Limitations to the car-substitution effect of MaaS. Findings from a Belgian pilot study

ABSTRACT

Mobility-as-a-Service (MaaS) has received widespread attention over the past couple of years amongst scholars, businesses, policymakers and mainstream media. Most coverage is oriented towards its possible gains for traveling individuals and the travel industry, while still lacking conceptual clarity and sufficient detail about its potential acceptance by the general public. This leads to varying perspectives on what MaaS precisely is and will be in the near future. In this study, we reflect upon the relationship between MaaS use and private car ownership, based on insights gained from a MaaS pilot study organized mid-2017 in Ghent (Belgium). This exploratory pilot study targeted 100 car-owning participants (i.e., Ghent University employees) and explored how these motivated people can replace or significantly reduce car use in return for a monthly mobility budget which they could spend on MaaS services. The study reveals that most respondents were apt to explore MaaS services (especially public transport and car sharing services), but a clear reduction of private car use remained difficult in a real-life setting. Despite being highly motivated to reduce car use and being given incentives, participants faced considerable difficulties in bypassing their personal car, especially for (non-repetitive) leisure trips. By drawing parallels with a similar debate in the transport literature from a couple of decades ago, we suggest that MaaS should be regarded as a complement – rather than a substitution – of private car use in the near future. The relationship between MaaS use and car ownership might in reality be more complex than generally acknowledged. In addressing these parallels, the paper opens up new critical questions for MaaS research in the future.

KEYWORDS

Mobility-as-a-Service; Car ownership; Travel mode shift; Mobility transition; Travel behavior; Ghent (Belgium)

HIGHLIGHTS

- Despite increased attention for MaaS, well-designed pilot studies are rare
- Results from an exploratory MaaS pilot study (100 participants) are presented
- Findings suggest MaaS mainly complements car possession and car use
- Interrelation between MaaS and private car is bound to be complex

1. INTRODUCTION

Mobility-as-a-Service (MaaS) is a mobility concept that has emerged over the past few years as a potential game-changer with regards to the way people travel. For one, MaaS claims to steer people away from personal car ownership to increased active travelling (i.e., walking and cycling), vehicle sharing, and multimodality. This bears the promise of a much-needed transition towards more sustainable and efficient mobility systems. Across Europe, the majority of people still travel by car on a daily basis (European Commission, 2013), despite signs of car ownership saturation and peak car (Focas & Christidis, 2017; Goodwin & Van Dender, 2013; Metz, 2013). Given the car's negative externalities, a considerable number of policymakers and transport planners are urgently seeking ways to change our travel behavior. It would appear that MaaS will partly solve

problems such as congestion, carbon emissions, air pollution, and shortage of parking space in the near future. Research consultancy firms state that MaaS will replace billions of private car journeys per year (e.g., Maynard, 2018). MaaS Global, one of the first MaaS orchestrators, is bound to beat the service level of a private car (Goodall et al., 2017). ABI Research forecasted in 2016 that global MaaS revenues will exceed $1 trillion by 2030 (ABI Research, 2016).

Such forward-looking expectations of so-called 'disruptions' often lack sufficient nuance and empirical support, being sales pitches by commercial organizations, think pieces or theoretical exercises at best. We believe the nuance is particularly missing because there is significant ambiguity surrounding MaaS as a concept (Jittrapirom et al., 2017, 2019), partly because it can contain multiple levels of integration within and between different types of transport (Lyons et al., 2019). Furthermore, only few studies have empirically examined MaaS platforms in real-life contexts (e.g., UbiGo (Sochor et al., 2014; 2015; 2016)). Therefore, from the next section onwards, we start by defining MaaS and its stakeholders (Section 2) and discuss how a review of the transport literature informed the pilot study we organized in Ghent (Section 3). Section 4 then reports on this MaaS pilot study which targeted 100 participants in mid-2017 in the urban region of Ghent (Belgium). This pilot is one of the first MaaS pilot studies and is unique because we targeted respondents who were likely to change their travel behavior and were highly motivated to participate. Insights from the literature were translated into selection criteria and operationalized in the recruitment process. We rewarded the respondents with a considerable incentive: a monthly mobility budget of 150, 250 or 350 euro was given to the participants, which they could spent through a MaaS application on their smartphone. By doing so, we purposefully recruited potential "early adopters" of MaaS technology. This is not uncommon in exploratory pilot studies, especially when the aim is to bring about general insights on a novel research domain (see for example, Vlassenroot et al., 2010; Sochor et al., 2014). Our small sample in Ghent does not claim to be representative for a larger population, which implies that findings cannot simply be generalized to a larger population.

We use the findings from our sample of potential early adopters to contribute to a much-needed debate about the interrelationship between MaaS and (private) car use. After focusing on the results of our exploratory panel in Section 5, we elaborate on this interrelationship in Section 6, by drawing parallels with a similar debate in the transport literature, where predictions about the potential substitution of physical travel by so-called 'virtual travel' practices (i.e. the usage of information and communication technologies) proved to be more complex in reality than expected beforehand. Finally, we address which implications these insights have for future research.

2. A MAAS DEFINITION AND STAKEHOLDERS

MaaS is an emerging concept in the world of mobility whereby information and communication technologies are put into place with the goal of improving and smoothening everyday travel. Based on current readings of MaaS (e.g., Ho et al., 2018; Jittrapirom et al., 2018; Lyons et al., 2019), and for the purpose of this paper, a comprehensive definition of MaaS should at least consist of the following three parts: (i) MaaS puts a user center-stage, in the sense that the on-demand travel needs of an individual are matched with a tailored mobility package or a "bundle" on offer (Hensher, 2017). The viability and success of MaaS depends on the mix of mobility services on offer; (ii) MaaS is a co-modal service. The power of MaaS lies in the fact that the technology makes plenty of travel modes more accessible to individual users (e.g., bike sharing, bike rental, car

sharing, car rental, taxi services, and public transport). Travel needs are fulfilled by seeking the most suitable combination of travel modes for the activity at hand. This can be a unimodal trip but can also be a combination of two or more seamlessly integrated and connected services offered by different mobility providers. This flexibility is meant to offer higher service levels than a privately-owned car and at least omits the chance of a travel mode "lock-in" (Jittrapirom et al., 2018); (iii) MaaS services are offered via a user-friendly digital interface, typically a smartphone application, and is part of the so-called platform economy (Pangbourne et al., 2018). Ideally, this tech solution offers more than integrated ticketing services alone, but also includes a real-time journey planner. Routing algorithms then compile a list of mobility services suitable to get the user from A to B the way he or she prefers.

In simple terms, MaaS satisfies the travel needs of individuals through a single digital interface that integrates the co-modal services of diverse mobility providers. This digital interface connects at least three core stakeholders: a user, a mobility orchestrator, and mobility providers or operators. This MaaS ecosystem can be extended with (data) analysts, employers, government agencies, and other companies. Mobility orchestrators are in the directors' seat, balancing the expectations of new and incumbent operators, and convincing them to join forces. For incumbent mobility operators, a shift might be needed because some operations (e.g., customer relationships, marketing) will no longer be required and more emphasis will be put on the mobility provider's core competences determined by service levels. For existing and new players in the field, a so-called MaaS ecosystem might generate new business models that potentially outclass the way mobility providers work today. To illustrate, MaaS platforms can incorporate other services, such as grocery delivery, cinema ticketing, and hotel reservations (Pangbourne et al., 2018; Sochor et al., 2016).

Government agencies and authorities are often involved to advance the necessary regulations (e.g. market access, service requirements) and make sure that the overall solution is more efficient, equitable and sustainable, enhancing public interest. They can decide to take the role of a mobility orchestrator, engage in public-private partnerships or leave the initiative to privately owned organizations. MaaS can be regarded in combination with local transport policies, as an innovative technology-driven mobility management service (Mulley, 2017). MaaS can translate location- and time-specific mobility measures into its services, such as making trips more expensive during peak hours, and rewarding the use of more sustainable travel modes (Strömberg et al., 2018).

MaaS users buy mobility services, not the transport modes itself (Kamargianni et al., 2015). MaaS therefore makes it possible to limit car ownership to an absolute minimum. The combination of transport modes with different strengths and weaknesses is believed to be more efficient, sustainable, and user-friendly than one single mode for all purposes. The result is a better and tailored service, something a traditional mobility provider cannot easily provide. This synergy makes MaaS an interesting mobility concept for local authorities who want to tackle current mobility problems like road congestion, traffic safety, and air pollution. It should not come as a surprise that MaaS has received a lot of media coverage lately and has sparked the interest of funding agencies and investors. Across Europe, MaaS alliances and networks are being established between a variety of stakeholders. For one thing, traditional players in the field and non-traditional (tech) firms understand that collaboration may be the best path to long-term growth.

A number of case studies and best practices are starting to appear in the transport literature (Goodall et al., 2017; Jittrapirom et al., 2017; Kamargianni et al., 2015; Streeting & Edgar, 2017; Vij

et al., 2018). Most of the research focuses on theoretical studies, e.g., feasibility studies. Up till now, UbiGo can be regarded as the only real-world field project that has been empirically analyzed. The UbiGo pilot project was organized in Gothenburg (Sweden) from November 2013 until April 2014 and involved 83 urban households. The participants had a monthly plan to pay for their travel expenses that included: bike sharing, car sharing, car rental, taxi, and public transport (Sochor et al., 2014, 2015, 2016). Early adopters often seemed attracted by curiosity. However, in order to remain motivated, the service had to offer convenience and an economic advantage for the user (Sochor et al., 2014). Another prominent existing project is Whim, which was launched in 2016 in Helsinki (Finland). Whim is an initiative of MaaS Global and is – besides in Helsinki – also operational in the West Midlands (United Kingdom) and has recently been launched in Antwerp (Belgium) and Amsterdam (the Netherlands). Their offer includes car rental, taxi, and public transport. Up till now, Whim does not include bike sharing and car sharing. Customers can pay on the go or subscribe for a monthly plan (MaaS Global, 2018). Besides Ubigo and Whim, existing MaaS (related) projects also include Smile in Austria, and Hannovermobil and Moovel in Germany (see, for instance, Smith et al. 2019). MaaS projects are mostly launched in Europe, although a MaaS project is currently planned in Las Vegas, United States (i.e., Shift (see Kammargianni et al., 2016)). Currently, mobility orchestrators target both the B2C and B2B market. With regards to the latter, large employers provide MaaS services to employees to organize their commute trips (e.g. 'Corporate MaaS' (Hesselgren et al., 2019)).

The main drivers for the success of these projects are the price of the services, the availability of and accessibility to different travel modes, and the user-friendliness of the application (Sochor et al., 2014). Privacy issues, partly related with MaaS payment (i.e., providing credit card information via smartphones), can also act as a potential barrier for people to join MaaS (Polydoropoulou et al., 2019). According to behavioral economics, an important barrier is that users tend to overvalue current benefits (of non-MaaS use) and undervalue potential gains (of MaaS use) which can partly explain the limited uptake of MaaS so far (Lund et al., 2017; Pankratz et al., 2017). Polydoropoulou et al. (2019) indicate that stakeholders can also witness certain institutional, social, financial, and operational/technical barriers hampering a MaaS implementation.

3. HOW THE LITERATURE INFORMED THE RECRUITMENT PROCESS OF PARTICIPANTS

In this section, we briefly summarize insights from the transport behavior literature which have shaped the recruitment process of our MaaS pilot study. First of all, travel mode choice is not a rational choice based on attitudes and preferences towards many alternatives, but often a choice based on past and routine behavior (Gärling & Axhausen, 2003; Van Acker et al., 2014). People choose travel modes that have provided them smooth, easy, and comfortable trips before (Aarts et al., 1998; De Vos & Witlox, 2017; Verplanken et al., 1997). Travel mode choices are part and parcel of daily, script-based routines, freeing the mind from unexpected and stressful situations, while making room for other and perhaps more important decisions (Gärling et al., 2001). The cost of searching for alternatives and constructing new travel routines is generally high, while expected benefits are uncertain at best.

Second, we know that travel behavior is largely mediated and shaped by long-term life decisions which can narrow the choices of travel modes at a person's disposal (Handy et al., 2005). Although the CEO of MaaS Global stated that the company aims to beat the service levels of owning a private car in Finland (see Goodall et al., 2017), there will most certainly be times and places where that is not going to be the case. In sparsely populated areas outside cities, it could be inefficient and

unsustainable, and therefore, not favorable to guarantee high service levels at all times. A lack of critical mass (beneath a certain demand threshold) hampers a widespread uptake of MaaS (Mulley, 2017). Matching the spatio-temporal features of all travel demand with an appropriate supply will remain a continuous challenge.

Third, travel behavior change is more likely to happen when changes occur in other domains of life (i.e., key life cycle events, such as starting a family, a new job, or moving to a new place) or when a serious incentive is offered to stimulate a change (Van der Waerden et al., 2003). This context changes and stimuli make attitudes and behavior-relevant information more prominent and influential, which may lead to new choices and decisions (Verplanken et al., 2008). A disruption of a stable context could be realized by measures such as providing habitual car drivers with a temporary free bus ticket (Abou-Zeid et al., 2012; Fujii & Kitamura, 2003), albeit at the risk of remaining very temporary changes (De Vos & Witlox, 2017). These insights complicate the idea that MaaS will simply substitute for car ownership and car use.

Based on these findings, we explicitly targeted candidates who were *most likely* to reduce the use of their personal car in return for a well-functioning MaaS offer. The recruitment process, incentives and rules of the pilot project will be the subject of the next section.

4. RESEARCH DESIGN OF THE MAAS PILOT STUDY

The pilot study was organized in and around Ghent, a medium-sized city (about 260,000 inhabitants) in the northern part of Belgium. Ghent – similar to most other (mainly North-Western) European medium-sized cities – struggles with car externalities such as road congestion, traffic safety, parking problems, and car emissions. The local government takes action to change this by for example implementing a sustainable urban mobility plan. Several car (and bike) sharing services were operational in Ghent during the pilot study, but no MaaS orchestrator had a MaaS platform up and running yet. The location of available mobility services is shown in Figure 1 included bike sharing, bike rental, public and private car sharing, car rental, taxi services, train, bus and tram.

We aimed to recruit frequent car users who live and work in – or closely around – Ghent. Due to access to communication channels and familiarity with the mobility policy of the employer, we focused on employees of Ghent University. We first announced the organization of this research through as much channels as possible (e.g., emails to heads of department and flyers distributed at all car parks of the university). Employees were asked to use a MaaS application and limit the use of their personal car for their everyday travel as much as possible during the trial (two and a half months from mid-April until the end of June 2017). Interested employees could apply via a recruitment survey.

A recruitment survey enabled us to make an informed decision about participation of candidates. These recruitment surveys are regularly used in the design of mobility panels (e.g., the Dutch mobility panel (Hoogendoorn-Lanser et al., 2015)). The survey specifically asked for a number of socio-economic characteristics (e.g., age, gender, home and work address) and included questions evaluating the willingness and likelihood of candidates to change their travel behavior (frequency of car use, use of smartphone, etc.). Three 'hard' criteria were used to pre-select candidates: (i) they needed to reside in the greater Ghent region, which meant they were likely to have reasonable access to many alternatives to the private car offered in a MaaS (such as car sharing services and

public transport); (ii) they had to have a private car at their disposal and regularly used the car for their commute (i.e., at least weekly); and (iii) they needed to own a smartphone with mobile data subscription or willing to take one, which was then paid for. After complying with these three criteria, additional 'soft' criteria (e.g., eagerness to participate, familiarity with alternatives for the car) were applied to make a final decision on who could participate and who not.

Moreover, as the chances for behavioral change are more likely when incentives are offered, we provided two kinds of incentives in return for the participants' efforts. The most important one being a significant monthly mobility budget. The size of the mobility budget was based on the frequency of car use for commuting purposes and the estimated value of the car they had at their disposal. There were three categories of subscriptions: a monthly budget of 150 euro, 250 euro, and 350 euro. This budget was made available in the smartphone application and could be spent on mobility services. Next and without much explanation, we mentioned that the five "top" participating respondents would be given a price of 500, 400, 300, 200 and 100 euro cash at the end of the project. For respondents who fully participated during the project, the remaining (unused) mobility budget was transferred to them at the end of the project.

Full participation entailed three types of commitment: respondents had to limit their private car use as much as possible, had to test the services of at least three different mobility providers, and had to fill out all three surveys during the project. Participants who did not seem to participate according to the agreements made beforehand, were contacted and removed from the pilot if necessary (partly to avoid including people that only participated for receiving the unused mobility budget). The possible changing travel behavior, and the overall attitude of the respondents towards MaaS were monitored through three online travel surveys (at the start, middle, and end of the project). A lot of questions were open-ended, allowing the participants to raise possible concerns and allowing us to have as much information as possible from this small-scale panel. This quasi-qualitative approach made it possible to fully capture participants' satisfaction levels and their concerns about the concept of MaaS. In addition, their travel data were collected as well. We kept close contact with the participants during the project through a dedicated mail service and social media (i.e., Facebook discussion group).

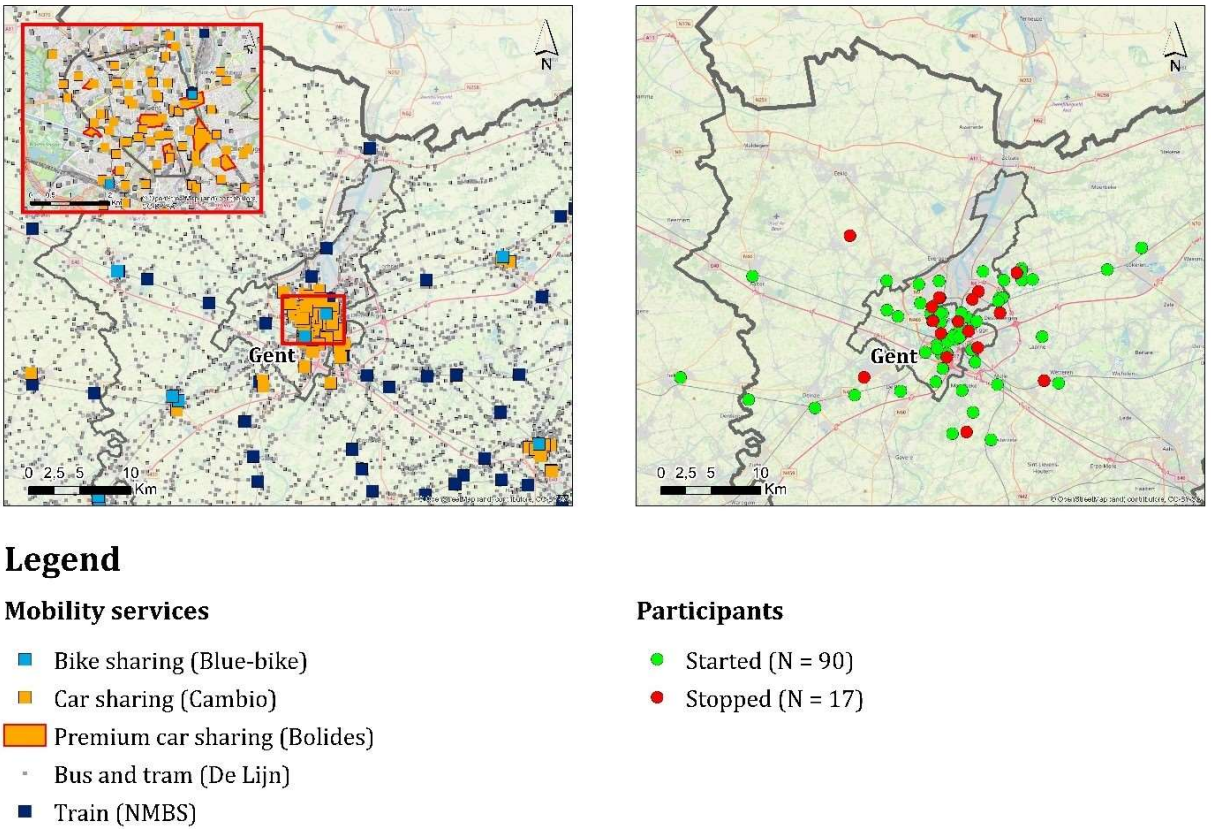

Figure 1: Map of the urban region of Ghent, with available mobility services offered in the MaaS pilot study (a) and places of residence of the participants who started and dropped out during the project (b).

In total, 578 employees of Ghent University filled out the recruitment survey. We invited 123 people to one of three information sessions, where the main purpose, our expectations and practical arrangements of the project were explained. At the end of each session, partakers needed to make clear whether they would (or not) like to participate. Eventually, 52 individuals were no longer interested, primarily because the requested commitment was perceived as too demanding (e.g., unwillingness to plan their trips during the pilot study period). We recruited 19 additional people, some of them being partners from already selected participants. In the end, 90 people officially started the project mid-April 2017. The socio-demographic characteristics of the participants are shown in Table 1. These participants are relatively young (77.7% is younger than 45), mainly co-habiting (only 17.7% is single), and are – due to recruiting Ghent University employees – highly educated (91.2% has a university degree). All participants live in the greater Ghent region and most of them live in the city of Ghent itself (65.6%, see Figure 1). The mobility budgets were spread more or less evenly across the participants. Since our sample is small and evidently biased (i.e., highly-educated employees), this sample should be regarded as an exploratory pilot and findings are indicative of bigger trends at best. Generalizing the findings from this exploratory pilot to larger populations is not possible, but given the lack of larger and more representative MaaS trials, some of the lessons learnt can be informative for (i) our current understanding of the relationship between MaaS uptake and car ownership and (ii) for designing future MaaS pilots.

Table 1: Socio demographic characteristics of the participants (N = 90)

Variable	Categories	Number	%
Gender	Men	39	43.3
	Women	51	56.7
Age distribution	18-24	3	3.3
	25-34	40	44.4
	35-44	27	30.0
	45-54	16	17.8
	55-64	4	4.4
Education (highest degree)	Secondary education	8	8.9
	Bachelor degree	16	17.8
	Master degree	43	47.8
	Doctor degree	23	25.6
Household composition	Living together with children	41	45.6
	Living together without children	33	36.7
	Single with children	3	3.3
	Single without children	13	14.4
Residential area	Ghent	59	65.6
	Suburb of Ghent	31	34.4
Mobility budget	€150	35	38.9
	€250	26	28.9
	€350	29	32.2

The participants indicated that (i) *Testing whether I can travel without a car*, (ii) *Positive effects on the environment*, and (iii) *Out of curiosity* were the main reasons for joining in. The expectations of the participants were rather diverse. Although a lot of participants indicated at the beginning of the project that they expected their travel behavior to become more multimodal and less harmful for the environment, a lot of them also expected more planning of trips and longer travel times.

In the MaaS pilot study, car sharing was provided by *Cambio*, *CarAmigo* and *Bolides*. *Cambio* and *Bolides* are public car sharing companies. *Cambio* provides a range of cars at fixed locations while *Bolides* provides premium cars at fixed zones. *CarAmigo* shares privately-owned vehicles. Most of these car sharing alternatives are located in the city center. Car rental was provided by *Enterprise*. The taxi service was provided by *V-Tax* and later by *Taxi Lochristi*. *De Lijn* provides public transport services by bus and tram throughout Flanders. *NMBS*, the national railway company of Belgium, decided not to take part. To avoid that train travel would not be considered as a possible option (given that it was not listed in the smartphone application), participants using the train got their ticket separately reimbursed. Bike rental was provided by *Max Mobiel* (currently *Fietsambassade Gent*). They offered a wide range of bicycles (conventional bikes, e-bikes, cargo bikes, folding bikes, tandems). Bike sharing was provided by *Blue-bike*. This (round-trip) bike sharing service was available at the two main train stations in Ghent.

Before we discuss the main outcomes of the study, two contextual guidelines need to be mentioned as well. First, we told our panel that the use of their personal car was still allowed, but we explicitly asked respondents to use their car as little as possible. By way of proof, we asked all participants to send us a picture of their car mileage at the beginning and at the end of the project. Participants were also asked to – in case of using their personal car for a certain trip – register this in the smartphone application and justify this car use. We also informed them that car use would be dissuaded by reducing their mobility budget based on distance travelled by car (tariff: 0.50 euro per kilometer). This budget reduction did not apply when members of their household used this car.

Second, the MaaS application used in this pilot study was a prototype developed by Touring Club Belgium, who commissioned the pilot study. Prior to the pilot study, we asked ten people to participate in a two-week trial of the MaaS application to make sure the app ran smoothly. The application did not include a trip planner, nor gave direct access to all possible available travel modes. Two snapshots of the app interface are shown in Figure 2. For the purpose of this pilot study, which was meant to mirror a fully developed situation, car sharing services and train tickets could be booked outside of the app and were manually credited to the mobility budget in the app. Users needed to choose the travel modes themselves, and could book and pay the services required via the app. Inevitable delay in the crediting process meant users were not always given a real-time overview of their remaining mobility budget and some additional effort was needed from them. We recognize that the MaaS uptake depends on the way the MaaS application served the needs of the respondents and that more sophisticated applications could lead to increased acceptance and use. Since a large majority of respondents was satisfied with the way the application functioned (and appreciated having access to the services of many different mobility providers), we are confident that a potential negative effect of using a prototype application is small.[1] Of course, a better-developed MaaS application might have resulted in even higher levels of satisfaction. It should, however, be noted that for the time being, very few MaaS applications are fully mature (e.g., use a multimodal trip planner).

[1] Most participants indicated that they were *satisfied* to *very satisfied* with various aspects of the application (e.g., lay-out, organization, booking/cancelling of travel options, payment of travel).

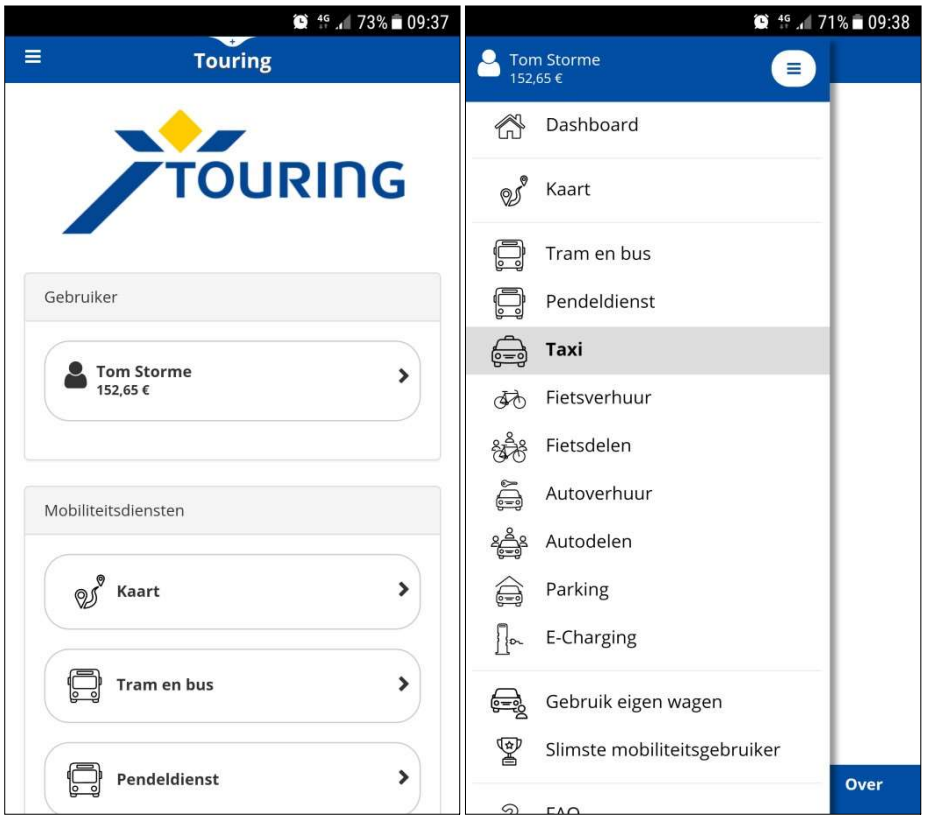

Figure 2: Screenshots of the MaaS smartphone application.

5. RESULTS

Despite our well-considered recruitment and relatively high incentives offered, 17 respondents dropped out at some point during the pilot study (see Figure 1) and decided to return to their "old" travel routines and habits. This dropout was mainly due to the hassle of planning trips, because of changes within the household (e.g., child birth, death of a relative), because they were unsatisfied with the services on offer or because they underestimated their dependency on their private car. As explained above, full participation entailed active use of the MaaS application and significant efforts to reduce their private car use. Based on travel data collected by the application and the surveys, we decided that seventeen more participants did not meet at least one of the three requirements.

5.1 No straightforward substitution of private car use

Private car use of respondents who fully participated reduced considerably, but nobody was close to fully substituting private car use (see Figure 3). Collectively, private cars still covered 42,000 km over the entire study period. Thirteen people had driven more than 1,000 km by private car. The use of the private car was mainly motivated by the fact that the alternatives were too much of a hassle (46% of trips), or the weather was too bad (12% of trips). Limiting car use was easier for routine commute trips, but less straightforward for leisure trips, as exemplified by the following statements:

P1 *"I mainly need my car for private trips, not so much for commute trips."*

P2 *"I would love to travel without a car, but in reality this will not be possible. For commute trips I have alternatives (bus, bike, train), but for bringing the children to their sports activities, we really need the car."*

Most participants (73.7%) specified that during the project they managed to have a car-free commute, while no one used their car on a daily basis. For leisure trips, the situation is somewhat different. More than half of the participants indicated that they use the car occasionally (i.e., on a weekly or monthly basis). Although we notice a clear reduction in car use, a total stop seemed infeasible for the large majority of respondents.

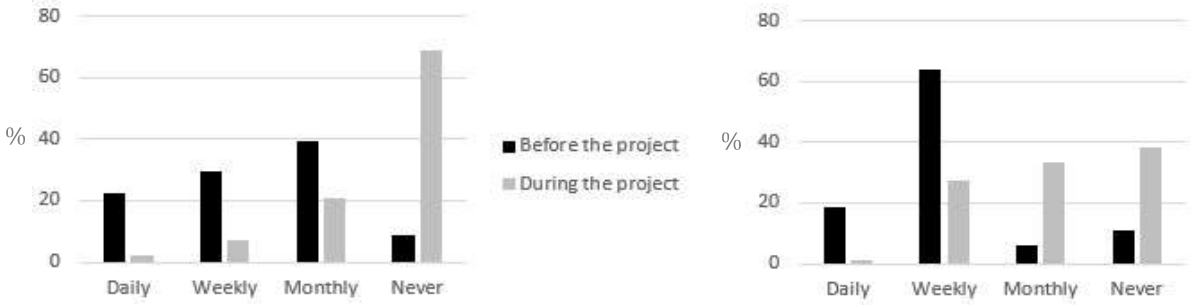

Figure 3: Frequency of private car use before and during (N = 81) the project for commute trips (left) and leisure trips (right)

5.2 Private car use to a considerable extent substituted by private (e-)bike use

Based on the number of trips and mobility budget participants spent, we conclude that not all private car use was simply substituted by MaaS use. Although the participants reported an increased frequency in the use of all travel modes on offer, we evaluated MaaS to remain below its potential. Only 35 reservations were made for bike rental, although these included 15 monthly reservations of e-bikes as well. From the travel surveys, we can safely assume that a large part of the car trips was substituted by the use of a privately owned (e-)bike.[2] Having permanent access to a privately-owned travel mode remains convenient and important. We believe MaaS will not always offer the best ways to travel within the city and for shorter distances. One of the participants indicates the following:

P3 *"For short trips, using my own bike remains the easiest, cheapest, most pleasant and most environment-friendly way of travelling."*

Of all the travel modes accessible in this pilot study, a shared car proved to be a suitable alternative used by three out of four participants. Collectively, 6,000 euro was spent on 229 shared car trips. One third of the budget was spent on using car sharing services and another one third was spent on penalized use of a respondents' private car. Slightly more than 90% of the respondents had used public transport, mainly bus and tram rides. Collectively 545 bus/tram tickets and 162 train tickets were bought. Very few people used taxi services (e.g., for a night out) or car rental services (as most still had access to their own car). On average, 130 euro was spent on the mobility services

[2] We did not collect data on private bike use in a travel diary on the MaaS app, to keep the panel fatigue as limited as possible. Participants nonetheless reported their frequency of bike use in the travel surveys. A substantial number of participants replaced (private) car trips by (private) bike trips.

(including penalized personal car use). We observed no significant difference between people with varying mobility budgets.

5.3 Private car use complementary to MaaS use

A large part of the respondents only had one car within the household. However, this car is often not only used by the respondent, but also by a possible partner or adult child(ren), or for providing services to other people within social networks. Half of all private car use was reportedly performed by and for others, suggesting that the private car can often be considered a shared car as well. Young adults regularly drive their parents' car in the weekends. Younger children were chauffeured to and from school and leisure activities (e.g., day care, youth movement, sports club, music school), (mobility-impaired) parents were chauffeured to and from supermarkets, etc. Furthermore, befriended parents agree to chauffeur other children living in the neighborhood, and are promised the return service. Car use is thus rooted in household routine practices and activities, which makes substituting privately-owned cars not straightforward (De Vos et al., 2012). It can also be argued that people often neglect chauffeuring trips when asked about their travel behavior (Schwanen, 2007), resulting in a possible underestimation of living without a car. Relating to the question why participants still used the car during the project, two participants indicated the following:

P4 *"Travelling by car is the easiest way of travelling with children."*

P5 *"I had to use my car because I had to help out my disabled parents."*

As long as the private car remains the only acceptable alternative to reach recurrent destinations, owning a car is easily justified. This especially holds true if there is no car sharing service within walking distance. In this regard, an important question remains whether MaaS will be able to reach sufficient critical mass (see Mulley, 2017). Until then, MaaS is bound to be complementary to the privately-owned car.

The travel surveys revealed that MaaS requires a new attitude towards daily travel patterns, as much more planning and organizing is needed, much more (perceived) uncertainty about travel times exists, and less caring should be in place about the way they travel (be it collective or individual, active or passive). For people undertaking many activities at various locations and times, this might result in stressful situations (in case of delays, crowded vehicles, etc.), or performing all these activities might simply not be feasible with MaaS. These people might consequently not be interested in substituting their private car use, but might see MaaS as a complementary service for certain types of multimodal trips whenever needed. One participant provides the following statement concerning these elements:

P6 *"No mobility service beats a private car in terms of flexibility, comfort, reliability, and user-friendliness."*

Taken together, we still see individual car ownership playing an important role in the mobility landscape of the near future. For now, it is hard to believe that MaaS will quickly lead to a considerable reduction of car ownership, but it should rather be seen as a complementary service. The following statement of one of the participants perfectly describes this conclusion:

P7 *"I do not use my car on a daily basis, but the thought of getting rid of it scares me."*

To conclude, given the well-considered selection of participants and the significant incentives they were offered in return for their efforts, we expected the uptake of MaaS to be much higher. Although the majority of respondents claimed that their personal car use was reduced, we believe the use of the MaaS application still remained below its potential. Based on participants' responses on the surveys and travel diary of private car use, we enumerated a number of reasons why MaaS will not easily substitute private car ownership for the years to come. The fact that (mostly urban) mobility enthusiasts face difficulties in reducing their car use when using a MaaS application casts certain doubts on the future of the MaaS concept.

6. DISCUSSION AND CONCLUSION

This paper addresses the question to what extent MaaS can be a satisfactory substitute for private car use. To the best of our knowledge, this has not been subject to much attention yet. Reflecting on the MaaS pilot project organized in Ghent (Belgium), we indicate that we cannot simply assume that MaaS schemes will drastically reduce car possession and car distance travelled. Even when providing highly-motivated participants with incentives for keeping car use at an absolute minimum, a substantial number of trips were covered by (private) car. Especially for leisure trips and chauffeuring trips, the personal car seemed difficult to bypass. In sum, these results rather suggest that MaaS should be regarded as a complement of a personal car rather than a substitution. People who are currently not able to travel to all their desired activities without using a car, will probably also not be able of doing so with MaaS. These results suggest that expectations from MaaS might be inflated and bring more nuance to the debate on the interrelationship between MaaS and private car ownership.

The potential effect of MaaS on people's travel behavior can to some extent be compared with the effects of telecommunication technologies on travel behavior. Although in the 1990s, there were high expectations about the substitution rates of physical travel by telecommunication technologies (e.g., telecommuting, video chat, e-shopping)(Cairncross, 2001), studies found rather limited effects of telecommunication technologies on travel behavior (see for example, Denstadli et al., 2012; Haynes, 2010). Mokhtarian (2003) suggested four possible cross-mode relationships between the two: first, substitution or the replacement of corporeal travel by virtual meeting practices; Second, modification or the influence one practice has on the other, without generating additional demand; Third, neutrality, or when there is no relationship between both; And fourth, complementarity when the use of one mode facilitates or accompanies the use of another mode (see also Denstadli & Gripsrud, 2010). By reviewing the literature, Mokhtarian (2003) suggests that substitution might take place on the short-term for specific applications, but that there is evidence that the interplay between both modes generates ever more travel in the long run (see also Lassen, 2009). It may be clear now from the literature that a simple, overall substitution effect is indeed highly unlikely (see Aguilera et al., 2012), indicating that besides substituting effects, also complementary effects, or even modification effects (i.e., telecommunication technologies resulting in more physical trips) occur (Mokhtarian, 2003; Mokhtarian & Tal, 2013; Salomon, 1986).

A similar line of reasoning can be applied to the effect of MaaS on people's travel behavior. MaaS might not only have a substituting effect on car use, but also a complementary effect on car possession, and it might even generate additional trips. MaaS could potentially stimulate more (private) car use and ownership (Transport Systems Catapult, 2016), since users might use MaaS to "test drive" several cars before making a purchase (Sochor et al., 2016). MaaS can lead to people engaging in more and longer trips, as the multimodal offerings might stimulate travel demand

within and between cities. MaaS can also result in people postponing buying a car or people deciding to sell their car, since some parts of the population have limited travel needs, such as young adults attending university (college) or retired people. Given the fact that car ownership is getting ever more expensive (especially in big cities), a MaaS subscription might be a suitable option for people with limited travel needs. Increasingly more consumers might become familiar with MaaS' digital offerings to manage their daily lives. Tech-savvy, younger consumers, who have grown up with these technologies, might be the ones to target.

Due to its experimental design and small and biased sample, this pilot study cannot provide robust conclusions on the potential success rate of MaaS schemes. Therefore, we call for more empirical real-world pilots in varying spatio-temporal situations and with different segments of the population to gain better insights into the potential effect of MaaS on people's travel patterns and experience in the near and further future. Currently, MaaS pilot studies are – due to being expensive and time consuming – still scarce and have small panels. Future studies could focus on how MaaS and private car use are sequenced over time and change the nature of our trips and activities, for example by allowing social networks to increase in size, quality or spatial extension. Future projects could also focus on how (potential) mobility innovations and spatial planning measures (such as automated vehicles, low-traffic city centers, road pricing, and transit-oriented developments) can affect the interrelation between MaaS and personal car use.

Acknowledgments

The pilot project described in this paper was funded by Touring Club Belgium, a motoring organization providing roadside assistance, insurance, medical insurance and legal support throughout Belgium. The authors would like to thank all the participants that contributed to the pilot study, and the four anonymous reviewers for their constructive comments and suggestions, making it possible to improve this paper.

REFERENCES

Aarts, H., Verplanken, B., van Knippenberg, A., 1998. Predicting behaviour from actions in the past: Repeated decision making or a matter of habit? Journal of Applied Social Psychology 28 (15), 1355-1374.

ABI Research, 2016. "ABI Research Forecasts Global Mobility as a Service Revenues to Exceed $1 Trillion by 2030". Available online: https://www.abiresearch.com/press/abiresearch-forecasts-global-mobility-service-rev/

Abou-Zeid, M., Witter, R., Bierlaire, M., Kaufmann, V., Ben-Akiva, M., 2012. Happiness and travel mode switching: Findings from a Swiss public transportation experiment. Transport Policy 19 (1), 93-104.

Ajzen, I., 1991. The theory of planned behavior. Organizational Behavior and Human Decision Processes 50 (2), 179-211.

Aguiléra, A., Guillot, C., Rallet, A., 2012. Mobile ICTs and physical mobility: Review and research agenda. Transportation Research Part A 46, 664-672.

Cairncross, F., 2001. The Death of Distance: How the Communications Revolution is Changing Our Lives. Harvard: Harvard Business Press.

Capros, P., De Vita, A., Tasios, N., Papadopoulos, D., Siskos, P., Apostolaki, E., Zampara, M., Paroussos, L., Fragiadakis, K., Kouvaritakis, N., Höglund-Isaksson, L., Winiwarter, W., Purohit, P., Böttcher, H., Frank, S., Havlík, P., Gusti, M., Witzke, H.P., 2013. Trends to 2050. Reference Scenario 2013. Available online: https://ec.europa.eu/transport/sites/transport/files/media/publications/doc/trends-to-2050-update-2013.pdf (accessed on 24 January 2019).

De Vos, J., Derudder, B., Van Acker, V., Witlox, F., 2012. Reducing car use: changing attitudes or relocating? The influence of residential dissonance on travel behavior. Journal of Transport Geography 22 (1), 1-9.

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 106, 364-373.

Denstadli, J.M., Gripsrud, T.E., 2010. Face-to-face by travel or picture – The relationship between travelling and video communication in business settings. In: Beaverstock, J.V., Derudder, B., Faulconbridge, J. & Witlox, F. (Eds.) International Business Travel in the Global Economy. London: Ashgate, pp. 217-238.

Denstadli, J.M., Julsrud, T.E., Hjorthol, R.J., 2012. Videoconferencing as a mode of communication: A comparative study of the use of videoconferencing and face-to-face meetings. Journal of Business and Technical Communication, 26(1), 65-91.

European Commission, 2013. Attitudes of Europeans towards urban mobility. Special Eurobarometer 406/ Wave EB79.4 – TNS Opinion & Social. Available online: http://ec.europa.eu/commfrontoffice/publicopinion/archives/ebs/ebs_406_en.pdf (accessed on 27 September 2018).

Focas, C., Christidis, P., 2017. Peak car in Europe? Transportation Research Procedia 25, 531-550.

Fujii, S., Kitamura, R., 2003. What does a one-month free bus ticket do to habitual drivers? Transportation 30 (1), 81-95.

Goodall, W., Dovey, T., Bornstein, J., Bonthron, B., 2017. The rise of mobility as a service. Deloitte Review 20, 112-129.

Goodwin, P., Van Dender, K., 2013. 'Peak Car' — Themes and Issues. Transport Reviews 33 (3), 243-254.

Gärling, T., Axhausen, K.W., 2003. Introduction: Habitual travel choice. Transportation 30 (1), 1-11.

Gärling, T., Fujii, S., Boe, O., 2001. Empirical tests of a model of determinants of script-based driving choice. Transportation Research Part F 4, 89-102.

Handy, S., Weston, L., Mokhtarian, P.L., 2005. Driving by choice or necessity? Transportation Research Part A 39 (2), 183-203.

Haynes, P., 2010. Information and communication technology and international business travel: Mobility allies? Mobilities, 5(4), 547-564.

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 98, 86-96.

Hesselgren, M., Sjöman, M., Pernestål, A., 2019. Understanding user practices in mobility service systems: Results from studying large scale corporate MaaS in practice. Travel Behaviour and Society. In Press. https://doi.org/10.1016/j.tbs.2018.12.005

Ho, C.Q., Hensher, D.A., Mulley, C., Wong, Y.Z., 2018. Potential uptake and willingness-to-pay for Mobility as a Service (MaaS): A stated choice study. Transportation Research Part A 117, 302-318.

Hoogendoorn-Lanser, S., Schaap, N., Olde Kalter, M.J., 2015. The Netherlands Mobility Panel: An innovative design approach for web-based longitudinal travel data collection. Transportation Research Procedia 11, 311-329.

Jittrapirom, P., Caiati, V., Feneri, A.-M., Ebrahimigharehbaghi, S., Alonso-González, M.J., Narayan, J., 2017. Mobility as a Service: A critical review of definitions, assessments of schemes, and key challenges. Urban Planning 2 (2), 13-25.

Jittrapirom, P., Marchau, V., van der Heijden, R., Meurs, H., 2018. Dynamic adaptive policymaking for implementing Mobility-as-a-Service (MaaS). Research in Transportation Business & Management. In Press. Doi:10.1016/j.rtbm.2018.07.001.

Jittrapirom, P., Marchau, V., van der Heijden, R., Meurs, H., 2019. Future implementation of mobility as a service (MaaS): Results of an international Delphi study. Travel Behaviour and Society. In Press. https://doi.org/10.1016/j.tbs.2018.12.004

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.

Kamargianni, M., Matyas, M., Li, W., Schäfer, A., 2015. A Feasibility Study for "Mobility as a Service" Concept in London. Available online via: https://www.ucl.ac.uk/bartlett/energy/sites/bartlett/files/fs-maas-compressfinal.pdf (accessed on 21 September 2018).

Lassen, C., 2009. Networking, knowledge organizations and aeromobility. Geografiska Annaler: Series B, Human Geography 91(3), 229-243.

Lund, E., Kerttu, J., Koglin, T., 2017. Drivers and barriers for integrated mobility services. A review of research. K2 Working Papers 3, 1-26. http://www.k2centrum.se/sites/default/files/drivers_and_barriers_for_integrated_mobility_services_k2_working_paper_2017_3.pdf (accessed on 24 January 2019).

Lyons, G., Hammond, P., Mackay, K., 2019. The importance of user perspective in the evolution of MaaS. Transportation Research Part A 121, 22-36.

Maynard, N., 2018. Why Mobility-as-a-Service is the Future of City Transport. White Paper. Juniper Research. pp.10.

MaaS Global, 2018. Whim. https://whimapp.com/

Metz, D., 2013. Peak car and beyond: the fourth era of travel. Transport Reviews 33 (3), 255-270.

Mokhtarian, P., 2003. Telecommunications and travel. The case for complementarity. Journal of Industrial Ecology, 6(2), 4357.

Mokhtarian, P.L., Tal, G., 2013. Impacts of ICT on travel behavior: a tapestry of relationships. In: Rodrigue, J.-P., Notteboom, T., Shaw, J. (eds.) The Sage Handbook of Transport Studies (pp. 241-260). London: Sage.

Mulley, C., 2017. Mobility as a Service (MaaS) – does it have critical mass? Transport Reviews 37 (3), 247-251.

Pangbourne, K., Stead, D., Mladenović, M., Milakis, D., 2018. The case of mobility as a service: A critical reflection on challenges for urban transport and mobility governance. In: Marsden, G., Reardon, L. (eds.) Governance of the Smart Mobility Transition (pp. 3348). Bingley: Emerald Publishing Limited.

Pankrats, D.M., Willigmann, P., Kovar, S., Sanders, J., 2017. Framing the future of mobility. Using behavioral economics to accelerate consumer adoption. Deloitte Review 20, 93-112. https://www2.deloitte.com/insights/us/en/deloitte-review/issue-20/overcoming-consumer-resistance-to-future-of-mobility-behavioral-economics.html (accessed on 24 January 2019).

Polydoropoulou, A., Pagoni, I., Tsirimpa, A., 2019. Ready for Mobility as a Service? Insights from stakeholders and end-users. Travel Behaviour and Society. In Press. https://doi.org/10.1016/j.tbs.2018.11.003

Salomon, I., 1986. Telecommunications and travel relationships: A review. Transportation Research Part A 20(3), 223-238.

Schwanen, T., 2007. Gender differences in chauffeuring children among dual-earner families. The Professional Geographer 59 (4), 447-462.

Smith, G., Sarasini, S., Karlsson, I.C.M., Mukhtar-Landgren, D., Sochor, J., 2019. Governing Mobility as a Service: Insights from Sweden and Finland. In: Finger, M., Audouin, M. (eds.) The Governance of Smart Transportation Systems. (pp. 169-188). Springer International Publishing.

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, 57-64.

Sochor, J., Strömberg, H., Karlsson, I.C.M., 2014. Travellers' motives for adopting a new, innovative travel service: Insights from the UbiGo field operational test in Gothenburg, Sweden. 21st World Congress on Intelligent Transportation Systems, Detroit, September, 2014.

Sochor, J., Strömberg, H., Karlsson, I.C.M., 2015. Implementing mobility as a service: Challenges in integrating user, commercial, and societal perspectives. Transportation Research Record: Journal of the Transportation Research Board 2536, 1-9.

Streeting, M., Edgar, E., 2017. Mobility as a Service. The Next Transport Disruption. L.E.K., Australia. Available online: https://www.lek.com/sites/default/files/insights/pdfattachments/LEK_SPecial_Report_Mobility_as_a_Service_Final.pdf (accessed on 27 September 2018).

Strömberg, H., Karlsson, I.C.M., Sochor, J., 2018. Inviting travelers to the Smorgasbord of sustainable urban transport: Evidence from a MaaS field trial. Transportation 45 (6), 1655-1670.

Transport Systems Catapult, 2016. Mobility as a Service. Exploring the opportunity for Mobility as a Service in the UK. Milton Keynes. Available online: https://ts.catapult.org.uk/wp-content/uploads/2016/07/Mobility-as-aService_Exploring-the-Opportunity-for-MaaS-in-the-UK-Web.pdf (accessed on 27 September 2018).

Van Acker, V., Mokhtarian, P.L., Witlox, F., 2014. Car availability explained by the structural relationships between lifestyles, residential location, and underlying residential and travel attitudes. Transport Policy 35, 88-99.

Van der Waerden, P.J.H.J., Borgers, A.W.J., Timmermans, H.J.P., 2003. The influence of key events and critical incidents on transport mode choice switching behaviour: A descriptive analysis. Proceedings of the International Conference on Travel Behaviour Research, Lucerne, August, 2003.

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 (5), 539-560.

Verplanken, B., Walker, I., Davis, A., Jurasek, M., 2008. Context change and travel mode choice: Combining the habit discontinuity and self-activation hypotheses. Journal of Environmental Psychology 28 (2), 121-127.

Vij, A., Sampson, S., Swait, J., Lambides, M., Hine, L., 2018. Mobility as a Service in Australia. Customer Insights and Opportunities. ITS Australia. Available online: https://www.its-australia.com.au/maasreport/ (accessed on 27 September 2018).

Vlassenroot, S., Brookhuis, K., Marchau, V., Witlox, F., 2010. Towards defining a unified concept for acceptability of Intelligent Transport Systems (ITS): the case of Intelligent Speed Adaptation (ISA). Transportation Research F 13 (3), 164-178.