doi:10.3141/2110-05

Shaheen, S. A., Mallery, M. A., & Kingsley, K. J. (2012). Personal vehicle sharing services in North America. *Research in Transportation Business & Management, 3*, 71-81. doi:10.1016/j.rtbm.2012.04.005

Shaheen, S. A., Martin, E. W., & Cohen, A. P. (2013). Public Bikesharing and Modal Shift Behaviour: A Comparative Study of Early Bikesharing Systems in North America. *International Journal of Transportation, 1*(1), 35-54. doi:10.14257/ijt.2013.1.1.03

Simma, A., & Axhausen, K. W. (2001). Structures of commitment in mode use: a comparison of Switzerland, Germany and Great Britain. *Transport Policy, 8*(4), 279-288. doi:10.1016/S0967-070X(01)00023-3

Sioui, L., Morency, C., & Trépanier, M. (2013). How Carsharing Affects the Travel Behavior of Households: A Case Study of Montréal, Canada. *International journal of sustainable transportation, 7*(1), 52-69. doi:10.1080/15568318.2012.660109

Skoglund, T., & Karlsson, I. C. M. (2012). Appreciated - but with a fading grace of novely! Traveller's assessment of, usage of and behavioural change given access to a co-modal travel planner. *Procedia - Social and Behavioral Sciences, 48*, 932-940. doi:10.1016/j.sbspro.2012.06.1070

Smile mobility. (2015). Results of the smile pilot. Retrieved from smile-einfachmobil.at/pilotbetrieb_en.html#dieergebnisse. Accessed on December 6th, 2017.

Smith, G., Sochor, J., & Karlsson, I. C. M. (2018). Mobility as a Service: Development scenarios and implications for public transport. *Research in Transportation Economics*. doi:10.1016/j.retrec.2018.04.001

Smith, J. R., & Louis, W. (2007). Do As We Say and As We Do: The Interplay of Descriptive and Injunctive Group Norms in the Attitude-Behaviour Relationship. *British Journal of Social Psychology, 47*, 647-666. doi:10.1348/014466607X269748

Sochor, J., Arby, H., Karlsson, I. C. M., & Sarasini, S. (2017). *A topological approach to Mobility as a Service: A proposed tool for understanding requirements and effects, and for aiding the integration of social goals.* Paper presented at the 1st International Conference on Mobility-as-a-Service, Tampere, Finland.

Sochor, J., Karlsson, I. C. M., & Strömberg, H. (2016). Trying out Mobility as a Service: Experiences from a field trial and implications for understanding demand. *Transportation Research Record: Journal of the Transportation Research Board, 2542*. doi:10.3141/2542-07

Sochor, J., Strömberg, H., & Karlsson, I. C. M. (2015). Challenges in integrating user, commercial and societal perspectives in an innovative mobility service. *Transportation Research Record: Journal of the Transportation Research Board, 2536*.

Spaargaren, G. (1997). *The ecological modernization of production and consumption: Essays in environmental sociology*: Spaargaren.

Spickermann, A., Grienitz, V., & von der Gracht, H. A. (2014). Heading towards a multimodal city of the future?: Multi-stakeholder scenarios for urban mobility. *Technological Forecasting and Social Change, 89*, 201-221. doi:10.1016/j.techfore.2013.08.036

Steg, L. (2005). Car use: lust and must. Instrumental, symbolic and affective motives for car use. *Transportation Research Part A: Policy and Practice, 39*(2), 147-162. doi:10.1016/j.tra.2004.07.001

Stephany, A. (2015). *The business of sharing: Making it in the new sharing economy*: Springer.

Stiglic, M., Agatz, N., Savelsbergh, M., & Gradisar, M. (2018). Enhancing urban mobility: Integrating ride-sharing and public transit. *Computers & Operations Research, 90*, 12-21. doi:10.1016/j.cor.2017.08.016

Stopka, U. (2014). Identification of User Requirements for Mobile Applications to Support Door-to-Door Mobility in Public Transport. *International Conference on Human-Computer Interaction*, 513-524.

Strömberg, H. (2015). Creating space for action-Supporting behaviour change by making sustainable transport opportunities available in the world and in the mind. *PhD Thesis, Chalmers University of Technology*.

Strömberg, H., Karlsson, I. C. M., & Sochor, J. (2018). *Inviting travelers to the smorgasbord of sustainable urban transport: evidence from a MaaS field trial*. Paper presented at the 97th Annual Meeting of the Transportation Research Board (TRB), Washington D.C., United States.

Strömberg, H., Rexfelt, O., Karlsson, I. C. M., & Sochor, J. (2016). Trying on change – Trialability as a change moderator for sustainable travel behaviour. *Travel Behaviour and Society, 4*, 60-68. doi:10.1016/j.tbs.2016.01.002

Suiker, S., & van den Elshout, J. (2013). *Measurement of the effects of the introduction of the Car2Go concept in Amsterdam (in Dutch)*. Paper presented at the Dutch National Traffic Convention.

Sunio, V., & Schmöcker, J.-D. (2017). Can we promote Sustainable Travel Behavior Through Mobile Apps? Evalution and Review of Evidence. *International journal of sustainable transportation, 11*(8), 553-566.

Swait, J. (1994). A structural equation model of latent segmentation and product choice for cross-sectional revealed preference choice data. *Journal of Retailing and Consumer Services, 1*(2), 77-89. doi:10.1016/0969-6989(94)90002-7

Tachet, R., Sagarra, O., Santi, P., Resta, G., Szell, M., Strogatz, S. H., & Ratti, C. (2017). Scaling Law of Urban Ride Sharing. *Nature Scientific Reports, 7*. doi:10.1038/srep42868

Tang, L., & Thakuriah, P. (2011). Will the psychological effects of real-time transit information systems lead to ridership gain? *Transportation Research Record: Journal of the Transportation Research Board, 2216*. doi:10.3141/2216-08

Tang, L., & Thakuriah, P. (2012). Ridership effects of real-time bus information system: A case study in the City of Chicago. *Transportation Research Part C: Emerging Technologies, 22*, 146-161. doi:10.1016/j.trc.2012.01.001

TCRP. (2004). Demand Responsive/ADA Traveler Response to Transportation System Changes (Transit Cooperative Research Program) *Synthesis Report 95, Federal Transit Administration, Washington D.C.*

ter Berg, J., & Schothorst, Y. (2015). *Car sharing in the near future (in Dutch). Veldkamp*. Retrieved from

Tertoolen, G., van Kreveld, D., & Verstraten, B. (1998). Psychological resistance against attempts to reduce private car use. *Transportation Research Part A: Policy and Practice, 32*(3), 171-181. doi:10.1016/S0965-8564(97)00006-2

The Economist. (2013). Daily chart: The cost of driving. Retrieved from https://www.economist.com/graphic-detail/2013/04/04/the-cost-of-driving. Accessed on May 29th, 2018

The Economist. (2016). It starts with a single app. *The Economist.* Accessed on June 22nd, 2018

Thøgersen, J. (2012). The importance of timing for breaking commuters' car driving habits. In Alan Warde & Dale Southerton (Ed.), *The Habits of Consumption* (Vol. 12, pp. 130-140). Helsinki: Helsinki Collegium for Advanced Studies.

Turrentine, T. S., & Kurani, K. S. (2007). Car buyers and fuel economy? *Energy Policy, 35*(2), 1213-1223. doi:10.1016/j.enpol.2006.03.005

UbiGo. (2017). UbiGo and Fluidtime pave new ways of mobility in Sweden. Press release, Gothenburg, October 17th, 2017.

Utriainen, R., & Pöllänen, M. (2017). *Review on Mobility as a Service in scientific literature*. Paper presented at the 1st International Conference on Mobility as a Service (ICoMaaS), Tampere, Finland.

Van Exel, N. J. A., & Rietveld, P. (2009). Could you also have made this trip by another mode? An investigation of perceived travel possibilities of car and train travellers on the main travel corridors to the city of Amsterdam, The Netherlands. *Transportation Research Part A: Policy and Practice, 43*(4), 374-385. doi:10.1016/j.tra.2008.11.004

Van Hagen, M., & Bron, P. (2013). *Enhancing the experience of the train journey: chaning the focus from satisfaction to the emotional experience of customers.* Paper presented at the 41st European Transport Conference (ETC), Frankfurt, Germany.

Van Wee, B., & Banister, D. (2016). How to Write a Literature Review Paper? *Transport Reviews, 36*(2), 278-288. doi:10.1080/01441647.2015.1065456

Vedagiri, P., & Arasan, V. T. (2009). Modelling modal shift due to the enhanced level of bus service. *Transport, 24*(2), 121-128.

Verplanken, B., Aarts, H., & van Knippenberg, A. (1997). Habit, information acquisition, and the process of making travel mode choices. *European Journal of Social Psychology, 27*, 539-560. doi:10.1002/(SICI)1099-0992(199709/10)27:53.0

Verplanken, B., & Roy, D. (2016). Empowering interventions to promote sustainable lifestyles: Testing the habit discontinuity hypothesis in a field experiment. *Journal of Environmental Psychology, 45*, 127-134. doi:10.1016/j.jenvp.2015.11.008

Wang, C., Quddus, M., Enoch, M., Ryley, T., & Davison, L. (2014). Multilevel modelling of Demand Responsive Transport (DRT) trips in Greater Manchester based on area-wide socio-economic data. *Transportation, 41*(3), 589-610. doi:10.1007/s11116-013-9506-1

Watkins, K. E., Ferris, B., Borning, A., Rutherford, G. S., & Layton, D. (2011). Where Is My Bus? Impact of mobile real-time information on the perceived and actual wait time of transit riders. *Transportation Research Part A: Policy and Practice, 45*(8), 839-848. doi:10.1016/j.tra.2011.06.010

Weckström, C., Mladenovic, M. N., & Ullah, W. (2017). User Perspectives on Emerging Mobility Services: Ex Post Analysis of Kutsuplus Pilot. Presentation at Aalto University, School of Engineering.

Wong, Y. (2017). *Emerging transport technologies and the modal efficiency framework: A case for Mobility-as-a-Service (MaaS)* Paper presented at the International Conference Series on Competition and Ownership in Land Passenger Transport (Thredbo 15), Stockholm, Sweden.

Woods, R., & Masthoff, J. (2017). A comparison of car driving, public transport and cycling experiences in three European cities. *Transportation Research Part A: Policy and Practice, 103*, 211-222. doi:10.1016/j.tra.2017.06.002

Yang, X.-H., Cheng, Z., Chen, G., Wang, L., Ruan, Z.-Y., & Zheng, Y.-J. (2018). The impact of a public bicycle-sharing system on urban public transport networks. *Transportation Research Part A: Policy and Practice, 107*, 246-256. doi:10.1016/j.tra.2017.10.017

Zografos, K. G., Androutsopoulos, K. N., & Apospori, E. (2012). User Acceptance and Willingness to Pay for the Use of Multimodal Trip Planning Systems. *Procedia - Social and Behavioral Sciences, 48*, 2405-2414. doi:10.1016/j.sbspro.2012.06.1211

Appendix A

Based on a literature review of peer-reviewed studies on all aspects of MaaS, Jittrapirom et al. (2017) proposed nine core characteristics of MaaS. These core characteristics are (in no particular hierarchical order):

1 The integration of transport modes, in which multiple modes are combined in one single platform, thereby allowing users to take trips using multiple modes. These modes can be both traditional modes (public transport, private cars and bicycles) and shared mobility modes.
2 The tariff option, i.e. the fact that MaaS platforms offer a choice between pay-as-you-go and mobility packages (containing certain amounts of kilometres-minutes-points that can be used for travelling in exchange for a monthly subscription fee).
3 A single platform, where users can plan, book, pay for and get tickets for their trips, as well as find real-time information.
4 Multiple actors, from customers and providers to platform owners, data management companies, and authorities amongst others, because MaaS is built on the interaction between such various parties.
5 The use of technologies, because MaaS relies on smartphones, Internet networks, ICT and data systems.
6 Demand orientation, as MaaS is a user-centric paradigm seeking to offer tailored solutions to users.
7 Registration requirement, which both facilitates use of the service and allows for customisation.
8 Personalisation that ensures the needs of users are met more efficiently. Travel history and expressed preferences serve to provide tailored recommendations.
9 Customisation, enabling users to modify the offered option based on their preferences.

These core characteristics can be translated into relevant research themes pertaining to travel preferences and travel behaviour. How might each of these core characteristics influence travel behaviour and travel preferences? For example, the first core characteristic raises two questions about travel preferences and behaviour. Given that the supply of shared mobility modes has grown in the past decade, to what extent have they influenced travel preferences and behaviour? Further, in terms of travel behaviour, what are the findings of experiments on transport integration? Table A.1 summarises these topics, some of which are common to multiple core characteristics.

Table A.1 Core characteristics of MaaS and relevant themes pertaining to travel behaviour and preferences.

Core characteristics of MaaS	Relevant themes from the angle of travel preferences and travel behaviour
Integration of transport modes	Shared mobility modes and travel behaviour/preferences Mobility integration and travel behaviour/preferences
Tariff option	Mobility integration and travel behaviour/preferences
One platform	ICT (esp. mobile/tablet applications) and transport behaviour Mobility integration and travel behaviour/preferences
Multiple actors	Mobility integration and travel behaviour/preferences
User of technologies	ICT (esp. mobile/tablet applications) and transport behaviour
Demand orientation	ICT (esp. mobile/tablet applications) and transport behaviour
Registration requirement	ICT (esp. mobile/tablet applications) and transport behaviour
Personalisation	ICT (esp. mobile/tablet applications) and transport behaviour
Customisation	ICT (esp. mobile/tablet applications) and transport behaviour

In summary, three main themes of interest emerged for the explorative literature study:

- Mobility integration, travel behaviour and preferences,
- ICT and travel behaviour; here, we mainly focus on applications,
- Shared mobility modes, travel behaviour and preferences.

These themes will be explored separately with relevant literature; see sections 3.2, 3.3 and 3.4. From these nine core characteristics, the user orientation is quite clear. According to Jittrapirom et al. (2017), a number of studies argue that the strategic goal of such intense user orientation is to achieve more sustainable transport patterns by providing people with personalised alternatives to private cars (Chowdhury & Ceder, 2016; Giesecke et al., 2016; König et al., 2016). Consequently, car ownership, and the willingness to shift from the car ownership paradigm, are other relevant themes to address in this explorative literature review; they are discussed in section 3.1, on travel behaviour and travel habits.

Appendix B

The literature review in this section is based on a selection of studies following multiple criteria. In June 2017, Utriainen and Pöllänen (2017) searched for “Mobility as a Service” in both the Scopus and ScienceDirect databases, compiling only peer-reviewed scientific articles and conference articles. In Scopus, they found 37 papers containing the term either in their titles, abstracts or keywords. Just under a year later that number had increased to 61. In ScienceDirect, the researchers found 33 peer-reviewed scientific articles and conference articles, while today that number has doubled to 66, with more papers published in early 2018 than in any other previous year. Since our literature study focuses on shifts in travel preferences and travel behaviour with MaaS, we searched the same databases three times (peer-reviewed journal articles and conference papers) with the following keywords (in all fields):

- Query 1: “Mobility as a Service” and “travel behaviour” (or “travel behaviour”). This yielded 11 papers in Scopus (four of which are conference papers), and 19 journal articles in ScienceDirect. Three papers were found in both databases, hence 27 unique papers were found with this query.
- Query 2: “Mobility as a Service” and “travel preference”. This yielded no papers in Scopus and two journal articles in ScienceDirect, one of which having already appeared in the previous query. This query therefore found one unique new paper.
- Query 3: “Mobility as a Service” and “modal shift”. This yielded one journal article in Scopus that had already appeared in Query 1, and 13 journal articles in ScienceDirect, of which four had already appeared in previous queries. This query therefore found nine new papers.

Of these 37 papers, 33 are not specifically focused on potential users and shifts in travel behaviour with MaaS; these papers primarily deal with perspectives beyond the scope of this study, or MaaS and users are only mentioned incidentally, or they focus on defining MaaS while referring to the findings of the four remaining relevant papers. Because four studies are not enough for a literature review, forward and backward snowballing techniques are used and applied to the four selected papers. To broaden the scope even more, forward snowballing was also applied to some of the 33 other relevant papers; in particular, those dealing with perspectives within the scope of our research were used as starting points for forward snowballing. The snowballing techniques are described in Van Wee and Banister (2016). Kitchenham and Charters (2007) consider these techniques as useful additions to systematic database searches. Forward snowballing yielded five additional relevant papers, while backward snowballing yielded four additional papers, of which three are overlapping. Note that, due to the limited amount of peer-reviewed research found, we decided to include four non-peer-reviewed studies in the selection, using the forward snowballing technique, of which one is an extension of a selected peer-reviewed conference paper. A second was included because it uses a Stated Preference experiment, which is particularly popular for studying the potential impacts of MaaS. A third is a study only available via a website, but is included because it is one of the only sources for results of an Austrian MaaS pilot. And the fourth study is a European report, included because it provides in-depth evaluations of two MaaS pilots, thereby providing extra information, as compared to sources directly related to each pilot. The final selection contains 14 studies and is detailed in Table B.1. The type of study (conference paper, journal article, other) is indicated, as are the main techniques used for gaining insights into MaaS and potential users.

Table B.1 Results from the systematic literature search of Mobility as a Service and its potential impacts on travel preferences and behaviour, conducted in May 2018. Listed in order of appearance in the systematic search.

Year	Authors	Type of paper	Type of study and research method	Country/region where the study is conducted	Q1[1]	Q2[2]	Q3[3]	FS[4]	BS[5]
2018	Smith, Sochor and Karlsson	Journal article	Development of MaaS scenarios through interviews	West Sweden	x		x		
2016	Karlsson, Sochor and Strömberg	Journal article	Evaluation of a MaaS pilot (qualitative and quantitative).	Gothenburg (Sweden)	x				
2016	Strömberg, Rexfelt, Karlsson and Sochor	Journal article	Comparative analysis including a MaaS pilot.	Gothenburg (Sweden)	x	x	x		
2015	Sochor, Strömberg and Karlsson	Journal article	Evaluation of a MaaS pilot (qualitative and quantitative)	Gothenburg (Sweden)	x				
2017	Ho, Hensher, Mulley and Wong	Conference paper	Stated Preference experiment on MaaS monthly bundles.	Sydney (Australia)				x	x
2017	Alonso-Gonzáles, Van Oort, Cats and Hoogendoorn	Conference paper	Stated Preference experiment on mode choice.	Amsterdam (The Netherlands)				x	
2016	Sochor, Karlsson and Strömberg	Journal article	Evaluation of a MaaS pilot (qualitative and quantitative)	Gothenburg (Sweden)				x	x
2018	Strömberg, Karlsson and Sochor	Conference paper	Evaluation of a MaaS pilot (qualitative and quantitative)	Gothenburg (Sweden)				x	x
2018	Matyas and Kamargianni	Journal paper*	Stated Preference experiment on MaaS monthly bundles.	London (UK)				x	
2017	Haahtela and Viitamo	Conference paper	Evaluation of the potential of MaaS through a survey and focus groups (qualitative and quantitative)	Finland					x
2018	Kamargianni, Matyas, Li and Muscat	Other: Report	Survey (attitudinal research).	London (UK)				x	
2017	Ratilainen	Other: Master Thesis	Stated Preference experiment on MaaS monthly bundles.	Helsinki (Finland)				x	
2015	Smile mobility	Other: Report (website page)	Evaluation of a MaaS pilot (qualitative and quantitative).	Vienna (Austria)					x
2017	Karlsson, Sochor, Aapaoja, Eckhardt, König	Other: Report	Impact assessment of MaaS, focused on in-depth evaluations of Smile and UbiGo.	-				x	x

1: Query 1
2: Query 2
3: Query 3
4: Forward Snowballing (studies with citations to at least one the four original papers)
5: Backward Snowballing (studies cited in at least one of the five original papers).
* When this literature study was conducted, this journal paper had not appeared yet. A conference paper from the 97th Annual Meeting of the Transportation Research Board in Washington from the same authors and with similar results was used.

Colophon

This is a publication by the Ministry of Infrastructure and Water Management
September 2018
KiM | Netherlands Institute for Transport Policy Analysis

ISBN/EAN
978-90-8902-195-3
KiM-18-A17

Authors
Anne Durand, Lucas Harms, Sascha Hoogendoorn-Lanser, Toon Zijlstra

Vormgeving en opmaak
VormVijf, The Hague

KiM Netherlands Institute for Transport Policy Analysis
P.O. Box 20901
2500 EX The Hague
Netherlands
Telephone: +31 (0)70 456 19 65

Website: http://english.kimnet.nl
E-mail: info@kimnet.nl

KiM publications can be downloaded as pdf files from our website: http://english.kimnet.nl.
You may also contact one of our staff members.

The KiM Netherlands Institute for Transport Policy Analysis conducts mobility analyses that are subsequently incorporated in national transportation policy. As an independent institute within the Dutch Ministry of Infrastructure and Water Management, KiM provides strategic research and policy analysis. The content of KiM publications is independent and does not need to reflect the views held by the minister and/or state secretary of the Infrastructure and Water Management ministry.

The KiM Netherlands Institute
for Transport Policy Analysis

This is a publication by the

Ministry of Infrastructure and Water Management

P.O. Box 20901 | 2500 EX The Hague
www.rijksoverheid.nl/ienm

http://english.kimnet.nl

ISBN: 978-90-8902-195-3

September 2018 | KiM-18-A17