THE SYDNEY MOBILITY AS A SERVICE (MaaS) TRIAL
DESIGN, IMPLEMENTATION, LESSONS AND THE FUTURE
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The Sydney Mobility as a Service (MaaS) Trial
Design, Implementation, Lessons and the Future

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Abstract
Australia’s first Mobility as a Service (MaaS) trial commenced in April 2019 in Sydney, running for two years. This report provides the background to the trial, technical and administration setup, and key findings. Key tasks central to running a trial are set out and a blueprint for how future trials should be undertaken, including how to get a trial up and running, is provided. In doing so, the report provides an overview of the team, the design of a mobility digital platform, identifying and negotiating with prospective modal suppliers, identifying and recruiting potential participants, onboarding and training of participants, monitoring and analysing the data throughout the trial period, and keeping the participants informed as the trial progresses. The report also details the process of co-designing mobility bundles for subscription and how various data sets, collected prior to and during the trial, were used in this process. The report documents lessons learnt and outlines post-trial activities such as post-trial survey, evaluation of the trial against its objectives, and data analyses, all designed to shed light on key questions about business models, commercial potential, and impacts on behavioural change.

Keywords: Mobility as a Service, MaaS, Sydney MaaS trial, subscription plans, business model, Tripi, onboarding, bundle design, mobility plans, bundle uptake, lessons learnt.

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1. Executive Summary

There is growing interest in ways to improve mobility services. This interest has emerged under the title of Mobility as a Service (MaaS), broadly defined as a type of service that, through a digital platform, enables users to plan, book and pay for multiple types of mobility service. Simply put ‘A one-stop travel management platform digitally unifying service inquiry, purchase and delivery’.

Powered by digital technology, mobility suppliers and those who bring them together through some aggregation structure (typically acting as a broker) to deliver an extended set of mobility choices, MaaS is seen as an ecosystem that can, through appropriate incentive-based regulation, offer a way forward for government and other interested parties to achieve a wide range of sustainability objectives such as reducing transport emissions and traffic congestion through reducing private car ownership.

At the centre of the MaaS ecosystem is a digital platform, typically in the form of a smart-phone application (or App), that integrates multiple mobility services for the users to search, book and pay. While required, a digital platform is not enough to make it beyond being an improved journey planner with a potentially convenient one-stop shop for all mobility services a traveller may want. This is the case even when the digital app can offer payment integration, but with a pay-as-you-go (PAYG) option only, with or without a personal mobility wallet function through which an integrated payment mechanism may be available. Emerging evidence suggests that smartphone apps offering a PAYG option only, which currently is the only option in most digital platforms promoted as MaaS, may not be enough to attract potential users, and where it has, it seems unlikely to change travel behaviour in ways that can benefit individuals and society as a whole.

What is often missing is a way to co-create MaaS offers to attract customers and encourage them to change travel behaviour in a way that delivers desirable changes to the performance of the mobility network at the aggregate level. MaaS requires some structure that can be adjusted to respond to such opportunities. This structure should include a suite of subscription bundles that offer varying combinations of relevant mobility services for a given subscription fee. The subscription bundles can be designed and adapted to accommodate the preferences and travel habits of potential subscribers while also achieving gains in key sustainability goals of government and other socially committed groups. In addition, the way in which MaaS might be delivered to the market must recognise the need for a structural outcome that aligns with the set of objectives set by interested stakeholders, notably the business case in terms of a commercial outcome or a net benefit outcome to society that is supported by public subsidy.

The broad commentary on MaaS is often unfocussed because of a lack of an agreed definition. This has led us to offer a clarifying definition of what constitutes MaaS (and what does not) to use as a reference benchmark to decide if a MaaS solution is being offered:

“MaaS is a framework for delivering a portfolio of multi-modal mobility services that places the user at the centre of the offer. MaaS frameworks are ideally designed to achieve sustainable policy goals and objectives. MaaS is an integrated transport service brokered by an integrator through a digital platform. A digital platform provides information, booking, ticketing, payment (as PAYG and/or subscription plans), and feedback that improves the travel experience. The MaaS framework can operate at any spatial scale (i.e., urban or regional or global) and cover any combination of multi-modal and non-transport-related multi-service offerings, including the private car and parking, whether subsidised or not by the public sector. MaaS is not simply a digital version of a travel planner, nor a flexible transport service (such as Mobility on Demand), nor a single shared transport offering (such as car sharing). ‘Emerging MaaS’ best describes MaaS offered on a niche foundation. This relates to situations where MaaS is offered on a limited spatial scale, to a limited segment of society or focused on limited modes of transport. The MaaS framework becomes mainstream when the usage by travellers dominates a spatial scale and the framework encompasses a majority of the modes of transport.”
As part of a commitment to gaining a better understanding of how MaaS, within our definition, might be implemented, the Sydney MaaS trial, the first in Australia, was proposed with a number of objectives of which sustainability in terms of private car usage and a test of commercial viability are prominent. These are:

- To explore appropriate transport service mixes and subscription plans for early adopters of MaaS
- To generate first-hand knowledge of actual MaaS experiences
- To assess the readiness of the current public and private transport mix in Sydney to support MaaS
- To advance the understanding of user uptake and willingness-to-pay for MaaS
- To test the ability to influence travel behaviour through introducing MaaS subscriptions
- To document the experience in designing, planning and undertaking a MaaS trial

The Sydney trial commenced planning in early 2019, with a pre-trial phase designed to ensure that all elements were in place, followed by the in-field trial during November 2019 through to mid-March 2020 (when we stopped suddenly due to COVID-19), and a post-trial analysis and evaluation period up to March 2021. The details of all aspects of the trial, in line with the objectives, are presented in the final report. There are many lessons learnt that can be used to guide any future MaaS initiatives with some key outcomes summarised in this executive summary.

The Sydney trial is the first trial worldwide with transparent reported quantitative evidence on MaaS bundle uptake and induced changes in travel behaviour, validating previous results from stated preference surveys with revealed preference data. As a fully transparent trial from design to implementation, to impact assessment and lessons learnt, we have been successful in developing a tripartite structure (broker, app developer, university) as a blueprint for future trials. Notably, this is one of the two well documented MaaS trials in the world (the other is UbiGo 1.0).

Some of the key findings are:

1. The majority of the people that signed up for the trial were frequent users of both public transport and private cars. This supports the notion that multi-modal travellers are more interested in MaaS than others, and contradicts the fear that MaaS does not appeal to car owners and frequent car users.

2. Although 82% of the people that registered interest for the trial had daily access to private cars, 17% of the participants reported that the experience of the trial changed their view of car ownership and 82% would have purchased the trialled offering if it became available after the trial. This indicates that the trialled service has potential to reduce car ownership, although the behaviour change was limited during the trial.

3. A will to support the development of a service that might help their employer and make the transportation system more sustainable was a main motivation for signing up for the trial, followed by a curiosity about MaaS and how the trialled MaaS service could increase their awareness of personal travel behaviour and improve its sustainability.

4. A large number of participants struggled with making the service through the Tripi app work for them. They seemed to value the support and feedback functions higher than the functions included in the trialled app (the multi-modal travel planner and the mobility wallet). This speaks to the novelty of MaaS, compared to existing transport services, and reiterates the notion that (much) more than an app and a set of subscription plans is needed to put together and disseminate MaaS offerings.

5. Those who have access to a large pool of customers through, for example, existing products or services, are in a better place to work with MaaS (as a broker).

6. We doubt that sustainable goals can be achieved without adequate financial rewards (including rewards for non-transport services) and that these make best sense as part of a subscription plan (i.e., a bundle offer). This can be best achieved by multi-modal reframed as multi-service. This requires a mix of services, including but not limited to transport services, for segmenting the market through subscription bundles.

7. PAYG by itself is unlikely to make a difference in respect of sustainable outcomes. It is bundle subscribers that decrease their car usage and that are more interested in continuing than PAYG subscribers.
8. Without a (monetary) incentive, travellers appear to see very little value in MaaS in the presence of existing apps that are improving all the time (such as Opal Connect, Apple Pay, Google Pay, and improved technical platforms that facilitate payment in addition to searching and planning) and hence one may not get enough buy-in to make a currently niche product scalable.

9. While a MaaS app (and hence technical actors) is important, it is only one of the many factors that we need to structure a successful MaaS program/product offer. Other key factors are customer service, data analysis capability, marketing, sales, and billing.

10. A breadth of different mobility service providers is fundamental and we must ensure a good suite of bundle offers allowing for no irrelevant modes.

11. An open-minded core team with complementary skills (business development, research, app development) that is committed to quality and open to piloting new ideas pragmatically is essential.

12. Relationship building and trust between mobility providers, customers, digital platform developer and provider, the broker and regulators is possibly the most challenging part of the MaaS delivery program. All seem to have different and sometimes conflicting objectives.

13. The trial was too short to be able to test the business case, and hence we could not find evidence of a sustainable business model without subsidy. Commercial claims to date have not been proven. We suggest that profitability goes hand-in-hand with scalability and without this, MaaS is unlikely to take off unless it is driven by financial support from government or other non-mobility sources.

14. The backbone of MaaS is public transport which is heavily subsided and hence a profitable business model for MaaS may need a level of (cross-) subsidy unless scalability can deliver enough customers to obtain a profit margin. It is not clear if scalability is possible.

15. While MaaS bundles themselves might not be profitable, once sustainability improvements are priced in, they might offer a viable (non-commercial) business model.

16. As with previous studies, this trial has several limitations. The sample was limited and not representative of the general population, and was confined to the Greater Sydney area.

17. The duration of the trial was curtailed by COVID-19 which was disappointing since the post-trial evaluation suggested growing interest in MaaS. However, we would have needed a much longer period and possibly participant numbers to test the scalability of MaaS.

18. Subtle changes to either service design, target group and/or context were found to significantly alter the users’ perception of and experience with MaaS and these need to be researched going forward.

### 2. Introduction

Mobility as a Service (MaaS) operates on a concept that public and private transport services can be integrated to provide everyday travellers a one-stop access to all services required through a common interface (Mukhtar-Landgren et al. 2016). MaaS is currently at the centre of the popular view on future collaborative and connected mobility. A commonly cited underpinning goal is to reduce car traffic (and its negative externalities—congestion and emissions) by enabling citizens to satisfy their mobility needs without them having to own assets such as automobiles, either conventional or self-driving, as well as opening new choices for non-car owners who previously had limited transport options (making some of them socially excluded). Facilitating MaaS developments, in itself, is not an objective. Rather, MaaS should be seen as a means to an end. From a public perspective, that end can be increasing the attractiveness of metropolitan regions, lowering negative externalities of the personal mobility system, reducing social exclusion, identifying new business opportunities, a combination of these, or something else (cf. Hensher 2018).

MaaS has received considerable attention from public and business decision-makers (for instance, the Finnish government has implemented new transport regulation meant to facilitate MaaS developments) and practitioners (examples of MaaS start-ups include MaaS Global in Finland, EC2B in Sweden and Moovel in Germany) as well as researchers (e.g., Hensher 2017, Jittrapirom 2017, Sochor et al. 2016, Matyas and Kamargianni, 2018). Still, the knowledge of MaaS is nascent, and we are yet to find evidence of how the alleged societal benefits of MaaS can be captured. The developments to date are comprehensively presented and reviewed in Hensher et al. (2020) and Hensher and Mulley (2020).
While the literature on MaaS is fast growing, many unknowns exist. These include a viable business model for MaaS, benefits to the society, the impacts of MaaS on its user’s behaviour which translate into changes to traffic observed on transport networks. One way to verify these unknowns is to undertake a trial. Trial objectives could be manyfold. Examples, expressed in the form of research questions, could be: whether integrating multiple complementary transport services into a MaaS platform improve the travellers’ experience in terms of cost, travel time, frequency, convenience, health benefits and perceived safety; whether MaaS contributes to improvements in broader community benefits such as better air quality, reduced congestion and greenhouse gas emission savings; or whether MaaS could provide a pertinent alternative to owning and using private vehicles.

The Sydney MaaS trial is a first in Australia, designed to meet the following objectives: (1) To explore appropriate transport service mixes for early adopters of MaaS; (2) To generate first-hand knowledge of actual MaaS experiences; (3) to explore commercially viable business model for MaaS as a pay-as-you-go vs. subscription plans; (4) To advance the understanding of user uptake and preferences for monthly mobility bundles; (5) To test the ability to influence travel behaviour through introducing MaaS solutions; and (6) To document the experience in designing, planning and undertaking a MaaS trial.

The design of the trial draws on insights and experiences, not all positive, from the MaaS trials in Europe in general (cf. Kamargianni and Matyas 2016) and in the Nordics in particular; for instance Ubigo in Gothenburg (SE) 2014, Whim in Helsinki (FI) 2016, and Rejsekortet in Copenhagen (DE) 2018. Although arguably paving the way for further MaaS developments and generating vital insights on the prospects and implications of MaaS (e.g., Karlsson et al. 2016, Smith et al. 2019a, Sochor et al. 2015, Stromberg et al. 2018, Hensher et al. 2020), these trials have not managed to establish how different bundles of mode mixes and payment models affect MaaS uptake and travel behaviour. MaaS cannot be rightfully labelled as an innovation before the concept is adopted and used. The MaaS conversation has thus far mostly focused on the development phase with more questions than answers in respect of its role in achieving societal net benefits and commercial value (Smith and Hensher 2020).

Thus far, very little is known about what transport services MaaS should include and how (or even if) these should be bundled into subscription plans1, to reap the potential societal benefits of MaaS. By leveraging on unique knowledge about potential MaaS users’ preferences acquired through previous research at the Institute for Transport and Logistic Studies (ITLS) at the University of Sydney (Ho et al. 2018, 2020), as well as Insurance Australia Group’s (IAG) existing relationships with a wide range of transport service providers in Sydney and a strong customer/value design focus, and SkedGo’s top-of-the-line multimodal travel planner TripGo, the Sydney trial is designed to address these two significant knowledge gaps. A graphical representation of the main components of the trial are given in Figure 1. Note that when we refer to subscription plans, this can also be a reference to a bundle.

The report is structured as follows. We begin with a brief overview of the trial setting and then present the key tasks that are central to running a trial. These include how to get a trial up and running - the team, the design of a mobility app, identifying and negotiating with prospective modal suppliers, promotion to potential participants, a pre-trial survey to establish base mobility activity, onboarding and training of participants, monitoring and data capture under pay-as you-go (PAYG) and subscription bundles, bundle design issues related to aims and incentives (see also Ho et al. 2020), data driven determination of incrementally introduced bundles, qualitative surveys to inform the next bundle offer, preparation and analysis data, and post-trial evaluation. The report concludes with commentary on what we have learnt in running a trial and in obtaining scalable buy in to MaaS products as well as the challenges and opportunities for MaaS post-COVID-192. There are a number of Appendices that provide more details of specific aspects of the trial, including a broader commentary on where we believe MaaS is heading and some of the big challenges.

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1 An issue that is of particular concern is whether modes that matter to individuals end up outside of MaaS offerings and are regularly used, limiting a comprehensive test of the impact of MaaS on travel behaviour.

2 A webinar was presented on 1 May 2020 and is available at https://imoveaustralia.com/news-articles/personal-public-mobility/2020-maaS-webinar-video-v2/
3. The trial motivation

The Sydney MaaS trial was motivated by findings from our earlier stated preference research (Ho et al. 2018) and the growing support from government and industry that MaaS will become a key platform for changing the patterns of sustainable mobility. There is only so much one can learn from stated preference studies which are useful in offering evidence of the potential interest in a new product where experience is typically non-existent. The rapid acceptance of unimodal Apps to book and/or pay for transportation services is suggestive of a willingness to adopt technological support mechanisms to inform on travel options (through trip planners) and undertake travel. What is missing, however, is a market test of how much appeal there is for particular integrated mobility services offerings, be they Pay as you Go (PAYG) or subscription-based, and what implications they may have on travel behaviour as well as broader societal impacts.

There is a lot of hype and rhetoric surrounding MaaS and very little evidence on whether it will be a feasible, viable or desirable way to investigate and undertake future travel (Hensher et al. 2020). It is early days to deliberate on whether its future is essentially niche or scalable to a broader travel market. The Sydney trial provides an opportunity to identify what might be of interest in a MaaS offering that aligns with the personal benefits to travellers, and contributes in a broader sense to achieving societal goals that have a sustainability focus. In designing, implementing and monitoring a MaaS trial, some crucial tasks need to be undertaken. We look at each in some detail in the following sections. The in-field component of the trial was completed at the end of April 2020 followed by a period of assessment. Findings reported in this paper are contributions to an ongoing suite of analyses. Importantly, by the middle of March 2020, six weeks before the end of the in-field trial phase, the COVID-19 pandemic resulted in participants curtailing all domestic and international travel outside of their city and suburbs and being told to work from home if possible. Despite this being unexpected, it has given us an unplanned opportunity to evaluate the possible impact, within the limits of the trial, of an extreme event on travel activity, as discussed later in this paper including scenarios for rebooting MaaS post-COVID-19.
4. The team and the collaboration process

A MaaS trial should recognise that an important objective is to establish, post-trial, whether there is evidence to suggest that a MaaS offering within the limits of what was assessed might have commercial merit. With this in mind, putting together a team that has this capability of assessing the prospect for MaaS to migrate in time to a commercial reality is important. The Sydney trial team comprises three groups – the University research team in ITLS at the University of Sydney that has familiarity with appropriate scientific ways of designing and evaluating MaaS products (including continually assessing and revising subscription plans), an industry team from IAG who have an interest in the potential market value of a new product, but importantly have expertise to contribute to all aspects of testing MaaS (including a brokering role between participants and transport service providers), and a technology company (SkedGo) which as a digital platform developer has the capability to develop and operate a customised multi-modal travel planner app and its extension as a MaaS app.

The MaaS trial is centred on collaboration between the trial participants (sourced from IAG staff3) and the research team. The main relationships between these actors can be summarised in ten major sets of activities (see also Figure 2):

1. **Prior to the in-field trial**, a survey instrument is designed to collect data on transport needs in a recent period as well as socio-demographics and opinions on different modes of transport as a reference point to be compared against throughout the trial. This pre-trial data is used as a main source to identify potential participants to the in-field trial. The data is also used to identify mobility profiles and interests in MaaS prior to the trial, and eligible participants for the trial.

2. **When participants are enrolled through onboarding**, business accounts are set up with all the transport providers and participants are provided with individual profiles for all transport modes included in the MaaS trial. This enables us to identify each participants’ use of these modes and their associated share of the cost. Participants are familiarised with the digital platform app called Tripi and may start using it (and the associated travel profiles) immediately. The team must provide daily tier-one support to the participants (e.g., during business hours or an agreed time).

3. **At the start of the first month**, Pay as you go is offered, but no subscription plans, as a way of enabling participants to become familiar with the Tripi app and to ensure that all active features are working properly for each participant. During this first-month learning period, which could be as long as four weeks for participants who were onboarded at the beginning of the month or two weeks for others, data collected on travel activity provides a baseline to assist in bundle design to commence at the beginning of the second month. Data collected in this PAYG period are used to assess any future changes in travel behaviour.

4. **By the start of the second month**, the participants are offered an initial subscription plan as an alternative option to PAYG. They are also shown an estimate of how much their average travel pattern from previous periods would cost on each new plan.

5. **By the start of subsequent months**, the participants are offered a further subscription plan as an option to the previous plan(s) and PAYG. Accumulated travel activity data is used to inform the design of plans. Again, they see an estimate of how much their average travel pattern from previous periods would cost on each new plan offered for the upcoming month.

6. **When a trip is completed**, the cost is charged to the broker’s account with the relevant transport provider. The broker then updates the participant’s back-office account for this trip (largely automatically). For some modes such as public transport, the usage and cost

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3 It was decided to focus on individual employees from IAG, which has a workforce of over 8,000 employees who reside and work throughout the Sydney metropolitan area. It is important to note that business travel was excluded from the trial, and individuals were responsible for paying their own personal travel costs incurred by participation in the trial. Clearly, MaaS in the future can be designed for individuals as well as groups such as households, friends, community groups and tourist groups. In a sense, the IAG participation is aligned with the idea of an employer-sponsored or supported MaaS offering.
information are updated in near real-time by the Tripi app, allowing the participants to track their usage (per mode) and overall mobility wallet balance (credit and debit). For other modes (such as car-rental, car-sharing) whose real time information is not available, transactions are updated at least daily when the broker received invoice from the corresponding mobility service providers.

7. **By the end of each in-field trial month**, summaries of travel activities and costs are provided to each participant in a mobility statement via email, and next month mobility bundles are confirmed/introduced. The participants are informed on how much each mobility bundle might cost them for the next month if their past travel patterns were to be repeated for the next month.

8. **From the second month onward**, each participant is invoiced for the travel they undertook in the previous month. Each participant is informed as to how much they have saved by subscribing to the monthly bundle they chose, compared to using Tripi as a PAYG user.

9. **Throughout the trial**, as a part of the co-creation process, feedback through qualitative interviews on participants' experiences is sought and the reasons why they have decided to stay with the previous monthly bundle or chose a newly offered bundle. This qualitative feedback is used as a supplementary source to data-driven analysis in the monthly incremental design of mobility bundles and informs the evaluation of the trial results.

10. **Throughout the trial**, all data on what trips the participant searches for, what modes they are offered at the time of making each trip, and what option they choose are collected and stored and made available to the research team. The participant's preferences for travel time, travel cost, and greenhouse gas emissions, are collected. A complementary program called Safer Journeys, run by IAG, involves some participant's cars fitted with tracking devices for rapid incident response, enabling us to assess the influence that MaaS has on private car use. Supplementary online surveys are undertaken to obtain additional feedback from participants that is additional to data captured through the Tripi App.
5. The design of a mobility app

Although the technology aspects are not the most innovative aspect of MaaS, technological-related developments are a necessary but not sufficient condition to pave the way for MaaS. The MaaS-related technology developments needed involve front-end and user-interaction developments as well as back-office developments, such as how data, offerings and payments are integrated, captured, stored and distributed across actors (Smith and Hensher 2020). The Tripi digital platform is an enhanced version of

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4 In Sampo’s Blog (Sampo Hietanen, CEO and Founder MaaS Global): MaaS that ‘Matters is MaaS that Scales’ (March 4, 2020), and he suggests that the discussion about technologies and payment structures, as important as it is, is beside the point if we are trying to define (or claim!) MaaS. To deliver MaaS, we need several things, of which a service assistant and a pricing model are the most important. Without those, you do not have MaaS.
SkedGo’s trip planner called TripGo with greater functionality to accommodate subscription plans and the mobility wallet. As shown in Figure 3, there are a number of important functions:

1. Ability for a user to log in and be uniquely identified by the App.
2. Ability for users to view the current balance of their mobility wallet, along with a history of activity (trips, invoices and other adjustments) making up that balance for the current and prior periods.
3. Ability for users to view the current-subscribed mobility plan (if any) including which modes enjoy discounts during this period.
4. Ability for users to browse the details of other mobility plans on offer, and opt-in to one plan for the next period.

Figure 3. Basic conceptual structure of how the app and dashboard interact with the SkedGo servers

A new bundle can easily be added into the system via the administration dashboard. The broker can specify the bundle name, and a short description of the bundle. As well as subscription fees and/or minimum spend amounts for the bundle, administration can also select which transport types are included in each bundle with corresponding percentage discount, or flat dollar amount discount.

The Tripi App and its associated back office platform was extensively tested by the broker in a closed-beta mode with a gradual ramp-up of user activity during the three months prior to it being moved to production mode for the commencement of the in-field trial. This was a very important period of assessment to ensure that the App performed as required and to minimise any disruption for participants.

5 Although the modes of offer are fewer than the capability of TripGo, due in part to the arrangements already in place between IAG and transport suppliers.
6 This process went smoothly, resulting however in 70 bugs with all required feature changes being quickly resolved.
6. Negotiating with prospective modal suppliers and integration

Securing participation of suppliers of transport services can be one of the most challenging aspects of developing a MaaS program, and especially their commitment to deep technical integration (planning, booking, payment). The Sydney trial was able to draw on the existing contractual arrangements in place between IAG and candidate transport services. For example, when a person insured by IAG has a car accident (be it they are injured and/or their car is damaged), they can, through their insurance policy, have access to a rental car, rideshare or taxi services for a fixed period of time with payment made by IAG. This simplified the process of negotiating with these existing transport providers, although there was still some amount of reticence in the beginning about participation of some service providers. Participating transport providers are Uber, Cabcharge, GoGet and Thrifty Car Rental. Opal electronic ticketing (all standard public transport services of public and private operators: bus, train, ferry) is included using standard Opal cards for participants. We explored the inclusion of e-scooters, bikes and private car sharing platforms, but none of the providers indicated they were ready for such an integration without the workaround of storing the broker’s credit card information against every user’s personal account, which was deemed unsuitable from a security standpoint.

6.1 Integration of providers

Varying levels of integration into the Tripi App were explored with each provider. The simplest is search integration, which means that when a user requests a trip between point A and point B, Tripi is able to check the location of services from a provider and their estimated costs and time taken for the trip, and map out a route for the user. It also suggests modal and route alternatives which we capture for later use in the choice modelling analysis as the choice set definition.

6.1.1 Search integration

Search integration is required for all providers except the hire car. Search integration allows users to see a list of possible methods for a given trip from point A to point B via each provider, by knowing the locations of the services and their cost estimates for the trip. GoGet currently requires that the vehicle be returned to the same pod from which it was collected, so it is best used for round-trips, and the estimated cost is for constant use of a vehicle which returns to point A rather than a direct comparison cost for a one-way trip. Hire car is excluded from requiring search integration given it is a special case expected to be booked in advance for use of a vehicle over multiple days for a variety of trips in a pre-defined location. It is not well-suited to returning a sensible result based on a point A to point B search. We proposed deferring to the hire car booking system as much as possible for the special case of a participant requesting a vehicle over a longer period, and instead provided a link for participants to make hire car bookings through a dedicated Thrifty portal for the trial.

6.1.2 Booking integration

The second form of integration is booking, which means the user is able to seamlessly book a service to complete a trip from the App. This can be undertaken via different levels (i.e., an application programming interface (API) or direct integration, deep linking, public/anonymous linking or no integration) in order of decreasing complexity, but for this trial we have prioritised deep linking as the preferred method of providing bookings, as it maintains a good user experience without the high-cost and technical complexity involved with creating and maintaining direct integration to a transport provider’s booking stack. Deep linking to a transport provider’s App or website involves passing some information such as a start and end point for a journey and the time the trip will be taken, and allowing the user to complete the booking outside of the MaaS App. We briefly summarise the functionality associated with each mode of transport within TripGo, the SkedGo main platform7 and the changes required for the enhanced trial app, Tripi.

7 See https://www.youtube.com/watch?v=GG0qho8IIZvY for a high level commentary on TripGo.
Beginning with Opal booking integration, since Opal does not require bookings ahead of time, there is no change needed in the baseline TripGo app. Participants are provided with an Opal card for all their public transport travel during the trial period (approved with TfNSW). For Uber, although TripGo has a direct integration where a booking can be made within the App, this integration only supports a user paying for each trip on their personal credit card, and does not support the use of ‘Uber Ride Profiles’, the method by which this trial is able to have participants book and have all their trips paid for centrally by the broker. Within Tripi, we replaced the direct integration with a deep link to the Uber App, where the destination is pre-populated and the MaaS Trial Ride Profile is left as the default method of payment for participants.

TripGo has an anonymous link to the GoCatch app for Taxi bookings (as at 16/08/19), previously with iterations offering users a phone number which they can click to call a taxi. For the trial, we preferred the GoCatch integration to be improved such that it would deep link to include the destination that a user entered into the MaaS App, and provide users with a phone number for 13CAB (the generic cab number) that they can click to call a taxi if they prefer. However, the deep linking was not technically possible to complete in the budget and timeframe of the trial, so the GoCatch App simply opens with the user’s profile and they must re-enter the destination if they wish to pre-book a taxi journey (although users can still complete taxi journeys in any taxi hailed from the street – see section below on taxi payment integration).

GoGet booking in TripGo occurs by opening the public website and requiring the user to log in. The trial team through IAG brokered discussions between GoGet and SkedGo to have the deep-linking functionality added to the GoGet App. This means that clicking a GoGet search result to make a booking automatically opens the GoGet App with the user pre-authenticated with a search at their current location. For hire car booking integration, the new link requirement outlined in the search integration directs users to a web-page for completing a hire car booking and is incorporated into the profile section of Tripi.

### 6.1.3 Payment integration

The payment integration design requires special attention as a central feature of an efficient MaaS program. All payments are facilitated by the broker, namely IAG. The aim is to provide a seamless experience to participants where all of their trips with associated costs are able to be shown to them, and they only need to make a single payment to the broker to access all modes. This is facilitated by IAG holding the master account with each provider, and passing on costs to participants via a separate invoice during the live trial period on a monthly basis. In addition, the ability for trips to be manually entered or edited via the MaaS back-end web portal is included across all modes where there are once-off entries associated with unforeseen variations, even though this is best automated. The data items are participant id, mode of transport, datetime of trip start, start location (if available), end location (if available), total cost and a note/free-text field. An API enabling trips to be logged in an automated fashion is required.

For Opal payment integration, Opal cards are procured by IAG for each participant and linked to several Opal accounts controlled by IAG. These accounts each have an IAG credit card linked to pay for all trips taken, and participants can use them for all personal trips just like any other Opal card. SkedGo provides an automated mechanism enabling log in and read of all new trips taken by each Opal card linked to these accounts on a regular basis (e.g., approximately 8 hourly, potentially more frequently if it does not cause an issue for the Opal site).

The Uber account set up by IAG adds participants as members of this account, allowing for centralised billing for all trips taken. This account shows up as a new Ride Profile within the Uber app, and any trips taken with this profile selected are billed to IAG on a monthly basis. A report of all trips taken by participants on this Uber account is available from the Uber portal in CSV format daily. These trips are entered into the MaaS back-end portal by the broker, preferably in an automated fashion via an API using the previously specified trip-entry method. Manual entry or editing for any errors is also required as previously specified.
A Cabcharge account, set up by IAG, adds participants as members of this account, which allows for centralised billing for all trips taken. Members added to this account are assigned a digital Cabcharge card which is available via the Apple Wallet on their iPhone. At the end of any taxi journey, a participant can select this digital Cabcharge card in the same way as they would choose an Apple Pay credit card, and simply tap their iPhone (or Apple Watch) on the taxi’s Cabcharge terminal to pay. For participants booking via GoCatch, a payment mode called “Cabcharge/Cash” exists which is selected to allow participants to pay with the digital Cabcharge card issued to them for the trial when they leave the cab, rather than with a credit card. A report of all trips taken by participants on this Cabcharge account is available from the Cabcharge Plus portal. These trips are entered into the MaaS back-end portal by the broker in an automated fashion via an API using the previously specified trip-entry method. Manual entry or editing for any errors is also required as previously specified.

A GoGet account set up by the broker adds participants as members of this account, which allows them to sign up, and then gives centralised billing for all trips taken. Members added to this account can book trips via the GoGet App on their phone while this account is selected. A report of all trips taken by participants on this GoGet account is provided by GoGet in .CSV format daily, inclusive of all hourly and km or toll charges. These trips are entered into the MaaS back-end portal by IAG, preferably in an automated fashion via API using the previously specified trip-entry method. Manual entry or editing for any errors is also required as previously specified.

Finally, a car rental account adds participants as members of this account, which allows them to book hire cars via an online booking tool customised for the trial, and gives centralised billing for all trips taken. A report of all trips taken by participants on this hire car account is provided daily. The default account set-up has the broker paying for all costs associated with the hire including tolls, unfilled petrol charges and damage. Petrol and damage charges are managed by the broker on a case-by-case basis where the terms-and-conditions of the trial that participants must cover these are clearly set out, and the broker passes them on. Hire car rentals are entered into the MaaS back-end portal by the broker, preferably in an automated fashion via an API using the previously specified trip-entry method. Manual entry or editing for any errors is also required as previously specified.

7. Promotion to potential participants

The internal communications activity at IAG, the broker, was designed to promote the MaaS Trial and recruit potential participants. We aimed to gather expressions of interest (completed surveys) from at least 150 valid participants (iPhone users only and Sydney based). Learning from the UbiGo trial in Sweden which has 83 households, the minimum valid participants desired was around 100. Over the month of August, the IAG MaaS team conducted two rounds of MaaS promotions, mainly focused on Darling Park 2 (the head office in Sydney), using a range of methodologies including promotional material, an information workshop, a video on MaaS, a Yammer posting and an online survey.

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8 The sentiment is captured as follows: As Sydney’s traffic gets worse, we are always looking for better ways to assist our staff in getting to and from work (and travel outside of the daily commute). IAG has partnered with the University of Sydney and a travel planner company to trial a new mobility program that can assist you in exploring alternative ways of travelling, and even saving money. We are running a trial called Mobility as a Service (MaaS) and are looking for 100 IAG staff living in Sydney who would like to join in to explore better ways of getting around our busy, congested city and suburbs. What is in it for you? Apart from the convenience of a single App on your smartphone to book and pay for travel using the increasing number of modal options available beyond the car (i.e., public transport using Opal, taxis, Uber, Go Get and even hire cars), you will be participating in Australia’s first trial that integrates, through a single platform on your phone, easy access to many forms of transport. In addition, during the trial you will be able to benefit from a range of financially attractive discounts on various modes of transport. The trial period is over 6 months, but you may join in for a month and see how you like it. If it works for you, you can continue to enjoy the flexibility and benefits of a range of mobility plans. We invite you to consider joining now. Places are filling up nicely, and if you are interested please contact XXXXX today to ensure a place on this exciting trial and become one of the pioneers in Australia in experiencing new ways of conveniently organising your travel through Mobility as a Service.
A challenge in the communications was bridging the knowledge gap employees had when it came to MaaS. As such, the communications strategy was divided into two phases: (1) What is Mobility as a Service, which focused on educating IAG employees on the MaaS concept and targeted early adopters and mobility enthusiasts; and (2) Why join our MaaS Trial which focused on highlighting the benefits and incentives of the MaaS Trial, and utilised personal mobility stories to highlight pain points associated with current travel methods.

In informing IAG employees on the concept of MaaS, the key focus of the education piece in phase 1 was ‘The Future of Transport’ panel and building a foundation within the existing internal communication platforms. The expert panel included key members of the project team. With an attendance of over 60 staff, the panel discussed what MaaS is, how it can benefit their mobility in Australia, and the opportunity to participate in the MaaS Trial. The idea that participants would be pioneers in Australia’s first truly multimodal MaaS trial was utilised as the core message. In addition, a landing page for both the event and the trial itself were created and posted onto The Vine, IAG’s internal intranet page. Following, an email was delivered to all employees who registered for the panel event. Furthermore, the IAG MaaS team was invited to several internal events to speak about the MaaS project such as the Data and Analytics Guild. At the end of July, a total of 71 IAG employees had completed the survey⁹ with 48 valid responders.

Phase 2 centred on ‘Why join our MaaS Trial?’ focused on highlighting the benefits of the MaaS Trial and personalising the mobility experience of travelling in Sydney. A key initiative of this phase was to highlight both extrinsic motivators (potential discounts, leadership endorsement) and intrinsic motivators (addressing pain points, increased convenience, and alignment to company purpose) of joining the MaaS Trial. The key initiatives were: (1) a promotional email as a form of communication that is most effective as it allowed a direct call to action to the survey. Leaders across IAG divisions were encouraged to distribute the email, including the Heads of both Customer Labs and Group Technology and (2) In-person promotion which enabled IAG and ITLS MaaS teams to engage with staff and converse about the trial to IAG employees.

Flyers with a QR code to the survey were also distributed to provide key trial information. In addition, there was (1) an App-naming competition: IAG staff were invited to enter a competition to name the MaaS app with a $100 Opal card as the prize; (2) High online visibility through a Vine article with clear trial requirements and intrinsic and extrinsic motivators, and (3) A grassroots campaign via Yammer utilising personal stories of employees to highlight their current pain points, and the potential of MaaS to solve them.

At the end of August 2019, a total of 222 IAG employees had completed the on-line survey, with 185 respondents owning an iPhone 5 or a newer version and living in the Sydney metropolitan area (i.e. eligible participants to the in-field trial). Figure 4 provides an overview of the uptake across the two months with hints on lessons learnt for future trials.

The two major spikes during August, which correlate to the direct Customer Labs email and the in-person lobby promotions, indicate two key findings when promoting the MaaS Trial. Firstly, endorsement from leadership through a direct email to IAG staff was the most effective method to promoting the trial. This is due to the necessary call to action, completing the survey, which could be accessed directly. Secondly, a widespread in-person presence sparked awareness/interest and allowed employees to engage in dialogue with team members. This suggested a clear barrier to participation was a lack of understanding around the MaaS concept, as identified in Phase 1. Furthermore, the App-naming competition successfully had over 40 entries. The winner and thus the name of the MaaS Trial App was Tripi. Interestingly, most participants were intrigued by the concept of MaaS and the intrinsic benefits rather than the financial incentives. This was supported by the commentary provided in the survey result which had common themes around the novelty of the App and addressing current pain points. It can be concluded that the promotions have successfully targeted the early adopters of the MaaS prospect and the proposed target of 150

⁹ Embedded within the survey was a video on MaaS - https://www.youtube.com/watch?v=3mUELpum-GQ – to understand what MaaS is all about in very simple terms.
eligible participants was reached. As a result, active internal communications were concluded as the MaaS team shifted its focus to onboarding the relevant employees into the MaaS trial.

8. Inviting participants for the in-field trial

Out of the 222 IAG employees who expressed interest in participating in the MaaS trial by completing the online pre-trial survey, 185 respondents are eligible to participate to the in-field trial, defined as owning an iPhone 5 or newer version and living in the Sydney metropolitan area. Given that the trial aims to on-board about 100 participants, it is necessary to identify who amongst these 185 are likely to participate, and more importantly, stay with the trial once on-boarded. Like any longitudinal study, the risk of sample attribution is a real concern. Since the onboarding process is time-consuming, taking at least 40 minute per participant, the study team aimed to reduce the risk of onboarded participants dropping out of the study after a short period of experiencing the Sydney Maas trial. To identify the risk, pre-trial data on the appealing of different feature of a MaaS app are used.

The pre-trial survey asked the participants to indicate, on a scale from 1 to 5, how appealing each of the following features is:

(i) Route your journey according to what matters to you! (e.g., multiple modes, cheapest journey, quickest time, lowest carbon emissions - it’s all your choice).
(ii) The ability to book across multiple modes of transport! (e.g., imagine stepping off the train and having your Uber waiting and ready).
(iii) A single payment portal for all transport modes, whether you choose a subscription plan or Pay-as-you-Go (PAYG).
(iv) The freedom to choose between payment models (i.e., pay per ride for different transport modes used vs. subscription to monthly bundles to access multiple modes of your choice, at discounted rates)

Individual scores associated with each of the four questions above were added to create a MaaS interest index. This index was then used as a proxy for the participant interest in MaaS, or the potential of them staying with the MaaS trial until the end due to their appreciation of a convenient MaaS app and/or financial incentive, in addition to their curiosity which has a separate question. Based on the MaaS interest
index, all eligible participants were ranked and grouped into four categories, namely definitely, yes, maybe and no, for recruitment. The definitely group includes pre-trial respondents who have an index of 20 (out of the maximum of 20), and hence we definitely want to invite them to participate in the in-field trial. The yes group includes respondents with a MaaS interest index of 18 or 19. The maybe group has a MaaS interest index of 16 or 17, with a MaaS curiosity score of 3 or higher (over 5). The great majority of respondents gave a score of 4 or 5, with the mean (standard deviation) of the four feature above being, respectively 4.33 (0.76), 4.38 (0.84), 4.22 (0.98) and 4.27 (0.89). The MaaS interest index had a mean of 4.44 and a standard deviation of 0.772.

Figure 5 plots the residential locations of all eligible participants against the Sydney train lines and stations where the black lines / dots are train routes / stops. The group each participant belongs to is colour coded as shown in the legend. There appears to be a strong correlation between home locations and train lines indicating high public transport use among the participants. This interactive tool is used for exploring the transport options available around each participant’s home in the processing of the recruiting and on-boarding participants for the trial. It is noted that transport options at work location are homogenously good for all participants since AIG offices locate in proximity of a major transport hub (Sydney CBD has most participants, followed by Parramatta – the second biggest employment hub, and Hurstville city – a major hub in the South).

9. Onboarding and training of participants

The onboarding of MaaS trial participants occurred as part of a staggered approach between late October (with first participants onboarded for the trial to go live on November 4) and late December 2019. In addition, 12 IAG staff members expressed interest in joining the trial once it had commenced and were onboarded in the first two weeks of January 2020. The onboarding team included five IAG MaaS Trial team members, with ITLS staff joining selected sessions to assist in documenting the journey.

Onboarding of trial participants took more time and resources than anticipated, with extra time required chasing up no-shows and staff that initially expressed interest in the trial but were non-responsive for long periods of time. A total of 98 sessions took place at the IAG head office (with a few in other offices), with between 1-3 participants onboarded in each session. The onboarding process took on average 15-20 minutes for sessions with ‘prepared’ and technology savvy participants, while large groups and non-technologically driven (or chatty) people taking up to 40-60 minutes.
It was reiterated during onboarding that all participants start on PAYG for the first month. Late trial entrants did not receive bundle offer communications (the first bundle offer, Fifty50, activated in December 2019; and the second bundle offer, Saver25, activated in January 2020) until they completed a period of PAYG experience using Tripi (approximately 2-3 weeks). In October, 26 people were onboarded and received a personal invoice for their first period Tripi expenditure. The official start date of the trial was November 4, 2019.

As part of the onboarding process, participants received a welcome pack which included (in an envelope) the trial timeline, a number of Tripi stickers, Tripi-branded Opal card, a GoGet pack and frequently asked questions. Participants were also provided terms and conditions for the program, and asked to agree to a participant information statement (as required by University of Sydney Ethics). Participants were also set up with a Cabcharge Digital FastCard account.

There were a number of items covered by the onboarding process. Key items explained include: (i) each item included in the welcome pack; (ii) PAYG as compared with subscription plans; and (iii) the participant information statement and terms and conditions. Participants were also asked whether they were involved in the Safer Journeys trial run by IAG (and whether they would be interested in joining) and if they consent sharing their Safer Journeys data with the MaaS Trial. The Safer Journeys trial was car-based with tracking technology installed so that car use kilometres can be measured, a crucial piece of data given an objective on reducing emission through reduced car use.

Some participants asked about the way in which discounts worked. For example, whether they could choose which modes were discounted (i.e., create their own subscription plan). Overall reaction to the onboarding from participants was ‘the process is straightforward’ and they seemed very open to the trial experience. Reminders from participants include they ‘look forward to potential savings on transport’. Two trial participants resigned from IAG in late 2019, which meant they were terminated from the trial as they no longer fulfilled the condition of IAG staff member to participate on this trial. As a result, an exit survey was developed ahead of schedule to ensure feedback from all participants leaving the trial was captured. This survey formed the basis of the final post-trial experience survey, discussed in a later section.

10. Establish base mobility activity

Under an ideal timeline, we would obtain all the necessary data from Tripi which includes actual travel activity and details on other trip opportunities that were shown but not chosen. This data, together with other data such as the Month 1 online survey designed to identify changes in travel behaviour between the prior period and the PAYG period (required as a control), plus the car usage data from the Safer Journeys project, will be overlaid with available modes of transport in the spatial context of actual observed travel, and used to create a series of rules to identify candidate bundles, given the challenges in ensuring subscription fees and discounts are attractive in at least one bundle and satisfy our overarching objectives.

While the pre-trial data analysis informs us of the modal mix used prior to the trial, it is not adequate to identify precise discounts attached to each mode that align with an attractive financial alternative to PAYG that does not impose pressure on the available budget to fund such incentives. It informed us of the frequency of use of specific modes (prior to the trial) and hence the likely impact that specific discounts might have on influencing behavioural change. We are specifically interested in the changes that align with sustainable modal outcomes such as greater use of public transport, and given the data obtained from the online survey on car use, the possibility of seeing the extent to which a bundle month’s activity reduces car use and hence CO₂ emissions, even if it is a switch to ride share and/or car share.

While recognising the desirability of this complete data source to design bundles, we were pushed back by the many tasks at the beginning of the trial, including setting up the back office to handle invoices and data entry, obtaining familiarity with new databases, parsing data, testing the Tripi app and candidate bundles, and demanding technical constraints (e.g., what rules we can and can’t use in Tripi to design monthly bundles), answering participants’ questions, to name just a few. We believed that without
utilising all data available in the first month of the trial (the period in which the first bundle had to be designed), the month 2 bundles can be adequately designed with much more limited, albeit still useful, data and tested during month 2. We use co-creation leading up to month 3 to learn about possible changes in the subscription fee and discounts that would be of interest in selecting a revised bundle for month 3, subject to it satisfying our objectives and financial constraints. This process of incremental bundle design is detailed in the next section with a more in-depth analysis in Ho and Hensher et al. (2020).

The limited data from the pre-trial survey provides an aggregate profile of modal use of eligible participants. For example, this survey provided data on the modal mix of travel (Figure 6) and the frequency of use of each mode (Figure 7), confirming the hypothesis from the residential locations along public transport lines. The data suggests that there is a high incidence of car and public transport users amongst the eligible participants, with many individuals showing multi-modal behaviour such as using both public transport and car modes (117), or even public transport, car and taxi/Uber modes (33). The incident of unimodal respondents (i.e., users of car or public transport only) are much lower, totalling 23 participants out of the 185 eligible participants.

![Multimodal behaviour of respondents eligible for in-field trial](image)

*Figure 6. Multimodal behaviour of pre-trial respondents eligible for the in-field trial*

When it comes to the frequency of use (Figure 7), there are many eligible respondents using public transport on a daily basis or quite often; from three to five times a week. The frequency of car use amongst these respondents is spread more evenly between the top three categories, which could be referred to as car-dependent users (almost daily), car frequent users (3 – 5 times per week), and car-infrequent users (once or twice a week). There are a few respondents who use cars much less often, including 10 car non-users. Very few eligible respondents use car-rental or car-share, and for those who did, the frequency of using these transport modes are quite low, typically between once per fortnight to once per month. However, ride-share (mainly Uber) occurs more often with a good spread of use from ‘never through to 1 or 2 times per week’. Taxi has a greater frequency of ‘never or 1 to 2 times per month’ compared to Uber with fewer trips for ‘1-2 times per week up to once a month’ compared to Uber. This evidence provides some clues on the current use of ride-share and car-share in setting affordable and attractive discounts in the design of the month 2 bundle.
11. Bundle design

One of the most challenging features in MaaS is the design of subscription bundles (Ho and Hensher et al. 2020). Although it is relatively straightforward to promote the notion of a subscription plan, it is not obvious what should be included in such plans. Reck et al. (2020) have reviewed the existing bundles offered in trials, real market offers and stated preference surveys (see also Hensher et al. 2020), including the motivation for such bundles (often a ‘suck-it-and-see’ approach) and one can at best describe the process as disjointed and lacking any clear guidance for ongoing design. This hampers comparative learning (and the meaningful design of subsequent studies) as it is unclear what the underlying design dimensions are and how to disentangle differences in design from differences in outcome. The latter include contradictory findings such as some authors arguing that customers do not prefer shared modes (carsharing, bikesharing, taxi) in their plans (Matyas and Kamargianni, 2018) while other authors have found a higher willingness to pay for carsharing in bundles (vs. stand-alone) suggesting that respondents do prefer some shared modes in their bundles (Guidon et al., 2020; Ho et al., 2018).

Three particularities apply to MaaS bundling. First, MaaS brokers (e.g., WHIM) that sell MaaS bundles might be different entities from the original (i.e., disaggregated) mobility service providers (e.g., Mobike, Lime). Second, MaaS bundles are typically offered as subscriptions, through which a customer would commit to buying a certain amount of different mobility services on a recurring basis (e.g., fortnightly or monthly). Third, while profit maximisation through price discrimination appears to be the main rationale for bundling in the broader literature, sustainability (or societal benefits) is an important reason for bundling in transportation. Historically, public transportation season tickets have been heavily subsidised to address market failure (tragedy of the commons) and incentivise sustainable travel. From a societal perspective, one hope is that MaaS might increase the share of intermodal alternatives compared to private car use and ultimately reduce car ownership, resolving the marginal cost problem.

Reck et al. (Table 1, 2020) distinguish between necessary design dimensions and complementary design dimensions. Necessary design dimensions are those that form the essential core of a MaaS bundle (i.e., without defining these, it would be incomplete) and comprise modes, metrics (i.e., the measurement unit used to define the entitlement to each mobility service), the area of validity of the bundle (‘geography’), the target unit to offer the bundle to (i.e., individuals, households or any other chosen grouping) and the subscription cycle (i.e., weekly, fortnightly, monthly). Complementary design dimensions can, but do not necessarily have to, be defined. They comprise the incentive structure, caps to the subsidised use of modes, non-transportation add-ons, whether a bundle is customisable and roll-over options for unused budget.
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</tr>
</thead>
<tbody>
<tr>
<td>Modes</td>
<td>Modes of transportation included in the bundle</td>
<td>Public transportation, carshare, (e-)bikeshare, e-scooters, taxi, car rental, ridehail</td>
</tr>
<tr>
<td>Metrics</td>
<td>Way in which the mobility budget / entitlement and consumption of a mode is measured</td>
<td>Time-based (minutes, hours, days), distance-based (km, miles), trip-based (number of trips)</td>
</tr>
</tbody>
</table>

**Necessary design dimensions**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geography</td>
<td>Area of validity</td>
<td>Single city, multiple cities, country</td>
</tr>
<tr>
<td>Market segment</td>
<td>Entity the bundle is designed for, and whether the bundle can be shared</td>
<td>Individuals (residents, tourists, commuters, seniors), households, employee groups</td>
</tr>
<tr>
<td>Subscription cycle</td>
<td>Period of single recurrence of a subscription</td>
<td>Weekly, fortnightly, monthly; Calendar or rolling</td>
</tr>
</tbody>
</table>

**Complementary design dimensions**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discounts</td>
<td>Type and granularity of rebate</td>
<td>Trip-based (20% / $5 off each trip), budget-based (subscription fee or top up $50, pay $45)</td>
</tr>
<tr>
<td>Caps</td>
<td>Limit to discounted trips / entitlements depending on the metric, also referred to as budgets</td>
<td>Time-based (30 hours / trips up to 30 min), distance-based (30 km), trip-based (10 trips)</td>
</tr>
<tr>
<td>Add-ons</td>
<td>Non-transportation services included in the bundle</td>
<td>Parking, coupons (e.g., shopping, accommodation, restaurants, food delivery)</td>
</tr>
<tr>
<td>Customizability</td>
<td>Bundles can be pre-defined by the mobility broker or personalized by the users</td>
<td>NA</td>
</tr>
<tr>
<td>Roll-over option</td>
<td>Transfers unused credit to the subsequent time period</td>
<td>NA</td>
</tr>
</tbody>
</table>

Given this background, we proposed an incremental approach to the design and introduction of MaaS bundles, adding an additional bundle each month after the initial PAYG period\(^{10}\). The advantage of this method is that we are able to learn from travel behaviour activity in the accumulated months and to use this as a data driven way to construct the next period bundle, always mindful of the overarching objectives such as reducing emissions\(^{11}\).

\(^{10}\)We used deep dive interviews to gain early insights into the types of issues that potential participants are likely to raise and what responses we can make as early as possible to mitigate any concerns. The main outcome of this process was a decision taken to focus month 1 on PAYG only and to extend the period to six weeks to ensure that adequate time is available to bed down any issues with participants using the App and the administration of the entire process, especially the obligations of the broker, the revenue trails through the mobility wallet, and the collation and analysis of data on the PAYG travel activities as input into the selection of bundle plan offers. We also needed time to write new computer routines (in R) to process data into a format required to understand travel activity and associated key performance indicators such as emissions.

\(^{11}\)In designing MaaS offerings, we are mindful of the need to link the approach to some appealing objectives (or goals). We agreed that the overarching main objective relates to finding ways to encourage participants to switch to more sustainable travel activity. Although this is a very generic laudable goal, we also decided to translate it into a more operational (and visible) objective which is related to moving to greater use of public transport (especially linked to reduced car use); however the possibility of multiple occupancy in car sharing schemes was also seen as having positive societal benefits. The ability of a participant to be able to switch some trip activity out of the private car was recognised as having challenges which are highly dependent on location of travel (i.e., the availability of sustainable alternatives) and the socio-demographic constraints on the need to use a private car for specific activities (e.g., taking young children to pre-school). However, we anticipate the ability to do this through car sharing in the future, with suppliers providing safety car seats for young children etc. At present we believe that some trips may be out of scope for the MaaS trial, even being in-scope in the future, and so we would need to identify these trips since such information is important in co-creating a plan that each participant is willing to
The trial approach renews the current plan automatically and as we introduce bundles incrementally, every month we give participants feedback on what will work best for them in the following month given recent travel activity and bundle choice. However, they must make a choice of a new bundle if they want to switch. This is a kind of individual marketing and sets our trial apart from others. The monthly “feedback and choose” is very innovative and allows for a customisation of personal preferences which should be a key feature of MaaS. We provide a synthesis below of bundle design but refer the reader to a more detailed report on the Sydney MaaS trial’s bundle design in Ho and Hensher et al. (2020).

12. Designing the incremental introduction of bundles

As a starting position, we agreed on a number of initiatives to guide the design of the PAYG and subsequent plans and/or bundles. We clarified the use of words such as plan, bundle and subscription. Our working definitions (interpretations) are as follows: A Plan is simply whatever a participant wishes to do; A Bundle is a mix of modal offerings that define the contents of a plan; and a Subscription is an upfront payment associated with a selected Plan; related to a monthly payment for a Bundle that can be cancelled anytime. Starting with month 1, allowing for a 4-week familiarity period with the App, but also including data capture of actual travel behaviour (ideally with fitted devices in a car to complement the data captured through the App for non-car travel, excluding capturing walking activity), this period enabled us to identify potential MaaS offerings that participants would be interested in testing during the following month (and which may continue as is or be revised through learning over the remaining months).

The design strategy used below was guided by a number of principles, as proposed in Reck et al. (2020). The first principle is that bundles are tools that serve a goal. The goal needs to be clarified before the bundles are designed and can vary from profit to behavioural change to customer retention or combinations thereof. This could be a challenge with differences between government and private sector interests and hence methods for bundle design might vary accordingly. The second principle is that data elicitation and bundle design have to be coordinated well if the aspiration is a data-driven bundle design. The Sydney trial is a nice example of a well-planned cascade with a pre-trial survey, an initial PAYG period and subsequent, sequential bundle design and introduction (Figure 8). The Sydney trial also shows how the data-driven approach has to be (temporally) substituted by a hypothesis-driven approach if data is not available as planned. The third principle is that a sequential and iterative approach to bundle design seems favourable in a data-driven setting, i.e., one that starts with one bundle and allows for evaluation and refinement once more data has been collected to launch subsequent bundles. Besides facilitating continuous learning, this might have a positive effect on trial participants (with appropriate feedback), keeping them interested in the trial.

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trial. Some of the features that we did not account for but are important in going forward are discussed in later sections on lessons learnt.
The data available to use in co-creating a month 2 plan include the pre-trial survey (prior to month 1 which went into the field in mid-July 2019), and travel activity captured through the Tripi App and the car-installed device\textsuperscript{12}. The bundles offered in months 2 to 4 are shown in Figure 9 which are respectively Fifty50 (December), Saver 25 (January), GreenPass (February) and SuperSaver25 (March), the latter replacing the Saver 25 bundle. We planned to return to PAYG in April 2020 but COVID-19 intervened. In the following sections, we discuss the core logic used in arriving at these bundles. In the PAYG month, several decisions were reached, notably agreeing on the incremental approach to the bundles, including putting an exploratory one out for the December period, and agreeing to use a metric of CO\textsubscript{2} abatement as a proxy for the success or otherwise of a change in behaviour during the trial, or as a result of use of a bundle.

The take up of bundles by month is summarised in Figure 10 and the transition between bundle subscriptions and PAYG as of March 2020 is summarised in Table 2. The monthly evidence is discussed in detail below but the evidence on take up of Bundles is very encouraging, at 46 percent in March\textsuperscript{13}. The percentage of participants subscribed to the Fifty50 bundle is 15%, and the numbers of for the SuperSaver25 and Green Pass bundles are 12% and 19%, respectively. This aggregate share from real preference evidence is similar to what has been found in stated preference studies such as Ho et al. (2018) and the first tangible evidence, as four participants from PAYG joined SuperSaver25, while another four participants who were on Saver25 in February switched to PAYG in March. Nobody on GreenPass was tempted by moving to another bundle, which saw the most growth and is also the one promoting the most sustainable travel, and the only one with a hard cap ($125 for "all you can eat" public transport). We now turn to a detailed assessment of the findings for each month associated with a bundle offer.

\textsuperscript{12} If the latter is not possible, then a short one page online survey to participants will be required that obtains data on car use during this first month. The latter data will not be as comprehensive as that which can be captured through the in-car device (which is trip specific); however it is better than no information on car use.

\textsuperscript{13} A comparison with available known evidence from stated preference studies such as Ho et al. (2018) is very encouraging. To make the comparison we must ignore the status quo and accounted for those who did not participate (stayed with status quo). 37% in the SP study choose a bundle, and for those who effectively participated in the trial, this figure is 36.44%.
Figure 9. PAYG and bundles for the PAYG and four bundle offer months of the trial

Figure 10. Summary of bundle take up by month: November 2019 – March 2020
Table 2. Bundle switching between February and March 2020

<table>
<thead>
<tr>
<th></th>
<th>Fifty50</th>
<th>Green Pass</th>
<th>PAYG</th>
<th>SuperSaver25</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fifty50</td>
<td>8</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>Green Pass</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>PAYG</td>
<td>4</td>
<td>3</td>
<td>43</td>
<td>4</td>
<td>54</td>
</tr>
<tr>
<td>Saver25</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>Total users</td>
<td>14</td>
<td>18</td>
<td>50</td>
<td>11</td>
<td>93</td>
</tr>
<tr>
<td>Percentage</td>
<td>15%</td>
<td>19%</td>
<td>54%</td>
<td>12%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Note: Column in February bundle, row is March bundle.

12.1 Bundle month #1 (December 2019) – Fifty50

For the first bundle month of December, limitations imposed by the Tripi digital platform required us to introduce the bundle in the last week of November (‘calendar month logic’) to commence at the beginning of December as different bundles cannot be offered to different people at different times (‘elapsed month logic’), and to pursue a ‘conservative approach’ with regards to incentives as bundles technically cannot be withdrawn during the trial unless no-one subscribes to them.

The design of the December bundle took the following logic:

1. $100 worth of incentives are available on average per person\(^1\)
2. Given the goal to reduce emissions through incentivising more sustainable travel, and public transport being the most sustainable available mode, we suggested spending at least $50 as incentives on public transport use. $50 incentives and the weekly $50 cap (monthly $200 cap) translates to the following pricing structure for public transport in a bundle: Free public transport would cost $200 - $50 (incentives) = $150 and a 75% discount on public transport would cost $200 * 0.75 – $50 (incentives) = $100
3. The specifics of the December holiday season such as less working days, inferior public transport service, and the increasing need to get chauffeured rides after parties suggest fewer than 4 weeks of regular public transport and higher than usual Uber/taxi use, and thus demand for bundles that include these modes
4. With a remaining budget of $50 worth of incentives per person, a $3 reduction per Uber/taxi ride is a conservative design that enables 50/3 = ~17 rides per person before the incentive budget runs out
5. We thus proposed a conservatively priced first December bundle at $50 that includes 50% discount on public transport and $3 discount on every Uber/taxi ride; referred to as the Fifty50 Bundle.

Looking ahead beyond December, the plan was to develop and introduce further bundles for January and subsequent months incrementally based upon the following principles: (1) Data driven (i.e., based on people’s actual consumption and travel behaviour); and (2) Insight driven (i.e., based on reviews of past experiences with prior bundles and calibrated with them).

We do, however, acknowledge, that while usage data will suggest which bundles might fit current behaviour best, it cannot advise on appropriate incentive structures to change travel behaviour. We do, however, have plenty of evidence from past travel behaviour research to suggest meaningful levers to assist our recommendations (see Hensher et al. 2020). One such lever to change behaviour is information. Sending each participant customised information together with the invoice at the end of each month via email with a few key data points is expected to have a strong effect on a change towards more sustainable modes and bundle uptake. These data points include: (1) Total cost this month; thereof, for use of private car (full cost approach); and potential cost savings with Bundle X assuming similar trips next month and (2) Total carbon emissions this month; thereof, for use of private car; and potential carbon

\(^{1}\) Based on a $50,000 allocation for financial incentives.
savings if changed X commuting trips to public transport. Although not implemented in the trial, this could in the future also be further expanded towards a nice nudging experiment (Thaler and Sunstein 2008) with some people getting different information from others.

12.2 Bundle month #2 (January 2020) – Saver25

Building on the insights on participants’ activities for December and current regular travel patterns and mode usage, we proposed that an attractive January bundle should support sustainable travel, especially regular commutes, and support flexible, daily outings without a private car. While one might initially think that encouraging car-based modes such as ride share and car share does not support a sustainability agenda, it has to be linked to both short-term and long-term impacts. In the short-term, carsharing might reduce emissions if smaller and more fuel-efficient vehicles are chosen. In the long-term, carsharing as well as Uber and taxi might change habits in relation to private car use and ownership. During the limited duration of the trial, we could not establish any change in car ownership (including the second car), other than possibly a consideration as to whether they will continue to own private car(s) (or not buy additional ones). We can, however, facilitate positive experiences with means to substitute car ownership by shared modes, and thereby contribute to a change in mindset towards sustainability.

Accordingly, we differentiated the goals of the trial by taking into account short-term effects (i.e., emissions) and long-term effects (i.e., intent not to buy or sell the/a second/third private car, which could be measured by asking about buying/selling intentions now and in the last week of the trial). Following this logic, we recommended detailing two initiatives for January:

1. A January bundle that supports both sustainable, regular commute and flexible outings (potentially with a lower entry barrier / subscription fee)
2. And available to all participants (including PAYG), a one-off discount of $10-25 for the first GoGet trip of users within the trial (with the main goal of nudging first time users towards trying out new modes). This can occur only once any time and is unrelated to a bundle.

In the following, we focus on initiative 1 above, which is linked to the bundle offer. We reiterate our established logic for public transport:

1. $100 worth of incentives per month continues to be available on average per person, assuming 100 participants.
2. Given our goal to reduce emissions and public transport being the most sustainable available mode, it was suggested to continue spending at least $50 of incentives on public transport.
3. $50 incentives and the (conservative, as few participants actually reach it) weekly $50 cap (monthly $200 cap) translates to the following pricing structure for public transport in a bundle:
   a. 50 % discount on public transport would cost $200 * 0.50 – $50 (incentives) = $50
   b. 40 % discount on public transport would cost $200 * 0.40 – $50 (incentives) = $30
   c. 25 % discount on public transport would cost $200 * 0.25 – $50 (incentives) = $0
4. Given that we want to decrease barriers to entry, we suggested to proceed with a 25 % discount on public transport, referred to as Saver25.

For the flexible component, we can, in principle, choose between discounts for car sharing, Uber and taxi. We face the following difficulties given evidence from December: Uber and taxi, which are already included in the December bundle, seem to be used by many, even during “regular work weeks”; car sharing, on the other hand, is only used regularly by two participants (thus far). This might change as more participants are onboarded and as travel demand for flexible, daily outings (as expected for January) increases. Yet, designing a bundle around carsharing and public transport risks only being attractive to a small subset of frequent carsharing users.

Taking into account the additional constraint that we want to decrease barriers to entry (subscription fee) and yet offer all three flexible modes to hedge the risk of designing a bundle only for frequent carsharing users, we have to use a different discount metric than a $ off each trip to design a bundle that will not be superior to the December bundle. We suggested offering a % discount on all three flexible modes (turning the constraints into an opportunity to test a different discount metric).
Consider the following bundle that satisfies all criteria mentioned so-far: (a) Subscription fee: $25 (-> lower barrier to entry), (b) 25% discount on public transport, and (c) 15% discount on Carshare, Uber and Taxi. The 15% discount for each Carshare, Uber and Taxi trip translates to average savings of $2.25 per GoGet trip, $3.75 per Taxi trip and $3.15 per Uber trip. Despite seemingly high values, this is a fairly conservative pricing approach, as only people spending more than $333 in January on these three modes will use more than the available and remaining $50 subsidy budget.

In order to test the appeal of the Saver25 bundle vs the December Fifty50 bundle and PAYG (we do not want to construct a bundle that is superior to the December bundle for most and risk cannibalising an existing bundle), we constructed hypothetical demands for January, building on our knowledge to date of travel made. First, we only use people that we have at least a full week (7 days) of data from (n=49). Second, we scale each person’s mobility demand to 31 days. Third, we adjust demand by acknowledging that most people will work less than four regular weeks (and thus commute using public transport less than four regular weeks) by decreasing OPAL trips by 25% (equivalent to 1 week), and some people will undertake more flexible trips by increasing the number of Uber and Taxi trips per person using a uniform distribution (minimum 0, maximum 3) and the average Uber/Taxi trip costs, and increasing the number of Carshare trips per person using a half positive normal distribution (minimum 0, maximum 2) with average Carshare costs and a higher mean (1.5) for households that have fewer cars than license holders (-> higher need of GoGet) a lower mean (1) for households with equal or more cars than license holders.

Using this hypothetical demand data, we compared the appeal (i.e., how many people would choose each bundle) of the new January bundle, the December bundle and PAYG, looking for complementarity between the three. Table 3 displays the results for variations in discount on flexible modes (Uber, Taxi, and GoGet). It reads as follows: using a 15% discount for flexible modes (column highlighted in green) for the January bundle, 12 people would (continue to) subscribe to the December bundle, 23 people would continue with PAYG and 14 people would subscribe to the January bundle. This is a nice distribution of bundles appealing to different people. We thus recommended the following bundle for January: Subscription fee: $25 (-> lower barrier to entry), 25% discount on public transport, and 15% discount on Carshare, Uber and Taxi. Key Marketing points associated with this bundle are a lower subscription fee than December and additional flexibility, by including Carshare.

Table 3. How many people would choose each bundle under varying discounts on flexible modes for the January Saver25 bundle?

<table>
<thead>
<tr>
<th></th>
<th>Number of subscribers by varying discount levels for flexible modes (Uber, Taxi, GoGet) for the January bundle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bundle</td>
<td>10%</td>
</tr>
<tr>
<td>December</td>
<td></td>
</tr>
<tr>
<td>- $50 subscription</td>
<td>12</td>
</tr>
<tr>
<td>- 50% PT</td>
<td></td>
</tr>
<tr>
<td>- $3 Uber/Taxi</td>
<td></td>
</tr>
<tr>
<td>PAYG</td>
<td>29</td>
</tr>
<tr>
<td>January</td>
<td>8</td>
</tr>
<tr>
<td>- $25 subscription</td>
<td></td>
</tr>
<tr>
<td>- 25% PT</td>
<td></td>
</tr>
<tr>
<td>- 10-20% Uber/Taxi/GoGet</td>
<td></td>
</tr>
</tbody>
</table>
12.3 Bundle month #3 (February 2020) - GreenPass

Figure 11 shows the number of users who are active (i.e., made a trip) on a daily basis since the trial was launched on the 4th November 2019. It is clear that many participants were quiet on Tripi between 20 December 2019 and 05 January 2020 inclusive. This period is identified as the Xmas and New Year shutdown for the purpose of establishing regular travel patterns for each participant. Despite December and January having specific seasonal characteristics, the data was used to estimate how much it would cost the participant in February under different bundles should their regular travel patterns be repeated in February 2020.

How does the bundle subscribers use of different transport modes compare to those who have always been on PAYG? Figure 11 compares Fifty50 users (Bundle #1) with PAYG users in terms of the extent to which they use different modes of transport offered via the MaaS trial. Note that reference to Saver25 (Bundle#2) is included only to show the period in which it was introduced (at the beginning of January 2020). In Figure 12, we compare the average trip number by bundle subscribers and PAYG users before and after the intervention (i.e., after the introduction of these bundles). The main idea is to see a change in the number of trips (one metric of behavioural change) after subscribing to a bundle. Think of this as a control vs treatment group where PAYG is the control. The reference to the bundle prior to its availability, as depicted in Figures 11 and 12, refers to those participants who subsequently chose a particular bundle plan even if during a previous period they were on PAYG.
The Fifty50 bundle was introduced in December 2019 and remained available for January 2020 when the current analysis was conducted. The marked difference between Fifty50 subscribers and PAYG users is shown in the average number of public transport trips (i.e., Opal) per person per week. During the period when only PAYG was offered (i.e., November 2019), those who later subscribed to the Fifty50 bundle show a much higher average number of PT trips than those who have always been on PAYG since being onboarded. During December 2019 when the Fifty50 bundle was first introduced, the average number of PT trips by Fifty50 subscribers reduced, possibly due to the Xmas and New Year shutdown period; however their level of PT usage was still higher than that of the PAYG users which appears to be more stable due, we suggest, to a larger sample size, i.e., more participants on PAYG than on the Fifty50 bundle in December 2019. Figure 12 also shows that the use of transport modes other than public transport were remarkably similar between the Fifty50 subscribers and PAYG participants.

In a similar way, Figure 13 compares the travel behaviour of Saver25 (Bundle #2) subscribers with that of PAYG users. Saver25 subscribers showed a lower level of PT use while a higher level of Taxi/Uber travel during the period up to 1 January 2020 when this bundle was first available. The lower entry barrier of the Saver25 bundle (a subscription fee of $25 per month) may have been one of the main appealing features of this bundle, which has 10 subscribers in January, compared to the Fifty50 Bundle #2 which has 14 subscribers in the same month.
Early evidence suggests that we have two good bundles in place to cater for different segments of the 91 participants to date. The Saver25 bundle is more attractive to participants with a lower level of PT use (around 4 – 5 trips per week) and one or two weekly Uber/Taxi trips. The Fifty50 bundle is appealing to participants with a higher level of PT use (around 8 – 10 trips/week in November 2019). Despite this high level of PT usage, many users did not reach the weekly Opal cap of $50 per week yet (see Figure 14).
From the Fifty50 and Saver25 evidence, we concluded that what was required for February 2020 is a bundle (Bundle #3) that serves relatively heavy PT users, either in terms of trips or fare. Now was felt to be the time to introduce a 'pure' public transport bundle (called GreenPass) which offers free travel on PT for a subscription fee. The question is how much the subscription fee would be so that this bundle is attractive to current PAYG users without reducing the attractiveness of the two existing bundles (Fifty50 and Save25)? To this end, a sensitivity analysis of the subscription fee was conducted. Table 4 shows the split of users by monthly bundle that is most financially appealing to them, assuming their historical and regular travel patterns are to be repeated in month 4, namely February 2020. It illustrates the importance of finding the right price for the bundle using sensitivity analysis. Individual regular travel patterns are established by summarising their travel records since being onboarded, excluding the Xmas and New Year shutdown period (20 Dec 2019 – 05 January 2020 inclusive).

<table>
<thead>
<tr>
<th>Most financially attractive bundle</th>
<th>$100 GreenPass fee</th>
<th>$125 GreenPass fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fifty50</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>PAYG</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Saver25</td>
<td>17</td>
<td>22</td>
</tr>
<tr>
<td>ProPT</td>
<td>51</td>
<td>22</td>
</tr>
</tbody>
</table>

Note: as of 20 January 2020, there are 90 Tripi participants: 14 on Fifty50 and 10 on Saver25 with the balance on PAYG.

We are able to retrieve, for each participant, their own travel record, with some having onboarded earlier than others, and some being more active on Tripi than others. The longer and the more active they have been on Tripi, the more valid the assumption that their historical travel pattern will be repeated. Figure 15 shows the progress of onboarding Tripi participants up to 20 Jan 2020, which indicates the period the participants have been using Tripi and hence, providing historical data for this analysis in designing the February bundle offer. Up to 76 participants were onboarded by the first week of Dec 2019, meaning that more than three-quarters of the participants have provided at least two weeks of travel records during the regular period of 2nd Dec – 20th Dec 2019, just before the Xmas shutdown by the time this analysis was undertaken. Up to 50 participants have provided more than one month of data to establish regular travel for this analysis. The evidence suggests that the estimated travel need for February is expected to be reliable for many participants. However, it should be noted that there are few participants who have been inactive on Tripi since they were onboarded. Most participants have been using Tripi at least as PAYG and they are highly likely to continue doing so in February, even given that they have made only a few trips via Tripi and the February bundle targets heavy PT users.
With a $100 subscription fee, the proposed February GreenPass bundle is likely to severely damage the Fifty50 bundle (0 users are estimated to find this bundle most attractive in the presence of the GreenPass in February). A $125 subscription fee results in a nice even split of users amongst the bundles (about 25% of users in each bundle).

Will we break the bank by offering this generous GreenPass bundle #3? While there are few participants who are heavy users of PT, many are still not hitting the Opal cap of $50 per week. Figure 16 shows the level of financial incentive provided to each participant. This is computed as the difference in monthly cost between a bundle and PAYG. As can be seen, a few participants (e.g., P012, P133, P177) would pay $100 less if they subscribed to the GreenPass bundle. Many will save between $50 and $75 per month under this bundle if their observed travel patterns are to be repeated in February 2020. Overall, the trial has the budget to afford this level of incentive.

In summary, the proposed monthly bundle #3 for February 2020 (GreenPass) is as follows: (a) unlimited use of public transport (free PT included in the bundle), (b) 15% discount for every Taxi and Uber trip, and (c) a subscription fee: $125 per month.

An interesting question is why have some PAYG users not subscribed to any bundle yet? This is a difficult question to answer, but preliminary analysis suggests that they are already multimodal users who already have access to a private car and use PT, Taxi, and Uber much less often than bundle subscribers. The trial offers limited levers to attract these people to subscribe to a bundle. In addition, it is not clear as this point whether attracting these multimodal users to a bundle would reduce their carbon footprint, which is one goal of the MaaS trial. An analysis of safer journeys data may help here, and a few one-on-one interviews with continuing PAYG users soon (in February) would provide more insight as to what the trial can do to reduce the cost to themselves and to the environment. The matter of car use and behavioural change is addressed below in month 4.

12.4 Bundle month #4 (March) – SuperSaver25

Month 4 is the last month for a new bundle, with a planned return to PAYG for the April month of the trial. Extensive analysis was undertaken of the data obtained up to late February (from Tripi and Safer Journeys) to inform the design of Bundle #4, and specifically what to do about car use. We decided to maintain a focus on public transport within the bundle, questioning the role that rideshare and car share
could play in reducing private car use while supporting the use of public transport as the preferred mobility mode, given capacity and passenger loadings.

Two initiatives were agreed to. The first was to revise the January Saver25 bundle to try and encourage greater use of public transport through a financial incentive associated with the first and last mile (access and egress) part of a door-to-door public transport trip. Specifically, we provided an additional financial incentive of $5 to use Uber to connect to and/or from public transport. In deciding how best to proceed, we drew on the broader literature on the impact of price of modal activity and considered the implications of subsidising Uber on the first/last mile. Reck and Axhausen (2019) investigated this matter in the USA context and several interesting issues emerged:

- In general, there are several ways of subsidising such trips: flat value subsidy (i.e., $5 off), % discount, or a flat fee for a first/last mile trip.
- Regardless of the subsidy scheme, ridership in most pilots has been surprisingly low or “not real” (i.e., people have been gaming the system by not taking a subsequent or previous PT trip — this is very important to control for) even where these trips have been provided at no extra charge (i.e., free).
- Reasons for low ridership can be operational, but also the additional price often exceeds the value of travel time savings (except for the very wealthy) and the additional transfer, wait time, insecurity to reach the bus/train provides an additional burden that might exceed the value of the first/last mile ride.
- Thus, on balance it is concluded that subsidised ridehailing for the first/last mile is likely not to be the panacea as often portrayed, and that subsidy schemes need to consider mainly income equity. Integration into local public transport price schemes (i.e., providing first/last mile trips for free if there is a subsequent / previous PT trip) as implemented in Seattle is the most equitable option.

We were unable to offer free first and last mile trips, given our incentive budget, but also had a concern about the impact of existing bus services in accessing and egressing a rail station. The compromise was to introduce a financial incentive for Uber only (determined also by the way Uber is integrated into Tripi) with a distance cap option in order to provide absolute certainty to participants that they would not face a situation where they were able to reach the station one morning within the cap, but then find no discount applied on another morning due to a surge or other minor pricing change pushing them over the distance limit? Analysis of travel in previous trial months suggested that 5kms covers 75 percent of participants (without checking whether they are on a plan or not). Participants deliver us their exact distance for every trip which also visible to participants via their Uber profile and what is used for their pricing; so it is beyond debate. We populated this distance value into the Notes field of the wallet of every Uber trip taken so that we can establish the eligibility to receive the first and last mile Uber discount.

In addition to this change to Saver25, now renamed as SuperSaver25, we also changed the 15% on Taxi and Uber to be a flat $3 reduction given feedback that participants prefer an absolute dollar amount. It became clear that most Uber and Taxi trips are relatively short, and so a $3 incentive is better value that a percentage, where the latter may be more appealing for long trips. We stayed with the subscription fee of $25/month and the 25 percent discount on all public transport trips. The take up of GoGet was essentially existing GoGet trips, and hence we did not see any benefit linked to the goals of the trial and removed the incentive.

As shown in Table 2, the sequential introduction of four bundles, with the Saver25 being revised as SuperSaver25, resulted in a drop in the number of SuperSaver25 bundle participants compared to Saver25 (down 14 to 11), but a very noticeable increase in the take up of the GreenPass - 18 in March compared to 12 in February where we only changed the rideshare discount from a percentage to an absolute amount. It is interesting that no participant on Green Pass was tempted to move to another bundle, with it having the most growth and also the one promoting the most sustainable travel, and the only one with a hard cap ($125 for "all you can ride" public transport).

What this suggests is that there appears to be a realisation of the benefits of the generous public transport offer in GreenPass, and that the attempt to lure car users (in particular) to use Uber as first and last mile public transport modes or indeed for those that already access public transport by walking
or car (park and ride or kiss and ride) show little interest in the still more expensive Uber offer. The number of participants taking advantage of this Uber offer is very small. For the car users, we also know that service levels (i.e., travel times, frequency, crowding, convenient etc.) are much more important influences on modal choice. However, we are impressed with the 36.5% take up of bundles, suggesting that the idea of a subscription fee and discounted multi-modal bundle has real merit but that the identification of the ‘best’ bundles, given the objectives, remains an ongoing challenge. PAYG, however, has been decreasing as each bundle is introduced in sequence.

The evidence from the bundle offers suggests that financial incentives offered to date are inadequate to get noticeable behavioural change, especially car use (See Figure 17). To try and find another way to attract car users into a more emission-friendly mode, it was decided in March to complement the revised SuperSaver25 bundle with an emission buster challenge, available to all participants.

Figure 17. Monthly car kilometres by Safer Journeys Participants

### 12.5 The emission busting challenge

One of the critical goals of this trial is to test the possibilities of building societal objectives into MaaS offers as a way to obtain more meaningful support from governments who aim to reach sustainable travel goals. The government support could be in the form of (extra) subsidy or discounts for services they run/regulate (e.g., PT) such that sustainable offers can also be financially attractive; however, the support could also be a reward for MaaS brokers if their MaaS products could help obtain societal goals set by the government such as reducing transport emissions. Thus, building societal objectives into MaaS effectively opens a new way to commercialise MaaS. To test this premise, the trial designed a new incentive which applies to all participants, giving everyone the chance to travel more sustainably, and when succeeded would be rewarded according. We name this initiative the emission challenge.

#### 12.5.1 The emission challenge

Unlike a monthly plan which targets a particular group of travellers, the emission challenge is an incentive aimed at all participants regardless of whether they have chosen any subscription bundle. That is, all participants are eligible for the rewarding scheme if they reduce their CO₂ emissions, compared to their own emissions in the previous month. Benchmarking emissions against the previous month’s emissions at the individual level allows individual effort in reducing CO₂, but care must be considered in designing the gamification to avoid participants gaming the scheme. One approach could be allocating a given number of winners/prizes for the entire cohort so that only the participants who cut their CO₂ emission
the most, compared to the previous month, would win a tangible prize from the challenge (e.g., $100, $200, $500).

An alternative approach is to classify participants into different groups/cohorts and define different rewarding schemes for each group/cohort. The different cohorts can be defined based on the bundle the participants subscribe to for that month, but a different taxonomy can be used such as grouping all participants with safer-journey data into one cohort to reward them for reducing private car use, observable via the safer-journey data. Compared to the first approach, this approach recognises that some travellers (e.g., heavy car-based users) can reduce their emissions more easily than other participants (e.g., those already using PT for many trips). Thus, it is important to use an appropriate metric in defining the emission challenge to create a fair playing field for all participants. Figure 18 indicates the amount of CO₂ emitted by various modes of transport as calculated in Tripi as informed to participants.

<table>
<thead>
<tr>
<th>Mode</th>
<th>CO₂ Emissions (g/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car*</td>
<td>140 g/km²</td>
</tr>
<tr>
<td>Motorbike</td>
<td>81 g/km¹</td>
</tr>
<tr>
<td>Taxi / TNC*</td>
<td>224 g/km²</td>
</tr>
<tr>
<td>Van / shuttle bus**</td>
<td>246 g/km²</td>
</tr>
<tr>
<td>Bus</td>
<td>56 g/km¹</td>
</tr>
<tr>
<td>Subway</td>
<td>65 g/km²</td>
</tr>
<tr>
<td>Intercity coach</td>
<td>32 g/km²</td>
</tr>
<tr>
<td>Plane</td>
<td>244 g/km¹</td>
</tr>
</tbody>
</table>

**How we calculate carbon emissions**

![Diagram of CO₂ emissions](https://via.placeholder.com/150)

This carbon cost is measured in kg of CO₂ emissions. The carbon emissions for a trip are the sum of the emissions of each segment, and are reported per passenger kilometre.

An analysis of the booked trip data at the participant level suggests that the total kilograms of CO₂ emissions per month varies substantially across the participants. Even for the same cohort of participants with safer-journey data, their weekly CO₂ emissions range from 2 to 300 kg per week. This wide variation reflects that participants use Tripi differently. The implication is that an absolute metric such as monthly CO₂ emissions is not appropriate for the emission challenge. Therefore, some relative metric is required to define the rewards for the challenge. For the same segment of participants with Safer Journeys data, the CO₂ emissions per km travelled, referred to as an emission rate, appears to vary within a meaningful range (see Figure 19), and hence is adopted to define the rewarding scheme for the emission challenge. The next question is how best to reward participants for reducing CO₂ emissions while preventing them gaming the scheme? This is dealt with in the next section.
Figure 19. CO2 emission per km travelled of MaaS participants with Safer Journeys data.
12.5.2 The risk of participants gaming the gamification

To reward different segments differently, it is necessary to assess the scope of each segment reducing CO₂ emissions by changing travel behaviour, particularly replacing carbon-heavy trips (e.g., Uber, GoGet) with more sustainable choices, including cancelling the entire trip or making these trips using a personal account instead of the Tripi account. While cancelling the entire trip reduces CO₂ emissions, making all or most CO₂ heavy trips using a personal account is considered as a behaviour that games the gamification, which the challenge aims to avoid. Analysis of the booked trip data suggests that by removing all Uber, taxi, car-rental and GoGet trips from their travel record (either not making these trips, or making these trips with a personal account so that data would not be captured), some participants may be able to reduce their CO₂ emission per km travelled by more than 60%.

A counter tactic to avoid participants gaming the scheme is to reward participants accordingly so that gaming the scheme would not result in any benefit. To this end, we analyse the total discounts that each participant may have to forgo in order to reduce their monthly emission rate, using January trip data as the base. Figure 20 shows the linear relationship between these two metrics by group of users based on the subscribed bundles. On average, a subscriber to the Fifty50 or the Saver25 bundle must forgo $1 in discount to obtain a 1% reduction in the emission rate. By contrast, most PAYG users, except for two users, can cut their emission rate by a large percentage (>20%) without losing any financial benefit. Thus, we can define the rewards for bundle subscribers based on the percentage reduction in the emission rate (e.g., $1 for 1% reduction in emission rate); however, rewarding PAYG users is problematic because there is no guarantee that they will not game the system and this will lead to a loss-loss situation: losing money and losing data (i.e., trips are not captured if they are made outside the Tripi app). Of note, for PAYG the relationship does not appear to be strong, as much driven by the two participants with forgone benefits.

![Figure 20. Individual forgone benefits per month in order to obtain a reduction in the emission rate by removing all GoGet, Taxi, Uber, and car-rental trips from Tripi](image)

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15 Note that the gamification design was developed in mid-February, and hence January was the latest full month of data available for analysis.
12.5.3 The solution

One way to mitigate the risk of participants gaming the challenge rewarding scheme is to limit the emission challenge to monthly subscribers; however, this would exclude many participants from the initiative and hence the impact on overall CO₂ emission reduction would be small. Finding a way to also reward PAYG users would open this up for all participants. The agreed solution is to frame the challenge as a group effort instead of individual efforts. Specifically, for every percent point reduction in the CO₂ emission rate that the entire cohort achieve, everyone will be rewarded by a $1 reduction in their monthly invoice. For example, if the group manages to reduce the average CO₂ emission per km travelled by 20%, every participant will receive a $20 discount.

Using gamification in MaaS design works best if users can track how they are going reasonably closely so that their savings are not a complete guess at the end of the month. Therefore, the regular feedback is important for the gamification to be effective. With that in mind, we aimed to provide weekly updates on individual emission rates and how the entire group is responding, using key statistics and bespoke graphs. An example personalised graph of CO₂ emission per km travelled is shown in Figure 21.

![Average CO₂ emission per km travelled (kgCO₂/km)](image)

*Figure 21. Personalised colour coded CO₂ emission per kilometre band travelled for an example participant P031*

In assessing the impact of the emission busting challenge, we looked at the data on private car travel, rideshare and GoGet but excluded Thrifty car-rental (which was negligible in its take up). The findings as of March 8 suggest that the entire cohort has increased CO₂ emissions (kg) by 1%, and hence there is no financial reward at all. This reinforces the calls for road pricing reform as a complement to the MaaS initiative (Hensher and Bliemer 2014, Hensher and Mulley 2014).

Soon after March 8, on March 12, the participants (employed by IAG) were advised that as a result of COVID-19 they had to cease all domestic and international air travel, and work at home as much as is feasible if they are in non-business-critical roles, with the offices largely being shut down where possible. Clearly this had an impact on the trial which we turn to in the next section, noting that despite this being unplanned, it will enable us to comment on an interesting phenomenon – the impact on MaaS of extreme events.
12.6 Final trial month (April) – Return to PAYG and COVID-19

One objective of the trial is to see how the experience brought about by the MaaS trial would change the way in which the participants travel in the future. Put differently, whether or not the participants’ travel behaviour observed during subscription months will sustain into the future and the extent to which it has through the trial provided evidence, within the limits of the tested bundles, on the potential prospect for MaaS to offer choices that are preferred by participants, as well sending positive signals on the potential of MaaS to align with broader societal objectives such as reducing emissions. Addressing this question is important as the answers can shed light on the level of financial subsidy required if MaaS is to maintain its observed travel activity in the presence of subscription plans. In simple terms, by returning to PAYG for all of April we should be able to identify the amount of travel activity that is changed and what this might suggest for the appeal of MaaS as a commercial proposition if subsidy is required.

Unfortunately, the COVID-19 pandemic meant that April was far from a normal travel activity period and so we were unable to undertake the planned comparison. The value of continuing the trial beyond March 12 had to be re-planned and it was decided initially to approach all subscribed participants and ask if they wanted to switch to PAYG instead of waiting for them to approach us and request the change. It was proposed that we would charge only 50% of the subscription fee for March given that the COVID 19 restriction was imposed in the middle of the month, while still allowing subscribers to enjoy the discount offered in the bundle they subscribed to. The cost was estimated to be small, a maximum of $62.50 for the 16 participants on the Green Pass, for example. The CO₂ challenge was not affected, since it is CO₂ per km travelled, so when people are working from home, these trips are not made and not contributing to the CO₂ rate, unless some or all of the trips now not undertaken through Tripi are car based while all trips made are by public transport, which is unlikely (more of the reversed when people use car and avoid PT under COVID-19 and social distancing).

In the week beginning 16 February, we saw a 20% drop in car kilometres (Figure 22)\(^{16}\); however this increased noticeably after March 12 when IAG encouraged all staff to work from home. Stage 2 of COVID-19 restrictions introduced by the Federal and State Governments (as of 28 March) reduced car kilometres substantially to only half of the kilometres observed the week before. Since mid-March however, we saw a progressive reduction in travel activity with only ten non-private car trips in total from all participants from Monday 23\(^{rd}\) March until 30\(^{th}\) March (including four GoGet trips), and not a single trip logged since Wednesday 25\(^{th}\) March. Disappointingly, we decided to stop the in-field trial component linked to Tripi for the final month of April when we planned to return to PAYG. Although the total number of trips dropped significantly (Figure 23), there are still quite a number of private car trips; hence the trial continued with Safer Journeys car data in April in order to study the impact of COVID-19 on overall travel activity.

\(^{16}\) The impacts for particular modes relate to the participants in the trial; although we know from the research of Beck and Hensher (2020) that declines in specific modes, notably Uber, were much greater in the wider population.
Figure 22. Impact of COVID-19 on travel activity by mode

Figure 23. Impact of COVID-19 on overall trips
13. Overall travel behaviour impacts

The in-field trial has provided a rich set of data extracted from the Tripi App, the Safer Journeys program for car users, ancillary on-line surveys and qualitative one-on-one interviews. The traveller behaviour impacts are a central focus of the trial, and within the constraints of the trial (exacerbated by COVID-19 in the last six weeks), we have identified a number of actual and potential behavioural responses. It is important to allow for ‘potential’ responses since some of the lessons learnt offer important guidance on what appears to be possible if the trial had continued and we had investigated revisions of tested bundles and financial incentives. The addition of an emission busting challenge has enormous appeal, and it an interesting extension of what is currently offered in all MaaS trials and real market offers.

What have we learnt in terms of behavioural response? We know that subscription plans with financial discounts can change travel behaviour; however the tested bundles, while showing increased interest in public transport, especially the GreenPass, are a direct benefit mainly to existing heavy public transport users with limited switching for other modes, especially the private car. This finding is reinforced by the sequential introduction at a monthly cycle of a new bundle that is informed by experience in previous months. There is also a curiosity effect with the bundle offers given the novelty of them, together with some amount of belief in being a good citizen given the promotion of sustainability outcomes and seeing if they, as a participant, might benefit personally from subscription to a bundle.

Exploratory analyses were conducted, and the evidence is encouraging although not conclusive. Figure 24, for example, shows the impact of the Fifty50 bundle on weekly trips by mode, including private car use for those participants who provided Safer Journeys data. It is clear that prior to 1st Dec 2020 (the blue vertical line), Fifty50 users travelled by car more than PAYG users. After subscribing to the Fifty50 monthly bundle, however, their weekly private car trips reduced and remained lower than their peers who were on PAYG for the entire 5-month period of the trial. The differences in Opal, GoGet and Taxi/Uber trips between the two groups of participants remain relatively the same, before and after 1st Dec 2020 when an intervention of Fifty50 was introduced.

Figure 24. Impact of the Fifty50 bundle subscription on weekly trips by mode
Extending the analysis above to other monthly bundle subscribers, Figure 25 shows similar results. Note that the vertical lines indicate when each monthly bundle was first introduced for subscription. It appears that following the subscription to a monthly bundle, be it the Fifty50, Saver25, GreenPass or SuperSaver25 bundle, the average weekly trips by private car reduced. Taking the GreenPass bundle and private car panel (2nd row) as an example, the green line (GreenPass bundle) lies above the black line for all of the period before the vertical green line (that indicates when the GreenPass bundle became effective). This means that before taking up the GreenPass bundle, GreenPass subscribers made more car trips per week than their PAYG counterparts. After selecting the GreenPass bundle, however, these subscribers’ average weekly car trips reduced and became smaller than the number of weekly car trips made by an average PAYG users, as indicated by the relative position of the green line vs. the black line.

This pattern (i.e., significant change to car use after bundle take up) is also observed for the Saver25 and SuperSaver25 users. However, it should be noted that the impact of SuperSaver25 may be confounded with the CO2 challenge, which was introduced at the same time as the SuperSaver25, although the truncated duration, due to COVID-19, of the emission buster test meant that we were unable to assess these two effects. Multi-variate modelling analysis is required to separate the impacts of SuperSaver25 from that of carbon buster challenge on the private car use.

The evidence of change in travel behaviour in meeting sustainability goals seems to be progressing in the right direction with encouraging signs, especially from the analysis of those participants who also subscribed to the Safer Journey’s Program, that there is some amount of reduction in car use and that sustainability goals can be achieved with fine tuning of discounts and a greater focus on public transport. Rideshare and carshare are currently no panacea in getting sufficient private car users to reduce car use and switch to more sustainable modes that offer reduced emission per passenger kilometre through sharing. The ability to reduce emissions through the buster challenge appears to be unsuccessful within the limited time it was offered before the COVID-19 impact came into force (March 12, 2020). In the next section we summarise the formal multivariate modelling undertaken with the Safer Journey’s sub sample to establish a relationship between bundle uptake and car kilometres.
14. Assessing the influence on MaaS bundles on private car use

In this section, we focus on the sub-sample of participants who also subscribed to the Safer Journey’s program which enabled us to obtain data on private car use. February 2020 was the last full month before COVID-19 restrictions came into force (in the middle of March). Figure 26 shows the relative monthly kilometres of participants who continued with PAYG compared to the participants who took up one of the three bundles. Overall, PAYG users exhibit the greatest amount of monthly private car kilometres. The unweighted average kilometres for the month of February are 658, 266, 477 and 222 respectively for PAYG, Fifty50, Saver25 and GreenPass and 284 kilometres for the all three bundles.

Although we are not able to indicate the specific circumstances of each participant in respect of their overall mobility requirements, the evidence across the trial participants that also are involved with the Safer Journeys program, is that their car kilometres in February are generally much lower than those individuals who continued with PAYG. This is a very important result suggesting that MaaS bundles do attract interest by active car users, and that these appear to be participants who rely less on the car for their mobility needs. We are not, however, able to conclude that subscription to a MaaS bundle has reduced car kilometres compared to what car usage would have been if the bundle subscription was not available. The only month that has similar periods that are not a special month like December and January are October and November, where the average monthly kilometres are respectively 513 and 474, still much more than the average of 284 for the bundle subscribers in February. In the formal modelling, however, we investigated this matter. This is reported in detail in Hensher, Ho and Reck (2020) and summarised below.

Of the 92 participants of the Sydney MaaS trial, 33 participants were also Safer Journeys Program subscribers. Car use of this subset of the MaaS participants, together with the MaaS monthly bundle subscription dataset, form the core datasets for this paper. For the purpose of assessing the impact of MaaS bundle subscription on private vehicle kilometres travelled, only Safer Journeys data between the time when a participant joined the trial and when s/he left were extracted and used for analysis. This is because not every participant joined the MaaS trial in November 2019, and not everyone continued active up to the end of the trial in March 2020. Also, few participants were active in the MaaS program (i.e., made trips using the Tripi app) but did not undertake any car trips in specific months. These are included to avoid biasing the data. In total, the dataset represents 171 participant months.
A summary of monthly MaaS bundle subscriptions and the switching between PAYG and bundles for these 33 participants is summarised in Figures 27 (as absolute numbers) and 28 (as percentage of participants). Over the four months between December 2019 and March 2020 when monthly bundles were available for subscription, 52 bundle offers were accepted. This includes a participant staying with or switching away from a bundle, including moving between bundles but excluding moving from a monthly bundle to a PAYG option. Overall, for the 171 participant months, the Fifty50 bundle offered in December through to March was chosen 36.5% of the time; Saver25, introduced in January, was selected by 15.4% of participant months; and in February when we introduced the GreenPass bundle, its popularity in February and March resulted in the highest participant month uptake of 38.4% of all bundles. The SuperSaver25 bundle that replaced the Saver25 bundle in March represented 9.3%.

![Monthly bundle of Safer Journey users: Nov 2019 - Mar 2020](image)

Figure 27. A high level summary of the absolute bundle uptake by month for Safer Journey’s participants

The evidence on the acceptance of monthly bundles is very encouraging, with the 91.9% for PAYG in December dropping to 81.6% in January and then 44.7% in February before increasing marginally to 46.2% in March. In the final month when all bundles are available (although SuperSaver25 replaced Saver25), we have a bundle take up of 53.8%\(^{17}\). The percentages for each bundle in March are 12.8%, 12.8% and 28.2% respectively for Fifty50, SuperSaver25 and GreenPass. This aggregate share from real preference evidence is within the range of what has been found in stated preference studies (30%-55%) such as Ho et al. (2018) and is the first tangible evidence of the external validity, at least at an aggregate level, of the stated preference survey responses\(^{18}\). What we are seeing is some learning of bundle experience, in part influenced by changing monthly travel needs. Given the sample size, however, care is taken in generalising this evidence.

\(^{17}\) This compares with 36.5 percent for all trial participants.

\(^{18}\) We must recognise that studies such as Ho et al. (2018) include respondents who do not have access to a car, and so a direct comparison of samples must be cautioned.
To investigate behavioural responses in more detail, we undertook a formal modelling exercise. Hensher, Ho and Reck (2020) developed a joint discrete-continuous model system to explain the choice between monthly bundles and PAYG (a discrete choice), and subsequently, the total monthly car kilometres (a continuous choice of the Poisson regression form given that data best seen as count data). Controlling for monthly differences due to other influences such as seasonal travel activity, the findings suggest that the offered bundles do have an encouraging impact on private car use. Within the limits of what was tested under the Sydney MaaS trial, indicative evidence suggests that MaaS has the potential to change travel behaviour in a way aligned with sustainability objectives, although this evidence should not be taken as suggesting that MaaS is a commercially viable mobility strategy.

The important findings are summarised as follows:

1. All other influences remaining unchanged, a one percent decrease in monthly car passenger trips will result in a 1.25 percent increase in the probability of choosing a bundle over PAYG; and for public transport trips a one percent increase in monthly public transport trips will result in a 0.820 percent increase in the probability of choosing a bundle over PAYG. As an example, if we work with the average bundle choice share of 0.349 and if we can achieve a 10 percent increase, on average, in monthly public transport trips, then we predict an increase in the probability of choosing a bundle of 8.2 percent, or an increase from 0.349 to 0.378. The equivalent change for a reduction in car passenger trips is 12.5 percent or an increase to 0.393. If this evidence was scalable, given the mix of MaaS bundles offered in the trial, we can expect a significant improvement in traffic congestion if we are able to reduce car kilometres by 6 to 10 percent, which is equivalent to returning the road environment to school holiday levels of congestion.

2. A 1 percent change in the average monthly financial savings will result in a 1.853 change in the probability of choosing a bundle over PAYG. Given the average bundle choice share of 0.349, this equates to a probability of bundle choice of 0.414 (≈ 0.349 × 1.853) for an additional 10 percent financial savings over PAYG.

3. Finally, at the mean monthly kilometres of 434, a 1 percent increase in the probability of choosing a bundle (from 0.349 to 0.353) is predicted to reduce monthly kilometres from 434 to 367 kilometres. If scalable over a large population of MaaS subscribers, this is a significant reduction in car kilometres.

The overall findings reinforce a position that a well-designed suite of subscription plans under MaaS can influence the use of the car in a positive and sustainable way, contributing to a reduction in emissions.
15. Qualitative interviews

In February 2020, qualitative interviews were conducted with a large proportion of participants in the trial\(^{19}\). The aim of this mid-trial interview was to guide future bundle design (specifically March 2020, by reviewing trial participant behaviour to date, including choice between PAYG and subscription plans. Other common behavioural patterns, changes before and during the trial period, and use of the Tripi application, were also identified.

As of late-January, there were 91 active participants in the MaaS trial.\(^{20}\) Interviews (framed as ‘conversations’) were arranged and confirmed with a total of 27 participants (30% of all trial participants). Due to last minute cancellations, a total of 22 participants proceeded with the interviews, representing 25% of the participant population (Table 5).

Interviews were conducted during business hours at the IAG head office (Darling Park, CBD) on Wednesday 5th, Thursday 6th and Monday 10th of February 2020. In total, 16 interviews were conducted face-to-face, whilst a further six were undertaken virtually (via the online platform Zoom) due to employees working from home (a regular feature of IAG employment prior to COVID-19 lock down). Interviews were semi-structured. Full details including an interview guide is given in Wong and Hensher (2020). The interviews were 30 minutes maximum in duration.

The sampling strategy was defined in terms of participants’ choice of subscription plans (or otherwise) during the months of November, December, January and February. In total, six segments were defined incorporating participants who stayed on PAYG throughout the four month period, participants who signed up to one (and only one) of three bundles offered during this period (i.e., Fifty50, Saver25 and GreenPass), participants who switched amongst these offered bundles, and the one participant who switched from a subscription plan back to PAYG. The sample selected for interview from each of these six segments and information for the bundles selected by each interviewee on a month-by-month basis is detailed in Wong and Hensher (2020).

Table 5. Sampling strategy for in-depth qualitative interviews

<table>
<thead>
<tr>
<th>Segment</th>
<th>Description</th>
<th>Sample</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PAYG only</td>
<td>6</td>
<td>51</td>
</tr>
<tr>
<td>2</td>
<td>PAYG then Fifty50</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>PAYG then Saver25</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>PAYG then GreenPass</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>Switch amongst bundles</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>Switch from bundle to PAYG</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

\(^{19}\) In addition we introduced a monthly MaaS Pulse Survey (MPS). This survey aims to capture experience and insights from trial participants. The first MPS was sent to participants who were onboarded before November 2019 and consists of four questions: (1) Would you recommend this service to colleagues and friends? (2) What you like about it? (3) What you do not like about it? and (4) Any suggestions for improvements? The same questions have been asked each month for consistency. The rolling MPS during February and March 2020 identified 39 Common themes / feedback: The main likes are discounted travel and having everything in one place. The main dislikes are monthly billing (fortnightly included wanting more providers included e.g. e-scooter lime and rideshare Ola. Inclusion of emission data is appreciated.

\(^{20}\) This number has since reduced by five due to employees leaving IAG.
A summary discussion of major findings themed by PAYG and subscription plan-specific feedback, behavioural change, use of the Tripi application and other feedback, is given below with more detail in Wong and Hensher (2020).

There is clear interest in MaaS, with 37% of participants up to end of February subscribed to a bundle. The designed bundles have attracted interest, although we have only limited evidence of the scalable potential of bundles due the number of bundles we have offered, but this is as many as existing real offers – indeed we exceed or equal the number in Whim/Ubigo/Mobil-Flat. The qualitative one-on-one interviews have suggested a number of factors influencing trial choices and to help inform key markets for future bundle design. The main factors are value for money of subscription plans, the issue of location and hence availability of modal alternatives despite offering them in a bundle, unusual travel patterns i.e., less habitual and more variety seeking, and the lack of awareness of the details of the subscription bundles because of the way information is provided, especially its clarity. The need for commitment arose as a real constraint on participants’ desire to subscribe, although a “novelty” or “curiosity” effect for the subscription plans was very apparent; people showing interest as they sought something “new and different”.

A very important response from almost all participants interviewed was that the onboarding process exceeded expectations, and the one-on-one time and dedication was both impressive and helpful in establishing commitment and enthusiasm. Participants stated that they are “super proud” of the trial and how it constitutes “innovation” as the “future of transport”. One of the largest complaints early in the trial (and subsequently resolved) was in providing improved communication, ex ante, of the (likely) cost savings under different subscription plans as compared with PAYG. Another important point was the exclusion of relevant modes (e.g., competing ridesharing providers, Ola and DiDi) from the offerings available through Tripi. If a relatively popular mode is excluded, it can have a negative impact on subscribing to Tripi and indeed to a bundle. Ola, for example, is less expensive than Uber even with the Uber discount in the bundles. DiDi has entered Sydney in March 2020 and offered even more attractive fares (a blanket 15% discount on all trips). This raises a question as to whether a single MaaS App can cover all relevant modes and variations.

What surprised the project team and the participants was seeing a complete record of their traffic history in one place which we provided after January 2020. People are used to having their Opal card silently recharging from one account and Uber trips automatically paid with a credit card. Participants were asking ‘Do I really spend this much on my travel?’ It was a wake-up call. The App also allows people to check out other ways to get from A to B. One person discovered a new bus route to work they never knew existed and says they’ve saved so much time.

The MaaS scheme homogenised all public transport trips and their prices, thereby effectively eliminating Opal policies already in place to encourage off-peak travel. In general terms, 99% of all trips were taken without use of the Tripi application. Real disruption would only occur when the core principles of travel-taking time and regarding multimodality: it is indeed interesting to find that subscribers are not as multimodal as one would have thought given previous SP publications.

An important finding from the in-depth qualitative interviews and our knowledge from extensive travel choice surveys over many years, tells us that levels of service (value of time, frequency, convenience etc.) are typically more important than fares or costs, yet in MaaS offers we, and all other MaaS products, focus on financial incentives. This suggests that MaaS programs should consider how they might offer a distinctive level of service (separate from the attraction of the digital platform) that is not available to travellers outside of a subscription plan. An example might be a guaranteed door-to-door personal service twice a week, effective when individuals have a change in routine that can benefit by a bespoke transport service.
16. Post-trial exit survey to establish experience with the trial

In early May, following the conclusion of the six month in-field trial, we planned to design a structured survey to obtain a broad range of feedback from participants. Due to the onset of restrictions in mid-March associated with COVID-19, we brought the survey forward to early April and launched it on April 7\textsuperscript{21}. The emphasis was, in many ways, an extension of the mid-trial qualitative interview script but with a focus on the role that the MaaS concept might play in the future if it were still in place. All participants were invited to complete the survey, with a $50 incentive, in contrast to the mid-term qualitative interview where there was no financial incentive. Some specific issues that we sought feedback on were the appeal and functionality of using the Tripi digital platform as well as frequency of using Tripi compared to other platforms outside of the trial; behaviour change, both modal and quantity, as a result of experiencing the offered bundles and future interest in bundles; the main obstacles to reducing emissions and what travel behaviour is changed as a result of the in-field trial finishing.

The survey questions are given in Appendix F and the main findings are summarised below. All but 4 participants completed the online survey.

**Maas Trial General Questions**
- 19.7% of individuals said they had pre-trial expectations
- 42.7% said they participated in the MaaS trial for potential cost savings; followed by 21.3% participants who said they participated out of curiosity; and 18.7% that participated to contribute to an IAG initiative

**Mobility plans**
- 60% of individuals opted-in to the mobility plans offered in the MaaS trial
  - 46.7% said they opted-in for potential cost savings; 9.3% because of the simplified payment (‘set and forget’), while 40% did not answer as they did not opt-in to any mobility plan.
- If the plans were available for purchase after the trial:
  - 24% of individuals said they would be ‘very likely’ to purchase the Fifty50 and GreenPass mobility plans if they were available after the trial; and 27% would be ‘very likely’ to purchase SuperSaver50.
  - 12% of individuals said they would be ‘very unlikely’ to purchase the Fifty50 and GreenPass mobility plans if they were available after the trial; and 17% would be ‘very unlikely’ to purchase SuperSaver50.
  - The largest % for all the plans was ‘somewhat unlikely’ which is 40% for Fifty50, GreenPass, Saver25 and SuperSaver50 plans; and 60% for the Saver 25 plan.
- 48% of individuals said the mobility plan had changed the way they travelled during that month (out of 60% since 40% did not opt-in to any mobility plans)
  - 25% said they were more conscious of their travel costs\textsuperscript{22}
  - 23% used discounted modes more often
  - 7% travelled more frequently
  - 3% used public transport more often
- 21% of participants said they did not opt in to a mobility plan because they could not estimate their travel usage; 21% said they do not usually use the discounted modes of transport with 12% because of price, while 3% do not like upfront payments.
  - This question was answered by everyone, even if they eventually choose a mobility plan – 29% of individuals said they did opt-in; hence this question was not applicable to

\textsuperscript{21} The text of the invitation was as follows: ‘We’re giving you a $50 digital gift card!* We need all participants to complete this final survey to let us know how Tripi changed your travel habits (if at all) and let us know which parts of it you’re going to miss, and which you would have changed!*Everyone who completes this survey (approx. 20 mins) by Friday 24th April will receive a $50 digital gift card to treat yourself during isolation. Your participant ID for completion of this survey is PXXX’

\textsuperscript{22} It is not clear whether it applies also to private car related costs.
them. 60% of individuals said they opted-in to a mobility plan eventually, suggesting that 31% participants did not opt-in to a mobility plan immediately.

- If the MaaS trial had continued, 41.3% participants would have selected the PAYG mobility plan for April; 20% would have chosen SuperSaver25; 18.7% GreenPass; and 14.7% Fifty50.

**Tripi App**

- If the app was available to the public after the trial, 37.3% of the participants said they would be 'very likely' to use it; 16% would be somewhat likely, while 26.7% would be very or somewhat unlikely to use it.
- 43% of individuals used the Tripi app to travel to or from work; 29% for shopping or leisure; and 5% used it for new or unknown routes.
- Wallet feature
  - 33.3% of individuals used the wallet feature less than once a month; 21.3% used it once a month; and 13.4% used it several times a week or once a day.

**Mode of transport (based on a 5-level rank with 1=most important and 5=least important)**

- 41% of the participants ranked convenience as the most important feature (1/5) when choosing a mode of transport; 25% ranked cost; 23% ranked safety; and only 7% ranked sustainability.
- 19% of individuals ranked convenience as the least important feature (5/5) when choosing a mode of transport; 8% ranked cost; 9% ranked safety; and only 8% ranked sustainability.
- The highest overall rank was for convenience with an average of 2.30, followed by cost with an average of 2.48, then safety with 2.80, and finally sustainability with an average of 3.06.

**Journey Planning Apps**

- Google Maps was ranked as the most preferred journey planning app, with an average rank of 2.11; the second most preferred was Tripview with a rank of 2.40; followed by Tripi with a rank of 2.67. The least preferred apps were Metarove with a rank of 4.75, followed by City Mapper (4.7) and Any Trip (4.40).

**Carbon emissions**

- 69% of participants are aware that the carbon emissions per journey were displayed in the Tripi app.
- 22.7% of individuals said they think the MaaS trial decreased their CO2 emissions, while 34.7% said it did not, and 37.3% indicated maybe.
- The main obstacle for individuals to reduce their CO2 emissions was the convenience of the private car (43%); followed by the obstacle that public transport is slower (24%) or not available (19%); or difficulty in accessing alternative modes (19%). 17% of individuals said they believe they are already using public transport as much as possible, or are already environmentally conscious.

**Post-trial**

- 83.1% of the participants would purchase the MaaS trial offering if it would become available.
- 66% of individuals said their view of car ownership was not changed by the MaaS Trial, while 15% said it has: 5% will reconsider purchasing a car; 5% would consider giving up their primary car; and 5% would consider giving up their secondary car.
- 33% of the participants said that their participation in the MaaS trial will change the way they travel in the future (they will maintain their new travel behaviours from the trial); 31% said their experience in the MaaS trial will not change the way they travel; and 31% said they are not sure yet.
- 16% of the participants said the subscription plans contributed ‘a great deal’ to their behavioural change, while only 5% said the journey planner had contributed ‘a great deal’. The ranking was between 1 = a great deal and 5 = not at all – where the subscription plans had an average rank of 3.18 and the journey planner a rank of 3.73.
- In a post COVID-19 world, 20% of individuals would reduce their taxi trips, 16% their Uber trips, 13% their personal vehicle trips, and 11% public transport. 28% of individuals would increase their public transport trips, 9% their personal vehicle trips, and 7% their Uber or Didi trips.
Participants were asked which mobility plan would they have chosen if the MaaS trial had continued during April, and the responses are presented in Figure 29 together with the subscriptions plans they choose during the trial. 40% of all participants would choose PAYG for April, while 21% would choose SuperSaver25. 38% of Fifty50 subscribers would choose PAYG, while 33% would continue with the Fifty50 mobility plan during April. Most of the GreenPass subscribers appear to be satisfied with this plan, as 59% would choose the same plan for April, while 29% would move to the PAYG option. The greatest majority, i.e., 90%, of the SuperSaver25 subscribers, would keep their mobility plan, while only 10% would move to the PAYG option.

Figure 30 presents the average ranking on how likely participants would be to purchase a mobility plan (or PAYG) given their subscriptions during the trial. A ranking of 1 represents very unlikely to purchase that plan and 5 represents very likely. All participants experienced PAYG in at least one month, so the blue bar represents the average willingness to purchase each plan for all participants. The highest ranked mobility plan is the SuperSaver25, where participants that chose the Saver and SuperSaver25 mobility plans are, on average, very likely to purchase it after the trial (average rank of 4.90 and 4.64, respectively). Fifty50 plan subscribers were on average likely to purchase the SuperSaver25 plan after trial (rank of 4.10) but more likely on average to continue with the Fifty50 mobility plan (rank of 4.29). GreenPass subscribers are on average very likely to purchase the GreenPass mobility plan after the trial (average ranking of 4.75) and would be on average likely to purchase the Fifty50 mobility plan (average ranking of 4.06). These results are interesting as they suggest that mobility plan subscribers were, on average, pleased with their plans and would be likely to purchase them if available after trial. PAYG subscribers, which represents the average rank for all users, are more likely to purchase the SuperSaver25 mobility plan (4.05) followed by Fifty50 plan (3.88).

Figure 31 presents future travel behaviour given the subscription plans used during the trial. 32% of participants said they will maintain their new travel behaviour from the trial, and 31% said they will go back to their previous travel behaviour. Interestingly, 60% of the SuperSaver25 participants will maintain their travel behaviour from the trial, while only 10% reported they would go back to their previous behaviour. The GreenPass subscribers were more divided, where 35% said they would maintain their travel behaviour and 35% would go back to their pre-trial behaviour. 38% of Fifty50 subscribers said they will maintain their trial behaviour, while 19% said they will go back to their pre-trial behaviour.

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23 To assist in interpretation: as an example, looking at the Green bar (i.e., GreenPass bundle), the figure shows that in total we have 17 participants (who did complete the exit survey) subscribing to this bundle at least one month (either February or March) given that the GreenPass was first introduced in February. Out of these 17 participants, 10 (~60%) would have subscribed to the GreenPass bundle if the trial continued in April 2020, 2 would have switched to Fifty50 and 5 to PAYG.
Figure 29. Mobility plan for April if the trial would have continued versus subscription mobility plans during trial
Figure 30. Likelihood of purchase of a mobility plan after trial given subscription during trial

*Includes participants who stated opted-in a mobility plan
Future travel behaviour change versus subscription during trial

*Labels represent the number of respondents

Figure 31. Future travel behaviour change given their subscription plans during trial
17. Are there signs of a business case and/or a societal proposition?

Providing monthly bundles in this trial involves a user-subsidy to incentivise sustainable travel behaviour amongst subscribers, apart from the administration and platform development costs. For the 5-month trial, the cost of subsidy is not large (see below); nevertheless, a budget is required to incentivise the participants to subscribe to a monthly bundle and use more sustainable transport modes such as public transport and car-shared instead of the private car. This raises the question as to whether incentives are a commercially viable option in the longer term. One way to answer this question is to quantify the average cost of incentivising participants under different monthly bundles and compare these with the benefits associated with average reduction in CO₂ emissions, a reasonable overarching objective, accounting for month-to-month variations in travel demand. This is a high-level analysis which shed some light on the commercial potential of MaaS post-trial.

Importantly, our focus is on the role of a user-subsidy to attract subscription to a plan or bundle and a fuller assessment of the business case requires an account for all costs involved in running a MaaS program and not just the subsidy outlay to attract subscribers. Also, achieving sustainability goals such as reductions in transport-related emissions, is not likely to be enough to justify investing in MaaS by the private sector unless it is accompanied by financial support that recognises a broad societal benefit. This is likely to require either subsidy support from government or from another source that is linked back into the MaaS offering that will most likely be a non-transport service such as retail discounting associated with equity investment into the MaaS product to attract such patronage.

Figure 32 shows the distribution of cost involved in incentivising monthly bundle subscribers through financial discounts. This cost is the difference between real cost paid by the MaaS integrator to the transport operator in providing the services (i.e., PT fare, taxi/Uber fare, and GoGet cost) to each participant for each month and the revenue collected from fares paid by the subscribers (total of discounted fares) plus the monthly subscription fee. Note that the discounted fares and the monthly subscription fee both varied across the monthly bundles. Note also that the monthly cost associated with incentivising participants, also referred to as subsidy cost hereafter, was zero for November 2019 since this was a learning month when all MaaS participants were defaulted to PAYG option, which charges zero membership fees and offers no financial discount to any mobility service included in the trial. A positive value on the x-axis of Figure 32 indicates that the cost to provide the services are more than the revenue collected, and hence a subsidy cost is required. Conversely, a negative value indicates that it costs the MaaS provider less than the amount they collected from user-paid fares and a membership fee, hence making a profit. As can be seen in Figure 27, individual subsidy cost per month ranges between -$30 to $180, with most participants receiving a subsidy of between $0 and $40 per month. However, Figure 32 also shows five outliers who were subsidised $80+ per month (two participants in January, one in February, and two in March 2020).

Over the five months of the trial, the total subsidy cost balanced to $2,167, with an average of $19 per subscriber per month (see Table 6). In return, an average CO₂ emission associated with travel was reduced by 56.70 kg per subscriber per month. That is, on average every dollar spent on incentivising the participants using more sustainable modes through monthly bundle subscriptions results in three kg reduction in CO₂ emissions per subscriber per month. Clearly, MaaS has the potential to obtain sustainable outcomes if monthly bundles are carefully designed to provide the right level of incentives for the participants to travel more sustainably or to maintain their sustainable travel. This does not, however, support a commercial case but it does suggest a subsidised business case that aligns with sustainability objectives.

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24 The costs to IAG as the broker were considerably more than initially anticipated. This cost will have a significant bearing on the business case; however it is our position that many of these costs are one-offs for set up and learning outlays that are expected to be reduced significantly once the process of running an established MaaS program is bedded down.
Before comparing the cost required to subsidise each monthly bundle against the environmental benefit associated with reduction in CO₂ emissions, it is useful to explain how the statistics presented in Table 6 are calculated. On the cost side, it is straightforward to compute exactly how much each subscriber was subsidised for each month of the trial (see the immediately previous paragraph). On the benefit side, it is much more complicated to estimate the amount of CO₂ each participant produced due to their monthly travels. First, each trip that the participant was observed to make requires the distance estimated so that CO₂ emissions per each trip can be computed, using the same emission rate (grams of CO₂ per km or per vehicle) that the Tripi app used in computing the CO₂ emissions for each transport mode (see Figure 18). To this end, the origin and destination of each trip were geocoded to obtain the locations in latitude and longitude, which were then used as an input into the routing algorithm, realised via ArcMap (Train and Bus modes) and Google Map (for car, taxi and Uber trips) to obtain travel time and travel distance. As for GoGet car-sharing and Thrifty car-rental trips, odometer readings before and after each hire were used to compute the total kms for each trip. CO₂ emissions for every trip were then computed as the product of distance travelled and the emission rate for the corresponding mode.

Total CO₂ emissions and kms travelled by each participant were a summation of all trip emissions and all trip kms, respectively for that person for each month. With these, we can compute the average monthly emission rate (i.e., CO₂ emission per km travel) for each participant by dividing the total CO₂ that the participant produced by the total kms they travelled. Comparing the CO₂ emission rate that each participant produced for the month they were on a bundle against the same statistic when s/he was on PAYG reveals the reduction in the emission rate at the individual level. Averaging this individual change to the emission rate across all subscribers to each bundle produces the results in the second last column of Table 6. Note that comparing the statistics before and after subscribing to a bundle removes interpersonal variations in travel demand; however, intra-personal variations (or month-to-month variations in travel demand) are still present; and hence the aggregate statistic (i.e., the average) is more accurate than the individual numbers. In a similar way, the average CO₂ reduction per person per month presented in the last column of Table 6 could be computed. Note that one should not compare the CO₂ emissions of subscribers with that of PAYG users because this comparison suffers from inter-personal variations, and more seriously sample-selection bias (or self-selection bias). The self-selection bias is a real concern because all participants were free to select a bundle for each month that best suits their travel for that month instead of being randomly allocated to a bundle by the study such that a control vs. treatment group comparison could be used.
Of the four monthly bundles tested in the Sydney MaaS trial, the Fifty50 bundle required the least funding to incentivise the participants, with an average subsidy cost per user per month ranging from $3.62 in December 2019 to $25.90 in January, while the subsidy cost reduced to less than $10 per subscriber per month in February and March, which are considered more typical months of travel than December and January. In return, the average CO₂ emissions produced by the Fifty50 subscribers was reduced by 55 to 65 kg per person per month. As far as a return-on-investment is concerned, the Saver25 bundle and its modified version, the SuperSaver25, were most successful. The Saver25 was first introduced in January 2020 and replaced with SuperSaver25 in March 2020 with a $5 Uber flat fare incentive added to address the first and last mile issues associated with public transport use. In February, on average the Saver25 bundle cost $21.55 per month to incentivise each subscriber. The benefit was a reduction of 145 kg of CO₂ per person per month, or a one-dollar subsidy for a seven kg of CO₂ reduction per month.

<table>
<thead>
<tr>
<th>Trial month</th>
<th>Monthly bundle</th>
<th>Users</th>
<th>Subsidy cost</th>
<th>Ave cost per person per month</th>
<th>CO₂ reduction per km (KgCO₂/km)</th>
<th>Ave CO₂ reduction per person-month (KgCO₂/person-month)</th>
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</thead>
<tbody>
<tr>
<td>2019-12</td>
<td>Fifty50</td>
<td>11</td>
<td>$39.77</td>
<td>$3.62</td>
<td>-0.008</td>
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<td>2020-01</td>
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<td>$25.90</td>
<td>0.015</td>
<td>26.50</td>
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<tr>
<td>2020-02</td>
<td>Fifty50</td>
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<td>$61.68</td>
<td>$4.74</td>
<td>0.007</td>
<td>64.79</td>
</tr>
<tr>
<td>2020-03</td>
<td>Fifty50</td>
<td>14</td>
<td>$131.94</td>
<td>$9.42</td>
<td>0.007</td>
<td>55.11</td>
</tr>
<tr>
<td>2020-02</td>
<td>GreenPass</td>
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<td>$30.56</td>
<td>0.003</td>
<td>31.90</td>
</tr>
<tr>
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<td>GreenPass</td>
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<td>$30.13</td>
<td>-0.007</td>
<td>31.52</td>
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<tr>
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<td>Saver25</td>
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<td>$306.20</td>
<td>$34.02</td>
<td>0.007</td>
<td>18.51</td>
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<tr>
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<td>$21.55</td>
<td>0.023</td>
<td>145.03</td>
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<td>SuperSaver25</td>
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<td>$9.24</td>
<td>0.014</td>
<td>153.74</td>
</tr>
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<td><strong>Total</strong></td>
<td></td>
<td><strong>114</strong></td>
<td></td>
<td><strong>$2,167.17</strong></td>
<td><strong>[$19.01]</strong></td>
<td><strong>[0.006]</strong></td>
</tr>
</tbody>
</table>

The GreenPass bundle costs the most to incentivise while the return in CO₂ emission is the lowest. On average, this bundle required $30 per person per month to incentivise and delivered 30 kg of CO₂ reduction, or an equivalent of $1 subsidy for 1 kg CO₂ reduction per month. Here, we must recognise that some segments of travellers have fewer choices of greener options than other segments, and this depends heavily on the mobility services included in the MaaS bundle. For the case of Tripi, public transport, car-share, car-rental, Uber and taxi were in the mix. Thus, it was difficult for GreenPass subscribers to travel more sustainably since these subscribers have already used the most sustainable modes of transport, namely public transport, amongst the modes on offers. The only way for these users to reduce their CO₂ footprint was to replace public transport trips with active modes such as walking and cycling, or to cancel the trip entirely. We would argue that the latter is not the premise of MaaS that aims to increase accessibility (without the need to rely on a private car) instead of reducing it. In contrast, the Saver25 and SuperSaver25 subscribers made a few trips on public transport and use taxi/Uber and GoGet car-sharing more often, and hence they have more opportunities than Fifty50 and GreenPass subscribers to reduce CO₂ emissions by replacing carbon-heavy trips with more sustainable trips (e.g., use bus instead of taxi for short trips, or use Uber and train instead of the private car or door-to-door Uber for long distance travel).

We conclude that there is an appetite for such a MaaS product, and that it can contribute to achieving sustainability goals; however, ongoing research is required to integrate the constituent parts and feature a business case that is attractive to both private interests, users and government. The trial has indeed commenced that journey, although the COVID-19 pandemic may require new initiatives in order to preserve and grow the appeal of MaaS, at least in the short to medium term when the popularity of the car is likely to escalate as a response to biosecurity in contrast to the use of the shared modes, public transport and rideshare.
18. Conclusions and insights as we look forward

The Sydney MaaS trial is truly innovative in many ways as well as being the first in Australia. The transparent nature of the trial ensures that lessons learnt are disseminated to a broad audience, in contrast to many trials and real applications where the evidence is at best scant and ambiguous (Hensher et al. 2020). In the previous sections of this report, we have documented the entire process from the pre-trial tasks required to prepare for an in-field trial, to the in-field trial process and behavioural findings, to the post-trial evaluation framework and findings. There is a lot more that we will report on in future papers, using the current paper as a reference source for the entire research program.

In setting out the conclusions, we want to highlight not only the behavioural evidence but also the critical things one should take on board in designing, implementing and assessing the MaaS trial, and using this experience to comment on what we might use to begin a dialogue on the commercial prospects of MaaS. As a word of caution, we have to be very careful in prescribing a future in any detail based on the findings from a single MaaS trial; however when we add the trial experience to our accumulated evidence from the broader literature (as in Hensher et al. 2020), we can offer a number of suggestions as to what might be the next set of actions to enable a MaaS committed community to move forward in proving the contextual value or otherwise of MaaS.

The Sydney trial is a rich example of a well-planned cascade with a pre-trial survey, an initial pay-as-you-go period, and subsequent, monthly sequential bundle design and introduction. Besides facilitating continuous learning, this has a positive effect on trial participants (with appropriate feedback) keeping them interested in the trial. The monthly “feedback and choose” is very important and allows for a customisation of personal preferences which should be a key feature of MaaS - no other trial or actual offering has this as far as we can tell! The Sydney trial also shows how the data-driven approach has to be (temporally) substituted by a hypothesis-driven approach if data is not available as planned, especially in the initial months.

The trial has not only identified what features of subscription bundles appeal to the travelling public, within the limits of what has been tested, it has also delivered a rich set of experiences in how to run an effective and efficient trial. We do, however, have a long way to go in identifying what we might call the winning product as measured by traveller, business and societal success factors25 (Reck et al. 2020, Smith and Hensher 2020, Ho and Hensher et al. 2020).

While this trial alone cannot possibly answer all the questions that surround the journey of exploration of the potential for MaaS, as a way to deliver improved societal benefits associated with mobility such as emission reductions, it has demonstrated that there is a traveller interest in MaaS, and that it is possible to develop a MaaS product that has appeal to segments of the travelling public; but that the design of a MaaS program is complex, and its success and scalability will always be linked to how individuals and groups respond to MaaS as a new way of satisfying their mobility needs and to do it in a way that achieves broad sustainable goals that are both relevant to individuals and society as a whole (Smith and Hensher 2020).

One of the questions we started with was whether a MaaS trial could demonstrate, through innovative ways to introduce subscription bundles, the prospect of reducing car use and hence emissions, as well as delivering a more convenient way of making travel choices in a market of growing modal opportunities. We also wanted to see what role conventional public transport plays in contrast to ridesharing and car sharing, in changing the modal mix in favour of more sustainable mobility outcomes. We have evidence that we can grow public transport use but that car use remains a challenge, even with an emission buster challenge aimed primarily at private car use. We believe that the approach is valid, but that we did not have enough elapsed time to refine this initiative, especially the level of financial reward, and ensure that all users are well informed about the benefits, recognising however that this is no guarantee of

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25 The success factors for MaaS trials are: behavioural fit (more multimodal people are more likely to sign-up than less multimodal people, and change will be gradual), ease to explore (option for no sign-up costs and pay-as-you-go functionality), value of integration (easier to use than Google Maps or single service provider apps), economic benefit (less expensive than buying tickets elsewhere), and behavioural change aligned with sustainable modes.
success. In addition, if this were to be a successful way of reducing emissions, it would still require careful thought as to how this might be funded as a commercial product. The analysis of participants that were also signed up to the Safer Journey's program provides encouraging evidence that those who subscribed to a bundle did on average, reduce their car kilometres.

With a relatively small number of participants, we can at best provide indications and possible triggers that do contribute to changing travel behaviour patterns of mobility that might or might not achieve the sustainability objectives we aspired to when scaled up to a larger population. The evidence supports a view expressed in many papers (summarised in Hensher et al. 2020) that mainstream public transport will remain core to the success of MaaS, but that rideshare and carshare can and do contribute through greater choice where flexibility and convenience is often delivered at an attractive price through car based sharing than through public transport. We must be mindful of the opportunity for rideshare in particular to also service the first and last mile of a public transport trip; however the testing of this in March through the SuperSaver25 bundle did not demonstrate a great deal of travel behaviour change, with very few participants choosing Uber as a mode to get to and/or from conventional public transport.

What might we have done differently? The obvious response relates to a greater number of participants, a longer period to test and refine bundles, and to ensure we have appropriate tests of ways to reduce private car use. There are also a few other lessons learnt. The most notable one is the ability to be more flexible in the design of the digital platform in order to test new ideas that arise such as caps on the amount of travel that can be subject to even larger discounts for specific modes, and the ability to allow for bundle design during any time that is appropriate when new evidence is identified. During the start-up period of the in-field trial it was recognised that not all participants would be ready through the onboarding program to commence the PAYG month 1 at the beginning; that is on Monday November 4, 2019. While collecting a full month of PAYG data (elapsed month strategy) and only offering bundles subsequently is preferred, Tripi was designed for what we refer to as a calendar month condition as distinct from elapsed month condition, resulting in some participants having a limited time under the November month to get used to Tripi and PAYG. This was not ideal for participants who needed more time to get used to the digital platform before having to choose between PAYG and a bundle. However, one has to be careful in allowing too much flexibility and revision since this has resource implications throughout the entire MaaS program as well as risking confusion for participants with too much change. On balance, we are confident that the progress made in the Sydney trial can offer a rich informative starting point for any future trials or indeed a market roll out of a MaaS product. The logistics of rolling out MaaS beyond a trial have been tested and we now are confident as to the operational requirements, and associated resources, as distinct from the more challenging marketing and take up tasks that ultimately determine the business case.

As we progressed with the entire trial process, we also recognised the need to take on board our complementary research on the MaaS ecosystem, which has provided a broader context setting framework to guide the way MaaS will need to be positioned going forward in order to have prospects as to its contribution to a new mobility future. A progressive and aspirational future for MaaS, to make a difference behaviourally and societally, should (a) be multi-modal26 and multi-service and door to door to recognise the diversity of community needs and delivery capability; (b) be mindful of societal goals and possible opportunities to incentivise MaaS with optional subsidies that are linked to outcomes aligned with broader government objectives; (c) offer an integrated pricing scheme across all (or many) modes, ideally with a one stop payment and should match the needs of actual and potential users through flexible packaging and pricing, with flexible monthly changes; (d) allow for seasonal variation in respect of modal needs so that monthly changes in subscriptions should be transparent and allowable without

26 Goletz et al. (2020) investigate inter-modality, defined as using more than one mode for a single trip, and suggest that it presents challenges for transport providers, and has its drawbacks for users, who prefer connections that do not require changing between transport modes. They investigated current intermodal mobility in four European metropolises: Berlin, Copenhagen, Hamburg and Paris and conducted an expert survey in which they asked experts about the future share and development of inter-modality, its future relevance and potential of inter-modality in transport planning, and how various factors on both the demand and supply side influence the level of intermodal activity. The finding suggests an increase in the share of intermodal trips, driven primarily by factors such as reduced vehicle ownership, but also by new mobility patterns; the latter explained by social factors such as urbanisation or digitalisation that affect the lifestyle of cities' inhabitants in the future.
penalty; (e) deliver greater informed choice than exists currently, with ease of entry (and exit) and participation; (f) open up the possibility of a shift to the sharing economy, where asset ownership, such as car ownership, is increasingly not necessary, provided it guarantees access to preferred modes of transport when required; (g) be flexible enough to offer subscription plans to groups (e.g., households, friends, employees, tourists in addition to individuals); (h) align with an appropriate governance model with a clear role for government; and (i) ensure trust and collaboration within the MaaS ecosystem.

We can expand a little more on a few of the conditions summarised above. A push towards individualisation and greater choice as a consequence of new digital capabilities needs careful consideration, creating significant challenges to how we manage the future of cities and other locations as having place utility rather than just mobility utility. Without government control, regulation and partnership, technologists might dictate the shape and nature of our cities for the coming century (just like the car did). The commercial operation of a fully integrated MaaS offering is challenging if not difficult, noting that the few actual MaaS products such as Whim or Ubigo (which in its version 2 in Stockholm has failed as of March 2021) are either pump primed by venture capital or government subsidy, and operational offerings are currently scarce. Expectations of operational MaaS seem, to date, to be optimistic. The challenge may be greater than expected and MaaS is in danger of becoming a hyped socio-technical phenomenon lacking full-scale implementations reaping the alleged benefits. The hype and rhetoric associated with many technologies means that a ‘level head’ is necessary, avoiding the technological deterministic mindset so as to ensure that technologies are not implemented for technologies’ sake, but rather leveraged to ensure societal advantage. MaaS at present seems to be slipping into the ‘trough of disillusionment’ of the Gartner’s Hype Cycle (Figure 33) and was summarised as having a ‘crisis of confidence’ (Hensher et al. 2019).

![Gartner Hype Cycle](https://www.gartner.com/en/research/methodologies/gartner-hype-cycle)

*Figure 33. The Gartner cycle*

One of the biggest challenges is the need for a cultural shift from ownership to access. The current mobility market is vastly dominated by private car use, often offering superior levels of service despite congestion (but look how crowded our trains and buses are). If MaaS can reduce car travel by 6-10% in congested areas, then it can return traffic to school holiday levels. But the advent of relatively inexpensive to own electric cars and 25% lower running costs is not a good look for MaaS if they stay in private hands. The redeemer is road pricing reform.

One thing MaaS has done is to create huge interest in seeing if a multimodal sharing future is achievable, worth it and impactful in appropriate ways. Technology is one thing, but the big challenge is behavioural and institutional. Are the biggest disruptions yet to come? Many of the present new mobility services, technologies and businesses cannot be regarded as ‘disruptive’ since they still try to earn revenue in traditional ways by transporting people. Real disruption would only occur when the core principles of travel taking time and travel being a derived demand are challenged. For example, autonomous technologies might mean that the travel time budget idea is altered, whilst collaboration with other sectors (e.g., property developers, retailers) might change the revenue model fundamentals of transportation companies. We refer to this as a move towards a multi-service view of MaaS in contrast to a focus predominantly on multi-modality. What we mean by this is that some of the services are not only the passenger mode discount, but discounts on non-transport services, for example, retail purchases, as well as having goods delivered to the subscriber, and especially where WFH becomes more popular, or MaaS points that can be redeemed for goods or gift cards. We finally can see the word ‘service’ being given a much broader and meaningful multi-sectoral definition, which may be the basis of a business case that can morph into a commercial proposition.

It seems appropriate to conclude this section with a synthesis from the founder of MaaS Global and someone who was there in the beginning of the MaaS journey:

*By definition MaaS consists of two elements: mobility and service. Mobility is individually experienced freedom to move as you wish, where you wish and when you wish. Service means that you do not own the means of production, you get it from a service provider when and how you need it. Therefore the discussion about technologies and payment structures, as important as it is, is beside the point if we are trying to define (or claim!) MaaS. The core of MaaS is the freedom of mobility without having to own a vehicle. To deliver MaaS defined this way, we need several things, of which a service assistant and a pricing model are the most important. Without these, you don’t have MaaS. The pricing model is essential to perceived freedom. It guarantees that the users know that they can get anywhere in a geographically defined space, anytime during a defined time span. It is certainly the more challenging of the two essential components (assistant and pricing) but it probably is also the game changer: you get it right and the change in consumer behaviour is accelerated to a whole new level. “A change that scales is the only change that matters. And that, in the end, is the true measure of MaaS.”* Hietanen (2020)

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27 A very recent survey indicated that commuters in Europe are choosing cars over public transport, and there is no significant trend in favour of active transport modes despite €16.3bn in EU funding, according to the European Court of Auditors (2020).


29 In commenting on Hensher (2020), Sampo Hietanen (MaaS Global) remarked: ‘….a really insightful article as usual. I would want to pick your brains in scenarios where MaaS is combined with housing. I see that combining those two is going to be ultimately the big breakthrough and have enormous impact on society. This is me agreeing with you on the paragraph in page 4 about ‘service’ being the key. I see that aspect being forgotten when we go through current issues of getting going’.
19. What does post COVID-19 look like for MaaS?

With the COVID-19 pandemic, we observed a wholesale reduction in the use of the shared modes of public transport and rideshare (Uber, Ola, Didi, taxis), bikeshare and carshare\(^{30}\) (Beck and Hensher 2020), in part due to restrictions that required large numbers of people to stay at home, and only essential workers to be out and about, many of whom were tradies and retail workers with adequate free parking when they drove their car. While use of all modes of transport declined, there remained a higher percentage of travel by the private car (Beck and Hensher 2020, Figure 21) given that fears of exposure to the virus were high in shared modes, whereas biosecurity risk was low, if non-existent, in the private car. So, what does this mean for MaaS in the immediate period, the medium term and the long term?

In setting a context within which to comment on possible MaaS futures, we list and discuss two main scenarios which are likely to represent alternative futures on the spectrum within which MaaS can reboot as a multimodal and multiservice offering.

**Scenario 1:** Travel will return to the pre-COVID-19 normal within a few months, with public transport, ride share and private car use showing very similar levels of use, crowding and congestion as before. Working from home (WFH) will have a limited impact. The rationale is that, although the situation is somewhat fluid and the likely response is very uncertain, with Australia’s success compared to other countries in minimising exposure and transmission (‘flattening the curve’), there is a real possibility that normality might return quicker, with perceptions of risk dissipating at a fast rate. Habit persistence is also a significant trait of human beings. Crowds, described as heaving, at shopping precincts on Mother’s day (10 May 2020) in Melbourne and Sydney, despite social distancing requirements in place, highlights this outcome.

**Scenario 2:** One of the most important policy levers now available\(^{31}\), in contrast to pre-COVID 19, is the effectiveness and growing acceptance of WFH. We have never had a real experiment of what might happen to the transport network in the presence of a growing interest in WFH. One of Australia’s leading banks, the National Australia Bank (NAB), for example, is reporting a 15% increase in productivity (associated with WFH) since travel restrictions. This evidence, and growing anecdotal evidence together with the Beck and Hensher (2020) findings from a National Survey, suggest the possibility of a noticeable shift to WFH and consequent changes in commuting (and non-commuting) travel demand (Hensher, Beck and Wei 2020). WFH will be encouraged all the while offices are required to practice social distancing and hence have to stagger working hours for staff, including the possibility of less days in the main office and the balance as WFH. Firms will be interested, as they can save on office space in the longer term (although NAB have just invested in a huge building or buildings at Redfern near the City of Sydney).

Scenario 2 is the one that we would like to see play out over the next 18 months, with employers supporting staggered working hours (even when there is no imposed external constraint to do so) for employees whose work aligns with this strategy, and also with the number of days working from home varying by negotiation, especially where there is substantive evidence of no productivity loss and desirably productivity gain. This is an opportunity for the sustainability charter of supporting mandating increased flexibility of office hours as a consequence of social distancing, which will oblige a number of

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\(^{30}\) While most e-scooter providers halted their operations in Switzerland (and only just restarted on May 6), bikeshare providers have continued to operate and have seen partially large increases in usage as well (also in NYC). Maybe this is a consequence of a balance between users having fewer travel options now and weighing risk to (literally) touch shared mobility. In Switzerland, the huge increase in bicycle use might be due to the excellent infrastructure and also the warm spring weather. Will it last? Time will tell.

\(^{31}\) Milan has a very interesting approach where the city is attempting a more sustainable restart with regards to transport, reimagining the city by reallocating street space from cars to cycling and walking, in response to the coronavirus crisis. https://www.theguardian.com/world/2020/apr/21/milan-seeks-to-prevent-post-crisis-return-of-traffic-pollution
businesses to introduce staggered working hours, and only requiring attendance at the main office on an agreed number of days per week\textsuperscript{32}.

Many sectors already support WFH pre-COVID-19 such as the technology sector. Importantly more generally and widespread now, WFH is a new\textsuperscript{33} policy lever to use to benefit the transport network\textsuperscript{34}. In particular, we want to never return to the peak phenomenon where we have excessive road congestion and public transport crowding\textsuperscript{35}. Governments need to not lose this opportunity, especially while social distancing is in place, assuming the anxiety around using public transport can be overcome fairly quickly\textsuperscript{36} to support a re-aligned network that also works for employers and employees and the wider community more broadly. Flattening the peaks has huge productivity benefits beyond passenger movements, with the freight distribution sector in particular gaining significant travel time savings and reduced costs of doing business. Some light goods movement can be picked up by underemployed Uber drivers and also by Community Transport.

While this new normal is ambitious, it may just be achievable for the first time in our history since the advent of the internal combustion engine, but it will also require a rethink of road user charges to ensure that the road network in particular does not deliver growing congestion through not only private car use but also increased road freight vehicle activity. The position of the private car is dependent on the extent of WFH, the staggered daily commute times and an in-place road user charge scheme. This is a very important point, and the latter will be necessary to at least provide funding (in contrast to an efficient pricing model) to support the revenue loss from public transport\textsuperscript{37} (which typically only recovers 24\% from the fare box) and other sources of mobility revenue loss, as well as supporting new initiatives in mobility investments (such as improved walking and cycling infrastructure). If governments desire to flatten the peaks, they may be prepared to offer tax relief to employers who arrange employer work hours in order to achieve this\textsuperscript{38}, especially after social distancing is relaxed. This can be seen as a very relevant transport demand management (TDM) initiative. The benefits may well outweigh the additional costs to society of a return to congestion\textsuperscript{39} and crowding. However, counteracting this may well be a longer term saving in office space rental\textsuperscript{40} as less employees need to be in the one location at any point in time\textsuperscript{41}.

\textsuperscript{32} Tangential to this initiative is a view that some public servants have a flexi day and want to ensure this is maintained when they work, to some extent, from home.

\textsuperscript{33} ‘New’ in the sense that there is a much broader interest in WFH given the forced circumstance. Telecommuting, for example, is not new (see Brewer and Hensher 1998) but has always struggled to get support from either employees or employers, and especially where the matching of employees and employers is required for it to be implemented. See also https://www.linkedin.com/pulse/why-do-we-meet-anyway-chance-relieve-burden-meetings-glenn-lyons/

\textsuperscript{34} The internet seems to be able to handle mass WFH.

\textsuperscript{35} Flattening of the curve is now replaced with the challenge to find ways to maintain flattening of the peak now that COVID-19 has done the hard work for us. ‘The camel has died’ and now we want to preserve ‘the horse’.


\textsuperscript{37} Some redistribution of tax money will have to happen – providing a good opportunity to highlight road pricing (once again), given also that fuel tax income will decrease with increasing electrification.

\textsuperscript{38} Which has associated emission reduction benefits.

\textsuperscript{39} In Australia, it is suggested that the annual cost of congestion in terms of lost productive and leisure time is $30billion (BITRE 2015).

\textsuperscript{40} However, with social distancing, office spaces will need to be rearranged and the ‘floor area to worker ratio’ will increase, possibly resulting in no gain.

\textsuperscript{41} However, there will be the issue of the costs of running an office from home and who might fund that.
19.1 The MaaS Reboot

Although operational changes will be required to support a more hygienic shared mode environment, they are a necessary but not sufficient condition for a significant return to public transport and ridesharing. The challenge is to get people back to public transport and ride share (at least until a vaccine is widely available and proven), or more generally away from the private car. If WFH and parking charges, in the absence of road pricing reform, do not contribute to taming road congestion, we risk growing the modal share in favour of the private car and a significant setback for MaaS, not only as a niche offering but as a scalable prospect.

The starting position has to be the MaaS elements that can ensure biosecurity safety, and the obvious candidates are micro-mobility modes such as e-scooters and bicycles, which are however mainly limited to short trips (possibly up to 5 kilometres), and car sharing (especially electric cars) from the rental market (for medium to longer trip lengths) that complies with stringent health assurances. One idea is to support carpooling through MaaS with a pre-approved group of individuals that are known and trusted by each sharing passenger. This is the familiar and very old idea of carpooling, but with a difference – no one passenger owns the car per se but arranges to share what might be best described as collaborative ownership and consumption of the modal service where there is trust in the provider. For this to happen, employers can play an important role, actively promoting sustainable mobility practices. This interpretation of the initial phasing back of MaaS aligns well with views of Sampo Hietanen, MaaS Global, who suggests that ‘The profitable part [of MaaS] is having access to a car on weekend’ otherwise MaaS is just a utility service. This may have to be reviewed as a seven days a week offer, under the ‘familiarity of sharing’ adage, which might be attractive where individuals can see the appeal of also being able to select a class of vehicle that best fits their activity needs, as linked to the particular subscription fee of a bundle plan (Reck et al. 2020).

We also believe that MaaS needs to be seen as more than a multimodal offering, but as a multiservice offering. What we mean by this is that some of the services are not only the passenger mode discount, but discounts on non-transport services, for example, retail purchases, as well as having goods delivered to the subscriber, and especially where WFH becomes more popular, or MaaS points that can be

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42 Examples for public transport including automatic doors to avoid touching entry and exit points both on trains and buses and also platforms, cleaning wash rooms more often (or even closing them) given they are a major source of disease transmission, separating bus drivers by a plastic separator (the two-thirds design used by many bus operators to enable some safe communication with passengers), no cash payments, the wearing of masks, and temperature check on entry to and exit from public transport. Also Apps are being developed such as SkedGo’s occupancy feature and COVID-19 alerts for public transport confidence: https://SkedGo.com/SkedGo-launches-occupancy-feature-and-COVID-19-alerts-for-public-transport-confidence/. This feature allows passengers to choose quieter routes and carriages, or switch to alternative forms of transport to maintain social distancing, such as cycling or e-scooters. The occupancy feature has been trialled using open source data from Transport for New South Wales in Sydney and can be rolled out worldwide, depending on data availability. For rideshare, the big challenge is how we might ensure that drivers clean the passenger areas every time someone alights and before someone gets on board. Rideshare may be more challenging than public transport in managing the biosecurity risk. It will also be interesting to see how micro-mobility providers ensure disinfection of vehicles. It has also been suggested that buses might be preferred over trains where the latter travel long distances underground in situations perceived as contained. With a bus, one can open the windows which is seen as an advantage regardless of whether it makes a difference to the health risk. Importantly, it will be easier to increase passenger capacity under social distancing through adding more buses into the network than increasing train capacity which is often at its limits given track constraints.

43 Although they are currently not legal in New South Wales.

44 In Zurich, for example, shared dockless e-scooters are used only for very short trips (median: 721m) while shared docked bikes (median: 1'312m) and shared docked/dockless e-bikes (median: 1'574m) are used for substantially longer trips. Of course, this is very context-dependent, but a first indication. See Reck, Guidon et al. (2020).

45 Carpooling historically has faced many difficulties in finding a match (i.e., fellow travellers). With the extra layer of trust required, it may be challenging to achieve this.

46 But we do not want to discourage informal lift-sharing between trusted groups using someone’s car – which is how carpooling started in the first place.

47 This has general appeal; despite it being a rather Finnish viewpoint since regular trips to the “summer cottage” (= shack!) is how Finns spend their free time.

48 We thank Glenn Lyons for his liking of this interpretation, which in his words ‘merits further attention’. 
redeemed for goods or gift cards. We finally can see the word ‘service’ being given a much broader and meaningful multi-sectoral definition, which may be the basis of a business case that can morph into a commercial proposition.

Under Scenario 1, we might expect MaaS in Australia, and more generally any COVID-19 affected economy, to reboot pretty much along the same lines as pre-COVID-19. It is under Scenario 2 that MaaS may have the greatest challenges but also opportunities, at least in the foreseeable future. MaaS may be a way of arresting a decline in public transport use by offering a first and last mile rideshare\(^{49}\) discount where the convenience of public transport is in place, although how we resolve the matter of hygiene in Uber and taxi remains a concern\(^{50}\). What is encouraging in Australia during the COVID-19 pandemic is that, with the exception of Western Australia that reverted all services to a weekend timetable, the service levels of urban public transport remained in place\(^{51}\). However, the resurrection of public transport as the centrepiece of MaaS may have to take a back role for a little while, as indeed will rideshare.

The design of MaaS bundles (Reck et al. 2020, Hensher et al. 2020) is likely to be affected by the preferred (and most likely) Scenario 2 from a societal perspective, with concerns about having to subscribe for a month when some days are WFH\(^{52}\). This is almost certain to influence responses to offered monthly subscription fees, and risks staying with pay as you go (PAYG), even outside of a digital platform that promotes modal integration in trip planning and selection.

Recommendation: Under Scenario 2, a bundle consisting of flexibility in choosing the subscription period, a micro-mobility mode for short local trips, a shared car for familiar sharers that is coordinated through the broker, and a rental car for individual use, may be a good first start as a reset offer after rebooting MaaS. Importantly, there may still be a need for the private car outside of the MaaS offer, but the offer may result in a reduction of the number of private cars in a household. Under Scenario 1, MaaS can resume as before but we might want to take advantage of prospective opportunities under Scenario 2, where possible.

20. Final comments

“This is really great. I’ve been searching for some evidence that a subscription model could actually work for the user, and oddly enough for all the focus in the MaaS industry, there has been very little research with real customers. I hope more MaaS projects do this kind of study to see if this is replicable.” Elliott McFadden, Greater Minnesota Shared Mobility Program Coordinator at Minnesota Department of Transportation

This report has documented the journey of the Sydney MaaS trial, highlighting all of the strategic, tactical and operational elements that were undertaken in order to deliver Australia’s first fully scoped MaaS trial. Along the way we have learnt a great deal about the importance of building trusting partnerships with all the key stakeholders, both those responsible for the trial (IAG, ITLS University of Sydney, SkedGo), and those who fed into the program as participants, suppliers and investors. We would argue that without the experience of the trial, we would not be in a position to make suggestions on what future MaaS products should focus on if they are to have some chance of continuity in a market environment where there is a sizeable amount of lack of knowledge about MaaS, and dare we say scepticism.

\(^{49}\) Some commentators have suggested that rideshare is part of the hyped ‘shared mobility’ concept rather than a reality arriving soon.

\(^{50}\) Will taxi drivers, for example, clean the seats and surrounding space every time a passenger gets out? There have been a lot of licences returned recently. https://www.theaustralian.com.au/nation/coronavirus-no-idle-threat-as-cabbies-in-decimated-taxi-industry-return-plates/news-story/5e359d5e047674789d09de2b4bc507c5

\(^{51}\) Continuing normal service levels has allowed customers to physically distance on trains and platforms.

\(^{52}\) Daniel Reck (Personal communication) in commenting on this says: ‘Interesting idea, one way this could work out is by taking up UbiGo’s idea of selling a number of PT daily passes instead of a monthly ticket to accommodate irregular / part time commutes.’
Without exception, every feature of the MaaS trial journey will be required again by those who will venture into the MaaS space, but hopefully with the benefit of the experience summarised in this report and its associated papers. One of our objectives was to document the trial so that there is transparency in every part of the trial, something missing in our view on every other trial and indeed actual MaaS offering. In so doing, we want to better inform others venturing into the MaaS space. If we were to refer to components of the MaaS ecosystem that are critical to its success, then they must be the identification of the nature and magnitude of the benefits to potential subscribers, which is central to the design of subscription bundles that have enough choices both with and between offered bundles to cover the attractive modal and multi-services, and that the digital platform is sufficiently rich to be able to respond to changes in the needs of growing MaaS subscription.

A number of papers have been prepared using the Sydney MaaS Trial data that involve modelling bundle uptake to identify key drivers of bundle subscription on travel behaviour (Appendix H), particularly the private car use (Appendix G), and modelling mode choice at the trip/journey level conditioned on a bundle subscribed to.

We conclude with a benchmarked definition of MaaS that we have arrived at after the accumulated experiences in running the Sydney Trial and giving many talks and dialogue on LinkedIn over the period 2019 to 2020.

This definition below was initiated by David Hensher (Institute of Transport and Logistics Studies (ITLS), University of Sydney) with extensive input from Natasha J Hinrichsen (Transport and Main Roads Qld), Sampo Hietanen (MaaS Global), Corinne Mulley (ITLS, University of Sydney), John Nelson (ITLS, University of Sydney) and Andy Taylor (Cubic).

There have been a number of very useful comments on our suggested definition of MaaS developed to improve clarity on what is MaaS and what is not MaaS, to be careful not to ‘stack’ too many elements into MaaS since it will end up being nothing more than the provision of mobility by any manner. One suggestion about TDM is a good example of important mobility enhancing strategies such as pricing policies re parking and road use and redesign of public transport to manage crowding, but these are not MaaS per se. Finally and importantly, MaaS is a framework, aligned in the past to the language of mobility management but is now more focussed. Usage and coverage determines whether it is mainstream or not. We have included the private car and parking but not made it explicit, and they are part of multi-modal mobility.

The definition is:

"MaaS is a framework for delivering a portfolio of multi-modal mobility services that places the user at the centre of the offer. MaaS frameworks are ideally designed to achieve sustainable policy goals and objectives. MaaS is an integrated transport service brokered by an integrator through a digital platform. A digital platform provides information, booking, ticketing, payment (as PAYG and/or subscription plans), and feedback that improves the travel experience. The MaaS framework can operate at any spatial scale (i.e., urban or regional or global) and cover any combination of multi-modal and non-transport-related multi-service offerings, including the private car and parking, whether subsidised or not by the public sector.

MaaS is not simply a digital version of a travel planner, nor a flexible transport service (such as Mobility on Demand), nor a single shared transport offering (such as car sharing).

‘Emerging MaaS’ best describes MaaS offered on a niche foundation. This relates to situations where MaaS is offered on a limited spatial scale, to a limited segment of society or focused on limited modes of transport. The MaaS framework becomes mainstream when the usage by travellers dominates a spatial scale and the framework encompasses a majority of the modes of transport. All the other variants that do not meet our definition might be referred to as ‘Aspiring MaaS’ given the normal usage of ‘aspiring’ having ‘hope’ or ‘ambitions’."

67
21. References


European Court of Auditors (2020). Sustainable urban mobility in the EU: No substantial improvement is possible without Member States’ commitment, Special Report 06. https://op.europa.eu/webpub/eca/special-reports/urban-mobility-6-2020/en/


22. Appendices in the accompanying report

A: MaaS mid-trial interviews report
B: MaaS bundle design
C: MaaS, government and private providers
D: SkedGo overview of the Sydney MaaS trial contribution
E: Mobility plan personas and motivations
F: Post Trial experience survey
G: Mobility as a Service and private car use
H: Drivers of Participant’s Choices of Monthly Mobility Bundles
I: Mobility as a Service users: Insights from a trial in Sydney
J: Mobility bundling and cultural tribalism - might passenger mobility plans through MaaS remain niche or are they truly scalable?
K: Mobility as a Service (MaaS) – Going Somewhere or Nowhere?
L: MaaS bundle design and implementation: Lessons from the Sydney MaaS Trial
Appendix A: MaaS mid-trial interviews report
Prepared by Yale Wong with input from David Hensher and Chinh Ho

Interview administration and sampling strategy

In February 2020, interviews were conducted with a large proportion of participants in the iMOVE-funded MaaS trial, all IAG employees. The aim of the interview process was to guide future bundle design as well as to provide feedback that can inform all aspects of designing and running a trial, by reviewing trial participant behaviour to date, including choice between PAYG and subscription plans. Other common behavioural patterns, changes before and during the trial period, and use of the Tripi application (the digital platform) were also identified.

As of late-January 2020, there were 91 active participants in the MaaS trial. Interviews (framed as ‘conversations’) were arranged and confirmed with a total of 27 participants (30% of all trial participants). Due to last minute cancellations, a total of 22 participants proceeded with the interviews, representing 25% of the participant population.

Interviews were conducted during business hours at the IAG offices (Daring Park, Sydney CBD) on the dates Wednesday 5th, Thursday 6th and Monday 10th of February 2020. In total, 16 interviews were conducted face-to-face, whilst a further 6 were undertaken virtually (via the online platform Zoom) due to employees working from home. Interviews were semi-structured (an interview guide is reproduced in the Appendix of this report), and took 30 minutes maximum in duration each.

The sampling strategy was defined in terms of participants’ choice of subscription plans (or otherwise) during the months of November, December, January and February. In total, six segments were defined incorporating participants who stayed on PAYG throughout the four month period, participants who signed up to and stayed with one (and only one) of three bundles offered during this period (these being Fifty50, Saver25 and Green Pass, each with varying levels of discounts applied to each mode, see Figure 1), participants who switched amongst these offered bundles, and the one participant who switched from a subscription plan back to PAYG.

![Figure 1: Three subscription plans and one PAYG option available as of February 2020](image)

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This number has since reduced by five due to employees leaving the company.
The sample selected for interview from each of these six segments are detailed in Table 1, whilst the Appendix offers further information for the bundles selected by each interviewee on a month-by-month basis.

Table 1: Overview of the sampling strategy and participant segments

<table>
<thead>
<tr>
<th>Segment</th>
<th>Description</th>
<th>Sample</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PAYG only</td>
<td>6</td>
<td>51</td>
</tr>
<tr>
<td>2</td>
<td>PAYG then Fifty50</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>PAYG then Saver25</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>PAYG then Green Pass</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>Switch amongst bundles</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>Switch from bundle to PAYG</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

A discussion of major findings themed by PAYG and subscription plan-specific feedback, behavioural change, use of the Tripi application and other feedback follow in this report.

Pay-as-you-go (PAYG) feedback

PAYG-only participants (Segment 1) comprised 56% of participants in the MaaS trial and the largest single segment amongst interviewees. This constituted 51 participants, of which 6 were selected for interview with the aim of understanding why they had opted to stay on PAYG rather than selecting any of the three subscription plans offered. In general, the reasons came under five broad themes.

The first reason relates to the value for money proposition of subscription plans. Whilst the combination of different subscription fees (flagfall) and modal discounts offer a range of entry points, it remains the case that a large number of participants perceived that they did not travel regularly enough to make these product offerings worthwhile. For instance, many IAG employees are able to work from home regularly (so may travel to a workplace only 2-3 days a week) in which case they did not deem a subscription plan to be worthwhile. Most interviewees also relied exclusively on public transport for journey-to-work travel which further meant that the multimodal nature of subscription offerings were not price attractive. In many ways, the MaaS plans were viewed in the context of fulfilling journey-to-work travel. Travel during the working day did not emerge.

Secondly, the issue of location is another key reason for participants' reluctance to subscribe to MaaS bundles. Several participants lived quite close to the CBD and relied on walking for most travel needs. Occasionally, Uber or GoGet would be used (2-3 times a month) for travel which required it (such as large shopping trips). For these subscribers, the choice of mode is between walking and Uber/GoGet, and so public transport discounts are not useful. The present bundle offerings are not geared towards such a modal combination but are instead public transport focused (and for good reason).

Thirdly, unusual travel patterns (largely seasonal) precluded interviewees from subscribing to the MaaS plans offered. Most participants saw a deviation in their routine during the holiday period in December and January, with many travelling interstate or overseas, so they would not travel enough during these months to see value from their plan. One participant was seconded to an interstate IAG office (Brisbane) for several weeks, whilst another was injured from a car accident (unrelated to MaaS trial travel) so worked from home for several months.

Fourthly, there existed a marked lack of awareness amongst a subset of the participants regarding the details of the subscription bundles offered (despite the onboarding process being very well received). This is a type of ‘inertia effect’ where habitual behaviour is preferred. One interviewee notes that they
were too “lazy” and that it took “too much effort” to look at the bundles. Another interviewee “muled over” the plans but did not pick them in the end. Others admitted to not have looked at them in detail. There was also a view amongst a considerable proportion of participants that the cost associated with subscription plans made virtually no difference to their budgets. This is weighed up against the need to commit to a plan for one month in advance.

Fifthly, the need for commitment arose as a real constraint on participants’ desire to subscribe. Even though the MaaS plans are offered on a month-to-month basis (and not yearly or more as is the case for mobile phone plans or home energy plans), participants questioned the need to subscribe for a service (i.e., transportation) they have always had access to on an as-needed basis. This is a very useful point which needs to be addressed in the marketing and promotion of MaaS. Many participants were uncertain about their travel in the coming week (let alone month). Uncertainty about mode choice, particularly with Uber, also precluded participants from selecting higher flagfall plans.

This information is particularly useful to help inform key markets for future bundle design. Clearly, there exists the opportunity to lower the barrier to entry for subscription plans to entice current PAYG users, the vast majority of which are not frequent enough travellers to see value in the plans. These participants do not require transport as often (on any mode, not just public transport), and so could benefit from lower tiers such as the $25 entry offered by Saver25. An important question remains, however, namely whether it is the objective of MaaS (or indeed desirable) to ‘force’ all users onto subscription bundles. Some literature has pointed to PAYG as the preferable approach for the design and format of MaaS (Vij et al., 2018; Reck and Axhausen, 2020), although it raises the question of how value may be extracted from the service supplier by the mobility broker/aggregator.

**Subscription plan feedback**

**General**

This section offers high-level feedback on subscription plans, including participants’ decision process for choosing to subscribe, as well as their desired model for subscriptions (considering the modal offering, discounts and other value adds). Subsequent sections consider each of the three plans offered so far (Fifty50, Saver25 and Green Pass) in greater detail.

Participants who opted to subscribe to a MaaS plan constituted 44% of those involved in the MaaS trial. This is encouragingly similar to the findings from some stated preference MaaS studies available in the literature (e.g., the stated shares of the MaaS plans across the sample in Ho et al. (2018) is 47.2% of which 36.2% indicated that they would subscribe to pre-defined MaaS plans tailored to their current travel patterns and a further 11% would use MaaS as PAYG), although a real world setting (such as this trial), and (particularly in this case) the characteristics of the participating cohort, can make a substantial difference due to issues around understanding and convenience, as compared with a survey-based setting aided by an interviewer.

Two distinct reasons emerged which motivated participants’ desire to subscribe in the MaaS trial. The first relates to a financial reward in terms of cost savings through modal discounts—although as evidenced by those opting to remain on PAYG, this did not apply to all people. One of the important pieces of feedback received is the almost universal preference for any potential savings to be communicated to participants on an ex ante basis. This is similar to some energy plans where the anticipated annual savings per plan are shown upfront. Participants indicated that they were not able to identify potential savings from subscribing and would need to make their own calculations to determine this amount (calling this process a “pain point”). Only a small minority of participants made any specific calculations of the potential savings (including on a spreadsheet!), with most relying on what could most accurately be described as a “hunch” of a financial reward. One participant even called it “rolling the dice”. Clearly, this could be a potential future function of Tripi. Participants indicated that the ex post communication of their actual savings (subscription versus PAYG) in their invoice was not sufficient and would much prefer for this to be available beforehand (based on expected travel in their next month).

In terms of the other reason for subscribing, a number of participants indicated a novelty or curiosity factor for the subscription plans. These participants may be described as ‘variety seekers’—the inverse of habitual behaviour. For these participants, variety appeared to trump any “couple of dollars of savings” which were deemed not significant enough to make a difference.

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There were a number of other crucial and interesting aspects of subscription plan feedback and participants’ transport use in general which were revealed through the interviews. Firstly, participants were far less multimodal then expected (at least amongst non-private car modes), as evidenced already by the high proportion of PAYG users. Clearly, this hinders participants’ propensity to subscribe, although if they were travelling regularly by public transport, value could still be extracted from a subscription plan with the other included modes largely ignored. Indeed, entitlements like Uber and taxi discounts were designed in the bundles as a ‘bonus’ feature around a public transport core, although some participants still felt that they were paying for modal offerings which they did not use. Some studies have indicated that including a mode of no interest has a negative impact on participants selecting a particular bundle (Guidon et al., 2020). However, there is currently limited information on how individuals might process the modal offerings (hence the importance of this trial), with the risk that some modes might be deemed irrelevant whilst their presence causes concern about the value of the subscription fee.

Interviewees also offered up a range of mode-specific feedback. In terms of public transport, there was a general lack of awareness around the nuances and complexities of the Opal fare structure. When probed, many interviewees could not answer whether they usually reached their daily or weekly Opal caps (the latter qualifying them for a 50% discount after eight trips). However, there did exist around three participants who were very thrifty and very much ‘on the ball’ in minimising their Opal fare and maximising the benefits from their subscription plans. Their experiences will be returned to shortly in the context of behavioural change. One user mentioned that non-government contracted (commercial offerings) like Manly Fast Ferry should be discounted, although they were not aware that OpalPay services are already discounted due to an error made by the MaaS trial team. This discount was hence not advertised in the trial.

Taxi and Uber were broadly regarded as equivalent except for a select few trial participants who were very much anti-taxi, due to previous poor experiences around vehicle cleanliness and driver attitude (their reluctance to share the route to be taken was cited as one example). Despite occasional negative media attention, there was no anti-Uber sentiment to the same regard; only a preoccupation around price, especially as compared with their competitor Ola. Ola was preferred by many as they were cheaper even with the 15% Uber discount provided as part of a subscription plan. Ola was also deemed to be far less aggressive than Uber with its surge pricing, whilst their service levels (in terms of wait time) was broadly similar, especially in the CBD. Whilst a small number of interviewees were ambivalent about Uber as compared with Ola (usually these were extremely infrequent users of ridehailing services), an overwhelming majority would prefer to have both Uber and Ola available within the Tripi application and MaaS subscription plans.54 Their desire to ‘multihome’ within one application to compare price and service offerings is consistent with the popularity of some products available in the market in other jurisdictions for both customers as well as ridehailing drivers/partners to use multiple service platforms. Taxis and Uber constituted, in qualitative terms, the next most popular modes of travel after public transport amongst Tripi trial users. A small number of participants, however, did mention that they have made taxi or Uber trips during the trial months but had forgotten to do so using the Tripi application. Some participants still used the CabCharge card for taxis and the MaaS trial business account in Uber (which is functionally no different), but others who didn’t do this in its entirety did not receive the benefit of the subscription plan discounts. The Thrifty car rental offering was interesting in that many participants did not realise how cheap it was (at $30 per day through IAG employee-wide discounts) prior to joining the trial. It is not clear, however, from the interviews whether this caused any discernible increase in car hire users. One of the reasons for this is that the hire car is also associated with a negative connotation amongst a number of trial participants—in ways which may only be described as ‘ideological’. Many held a negative association in terms of the costs of rental cars (despite the low daily rate), through the excess hidden fees charged and insurance requirements (perhaps arising from personal bad experiences). Car rental was also not needed in Sydney since so many of the participants had their own vehicle, and when they are not available (for example, because of an accident), then a replacement would be arranged by their insurance company. For others without their own cars, they would default to GoGet carsharing—since they never used the vehicles for more than two hours at one time. GoGet in general, however, also

54 In mid-March 2020, DiDi launches in Sydney with 50% off all rides for the first month. This will bring about a major change in terms of comparative price of trips for different ridehailing providers.
suffers itself from poor availability in some areas and, the more important concern, assurance of availability. One participant mentioned that Car Next Door would be a more convenient option for them.

One of the important questions posed to interviewees was what their ideal subscription model would look like. In general, this centred around greater discounts on modes used by the specific participant, and the removal of enticements on modes they did not use, thereby supporting the findings in Guidon et al. (2020). Public transport was almost universally regarded as important, especially in the first/last mile context to train stations. Short trip Uber discounts (5-7km) for these access/egress purposes emerged as suggestions for inclusion, as well as how the connection can be made more seamless. Some participants mentioned micromobility modes like bike and scooter sharing as desirable in the future—especially Lime which was stated as “fun” but “very expensive”. Interestingly, most who sought bikesharing inclusion in the bundles did not currently use the service, but suggested Tripi could entice them to try the service since there would be no more annoyance of installation, registration and downloading of multiple applications.

Some employees offered more radical suggestions for the design of future MaaS plans, including ways to incentivise carpooling with other employees (Liftango is a company active in this space), as well as Uber Eats credit discount (some participants mentioned that they use food delivery 1-2 times per fortnight so this is a recurring expense). Ways to incorporate a petrol discount was also mentioned. In terms of modal discounts, there was an overwhelming preference for a dollar over a percentage discount—this being more advantageous for shorter trips.

Fifty50

Fifty50 was the first MaaS bundle offered in December 2019 and saw a take up of 13 (against 91 participants) to date. It offered 50% off of public transport and $3 off of every ridesharing trip (Uber, taxi) for a monthly subscription fee of $50. Being the first plan, Fifty50 drew “curious” users who sought something “new and different”, with participants noting a feeling of “delight” at seeing the discounting model. The plan is multipurpose and attracted many price conscious participants. Feedback received indicated that Fifty50 was good value for those who are public transport dependent with a fixed routine, including those who rarely (if any) use any of the other included offerings like Uber, taxi, GoGet and Thrifty. One participant caught the ferry frequently (which is comparatively more expensive than bus, train and light rail), and so public transport savings were substantial. They subsequently signed up to the Green Pass when it became available for February 2020.

Saver25

The main attractions of Saver25 are its low price entry point and discount on GoGet trips, designed to target those who have not previously tried the mode. It offered 25% off of public transport, 15% off of every rideshare trip (Uber, taxi) and every GoGet carsharing trip for a monthly subscription fee of $25. The lower tiered entry made the plan more attractive for infrequent users of public transport, although there is no evidence of a higher proportion of participants choosing this plan as compared to other more expensive offerings. For one participant (who considered themself niche) working part-time (in the office 1 day and working from home 2 days a week), Saver25 allowed savings of a few dollars every month. One of the criticisms of Saver25 was confusion around the “25%” discount since it did not apply to all modes. This shows the importance and power of ‘labelling’.

The GoGet component was also disappointing in delivering the expected outcome. No qualitative evidence emerged of participants trying to use GoGet who had not previously used it. The Saver25 enticement hence did not drive any behavioural change in this respect, but rather only benefited existing (often heavy) users of GoGet. These are well endowed participants (a high-level executive without their own car, for instance) who would rely on GoGet and Uber regardless of their price—their monthly bills being into the thousands of dollars. These are some extremely non-price conscious customers, who have even indicated a willingness to pay a higher subscription fee for greater discounts on point-to-point modes (e.g., $150/month for 50% of Uber). For the majority of the participants, the GoGet discount in Saver25 simply did not make GoGet any more convenient. Convenience is often a function of pod distance and other booking considerations like lead time, as well as the general inflexibility of return-to-base carsharing schemes. Most participants owned their own car anyway which is far more convenient and already regarded as a sunk cost.
Green Pass

Green Pass presented with the highest entry hurdle of the three subscription plans offered, with a $125 flagfall (subscription) price, but also generous modal discounts. It offered free public transport and 15% off of every ridesharing trip (Uber, taxi). Green Pass subscribers noted that with enough regular public transport use the plan presented itself as a saving as compared with weekly Opal capped fares.

Behavioural change

Influencing behavioural change towards the use of more sustainable modes of transport is an important motivation and rationale for MaaS. When questioned directly on notable changes in travel activity since participating in the MaaS trial, interviewees usually could not identify any changes or revealed only minor changes in their travel behaviour (saying this was not “front of mind”). The majority of these changes involved taking more public transport but at the margin only (perhaps 1-2 additional public transport trips per fortnight). In the instances where this was cited as the case, the trip would have previously been undertaken in a car, either belonging to oneself, a friend, or another family member. The desire not to inconvenience others in the case of needing ‘lifts’ was raised, as well as the more conscious desire to make the most of the public transport entitlements within a subscription plan (to reach the threshold where savings could be made). There was one case cited where such ‘lifts’ were replaced by Uber trips because of the subscription plan discounts. Two ‘lifts’ per month would be replaced by Uber, but this was again a minor amount as the participant was still relying on ‘lifts’ 2-3 times a week.

Participants held a number of expectations for how they might rearrange their travel behaviour under MaaS at the beginning of the trial. Many had an “open mind” and participated as “good corporate citizens”, without expecting very much in financial rewards. The ability to save money hence exceeded expectations, being hailed as a “surprise” by some. A number of participants were “very sceptical” in how much of a difference MaaS could make to their travel freedom due to the limited number of service options available in their area. Some suggested how MaaS might make it more price friendly to use Uber in these contexts, but this did not end up meeting the price expectations of these participants. A couple of interviewees raised how the MaaS trial would place their own spend on the car front and centre, especially given initial interest in the Safer Journeys alignment and costs. This has not eventuated in line with their expectations as costs between car and alternative modes have not been communicated in aggregate, beyond on a trip basis within the Tripi journey planner. More details surrounding participants’ use of the Tripi application follows in the next section.

Another important question posed to interviewees was how the Tripi application and financial rewards through MaaS plans could better help participants to travel more sustainably. What emerged was a number of impediments to changes in behaviour, and how limited a digital platform and combined payment structures are to nudge behavioural change as compared to the physical service offering available (such as service coverage, span and frequency). This very point is made in Lyons et al. (2019). In the majority of cases, participants noted that they would choose public transport only if it was already convenient. One benchmark suggested was that public transport would only be considered if it were less than double the time it took to drive the same trip. Another participant suggested that they would opt for Uber rather than public transport (their usual option) when “wrecked” after a long day—suggesting that other circumstantial reasons take precedence over factors within the domain of influence of the MaaS trial. There existed a set of well-off and time poor participants (appearing to be IAG senior executives) who would often rely on taxis and Uber for a large proportion of trips. Their homes were in the inner west and inner east suburbs so cost-wise these modes are not excessive. However, it appeared they would default to them whenever they were “running behind schedule”—being the quickest way to travel place-to-place. What they suggested could be useful so that they could have space to consider other modes of travel was by syncing Tripi with their phone calendar, such that another calendar event blocked as “travel time” (on whatever mode of their preference) could be created automatically for them.

A major consideration during the past four months of the MaaS trial is the impact of the Christmas/New Year holiday period on participant travel behaviour—particularly relating to their use of the Tripi

55 Safer Journeys is an IAG group initiative (also available to the general public) to detect and respond to collisions in real-time, via an installed tag in each vehicle - see [https://saferjourneys.com.au](https://saferjourneys.com.au)
application and MaaS subscription discounts. As already mentioned, many IAG employees took leave, whilst others worked from home during this quieter period. There would therefore be a reduced travel demand making subscription plans more marginal in terms of the financial savings which can be extracted. There would also be a shift from journey-to-work to other trip purposes, necessitating use of more personalised transport modes like GoGet and Thrifty. This was the purpose of the Saver25 bundle discount in enticing participants to try these modes, and supported by some participants who took to hiring Thrifty during the holiday period. One participant worked from the IAG Brisbane offices throughout the month of December so was able to use their Uber discount, linked to Tripi. In many cases, however, participants used their personal vehicle for these non-work trips, making PAYG a more attractive proposition. A number of participants indicated that they had meant to cancel a previously subscribed plan to return to PAYG during this period but had neglected to do so, with some even losing money because they had stayed on a subscription plan. It is also worth noting that although the plan automatically rolls forward to renew for the next month, participants get feedback on what will work best for them and the opportunity to switch to a new bundle. This form of individualised marketing is unique amongst other MaaS offers like Whim.

In terms of any impacts to travel taken outside of the Tripi application (namely driving and other ridehailing services like Ola), interviewees indicated again that any change as a result of the trial only occurred at the margins. For most people who owned their own car, driving still made sense for those trips undertaken by car. A couple of participants who used to rely on ‘lifts’ did so less often (switching to Uber or public transport instead), so as not to be a burden on others. This was especially true for one participant who held no driving licence, in the late 20s age group. When questioned why this was the case, they cited that there had been no time to get one, no one to teach them, and also that people get “complacent” after learning to drive (i.e., they would just drive everywhere).

A number of unintended consequences surrounding the use of Tripi and the subscription plans were also explored. A small number of participants indicated a tendency to ‘game’ the Opal system in the past, by deliberately going out of their way to maximise the number of Opal journeys made in the first two days of the week to reach the weekly cap and hence 50% discount on subsequent trips. This also applies in the context of the choice of mode in areas like along Sydney Harbour and Parramatta River where both rail/bus and ferries are available. Full fare rail/bus trips will be taken early on in the week whereas upon reaching the Opal cap more expensive ferries will be preferred due to the discounted rate. Such behaviour is far more widespread than the trial offering on Opal so cannot be attributed to the discounts offered. However, the subscription plan discounts do effectively eliminate these Opal policies and homogenises all trips and their prices. Subscribers therefore self-proclaimed to be able to “relax a bit” in their choice of mode and time of travel. In another example of behavioural shift—and particularly evident amongst more thrifty segments of the participants—but was the previous habit of travelling off-peak on trains to receive a 30% discount in fares. Again, the subscription plans make such behaviour no longer relevant, but it does not aid in the government’s peak-spreading agenda.

One final observation was the participant who shared their Opal card (and hence public transport credits) amongst family members. The participant realised that this was against the terms and conditions of the MaaS trial (and inscribed from the latest Green Pass subscription plan onwards, although participants likely still not be aware of the condition), but reluctantly shared this behaviour anyway when probed.

**Tripi application**

The Tripi application in encompassing the journey planner and digital wallet functions was thought to constitute a major value proposition of the MaaS trial for participants. What eventuated, however, was very limited reliance amongst the participants on the journey planner, with many indicating an overwhelming preference for competing providers such as Google Maps and Apple Maps. Many interviewees had never opened up the Tripi journey planner since the onboarding process, and have clicked through to the application less than 10 times during the four months of trial so far. The preference for competing products was mainly due to habit, but also design and functionality. For instance, some

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56 These participants even shared how the order of bus+train or train+bus mattered in terms of the total fare paid (due to the blunt nature of the Opal transfer discount being applied to the second trip).
stated that Google Maps’ multimodal features were better, and preferred their more colourful interface in showing mode colours, line names and route numbers at a glance—consistent with the pictograms used by Transport for NSW. The design of Tripi is more minimalist in regard.

A number of participants criticised Tripi for being “slow”, “buggy” and “unreliable”. One stated that they experienced occasional crashes, before the application stopped working in its entirety, displaying the error message “expired” (on further investigation it turned out they had not updated the application beyond its Beta version). Interviewees noted that Tripi sometimes had issues identifying the user’s present location, as well as problems displaying real-time service information. The logic for the mode ‘walk’ was inadequate, as selecting a preference for walking led to a walk-only option (even for a trip 9 hours in length) being displayed as the sole option in the journey planner. No feedback was forthcoming in terms of how well Tripi incorporated service disruption information. A couple of participants correctly identified that Tripi and TripGo were essentially the “same app” (Tripi being a white label of TripGo), but preferred TripGo due to familiarity and no notable benefits in Tripi. Only a very small number of participants offered positive feedback on the Tripi journey planner. Generally, these people were less well informed about alternative journey planners on the market. A number even mentioned they would revert to the 131 500 website on their computer for journey planning purposes (this website having been superseded by transportnsw.info since around one decade ago). Some participants mentioned they used Google Maps on their phone for routing purposes, not being aware that a journey planner is also available.

One of the key insights around travel behaviour and use of the Tripi application is that participants overwhelmingly already decide their mode of transport before using a journey planner to check the schedule (in the case of public transport), or Google Maps for its navigation features (in the case of driving). This choice is often predicated on existing knowledge of the destination, routes and their availability. When presented with hypothetical scenarios in which a destination is unfamiliar to the participant, many would revert to driving or ask a friend/family member rather than using a journey planner. This shows habitual behaviour within the participants to dominate those who would identify as variety seekers. Participants were far less multimodal than expected and also cited “more hassle [in] using an application”. When asked about the Tripi journey planner experience, no interviewee was able to recall CO₂ emissions being presented as a metric associated with each suggested trip. This hasn’t been aided by design and presentation of carbon emissions within the application which is shown in a very light grey. Almost universally, participants indicated that whilst emissions were important on a macro level, it would not influence their choice of modes on a trip basis.

In cases where public transport as a mode has been selected (or where public transport is a regular trip), then participants were far more likely to use a timetable service (mainly TripView57) to view schedules. TripView can save regular trips and has a simpler interface to navigate (albeit with reduced functionality) than a multimodal journey planner like TripGo/Tripi. Whilst TripGo/Tripi is also able to save and view timetables, this function is not located at the forefront of the application. SkedGo made the internal decision to design their applications as journey planners as the core (and, by extension, target market of users), whilst timetables are located deeper within the application several clicks away.

The low engagement with Tripi meant that quite a few users neglected to use the application to call Uber/taxi trips (as already mentioned). Some participants suggested they could no longer remember how to arrange non-public transport trips, which were demonstrated some four months ago in the onboarding process. Public transport travel with a physical Opal card does not face this problem. Some suggestions were offered up by participants to help make Tripi more relevant for them. One interviewee suggested the use of push notifications to help them remember to use the application. Another suggested ways to gamify the application—and linked to the issue of the poor walking preference algorithm—allowing users to set a target number of kilometres to walk each week, then routing their trip options accordingly. Criticism was also made in terms of the need to save more destinations than just home and work (like the gym and other points of interest). The ability to create waypoints and trip chain (as available in Google Maps) was also raised—i.e., travelling from A to B via C. It is clear that Tripi needs to better identify its value add and present this more effectively to the end user.

57 See https://transportnsw.info/apps/tripview
Other feedback

To conclude each interview, some higher-level feedback on participants’ experiences of the MaaS trial were sought. Interviewees were generally very satisfied with the trial to date, with an almost universal view that the onboarding process exceeded expectations. Participants were full of praise for the one-on-one time and dedication spent in personally onboarding each participant, as opposed to more generic emails and instructions as many had initially thought would happen. Only a small number indicated an extended time of no communication between the initial survey in mid-2019 and them being notified of the next steps. Support from the trial team throughout the past four months has also been very positive. Communication was swift as exemplified by one respondent who was incorrectly charged a taxi trip on her account—this being quickly investigated and then rectified.

Many interviewees noted that they shared their experience of participation in the trial with colleagues, friends and family. Participants have stated that they are “super proud” of the trial and how it constitutes “innovation” as the “future of transport”. The subscription plans and ability to save were popular features, far more than the unifying application interface. Some participants showed interest in joining the trial in the future, both internal and external to IAG (although many of these external participants used Android phones so would therefore not be eligible). As part of the interview, participants also wondered what would happen beyond the trial, including whether the service offering would be extended to the broader market.

The interviews also revealed a few additional areas of improvement. Participants asked to use Opal contactless via near-field communication as part of Tripi, rather than being issued with a separate Tripi Opal card. Participants also asked for GoGet access to be programmed onto this same card. One of the biggest gripes (as mentioned) remain in better communicating the cost savings under different subscription plans as compared with PAYG on an ex ante basis. A range of feedback was also received relating to the invoicing component of the trial. On the one hand, participants suggested that transport had to be “invisible” to the end user as much as possible; but on the other hand, a clear communication of itemised spend was also desired. The monthly invoicing process brought greater clarity to users of their transport costs on a monthly basis. This number generally exceeded people’s budget expectation (some labelled this as “bill shock” and even contacted the support team to verify their amount, though it is unclear whether this had any influence on subsequent bundle choice), given they are used to being billed in far shorter temporal increments. Equally so, however, participants felt that aggregating by month made individual trip costs far less transparent. This is especially the case for those who had subscribed to a MaaS plan, as itemised trip costs in the Tripi wallet are then no longer displayed (all showing as $0). What participants seek are trip-level costs in real time, together with a summary invoice aggregated by mode.

In general, the interviewees were satisfied with the monthly billing model, although some suggested that a fortnightly cycle might work better since it aligns with the pay cycle. Post-pay was well received, although one participant suggested that paying the subscription fee upfront and then being charged on a trip basis might aid in cost visibility. Almost universally, negative feedback was received on the 2% credit card surcharge. Participants labelled this as “outdated”, and suggested that such fees should be borne by the supplier rather than the end user. In seeking to avoid the surcharge, participants opted for a bank transfer instead, even though it was far less convenient. Participants suggested that alternative means of payment should be explored such as PayPal and direct debit. Finally, a small number of participants indicated (or rather, apologised) that since the invoice emails were received on their work account (which they did not check every day), then there would be an inevitable delay in their payment.

An underlying objective of MaaS and the design of subscription products is for users to reduce their reliance on private vehicles. A number of participants had already reduced their vehicle ownership well before the start of the trial. In general, no interviewee indicated that they were thinking of selling their car as a result of the trial. Quite a number of people, however, were already thinking through the costs of ownership well before the MaaS trial, with many justifying their extra costs by circumstantial requirements like the need to transport children or sporting equipment. Many of the participants’ cars are very poorly utilised and this was very much self-recognised by the interviewees. Some had calculated that they would save $3,000-$5,000 per annum were they to sell their car and move to GoGet. However, the convenience and assurance of vehicle availability remain challenges which prevented them from doing so. Participants did not like that GoGet vehicles had to be returned back to base and at a specific time. Car Next Door, as a competitor to GoGet and not included in the trial, was also identified.
as being accompanied by annoyances like the need to download an application, book, inspect and take photos of vehicle damages. On the other hand, participants’ own cars were viewed as an extension of their home.

The trial has been limited to date in driving behavioural change. More work needs to be done to explore how to nudge trial participants, including better communicating the costs of car ownership, as well as offering the assurance (and confidence) that a combination of non-ownership modes supported by a digital MaaS platform will be able to meet all of their needs.

It is hoped that a follow up survey at the end of the full trial in early May might identify the extent to which there has been at least some initial thinking amongst participants about future mobility options that might be better aligned with sustainability goals, even if the trial to date has not been long enough to capture significant behavioural change. The March 2020 revisions of the bundle offering (in particular, around first/last mile distance-limited Uber discounts and feedback on emissions) are being designed to offer some opportunities to contemplate behavioural change which will be monitored and assessed in April.

Summary and recommendations
The mid-trial interviews have been successfully conducted on 22 participants out of a total 91 in the MaaS trial. The interviews have revealed a number of important findings:

• An encouraging conversion rate from PAYG to subscription plans (and virtually no conversion amongst subscribers back to PAYG)
• In general, poor communication between the relative cost differences between subscription plans and PAYG, as well as between car ownership and the use of alternative modes
• The exclusion of the relevant mode Ola from the trial offering and bundles—this can have a negative impact on participants’ willingness to subscribe
• The relative lack of appeal of GoGet and Thrifty
• Service levels (particularly of public transport) being far more important than potential cost savings
• Incentives that impact on reductions in car use appearing to be essential in achieving key sustainability outcomes
• The desire for first and last mile travel to public transport to be better addressed and incentivised
• The Tripi application being disappointing in the use of its journey planning functions (with TripView and Google/Apple Maps being preferred), although the digital wallet feature remains valuable

These qualitative findings offer important insights which help enhance the quantitative dataset on subscription plan choice and travel behaviour obtained so far. Together, they form the basis of informing the following recommendations:

• Offer ex ante advice on the cost savings (if applicable) under different subscription plans as compared with PAYG and communicate this more effectively
• Offer clear advice on the relative cost differences between car ownership/usage as compared with the use of alternative modes through the MaaS trial (possibly on an ex post basis given previous months’ usage)
• Better target Uber discounts when used as an access/egress mode in conjunction with public transport (which was addressed in the March bundle offering)
• Explore how Ola (and subsequently Didil) may be able to be incorporated within any on-going trial, perhaps in the form of an invoice rebate on the submission of receipts
• Explore how the Tripi application could be enhanced and encourage participants to use the journey planning features (perhaps aided by gamification)
• Remove the 2% credit card surcharge—how this is handled individually by each service provider (e.g., Uber, GoGet, taxi) will need to be examined

At the completion of the six month trial, it is essential to design and implement an exit survey. This survey should as a minimum learn from these mid-trial findings and seek further information on the following matters:

• If the trial had continued would participants have stayed with a specific bundle or switched to another bundle (or reverted/stayed with PAYG)?
• What would participants like to see changed to make bundles more attractive to them?
• What information would participants want as feedback to inform their future travel decisions?
• What did participants like and not like about the Tripi application?

References


## Appendix A1 - Respondent sample and take up of bundles

### MaaS Mid Trial Interview Schedule

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Appendix A2 - Interview guide

[Segment 1] PAYG vs. Subscription

- Why have you been choosing PAYG since you commenced the trial?
- What could we do to make monthly subscription offers more attractive for you to consider subscribing?
- If given the choice again, would you have selected a monthly subscription in any month?

[Segment 2-6] PAYG vs. Subscription

- Which are the factors that entice you to choose a monthly subscription plan rather than using MaaS as PAYG?
- What else would you like to see in the monthly bundle offers?—e.g., more transport modes, more discounts
- If given the choice again, would you have selected the subscription plans you chose?

Subscription plan design

- What would your ideal subscription model look like?—e.g., consider modes, discounts, other value adds
- Which Tripi modes are most relevant for you and which are most irrelevant?—e.g., consider carsharing and Uber vs. Ola vs. Didi

Behavioural change

- How has your daily travel changed since participating in this MaaS trial? What are the most notable changes in your travel activity?
- How does this compare with your expectations at the beginning of the trial?
- Are there any trips you presently take where you can travel more sustainably? What are the impediments and how can we entice you to change your behaviour?
- How did your travel behaviour during the Christmas/New Year holidays affected your usage of the application and MaaS trial credits?
- What travel do you take outside of the Tripi application (e.g., driving)? How has this changed before and during the trial?

Tripi application

- How has your reliance on the application changed during the trial period?
- What metrics do you take into account when choosing your trip?—e.g., consider cost, time, CO₂, calories
- Do you have any feedback on the application? What are two aspects you would like to change?

Other feedback

- How satisfied are you with the onboarding process and information provided to help you as a MaaS trial participant?
- Have you shared your participation in the MaaS trial with family and friends? Why or why not?
- Has the MaaS trial affected your plans for car ownership now or in the future?
- Are there any other feedback you would like to share with the MaaS trial team?
Appendix B: MaaS bundle design

MaaS Bundle Design

Daniel J. Reck\textsuperscript{a,b,*}, David A. Hensher\textsuperscript{b}, Chinh Q. Ho\textsuperscript{b}

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Abstract

Mobility service bundling has received a lot of attention from researchers and practitioners due to its centrality to Mobility as a Service (MaaS) business models and potential to foster sustainable travel behaviour. Stated choice studies have to date been used to explore the willingness to pay for MaaS bundles and their components. Despite an increasing number of academic studies and commercial trials, there is a surprising dearth of research on how to design MaaS bundles in the first place. Comparative learning is further limited as the designs of choice experiments and studied bundles differ widely. What are the underlying design dimensions and how can we separate differences in outcome from differences in design? We address this gap by (1) conducting an extensive literature review on MaaS bundle design and synthesizing ten fundamental design dimensions, (2) extending the Design of Designs literature to develop a framework to systematically relate and compare design, methods and outcome of stated choice studies in general, and (3) applying our framework to MaaS bundle design and developing a research agenda, structuring future endeavours in this field.

Keywords: Mobility as a Service, MaaS, Bundling, Design of Design, DoD, Choice Experiment
Introduction

Recent technological advances have led to a surge of shared transportation modes in cities worldwide with e-bikes and e-scooters being the latest additions. This development has inspired the concept ‘Mobility as a Service’ (MaaS), which seeks to integrate emerging shared modes with more conventional public transportation (PT) to facilitate seamless (intermodal) planning, booking and payment through a single app. While different stakeholders associate different objectives with MaaS, the concept is relevant from a societal perspective as it could induce sustainable changes in travel behaviour such as decreasing private car ownership and increasing the use of shared, largely low emission-powered modes (Hensher and Mulley, 2020; Jittrapirom et al., 2017; Kamargianni et al., 2016; Mulley, 2017; Wong et al., 2020).

Under a MaaS scheme, users typically have the choice to pay per trip or subscribe to bundles of mobility services. How to design these bundles is central to their potential of inducing behavioural change (e.g., should more discount be granted for more sustainable modes?) and business models of providers (the ‘classic’ argument for bundling is price discrimination) and has therefore sparked the interest of both transportation researchers and practitioners. Perhaps surprising given the increasing number of stated choice studies on willingness to pay for MaaS bundles and its components (Caiati et al., 2020; Feneri et al., 2020; Guidon et al., 2020; Ho et al., 2018; Ho et al., 2020a; Matyas and Kamargianni, 2019a; Mulley et al., 2020) and the increasing number of commercial trials (e.g., UbiGo, swa Augsburg, WHIM, zengo), basic research on how to design MaaS bundles is missing. The result is a growing bouquet of varieties of stated choice experiments and commercial bundle designs (in terms of included modes, ‘metrics’ to measure the consumption of mobility services, and discount schemes). This clearly hampers comparative learning (and indeed informed design of subsequent studies) as it is unclear what the underlying design dimensions are and how to disentangle differences in design from differences in outcome. For example, some studies report a negative average willingness to pay for carsharing (e.g., Matyas and Kamargianni, 2019a) when included in a MaaS bundle while others report the opposite (e.g., Guidon et al., 2020; Ho et al., 2018). A natural question to ask is whether this difference in outcome originates in differences in bundle design.

We contribute to the evolving literature and practice on MaaS bundles in several ways. First, we conduct an extensive literature review on MaaS bundle design (Section 2) and synthesize existing academic and commercial MaaS bundle designs towards ten fundamental design dimensions (Section 3). These can be used by practitioners, academics and policy-makers to design future MaaS bundles of which we will likely see many in different parts of the world in the coming months and years. Second, we develop a framework to systematically compare stated choice studies on MaaS bundle design and disentangle differences in outcome from differences in bundle design by expanding the literature on Design of Designs (DoDs) (Hensher, 2004; Caussade et al., 2005; Hensher, 2006a; Hensher, 2006b) to include not only ‘statistical’ design dimensions (how many alternatives, attributes, levels) but also ‘behavioural’ (which attributes and levels in which configuration) (Section 4). While this relationship remains to be empirically tested, it already proves useful in several ways: (a) to systematically compare stated choice studies and develop hypotheses as to the origin of differences in outcome, and (b) to systematically identify research gaps and thus establish a research agenda for stated choice studies on MaaS bundle design. Importantly, the extension of the Design of Designs literature and the resulting framework is not limited to MaaS bundle design. It applies to any topic stated choice studies are being conducted upon and thus serves as a useful meta framework for research using stated choice studies in general.
Literature review

MaaS

Though the term MaaS is generally perceived as having been conceived only in 2014 (Heikkilä, 2014), Caiati et al. (2020) note that it was previously described (in the non-transportation literature) by Meurer (2001, p. 48) referring to carsharing and carpooling as “mobility as a service” “readily available as well as highly attractive for potential consumers”, resulting in a new conception of mobility where “ownership and use do not necessarily have to be one and the same”. While the term may have thus already been conceived in 2001, the concept of mobility integration across several dimensions and modes is much older. Mulley (2017) argues that ‘Mobility Management’ is one predecessor, with the US Department of Transportation (DoT) stating as early as 1991: “The Mobility Manager accomplishes its goals by linking together all travel modes – bus, taxi, vanpools, express bus, specialized services, carpools etc. at an informational level and, in most cases, at a transactional level as well” (US DoT, 1991, p. 16). Indeed, one could argue that public transportation organizations were predecessors of Mobility Management, integrating planning, booking and payment across various public transportation providers as early as 1965 in Germany. Further examples include the train service provider (NS) in the Netherlands, which has integrated access to carsharing, bike sharing and taxi into their smart card system, and London’s Oyster card integrating public transportation with carsharing (Caiati et al., 2020; Kamargianni et al., 2016). Technological progress arguably enabled the current excitement around MaaS, most importantly innovating the access to new and shared transportation modes, intermodal trip-planning, booking and payment through a single app.

MaaS has garnered substantial scholastic attention during the past five years (for an overview, see Hensher et al., 2020a) ranging from demand-side research on the willingness to pay for MaaS bundles (e.g., Guidon et al., 2020; Ho et al., 2018, 2020a; Matyas and Kamargianni, 2019a) and motivations to subscribe (Alonso-González et al., 2020; Schikofsky et al., 2020) to supply-side research on business models (Kamargianni and Matyas, 2017; Wong and Hensher 2019; Polydoropoulou et al., 2020) and future bus contracts (Hensher, 2017) to governance (e.g., Cottrill, 2020; Doherty et al., 2017; Hirschhorn et al., 2019; Pangbourne et al., 2020; Smith et al., 2020). Recent contributions aim to structure the field by actors and levels of integration. Sochor et al. (2015) first identified the emerging actor MaaS broker, aggregating services offered by mobility providers to end users. Smith et al. (2018) further split the MaaS broker into (potentially) two separate actors: the MaaS integrator and the MaaS operator. More recently, several authors introduced MaaS topologies (Hensher et al., 2019; Lyons et al., 2019; Sochor et al., 2018) to clarify the levels of integration. These typically range from no to full integration (see Fig. 1). Bundling mobility services into plans is typically seen as the step proceeding the full integration of operation, information and transaction, though this sequence is not necessarily followed in practice58.

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58 The MaaS pilot in Augsburg, Germany, is an example where a MaaS bundle was introduced before the operational, informational and transactional integration (Reck and Axhausen, 2019).
Bundling

Despite the recent excitement in the context of MaaS, bundling is not a new idea and originated in many literatures, notably Marketing\(^5^9\). Stremersch and Tellis (2002) provide a comprehensive synthesis of its origins and definitions which is helpful to reiterate to align terminology. They define bundling as “the sale of two or more separate products in one package” (p. 56) with the term product used for goods and services. They further define bundling focus and bundling form as two main dimensions to structure the field. Bundling focus refers to the level of integration of the products in the package with price bundling defined as a package without any integration and product bundling defined as a package with value-adding integration. Bundling form is divided into pure bundling (“the firm sells only the bundle and not (all) the products separately”) and mixed bundling (“the firm sells both the bundle and (all) the products separately”) (p. 57).

Bundling is pervasive in many areas of life, such as fixed-price menus, telecom packages, and personal computers (Stremersch and Tellis, 2002). Besides one-off transactions, they might take the form of

\(^{59}\) There is also a large literature in economics and law. For the many situations where bundling is observed, the reason why separate goods are sold as a package is explained by economies of scope in production or by reductions in transactions and information costs, providing benefit to the seller, the buyer or both. This is the presumptive explanation for bundling when it occurs in highly competitive markets (for a review, see Kobayashi, 2005).
subscriptions such as mobile phone plans (e.g., voice, data, SMS, music streaming services) or fitness studio access (e.g., equipment, courses, spa). In the field of transportation, bundling frequently occurs in the form of travel packages (e.g., flight, hotel, car-rental, excursions) and public transportation season tickets (e.g., bus, tram, train).

As the commercial goal behind bundling is revenue maximization, various tariff structures can be considered to exploit consumer preference heterogeneity. Caiati et al. (2020) suggest four typical tariff structures for subscriptions in reference to the literature on multipart pricing (Lambrecht et al., 2007; Iyengar et al., 2008; Köhler et al., 2014): pay per use, two part tariffs, three part tariffs and flat rates. While pay per use and flat rates are common in everyday life (PT: single tickets and season tickets), two part tariffs include a recurring fixed charge and a variable (often reduced) usage charge, and three part tariffs include an additional allowance. Two and three part tariffs are often used for pricing shared mobility services (e.g., carshare, bikeshare).

MaaS bundling

The new multitude and increasing integration of transportation modes has inspired the idea of mobility plans (i.e., packages / bundles of mobility services) or MaaS bundles. In Stremersch and Tellis’ (2002) framework they would be categorized as mixed bundles, as singular mobility services (e.g., carsharing, bikesharing) would typically continue to be sold separately, and somewhere between product and price bundles depending on the degree of integration (cf. MaaS topologies). Interestingly, and in contrast to current MaaS topologies (cf. Fig. 1), we argue that MaaS bundles do not depend on prior integration, i.e. there can be sole price bundles (cf. Footnote 1). Fig. 2 integrates MaaS topologies into Stremersch and Tellis’ (2002) bundling framework.

Three particularities apply to MaaS bundling. First, MaaS brokers / aggregators (e.g., WHIM) that sell MaaS bundles might be different entities from the original (i.e., disaggregated) mobility service providers (e.g., Mobike, Lime). Second, MaaS bundles are typically offered as subscriptions, through which a customer would commit to buying a certain amount of different mobility services on a recurring basis (e.g., fortnightly or monthly). Third, while profit maximization through price discrimination appears to be the main rationale for bundling in the Marketing and Economics literature, sustainability (or societal

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*Footnote 1:* We use this term subsequently to remain consistent with the Marketing literature.
benefits) is an important reason for bundling in transportation. Historically, public transportation season tickets have been heavily subsidized to address market failure (tragedy of the commons) and incentivize sustainable travel. From a societal perspective, one hope is that MaaS might increase the share of intermodal alternatives compared to private car use and ultimately reduce car ownership.

The configuration of MaaS bundles has become a topic of interest for transportation researchers and practitioners due to their centrality in business plans. This can be attributed to the possibility of price discrimination (the 'classic' Marketing argument for bundling) and the 'flat rate effect' (i.e., some people prefer a subscription even though they would pay less under a pay-per-use scheme) (Axhausen et al., 1998; Lambrecht and Skiera, 2006; Train et al., 1991; Wirtz et al., 2015). Most peer-reviewed academic research on the configuration of MaaS bundles has thus-far focused on eliciting consumer preferences using stated choice surveys (e.g., Caiati et al., 2020; Feneri et al., 2020; Guidon et al., 2020; Ho et al., 2018; Ho et al., 2020a; Matyas and Kamargianni, 2019a; Mulley et al., 2020), while only few researchers have followed other methods such as relating city characteristics to bundle contents/levels (Esztergá-Kiss and Kerényi, 2020) and (directly) relating current mobility costs to willingness to pay for MaaS bundles using linear regression analysis (Liljamo et al., 2020). In the following, we focus on studies implementing stated choice surveys and discrete choice modeling to explore consumer preferences and latent demand for MaaS bundles. Methodologically, most authors of these studies used surveys to present varying bundle configurations to participants and subsequently modeled the willingness to subscribe or the willingness to pay for bundles as a whole and individual components. Fig. 3 shows an example from a study recently conducted by the authors (Ho et al., 2020a).

In the following subsection (2.3.1.), we provide an overview of the main academic studies following a stated choice approach with a particular focus on MaaS bundle designs, relevant demand-side factors and overall study outcome, before briefly introducing existing commercially offered MaaS bundles (subsection 2.3.2.). The heterogeneity of MaaS bundle designs employed in research and practice motivates a synthesis, which we introduce in subsection 2.3.3., develop and expand into a framework for future research in the remainder of this paper.

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61 Panou et al. (2015) have noted that (mixed) service bundling can increase the competitiveness of low market share transportation services, particularly when bundled with complementary transportation services and recreational packages.
Peer-reviewed academic studies following a stated choice approach

Ho et al. (2018) and Matyas and Kamargianni (2019a) were among the first to highlight and analyse the research gap on consumer preferences for MaaS bundles in the peer-reviewed academic literature. Ho et al. (2018) conducted a stated choice survey in Sydney, Australia, to analyse the potential uptake of MaaS plans and the willingness to pay for its components. In a design similar to their later study (cf. Fig. 3), they asked participants to choose between four options: their current travel record (as by participants’ answers to prior questions), two MaaS bundles (‘Plan A/B’) and a ‘Pay-As-You-Go Plan’. MaaS bundles were structured by mode (PT, round-trip/one-way carshare, taxi, Uber Pool) with mode-specific attribute levels pivoted around participant’s current travel record\(^{62}\). For example: a participant who specified 4 days of PT use in the past fortnight would see plans with 4, 6 or 8 days of unlimited public transportation included, while a participant who specified 8 days would see plans with 8, 10 or 12 days of unlimited public transportation included. Each bundle also included carshare (specified in allowance by hour, advance booking time and hourly rate beyond the allowance) and % discounts for every taxi and Uber Pool trip. Additionally, they tested a roll-over option for unused credit. Overall, the authors concluded that almost half of all participants would take up a MaaS bundle, while uptake varied substantially across the population and was correlated\(^{63}\) with current mobility tool usage (pattern of product demand). Bundles were most attractive to infrequent car users and least to car non-users, while discounts for taxi and ride-hailing only appealed to regular taxi/Uber users.

Matyas and Kamargianni (2019a) conducted a stated preference survey in Greater London, UK. They asked participants to choose among 3 MaaS bundles that were structured around 4 modes: public transportation, bikeshare, carshare and taxi. Additionally, they allowed customers to create their own bundle (Matyas and Kamargianni, 2019b). In contrast to Ho et al. (2018), public transportation levels were: none / unlimited bus / unlimited usage of all PT modes in ‘your zone’. Bikeshare levels were: none / unlimited access + 30 min use while carshare and taxi levels were pivoted around current usage (carshare in hours and days, taxi in miles). Interestingly, the authors also included extra features such as dinner and food delivery vouchers. Estimating a mixed MNL model, the authors found negative coefficients for shared modes besides PT (carshare, bikeshare, taxi), implying that respondents do not prefer any of these shared modes in their MaaS plans. Interestingly, \(~\sim 38\%\) of all respondents would have still considered buying a MaaS plan, however, the authors note that this could be due to the hypothetical nature of the experiment. In their successive work, Matyas and Kamargianni (2019b, 2020) found a strong correlation between currently used modes and stated preferences (as did Ho et al., 2018) hypothesizing the reason to be habit persistence, as well as between bundle uptake and socio-demographics (i.e., age, occupation, income, education). The latter finding was confirmed and extended by Alonso-Gonzalez et al. (2020), who identified five latent clusters in attitudes and socio-demographics towards MaaS.

\(^{62}\) The innovative nature of MaaS requires sound introduction, presentation and design of stated choice experiments so that respondents can understand and relate to the implications of the alternatives in light of their situation. Several authors have adopted different methods to ease and investigate the ‘hypothetical bias’ (Hensher, 2010). Ho et al. (2018) showed each participant a two-minute video explaining MaaS and its potential benefits (https://vimeo.com/96486671). Most authors use a pivot design and/or reference alternatives to design MaaS bundles around current travel behaviour as reported by each participant to effectively frame the choice task in each individual’s decision context and thus reduce the hypothetical bias associated with the SP design (Caiati et al., 2020; Feneri et al., 2020; Ho et al., 2018; Ho et al., 2020; Matyas and Kamargianni, 2019a; Mulley et al., 2020). However, to what extent carefully designed SP experiments reduce the hypothetical bias and truly reflect the market demand for innovative products like MaaS remains an open question until RP data is available.

\(^{63}\) Methodologically, a Cholesky representation of the influencing attributes can be used in advanced choice models to test for the correlation structure of bundles; and at the alternative level, error components can be used to assess differences in unobserved variance (Hensher et al., 2015).
Guidon et al. (2020) conducted a discrete choice experiment in Zurich, Switzerland, to analyse the valuation of components in MaaS bundles vs stand-alone. Participants were shown several choice situations for individual services and service bundles. Once again, the bundles were structured around modes as attributes including public transportation (monthly ticket with varying geographical coverage), carshare (varying kilometres included), bikeshare (varying hours included), e-bikeshare (varying hours included) and taxi (varying minutes included). Additionally, the authors investigate park and ride (varying days included). The authors find a higher willingness to pay for public transportation and carshare64, and a lower willingness to pay for bikeshare (normal and e-bike) and taxi in a bundle when compared to stand-alone services, suggesting that customers only prefer certain shared modes (carshare) in their plans. This finding resonates with the correlation between currently used modes and stated preferences found by Ho et al. (2018) and Matyas and Kamargianni (2019a). However, it stands in contrast with the overall negative evaluation of carshare in a bundle in London (Matyas and Kamargianni, 2019a). One can only speculate about the reasons, which may be due to regional or methodological differences in eliciting and analysing customer preferences.

Ho et al. (2020a) later conducted a second stated choice survey in Tyneside, UK, to analyse differences and similarities in demand for MaaS bundles between the UK and Australia. Bundles were again structured around available modes (cf. Fig. 3) and included public transportation (varying number of days with unlimited travel), round-trip / one-way carshare (varying allowance in hours, advance booking time and hourly rate beyond the allowance), taxi (varying % discount) and bikeshare (varying allowance in hours and rate beyond the allowance). The results of this study confirm the previous hypothesis of a strong correlation between current mobility use and potential bundle uptake, and further suggest that while participants value the convenience of MaaS apps, they are not (yet) prepared to pay for it as the willingness to pay for most modes in the bundle is below the market price and the pay-as-you-go plan exhibits a negative coefficient. This finding contrasts Guidon et al. (2020), who estimate a high and positive willingness to pay (between 104 and 127 CHF) for an integrated smartphone app and a higher willingness to pay for carshare, public transportation and park and ride in bundles vs stand-alone. Again, to-date we can only speculate about the reasons for this difference.

Caiati et al. (2020) pursued a different approach to investigate latent demand for MaaS bundles. While previous studies presented participants (variations of) predefined bundles, Caiati et al. (2020) allowed participants to design their own bundles from previously defined elements, thus following a ‘portfolio choice’ approach (Wiley and Timmermans, 2009). Participants could design their own bundles from a large variety of transport modes (PT, e-bikeshare, e-carshare, taxi, car rental, rideshare, on demand bus), pricing schemes (from pay-as-you-go to pay-as-you-go with discounts, allowances of different sizes up to flat rates), geographical scope (regional, national) and extra features (service level guarantees such as maximum wait time, maximum pre-book time, and additional information and payment integration services such as real time notifications, app synchronization with personal agenda, parking payment, mobility tracker with CO2 / kcal information). Overall, estimation results indicate that the price of the monthly subscription and social influence variables have a strong effect on bundle uptake. In line with previous studies, PT appears to be the most preferred transportation mode, while preference for other modes depends on socio-demographic profiles and transport-related characteristics. Interestingly, this study further reveals that the design of discount schemes may have an influence on uptake. For example, while an allowance of 120 min e-carshare has a positive estimated coefficient (0.17), pay per use with a 20% discount on the standard fare has a negative estimated coefficient (-0.10). Similar effects can be observed for most other modes. This finding motivates a hypothesis explored later in this paper that expresses a possible relationship between the behavioural design (e.g., design of discount schemes) of a MaaS bundle, and outcome (e.g., in terms of willingness to pay or direct utility).

64 Methodologically, threshold prices can be tested using methods detailed in Swait (2001) and Hensher and Rose (2012).
Mulley et al. (2020) also pursued a different approach from the previous papers in that they investigate whether MaaS in Australian community transport (CT) can provide a sustainable future, whereas most previous papers focused on younger generations in major cities. Specifically, they surveyed CT clients from five major providers in New South Wales and Queensland employing a stated choice experiment. Given the CT context of this study, MaaS bundles were structured differently (by common trip purpose) than in previous studies, thus comprising ‘shopping bus’, ‘social outings’, ‘medical transport’ and ‘emergency taxi service’. Attribute levels were ‘number of trips included in the bundle’ and pivoted around current usage of modes (i.e., participants were grouped into three groups, ‘frail’, ‘active’ and ‘mobile’ based on their responses). Overall bundle discounts varied between 0% and 20% of the added value of individual trips. The results of this study suggest that shifting the funding from CT operators to CT clients might pose a challenge for CT providers as willingness to pay estimates for each trip type were lower than CT providers’ unit costs.

Finally, Feneri et al. (2020) conducted a stated adaptation experiment in Rotterdam, Amsterdam, and Utrecht in the Netherlands. While previous studies focused on exploring consumer preferences in and willingness to pay for potential bundles, Feneri et al. (2020) investigated the intended behavioural change (of transportation mode) as a result of subscribing to a MaaS bundle. While studies with revealed preference data from the Sydney MaaS trial are on their way (Hensher et al., 2020b; Ho et al., 2020b), this study builds some first hypotheses, complementing previous evidence from the UbiGo trial in Sweden (Sochor et al., 2015; Strömberg et al., 2018). Participants were presented four MaaS bundles to choose from, which were structured around modes (PT, carshare, e-bikeshare, taxi). Levels for public transportation ranged from pay-as-you-go to 20/40% discount to flat rate, for carshare/taxi from pay-as-you-go to 10/20/30% discount, and for e-bikeshare between 75% discount and free usage. The authors then asked the participants how their mode of transportation would have changed imagining they had subscribed to a bundle. Results indicate that a combination of monthly fees and discounts for the different modes primarily influences the increase / decrease of each mode under the influence of a bundle.

**Commercially available MaaS bundles**

We identify four main providers of commercially available MaaS bundles: Whim (by far the largest and only international provider, now (as of May 2020) offering MaaS bundles in Finland and the Netherlands, pay-as-you-go in the UK and Austria, and rolling out in Japan and Singapore), UbiGo (Sweden), Stadtwerke Augsburg (Germany) and zengo (Switzerland).

UbiGo arguably has been one of the first providers to offer MaaS bundles in Gothenburg as early as 2013. Relaunched in Stockholm in 2019, they employ an innovative approach by offering their customers to customize bundles every month and targeting households instead of individuals (i.e., bundle allowances can be shared among all members of a household). Public transport day tickets can be purchased in bulks of 10 (i.e., 10, 20, 30, 40) discounting price with increased quantity, carpool can be purchased in hours (i.e., 3, 6, 12, 18, 24, 30), again discounting price as purchase quantity increases, and car rental / taxis are charged per use.

Whim offers a variety of MaaS bundles depending on local availability. It first launched in Helsinki (Finland), where they continue to offer three MaaS bundles and a pay-as-you-go plan (as of 1 May 2020). Bundles, as in most academic studies, are structured around modes and include 1 to 3 levels (‘Whim Urban 30’ currently priced at ~60€ per month, ‘Whim Weekend’ priced at ~250€, and ‘Whim Unlimited’ priced at ~500€). Public transport is included either as a ‘30-day ticket’ or as ‘unlimited single tickets’ (which can presumably be shared). Bikeshare rides are included up to a maximum duration of 30 min. Taxis show a wide variety of schemes, ranging from an allowance of 4 x 10€ (max. 5 km rides) to
a flat discount of 15% on all rides to a flat rate. Car rentals also show a wide variety of schemes, ranging from a flat fee of 49€ / day to free car rentals on weekends or flat rates for every day. Since very recently, -scooters can be booked through the Whim app, however regular prices apply. Antwerp (Netherlands) is the only other market, where Whim offers a bundle to date, which is constituted of a monthly PT ticket for trams and buses, unlimited bikeshare, a cap on taxi trips up to 5 km of 10€ and a flat fee for car rental of 49€ / day.

Stadtwerke Augsburg offer two MaaS bundles in the city of Augsburg (Germany). Both are structured around modes and include a monthly PT ticket (for unlimited trips in buses and trams), unlimited bikeshare trips up to 30 min, and a varying allowance of carshare (15 hours / 150 km for the smaller bundle priced at ~80€, 30 hours / unlimited km for the larger bundle priced at ~110€).

Finally, zengo offers 3 MaaS bundles in the city of Geneva and Lausanne (Switzerland). Interestingly, they follow yet another operating model. While each bundle consists of a public transportation season ticket, the bundles contain a varying number of tokens ("jetons") (1 for their smallest bundle priced at 96 CHF per month, 2 for the medium bundle priced at 126 CHF and 4 for the largest bundle priced at 186 CHF), which can each be used for a taxi trip within the geographical scope of the city’s public transportation network, 12 hours of car rental, or a 4 month test membership of the local carshare provider. In Lausanne, customers are additionally allowed to use bikeshare up to 30 mins (e-bikeshare up to 15 mins) for free.

Research gaps and motivation for the remainder of this paper

Our overview of academic stated choice studies investigating consumer preferences and latent demand for MaaS bundles (2.3.1.) and of commercially available MaaS bundles (2.3.2.) gives a first impression of the different ways MaaS bundles can be designed, and along which dimensions they can be varied. Without doubt, our stock-taking may also overwhelm interested readers, prompting to synthesize the main dimensions of variation. And indeed, this is one of the premier motivations for writing this paper and our first goal for the remainder of this paper (Section 3).

This synthesis further enables us to conduct a first systematic comparison of existing studies on MaaS bundle design. This is particularly useful to identify reasons for the partially contradictory outcomes of previous studies. For example, Guidon et al., 2020 find a positive willingness to pay for carshare in bundles (even higher then when offered as a stand-alone product), whereas Matyas and Kamargianni (2019a) find negative coefficients for carshare in their bundles. Another example is the willingness to pay for an integrated smartphone app, which is highly positive in one study (Guidon et al., 2020), and negative in another (Ho et al., 2020a). While differences might be due to location or methodological differences in data elicitation and analysis, could they also be due to more subtle differences in bundles design? One example is the ‘metric’ used to measure the ‘consumption’ of mobility services and the mobility allowance (‘budget’, cf. Hensher, 2017). While Guidon et al. (2020) use a distance-based metric (number of km) to define the allowance of carshare trips, Matyas and Kamargianni (2019a) use a time-based metric (number of hours), while others used trip-based metrics (number of trips). While our hypothesis of a relationship between the design dimensions of a MaaS bundle in a stated choice study and study outcome (e.g., willingness to pay) remains to be tested empirically, a recent study by Caiati et al. (2020) (summary see above) suggests such a relationship.

In Section 4, we explore this conceptual link between study design and study outcome by extending the Design of Designs literature (Hensher, 2004; Caussade et al., 2005; Hensher, 2006a; Hensher, 2006b) to consider not only statistical design dimensions, but also behavioural design dimensions. This conceptual extension enables us to conduct a systematic comparison of existing studies along statistical and
behavioural design dimensions – a first approach to disentangle differences in design from differences in outcome. Second, and perhaps equally important, our comparison systematically identifies research gaps and thus serves as a framework for future research on MaaS bundle design.

Synthesizing the main design dimensions for MaaS bundles

Our synthesis of existing stated choice studies (cf. 2.3.1.) and commercial trials (cf. 2.3.2.) yields ten design dimensions along which MaaS bundles systematically vary (in their entity, we call them a first ‘master design’ for MaaS bundles). In the following, we first introduce each dimension in a practical way providing suggestions and lessons learnt from three projects the authors are involved in (3.1. and 3.2.). We then present an overview of how bundle designs from stated choice studies and commercial trials can be mapped and compared along these dimensions (3.3.).

In principle, we distinguish between necessary design dimensions and complementary design dimensions (cf. Table 1). Necessary design dimensions are those that form the essential core of a MaaS bundle (i.e., without defining these, it would be incomplete). They comprise modes, metrics (i.e., the measurement unit used to define the entitlement to each mobility service), the area of validity of the bundle (‘geography’), the market segment to offer the bundle to (i.e., individuals, households or any other chosen grouping) and the subscription cycle (i.e., weekly, fortnightly, monthly). Complementary design dimensions can, but do not necessarily have to, be defined. They comprise the incentive structure, caps to the subsidized use of modes, non-transportation add-ons, whether a bundle is customizable and roll-over options for unused budget.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Examples</th>
</tr>
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<tbody>
<tr>
<td><strong>Necessary design dimensions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modes</td>
<td>Modes of transportation included in the bundle</td>
<td>Public transportation, carshare, (e-)bikeshare, e-scooters, taxi, car rental, ridehail</td>
</tr>
<tr>
<td>Metrics</td>
<td>Way in which the mobility budget / entitlement and consumption of a mode is measured</td>
<td>Time-based (minutes, hours, days), distance-based (km, miles), trip-based (number of trips)</td>
</tr>
<tr>
<td>Geography</td>
<td>Area of validity</td>
<td>Single city, multiple cities, country</td>
</tr>
<tr>
<td>Market segment</td>
<td>Entity the bundle is designed for, and whether the bundle can be shared</td>
<td>Individuals (residents, tourists, commuters, seniors), households, employee groups</td>
</tr>
<tr>
<td>Subscription cycle</td>
<td>Period of single recurrence of a subscription</td>
<td>Weekly, fortnightly, monthly; Calendar or rolling</td>
</tr>
<tr>
<td><strong>Complementary design dimensions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discounts</td>
<td>Type and granularity of rebate</td>
<td>Trip-based (20% / $5 off each trip), budget-based (subscription fee or top up $50, pay $45)</td>
</tr>
<tr>
<td>Caps</td>
<td>Limit to discounted trips / entitlements depending on the metric, also referred to as budgets</td>
<td>Time-based (30 hours / trips up to 30 min), distance-based (30 km), trip-based (10 trips)</td>
</tr>
<tr>
<td>Add-ons</td>
<td>Non-transportation services included in the bundle</td>
<td>Parking, coupons (e.g., shopping, accommodation, restaurants, food delivery)</td>
</tr>
<tr>
<td>Customizability</td>
<td>Bundles can be pre-defined by the mobility broker or personalized by the users</td>
<td>NA</td>
</tr>
<tr>
<td>Roll-over option</td>
<td>Transfers unused credit to the subsequent time period</td>
<td>NA</td>
</tr>
</tbody>
</table>
Necessary design dimensions

Choosing which modes to include in a bundle involves clarity on a number of questions beyond availability. Common choices include public transportation, carshare, (e-)bikeshare, ridehail, taxi and car rental. Emerging modes such as shared e-scooters have not yet been part of stated choice studies on MaaS bundles or commercial trials. While the inclusion of more modes (and providers) on a pay-per-use scheme arguably increases the value of integration, willingness to pay for the overall MaaS bundle might decrease with more modes included (especially where modes are of little or no interest). Guidon et al. (2020) found that the willingness to pay in Zurich was higher for public transportation and carsharing in bundles than for stand-alone services, while the opposite was true for (e-)bikesharing and taxis. Depending on the desired degree of integration, including more modes might substantially increase the development costs of the software backend due to the complexity of each individual application programming interface (API), as well as increase the complexity of commercial negotiations with mobility service providers due to the competition of potentially multiple providers of the same mode. Indeed, we currently have limited information on how individuals might process the model offerings, with the risk that some modes might not be of interest but their presence causes concern about the value of the subscription fee (‘why pay for something I will not use’).

After deciding which modes to include, one has to decide how. This is a question of ‘metrics’ (i.e., the way in which a mobility budget / entitlement to each mode is measured). Metrics can be time-based (minutes, hours, days), distance-based (kilometres, miles), trip-based (number of trips), combinations of these (i.e., a cost per minute plus a trip-based fee to unlock a shared e-scooter) or simply flat rates (note that flat rates might be constrained using caps). Different metrics have different advantages, need to be considered together with caps and discounts and should be chosen in alignment with the overall objective for offering the MaaS bundle (i.e., profit maximization, sustainability, customer retention). As time-based or distance-based metrics measure the amount of consumption, they are generally more suitable to be applied to modes that incur higher marginal costs of production (e.g., taxi, ridehailing, car rental, carsharing). Flat rates are more suitable for other modes such as bikesharing or public transportation and are particularly useful to encourage sustainable changes in travel behaviour as marginal (monetary) costs of use drop to 0. Trip-based metrics can be used in conjunction with caps to nudge customers to try new modes (e.g., by allowing few heavily subsidized rides for specific modes). Finally, choosing similar metrics for multiple modes allows caps to be shared (i.e., a certain number of minutes to be used both for shared e-scooters and bikesharing).

The area of validity (geography) is usually bounded to the service areas of the different operators within a single city. However, expanding this area to multiple cities or even a whole country (always bounded by each operator’s service area, of course) adds value for long-distance commuters and travellers – arguably one main use-case for shared transportation modes – and levels the service area of the MaaS bundle with the service areas of individual operators which often operate in multiple cities anyways.

The market segment the bundle is designed for can be individuals (e.g., residents, commuters, tourists, senior citizens), households or any other grouping (e.g., employee groups). Offering bundles to households (and offering members to share allowances) might be a way to decrease monthly variability of demand for certain modes with high marginal costs (e.g., carsharing, car rental) and thus increase the willingness to subscribe (Reck and Axhausen, 2020). Also, if reducing car use/ownership is an objective, households might be the right market segment as cars often serve multiple members of a household. Yet, this might be difficult to implement as certain operators restrain simultaneous rentals of vehicles (e.g., bikesharing or e-scooters) or impose age restrictions (e.g., carsharing). Employees can be another target group for corporations aiming to subsidize more sustainable transportation compared to conventional
car lease arrangements. Finally, travel packages are most established in tourism, where, for example, multi-day public transport passes are often combined with entries to museums.

Last but not least, the subscription cycle (e.g., weekly, fortnightly, monthly) has to be decided upon. Local customs arguably are most important here and cycles can be by calendar or rolling.

**Complementary design dimensions**

Discounts can be trip-based or budget-based. Trip-based discounts can be differentiated by mode and range from percentage-based discounts (i.e., 20% off each trip) to absolute discounts (i.e., $5 off each trip) and maximum charges per trip (i.e., $15). Absolute discounts per trip favour short rides. Budget-based discounts are more general and can be implemented through a subscription fee or a ‘mobility wallet’ (i.e., top up $50, pay $45). The choice of the discounts is deeply intertwined with their overall goal, i.e., if more sustainable travel is desired, higher discounts should be given to more sustainable modes. At the same time, discounts on less sustainable modes (in the short-term) may have more potential to replace private car trips (i.e., taxi, ridehailing, car rental, carsharing) and thus encourage less car ownership in the long-term, although this has to be carefully considered if it risks in the long term reducing public transport use and add car-based kilometres to the system. The design of discounts can, but does not need to be, decoupled from their source of funding. Funding sources depend on the overall business model of the MaaS broker (see Hensher et al., 2020a, Chapter 8 for details) and can stem from government subsidies for reduced emissions (‘reversed emission taxing’) and car ownership or bulk contracts between the MaaS broker and the mobility service providers. Corporations can be another sponsor if they are willing to expend for providing greener mobility options for their employees. Finally, individual customers can play a role by spending more than they would under a pay-per-use regime due to the flat rate bias.

Discounts are closely related to caps (also referred to as budgets). Caps depend on the metric used to measure the consumption of each mode and thus also vary from trip-based (i.e., 10 free trips) to time-based (i.e., 30 included hours of carsharing) and distance-based (i.e., 300 included kms of carsharing). Flat rates can also be capped (i.e., commonly bikeshare flat rates only include unlimited rides up to 30 min). Caps are handy to calculate subscription fees (i.e., the fee a user pays to receive the discounts) and limit expenses of the MaaS broker. As such, they are often applied to modes where the marginal cost of production is relatively high (e.g., taxi, ridehailing, car rental, carsharing). Including a number of free carsharing / ridehailing / taxi trips might also encourage customers to try out new modes (some potentially being alternatives to the private car) and thus contribute to long-term sustainability objectives should they be important in the overall design.

MaaS bundles can be complemented with various add-ons. Different add-ons appeal to different customers, might be more or less related to the main purpose of the bundle (passenger transportation) and might depend on local customs. In Japan for example, rail tickets are often bundled with vouchers for restaurants, supermarkets or accommodation. Matyas and Kamargianni (2019a) have analysed add-ons such as a dinner or food delivery vouchers in the UK (which, however, turned out to be insignificant regressors for bundle uptake in their models). Guidon et al. (2020) included parking (park-and-ride) in their study in Switzerland, which turned out to be significant for bundle uptake and customers exhibited a higher willingness to pay (on average) for park and ride in bundles than as a stand-alone service. Caiati et al. (2020) include service level guarantees (e.g., maximum pick-up time for taxis) and additional payment and information integration services in their add-ons.

65 Note that some countries require MaaS brokers to hold a bank license to store credit. Conversion to tokens can be a potential way to circumvent this.
Bundles can be fixed or customizable. The latter requires more sophisticated software front-ends but allows customers to co-create their own bundle based on their needs. A customization option can be one-off or recurring (every subscription cycle). Budgets can further include a roll-over option which automatically transfers unused credit to the subsequent cycle. This is preferable from a customer perspective but reduces profit for the MaaS provider all else held constant.

Mapping and comparing bundle designs along design dimensions

Table 2 maps existing MaaS bundle designs from peer-reviewed academic stated choice studies (2.3.1.) and commercial trials (2.3.2.) to the ten design dimensions introduced previously. It is intended as a summary and synthesis of the previous two sections. As all elements (academic studies, commercial trials and design dimensions) have been introduced in detail, Table 2 is thus not further described here.

Disentangling differences in design from differences in outcome

Reviewing the literature on stated choice studies exploring consumer preferences for MaaS bundles (Section 2.3.1.), we noted that outcomes are partially contradictory. For example, Guidon et al., 2020 find a positive willingness to pay for carshare in bundles, whereas Matyas and Kamargianni (2019a) find negative coefficients for carshare in their bundles. Another example is the willingness to pay for an integrated smartphone app, which is highly positive in one study (Guidon et al., 2020), and negative in another (Ho et al., 2020a). While differences might be due to location or methodological differences in data elicitation and analysis, could they also be due to more subtle differences in bundles design? One example is the ‘metric’ used to measure the ‘consumption’ of mobility services and the mobility allowance (‘budget’, cf. Hensher, 2017). While Guidon et al. (2020) use a distance-based metric (number of km) to define the allowance of carshare trips, Matyas and Kamargianni (2019a) use a time-based metric (number of hours), while others used trip-based metrics (number of trips). While our hypothesis of a relationship between the design dimensions of a MaaS bundle in a stated choice study and study outcome (e.g., willingness to pay) remains to be tested empirically, a recent study by Caiati et al. (2020) suggests such a relationship.

Exploring the conceptual link between design and outcome

Hensher (2004) asked a similar question in a different context in his seminal paper titled: “Identifying the Influence of Stated Choice Design Dimensionality on Willingness to Pay for Travel Time Savings”. He conducted a stated choice experiment in which only design dimensions (i.e., number of choice sets, number of alternatives in each choice set, number of attributes per alternative, number of levels of each attribute and range of attribute levels) - in their entirety of combinations referred to as the Design of Designs (or then ‘master design’) - were systematically varied. Subsequently, he estimated a mixed logit model in which design dimensions were interacted with the attribute parameters to explore differences in willingness to pay for travel time savings. He found that design dimensionality does indeed influence variations in willingness to pay for respondents in Sydney (Hensher, 2004; Hensher, 2006a; Hensher, 2006b). Caussade et al. (2005) later used Hensher’s (2004) design for a repeat study in Santiago de Chile. They estimated a heteroskedastic logit model with the scale parameter specified as a function of design dimensionality. Their results showed that all design dimensions affect choice variance (and consistency), yet no systematic effects on willingness to pay estimates were found.
<table>
<thead>
<tr>
<th>Study</th>
<th>Necessary design dimensions</th>
<th>Complementary design dimensions</th>
<th>Customizable</th>
<th>Roll-over option</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Academic studies</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caiati et al. (2020)</td>
<td>PT trips / flat rate</td>
<td>no</td>
<td>Service levels guarantees, additional information and payment integration services</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>e-Mobility hours¹</td>
<td>(no)²</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>e-Carshare km¹</td>
<td>(no)²</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Taxi trips</td>
<td>(yes)¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Car rental days¹</td>
<td>(yes)¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ride share km¹</td>
<td>(yes)¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>On demand bus trips¹</td>
<td>(no)²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feneri et al. (2020)</td>
<td>PT trips / flat rate</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Carshare trips</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Taxi trips</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>e-Bikeshare NA (flat rate)</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guidon et al. (2020)</td>
<td>PT NA (flat rate)</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Carshare km</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bikes share hours</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>e-Bikeshare hours</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ho et al. (2018)</td>
<td>PT days</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Carshare trips</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Taxi trips</td>
<td>yes</td>
<td></td>
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</tr>
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</table>

**Table 2.** Comparing MaaS bundle designs in peer-reviewed academic stated choice studies and commercial offerings along identified design dimensions.
<table>
<thead>
<tr>
<th>Study</th>
<th>Modes</th>
<th>Metrics</th>
<th>Geography</th>
<th>Subscription cycle</th>
<th>Discounts</th>
<th>Cops</th>
<th>Add-ons</th>
<th>Customize-ability</th>
<th>Roll-over option</th>
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<tbody>
<tr>
<td><strong>Ho et al. (2020)</strong></td>
<td>PT</td>
<td>days</td>
<td>Tyneside</td>
<td>individual month</td>
<td>subscription fee</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>Carshare</td>
<td>hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bikeshare</td>
<td>hours</td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Taxi</td>
<td>trips</td>
<td></td>
<td></td>
<td>no</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Matyas and Kamar-ghani (2018)</strong></td>
<td>PT</td>
<td>NA (flat rate)</td>
<td></td>
<td></td>
<td>no</td>
<td></td>
<td></td>
<td>Dinner and food delivery vouchers</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>Taxi</td>
<td>miles</td>
<td>London</td>
<td>individual month</td>
<td>yes</td>
<td>yes</td>
<td></td>
<td></td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>Carshare</td>
<td>hours</td>
<td></td>
<td></td>
<td>yes</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bikeshare</td>
<td>hours</td>
<td></td>
<td></td>
<td>no</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mulley et al. (2020)</strong></td>
<td>Shopping bus</td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>Social outings</td>
<td>trips</td>
<td>New South Wales, Queensland</td>
<td>individual month</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>Medical transport</td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>Emergency taxi service</td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
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### Table 2 (ctd.)

<table>
<thead>
<tr>
<th>Study</th>
<th>Modes</th>
<th>Metrics</th>
<th>Geography</th>
<th>Market segment</th>
<th>Subscription cycle</th>
<th>Discounts</th>
<th>Caps</th>
<th>Add-ons</th>
<th>Customize-ability</th>
<th>Roll-over option</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WHIM</strong></td>
<td>PT</td>
<td>NA (flat rate)</td>
<td>Helsinki</td>
<td>individual</td>
<td>30 days</td>
<td>subscription fee</td>
<td>(no)$^2$</td>
<td>no</td>
<td>no</td>
<td>no</td>
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<tr>
<td>Bikeshare</td>
<td>minutes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>no</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rental car</td>
<td>days$^4$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>no</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taxi</td>
<td>km</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>pre trip (%/€$^3$)</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mobil Flat</strong></td>
<td>PT</td>
<td>NA (flat rate)</td>
<td>Augsburg</td>
<td>individual</td>
<td>month</td>
<td>subscription fee</td>
<td>(no)$^2$</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Bikeshare</td>
<td>minutes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>no</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carshare</td>
<td>hours &amp; km</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Commercial trials &amp; products</strong></td>
<td>PT</td>
<td>days</td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
<td></td>
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<tr>
<td>Carshare</td>
<td>hours</td>
<td>Stockholm</td>
<td>household</td>
<td>month</td>
<td></td>
<td>volume flexibility$^5$</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
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<td>Rental car</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Taxi</td>
<td>hours &amp; km</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>none</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>zengo</strong></td>
<td>PT</td>
<td>NA (flat rate)</td>
<td>Geneva</td>
<td>individual</td>
<td>month</td>
<td>subscription fee</td>
<td>no</td>
<td>no</td>
<td>yes (token)</td>
<td>?</td>
</tr>
<tr>
<td>Carshare</td>
<td>membership</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rental car</td>
<td>hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>no</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taxi</td>
<td>trips</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes (token)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Caiati et al. (2020) conducted a portfolio-choice experiment with various metrics per mode, offering pay per ride and trip-based discounts next to mode-specific metrics, discounts & caps.
2 Unlimited up to 30 min / 1 h.
3 Whim Urban 30: 10€ max charge, Whim Weekend: 15% discount
4 Whim Urban 30: 49€/day, Whim Weekend: free on weekends, Whim Unlimited: flat rate
5 Discount for higher purchased volumes but additional price for flexibility (PT day passes vs individuum-bound monthly tickets)
The ‘Design of Designs’ stream of research helps to differentiate between and examine the impact of what we call ‘statistical design dimensions’. Identifying the impact of statistical design dimensionality on choices and ultimate study outcome (here: willingness to pay) clearly contributes to disentangling differences in design from differences in outcome. Yet, we argue that this picture is incomplete. Not only the number of choice situations, alternatives, attributes and levels, but also their selection (i.e., which attributes and levels) could impact study outcome.

Introducing behavioural design dimensions

Extending the Design of Designs literature on statistical design dimensions (number of choice situations, alternatives, attributes and levels), we introduce the concept of behavioural design dimensions (selection of attributes, levels and metrics by which attribute levels are measured) to describe sources of differences in the design of stated choice experiments comprehensively. While it is obvious that different attributes and levels should be chosen for different areas of application of stated choice experiments (i.e., transportation mode choice vs mobile phone contract choice), it is less obvious why different attributes, levels and metrics are chosen for stated choice experiments within a certain area of application (if testing them is not the specific motivation for the study, of course).

Consider our example of MaaS bundles. Several authors have conducted stated choice studies to examine the willingness to pay for MaaS bundles as a whole and each component individually. Despite this very same area of application and study objectives, the attributes, levels and metrics chosen to define the bundles vary substantially (cf. Table 2). While all studies display the modes that are included in each bundle, the price for each bundle and the subscription cycle, some include additional attributes such as roll-over options or customizability. The greatest variance, however, lies in ways in which the budget is measured (‘metric’ – see example above). In general, attributes (e.g., modes, price, roll-over option, customizability), metrics (time-based, trip-based, distance-based) and levels for each attribute (e.g., range of modes and prices) vary in the design of stated choice experiments.

Some amount of variation of these behavioural design dimensions from one study to the next is preferable to learn about their (relative) influence. However, we argue that varying too many statistical design dimensions simultaneously compromises comparability amongst studies, especially if the context of the study (e.g., geographical, environmental and institutional settings) is also varied. This is due to multiple confounding effects.

An example in our area of application is the preference of consumers for shared modes in MaaS bundles. Guidon et al., 2020 find a positive willingness to pay for carshare in bundles, whereas Matyas and Kamargianni (2019a) find negative coefficients for carshare in their bundles. Another example is the willingness to pay for an integrated smartphone app, which is highly positive in one study (Guidon et al., 2020), and negative in another (Ho et al., 2020a). Due to many differences in study design (and indeed a missing overarching framework to even compare the design of MaaS bundles before this paper), to date it remains unclear what the influence of specific design variations on outcome is, how to compare these studies systematically and how to design new studies with ‘informed’ variations.

Towards a holistic Design of Designs

It is here that the potential of a holistic Design of Designs, comprising both statistical and behavioural design dimensions, becomes apparent. In their entirety, the statistical and behavioural design dimensions (‘master designs’) describe all potential structural variation in experimental designs. Thus, they define a grid in which researchers can systematically compare stated choice studies, identify empirical research gaps and design new experiments accordingly (Fig. 4). If subsequent contextual variation (e.g., attribute
ranges and values, place, sampling) and modelling methods are comparable (note that aspects such as respondent socio-demographics, the recruitment process, and the framing of MaaS can have a substantial impact on the results), this is a structured way to describe and disentangle differences in design from differences in outcome.

![Fig. 4](image)

**Fig. 4.** Schematic classification of stated choice experiments along statistical and behavioural design dimensions to systematically relate differences in (behavioural) design to differences in outcome.

**Application to MaaS bundle design**

In the outset of this section, we identified partially contradictory findings of several studies with respect to preferences regarding carshare in a bundle. We can now use the analysis scheme described above (Figure 4) to systematically compare studies to develop hypotheses as to the origin of the differences. Table 3 displays the resulting comparison (for readability, we focus on carshare only, and further exclude two studies that either do not include carshare, or do not estimate coefficients / WTP for carshare per se and are thus not comparable in outcome). Our interest lies in identifying reasons for the negative coefficients of carshare in the study by Matyas and Kamargianni (2019a). It is important to note that this table only serves as an illustrative example. Similar tables can be created for any mode or indeed any attribute of any set of stated choice studies as long as the underlying behavioural design dimensions are known.

We recapitulate that the study by Matyas and Kamargianni (2019a) is the only study that exhibits negative coefficients for carshare in a MaaS bundle (-0.437 for a daily pass and -0.022 for an hourly allowance). While differences comparing any two studies are manifold (e.g., metric, add-ons, roll-over option, customizability), there are only two systematic differences when comparing Matyas and Kamargianni (2019a) to all others. First, they conduct their study in a different place (London). Second, they use a random design while others used pivot or efficient designs. For random designs, attribute levels are selected for all choice tasks in a random manner, without recognizing previous patterns of demand (i.e., carsharing usage) or socio-demographics (i.e., driving license ownership). This might result in a situation where many participants might not prefer carsharing in their bundles where in other studies they might not have been asked due to previous patterns of demand or socio-demographics. Hence, on average, the parameter associated with carsharing is negative.
Table 3. Systematic comparison of MaaS bundle design study designs and outcomes focusing on carshare.

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<td>hours</td>
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*** p < 0.01, ** p < 0.05, * p < 0.1.
A research agenda for stated choice studies on MaaS bundle design

As argued in Section 4.1., the knowledge of behavioural and statistical design dimensions enables researchers to systematically compare previous stated choice studies, but also to identify empirical research gaps and design new experiments accordingly. Table 4 exhibits a comparison of all peer-reviewed academic stated choice studies on MaaS bundle design that we discussed in our literature review and highlights commonalities in their behavioural design. It also allows the identification of empirical research gaps (highlighted in italic). These include the impact of emerging modes (e.g., e-scooters), households or specific groups of individuals (i.e., tourists, senior residents) as the subscribing unit of MaaS bundles (cf. UbiGo) effectively sharing the allowances of a bundle, and certain add-ons (shopping, accommodation). Subsequent studies can thus be designed in a more ‘informed’ way to replicate existing studies in a different context, or complement studies and test new aspects of MaaS bundle design.

Table 4. Systematic comparison of MaaS bundle design study designs to identify research gaps.

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<tr>
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<td>Shopping</td>
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<tr>
<td></td>
<td>Accommodation</td>
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Research gap
The next steps in the evolution of our understanding of the influence of statistical and behavioural design dimensions should further include a Design of Design stated choice study, enabling us to identify in a more holistic way, the role that specific (configurations of) statistical and behavioural designs play in study outcome. Applied to MaaS bundles, the study would investigate the role that specific (configurations of) modal offerings play in individuals’ choices of MaaS bundles, revealing preferences and willingness to pay (or not) for specific service constructs. In addition to the influence of statistical and behavioural design dimensionality, local context will also have to play a role.

Conclusion

The question of how to design MaaS bundles for a particular purpose has motivated us to conduct a thorough review of the existing literature. We found that previous stated choice studies on MaaS bundles exhibit great variation in experimental design, which - without an overarching framework - hampers systematic comparison to explain the partially contradictory findings and design new studies with well-informed variations in design. Previous literature (the Design of Designs stream) only helps to identify differences in statistical design (e.g., how many choice sets, attributes and levels) but not in the specific selection of attributes, levels and metrics. In response, we develop the concept of the behavioural design for stated choice experiments. A behavioural master design lists all relevant attributes, levels, metrics and configurations thereof for stated choice studies in a specific field of application and thus conceptualizes the so-far uncaptured part of variation in experimental designs. As a result, experimental designs can be described as permutations in a grid of a statistical and a behavioural master design. This enables systematic comparison of experimental designs, the identification of empirical research gaps and informed design of new studies. We show the practical value of this conceptual contribution by developing a behavioural master design for MaaS bundles, comparing previous experimental designs of stated choice studies and identifying empirical research gaps accordingly.

Acknowledgements

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References


Appendix C: MaaS, government and private providers

What role might or should Government play in MaaS?

A theme that is emerging as we investigate the role that Mobility as a Service (MaaS) might play in the future is the role that the public sector will have in the delivery to market of MaaS products. There are a growing number of views, ranging from the public sector remaining as the arms-length regulator who has no active engagement in participation of delivering a specific MaaS product and, in addition to its involvement in public transport operations (actively or through subsidy provision), having an active role in the delivery of a MaaS product through its investment in a business (equity) and/or managing a MaaS offering.

Separately, and adding a complication, is the generally accepted position that public transport must be central to the provision of a MaaS offering otherwise it will be nothing more than an extension of existing stand-alone car-based mobility services (with the exception of bicycles) such as Uber, GoGet and Car next door. If conventional public transport is to be in the mix of MaaS services, this inevitably means that subsidised public transport will have to join with commercially-focussed private sector mobility services to define a MaaS bundle, offered through a subscription plan. We ignore PAYGO, which can exist under an integrated multimodal App or, as is currently the case, with separate Apps for each mode; however we do not describe this as MaaS.

With public subsidy (to conventional public transport and community transport) in the mix, we have a challenge as to how MaaS might be delivered into the market by suppliers who have a contract with a broker (or aggregator) to deliver service to customers through a subscription plan that will need to be financially more appealing than PAYGO. However, even if public transport is subsidised in MaaS, and as long as the subsidy is not more than what public transport is subsidised outside of a MaaS plan, there should in principle, at least, be no issue with existing levels of subsidised public transport being offered as part of the bundle in as many MaaS businesses as are interested in entering the market. But as set out below, there might be real opportunities for government to use the MaaS setting to achieve a number of societal objectives through further subsidy incentives.

The providers of public transport who fund the services (as distinct from those organisations who operate them – typically contracted under a gross cost contract), would not (or should not) have any issues under such a plan, and do not need to be a broker, but simply be treated like any supplier of mobility services into a MaaS offering. It is possible that the presence of subsidised public transport (at the same level as all existing public transport) might appeal to other modal suppliers who participate, since it exposes them to potentially new market opportunities of customers used to choosing public transport, who now can be better informed about the role of other mobility options that may suit in a small or large way over time. But it could go another way - namely commercial suppliers may be nervous about participating if public transport becomes the dominant mode of choice in the mix.

Alternatively, the public sector may wish to be an active participant in the brokerage role, which under an economic deregulated MaaS model would inevitably cause many problems of conflicts of interest let alone the risk of stretching their resources as the number of MaaS brokers grow (although the issue is controversial – MaaS may simply be no more than a niche offering). Being the regulator and provider in a selective number of MaaS offerings (but not all such offerings in the same market) is almost certainly a case of unfair competition and regulatory conflict. However, in time the market may evolve into one of a very few players (not necessarily a natural monopoly – possibly an oligopoly), and government

66 A necessary condition is that all MaaS plans have the same level of subsidy for public transport – this could be less or indeed more (if you want to nudge behaviour) than the subsidy outside a MaaS bundle. If we take this to the next stage, a competitive market could mean that MaaS operators get different levels of subsidy – why not? The challenge is affordability to government.

67 Where government subsidises all PT tickets (as in Sweden and Australia) or it subsidises certain peoples’ use of PT (as in Finland), this makes it more or less straightforward to include PT in privately managed MaaS bundles. One would need more info about the users in the latter case. In Sweden, there is no discussion on whether or not MaaS providers should be able to resell subsidised PT tickets (we discuss if they should get commissions on top of that), but MaaS Global can only resell single PT tickets to the unsubsidised price.

68 For commercial unsubsidised services in an economic deregulated market, operators may choose who to give a subsidy to and thus influence the market by cartel behaviour? Fair trading behaviour is only legislated between operators.
may see, through MaaS, a mechanism to reduce private car use through promoting the sharing appeal of MaaS, and hence wish to have some control over the evolution of MaaS.

One possible way to do this is to use competitive tendering (or franchising) that has attached to it a value for money proposition designed to offer financial incentives, much like optimal subsidy, to achieve broad social welfare and efficiency objectives. In promoting tendering, we are mindful of the financial burden from the public purse of subsidising too many MaaS offerings. Specifically, government may offer an attractive subsidy (that is better than current subsidy levels for public transport) for MaaS bundles (and not just the already subsidised (outside of MaaS) public transport component) designed to encourage subscription as long as subscribers, for example, agree to reduce car use by an agreed amount\textsuperscript{69}. This very specific societal objective forces the subscriber (be it an individual, a group such as a household) to think about behaviour change issues at sign-up. While the aggregator would manage an appropriate bundle price, government has an opportunity to use MaaS to support some societal objectives through essentially paying the broker to fund the bundle price through the subscriber and subsidy contributions. This seems a potentially attractive way to meet an objective of reduced car use; but unlike road pricing reform, attacking it from an angle that might be politically more palatable. If a subscriber does not own or use a car, then other incentives might be considered that are also aligned with societal objectives.

Through benchmarking and monitoring, the full agreed financial gain to travellers, through the App being used by subscribers, can only be obtained where the agreed level of private car use reduction is achieved (with some possible partial reduction permissible in the initial period(s) with a lesser subsidy support as appropriate until the achievable realistic levels of reduced car use are identified). The level may vary according to whether the private car is electric or not. Otherwise the MaaS plan (under the same broker) reverts to a less attractive bundle price that might still be better than purchasing a mobility service from each provider separately (under PAYGO\textsuperscript{70}), although there is a challenge here as to how price discounts and/or non-financial rewards might be funded. The subsidy offered would clearly have to support all mobility services within the bundled MaaS offering, although it can be designed in such a way that some modes which are deemed more environmentally friendly (reducing emissions and congestion) or health benefit inducing (cleaner air and more active travel) might attract a greater level of optimal subsidy.

This idea should have great appeal to all stakeholders and might be the only basis within which the public sector becomes active and ensures no conflict of interest between its role as a regulator and its role in securing specific global goals and objectives which it has a mandate to deliver on. It does not have to be, and I would suggest should not be, the active broker. Government hence can remain a regulator, and fulfil a role as a champion for MaaS, supporting and enabling its development through policy guidance and legislation, with its operating arm charged with providing public transport as a supplier only, with broker entry into a subsidised MaaS offering only permissible through a competitive tendered contracting model. This contract will have conditions that have to be met in terms of specific levels of subsidy being allowed when the broader societal objectives, which are likely to differ across geographical jurisdictions (e.g., Sweden versus Finland), are met\textsuperscript{71}. Under this model, government will be best suited as a monitoring agency (even if they outsource this task to a benchmarking specialist to achieve independent objective outcomes), with data required to be supplied to the monitoring agency in order to pay the subsidy. Where the broker fails to deliver on the KPIs, the subsidy is not paid and hence a shortfall must be funded by the broker. This provides a mechanism to ensure that the designed subscription bundles are geared to attracting customers from those that align with the agreed (and quantified to minimise ambiguity) societal obligations. Government can reserve the right to cancel the contract and retender (provided this is clearly articulated in the terms of the contract that is subsidy linked).

\textsuperscript{69} In general, travel behaviour change should follow sufficient incentives; however it is appealing to identify some very specific incentives that government is willing to support financially as part of their mandate. An important consideration is to properly segment the market and appeal appropriately to the relevant segments, with subsidy divided up differently in line with societal benefits.

\textsuperscript{70} People may just opt for PAYGO in the first place because they feel it is simpler and more familiar. Hence, marketing the concept of MaaS and its benefits becomes very important and there must be a role for government in this.

\textsuperscript{71} Simply put, compliance with a societal objective such as a specific reduction in car use must be satisfied. The subsidised price cannot be guaranteed to be a sufficient incentive to shift behaviour and thus meet the social objectives? It is easy to capture relevant data from Apps, and in the case of car use it will require data on prior car use to establish a level of reduction.
Importantly, the tendering process can allow for more than one successful bidder\textsuperscript{72}, unlike conventional public transport contracts where competition for the market (in contrast to competition in the market) results in only one successful bidder (presumed to be the most efficient operator under natural monopoly) and is commonly limited to a much smaller geographical jurisdiction than is required to deliver a very locationally flexible MaaS product, operational nationwide. A MaaS offering may still also be offered under free market entry, but one wonders whether it would survive financially; one suspects this is unlikely. While there is a potential problem with tendering, compared to open APIs, in that the government has to specify what it wants, which might limit the action space for external MaaS providers, this may be necessary if public subsidy levels beyond the current standard PT subsidy to all public transport becomes an instrument to grow MaaS participation aligned to achieving a broad base of societal objectives.

We acknowledge however that there will be challenges in implementing such a plan. These will include the need to (i) agree on what the societal goals are, (ii) develop short-term and long-term KPIs for these goals, and (iii) analyse whether or not the services are delivering on the KPIs. For instance, if the main goals are to reduce car usage and exclusion from the transport system, we need good data on how the users of the services travelled prior to adopting the service. This has remained a problem when developing the contractual framework for mobility partners in West Sweden.

In summary, we believe that apart from the regulatory role of government (administered through a public sector agency), there is a very appealing separate role for government in supporting an optimally subsidised MaaS program under very specific conditions for subscription plans that can deliver on the societal goals and objectives that provide the basis for justifying optimal subsidies. This subsidy logic is no different to what is currently the situation with stand-alone contracts for modal services. Alternatively, MaaS products with a discount model funded from any source can deliver similar outcomes to customers but not necessarily linked to societal objectives; hence the approach being suggested has very general appeal as a way of offering a financial incentive as a mechanism to ensure that a MaaS bundle is preferred to a PAYGO model. Without this we speculate that the MaaS idea will have very limited customer support and will at best be a niche offering with no prospects of scalability.

\textsuperscript{72} West Sweden is currently trying to initiate an open/ongoing tender for mobility providers.
Appendix D: SkedGo overview of the Sydney MaaS trial contribution

The experience of participating and facilitating the MaaS trial in conjunction with USYD and IAG was a rewarding and educational experience. Bringing together three different organisations with very different backgrounds, tech, corporate and academic, and the relevant representatives from each party, was an often challenging, but ultimately rewarding experience. The process of understanding the relevant goals and objectives of each party, and how they could be related to the trial (and the application of each individual’s skill set to providing MaaS generally) led to some interesting insights.

Perhaps the greatest insight was understanding how important it is for collaboration between all stakeholders in the provision of a workable, financially sustainable, and ready for market MaaS solution. While SkedGo has been a proponent and facilitator of MaaS for 10 years, the industry is changing very rapidly, and understanding and incorporating the corporate viewpoint of IAG, along with the research goals of USYD, has been invaluable in helping us to gain insight into the motivations, and importance of other stakeholders in the MaaS space.

Successes of the Trial

Arguably, the ultimate goal of MaaS is to provide a type of service that through a joint digital channel enables users to plan, book and pay for multiple types of mobility service. The goal actually is to achieve broader objectives of a societal nature recognizing the role that many stakeholders can play. Overall for it to be relevant:

- It should aspire to be multi-modal and door to door to recognise the diversity of community needs and delivery capability.
- It needs to be mindful of societal goals and possible opportunities to incentivise MaaS with optional subsidies that are linked to outcomes aligned with broader government objectives.
- It needs to offer an integrated pricing scheme across all (or many) modes, ideally with a one stop payment.
- It must match the needs of actual and potential users through flexible packaging and pricing, with flexible monthly changes, seasonal variation re modal needs, and definitions of membership (individual, any type of group)

It must deliver greater choice than exists currently, with easy of entry (and exit) and participation.

One of the initial non-technical challenges, to achieve true end-to-end payment, revolves around reconciliation of payments across multiple transport service providers. The implementation of the MaaS platform/app Tripi, that included payment subscriptions and/or bundles, required the design of a process that could handle payments made to different transport providers, both public and private, and the reconciliation of these for an individual user of multi-modal journeys.

IAG were instrumental in facilitating this reconciliation process. The size of IAG allowed IAG to provide the resources, technical, administrative and financial, that allowed for the consolidation and maintenance of the participants mobility budgets, in ways a smaller company like SkedGo could not have. This freedom from the financial constraints or maintaining these mobility budgets allowed SkedGo to focus on the technical delivery of this system. SkedGo was able to provide a dashboard to allow IAG to maintain users and users’ bundles, subscriptions and budgets, creating an interaction between the dashboard and the Tripi app. The success of the collaboration in this way really demonstrated how this relationship is essential, where the technical knowledge or SkedGo, combined with the resource depth of IAG is a vital part of the success of a MaaS platform.

In terms of specific things that worked well for SkedGo as a technology provider, our implementation has been reliable, and our ability to respond quickly to changes on the TSP side was vital, e.g., Opal revamped their site and rendered our implementation useless.
Room for improvement

One of the main challenges for SkedGo was that the project evolved organically, in that decisions about what could and couldn’t be done were made throughout the project. From a technical viewpoint, this is extremely draining on a resource restricted company like SkedGo.

While we accept that this was in the nature of the project, and hard to avoid, a framework more clearly outlining the technical outcomes of the trial, and the resources that were allocated to each goal, would have allowed SkedGo to better plan and manage resources. A clearly defined scope of works, incorporating a story board with user flows for both participants in the trial as well as the admins running the dashboard managing the bundles would have been ideal.

Prior to the commencement of the development work, there should have been more scoping work done, from SkedGo side. Often the meetings (prior to the development work required) were dominated by high level concepts. All stakeholders were involved in every meeting. We feel there would have been a more productive process were particular elements of the project were compartmentalised, from bundle design, to technical processes, and research goals etc. with specific meetings to address each element. SkedGo should have endeavoured to outline the nuts and bolts of the functioning of the app.

Another thing we would consider doing differently is, again, from a technology provider viewpoint. Ideally, we would have proper engagement with providers to obtain access to their APIs/data directly, instead of using hacks or work arounds. This is subject to the cooperation of the provider, and particularly relevant when it came to the Opal card integration. If this direct access to the provider data etc. is realised, our solution would be much more reliable, and ready to change based on open dialogue with the providers.

Lessons learned

For SkedGo, this trial highlighted the importance of the collaboration between many stakeholders in the delivery of a MaaS solution, while at the same time demonstrating the need for a structured and measured approach in the different areas, and with the different stakeholders, of the solution.

In addition, securing complete cooperation from providers prior to the development work, as well as the associated data relevant to the providers, would have been ideal. How this is too be achieved will often come down to legislation.
# Appendix E: Mobility plan personas and motivations

<table>
<thead>
<tr>
<th>Mobility Plan</th>
<th>PAYG</th>
<th>Economisers</th>
<th>Simplifiers</th>
<th>Car downsizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persona</td>
<td>First time/ Infrequent user</td>
<td>Existing highest PT users</td>
<td>Utilise multiple modes of transport</td>
<td>e.g. Two car household attempting to downsize</td>
</tr>
</tbody>
</table>
| Behaviour     | • May be a new user who is familiarising themselves with the app  
• Convenience to use app when necessary i.e. infrequent travellers of certain modes | • Motivation driving PT use may be different but resulting behaviour is similar (green travel/ save money/ city job) | • Convenience of single app/ bill across all the transport modes they currently utilise  
• Already use a mixture of modes  
• May already have reduced car use | • Second car not utilised often  
• Recognise pain points associated with two-car ownership  
• Convenience of second car is not outweighed by alternative transport modes |
| Motivation to target these customers | • Allow user to experience the app  
• See potential benefits of subscribing to other packages | • Support existing behaviour to create a ‘sticky’ customer | • See Tripi as a way to handle using multiple services  
• Least motivated by financial discounts and may enjoy intrinsic benefits of MaaS | • Reduce car use in Australia and motivate more sustainable modes of transport |
| Customer’s existing pain points (based on early interviews) | • Reduce fear/ inconvenience of trying new transport modes | • Inconvenient to access transport hubs typically supplemented by car ownership  
• Restriction due to timetabling and routing, particularly for bus services, pushed users towards more expensive options such as Uber. | • Separate app/ invoice for each transport mode  
• Car maintenance and cost of ownership  
• Lack of personalisation in travel needs across several modes | • Car maintenance and cost of ownership recognised  
• Parking/ congestion consistent pain points for car use  
• Fluctuating costs (surcharges) for ride-share make it unreliable  
• Limited access to car-share/ car hire options in area |
| Potential discount mechanisms | N/A | • Subscription fee: >$150 - <$200  
• Unlimited PT use  
• Capped $x discount on Uber (time restrictions?) | • Provide reasonable (but small) discounts across all modes which are balanced by a subscription fee | • Percentage discounts on car-share services (Long distance use)  
• Capped $ discount on rideshare modes (short-distance use) |
Appendix F: Post trial experience survey

Sydney MaaS Trial Exit Survey Report

Analysis and drafting undertaken by Dr Camila Balbontin with review and edits by Dr Chinh Ho and Professor David A. Hensher

1 June 2020

The Exit Trial Survey was answered by 72 participants, 42 of whom stated they opted-in to a mobility plan during the trial while others did not. This survey included questions about participant attitudes before the trial started, during the trial and after the trial. In this report we present the main findings.

Figure 1 shows the main reasons for participating in the MaaS trial, where 41.7% said they participated in the MaaS trial for potential cost savings; followed by a 22.2% that said they participated out of curiosity; and 16.7% said they participated to contribute to an IAG initiative.

During the trial, different mobility plans were offered; hence not all mobility plans were available during the same period. Figure 2 represents how many participants used MaaS as a monthly subscriber vs. pay as they go (PAYG) option during the trial. A participant is considered to be a user of a plan if they selected it for at least one month. Participants were able to change plans each month, so if a participant chose two different plans during the whole trial, they will be considered as a subscriber for those two plans. The descriptions of the number of mobility plans (excluding PAYG) and including PAYG are shown in Table 1, which shows that on average people subscribed to 0.82 mobility plans during the trial and everyone subscribed at least one month to PAYG. Since all participants were default to the PAYG option for the first month of joining the trial, regardless of when that first month was (Nov or Feb), all participants experienced the PAYG option for at least one month, and hence PAYG users represent 100% of sample. 29.2% of respondents subscribed to the Fifty50 mobility plan for at least one month, 23.6% to the GreenPass mobility plan, 15.3% to the Saver25, and 13.9% to the SuperSaver25.
Figure 2: Individual Trial Subscriptions

Table 1: Descriptives on number of mobility plans and PAYG subscribed during trial

<table>
<thead>
<tr>
<th>Number of mobility plans subscribed during trial (excl. PAYG)</th>
<th>Mean (std dev)</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.82 (0.84)</td>
<td>0.82 (0.84)</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Number of mobility plans or PAYG subscribed during trial</td>
<td>1.82 (0.84)</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

Figure 3 presents the main reasons for opting-in to a mobility plan, 78.6% said they did so for potential cost savings; 14.3% said they opted-in because of the simplified payment ('set and forget').

What was your main reason for opting into a mobility plan?

- Potential cost saving: 78.6%
- Simplified payment ('set and forget'): 14.3%
- Curiosity: 4.8%
- Motivation to use public transport: 2.4%

*Includes participants who stated opted-in a mobility plan

Figure 3: What was your main reason for opting into a mobility plan?
Participants were asked if their travel behaviour had changed during the trial, which is presented in Figure 4 together with their subscription plans during the trial. This figure includes 42 participants that stated they opted-in to a mobility plan. 48% of respondents (represented as PAYG subscribers) stated they did not change their travel behaviour, although four of these participants also selected the option saying they were more conscious of their travel costs — they are considered in both options as maybe they were more conscious of their travel costs but that did not change their behaviour. 48% of the Fifty50 subscribers said they were more conscious of their travel costs, 33% said they used discounted modes more often, and 48% said their trips did not change. 50% of the GreenPass subscribers said they used discounted modes more often, 44% said they were more conscious of their travel costs, and 31% said their behaviour did not change. 70% of the SuperSaver25 subscribers said they used discounted modes more often, 50% said they were more conscious of their travel costs, and 50% said they did not change their behaviour. 55% of the Saver25 subscribers said they did not change their behaviour, and 45% said they used discounted modes more often and were more conscious of their travel costs.

Figure 5 shows participants’ opinions regarding the CO₂ emissions reductions during the trial by the different subscription plans. 21% of all participants think that their emissions were reduced, 36% think they were not, and 38% are not sure. Considering only the Fifty50 mobility plan subscribers, 43% think their CO₂ emissions were reduced and 24% think they did not. 30% of the SuperSaver25 subscribers think their carbon emissions were reduced, while 40% think they were not. 29% of the GreenPass subscribers think their CO₂ emissions were reduced, while 29% think they were not.
Figure 4: Travel behaviour change during trial versus their trial subscription plans

*Labels represent the number of respondents
*Includes participants who stated opted-in a mobility plan
Overall, do you think the MaaS trial decreased your CO2 emissions?

*Labels represent the number of respondents

Figure 5: Carbon emissions reduction versus subscription plans during trial
The reasons for not opting into a mobility plan are presented in Figure 6. Of the trial participants who did not subscribe to a monthly plan at least one month of the trial period, 19.4% reasoned that they could not estimate their travel usage. Interestingly, about one in five (20.8%) stated that they did not subscribe to a bundle because they do not usually use the discounted modes of transport included in that bundle. This finding highlights the importance of understanding individual travel needs in designing monthly bundles that appeal potential users. The finding also lend credits to previous SP studies (Guidon et al. 2020, Ho et al. 2020) which found that users prefer ‘pay-per-ride’ to monthly allowance for unpopular modes of transport such as car-shared and bike-shared. Only a small percentage of trial participants (~15%) stated that they did not subscribe to monthly plan because of the entry barrier, whether this is a bundle price (12.5%) or its upfront payment (2.8%).

![Figure 6: Why did you choose not to opt into a mobility plan?](image)

All participants were asked to rank four factors in order of importance when choosing a mode of transport (1 most important and 5 least important). The results are presented in Figure 7. 42% of individuals ranked convenience as the most important feature (1/5) when choosing a mode of transport; 28% ranked cost; 22% ranked safety; and only 7% ranked sustainability. 18% of individuals ranked convenience as the least important feature (5/5) when choosing a mode of transport; 8% ranked cost; 10% ranked safety; and only 7% ranked sustainability. The highest overall rank was for convenience with an average of 2.28 followed by cost with an average of 2.50, then safety with 2.78, and finally sustainability with an average of 3.04. Remember it is a rank between 1 = most important to 5 = least important.
Figure 7: Stated importance of factors including mode choice
The Tripi journey planner app was available for participants throughout the trial and the main reasons to consult it are presented in Figure 8. 42% of participants stated they used the Tripi journey planner to travel to or from work; 29% for shopping or leisure; and 6% used it for new or unknown routes.

Participants were also asked to rank different journey planning apps they have used based on their preference (1 most preferred, 5 least preferred). The results are presented in Table 2. Google Maps was ranked as the most preferred journey planning app, with an average rank of 2.12; the second most preferred was TripView with a rank of 2.44; followed by Tripi with a rank of 2.67. The least preferred apps were Metarove and City Mapper with a rank of 4.67, followed by Any Trip with 4.25.

Table 2: Journey planning apps ranking (1 most preferred to 5 least preferred)

<table>
<thead>
<tr>
<th>Journey planning app</th>
<th>Mean (std dev)</th>
<th>Missing responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Google Maps</td>
<td>2.12 (1.61)</td>
<td>5</td>
</tr>
<tr>
<td>TripView</td>
<td>2.44 (1.52)</td>
<td>26</td>
</tr>
<tr>
<td>Tripi</td>
<td>2.67 (1.17)</td>
<td>8</td>
</tr>
<tr>
<td>Tripgo</td>
<td>2.80 (1.62)</td>
<td>62</td>
</tr>
<tr>
<td>Opal Travel</td>
<td>2.90 (1.20)</td>
<td>34</td>
</tr>
<tr>
<td>Transit</td>
<td>3.14 (1.57)</td>
<td>65</td>
</tr>
<tr>
<td>NextThere</td>
<td>3.22 (1.56)</td>
<td>63</td>
</tr>
<tr>
<td>Moovit</td>
<td>3.83 (0.75)</td>
<td>66</td>
</tr>
<tr>
<td>Any Trip</td>
<td>4.25 (0.96)</td>
<td>68</td>
</tr>
<tr>
<td>Triptastic</td>
<td>4.25 (0.96)</td>
<td>68</td>
</tr>
<tr>
<td>City Mapper</td>
<td>4.67 (0.52)</td>
<td>66</td>
</tr>
<tr>
<td>Metarove</td>
<td>4.67 (0.58)</td>
<td>69</td>
</tr>
</tbody>
</table>

Number of respondents 72
Participants were asked which mobility plan would they have chosen if the MaaS trial had continued during April, and the responses are presented in Figure 9 together with the subscriptions plans they choose during the trial. 40% of all participants would choose PAYG for April, while 21% would choose SuperSaver25. 38% of Fifty50 subscribers would choose PAYG, while 33% would continue with the Fifty50 mobility plan during April. Most of the GreenPass subscribers appear to be satisfied with this plan, as 59% would choose the same plan for April, while 29% would move to the PAYG option. The greatest majority, i.e., 90%, of the SuperSaver25 subscribers, would keep their mobility plan, while only 10% would move to the PAYG option.

Figure 10 presents the average ranking on how likely participants would be to purchase a mobility plan (or PAYG) given their subscriptions during the trial. A ranking of 1 represents very unlikely to purchase that plan and 5 represents very likely. All participants experienced PAYG in at least one month, so the blue bar represents the average willingness to purchase each plan for all participants. The highest ranked mobility plan is the SuperSaver25, where participants that chose the Saver and SuperSaver25 mobility plans are, on average, very likely to purchase it after the trial (average rank of 4.90 and 4.64, respectively). Fifty50 plan subscribers were on average likely to purchase the SuperSaver25 plan after trial (rank of 4.10) but more likely on average to continue with the Fifty50 mobility plan (rank of 4.29).

GreenPass subscribers are on average very likely to purchase the GreenPass mobility plan after the trial (average ranking of 4.75) and would be on average likely to purchase the Fifty50 mobility plan (average ranking of 4.06). These results are interesting as they suggest that mobility plan subscribers were, on average, pleased with their plans and would be likely to purchase them if available after trial. PAYG subscribers, which represents the average rank for all users, are more likely to purchase the SuperSaver25 mobility plan (4.05) followed by Fifty50 plan (3.88).

Figure 11 presents future travel behaviour given the subscription plans used during the trial. 32% of participants said they will maintain their new travel behaviour from the trial, and 31% said they will go back to their previous travel behaviour. Interestingly, 60% of the SuperSaver25 participants will maintain their travel behaviour from the trial, while only 10% reported they would go back to their previous behaviour. The GreenPass subscribers were more divided, where 35% said they would maintain their travel behaviour and 35% would go back to their pre-trial behaviour. 38% of Fifty50 subscribers said they will maintain their travel behaviour, while 19% said they will go back to their pre-trial behaviour.

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73 To assist in interpretation: as an example, looking at the Green bar (i.e., GreenPass bundle), the figure shows that in total we have 17 participants (who did complete the exit survey) subscribing to this bundle at least one month (either February or March) given that the GreenPass was first introduced in February. Out of these 17 participants, 10 (~60%) would have subscribed to the GreenPass bundle if the trial continued in April 2020, 2 would have switched to Fifty50 and 5 to PAYG.
If the MaaS Trial had continued, which mobility plan would you have selected for April?

**Figure 9:** Mobility plan for April if the trial would have continued versus subscription mobility plans during trial

*Labels represent the number of respondents*
Figure 10: Likelihood of purchase of mobility plan after trial given subscription during trial

*Includes participants who stated opted-in a mobility plan
Figure 11: Future travel behaviour change given their subscription plans during trial

*Labels represent the number of respondents
References


Appendix G: Mobility as a Service and Private Car Use

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28 November 2020

Abstract

Australia’s first Mobility as a Service (MaaS) trial commenced in April 2019 in Sydney, running for two years. The objective of the trial is at least twofold – to assess interest in various MaaS subscription plans through bundling public transport, rideshare, car share and car rental with varying financial discounts and monthly subscription fees, in contrast to pay as you go (PAYG); and to assess the extent to which the use of the private car might change following a subscription to a monthly mobility bundle. This paper assesses the second objective by investigating the potential for changes in monthly car use in the presence of a MaaS program. There is no previous research that we are aware of that has tested the relationship between MaaS bundle uptake and private car use. The paper develops a joint discrete-continuous model system to explain the choice between monthly bundles and PAYG, and subsequently, the total monthly car kilometres. Controlling for monthly differences due to other influences such as seasonal travel activity, the findings suggest that the offered bundles do have an encouraging impact on private car use. Within the limits of what was tested under the Sydney MaaS trial, indicative evidence suggests that MaaS has the potential to change travel behaviour in a way aligned with sustainability objectives, although this evidence should not be taken as suggesting that MaaS is a commercially viable mobility strategy.

Keywords: Mobility as a Service (MaaS), MaaS trial, Sydney, mobility bundles, Pay as you go (PAYG), MaaS subscription, Discrete-continuous model, Poisson regression, elasticities, marginal effects, car use

Acknowledgments: The Sydney MaaS Trial is a project of the iMove Cooperative Research Centre (CRC) Program. The partners in the trial are the Institute of Transport and Logistics Studies (ITLS) at The University of Sydney Business School, Insurance Australia Group (IAG) as the industry lead partner, SkedGo as the digital platform developer, and the iMove CRC. We are grateful for the contributions of other members of the project team, especially Andre Pinto (ITLS), Sam Lorimer, Hugh Saalmans, David Duke, and Ivy Lu of IAG. Daniel Reck is a research associate in ITLS and a doctoral student at ETH. We also thank three referees for very insightful comments that have materially improved the paper.

Introduction

Mobility as a Service (MaaS) has generated a huge amount of interest as a prospective way to garner a greater commitment to mobility activity that aligns with achieving sustainability objectives such as reducing road congestion and emissions. At the same time, MaaS gives travellers greater choices through targeted information on multi-modal travel planning with the support of a digital platform (Sochor et al. 2016, Smith and Hensher 2020, Wong et al. 2020). In contrast to an almost-daily-commentary on the virtues of MaaS and a growing number of researchers questioning whether MaaS is scalable or niche, very few MaaS schemes present in real markets. There appears to be a plethora of digital platforms promoted as MaaS, even though most are trip planners with a pay as you go (PAYG) option. These
enhanced digital platforms, typically in a smart-phone app, enable users to obtain information about travel options as well as booking of multi-modal mobility services available on the platform. While this all sounds very appealing, we have yet to see a MaaS product that is a successful business model and which offers various multimodal bundles through a subscription plan, despite a number of applications such as Whim in Finland, Ubigo in Sweden, and swa Augsburg in Germany (see Hensher et al. 2020, Chapter 3 for details).

Generally, there is a lot of hype and rhetoric surrounding MaaS and very little evidence on whether it will be a feasible, viable or desirable way to investigate and undertake future travel (Hensher et al. 2020, Hensher 2020, Hensher and Mulley 2020a). It is early days to deliberate on whether its future is essentially niche or scalable to a broader travel market. The Sydney trial provides an opportunity to identify what might be of interest in a MaaS offering that aligns with the personal benefits to travellers, and contributes in a broader sense to achieving societal goals that have a sustainability focus.

In the following section, we briefly synthesise the broader literature on MaaS with a focus at the end of the review on what existing evidence there is from a real world multi-modal MaaS trial on modal change. We then introduce the Sydney MaaS trial and its objectives, followed by the trial process, especially the promotion of the trial to potential participants. The next section outlines the design of the bundles (subscription plans), followed by the joint model system of bundle choice and car use. We then provide a descriptive profile of the data and behavioural evidence, followed by the model results, the take up of bundles in general and the relationship between monthly private car kilometres and bundle take up. The findings are then discussed followed by a set of conclusions. The focus of this paper is on establishing any evidence that multi-modal MaaS bundles can contribute to changing car usages in a positive way.

**Literature review on MaaS**

The literature on MaaS subscription plans (or “MaaS bundles” to recognise its origin in the economics and marketing literatures) is young and quickly growing. It builds on the core idea of MaaS to innovate access to transport services by integrating them across operational, informational and transactional dimensions (Hensher et al., 2019; Lyons et al., 2019; Sochor et al., 2018). In fully integrated systems, it is envisaged that users will be able to choose between ‘pay-as-you-go’ (PAYG) and monthly subscription plans (“MaaS bundles”). The societal motivation for MaaS in general (and MaaS bundling in specific) is to change travel behaviour from private car ownership and usage to a service-based, more sustainable and intermodal way of travelling (Hensher and Mulley, 2020; Jittrapirom et al., 2017; Kamargianni et al., 2016; Mulley, 2017; Wong et al., 2020).

MaaS bundle design has recently become an active area of research due to its centrality to MaaS business models and its potential to promote sustainable travel behaviour (for a recent review, see Reck et al., 2020). Given the lack of sizeable trials, most studies to date are based on stated preference surveys aimed to identify potential user groups, their willingness to pay, and, to, estimate the size of the potential market (e.g., Caiati et al., 2020; Feneri et al., 2020; Guidon et al., 2020; Ho et al., 2018; Ho et al., 2020b; Matyas and Kamargianni, 2019; Mulley et al., 2020; Polydoropoulou et al., 2020). Results from these studies indicate a potentially large market for MaaS bundles (e.g., almost half of all participants in the study conducted by Ho et al., 2018, in Sydney would have bought one of the presented MaaS bundles). Hypothetical uptake is typically found to vary substantially across the samples and to be correlated with previous mobility usage (Ho et al., 2018; Ho et al., 2020a; Matyas and Kamargianni, 2019; Polydoropoulou et al., 2020). There is still some ambiguity whether customers are ready to pay for an integrated travel app per se (Guidon et al., 2020, find a positive willingness to pay in their study in Switzerland, while Ho et al., 2020, find the opposite for the UK). Social influence variables and socio-demographic profiles also appear to influence bundle uptake with younger age,
higher education and higher income levels, positively influencing hypothetical bundle uptake (Caiati et al., 2020; Matyas and Kamargianni, 2020).

The Sydney MaaS trial was motivated by findings from our stated preference research and that of others (Ho et al. 2018, Matyas and Kamargianni 2019) and the growing support from government and industry that MaaS will become a key platform for changing the patterns of sustainable mobility. There is only so much one can learn from stated preference studies which are useful in offering evidence of the potential interest in a new product where experience is typically non-existent. The rapid acceptance of unimodal Apps to book and/or pay for transportation services is suggestive of a willingness to adopt technological support mechanisms to inform on travel options (through trip planners) and undertake travel. What is missing, however, is a transparent market test of how much appeal there is for particular integrated multi-modal mobility services offerings, be they Pay as you Go (PAYG) or subscription-based, and what implications they may have on travel behaviour as well as broader societal impacts (Hensher et al. 2020, page 61). The only transparent trial including subscription bundles to date that has concluded is the UbiGo experiment in Gothenburg. It has been thoroughly evaluated, and the results widely disseminated (see Sochor et al, 2015; Sochor et al., 2016; Strömberg et al., 2016; Strömberg et al., 2018 and also Hensher et al. 2020 for details). Among other things, the evaluators concluded that the participating households in general appreciated the piloted service since UbiGo helped them try out unfamiliar transport modes (Strömberg et al., 2016) and made multi-modal travelling less expensive and more convenient (Sochor et al., 2015). All in all, it seemed to promote changes in the households’ transport patterns towards more use of public transport and active modes during the trial (Sochor et al., 2016). By means of qualitative analyses of the questionnaires and personal interviews, a follow up study by Strömberg et al. (2018) found that UbiGo induced behavioural changes in mode choice for 42% of the sample. The overall trend was less car use and more walking; however, some individuals used substantially more carsharing than before. While the UbiGo trial indisputedly has provided many invaluable lessons for subsequent MaaS trials and is one of the best documented trials yet, it also has shortcomings. One is the self-reported nature of all data which is known to be subject to response biases (i.e., social desirability bias, acquiescence bias). As the authors conclude, it is thus “difficult to draw any general conclusions regarding how many people will change behaviour due to a service of this type and how big the changes will be” (Strömberg et al. 2018, 1668)."

To the best knowledge of the authors, the Sydney MaaS trial is one of two studies to transparently analyse MaaS bundle uptake based on real purchasing decisions of trial participants, the other being the UbiGo trial, referred to above, and thus is unique in its explanatory power, as it is not subject to hypothetical bias as previous stated preference studies.

The Sydney MaaS Trial

The Sydney MaaS trial, which commenced in April 2019 as a two year project, was designed to obtain contributing evidence on whether MaaS is a value added mobility proposition. It is the first MaaS trial in Australia, collecting revealed preference data on actual choice made, and has the following objectives: (1) To explore appropriate transport service mixes and subscription plans for early adopters of MaaS; (2) To generate first-hand knowledge of actual MaaS experiences; (3) To advance the understanding of user uptake and willingness to pay for MaaS; (4) To test the ability to influence travel behaviour through introducing MaaS solutions; and (5) To document the experience in designing, planning and undertaking a MaaS trial.

Partners in the trial are the Institute for Transport and Logistic Studies (ITLS) at the University of Sydney, The Insurance Australia Group (IAG) and SkedGo. The trial leveraged off of unique knowledge about potential MaaS users’ preferences acquired through previous research at ITLS (Ho et al. 2018, 2020), as well as IAG’s existing relationships with a wide range of transport service providers in Sydney and a strong customer/value design focus, and SkedGo’s multimodal travel planner TripGo, which was modified for the trial as Tripi. A graphical representation of the main components of the trial are given in Figure 1.

76 Whim never undertook a trial that is reported in any source. The other trial of particular interest which is active as of September 2020 is Mobil-flat in Augsburg, Germany (see Hensher at al 2020, Ch 4.2.4).
This paper explores the relationship between subscription to a MaaS bundle in contrast to staying with PAYG and what influence, if any, the decision to subscribe to a bundle through choosing one of the offered bundles has on private car use. *Tripi*, the digital platform used in the trial, did not capture car use; however, a complementary program called *Safer Journeys*, run by IAG, provided car use data for a subset of participants who also subscribed to this complementary program. Participants were asked whether they were involved in the *Safer Journeys* program and whether they would be interested in joining, and if they consent to sharing their *Safer Journeys* data with the MaaS Trial.

Before detailing the design and implementation of the subscription bundle, we provide an overview of how the participants were selected, including the extensive information and marketing program designed to inform individuals about MaaS and to encourage further inquiry as potential participants. The process of bundle design follows and then a modelling approach is presented to model the choice between PAYG and a bundle, followed by evidence on bundle take up and the impact this has had on adjustments in car use. We conclude with a discussion on the importance of this research which is a first effort to identify the potential impact of MaaS on car use reduction, which is one of the main sustainable arguments for MaaS.

The Trial Process: Promotion of the MaaS Trial to potential participants

The internal communications activity at IAG, the broker, was designed to promote the MaaS Trial and recruit potential participants. We aimed to gather expressions of interest (completed surveys) from at least 150 valid participants (iPhone users only and Sydney based). Learning from the UbiGo trial in Sweden which has 83 households, the minimum valid participants desired was around 100. Over the

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77 Although the possibility of undertaking a journey by car was shown in the options, the use of the car was not tracked.
78 Safer Journeys is a car-based program with GPS tracking technology installed to make car journeys safer, by for example deploying an ambulance to the accident location if the driver did not answer the phone from the call centre who recognises some sudden incidents that may have happened with the trip, based on the tracking data. A by-product of this program is that private car use can be tracked and used as a complementary data source to assess the success of the MaaS trial in terms of reducing emissions through reduced car kilometres.
month of August, the IAG MaaS team conducted two rounds of MaaS promotions, mainly focused on the head office in Sydney, using a range of methodologies including promotional material, an information workshop, a video on MaaS, a Yammer posting and an online survey.

A challenge in the communications was bridging the knowledge gap employees had when it came to MaaS. As such, the communications strategy was divided into two phases: (1) What is Mobility as a Service, which focused on educating IAG employees on the MaaS concept and targeted early adopters and mobility enthusiasts; and (2) Why join our MaaS Trial (August) which focused on highlighting the benefits and incentives of the MaaS Trial, and utilised personal mobility stories to highlight pain points associated with current travel methods.

In informing IAG employees on the concept of MaaS, the key focus of the education piece in phase 1 was ‘The Future of Transport’ panel and building a foundation within the existing internal communication platforms. The expert panel included key members of the project team. With an attendance of over 60 staff, the panel discussed what MaaS is, how it can benefit their mobility in Australia, and the opportunity to participate in the MaaS Trial. The idea that participants would be pioneers in Australia’s first truly multimodal MaaS trial was utilised as the core message. In addition, a landing page for both the event and the trial itself were created and posted onto Vine, IAG’s internal intranet page. Following, an email was delivered to all employees who registered for the panel event. Furthermore, the IAG MaaS team was invited to several internal events to speak about the MaaS project such as the Data and Analytics Guild. At the end of July, a total of 71 IAG employees had completed the survey with 48 valid responders.

Phase 2 centred on ‘Why join our MaaS Trial?’ It focused on highlighting the benefits of the MaaS Trial and personalised the mobility experience of travelling in Sydney. A key initiative of this phase was to highlight both extrinsic motivators (potential discounts, leadership endorsement) and intrinsic motivators (addressing pain points, increased convenience, and alignment to company purpose) of joining the MaaS Trial. The key initiatives were: (1) a promotional email as a form of communication that is most effective as it allowed a direct call to action to the survey. Leaders across IAG divisions were encouraged to distribute the email, including the Heads of both Customer Labs and Group Technology and (2) In-person promotion which enabled IAG and ITLS MaaS teams to engage with staff and converse about the trial to IAG employees.

Flyers with a QR code to the survey were also distributed to provide key trial information. In addition, there was (1) an App-naming competition: IAG staff were invited to enter a competition to name the MaaS app with a $100 Opal (Sydney public transport) card as the prize; (2) High online visibility through a Vine article with clear trial requirements and intrinsic and extrinsic motivators, and (3) A grassroots campaign via Yammer utilising personal stories of employees to highlight their current pain points, and the potential of MaaS to solve them.

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79 The full details are available on request, but the sentiment is captured as follows: As Sydney’s traffic gets worse, we are always looking for better ways to assist our staff in getting to and from work (and travel outside of the daily commute). IAG has partnered with the University of Sydney and a travel planner company to trial a new mobility program that can assist you in exploring alternative ways of travelling, and even saving money. We are running a trial called Mobility as a Service (MaaS) and are looking for 100 IAG staff living in Sydney who would like to join in to explore better ways of getting around our busy congested city and suburbs. What is in it for you? Apart from the convenience of a single App on your smartphone to book and pay for travel using the increasing number of modal options available beyond the car (i.e., public transport using Opal, taxis, Uber, Go Get and even hire cars), you will be participating in Australia’s first trial that integrates, through a single platform on your phone, easy access to many forms of transport. In addition, during the trial you will be able to benefit from a range of financially attractive discounts on various modes of transport. The trial period is over 6 months, but you may join in for a month and see how you like it. If it works for you, you can continue to enjoy the flexibility and benefits of a range of mobility plans. We invite you to consider joining now. Places are filling up nicely, and if you are interested please contact XXXXX today to ensure a place on this exciting trial and become one of the pioneers in Australia in experiencing new ways of conveniently organising your travel through Mobility as a Service.

80 Embedded within the survey was a video on MaaS - https://www.youtube.com/watch?v=3mUELpum-GQ to understand what MaaS is all about in very simple terms.
At the end of August 2019, a total of 222 IAG employees had completed the on-line survey, with 185 respondents owning an iPhone 5 or a newer version and living in Sydney metropolitan area (i.e. eligible participants to the in-field trial). Figure 2 provides an overview of the uptake across the two months with hints on lessons learnt for future trials.

![Rate of expression of interest from potential participants by completing pre-trial survey](image)

The two major spikes during August 2019, which correlate to the direct Customer Labs email and the in-person lobby promotions, indicate two key findings when promoting the MaaS Trial. Firstly, endorsement from leadership through a direct email to IAG staff was the most effective method to promoting the trial. This is due to the necessary call to action, completing the survey, which could be accessed directly. Secondly, a widespread in-person presence sparked awareness/interest and allowed employees to engage in dialogue with team members. This suggested a clear barrier to participation was a lack of understanding around the MaaS concept, as identified in Phase 1. Furthermore, the App-naming competition successfully had over 40 entries. The winner and thus name of the MaaS Trial App was Tripi. Interestingly, most participants were intrigued by the concept of MaaS and the intrinsic benefits rather than the financial incentives. This was supported by the commentary provided in the survey result which had common themes around the novelty of the App and addressing current pain points. It can be concluded that the promotions have successfully targeted the early adopters of the MaaS prospect and the proposed target of 150 eligible participants was reached. As a result, active internal communications were concluded as the MaaS team shifted its focus to onboarding the relevant employees into the MaaS trial.

Out of the 222 IAG employees who expressed interest in participating in the MaaS trial by completing the online pre-trial survey, 185 respondents were eligible to participate to the in-field trial, defined as owning a iPhone 5 or newer version and living in the Sydney metropolitan area. Given that the trial aims to on-board about 100 participants, it is necessary to identify who amongst these 185 are likely to participate, and more importantly, stay with the trial once onboarded. Like any longitudinal study, the risk of sample attrition is a real concern. Since the onboarding process is time-consuming, taking at least 40 minute per participant, the study team aimed to reduce the risk of onboarded participants dropping out of the study after a short period of experiencing the Sydney Maas trial. To identify the risk, pre-trial data on the appealing of different features of a MaaS app are used. The pre-trial survey asked the participants to indicate, on a scale from 1 to 5, how appealing each of the following features is:
(i) Route your journey according to what matters to you! (e.g., multiple modes, cheapest journey, quickest time, lowest carbon emissions - it’s all your choice).
(ii) The ability to book across multiple modes of transport! (e.g., imagine stepping off the train and having your Uber waiting and ready).
(iii) A single payment portal for all transport modes, whether you choose a subscription plan or Pay-as-you-Go (PAYG).
(iv) The freedom to choose between payment models (i.e., pay per ride for different transport modes used vs. subscription to monthly bundles to access multiple modes of your choice, at discounted rates)

Individual scores associated with each of the four questions were added to create a MaaS interest index. This index was then used as a proxy for the participant interest in MaaS, or the potential of them staying with the MaaS trial until the end due to their appreciation of a convenient MaaS app and/or financial incentive, in addition to their curiosity which has a separate question. Based on the MaaS interest index, all eligible participants are ranked and grouped into four categories, namely definitely, yes, maybe and no, for recruitment. The definitely group includes pre-trial respondents who have an index of 20 (out of the maximum of 20), and hence we definitely want to invite them to participate in the in-field trial. The yes group includes respondents with a MaaS interest index of 18 or 19. The maybe group has a MaaS interest index of 16 or 17, with a MaaS curiosity score of 3 or higher (over 5). The great majority of respondents gave a score of 4 or 5, with the mean (standard deviation) of the four feature above being, respectively 4.33 (0.76), 4.38 (0.84), 4.22 (0.98) and 4.27 (0.89). The MaaS interest index had a mean of 4.44 and a standard deviation of 0.772.

Figure 3 plots the residential locations of all eligible participants against the Sydney train lines and stations where the black lines / dots are train routes / stops. The group each participant belongs to is colour coded as shown in the legend. There appears to be a strong correlation between home locations and train lines indicating high public transport use among the participants. This interactive tool was used for exploring the transport options available around each participant’s home in the processing of the recruiting and on-boarding participants for the trial. It is noted that transport options at work location are homogenously good for all participants since IAG offices locate in proximity of a major transport hub (Sydney CBD has most participants, followed by Parramatta – the second biggest employment hub, and Hurstville city – a major hub in the South).

Figure 3. Spatial distribution of eligible participants’ home: pre-trial survey conducted in August 2019
As discussed below, in this paper we have used the data on a subset of participants, approximately one-third of the participants, who were also members of the Safer Journeys Program since this provided the evidence required on changing car use. Other papers have studied bundle choice for the entire set of participants (e.g., Ho et al 2020a), but we were unable to investigate car use changes with those not involved with the Safer Journeys Program. We recognise that the resulting participants are a screened set of interested individuals, and as such are not a representative sample; however we believe that the success of MaaS beyond being a niche product will be heavily dependent of support and engagement from employers, and the approach we have adopts aligns well with this view.

Before discussing the design of the bundles and how they are used together with PAYG, we need to make a comment on the fact that the participants in the trial are drawn for a single employer and hence there is the prospect that some participants may know each other (despite IAG having over 8000 employees). While we believe that the support of employers will be a very important feature of the promotion of MaaS (linked to corporate sustainability charters), we recognise the possibility that the presence of participants from the one organisation may result in a response to MaaS that might otherwise be different from participants who have no connection at all. There is an extensive literature in sociology and social psychology that reaffirms this fact; however this should not be seen as negative consequence, since the marketing literature promotes the position of social norms having a positive impact on many product plans (Melnyk 2010). We suggest that the connection to a single employer has an advantage which may result in greater interest and support for MaaS, but not necessarily in choosing between PAYG and a bundle, the specific focus of this paper. Hensher et al. (2020a) discuss an initiative through MaaS to frame a challenge as a group effort instead of individual efforts to reduce emissions. Specifically, for every percent point reduction in the CO₂ emission rate that the entire cohort achieve, everyone would be rewarded by a $1 reduction in their monthly invoice. For example, if the group manages to reduce the average CO₂ emission per km travelled by 20%, every participant will receive a $20 discount. Sadly, the advent of COVID-19 resulted in this initiative being suspended after only 2 weeks.

Bundle Design

The MaaS trial in Sydney adopted a data-driven incremental approach to the design of monthly bundles for the participants to subscribe to (See Figure 4). Yet, how do you design initial bundles before a trial has even started? Most importantly, and although the trial only officially started in November 2019, all participants were initially on-boarded as PAYG users. This allowed the participants to gain experience with the MaaS app while the trial team could collect initial booking data and combine it with data from the pre-trial survey to design a first bundle for December 2019. With each following month, more booking and tracking data was available to design the subsequent bundles and test both their economic viability and relative competitiveness against previous booking data. The latter was important as the trial team wanted to design a balanced set of bundles without dominant alternatives. Monthly bundles were thus gradually developed along the dimensions outlined in Reck et al. (2020) and introduced in December 2019 (‘Fifty50’), January 2020 (‘Saver25’), February 2020 (‘GreenPass’) and March 2020 (‘SuperSaver25’). Reck et al. (2020) review the growing number of papers that have investigated the role of bundles in MaaS. Two papers of particular interest are Caiati et al. (2020) and Feneri et al. (2020).
Figure 5 summarises these monthly bundles. Once introduced, the monthly bundles remained available for subsequent months of the trial, except for the Saver25 bundle\textsuperscript{136} which was replaced in March by the SuperSaver25 bundle. The latter aims to encourage greater use of public transport through a financial incentive associated with the first and last mile (access and egress) part of a door-to-door public transport trip. Specifically, in addition to the Saver25 offers, the SuperSaver25 added a $5 Uber flat fare for the subscribers to connect to/from public transport trips. Free first and last mile trips were considered but were rejected due partly to the available incentive budget, and partly to a concern about the impact of this offer on existing bus services in accessing and egressing a rail station. The compromise was to introduce a financial incentive for Uber only (determined also by the way Uber is integrated into Tripi) with a distance cap option in order to provide absolute certainty to participants that they would not face different Uber fares for the same trip, for example, from their home to a local train station, regardless of the time of the day these trips were undertaken. Using distance (cf. fare) as a cap to define eligible Uber trips for the flat fare is important since Uber has a surge price (i.e., high demand price), which may result in a situation where users pay different fares for the same distance travelled. Analysis of data collected prior to the introduction of the SuperSaver25 bundle in March 2020 suggested that 75 percent of participants live within 5 kms of a train station, with PAYG users generally living slightly further from a train station than bundler subscribers.

In addition to this change to Saver25, renamed as SuperSaver25, we also changed the 15% on Taxi and Uber to be a flat $3 reduction, given feedback that participants preferred an absolute dollar amount. It became clear that most Uber and Taxi trips are relatively short, and so a $3 incentive is better value that a percentage, where the latter may be more appealing for long trips. We stayed with the subscription fee of $25/month and the 25 percent discount on all public transport trips. Car-based options were provided through GoGet and Car rental\textsuperscript{82}. The take up of GoGet was essentially existing GoGet trips, and hence we did not see any benefit linked to the goals of the trial and removed the incentive. In the current paper, we take the bundles as given, with details on how they were designed in a forthcoming paper.

\textsuperscript{136} This bundle has the same subscription fee and public transport discount as SuperSaver25 but rideshare had a 15% discount per ride instead of the $3 discount and there was no Uber discount for the first and last mile.

\textsuperscript{82} In a Webinar hosted by Global MaaS Transit on April 17, 2020, by Sampo Hietanen, Founder & CEO, MaaS Global titled ‘Mobility-as-a-Service - The End of Car Ownership?’, in response to a question, Sampo said that ‘the profitable part [of MaaS] is having access to a car on weekend otherwise MaaS is just a utility service.’ The Sydney trial accommodated this feature through GoGet and car rental. This is also a position supported by research in Belgium by Storme et al. (2020).
Figure 5. PAYG and monthly bundles offers over the 5-month trial, current as of March 2020

The Joint Model System of Bundle Choice and Car Use

Our interest is on identifying what might be influences on the choice made between PAYG and a bundle, and how this further translates into changes in private car use. There are a number of possible ways of investigating the take up of MaaS bundles, especially if it is assumed that the technology is new, and hence there is a need to explain user adoption of new technologies and how these can affect user acceptance. The previous section, where we outlined the process of engaging with potential participants, is reflective of ways to ensure there is an understanding of how MaaS links into well known trip planning apps. We would argue, however, that the digital platform as represented by Tripi, which is essentially a trip planner, is something that is somewhat well known today and as such, the technology is not new and little understood. As such, the modelling approach is logical and straightforward given the data that we have (discrete choice for PAYG or bundle, then count for monthly car km). The exit survey at the conclusion of the trial reinforced this level of knowledge, where familiarity with trip planners is surprisingly widespread in Sydney, with many apps now being used on a regular basis (Table 1).

Participants were asked to rank different journey planning apps they have used and/or are aware of based on their preference (1 most preferred, 5 least preferred). Google Maps was ranked as the most preferred journey planning app, with an average rank of 2.12; the second most preferred was TripView with a rank of 2.44; followed by Tripi with a rank of 2.67. The least preferred apps were Metarove and City Mapper with a rank of 4.67, followed by Any Trip with 4.25. This evidence, together with the way we engaged with potential and onboarded participants, gives us confidence in the appropriateness of the modelling approach we have selected.

83 A number of models and frameworks have been developed to explain user adoption of new technologies and these can affect user acceptance. These are summarised in Taherdoost (2018), of which the main focus of all methods is on the social and psychological aspects of users use in their quest for motivation and satisfaction, drawn from sociology and social psychology. The Theory of Planned Behaviour (TPB) is an approach we are familiar with and it does have merit, where perceived behavioural control (PBC) is added which is determined by the availability of resources, opportunities and skills, as well as the perceived significance of those resources, opportunities and skills to achieve outcomes. TPB assumes person’s behavioural intention (BI) is affecting individual’s behaviour, using the PBC for individual’s actions which are not under volitional control. By adding PBC, not only realistic limitations is composed but also, a self-efficacy type factor is achieved. Moreover, PBC has the direct influence on actual behaviour as well as the indirect affect through the behavioural intentions.
Table 1. Journey planning apps ranking (1 most preferred to 5 least preferred)

<table>
<thead>
<tr>
<th>Journey planning app</th>
<th>Mean (std dev)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Google Maps</td>
<td>2.12 (1.61)</td>
</tr>
<tr>
<td>TripView</td>
<td>2.44 (1.52)</td>
</tr>
<tr>
<td>Tripi</td>
<td>2.67 (1.17)</td>
</tr>
<tr>
<td>TripGo</td>
<td>2.80 (1.62)</td>
</tr>
<tr>
<td>Opal Travel</td>
<td>2.90 (1.20)</td>
</tr>
<tr>
<td>Transit</td>
<td>3.14 (1.57)</td>
</tr>
<tr>
<td>NextThere</td>
<td>3.22 (1.56)</td>
</tr>
<tr>
<td>Moovit</td>
<td>3.83 (0.75)</td>
</tr>
<tr>
<td>Any Trip</td>
<td>4.25 (0.96)</td>
</tr>
<tr>
<td>Triptastic</td>
<td>4.25 (0.96)</td>
</tr>
<tr>
<td>City Mapper</td>
<td>4.67 (0.52)</td>
</tr>
<tr>
<td>Metarove</td>
<td>4.67 (0.58)</td>
</tr>
</tbody>
</table>

Formally, we have two models, one representing the choice between taking up a MaaS bundle and choosing to stay with PAYG, and the other the monthly kilometres travelled by a private car. This is a discrete-continuous choice model (simultaneous equation) system, where the discrete component is either a logit or probit form, and the continuous component is a count model such as a zero inflation Poisson regression. The binary choice model for PAYG versus a bundle is defined by a binary outcome $y_i$ taking the values 0 (for PAYG) and 1 (for bundle) with the probability of choosing a bundle defined as:

$$\text{Prob}[y_i=1] = F(\beta'x_i)\text{ such that } F(\beta'x_i) \geq 0 \text{ and } 0 < F(\beta'x_i) < 1. \quad (1)$$

We first estimate the binary choice model as logit by maximum likelihood to obtain estimated parameters for influences on a bundle vs PAYG choices, and then use the estimated model to compute, for each participant, a predicted probability of choosing a bundle. This probability is then fed into a Poisson regression model for monthly car kilometres (see below). The estimation at both steps is consistent; however we still need to correct the estimated asymptotic covariance matrix for the estimator at step 2 for the randomness of the estimator carried forward from the binary choice model. The standard Murphy and Topel (1985) correction is implemented, so that the standard errors and hence the $t$-values of the Poisson model are asymptotically efficient.

The amount of monthly car kilometres travelled by each participant in the trial is obtained from their participation in the Safer Journey’s program. Monthly kilometres is a positive number compliant with a count model such as zero inflation Poisson (ZIP)\(^84\) with latent heterogeneity\(^85\). It is connected to the binary choice model by the method described above. As a non-negative continuous count value, with truncation at zero, discrete random variable, $Y_i$, observed over a period of length $T_i$ (i.e., a month) and observed kilometres, $y_{in}$ ($n$ observations), the Poisson regression model is given as equation (2).

\(^{84}\) Often, the numbers of zeros in the sample cannot be accommodated properly by a Poisson model where it would under-predict them resulting in what is referred to as an “excess zeros” problem. Because the Poisson model assumes that the conditional variance of the dependent variable is equal to the conditional mean, in most count data sets, the conditional variance is greater than the conditional mean, often much greater, a phenomenon known as over-dispersion. Standard errors will as a result be underestimated. If data consist of non-negative, highly skewed sequence counts with a large proportion of zeros, zero-inflated models are useful for analysing such data. A Zero-inflated Poisson (ZIP) model has two kinds of zeros: “true zeros” and “excess zeros.” (Lambert 1992). For example, investors (traders) who sometime just did not trade that week versus investors who never ever do. The zero-inflated Poisson (ZIP) model employs two components that correspond to two zero generating processes. The first process is governed by a binary distribution that generates extra zeros. (e.g., the binary logit model). The second process is governed by a Poisson distribution that generates count (counting zeroes), some of which may be zero. The two model components are described by equations 2-5.

\(^{85}\) We also proposed and estimated a negative binomial model which is appropriate, like Poisson, for count data. The overall fit and statistical significance of parameters was inferior to Poisson.
\[ \text{Prob}(Y = y_n | x_n) = \exp(y_n \lambda_n), \quad y_n = 0,1, \ldots; \quad \log \lambda_n = \beta_x x_n. \]  

(2)

In this model, \( \lambda_n \) is both the mean and variance of \( y_n \); \( E[y_n | x_n] = \lambda_n \). We allow for unobserved heterogeneity as well as consider the ZIP form for count data (see Greene 2000) to recognise the possibility of partial observability if data on monthly kilometres being observed for any period within the four months exhibits no car use\(^{86}\). Specifically, the answer ‘zero’ could arise from two underlying responses. If we were unable to capture any car use, we would only observe a zero; however, the zero may be due to the measurement period (i.e., a particular month) and the response might be some positive number in other periods. We define \( z = 0 \) if the response would always be 0, 1 if a Poisson model applies; \( y \) = the response from the Poisson model, then \( zy \) = the observed response. The probabilities of the various outcomes in the ZIP model are:

\[ \text{Prob}(y = 0) = \text{Prob}(z = 0) + \text{Prob}(z = 1) \times \text{Prob}(y = 0 | \text{Poisson}) \]  

(3a)

\[ \text{Prob}(y = r > 0) = \text{Prob}(z = 1) \times \text{Prob}(y = r | \text{Poisson}). \]  

(3b)

The ZIP model is given as (Greene 2017) \( Y_n = 0 \) with probability \( q_n \), and \( Y_n \sim \text{Poisson}(\lambda_n) \) with probability \( 1 - q_n \) so that

\[ \text{Prob}(Y_n = 0) = q_n + (1 - q_n)R_d(0), \quad \text{and} \]  

\[ \text{Prob}(Y_n = r > 0) = (1 - q_n)R_d(r) \]  

(4)

where \( R_d(y) \) is the Poisson probability = \( e^{\lambda_n} \lambda_n^y / y! \) and \( \lambda_n = e^{\beta \text{'} x_n} \). We assume that the ancillary, state probability, \( q_n \), is distributed normal. Then,

\[ v_n = \tau \ln(\lambda_n) = \tau \beta \text{'} x_n \]  

(5)

Equation (5) defines a single new parameter (which may be positive or negative). If there is no (or little) evidence of zero kilometres in any observations, then we do not expect the \( \tau \) parameter to be statistically significant, and we can default to the Poisson form with normal latent heterogeneity.

The two models are estimated using the combined data from the Safer Journeys program (monthly car use) and the data obtained from the Tripi app and the pre-trial survey. The former provided details of the bundles chosen each month and the latter socio-demographic information of each participant.

**Descriptive Profile**

Of the 92 effective participants of the Sydney MaaS trial, 33 participants were also the Safer Journeys Program subscribers. Car use of this subset of the MaaS participants, together with the MaaS monthly bundle subscription dataset, form the core datasets for this paper. It is worth mentioning that car use data prior to the MaaS trial was also available since the Safer Journeys scheme was launched before the MaaS trial was conducted. However, for the purpose of assessing the impact of MaaS bundle subscription on private vehicle kilometres travelled, only Safer Journeys data between the time when a participant joined the trial and when s/he left were extracted and used for analysis. This is because not every participant joined the MaaS trial in November 2019, and not everyone continued active up to the end of the trial in March 2020. Also, few participants were active in the MaaS program (i.e., made trips using the Tripi app) but did not undertake any car trips in specific months. These are included to avoid biasing the data. In total, the dataset represents 171 participant months. A summary of monthly MaaS bundle subscriptions and the switching between PAYG and bundles for these 33 participants is provided in Figures 6 (as absolute numbers) and 7 (as percentage of participants). Over the four months between December 2019 and March 2020 when monthly bundles were available for subscription, 52 bundle offers were accepted. This includes a participant staying with or switching away from a bundle, including moving between bundles but excluding moving from a monthly bundle to a PAYG option. Overall, for the 171 participant months, the Fifty50 bundle offered in December through to March was chosen 36.5\%
of the time; Saver25, introduced in January, was selected by 15.4% of participant months; and in February when we introduced the GreenPass bundle, its popularity in February and March resulted in the highest participant month uptake of 38.4% of all bundles. The SuperSaver25 bundle that replaced the Saver25 bundle in March represented 9.3%.

The evidence on the acceptance of monthly bundles is very encouraging, with the 91.9% for PAYG in December dropping to 81.6% in January and then 44.7% in February before increasing marginally to 46.2% in March. In the final month when all bundles are available (although SuperSaver25 replaced Saver25), we have a bundle take up of 53.8%. The percentages for each bundle in March are 12.8%, 12.8% and 28.2% respectively for Fifty50, SuperSaver25 and GreenPass. This aggregate share from real preference evidence is within the range of what has been found in stated preference studies (30%-55%) such as Ho et al. (2018) and is the first tangible evidence of the external validity, at least at an aggregate level, of the stated preference survey responses. What we are seeing is some learning of bundle experience, in part influenced by changing monthly travel needs. Given the sample size, however, care is taken in generalising this evidence.

Figure 6. A high level summary of the absolute bundle uptake by month for Safer Journey’s participants

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87 This compares with 36.5 percent for all trial participants.
88 We must recognise that studies such as Ho et al. (2018) include respondents who do not have access to a car, and so a direct comparison of samples must be cautioned.
Figure 7. The percentage distribution of PAYG and bundles subscription for each month (note: each month sums to 100%).

Figure 8 shows the monthly car kilometres at the participant level and the monthly bundle they were on for each month. Figure 8 also identifies, on the x-axis, the month each Safer Journeys user joined the MaaS trial and the month they left the trial. On the other hand, the vertical axis shows private car kms travelled on a log10 scale while the colours identify the participant’s mobility agreement, be it a PAYG user or a monthly subscriber. Overall, a lot of variation in monthly car kilometres can be observed at the individual level, with December being most substantial. This is expected in the holiday season when many travellers would typically use car more, especially for longer road trips (e.g., P042 drove from Sydney to Melbourne and back) or do not use their private car at all (e.g., P178, P082).

Without an intervention of monthly mobility bundles, car use after the holiday season was expected to go back to normal, and the total kms travelled in January and February 2020 should be comparable with that in November 2019 for PAYG users. This expectation is observed in several PAYG participants such as P002, P004, P007 (see Figure 5). After taking up a bundle, these participants appear to reduce their monthly car kilometres, while very little change in monthly car kilometres was observed for those who continued to use MaaS as a PAYG user (P031, P099, P173). While month-to-month variation in car kilometres is an issue that needs to be acknowledged in this descriptive analysis, the evidence is that MaaS subscriber’s car kilometres in February are generally much lower than those individuals who continued with PAYG. The average kilometres for February are 658, 266, 477 and 222 respectively for PAYG, Fifty50, Saver25 and GreenPass (an average of 284 kilometres for all three bundle subscribers). This is a very important result suggesting that MaaS bundles do attract interest by active car users, and that these appear to be participants who rely less on the car for their mobility needs. We are not, however, able to conclude that subscription to a MaaS bundle has reduced car kilometres compared to what car usage would have been if the bundle subscription was not available. The only months that have similar periods for travel activity comparison, that are not a special month like December and January, are October and November, where the average monthly kilometres are respectively 513 and 474, still much more than the average of 284 for the bundle subscribers in February. In the formal modelling below, we investigate this matter.

---

89 Two participants resigned their position at IAG during the trial and hence they were required to leave the trial.
90 In Australia, December is very much a party month with an elevated use of rideshare, and January is the main holiday month with reduced metropolitan travel (hence local public transport) and increased use of air and car for long distance travel.
Model Results for Trial Months with Mobility Bundles

The model system estimated for the choice between PAYG and a bundle, as well as monthly car kilometres, considered a number of variables that describe the socioeconomic status of the participants, the incentives offered with each bundle including the change in the metric for ride share (from a percentage to dollars) and the amount of money saved per month compared with PAYG. Table 2 summarises the data items that were considered in various models, resulting in the preferred model summarised in Table 3. Specifically, we found that a series of dummy variables associated with each specific bundle and the associated trial month (e.g., December Fifty50 bundle), relative to PAYG, did not provide as good a behaviourally and statistically significant explanation of the choice between PAYG and bundles in contrast to modal trip activity by each mode during the trial, month-specific dummy variables, estimated financial savings each month associated with bundle selection,\textsuperscript{91} and socioeconomic characteristics.

Table 2. Descriptive Statistics of Data (Sample size = 171 participant months)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Units</th>
<th>Mean (standard deviation)</th>
<th>Range (min, max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly kilometres</td>
<td>kilometres</td>
<td>433.9 (587)</td>
<td>6.5, 3708</td>
</tr>
<tr>
<td>Pay as you go</td>
<td>proportion</td>
<td>0.651</td>
<td>0,1</td>
</tr>
<tr>
<td>Fifty50 bundle</td>
<td>1,0 (Dec-Mar)</td>
<td>0.127</td>
<td>0,1</td>
</tr>
<tr>
<td>Saver25 bundle</td>
<td>1,0 (Jan-Feb)</td>
<td>0.054</td>
<td>0,1</td>
</tr>
<tr>
<td>SuperSaver25 bundle</td>
<td>1,0 (March 1-20)</td>
<td>0.033</td>
<td>0,1</td>
</tr>
<tr>
<td>Green Pass</td>
<td>1,0 (Feb-March 1-20)</td>
<td>0.134</td>
<td>0,1</td>
</tr>
<tr>
<td>Gender</td>
<td>Male = 1, Female = 0</td>
<td>0.597</td>
<td>0,1</td>
</tr>
<tr>
<td>Age</td>
<td>Years</td>
<td>40.87 (8.54)</td>
<td>30,60</td>
</tr>
<tr>
<td>Adults in household</td>
<td>Number</td>
<td>2.27 (0.76)</td>
<td>1,5</td>
</tr>
<tr>
<td>Children in household</td>
<td>Number</td>
<td>1.13 (0.84)</td>
<td>0,2</td>
</tr>
<tr>
<td>Car licenced drivers in household</td>
<td>Number</td>
<td>2.13 (0.70)</td>
<td>1,5</td>
</tr>
<tr>
<td>Number of cars in household</td>
<td>Number</td>
<td>1.62 (0.75)</td>
<td>1,4</td>
</tr>
<tr>
<td>Access to a car</td>
<td>Access to a car = 1</td>
<td>0.893</td>
<td>0,1</td>
</tr>
<tr>
<td>Subscribe to a bundle</td>
<td>1,0</td>
<td>0.349</td>
<td>0,1</td>
</tr>
<tr>
<td>Sample month participation -</td>
<td>1,0</td>
<td>0.228</td>
<td>0,1</td>
</tr>
<tr>
<td>December</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample month participation -</td>
<td>1,0</td>
<td>0.255</td>
<td>0,1</td>
</tr>
<tr>
<td>January</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample month participation -</td>
<td>1,0</td>
<td>0.255</td>
<td>0,1</td>
</tr>
<tr>
<td>February</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{91} Defined as the estimated saving associated with a subscribed bundle (i.e., the bundle the participant actually subscribed to for that month) compared to the cost outlay under PAYG. A negative value indicates that the subscribed bundle is more expensive than PAYG, and a positive estimate indicates a saving. We set PAYG to $0.
Sample month participation - March 1,0 0.262 0,1
December Fifty50 bundle 1,0 0.022 0,1
January Fifty50 bundle 1,0 0.034 0,1
February Fifty50 bundle 1,0 0.040 0,1
March Fifty50 bundle 1,0 0.034 0,1
January Saver25 1,0 0.013 0,1
February Saver25 1,0 0.040 0,1
February GreenPass 1,0 0.060 0,1
March GreenPass 1,0 0.074 0,1
March SuperSaver25 1,0 0.033 0,1

Weekly modal travel activity:
Car driver trips Number 44.13 (29.4) 2,131
Car passenger trips Number 0.041 (0.26) 0,2
Public transport trips Number 22.59 (16.19) 2,76
Rideshare (taxi and Uber) trips Number 3.31 (4.11) 1,25
Estimated monthly financial saving on the subscribed bundle compared to PAYG $ per month 6.97 (16.42) -28.72

Subscription bundle fee and discounts:
Subscription fee $ per month 25.33 (42.91) 0,125
Public transport discount % 21.44 (35.25) 0,100
Ride share discount $ 0.483 0, 3
Ride Share discount % 1.933 0,15
Car share discount % 0.805 0,15

In estimating the models, given that the unit of analysis is a participant month and there is more than one observation per participant, the data structure is like a panel (repeated observations for each respondent) and hence there exist observations in a group that are likely to be correlated through common latent heterogeneity across four months. This sequential time period of data, defined by the month, is accommodated through a cluster algorithm (Greene 2000) that is similar to a random effect. The parameter estimator is unchanged, but an adjustment is made to the estimated asymptotic covariance matrix (see Greene 2017) to correct the standard errors. We tested for fixed and random effects; however, the fixed effect model did not work due to sample size, and the random effects model failed to converge. A random parameter form (normally distributed) for monthly kilometres was investigated, but it was found to be statistically non-significant due, we suspect again, to sample size.

<table>
<thead>
<tr>
<th>Table 3. Model results</th>
<th>Parameter estimates</th>
<th>Clustered standard errors</th>
<th>z-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Discrete Choice: Binary Logit Bundle (1) vs PAYG (0)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.7098</td>
<td>3.272</td>
<td>-0.22</td>
</tr>
<tr>
<td>February dummy variable (1,0)</td>
<td>2.2856</td>
<td>0.943</td>
<td>2.42</td>
</tr>
<tr>
<td>March dummy variable (1,0)</td>
<td>2.7440</td>
<td>1.277</td>
<td>2.15</td>
</tr>
<tr>
<td>Monthly car passenger trips</td>
<td>-28.096</td>
<td>2.354</td>
<td>-11.93</td>
</tr>
<tr>
<td>Monthly public transport trips</td>
<td>0.0702</td>
<td>0.019</td>
<td>3.57</td>
</tr>
<tr>
<td>Monthly savings in costs for a bundle cf. PAYG (log$)</td>
<td>41.572</td>
<td>1.203</td>
<td>34.57</td>
</tr>
<tr>
<td>Male (1,0)</td>
<td>-1.7499</td>
<td>0.962</td>
<td>-1.82</td>
</tr>
<tr>
<td>Car licenced drivers in household</td>
<td>-3.7002</td>
<td>2.261</td>
<td>-1.64</td>
</tr>
<tr>
<td>Restricted log likelihood</td>
<td>-22.170</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Psuedo R²</td>
<td>0.780</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Continuous model of Monthly Car Kilometres: Poisson model with normal heterogeneity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>6.1751</td>
<td>0.0272</td>
<td>227.3</td>
</tr>
<tr>
<td>Access to a car (1,0)</td>
<td>1.1223</td>
<td>0.0209</td>
<td>53.52</td>
</tr>
<tr>
<td>Age of participant (years)</td>
<td>-0.0339</td>
<td>0.00052</td>
<td>-43.72</td>
</tr>
<tr>
<td>Gender of Male (1,0)</td>
<td>-0.2834</td>
<td>0.0088</td>
<td>-32.38</td>
</tr>
<tr>
<td>Number of children in household</td>
<td>0.1174</td>
<td>0.0055</td>
<td>21.44</td>
</tr>
<tr>
<td>Predicted probability of choosing a monthly bundle</td>
<td>-0.6690</td>
<td>0.0114</td>
<td>-60.05</td>
</tr>
<tr>
<td>Sigma</td>
<td>0.584</td>
<td>0.012</td>
<td>47.90</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-36,637.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Psuedo R²</td>
<td>0.134</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vuong statistic vs Poisson (favours the extended model)</td>
<td>6.147</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Discussion of the choice between take up of a bundle and PAYG

We begin by discussing the binary choice logit model. The overall goodness of fit is very impressive with a pseudo $R^2$ of 0.780. Except for the two socioeconomic characteristics (male and number of licensed car drivers in a household) and the constant, the variables are statistically significant at the 95 percent level of confidence. The socioeconomic characteristics are statistically significant at a slightly lower level of statistical confidence.

Initially, we had anticipated that we might be able to introduce a series of variables to represent the subscription fee and the mode-specific discounts, since although they do not vary within a particular bundle offer, they do vary across the offered bundles. However, these variables are highly correlated and result in a very unstable bundle choice model. The amount of variance is not sufficient to capture the role of such discounts, and indeed is a reason why revealed preference data like that in the trial creates challenges in model estimation, and is one of the justifications why stated preference data is appealing. Until there is sufficient variation in the incentives and subscription fees associated with real market offerings of MaaS bundles, there will be limitations to using such data in studying bundle choice. This may require the pooling of many MaaS products to be able to obtain sufficient variation. However, we found that the variation in the financial savings associated with each bundle (Table 2) relative to PAYG for each participant, enables this influence to be tested. All other influences remaining constant, we find that as the financial savings increase, the probability of choosing a bundle increases. The extent of the change is presented below as a semi-elasticity.

Two dummy variables for the months of February and March were statistically significant and positive. What this suggests, and reaffirms what we know about take up of bundles as we offer additional bundles in a monthly sequence, is that relative to the previous months of December and January, the probability of choosing a bundle increases as we move monthly through the trial. This is very reassuring and supports the way in which we assessed new bundles given the experience with previously introduced bundles. The way the trial was designed provides strong clues as to how bundles can be designed through time. A caveat must be mentioned, namely Covid-19, which has had a massive impact on travel in general after March 12\textsuperscript{92}, with the greatest impact on public transport and ride share patronage (Beck and Hensher 2020). Car use has continued, but in general it also dropped (see Figure 5). What we can say, however, is that car use was greater in December and January than in February and March up to the 12\textsuperscript{th} March.

Finally, we found that two socioeconomic characteristics, gender and the number of licensed drivers in a household, were statistically significant negative influences on the probability of choosing a bundle, suggesting that male participants and those in households with more driving licences are less likely, holding all other influences constant, to choose a bundle over PAYG. The other socioeconomic characteristics in Table 1 were not found to be statistically significant.

Care must be taken in interpreting the numerical magnitude of each parameter estimate since they are non-comparable in this logit non-linear form, and hence below we present partial effects and elasticities as a way of meaningfully comparing the impacts of each bundle component. The behavioural sensitivity of the probability of choosing a bundle compared to PAYG for each of the explanatory variables can be given by an elasticity and a partial effects indicator. For the logit form, the elasticity of the probability is given in equation (6) and the partial (or marginal) effect in equation (7).

$$
\frac{\partial \log E(y | x)}{\partial \log x_k} = \frac{x_k}{E(y | x)} \cdot \frac{\partial E(y | x)}{\partial x_k} = \frac{x_k}{E(y | x)} \cdot \text{marginal effect}
$$

(6)

$$
\frac{\partial E(y | x)}{\partial x} = \frac{\partial F(\beta' x)}{\partial x} = \frac{dF(\beta' x)}{d(\beta' x)} \beta = F'(\beta' x) \beta = f(\beta' x) \beta
$$

(7)

The direct elasticity of the probability of choosing a bundle compared to PAYG with respect to the number of monthly public transport trips is 0.820 (with a $t$-value of 3.86 and a 95 percent confidence interval of 0.042 to 1.24 using the Delta method). The direct elasticity of the probability of choosing a

\textsuperscript{92} On March 12, all participants as employees of IAG were advised to work at home where possible and all non-local domestic and international travel was to cease, which aligned with the Stage 2 restrictions imposed on Society on March 20 (Beck and Hensher 2020).
bundle compared to PAYG with respect to the number of monthly car passenger trips is -1.25 (with a t-value of 3.38 and a 95 percent confidence interval of -1.978 to -0.527). Thus, all other influences remaining unchanged, a one percent decrease in monthly car passenger trips will result in a 1.25 percent increase in the probability of choosing a bundle over PAYG; and for public transport trips a one percent increase in monthly public transport trips will result in a 0.82 percent increase in the probability of choosing a bundle over PAYG. As an example, if we work with the average bundle choice share of 0.349 (Table 1) and if we can achieve a 10 percent increase, on average, in monthly public transport trips, then we predict an increase in the probability of choosing a bundle of 8.2 percent, or an increase from 0.349 to 0.378. The equivalent change for a reduction in car passenger trips is 12.5 percent or an increase to 0.393. If this evidence was scalable, given the mix of MaaS bundles offered in the trial, we can expect a significant improvement in traffic congestion if we are able to reduce car kilometres by 6 to 10 percent, which is equivalent to returning the road environment to school holiday levels of congestion.

For the average monthly financial savings, since it is transformed as a natural logarithm, we have to use a semi-elasticity formula (equation 8), interpreted as the change in probability for a 1% change in x. That is, a semi elasticity formula measures the relationship between a percentage change in X and an absolute (not percentage) change in Y, and hence we refer to a unit increase in the explanatory variable (not percentage, but change in percentage points).

\[
\frac{\Delta Prob}{100* \frac{\Delta x}{x}} = \frac{\beta Prob(1-Prob)}{100}
\]

(8)

The model obtains a semi-elasticity of 1.853 (t value of 4.4) for average monthly financial savings relative to PAYG. A 1 percent change in the average monthly financial savings will result in a 1.853 change in the probability of choosing a bundle over PAYG. The average change in the probability of choosing a bundle when the average savings increases by 10% (noting a change in the log of .1 is about a 10% increase in the average savings), is .185 or 18.5 probability of bundle choice points. Thus, given the average bundle choice share of 0.349, this equates to a probability of bundle choice of 0.414 (= 0.349 × 1.853) for an additional 10 percent financial savings over PAYG.

For the remaining variables, we have calculated the partial or marginal effects. The average marginal effect provides an effect on the probability. It is the average change in the probability when an explanatory variable increases by one unit. When a variable is a dummy variable, we have to take the exponential. The marginal effect parameters (with t values in brackets) for the February dummy, the March dummy, male, and number of household members with a driver licence are respectively 0.129 (3.83), 0.177 (2.61), -0.076 (1.56) and -0.289 (1.12). For example, for the February dummy variable influence, we obtain \(\exp(0.129) = 1.138\) suggesting that we are 11.38% more likely to choose a bundle in February compared to December and January; the equivalent percentage for March is \(\exp(0.177) = 1.194\) or 11.94% more likely to choose a bundle in March compared to December and January. The main implication of all of these findings is that they provide suggestions for ways of harnessing MaaS as a policy instrument supporting sustainable transport outcomes.

**Discussion on the relationship between monthly private car kilometres and bundle take up**

Turning to the Poisson regression model (in Table 3), with monthly kilometres defined as an integer for the Poisson count model, the overall goodness of fit (as pseudo R\(^2\)) is 0.134. The tau (\(\tau\)) parameter (equation 5) associated with the zero inflated Poisson model with normal heterogeneity was not statistically significant and so we opted for the Poisson model with normal heterogeneity, where the sigma (\(\sigma\)) parameter, the standard deviation of heterogeneity, is statistically significant at the 1 percent level. The Vuong statistic of 6.147 suggests that the estimated extended Poisson model in Table 2 is favoured over an unaltered Poisson model.

Four socioeconomic characteristics have a statistically significant influence on monthly car kilometres, namely access to a car, participant age, gender, and the number of children in the household. All other
influences remaining constant, having access to a private car increases monthly car kilometres, but older participants tend to drive less than younger participants, with male respondents having fewer monthly car kilometres than female participants. Households with more children tend to use their cars much more, as might be expected. These findings are sample-specific and so cannot be generalised, although it does suggest that there are socioeconomic segments associated with car use which translates into differences in the propensity to take up a bundle compared with PAYG if someone decides to participate in MaaS.

Finally, we have included the predicted bundle choice as a probability measure obtained from the binary logit model of bundle vs PAYG. It is a statistically significant and negative effect which indicates that, ceteris paribus, if the probability of choosing a bundle increases, then there is an expected reduction in monthly car kilometres. The parameter estimates of a Poisson regression may be interpreted as semi-elasticities as discussed above in equation 8.93 The parameter of -0.669 for the probability of choosing a bundle indicates that, ceteris paribus, if we increase the probability by 1 percent, we expect to have a 66.9 absolute reduction in monthly car kilometres. At the mean monthly kilometres of 434, a 1 percent increase in the probability of choosing a bundle (from 0.349 to 0.353) is predicted to reduce monthly kilometres from 434 to 367 kilometres. If scalable over a large population of MaaS subscribers, this is a significant reduction in car kilometres. The partial effect and hence semi-elasticity increases at a decreasing rate as the probability of choosing a bundle increases, although the deviation from a linear effect is small.

General Discussion, Conclusions and Limitations

Part of the remit for MaaS is to offer a more attractive way for individuals (and groups of any denomination) to be better informed about multi-modal mobility options. This in turn opens up opportunities to encourage changes to travel behaviour that not only provide direct benefits to the travelling public, but also support achieving broader societal goals. One of the overarching themes in the MaaS ecosystem is the desire to reduce private car use, and as a consequence contribute to the reduction in emissions and other negative externalities such as traffic congestion. The findings of this study reinforce a position that a well-designed suite of subscription plans under MaaS has the potential to influence the use the car in a positive and sustainable way, contributing to a reduction in emissions.

The Sydney MaaS trial was well placed to investigate how MaaS may appeal to personal and societal agendas. In this paper, we have focussed on the trial activities of the sub sample of participants who have provided data on their car use over the months in which subscription bundles have been offered, starting with a single bundle in the first month after a PAYG familiarisation period with the digital platform (the Tripi App), and then incrementally adding a bundle each month. The sequential enhancement of bundles offers an innovative way of learning by doing with a sample of participants, such that the opportunity to grow interest in a bundle may be increased through analysis of each month’s travel activity and bundle choices. This was indeed an appropriate strategy since it resulted in a slow but noticeable move away from PAYG to bundles (see Figures 3 and 4), even if PAYG remained the dominant way94 of using Tripi and participating in the trial.

With the growing preferences favouring specific bundles, we wanted to know if there was an impact on monthly car use, and what features of the bundles in particular might be the main triggers for changing patterns of car use. Using a joint discrete and continuous choice model system to study the influences on the choice between a bundle and PAYG (the discrete choice model), and the influences on monthly private car kilometres (the count model), the evidence suggests that a subscription to a monthly mobility bundle, within the context of the bundles offered each month, can influence monthly car use in a statistically significant way. This is encouraging evidence.

This study has provided evidence within the limits of the empirical setting that the combination of a subscription fee and a suite of behaviourally appealing mode-specific financial discounts appears to gain patronage for MaaS bundles and impact on private car use. If shown to be the case in other trials

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93 Suppose x is not a log variable, then β associated with x can be interpreted as a semi-elasticity, meaning that a one unit change in x will change E[y | x] by 100β (Wooldridge 2002).
94 Especially for all trial participants and not just the Safer Journeys participants.
in progress or planned, or indeed real offers, then having monthly mobility bundles for subscription has the prospect of being a real contribution to whether MaaS is to grow in a scalable way or remain a niche construct. A qualitative survey with 22 sampled trial participants, which was conducted in the middle of the trial to gather evidence for monthly bundle design, suggests that a good number of individuals are looking for a multimodal subscription plan (preferably with two or three modes at the most), with attractive financial benefits, and that a digital platform under PAYG alone is unlikely to be of interest to the majority of improved mobility aspirants. This does suggest that money talks, despite the added recognition of the importance of good quality public transport and rideshare services, in terms of convenience, reliability, safety, transfers and travel times. Thus, without attractive financial incentives, especially where there are no service enhancements only available to MaaS subscribers,95 the evidence in this one study suggests that the likelihood of MaaS achieving noticeable outcomes aligned with sustainability objectives may be unlikely to be achieved.

The current paper has shown, through the Sydney trial, that there appears to be an appetite, despite the small number of participants, for a multi-modal MaaS product, and that it can potentially contribute to achieving sustainability goals; however, a lot of ongoing research is required to integrate the constituent parts and feature the business case (or commercial case) for MaaS, which is not the focus of this paper, that is attractive to both private interests, users and government. The trial has indeed commenced that journey, although the Covid-19 pandemic may require new initiatives in order to preserve and grow the appeal of MaaS, at least in the short to medium term when the popularity of the car is likely to escalate as a response to biosecurity in contrast to the use the shared modes, public transport and rideshare.

Although this paper has presented new evidence on the potential influence that subscription bundles compared to PAYG may have on car use for participants of a trial, we have to moderate the findings to recognise that we are assessing this important sustainability link in the context of specific bundles and a limited sample of participants who all work for one very large employer. This setting of a small sample, however, is not new and is also aligned with the few MaaS trials that have presented evidence. The number of bundles and the way they were carefully designed should be seen as an innovative way to introduce bundles designed to encourage greater use of more sustainable modes, especially public transport, and definitely at this very early stage in the learning experience with MaaS in practice. We had planned more but COVID got in our way (challenge) and thus prevented the “back to PAYG final month” to measure any mid-term changes in travel behaviour without the influence of any bundle. Until an analyst has actually undertaken the design, execution and analysis of a trial such as the Sydney MaaS trial, we would suggest that there is likely to be a distinct lack of appreciation of the complexities involved in bringing together suppliers, customers, a digital platform developer and a broker (or aggregator). This journey has been detailed in Hensher et al. (2020a).

The MaaS trial process is complex in its behavioural structure and the logistics of integrating many features of a real world delivery of MaaS, entailing transport suppliers, customers of the offered services, the broker or integrator and the functionality of the digital platform used by end user customers as well as the search, booking and payment integration (see Figure 1). The communications strategy was designed to inform potential participants on what MaaS is and what it potentially can offer them and they had to choose whether to participate or not. We know from the mid-trial qualitative interviews that some participants joined because of their views on sustainable travel, others out of curiosity, and others because their colleagues had suggested it was a great idea. While participation does result in some amount of self-selection bias (there is no random selection present), we would argue that this is present in any real world offering where advertising and other communication channels are designed to get people interested and to participate. We are unable to claim that the communication plan alone resulted

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95 Mobility mode providers have shown no interest to date in offering service enhancements that are only available to MaaS subscribers; and hence financial incentives are the only levers available unless non transport services such a retail can offer MaaS bundle specific rewards, something we suggest will be necessary to support a business model and commercial case. The idea of multimodality should then be read as multiservice MaaS.

96 This paper focusses on a sub set of the participants, namely members of the Safer Journeys program which was required to be able to track changes in car use consequent on choosing a bundle. In Ho et al. (2020a), we focus on the entire sample of participants to investigate the choice between PAYG and specific bundles, but without the ability to account for car use.
in a successful uptake, but we would suggest that it was a positive contributor. Also with participants drawn from the one organisation, but noting IAG has 8,000 employees, the great majority did not know each other prior to the trial; however they shared, as might be expected, their experiences with a number of other participants during the trial and this in itself may have positive or negative impacts; however that is the reality of the market place with leaders and followers etc. What but these influences in they exist as statistically significant are contained in the unobserved random component of the estimated models. Hence they are not ignored, but are treated in an implicit appropriate way.

Finally, the Sydney MaaS trial presents new evidence (or knowledge) on the prospect of MaaS through subscription bundles to influence car dependence and this is good sustainable outcome. What we do not know, however, is whether that is dependent on the specific bundles offered (and we suspect it is) and the extent to which such evidence might be scalable beyond the trial participants. We encourage further research on co-creating bundles with potential participants in order to see the extent of preference heterogeneity in bundle uptake and then to test this through further trials.

There are always limitations of any study, and no more so in the execution of something as complex as a multi-modal MaaS trial that we would like to recognise and use as guidance in any future MaaS trials. Specifically, we would like to have a larger sample and to ensure that all modal activity of all participants is captured through the trial digital platform and through other mechanisms. This is especially important if we are to measure the full impact of MaaS on emission reductions. We would also want to engage with a larger number of employers despite a recognition that the influence of an employer on encouraging staff to consider participating in MaaS is an undeniably valuable feature of the entire MaaS program, especially when there is still little experience with MaaS. We would also want to consider broadening the incentives to include loyalty programs that are not transport, such as retail purchases. We call this multi-service in contrast to multi-modal (see Hensher and Mulley 2020). Finally, with a larger sample there is an opportunity to also identify the role that communications and information sharing has on behavioural responses in a MaaS program, and in particular whether these features of process influence the choice of subscription plan or PAYG and changes in car dependency.

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Appendix H: Drivers of Participant’s Choices of Monthly Mobility Bundles: Key Behavioural Findings

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Abstract

Australia’s first Mobility as a Service (MaaS) trial commenced in April 2019 in Sydney. A key objective of the trial is to assess interest in various MaaS subscription plans through bundling public transport, ride share, car share and car rental with varying financial discounts and monthly subscription fees, in contrast to pay as you go (PAYG). This paper develops a mixed logit choice model to investigate the participants’ choice between PAYG and four subscription plans (or bundles) that were incrementally introduced over a 5-month period. This is the first paper to model real uptake as previous studies are based on stated preference data. New evidence is provided on what role financial savings, estimated using tracking technology embedded in the MaaS app, play in the context of modal offerings and a monthly subscription fee as well as socio-demographic and seasonal effects. Behaviourally, we present evidence on the extent of take up of each bundle relative to PAYG as well as elasticity estimates for all exogenous influences and estimates of willingness to pay and scenario assessment, particularly for how much someone would have to save over a previous month’s cost outlay to be willing to subscribe to a particular bundle in a subsequent month. Within the context of the trial, the findings suggest a substantial market for mobility bundles but PAYG is an option preferred by many, particularly those with varying travel needs. We are, however, not in a position yet to conclude that these choices necessarily align with a contribution to societal sustainability goals.

Keywords: Mobility as a Service (MaaS), MaaS trial, Sydney, mobility bundles, Pay as you go (PAYG), MaaS subscription, mixed logit model, willingness to pay, elasticities

Acknowledgments: The Sydney MaaS Trial is a project of the iMove Cooperative Research Centre (CRC) Program. The partners in the trial are the Institute of Transport and Logistics Studies (ITLS) at The University of Sydney Business School, Insurance Australia Group (IAG) as the industry lead partner, SkedGo as the digital platform developer, and the iMove CRC. We are grateful for the contributions of other members of the project team, especially Goran Smith, Andre Pinto (ITLS), Sam Lorimer, Hugh Saalmans, David Duke, and Ivy Lu of IAG. We thank two referees for constructive comments.

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Introduction

Mobility as a Service (MaaS) is currently at the centre of the popular view on future collaborative and connected mobility. MaaS operates on a concept that public and private transport services can be integrated to provide everyday travellers a one-stop access to all services required through a common interface. While the literature on MaaS is fast growing (see Hensher et al. 2020 for a detailed synthesis of progress to date), many unknowns exist. These include preferences for specific subscription plans, a viable business model for MaaS, benefits to society, and the impacts of MaaS on its user’s behaviour which translate into changes to traffic observed on transport network.

One way to verify these unknowns beyond previous stated preference studies, which are subject to hypothetical bias (Hensher, 2010), is to undertake a trial. Trial objectives could be many folds. Examples, expressed in the form of research questions, could be whether integrating multiple complementary transport services into a MaaS platform improves the travellers’ experience in terms of cost, travel time, frequency, convenience, health benefits and perceived safety; whether MaaS contributes to improvements in broader community benefits such as better air quality, reduced congestion and greenhouse gas emissions; and whether MaaS could be provide a pertinent alternative to owning and using private vehicles.

The only transparent trial to date that has concluded is the UbiGo experiment in Gothenburg. It has been thoroughly evaluated, and the results widely disseminated. Among other things, the evaluators concluded that the participating households in general appreciated the piloted service since UbiGo helped them try out unfamiliar transport modes (Strömberg et al., 2016) and made multi-modal travelling less expensive and more convenient (Sochor et al., 2015). All in all, it seemed to promote changes in the households’ transport patterns towards more use of public transport and active modes during the trial (Sochor et al., 2016). By means of qualitative analyses of the questionnaires and personal interviews, a follow up study by Strömberg et al. (2018) found that UbiGo induced behavioural changes in mode choice for 42% of the sample. The overall trend was less car use and more walking; however, some individuals used substantially more carsharing than before. While the UbiGo trial undisputedly has provided many invaluable lessons for subsequent MaaS trials and is one of the best documented trials yet, it also has shortcomings. One is the self-reported nature of all data which is known to be subject to response biases (i.e., social desirability bias, acquiescence bias). As the authors conclude, it is thus “difficult to draw any general conclusions regarding how many people will change behaviour due to a service of this type and how big the changes will be” (Strömberg et al. 2018, 1668).

In responding to the challenge to test MaaS in a real market, the Sydney MaaS trial, a first in Australia, was developed and designed to meet the following objectives: (1) To explore appropriate transport service mixes for early adopters of MaaS; (2) To generate first-hand knowledge of actual MaaS experiences; (3) To explore commercially viable business model for MaaS as a pay-as-you-go vs. subscription plans; (4) To advance the understanding of user uptake and preferences for monthly mobility bundles; (5) To test the ability to influence travel behaviour through introducing MaaS solutions; and (6) To document the experience in designing, planning and undertaking a MaaS trial. The achievement of these objectives has been reported on in detail in a number of other papers (notably Ho et al. 2020a, and Hensher et al. 2020a,b); however we have yet to present the findings from a formal discrete choice modelling exercise to enable us to predict the uptake of specific bundles compared to pay as you go (PAYG) as a way to promote the use of specific modes, especially public transport, with anticipated reductions in the use of less sustainable modes. This is the focus of the current paper.

The paper is organised as follows. We begin with a brief overview of the literature on MaaS bundling and previous stated preference studies. We then introduce the setting within which the Sydney MaaS trial took place, followed by a discussion of the subscription bundles and their take up. This is followed by a discussion of the financial savings associated with bundle that participants subscribe to. The modelling approach is then presented followed by a descriptive overview of the data collected over the five months of the trial, and then model results are set out and discussed, including a number of key elasticity and willingness to pay indicators that inform us of the behavioural responsiveness of various

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97 Whim never undertook a trial that is reported in any source. The other trial of particular interest which is active as of September 2020 is MobilFlat in Augsburg, Germany (see Hensher at al 2020, Ch 4.2.4).
influences on choosing a MaaS subscription plan. We conclude with comments on what the evidence might mean for an ongoing commitment to MaaS.

**Literature review**

The literature on MaaS subscription plans (or “MaaS bundles” to recognise its origin in the economics and marketing literatures\(^98\)) is young and quickly growing. It builds on the core idea of MaaS to innovate access to transportation services by integrating them across operational, informational and transactional dimensions (Hensher et al., 2019; Lyons et al., 2019; Sochor et al., 2018). In fully integrated systems, it is envisaged that users will be able to choose between ‘pay-as-you-go’ (PAYG) and monthly subscription plans (“MaaS bundles”). The societal motivation for MaaS in general (and MaaS bundling in specific) is to change travel behaviour from private car ownership and usage to a service-based, more sustainable and intermodal way of travelling (Hensher and Mulley, 2020; Jittrapirom et al., 2017; Kamargianni et al., 2016; Mulley, 2017; Wong et al., 2020).

MaaS bundle design has recently become an active area of research due to its centrality to MaaS business models and its potential to promote sustainable travel behaviour (for a recent review, see Reck et al., 2020). Given the lack of sizeable trials, most studies to date are based on stated preference surveys aimed to identify potential user groups, their willingness to pay, and, to, estimate the size of the potential market (e.g., Caiati et al., 2020; Feneri et al., 2020; Guidon et al., 2020; Ho et al., 2018; Ho et al., 2020b; Matyas and Kamargianni, 2019; Mulley et al., 2020; Polydoropoulou et al., 2020). Results from these studies indicate a potentially large market for MaaS bundles (e.g., almost half of all participants in the study conducted by Ho et al., 2018, in Sydney would have bought one of the presented MaaS bundles). Hypothetical uptake is typically found to vary substantially across the samples and to be correlated with previous mobility usage (Ho et al., 2018; Ho et al., 2020b; Matyas and Kamargianni, 2019; Polydoropoulou et al., 2020). There is still some ambiguity whether customers are ready to pay for an integrated travel app per se (Guidon et al., 2020, find a positive willingness to pay in their study in Switzerland, while Ho et al., 2020, find the opposite for the UK). Social influence variables and socio-demographic profiles also appear to influence bundle uptake with younger age, higher education and higher income levels, positively influencing hypothetical bundle uptake (Caiati et al., 2020; Matyas and Kamargianni, 2020).

To the best knowledge of the authors, this is one of two studies to transparently analyse MaaS bundle uptake based on real purchasing decisions of trial participants, the other being the Ubigo trial, referred to in the introduction, and thus is unique in its explanatory power, as it is not subject to hypothetical bias as previous stated preference studies.

**A high-level overview of the Sydney MaaS trial setting**

The Sydney MaaS trial, which commenced in April 2019 as a 2-year project, was designed to obtain contributing evidence on whether MaaS is a value-added mobility proposition in the presence of the existing transport options and digital platforms. Partners in the trial are the Institute for Transport and Logistic Studies (ITLS) at the University of Sydney, The Insurance Australia Group (IAG) and SkedGo. The trial leveraged off of unique knowledge about potential MaaS users’ preferences acquired through previous research at ITLS, as well as IAG’s existing relationships with a wide range of transport service providers in Sydney and a strong customer/value design focus, and SkedGo’s multimodal travel planner TripGo, which was modified for the trial as Tripi. A graphical representation of the main components of the trial are given in Figure 1. Details of all aspects of the trial are provided in Ho et al. (2020a) and Hensher et al. (2020b, forthcoming). For brevity purposes, we provide a high-level summary of the key steps in relation to setting up the trial and designing monthly bundles for subscription.

We requested all potential participants to complete a pre-trial survey as a way to express their interest in joining the 6-month in-field trial, which was cut short by one month due to the surge of COVID-19. This

\(^{98}\) For reviews of these literatures, see Kobayashi (2005) and Stremersch and Tellis (2002).
pre-trial survey collected data on transport needs in a recent period as well as socio-demographics and opinions on different features of a MaaS app. The latter includes the app’s ability to define route journeys according to user’s preferences (i.e., journey planner), book across multiple modes of transport, pay for all transport services, and switch between payment models (pay per ride or subscribe to monthly bundles to access transport modes of user’s choice at discounted rates). All eligible participants (i.e., who own an iPhone 5 or a newer version and work in the Sydney Metropolitan Area) were ranked according to their expressed interest in MaaS, with the top 150 potential participants invited to join the trial and proceed to an on-boarding process. In a one-on-one onboarding session, each participant was provided a welcome pack which included the trial timeline, several Tripi stickers, a Tripi-branded Opal card, a GoGet pack and answers to frequently asked questions. The study team also helped the participants set up the Tripi app and showed them how to use it to book, pay and manage their travel during the in-field trial period.

When it comes to bundle design, we adopted an incremental and co-design approach to designing monthly bundles. Over the 5-month trial period, four monthly bundles were designed and introduced incrementally (i.e., one new monthly bundle at a time), plus a PAYG option which participants were defaulted to when they first joined the trial. That is, the first month of the trial offered only PAYG option to all participants. The second month introduced the first monthly bundle, while the third month added a second monthly bundle and so on. We used the pre-trial survey data and cumulative trip data collected from each participant, using tracking technology embedded in the MaaS app, from the first date when they joined the in-field trial to design and test, in an incremental manner, four distinct bundles. These bundles individually target a certain group of participants (i.e., market segment) and collectively aim to alter travel behaviour towards more sustainable travel choices, such as using more public transport and less carbon-heavy modes including the private car and Uber/Taxi (see the next section for more details).

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99 Information on socio-demographics collected includes age group, gender, home and work address, driver’s licence, number of household adults and children, access to a car and number of household cars, and number of household drivers. Participant income was not sought due to confidentiality issues within the company in which participants are employed. More specifically, the pre-trial survey was run by IAG members of the study team, and thus, seeking information on income necessarily results in a revelation of the participant’s income to their colleagues, which is against the employer policy and/or code of conduct.
Monthly bundle choice and switching

The MaaS trial in Sydney, Australia, adopted an incremental approach to the design of monthly bundles for the participants to subscribe to. Every month, cumulative data on trips made by the participants were analysed and a new monthly bundle was designed to target a specific segment of the participants. This incremental approach to bundle design is deemed most appropriate for two reasons. First, while some data on individual participant’s demand for various transport services were collected in the pre-trial survey, the insights gained from analysing this dataset were limited to the desired features of a MaaS digital platform and socio-environmental context of the potential participants. Thus, pre-trial data are not sufficient to form an accurate basis for how much of different transport services each participant would require for their monthly travel. Second, participants were on-boarded gradually, and thus introducing all monthly bundles at once would risk missing some emerging segments and create unnecessary admin and technical work (in the backend to implement the rules) to manage these bundles. The second reason is evidenced in Figure 2 which shows the progress of on-boarding the participants. Most of the participants were on-boarded in November and December 2019, with a few more participants joining the trial in January 2020. By the 20th January 2020, the on-boarding was completed with a total of 93 participants.

![Figure 2. Progress of on-boarding participants to the Sydney MaaS trial](image)

Over the course of the five-month trial, four monthly bundles were designed and incrementally introduced for subscription, plus a PAYG option that all participants were defaulted to for the first month they joined the trial, whenever this would be (see the progress of on-boarding the participants during the trial above). This default rule means that for the first month of the trial (i.e., November 2019), PAYG was the only option available. This first month of PAYG provided important data for the MaaS study team to conduct segmentation analysis and design monthly bundles that best suits these segments, based on their travel demands for the various mobility services the trial offers via a smart-phone app called Tripi.

Details of the bundle design process are given in Ho et al. (2020a) and Hensher et al (2020b) with key facets included herein to ensure that each bundle’s heritage is clear. Reck et al. (2020) provides a recent overview and a framework on for MaaS Bundle Design that was developed based on learnings from Sydney MaaS trial and the Augsburg MaaS trial. Other contributions to the small but growing literature
on bundle design in MaaS are Matyas and Kamargianni (2019), Ho et al. (2018), Caiati et al. (2020) and Guidon et al. (2020); and in all cases the findings are based on a stated choice experiment.

In the Sydney trial, the first monthly bundle, called Fifty50, was offered in late November and became active on the 1st December 2020. As the first bundle, we had limited knowledge of support or otherwise for bundles. The following logic was used in arriving at a bundle to offer. We budgeted $100 worth of incentives per participant per month to incentivise the participants. Given the goal to reduce emissions through incentivising more sustainable travel, and public transport being the most sustainable available mode, we suggested spending at least $50 as incentives on public transport use. $50 incentives per person per month and the weekly $50 “cap” on Opal card\(^1\) (monthly $200 cap) translates to the following pricing structure for public transport in a bundle: unlimited use of public transport would cost the MaaS operator $200 - $50 (incentives) = $150 per person per month, and offering a 75% discount on public transport would cost the MaaS operator $200 * 0.75 - $50 (incentives) = $100 per month per person. The specifics of the December holiday season such as less working days, inferior public transport service, and the increasing need to get chauffeured rides after parties, suggest fewer than four weeks of regular public transport and higher than usual Uber/taxi use, and thus demand for bundles that include these modes. With a remaining budget of $50 worth of incentives per month per person, a $3 reduction per Uber/taxi ride is a conservative design that enables 50/3 = ~17 rides per person per month before the incentive budget runs out.

We thus proposed a conservatively priced first December bundle at $50 that includes a 50% discount on public transport using Opal cards, which are eligible smart-card tickets for buses, trains, light rails, ferries and the on-demand transport BRIDJ buses; and a $3 discount on every Uber/taxi ride. This Fifty50 bundle was well received with 11 subscribers taking up the bundle in December 2019 (see Figure 3).

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\(^1\) Opal is a smartcard used for all public transport modes in Sydney. While Opal fares are calculated for each trip undertaken based on distance-band, transport mode and time of day travel, a weekly Opal cap of $50 is applied such that an unlimited use of public transport using the same Opal card will cost a maximum of $50 per week.
As more and more participants joined the trial, the PAYG segment becomes larger since all participants were required to join Tripi as a PAYG user for the first month. Thus, further segmentation analysis was conducted to identify new segments that could be targeted with new monthly bundles. Each month the trial introduced one new monthly bundle that targeted a particular segment amongst the PAYG users, instead of attracting the existing subscribers of other bundles. The Saver25 monthly bundle was first introduced in late December for subscription and use in January 2020. Likewise, a GreenPass bundle was introduced in February 2020. It is noted that once introduced, these monthly bundles remained available for the subsequent months of the trial, except for the Saver25 which was replaced by the SuperSaver25 in March 2020 (for an overview of all available bundles, see Figure 4).

As can be seen in Figure 3, the design of monthly bundles was quite successful in terms of attracting PAYG users instead of the existing subscribers as the months progressed (in March 2020, a total of 43 users had subscribed to a bundle), although few switches between bundles can be observed. For example, the Saver25 bundle was introduced in January 2020, which had 10 participants subscribed, of which eight subscribers were previously on PAYG while two subscribers switched from the Fifty50 bundle. Similarly, the GreenPass bundle was introduced in February 2020, which was subscribed to by 12 participants, with seven from PAYG users and five from the Fifty50 bundles. The number of subscribers to this bundle increased to 18 participants in March 2020 when it was re-offered. Interestingly, all 12 subscribers to the GreenPass bundle in Feb 2020 stayed with this bundle in March, suggesting that these subscribers find good value in the GreenPass bundle. This monthly bundle also attracted six new subscribers in March 2020. Finally, SuperSaver25, that replaced the Saver25 in March 2020, had 11 subscribers, of which six were previously on the Saver25 bundle while four came from PAYG and one from the Fifty50 bundle. It is not surprising that the majority of the SuperSaver25 subscribers were previously Saver25 subscribers who individually received a personal phone call from the MaaS study team informing about the changes before the communication email went to each of the participants.

![Figure 4. Monthly plans when they were (a) first offered to participants and (b) fine-tuned in March 2020](image-url)
In addition to replacing the Saver25 bundle with the SuperSaver25 bundle, another minor revision took place in March which changed the percentage discount offered in the GreenPass and Saver25 bundles to the fixed dollar discount for Taxi and Uber trips (i.e., the 15% discount was changed to a $3 discount for every Uber and Taxi ride). Unlike the replacement of Saver25 which was suggested by data analysis of the previous trial months, the revision of the percent discount to a dollar discount was driven by feedback received from the participants who took part in the mid-trial interviews who indicated that they prefer an absolute dollar amount (Ho et al. 2020a, Hensher et al. 2020b). It became clear that most Uber and taxi trips are relatively short, and so a $3 incentive is better value that a percentage, where the latter may be more appealing for long trips. Details of the revisions are summarised in Figure 4 with the top summarising the monthly bundles when they were first offered and the bottom showing the same after fine-tuning in March 2020.

Apart from the monthly bundles, two special offers were introduced to test participants’ willingness to use GoGet car-sharing and to reduce the cost to the environment (i.e., emissions) of their travel. More specifically, a GoGet car-sharing credit worth $20 was offered to all participants in January 2020, regardless of which monthly bundle they subscribed to, including PAYG, with the main goal of nudging first time users towards trying out new modes. This can occur only once any time in January 2020 and is unrelated to a bundle. We found that the take up of GoGet was essentially existing GoGet trips, and hence we did not see any benefit linked to the goals of the trial, and removed the incentive associated with GoGet car-share in all March bundles.

Another special offer relates to a group CO₂ challenge which was introduced in March 2020 (see Hensher et al. 2020b for full details), which aimed to test the potential use of gamification in changing travel behaviour to obtain societal goals of MaaS in reducing emissions associated with travel. This challenge, was posed as a group effort with an incentive to each participant of $1 for every percentage reduction in average CO₂ emission per km travelled that the entire cohort would obtain by the end of the March, using February 2020 CO₂ emission as the benchmark. In assessing the impact of the emission challenge, we looked at the data on private car travel, ride share and GoGet but excluded Thrifty car-rental (which was negligible in its take up). The findings as of March 8 suggest that the entire cohort had increased CO₂ emissions (kg) by 1%, and hence there is no financial reward; but with Covid-19 restrictions after March 12, we cannot conclude anything about the potential impact of such an initiative to reduce car use. Further analyses excluded the influence of these offers from individual monthly bundle choices and switching.

While the month-on-month changes to bundle subscriptions presented in Figure 3 are useful for identifying the size of each travel segment, the aggregate nature of the results means that the participant segment that each bundle should target cannot be identified. To this end, an individual analysis of monthly bundle subscription is conducted and the results presented in Figure 5. Based on the dynamics of bundle subscription at the individual level, key segments of travellers can be identified and their travel patterns, before and after subscribing to a monthly bundle, can be analysed further for an improved understanding of why these people subscribed to a certain bundle. For example, the same dynamics of bundle subscription can be observed for participants P002, P005, P008, and P040 (SuperSaver 25); for participants P037, P072, P082, P083, P089 (Green Pass); and for PAYG users (P011, P014, P016, P018, P019, P022, P024, etc.). That is, these participants stayed with PAYG since joining the trial, but took up SuperSaver25 in March 2020, while ignoring its pedigree, the Saver25 bundle, which was available in January and February 2020. The Saver25 bundle is very similar to the SuperSaver25 offer, except for the latter adding a $5 flat fare for any Uber trip that connects to/from public transport trips and is up to 5 km. It is therefore reasonable to conclude that these people may be attracted by the $5 flat fare for Uber trips that connect to/from public transport trips. Similarly, we can identify the patterns for Fifty50 or GreenPass. More detailed analyses could then be performed on each group of the participants to identify the commonalities in their travel patterns, environmental settings, and socio-demographics that lead to the same preferences for the monthly bundle.
Figure 5. Temporal transitions of monthly bundle subscription at the participant level
Exploratory analysis

The initial exploratory analysis aims to identify the key drivers of monthly bundle subscriptions for the purpose of market segmentation. More specifically, each monthly bundle is likely to serve a particular group of users better than other groups. It is therefore useful for the business case and potential commercial proposition to understand the size of each segment and their preferences, including willingness to pay such that MaaS providers can design monthly bundles and assess their potential in a given market. The exploratory analysis considers the impact of the following factors on individual decision on monthly bundle subscription:

- Multimodality
- Monthly Opal outlay (i.e., cost of using train, bus, ferry, and BRIDJ)
- Intra-person week-to-week variation in travel demand/patterns
- Number of days active on Tripi
- The bundle the participant was on in the previous month

Figure 6 displays monthly outlay for all travel modes (e.g., bus, car-rental, ferry) of individuals who stayed with PAYG since onboarding. We find that many participants, identified by their IDs such as Pxxx, who stayed with PAYG are unimodal train travellers (P017, P036, P038, P068, P070, P073, P081, P086, P098, P181, P173, P058). This is evidenced by the fact that the monthly cost by mode for these participants is mostly single-coloured. By contrast, bundle subscribers, particularly the Saver25 in February, are most likely to be multi-modal users (see Figure 7).

The participants had access to all of the offered modes in the bundles, since Sydney is well served by public transport, ride share, and car share. We recognise that there are situations in other contexts where this would not be the case and hence some bundles would be inappropriate.

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Figure 6. Monthly cost breakdown for participants who stayed with PAYG since onboarding

101 For exploratory analysis presented herein, February is selected as a regular full month of the trial when all participants have been on-boarded and have been back to work after the holiday. The modelling analysis, however, is able to consider all five months of the trial while accounting for disruptions such as Christmas/New Year holiday and COVID-19 due to the multivariate nature of the adopted model.
Figure 7. Monthly cost breakdown for participants who subscribed to (a) Saver25 bundle and (b) GreenPass bundle in Feb 2020.
To explore the impact of traveller's multimodal behaviour on monthly bundle subsection, an entropy-index (Ho and Mulley, 2015, Cervero and Kockelman, 1997) is used as a proxy for multimodality. The entropy is equal to \( \frac{1}{N} \sum_{i=1}^{N} p_i \ln(p_i) \) with \( p_i \) the proportion of trips made by mode \( i \) to the total number of trips made by each individual, and \( N \) the number of modes available in Tripi (i.e., train, bus, ferry, taxi, Uber, GoGet, and car rental).\(^{102}\) The index has a mean of 0.349, a standard deviation of 0.256 and a range from 0 to 0.946. Looking ahead, this index was considered in choice model estimation but was not found to be statistically significant. Upon closer investigation, this entropy index is higher for the Saver25 and SuperSaver25 bundles (~0.5) than for other subscription plans, including PAYG, Fifty50 and GreenPass (~0.32), successfully measuring the multimodality behaviour of these subscribers as observed in the exploratory analysis; however, the number of participants subscribing the Saver25 and SuperSaver25 bundles are quite small (22 and 11 monthly bundles respectively). These small sample sizes may well be the main reason for this index being statistically insignificant in distinguishing individual preferences for bundles vs. PAYG.

In respect of the monthly public transport outlay (i.e., Opal cost of using train, bus, ferry, and BRIDJ), since there are very few Uber and taxi trips per person per month, we can assume that an individual decision to subscribe to each of the four monthly bundles is somewhat limited to the potential savings on the Opal cost. By definition, when the monthly Opal cost outlay is smaller than $100, it is not worth paying the membership fee in return for the discount on Opal trips. For example, at $100 per month, a participant is indifferent between travelling as PAYG users and as Fifty50 users since the cost of subscription to the latter is $50 and the discount received is 50% × 100 = $50. The same logic applies for Saver25 when we ignore the benefits associated with taxi and Uber discounts offered under this bundle (more on this below). As shown in Figure 7b, participants subscribing to the GreenPass bundle in February 2020 have a high monthly Opal outlay, typically exceeding $125 such that it is worth it to pay the $125 membership fee to travel free on public transport. It is also noted that these participants also show multimodal behaviour, which can be seen by the different coloured bars within the same participant. This is one of the reasons why multivariate analysis (i.e., choice modelling) is required to separate the impact of potential cost savings from other factors, such as multi-modality, on bundle subscriptions.

Intra-person week-to-week variation in travel demand/patterns are an informative way of tracking changes through time in travel activity and what impact this may have on bundle choice. Reck and Axhausen (2020) analysed how intra-person week-to-week variation in travel demand impacts the viability of MaaS bundles using RP data from Denmark. They found that stability in travel demand indeed is an important criterion for the financial viability of individual modal components in MaaS bundles and that week-to-week variation in shared modes (i.e., carsharing, bikesharing, taxi) is often too high for them to be included in recurring bundles. In turn, PAYG is suggested as a more suitable way of including them in MaaS solutions. Informal feedback from participants in the Sydney MaaS trial suggests that variations in travel demand from one month to the next indeed has an impact on bundle subscription. Figure 6 shows that a few PAYG participants (P070, P086, P017, P011, P098) have a monthly Opal outlay in excess of $125 for some months, while the outlay for other months are smaller than $100. This variation may well be one of the factors that explains why these participants chose PAYG, even for the month that their travel cost would exceed the value that they would be financially better off by subscribing to any bundle on offer rather than using PAYG. Two indices, referred to as intra-personal week-to-week travel variation (IWTV) that measure the average variation in PT trips and Uber/taxi trips are investigated in modelling

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\(^{102}\) Here, we must recognise the potential bias due to self-selection. Specifically, prior to the trial no participant was using the SkedGo App, TripGo, which was the foundation for the enhancements associated with Tripi. All participants were offered the Tripi app for searching and planning their journeys during the trial period, and thus, it is possible that the multimodal journeys facility, and hence the multi-modality index, might be influenced by the options listed by the Tripi app; however, the Tripi app allows its users to set up their priorities, including time, cost, hassle, CO\(_2\) convenience, so that the resulting transport options are listed in an order that reflects individual preferences. This reduces the potential self-selection bias of the journey planner app. We also ran an exit survey, seeking participant preferences for journey planner app (amongst other things). The results indicated that, on a scale from 1 (most preferred) to 5 (least preferred) Google Maps was ranked top, with an average score of 2.12; followed by TripView (2.44) and Tripi (2.67). The least preferred apps were Metarove and City Mapper (4.67). Thus, while Tripi provides a journey planning capability, the participants may prefer and use another app to plan their journeys if they wish.
to capture the impact of travel variation on bundle subscription. The intra-personal day-to-day travel variation (IDTV) described in Stopher (2012) and Li et al (2018) are adapted to measure IWTV.

The number of days active on Tripi is a special consideration for December and January which were disrupted by the Christmas shutdown and New Year holiday travel when some participants were not using Tripi for a part or all of the month for which subscription fee is payable. For the purpose of computing this metric, a participant is said to be active if they have at least one trip recorded to the Tripi or the Safer Journey\textsuperscript{103} database. Finally, the previous bundle a participant was on is a relevant metric designed to capture an inertia effect and/or ‘forgetfulness’ effect, the latter relating to forgetting to change a bundle by the first of each month, the date required to allow bundle switching, and hence becoming stuck with the previous bundle for the current month.

The model form – Mixed Logit with correlated random parameters

The mixed logit model differs from the MNL model in that it assumes that at least some of the parameters are random, following a certain probability distribution (Hensher et al. 2015). These random parameter distributions are assumed to be continuous over the sampled population. The choice probabilities of the mixed multinomial logit (MMNL) model, \( P_n^* \), depends on the random parameters with distributions defined by the analyst. The MMNL model is summarised below in (1).

\[
Prob(choice_{ns} = j | x_{nj}, z_n, v_n) = \frac{\exp(V_{nj})}{\sum_{j=1}^{J}\exp(V_{nj})}
\]

where

\[
V_{nj} = \beta^\prime x_{nj}
\]

\[
\beta_n = \beta + \Delta z_n + \Gamma v_n
\]

\( x_{nj} \) = the \( K \) attributes of alternative \( j \) in choice situation \( c \) faced by individual \( n \),

\( z_n \) = a set of \( M \) characteristics of individual \( n \) that influence the mean of the taste parameters; and

\( v_n \) = a vector of \( K \) random variables with zero means and known (usually unit) variances and zero covariances.

The MMNL model embodies both observed and unobserved heterogeneity in the preference parameters of individual \( n \). Observed heterogeneity is reflected in the term \( \Delta z_n \) while the unobserved heterogeneity is embodied in \( v_n \). Structural parameters to be estimated are the constant vector, \( \beta \), the \( K \times M \) matrix of parameters \( \Delta \) and the nonzero elements of the lower triangular Cholesky matrix, \( \Gamma \), the latter to account for interdependencies between random parameters. The expected probability over the random parameter distribution can be written as equation (2).

\[
E(P_n^*) = \int_{\beta} P_n^*(\beta) f(\beta | \Omega)d\beta.
\]

\( f(\beta | \Omega) \) is the multivariate probability density function of \( \beta \), given the distributional parameters \( \theta \). By using a transformation of \( \beta \) such that the multivariate distribution becomes semi-parametrical, we can write Equation (2) as equation (3).

\[
E(P_n^*) = \int_{z} P_n^*(\beta(z | \Omega)) \phi(z)dz,
\]

\textsuperscript{103} Safer Journeys is a car-based program with GPS tracking technology installed to make car journeys safer, by for example deploying an ambulance to the accident location if the driver did not answer the phone from the call centre who recognises some sudden incidents that may have happened with the trip, based on the tracking data. A by-product of this program is that private car use can be tracked and used as a complementary data source to assess the success of the MaaS trial in terms of reducing emissions through reduced car kilometres.
\( \beta(z \mid \Omega) \) is a function of \( z \) with parameters \( \Omega \), and where \( \phi(z) \) is the multivariate non-parametrical distribution of \( z \). It is common to use several (independent) univariate distributions\(^{104} \) instead of using a single multivariate distribution, such that Equation (3) can be written as equation (4).

\[
E(P_n) = \int_{z_1} \cdots \int_{z_K} P_n(z_1, \ldots, z_K | \theta_1, \ldots, \theta_K) \phi_1(z_1) \cdots \phi_K(z_K) dz_1 \cdots dz_K. \tag{4}
\]

\( \beta(z_1 \mid \mu, \sigma) = \mu + \sigma z_1 \) with \( z_1 \sim N(0,1) \) following a standard normal distribution, as used herein. Note that a fixed parameter is a special case of a random parameter, such that all equations also hold in the case that only some of the parameters are considered random. For a fixed parameter \( \beta_k \) we take \( \beta_k(z_k \mid \mu_k) = \mu_k \), and \( \phi_k(z) = 1 \). Models involving multivariate distributions are generally limited to situations in which all random parameters are assumed to be normally distributed, and involve correlating the random parameters via a process known as Cholesky decomposition. To calculate the elements of this matrix given \( \Omega \), equations 5a-5d are utilised.

\[
s_{ii} = \sqrt{\eta_{ii}}, \forall k = l = 1 \quad \text{(the first diagonal element)} \tag{5a}
\]

\[
s_{ii} = \sqrt{\eta_{ii} - \sum_{k=1}^{i-1} s_{ik}^2}, \forall k = l \neq 1 \quad \text{(all other diagonal elements)} \tag{5b}
\]

\[
s_{ij} = (\eta_{ii})/s_{ii}, \forall k = l, i \neq l \quad \text{(lower off-diagonal elements in the first column)} \tag{5c}
\]

\[
s_{kl} = (\eta_{kl} - \sum_{k=1}^{i-1} s_{ik} s_{ik})/s_{kk}, \forall k \neq l, k \neq l \quad \text{(lower off-diagonal elements not in the first column)} \tag{5d}
\]

Once computed, the values for \( \omega_1 \) are determined as shown in (7), which may be rewritten as (8).

\[
\begin{pmatrix}
\omega_1 \\
\omega_2 \\
\omega_3 \\
\omega_4
\end{pmatrix} =
\begin{pmatrix}
s_{11} & 0 & 0 & 0 & z_1 \\
s_{21} & s_{22} & 0 & 0 & z_2 \\
s_{31} & s_{32} & s_{33} & 0 & z_3 \\
s_{41} & s_{42} & s_{43} & s_{44} & z_4
\end{pmatrix},
\]

\[
\omega_1 = s_{11} z_1,
\omega_2 = s_{21} z_1 + s_{22} z_2,
\omega_3 = s_{31} z_1 + s_{32} z_2 + s_{33} z_3,
\omega_4 = s_{41} z_1 + s_{42} z_2 + s_{43} z_3 + s_{44} z_4,
\]

where \( s_{ij} \) are parameters to be estimated, and \( z_k \) are draws from univariate standard Normal distributions. \( \omega_2 \) are reported in Table 2 below for the diagonal and off-diagonal components of the L matrix.

\(^{104}\) Note that if one would not like to assume independent random variables, then one can sample directly from the multivariate distribution. In case of a multivariate normal distribution, this is possible through a Cholesky decomposition, see e.g., Hensher et al. (2015).
We have allowed for the panel nature of the data. The derivation of the log-likelihood functions of the panel formulations of the MMNL model differs to those of their equivalent cross sectional forms in that the choice observations are no longer assumed to be independent within each respondent (although the independence across respondents assumption is maintained). Mathematically, this means that $E(P_{12}) \neq E(P_1)E(P_2)$, hence the log-likelihood function of the panel MMNL model may be represented as:

$$\log E(L_n) = \sum_{n=1}^{N} \log E \left( \prod_{s \in S_n} \prod_{j \in J_n} \left( P_{nj} \right)^{y_{nj}} \right).$$

(9)

where $N$ is the total number of trial participants ($N = 93$), $S_n$ is the number of trial months that individual $n$ has a choice of subscription plan. Note that the value of $S_n$ varies across participants, with those who joined the trial in November 2019 having four choices of monthly subscription, while those who joined the trial in January 2020 have two choices to make for monthly subscription (i.e. Feb and Mar 2020).

Descriptive overview of the trial

The rich data available from the trial has been integrated into a format suitable for choice modelling. We have captured data from the pre-trial travel activity survey which included socio-economic details, residential and work locations, and modal use in terms of frequency of use. The mobility activity captured through the digital platform Tripi during the trial was used to construct a number of measures of travel response associated with the take up of specific bundles or the use of PAYG.

Given that we are particularly interested in how participants’ travel activity and costs outlays, especially cost savings, influence MaaS bundle choices, we have constructed a number of measures designed to test for candidate influences on selection of a specific bundle or PAYG, as summarised in Table 1 with the overall set of variables in the data compiled for the analysis herein. Most notably, these are the estimated monthly saving by subscribing to a specific bundle instead of PAYG, the percent cost outlay compared to the previous monthly cost for each of the available modes (public transport, ride share and car share), and the intra-personal week-to-week travel variation (IWTV) for each of the modes. In recognising that the participant data is collected over a number of months with noticeable seasonal variation in mobility activity, for example the December and January holiday months compared with the February and March period, we have controlled for these effects through monthly dummy variables.

The profile of the sample is summarised by a number of key indicators in Figure 8 to 10 for participants choosing each bundle and PAYG. The number of active days represents the number of days in the subscription month with travel activity, and is included in the formal choice model to recognise these difference in temporal (anticipating) participant rates which may influence choices made. Although the average number of active days in a subscription month for the trial sample is 16.18 days, the average varies from 13.67 days for PAYG through to 21.43 days for Saver25, with 17.77 days for GreenPass, 18 for SuperSaver25 and 18.75 for Fifty50. It is interesting to note the much lower average number of days for PAYG, which may be a contributing influence on participants’ decisions to stay with PAYG, given that the bundles are monthly commitments. This is an important point since it appears that participants may be reticent about subscribing to a monthly bundle when they do not anticipate regular travel over most weekdays (at least) throughout a month. In the post-Covid-19 period, we expect this to be a concern that will require careful thought on the subscription period for MaaS bundles with increasing working from home (see Hensher 2020).
Table 1. Descriptive statistics of the sample

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (Standard Deviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>number of days joined Tripi when the Communications email sent out</td>
<td>46.34 (27.6)</td>
</tr>
<tr>
<td>number of days joined Tripi by the end of the month when choice of bundle must be made</td>
<td>56.43 (25.9)</td>
</tr>
<tr>
<td>monthly cost estimated in the Communications email ($)</td>
<td>181.2 (127.5)</td>
</tr>
<tr>
<td>estimate monthly saving by subscribing to the bundle instead of PAYG ($)</td>
<td>5.93 (26.19)</td>
</tr>
<tr>
<td>cost of previous month travel ($)</td>
<td>337.85 (363.0)</td>
</tr>
<tr>
<td>percent cost of PT to previous monthly cost</td>
<td>0.727 (0.305)</td>
</tr>
<tr>
<td>percent cost of taxi/Uber to previous monthly cost</td>
<td>0.235 (0.270)</td>
</tr>
<tr>
<td>percent cost of GoGet to previous monthly cost</td>
<td>0.037 (0.154)</td>
</tr>
<tr>
<td>user’s own estimate of monthly cost</td>
<td>174.4 (142.8)</td>
</tr>
<tr>
<td>user’s own estimate of monthly saving if subscribe to a bundle</td>
<td>2073 (25.45)</td>
</tr>
<tr>
<td>Commuting distance (km)</td>
<td>15.13 (13.82)</td>
</tr>
<tr>
<td>average IWTV for PT trips</td>
<td>1.811 (0.998)</td>
</tr>
<tr>
<td>standardised index of IWTV for PT trips</td>
<td>0.728 (0.178)</td>
</tr>
<tr>
<td>percentage of variation in PT trips to average number of weekly PT trips</td>
<td>0.265 (0.139)</td>
</tr>
<tr>
<td>average IWTV for taxi/Uber/GoGet trips</td>
<td>0.039 (0.208)</td>
</tr>
<tr>
<td>standardised index of IWTV for taxi/Uber/GoGet trips</td>
<td>0.033 (0.157)</td>
</tr>
<tr>
<td>percentage of variation in taxi/Uber/GoGet trips to average number of weekly taxi/Uber/GoGet trips</td>
<td>0.018 (0.089)</td>
</tr>
<tr>
<td>number of active days in the subscription month</td>
<td>16.18 (7.81)</td>
</tr>
<tr>
<td>number of household adults (adults)</td>
<td>2.187 (0.823)</td>
</tr>
<tr>
<td>number of household children</td>
<td>0.798 (0.911)</td>
</tr>
<tr>
<td>having access to private car = 1 (caracc)</td>
<td>0.765</td>
</tr>
<tr>
<td>number of household drivers (hhdriv)</td>
<td>1.925 (0.772)</td>
</tr>
<tr>
<td>number of household cars (hhcar)</td>
<td>1.242 (0.786)</td>
</tr>
<tr>
<td>subscribe to Fifty50 in the previous month</td>
<td>0.135</td>
</tr>
<tr>
<td>subscribe to GreenPass in the previous month</td>
<td>0.056</td>
</tr>
<tr>
<td>subscribe to Saver25 in the previous month</td>
<td>0.090</td>
</tr>
<tr>
<td>has driver licence = 1</td>
<td>0.895</td>
</tr>
<tr>
<td>age &lt;=24 years dummy</td>
<td>0.039</td>
</tr>
<tr>
<td>age 25 - 34 years dummy</td>
<td>0.343</td>
</tr>
<tr>
<td>age 35 - 44 years dummy</td>
<td>0.377</td>
</tr>
<tr>
<td>age 45 - 54 years dummy</td>
<td>0</td>
</tr>
<tr>
<td>age 55 - 64 years dummy</td>
<td>0.054</td>
</tr>
<tr>
<td>male participant dummy</td>
<td>0.472</td>
</tr>
<tr>
<td>Age in years</td>
<td>28.98 (16.31)</td>
</tr>
<tr>
<td>Households with zero cars</td>
<td>0.112</td>
</tr>
<tr>
<td>Households with one car</td>
<td>0.611</td>
</tr>
<tr>
<td>Households with two or more cars</td>
<td>0.263</td>
</tr>
<tr>
<td>Proportion of sample in January 2020</td>
<td>0.231</td>
</tr>
<tr>
<td>Proportion of sample in February 2020</td>
<td>0.297</td>
</tr>
<tr>
<td>Proportion of sample in March 2020</td>
<td>0.348</td>
</tr>
<tr>
<td>Proportion of sample in December 2019</td>
<td>0.123</td>
</tr>
</tbody>
</table>

The socio-economic profile has some noticeable differences between the chosen bundle and PAYG. Those who chose GreenPass and SuperSaver25 have on average 0.32 and 0.36 children respectively, which is much lower than Fifty50 (0.90) and SuperSaver25 (1.07), and PAYG comes in at 0.79 children. In contrast, the average number of adults in a household associated with participants choosing a bundle or PAYG are very similar, averaging from 2.0 (SuprSaver25) to 2.4 (Saver25). The most interesting result is the incidence of access to a car, which is very flat across all alternatives, varying from 0.73 for GreenPass to 0.82 for Saver25 and, with similar standard deviations, might explain why this was not statistically significant in the choice model. The number of household cars, however, does vary much more across the chosen bundles and PAYG, from 1.05 for GreenPass to 1.57 for Saver25. The choice model results below find the number of household cars to have an influence on the alternatives offered. Although there are sizeable differences in the number of participants in each age category, there is very little variation within an age category across the chosen bundles and PAYG. This may explain why, in the choice modelling, the conversion of age to a continuous variable was the only way to engender variation in age across the sample that was able to be related to bundle and PAYG choice.
The left hand side of Figure 9 shows the profile of three monthly cost indicators, namely the cost of travel in the previous month (pmthcost), the user’s own estimate of the monthly cost outlay for the next month (uestcost) if they were to repeat the travel patterns observed to date, and the user’s own estimate of the monthly cost savings (uestsave) if they subscribe to a bundle instead of paying-as-they-go. The profiles show that a participant’s estimate of cost outlays is, on average, greatest for participants who chose Saver25 ($332.9) and the lowest for those who chose PAYG ($129.7). This is an interesting finding, suggesting that when one has a lower travel cost outlay per month, the likelihood of choosing a bundle decreases, possibly because the expectation of a financial savings is going to be smaller compared to those participants who have a greater financial outlay. While intuitive, the results lend credit to previous SP studies of Ho et al. (2018, 2020b) in that users’ current travel patterns (multimodality, transport cost per month) is a good indicator of viability of bundles. This finding provides an important indicator criterion in identifying MaaS segments. The perceived average user savings is very small in the range of $12 for SuperSaver25 choosers and $39.87 for GreenPass, with $17.6 for Saver25 and $15.6 for Fifty50.

The right hand side of Figure 9 shows the proportion of the modal cost relative to monthly cost of travel for participants choosing a bundle or PAYG. As a proportion, this metric is bound between zero and one, with the value of zero for any particular mode (or modes of the same type such as taxi and Uber) indicating that the subscribers do not use that mode. The greatest proportion of cost outlay for public transport is associated with the GreenPass subscribers at 87%, which is expected given that subscribers to this bundle are heavy public transport users (and hence willing to pay the highest subscription fee of $125 per month to travel on PT for free). By contrast, the proportion of PT cost to monthly cost is lowest for Saver25 and its successor, the SuperSaver25 (at around 48%), while that for the Fifty50 and PAYG users is much higher, at 77% and 72% respectively. Note that the monthly cost for PAYG users is lowest (see Figure 9), which may explain why they stayed with PAYG even though various bundles offer generous discounts for PT fares. For taxi and Uber, the greatest proportion of monthly month is for Saver25 and SuperSaver25 subscribers, on average accounting for about 45% of the monthly transport cost. This proportion is much smaller, at around 20% the Fifty50 and PAYG users, and 12% for GreenPass subscribers. For car share (i.e., GoGet), with so few participants selecting to use GoGet, the results are uninformative. The message in this evidence is that the choice of monthly bundle is likely to show a significant influence from this indicator, with GreenPass users opt in for PT discounts while Saver25 users are in for discount to ride share. We test these assumptions in the model estimation, and results are reported below.
The final descriptive profile, presented in Figure 10, refers to variations in the number of modal trips that is designed to capture impacts on bundle choice. We have developed a measure to capture the average \((m_\text{IWTV})\), the standardised index \((z_\text{IWTV})\) and the proportional \((p_\text{IWTV})\) intra-personal week-to-week travel variation (IWTV) for public transport \((\text{IWTV}_{\text{pt}})\), and for taxi/Uber (ride-share) and car-share (GoGet) combined \((\text{IWTV}_{\text{tg}})\). The greater the variation, the more likely we suggest that participants might be more careful in committing to a bundle, which in a sense is linked to variety seeking in contrast to habitual mobility behaviour.

Looking at the mean variations \((m_\text{IWTV})\), we find on average for public transport, the greatest variation for choosers of GreenPass and Fifty50, with the other two bundles and PAYG being similar \((1.56 \text{ to } 1.71)\), and for ride share and car share, the greatest variation is with choosers of Saver25 and SupeSaver25, both of which were designed to focus on grow use of these modes with a lower entry barrier (subscription cost of $25 per month). The mean variation for PAYG, Fifty50 and GreenPass for ride share and car share is so small that it suggests habitual weekly behaviour. What this suggests, to some extent, is that a greater variation in trip activity between weeks does tend to increase the chance of choosing some bundles but not all bundles; however when we consider the standardised index \((z_\text{IWTV})\), we find almost no difference associated with public transport across all alternatives; with the same applying for ride share and car share, except for Saver25 which exhibits sizeable standardised variation. Finally the proportional variation of modal trips relative to the average number of weekly modal trips is almost identical for public transport (in the range of 0.24 to 0.28); and for ride share and car share the range is negligible from 0 to 0.06, with again choosers of Saver25 showing the greatest variation.

**Figure 10. Variation in monthly mode-specific trip activity for participants choosing each bundle and PAYG**
In concluding this descriptive assessment, it is important to note that the profiles above are presented at their average levels, within participants choosing each bundle, whereas in the choice model estimation in the next section we allow for the full distribution across all participants, which can be expected to result in a different set of behavioural inferences.

Model results

The final MNL model is summarised in Table 2. The overall goodness of fit is very impressive with a pseudo $R^2$ of 0.60. In selecting this model form, we also estimated other choice model forms including nested logit, random regret, latent class, random regret latent class, error components and combinations thereof, but none were found to improve on the mixed logit model with Cholesky decomposition included to account for correlated random parameters.

Three variables are represented through random parameters, namely the estimated monthly savings by subscribing to Fifty50, GreenPass and Saver25 (or SuperSaver 25 in March) bundles. 1,000 Shuffled Halton draws were used. All are statistically significant at the mean and standard deviation and of the expected positive sign, although the mean estimate for Saver25/SuperSaver25 is marginally significant at 1.85 but with a significant standard deviation beta well above the 95 percent confidence level, with t-value at 2.60. The estimated monthly savings to subscribing to a bundle is a very significant source of preference heterogeneity as captured by the random parameters and their Cholesky decomposition.

This suggests that a higher estimated monthly savings has a positive impact on the probability of choosing a bundle, which aligns with the role that financial discounts might play in promoting a subscription to a bundle offer. The Cholesky parameter estimates, accounting for the interdependence between the random parameters, play an important role in purging the mean and standard deviation estimates of correlation amongst the estimates. As shown in Table 2, the diagonal and off-diagonal parameter estimates are in the main statistically significant, and indeed the model in which we assumed independent random parameter effects resulted in some statistical insignificance for the standard deviation beta for Saver25/SuperSave25. Without Cholesky, the random parameters have to be a constrained normal to obtain significant SD betas, essentially constraining the full distribution in capturing preference heterogeneity. The pairwise correlations between the random parameter estimates for these three bundles are 0.647 between the GreenPass and Saver25/SuperSaver 25, 0.895 for Fifty50 and Saver25/SuperSaver25 and 0.893 for Fifty50 and GreenPass. The extent of the behavioural response is discussed later when we report and interpret the elasticity estimates and simulated scenarios.

Turning to PAYG, in addition to controlling for the month of participation, we find that there are some statistically significant socio-economic influences on the probability of choosing PAYG and to stay with it over time. Male participants are associated with a statistically significant positive parameter estimate, suggesting that they have a greater propensity to choose PAYG compared to female participants, and interestingly, households with one car and with two plus cars, compared to zero car households, both have a lower probability of choosing PAYG compared to choosing a bundle. This is an interesting finding given that it was thought, a priori, that households with cars might be less inclined to choose a bundle which offers mobility options that are likely to reduce the need to use household cars. The evidence suggests this is not the case, and knowing that having more cars in the household is not a negative influence on subscribing to a bundle is a very powerful finding.

We also found that participant age has a statistically significant negative influence on the probability of choosing PAYG, and hence it is expected that older participants have a lower probability of choosing PAYG compared to young participants. We might speculate that younger participants in general have greater flexibility in their travel activity needs, described as less fixed in their ways, compared to older

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105 Including error components was problematic in its impact on other variables of interest which become statistically non-significant.
106 Train et al. (2004) proposed a refinement of the method of Halton sequences that involves assembling the pools of draws that are deterministic of a Markov chain, and shuffling them before using them in estimation, as a way of further reducing imposed correlation.
107 It is interesting to note that without accounting for the interdependencies between the random parameters, we may have artificially adopted a constrained distribution to obtain statistically significant parameter estimate while denying the full representation of the distribution of preference heterogeneity.
people, and are much more satisfied to pay as they go. However, as shown in Figure 11, we see that the relatively very young (12 persons in the sample) have a low propensity to choose PAYG, in contrast to participants in their 30s (13 participants) and 40s (11 participants); however there is overall a stronger propensity to choose a bundle, particularly participants in the 25 – 34 age bracket. The 16 participants over 65 also generally preferred a bundle to PAYG. We retained the single age variable after testing a set of dummy variables for age range (Figure 11), which were found to be statistically insignificant.

![Figure 11. Choice of monthly bundle by age groups](image)

We also investigated other available socioeconomic variables such as car access and licence holding (Table 1), and none of them had a statistically significant influence in the utility expressions of any of the five alternatives.

We wanted to see if the participants follow a suggestion made to them of not taking a bundle if they joined Tripi less than a certain duration such as two weeks by the end of the month when choice of bundle must be made. We found that a dummy variable distinguishing up to three weeks from more than three weeks worked best and was statistically significant in contrast to periods of one or two weeks. The duration of this effects was extensive, ranging for 3 days to 102 days, with a mean of 56 days.

The number of days active in a month is a statistically significant conditioning effect since we expect and find that the more active days in a month, the higher the probability of choosing Fifty50 and GreenPass bundles compared to PAYG, Saver 25 and SuperSaver25. The cost of the previous month’s travel is significant and positive in all of the bundle alternatives, suggesting that the more the participant spends in a previous month, the more likely they are to take up a bundle. This is a very important finding, indicating that trial participants are clearly hoping to benefit by bundle subscription, especially when the monthly transport cost outlay, and hence the potential saving, justifies the subscription fees of at least one monthly bundle.

An interesting variable investigated relates to the percent cost of a specific mode cost relative to the previous monthly cost in a bundle. The mean values in the sample are 72.7%, 23.5% and 3.7% respectively for public transport, ride share and care share. The evidence supporting this expectation varies across the bundles, which is encouragingly consistent with our effort to ensure that we offered up, incrementally, various bundles that did not necessarily dilute the take up of other bundles. We found that the percentage of the cost of public transport relative to the previous month’s cost for the GreenPass was positive and statistically significant, suggesting that again with the high incidence of public transport use under free travel offered by this bundle, the cost gain is sizeable and attractive in the selection of GreenPass. In Saver25 and SuperSaver25, however, we found statistically significant parameters for the percent cost of taxi/Uber and also GoGet compared to the previous month, with positive signs and similar magnitudes, suggesting that, ceteris paribus, when the share of monthly costs associated with the use of flexible modes (taxi, Uber, and GoGet which are generously discounted in the Saver25 and SuperSaver25 bundles) increases, participants prefer to choose Saver25 and SuperSaver25 bundles compared to the PAYG, Fifty50 and GreenPass options.
The final variable that was statistically significant and associated with Saver25 and SuperSaver25 is the percentage of variation in public transport trips around the average number of weekly public transport trips. This variable, tested for each mode initially, is designed to establish whether variations in modal trip activity impact on the choice of a bundle compared to PAYG as discussed in a previous section. For each of public transport, ride share and car share, we considered three specifications: the average intra-personal day-to-day travel variation (IWTV) for specific modal trips, the standardised index of IWTV for such trips, and the percentage of variation in modal trips relative to the average number of

<table>
<thead>
<tr>
<th>Variables</th>
<th>Units</th>
<th>Alternatives</th>
<th>Parameter estimates (t-value)</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean of random parameters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated monthly saving by subscribing to a bundle $/month</td>
<td>Fifty50</td>
<td>0.0680 (3.18)</td>
<td>0.026 to 0.1099</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GreenPass</td>
<td>0.1080 (4.38)</td>
<td>0.059 to 0.156</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Saver25</td>
<td>0.0657 (1.85)</td>
<td>-0.004 to 0.135</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SuperSaver25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard deviation random parameters (normal distribution)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated monthly saving by subscribing to a bundle $/month</td>
<td>Fifty50</td>
<td>0.0919 (3.73)</td>
<td>0.044 to 0.140</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GreenPass</td>
<td>0.0787 (4.31)</td>
<td>0.043 to 0.115</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Saver25</td>
<td>0.1479 (2.60)</td>
<td>0.036 to 0.260</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SuperSaver25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-random parameters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1,0</td>
<td>PAYG</td>
<td>1.0146 (2.25)</td>
<td>0.129 to 1.900</td>
</tr>
<tr>
<td></td>
<td>years</td>
<td>PAYG</td>
<td>-0.0391 (-2.63)</td>
<td>-0.068 to 0.010</td>
</tr>
<tr>
<td>Age</td>
<td>1,0</td>
<td>PAYG</td>
<td>-3.0372 (-2.47)</td>
<td>-5.44 to -0.630</td>
</tr>
<tr>
<td>1 car in household</td>
<td>1,0</td>
<td>PAYG</td>
<td>-4.326 (3.08)</td>
<td>-7.080 to 1.580</td>
</tr>
<tr>
<td>2 or more cars in household</td>
<td>1,0</td>
<td>PAYG</td>
<td>1.8884 (2.22)</td>
<td>0.218 to 3.558</td>
</tr>
<tr>
<td>January monthly participation</td>
<td>1,0</td>
<td>PAYG</td>
<td>1.4454 (1.92)</td>
<td>-0.027 to 2.918</td>
</tr>
<tr>
<td>February monthly participation</td>
<td>1,0</td>
<td>PAYG</td>
<td>1.8123 (2.22)</td>
<td>0.214 to 3.411</td>
</tr>
<tr>
<td>March monthly participation</td>
<td>1,0</td>
<td>All Bundles</td>
<td>1.8581 (2.19)</td>
<td>0.192 to 3.524</td>
</tr>
<tr>
<td># days joined Trip by end of month &lt; 21 days</td>
<td>1,0</td>
<td>Fifty50</td>
<td>-6.9942 (-3.72)</td>
<td>-10.00 to -3.121</td>
</tr>
<tr>
<td>Bundle specific constant</td>
<td></td>
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<td>Bundle specific constant</td>
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<tr>
<td>Bundle specific constant</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Number of active days in the month</td>
<td>#days/month</td>
<td>Fifty50</td>
<td>0.0814 (2.07)</td>
<td>0.004 to 0.158</td>
</tr>
<tr>
<td></td>
<td>#days/month</td>
<td>GreenPass</td>
<td>0.1591 (2.36)</td>
<td>0.027 to 0.291</td>
</tr>
<tr>
<td>Number of active days in the month</td>
<td>#days/month</td>
<td>All Bundles</td>
<td>0.0045 (2.24)</td>
<td>0.001 to 0.009</td>
</tr>
<tr>
<td>Cost of previous month travel $/month</td>
<td>0 to 1</td>
<td>GreenPass</td>
<td>2.7481 (1.60)</td>
<td>-0.708 to 6.200</td>
</tr>
<tr>
<td>Proportion of Uber/Taxi cost to monthly cost</td>
<td>0 to 1</td>
<td>Saver25</td>
<td>2.3075 (2.10)</td>
<td>0.053 to 4.56</td>
</tr>
<tr>
<td>Proportion of carshare cost to monthly cost</td>
<td>0 to 1</td>
<td>Saver25</td>
<td>6.7628 (2.95)</td>
<td>2.274 to 11.251</td>
</tr>
<tr>
<td>Proportion of variation in PT trips to average weekly PT trips</td>
<td>0 to 1</td>
<td>Saver25</td>
<td>-3.5368 (-1.60)</td>
<td>7.910 to 0.836</td>
</tr>
<tr>
<td>Diagonal values in Cholesky matrix, L</td>
<td>Fifty50</td>
<td>Fifty50</td>
<td>0.9186 (3.73)</td>
<td>0.043 to 0.141</td>
</tr>
<tr>
<td></td>
<td>GreenPass</td>
<td>GreenPass</td>
<td>0.0354 (1.72)</td>
<td>-0.005 to 0.076</td>
</tr>
<tr>
<td></td>
<td>Saver25/SuperSaver25</td>
<td>Saver25</td>
<td>0.0432 (1.40)</td>
<td>-0.019 to 0.106</td>
</tr>
<tr>
<td>Below diagonal values in L matrix</td>
<td>Fifty50/GreenPass</td>
<td>0.0703 (3.38)</td>
<td>0.030 to 0.111</td>
<td></td>
</tr>
<tr>
<td>Fifty50/Saver25/SuperSaver25</td>
<td>0.1323 (2.65)</td>
<td>0.034 to 0.231</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GreenPass/Saver25/SuperSaver25</td>
<td>0.0499 (-0.96)</td>
<td>-0.152 to 0.052</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Covariances of random parameters</td>
<td>Fifty50</td>
<td>0.0065 (1.89)</td>
<td>-0.000 to 0.013</td>
<td></td>
</tr>
<tr>
<td>GreenPass</td>
<td>0.0121 (1.70)</td>
<td>-0.002 to 0.026</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saver25/SuperSaver25</td>
<td>0.0075 (1.12)</td>
<td>-0.006 to 0.021</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Log-likelihood at convergence -578.83
Restricted log-likelihood -489.27
McFadden Pseudo R² 0.600
AIC/sample 1.473
Sample size 304
weekly trips by that mode. Only one effect was identified as statistically significant, suggesting that a greater percentage variation around the mean for public transport trips tends to reduce the probability of choosing Saver25 and SuperSaver25 compared to PAYG and the other two bundles.

None of the dummy variables associated with the bundles the participant had subscribed to was on in the last month were statistically significant, suggesting that the inertia effect, caused by, for example, the cost of transaction or forgetfulness, is negligible. This is because all participants were reminded via personal emails to make choices for the following month’s subscription by the end of each month, and switching monthly bundles incurs no cost, but a tap on the Tripi app. Put it differently, participants were free to choose any monthly bundle they see fit for the following month, irrespective of their current subscription.

We also tested distance of commuting trips, an obvious “main trip” for all participants, as an explanatory variable in our model given that it plays a major role in day-to-day decisions of people, but this variable was statistically insignificant, given the inclusion of other variables. Thus, to model individual choices of mobility bundles for the entire month, we suggest that trip-specific indicators such as trip distance and duration are less appropriate than other composite metrics included in the model such as the estimated monthly cost, and percent cost of public transport, taxi, and car-share to the previous months cost. One possible explanation is that while trip duration and distance may have a major role in the decision of individuals at the trip level, such as the choice of travel modes, at the longer time horizon of a month’s worth of travel, the impact of these trip-specific metrics on mobility choice is less clear, and possibly is already captured by other composite metrics such as monthly cost savings. Despite the statistical significance of the parameter estimates discussed in Table 2, care must be taken in interpreting the numerical magnitude of each parameter estimate since they are non-comparable in this logit non-linear form, and hence below we present elasticities as a way of meaningfully comparing the impacts of each bundle component. Elasticities are more informative since they combine the parameter estimates with the levels of the variables and the choice probability outcomes to reveal behavioural responsiveness of interest in the probability of selecting a bundle. For the logit form, the point (or marginal) elasticity of the probability is given in equation (10), and the marginal effect in equation (11).

\[
\frac{\partial \log E(y|x)}{\partial \log x} = \frac{x_k}{E(y|x)} \cdot \frac{\partial E(y|x)}{\partial x} = \frac{x_k}{E(y|x)} \cdot \text{marginal effect} \tag{10}
\]

\[
\frac{\partial E(y|x)}{\partial x} = \frac{\partial F(\beta x)}{\partial x} = \frac{dF(\beta x)}{d(\beta x)} \beta = F'(\beta x)\beta = f(\beta x)\beta \tag{11}
\]

The point elasticity estimates of interest are summarised in Table 3. All the elasticities are statistically significant at the 95% confidence interval or better\(^{108}\). In interpreting Table 3, an elasticity is with respect to a change in \( X \) in row choice on column choice — the probability of choosing a specific bundle or PAYG; and direct elasticities are shared in grey and non-shaded values are cross-elasticities. As an example of the interpretation of the elasticity estimates, the estimated monthly saving by subscribing to a bundle ($/month) is as follows: a 1 percent (or marginal) increase in the estimated savings associated with choosing the Fifty50 bundle results in a 0.7332 increase in the probability of choosing Fifty50. The largest switch of another bundle or PAYG is from Saver 25. Likewise, a 1 percent increase in estimated savings associated with choosing the GreenPass bundle results in a 0.8423 increase in the probability of choosing GreenPass and 1.0045 in the probability of choosing Saver25. Extrapolating to non-marginal changes is risky and is discussed later in this section where we undertake simulated scenarios and report the implied direct arc elasticity as a way of accounting for behavioural responses associated with large non-marginal changes.

In reviewing all the findings in Table 3, with a few exceptions they are relatively inelastic (i.e., less than 1.0). The exceptions are 1.1349 for the number of days a participant joined Tripi by end of month when choice of bundle must be made for GreenPass, 1.0045 for the estimated monthly saving, and 1.2387

\(^{108}\) These results are available on request, including t-values and 95% confidence intervals. In computing elasticities, it is complex to compute the asymptotic standard errors. In NLOGIT, used in model estimation, we have developed approximation method using the Krinsky and Robb method to obtain the standard error estimates, enabling derivation of t-values and confidence levels. See Hensher et al. (2015) for more details.
and 1.7778 respectively for the cost of previous month travel associated with Saver25 and SuperSaver25. The great majority of the direct point elasticities less than unity are in the range between 0.5 and 0.85 regardless of sign. Since we have no extant literature to draw on, given the uniqueness of this modelling activity, there is no way of establishing the portability and reinforcement of the empirical evidence. What we can conclude is that there is significant behavioural responsiveness to changes in the levels of almost all the explanatory variables, which suggests that the choice of a specific bundle and PAYG can be quite volatile and hence, unlike other modal situations where manipulating travel costs and times have a far lesser behavioural responsiveness (i.e., sensitivity), this is not the case in MaaS. This is an important finding for designing and pricing MaaS bundles in practice as it suggests that the choice of a specific bundle and PAYG can be quite volatile and hence, unlike other modal situations where manipulating travel costs and times have a far lesser behavioural responsiveness (i.e., sensitivity), this is not the case in MaaS. This is an important finding for designing and pricing MaaS bundles in practice as it suggests that modular designs (as trialled in the UbiGo project in Sweden), where each individual / household can design their own MaaS bundle, might be superior to pre-defined MaaS bundles in exploiting the multiplicity of different willingness to pay levels for profit maximization.

This noticeably high (relative) behavioural response provides very encouraging signs for developing MaaS subscription bundles that will appeal to the market. To take one example, if we can identify a cost saving of 10 percent associated with a bundle compared to what people are currently outlaying, assuming this can be interpreted as marginal, then the probability of choosing each of the bundles we have designed and offered increases by 7.3 percent for Fifty50, 10 percent for Saver 25, 8.4 percent for GreenPass and 8.8 percent for SuperSaver25. Likewise, if we can identify individuals that exhibit a greater incidence of habitual behaviour in respect of weekly public transport trips, at least reducing variation by 10%, which is currently on average at 26.5%, the probability of choosing a bundle increases by 5.2% for Saver25 and 58.3% for SuperSaver25.

Table 3. Summary of direct and cross elasticities

<table>
<thead>
<tr>
<th></th>
<th>PAYG</th>
<th>Fifty50</th>
<th>Saver25</th>
<th>GreenPass</th>
<th>SuperSaver25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated monthly saving by subscribing to a bundle ($/month)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fifty50</td>
<td>-0.0758</td>
<td>0.7332</td>
<td>-0.5136</td>
<td>-0.4332</td>
<td>-0.3437</td>
</tr>
<tr>
<td>Saver25</td>
<td>-0.0224</td>
<td>-0.1811</td>
<td>1.0045</td>
<td>-0.0599</td>
<td>-0.4455</td>
</tr>
<tr>
<td>GreenPass</td>
<td>-0.0291</td>
<td>-0.2933</td>
<td>-0.1401</td>
<td>0.8423</td>
<td>-0.1957</td>
</tr>
<tr>
<td>SuperSaver25</td>
<td>-0.0028</td>
<td>-0.0542</td>
<td>-0.2335</td>
<td>-0.0367</td>
<td>0.8788</td>
</tr>
<tr>
<td>Number of days joined Tripi by end of month</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fifty50</td>
<td>-0.1321</td>
<td>0.7189</td>
<td>-0.2884</td>
<td>-0.2728</td>
<td>-0.2616</td>
</tr>
<tr>
<td>GreenPass</td>
<td>-0.0796</td>
<td>-0.2993</td>
<td>-0.1309</td>
<td>1.1349</td>
<td>-0.2211</td>
</tr>
<tr>
<td>Cost of previous month travel ($/month)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fifty50</td>
<td>-0.1083</td>
<td>0.7697</td>
<td>-0.4216</td>
<td>-0.3248</td>
<td>-0.5017</td>
</tr>
<tr>
<td>Saver25</td>
<td>-0.0428</td>
<td>-0.1553</td>
<td>1.2387</td>
<td>-0.0644</td>
<td>-0.6854</td>
</tr>
<tr>
<td>GreenPass</td>
<td>-0.0427</td>
<td>-0.1822</td>
<td>-0.0981</td>
<td>0.6902</td>
<td>-0.1898</td>
</tr>
<tr>
<td>SuperSaver25</td>
<td>-0.025</td>
<td>-0.0968</td>
<td>-0.3592</td>
<td>-0.0653</td>
<td>1.7778</td>
</tr>
<tr>
<td>Percent cost of Ride Share (Uber, Taxi) to previous month cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saver25</td>
<td>-0.0302</td>
<td>-0.0674</td>
<td>0.553</td>
<td>-0.0179</td>
<td>-0.1695</td>
</tr>
<tr>
<td>SuperSaver25</td>
<td>-0.0092</td>
<td>-0.027</td>
<td>-0.0889</td>
<td>-0.013</td>
<td>0.4951</td>
</tr>
<tr>
<td>Percent cost of Car Share (GoGet) to previous month cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saver25</td>
<td>-0.0128</td>
<td>-0.0122</td>
<td>0.2432</td>
<td>-0.0045</td>
<td>-0.1821</td>
</tr>
<tr>
<td>SuperSaver25</td>
<td>-0.0059</td>
<td>-0.0039</td>
<td>-0.0954</td>
<td>-0.0038</td>
<td>0.3083</td>
</tr>
<tr>
<td>Percent of variation in PT trips to average # weekly PT trips</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saver25</td>
<td>0.0287</td>
<td>0.0637</td>
<td>-0.52</td>
<td>0.0214</td>
<td>0.1401</td>
</tr>
<tr>
<td>SuperSaver25</td>
<td>0.0136</td>
<td>0.0321</td>
<td>0.0735</td>
<td>0.02</td>
<td>-0.5825</td>
</tr>
</tbody>
</table>
It is clear, despite the limited sample size, that there is interest in MaaS subscription plans if they are designed to appeal to the market (Table 4). The sample uptake for each of the bundles and PAYG is, respectively for PAYG, Fifty50, GreenPass and Saver 25, for February as the last full month before Covid-19 stopped most travel activity, 52.5%, 16.3%, 16.23% and 15%, representing 47.5% preference for one of the offered bundles. The estimated MMNL model (but not calibrated) has been able to come close to predicting this relative uptake, with the equivalent mean choice shares being 49.5%, 18.7%, 10.8% and 21%, giving a total of 50.5% preferring to choose a MaaS subscription plan.

Table 4. Probability of choosing PAYG and each bundle in February 2020

<table>
<thead>
<tr>
<th>Choice of alternative</th>
<th>Months available</th>
<th>Predicted probability (actual choices)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAYG</td>
<td>All months</td>
<td>0.495 (0.525)</td>
</tr>
<tr>
<td>Fifty50</td>
<td>December to March</td>
<td>0.187 (0.163)</td>
</tr>
<tr>
<td>GreenPass</td>
<td>February, March</td>
<td>0.108 (0.163)</td>
</tr>
<tr>
<td>Saver25</td>
<td>January, February</td>
<td>0.210 (0.150)</td>
</tr>
<tr>
<td>SuperSaver25</td>
<td>March</td>
<td>Revised Saver25 N/A February</td>
</tr>
</tbody>
</table>

The marginal rate of substitution (MRS) between two specific influences of interest are now discussed, namely monthly cost savings and the previous month’s cost outlay. These are the equivalent of a willingness to pay or accept measure. We used the delta test (Hensher et al. 2015) to obtain the standard errors for each MRS estimate. The mean estimate of $25.18 (t-value of 1.89) suggests that, ceteris paribus, a representative individual is willing to subscribe to a Fifty50 bundle (priced at $50) in a particular month if it saves, on average, $25.18 per month over the previous months cost, although the 95% confidence interval of -0.97 to 51.34 suggests a range in which willingness to subscribe exists as lower and higher estimates. The equivalent MRS for GreenPass (priced at $125) is $32.55 (t-value of 2.07) and for Saver25 (priced at $25) it is $30.91 (t-value of 1.65). The 95% confidence intervals, respectively for Fifty50, GreenPass and Saver25, are -$0.97 to $51.3, $.79 to $63.1, and -$5.78 to $67.6.

While the MRS is on value, in order to identify the extent to which changes in monthly financial savings over the previous month influence the probability of choosing each of the bundles and PAYG, we simulated a scenario in which we varied the savings from -$200 to $200 with a $10 increment. The results, shown in Figure 14, show very clearly the extent of switching to a bundle away from PAYG as the savings increases in the positive range. As might be expected, a negative savings is associated with a higher probability of choosing or staying with PAYG, although there is a small amount of bundle uptake, presumably for other reasons which were identified in the mid-trial and end of trial surveys as including curiosity and potential convenience in using a single app (Hensher et al. 2020b) and the flat rate effect (Reck et al., 2021). When the savings are positive and increase, we see an increase in the probability of choosing a bundle, with the greatest probability increase being for Fifty50, followed by GreenPass, with Saver25 flattening out once the savings reached around $100 per month. Note that the largest cost saving in the trial is $81 per month (Figure 15), with the greatest incidence of a positive saving in the range of $10 to $50. There are also a significant number of negative savings which equate with the dominance of choosing PAYG over that range, and which would have to be reviewed in a continuing MaaS program. This is an important finding as it indicates that there might be a business model in MaaS bundle provision when the mean MRS (e.g., $32 for GreenPass) plus provider subsidies ($50) is lower than its market price ($125).

The evidence suggests that financial savings do attract interest and take up of a bundle, and that the savings do not have to be overly large per month to influence this outcome. An important message from the trial is the critical importance of providing feedback to subscribers on a very regular basis of the amount of money outlaid in a month, and the potential savings associated with undertaking the exact same trips through subscription to a bundle plan. Cost feedback was identified by participants as a very positive feature of the trial, revealing cost outlays that many had never realised they made.

109 We have chosen February as the last full month given that after March 20, with the onset of restrictions associated with Covid-19, travel activity reduced substantially and we provided a 50% fee reimbursement of the subscription fee for the balance of March for participants who had subscribed to a bundle.
Figure 12. Simulated scenario impact of estimated monthly savings ($) by subscribing to a bundle vs. PAYG

Figure 13. The distribution of monetary savings between months for all bundles
Finally, the simulated scenarios have an underlying implied arc elasticity which can differ from the point elasticities in Table 3, given the non-marginal numerical magnitude of the changes in monthly cost savings. The equivalent arc direct elasticities (with point elasticities from Table 3 in brackets) are 0.418 (0.733) for Fifty50, 0.016 (1.00) for Saver25, 0.313 (0.842) for GreenPass, and 0.151 (0.879). These differences are substantial and are a reminder that point elasticities are valid at the margin for very small changes, but are unreliable for non-marginal large changes. Specifically, in the case of changes in monthly cost savings, a point elasticity over-estimates the behavioural response by a significant amount, and hence must not be used for such large changes.

Conclusions

This paper is the first revealed preference study, in contrast to earlier stated preference studies, to develop a choice model to assess the interest in MaaS subscription bundles compared to PAYG. Using the Tripi app developed by this trial, we have been able to track individual mobility, obtaining rich data and use them to establish individual travel needs of a sample of trial participants. Understanding individual travel needs through such tracking technology is crucial for segmenting the travel market and targeting them with attractive mobility bundles that have the potential to achieve MaaS objectives. Using the data collected through the MaaS app, together with the pre-trial and Safer Journeys datasets, we have been able to identify significant markets among the participants and incrementally develop and introduce mobility bundles that are appealing to the participants in the presence of the default PAYG option.

The findings are a transparent contribution to a topic that has garnered huge interest and often been subject to what is referred to as hype and rhetoric (Hensher et al. 2020). What has been missing is rigorous evidence on whether MaaS through subscription plans or bundles, has the potential to be of interest to segments of the population or the population more generally. While no one denies the desire to find, through innovative mobility services, better ways of supporting sustainability goals, the question remains as to whether MaaS is a force to do this, in a niche sense or in a scalable manner.

While the challenge is still out there, the Sydney trial has shown that with an appropriate level of incentive and a mix of subscription bundles targeting different market segments, MaaS could obtain a sizeable uptake. It is suggested from this study and the modelling activity, that noticeable savings in travel outlays matter and can influence the support for MaaS bundles, provided there is enough variation in bundle offers to accommodate the many and varied needs of the population. Here, we must recognise that despite obvious savings to monthly transport costs, some customers still prefer the flexibility of the PAYG option as this is more suitable for their travel needs which vary every week/month. This is evidenced by the statistical significance of the two metrics (i.e., IWVT and number of active days in the subscription month) that capture the variation in travel needs. The more the MaaS operator understands how their yet-to-subscribe customers may travel differently from one week/month to the next, the easier it is for the operator to design subscription bundles that attract people with a variation in travel need. Within the setting of the Sydney trial that lasted for five months, we have successfully designed four subscription bundles that attracted a significant percentage of the participants. With a longer trial period or a full launch of MaaS products such as Whim and a bigger population to target, new market segments could be identified and targeted with appropriate subscription bundles to increase uptake as a mean to alter travel behaviour towards more sustainable choices.

In suggesting that MaaS have real potential to contribute to the broader goals of society through changing travel behaviour that aligns with sustainability improvements, such as reduced emission and congestion, there is no guarantee that this will secure a business model that in any sense might be described as having commercial legs. This will in time be established and may require greater financial support from government (see Hensher et al. 2020 for a detailed discussion of this broader MaaS agenda), but we would suggest that the design, introduction and monitor of subscription bundles that the current paper claims contributions, is essential to the future of MaaS, and that PAYG alone is unlikely to have the capability of growing the market and delivering sustainable outcomes. In ongoing research, we are investigating the influence that specific modes play in the take up of particular subscription plans.

Given the (meant to be) relatively small sample size of the Sydney trial (although similar in size to the few trials to date) and the adopted model, which assumes no endogeneity bias, a common assumption in
discrete choice models, the model outputs including parameter estimates and elasticities must be interpreted carefully and transferred elsewhere or generalised to large population with caution. It is possible that the relationships between monthly savings and cost outlay on a specific transport mode to monthly transport cost, for example, with the likelihood of subscribing to a particular bundle will change in a model that accounts for endogeneity through modelling techniques such as control functions (Train, 2009), although recent research by Hensher et al. (2020) suggests that endogeneity tends to not be an issue in many carefully defined choice models in respect of behavioural outputs such as elasticities and values of travel time savings. Future research needs to consider the endogeneity issues and investigating the extent to which the many relationships reported in the current paper are sensitive to model specification. Finally, self-selection biases cannot be ruled out; however, it was not the focus of the study to be representative of the overall population but rather to explore the adoption and usage of an innovative MaaS app.

Authors’ contributions
All authors designed the MaaS trial approach and contributed equally to the writing of this paper. Chinh Ho was responsible for the intricate extraction of data from the pre-trial surveys and the in-field trial digital platform. David Hensher undertook the model estimation and initial interpretation of the modelling results and simulation application. Daniel Reck contributed to the development of the overall bundle design framework and the incremental approach. All authors undertook the overall review and final editing of the paper.

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Appendix I: Mobility as a Service users: Insights from a trial in Sydney

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Abstract

Despite the mounting number of Mobility as a Service (MaaS) schemes around the world, the accounts of the user perspective are still scarce. To address this knowledge gap, this paper reports users’ experiences from a MaaS trial in Sydney, Australia. Based on questionnaires and interviews, it analyses who participated in the trial and why, how they used the trialled service, and what experiences they reported. The contribution to the literature on MaaS is three-fold. Firstly, the majority of the people that signed up for the trial were frequent users of both public transport and private cars. This supports the notion that multi-modal travellers are more interested in MaaS than others and contradicts the fear that MaaS does not appeal to habitual car users. Secondly, a desire to contribute and curiosity were the main drivers for signing up for the trial, which reinforces earlier findings on MaaS users’ motivations. Thirdly, the participants struggled with making the service work for them. They, moreover, seemed to value the support and feedback functions higher than the trialled app. This speaks to the novelty of MaaS, compared to existing service models, and reiterates the notion that much more than an app is needed to develop and disseminate MaaS.

Keywords: Mobility-as-a-Service; MaaS; User Perspective; Trial; Tripi; Sydney

Introduction

Mobility as a Service (MaaS), i.e., a type of service that through a joint digital channel enables users to plan, book, and pay for multiple types of mobility services (Smith 2020), has in recent years emerged as a hot topic within the transport sector. The core idea is to create links between complementary mobility services, and thus make it easier for people to compile an offering that meets the majority of their mobility needs (Hietanen 2014). This is thought to improve the attractiveness of travelling via mobility services, as compared to owning and using a private car. Hence, the introduction of MaaS might trigger travel behaviour changes that are aligned with the global sustainable development goal on safe, affordable, accessible, and sustainable transport systems for all (cf. UN 2015).

However, MaaS’ impact on transport systems assumes that when MaaS is available, users adopt and use MaaS and that this influences their travel patterns and/or mode choice behaviour. To understand the user perspective on MaaS is therefore central for identifying the future prospects of MaaS (Lyons 2020). Still, despite frequently being labelled as a “user-centric” concept (e.g., Kamargianni & Matyas 2017), few studies have reported empirical evidence on who the early adopters of MaaS are, if the adoption has led to any changes in travel behaviour, and what the users’ general impression of MaaS is (Karlisson 2020). Hence, better documentation and dissemination of empirical evidence from past, ongoing, and future MaaS trials has been called for (Hensher et al. 2020).

The most detailed account of the user perspective on MaaS is arguably from the 2013–2014 UbiGo trial in Gothenburg, Sweden. Drawing on interviews, questionnaires, and travel diaries, four user types were identified: people that wanted to test living without owning a car (13%); people that wanted to get access to a car without purchasing one (30%); people that wanted a better way to access multiple mobility services (23%); and people that wanted cheaper access to public transport (34%) (Strömberg et al. 2018). The participants were at first primarily motivated by curiosity. The curiosity faded away with experience though. By the end of the trial, convenience/flexibility had replaced curiosity as the most dominant motivating factor (Sochor et al. 2014). Regardless of this shift in motivation, the participants seemed to be happy with the trialled service; 97% wanted to...
remain as customers after the trial (Sochor et al. 2016). The service also influenced their travelling in terms of mode choice, pre-trip planning activities, destinations, and trip chaining (Sochor et al. 2015). These changes resulted in the participant group traveling less overall and becoming more satisfied with their travelling (ibid.). In terms of mode choice, the travel diaries that the participants filled in ex-ante and during the trial indicated a decrease in the use of private cars (around 50% for both the number of trips and vehicle kilometres) as well as increased use of carsharing, bicycling, and public transport (Sochor 2020).

Since the UbiGo trial, a few other trials and commercial operations have added to the understanding of the user perspective on MaaS. In terms of who the MaaS users are, a questionnaire analysis of the 2014 SMILE trial in Vienna, Austria, found that the participants were predominantly male and 20-40 years old with a university degree (Karlsson et al. 2017). Moreover, the majority owned a private car. In contrast, a questionnaire analysis of the ongoing operation of Whim in Helsinki, Finland, found that the average user did not own a car, although they were also majority male and 20-50 years old (Luukkainen 2020). The analysis of the ongoing EC2B trial in Gothenburg, Sweden, did not reveal an overrepresentation of men though, but found that older people were more reluctant to use the transport services (Smith et al. 2019). With the exception of the NaviGoGo trial in Dundee and North East Fife, Scotland (see Hensher et al. 2020), few MaaS trials have targeted children and young people.

Regarding drivers and barriers for MaaS adoption, the responses to the Whim questionnaire reinforced the findings from the UbiGo trial by highlighting price, convenience, flexibility, and the access to different transportation modes as primary motivations. Interestingly, environmental concerns were not reported as an influential factor by either UbiGo participants or Whim customers. On the contrary, the analysis of the EC2B trial identified that an outspoken ambition to drive less was one of the participants’ main motivators in the initial phase of the adoption process, alongside gaining access to a variety of vehicles, curiosity, potential cost savings, and a wish to support the research project (Smith et al. 2019). By triangulating sales statistics, questionnaires, interviews, and observations, this analysis also mapped what types of user problems hindered different phases of the adoption process. A perceived need for either long or frequent car trips hindered the persuasion phase, while a tedious onboarding process and the complexity of the service dampened the participants’ enthusiasm during the decision and acclimatization phases. As the participants started to normalize the usage of the trialled service, the annoyance with the barriers that hindered the effective use of the included transport services grew (ibid.).

Both MaaS Global (the company behind Whim) and the Berliner Verkehrsbetriebe, which runs Jelbi in Berlin, Germany, have reported significant levels of adoption and use (see Ramböll. 2019; Trafi 2020). Yet, neither of these actors have disseminated any (reliable) data on changes in travel behaviour. Instead, the few empirical investigations on travel behaviour changes that exist have focused on self-reported data from smaller-scale trials111. Based on questionnaire data from Ghent, Belgium, Storme et al. (2020) concluded that MaaS should be regarded as a complement to private cars (in contrast to as a substitution) since the participants did not reduce their car use during the trial despite stating that they were motivated to do so and being offered financial incentives if they did. Conversely, about half of the participants in the SMILE trial affirmed that they had increased their use of public transportation, while 21% stated they had reduced their use of private cars (Karlsson et al. 2017). The participants in the EC2B trial reported similar changes; car owners used their cars to a lesser degree. The car owners moreover said that they had replaced the car trips with public transport, bicycling (both regular and electrically assisted), and walking. Although the participants noted that EC2B enabled these changes by providing access to a range of transport services and a smooth way to test them, the most important factors seemed to be the central location of the apartment complex, the lack of residential parking, and the vicinity to public transport stops (Smith et al. 2019).

In summary, the empirical evidence on who the MaaS users are, what motivates them to adopt MaaS, and how MaaS influences their travel behaviour is both mixed and limited112. In general, the understanding of the experience of becoming a MaaS user and using MaaS is incomplete113. Given the interest in MaaS, and the key role of users in the MaaS innovation process, this knowledge gap warrants more research into the user perspective on MaaS.

Setting out to contribute to a richer understanding of the user perspective on MaaS, this paper reports users’ experiences of participating in a research driven MaaS trial that took place in Sydney, Australia, November 2019 – March 2020114. In particular, the analysis addresses the following research questions:

(i) Who participated in the trial, and why?
(ii) How did the participants use the trialled service?
(iii) What experiences did the participants report?

111 Self-reported data sources are known to have limitations in estimating travel behaviour changes since people tend to under-report short trips while exaggerating other aspects such as the time spent walking or on public transport due to rounding effects (e.g., Gerike, 2015).
112 For a review of the empirical evidence on MaaS users, use, and effects, see Karlsson (2020).
113 For an overview of findings related to the user perspective on MaaS, see Sochor (2020).
114 Findings from the trial have previously been reported in Hensher et al. (2021a, 2021b), Ho et al. (2021a, 2021b) and Wong (2021).
The Sydney MaaS trial

The MaaS trial analysed in this paper was funded by iMove Australia and planned, executed and evaluated by a consortium consisting of the Institute of Transport and Logistics Studies at the University of Sydney Business School (ITLS), the Insurance Australia Group (IAG), and SkedGo. The logic behind the trial was to complement the learnings from the undertaken MaaS trials in Europe (cf. Hensher et al. 2020) by leveraging previous research findings on the preferences of potential MaaS users in Australia (e.g., Ho et al. 2018), as well as IAG’s existing relations with mobility service providers in Sydney and SkedGo’s multimodal travel planner TripGo. In particular, the trial set out to improve the understanding of how subscription design affects MaaS uptake and travel behaviour; in other words what mobility services should MaaS include and how should these be bundled and priced into mobility plans in order to attract users and help users live less car-centric lifestyles?

The trial was situated in the Sydney metropolitan area, Australia (Greater Sydney). This was deemed an appropriate institutional setting for a MaaS trial for several reasons. Sydney is a comparatively large city (ca 5.2 million inhabitants) with a well-developed public transport system as well as a rich supply of mobility services. At least in theory, this enables the creation of comprehensive MaaS bundles. Yet, the car modal share is fairly high (approximately 70% during weekdays and 80% during weekends, see Ho and Mulley 2013) compared to cities of similar size in Europe, Asia, and South America (cf. LTA 2011). This indicates that there is room for improvement. Furthermore, the state authority responsible for the public transport system, Transport for New South Wales, has shown interest in new ways of improving the public transport offering in Sydney (Smith & Hensher 2020).

The MaaS service that was tested during the trial was named Tripi. In terms of technology components, the Tripi service included a smartphone app, an admin dashboard, and back-office servers. The dashboard enabled the trial team to manage mobility plans and invoices, while the participants could search, book, and pay for the included mobility services via the app: public transport (Transport for New South Wales), car rental (Thrifty), car sharing (GoGet), ride-sourcing (Uber), and taxi (Cabcharge). The app additionally featured a mobility wallet function through which the participants could view the details of the mobility plans as well as their current credit balance and their history of transaction activities. During the first month of the trial, participants were only offered a PayGo option. Subsequently, as the trial progressed (November 4 2019 – March 3 2020), four additional monthly plans were introduced: Fifty50, Saver25, GreenPass, and SuperSaver25, see Table 1.

<table>
<thead>
<tr>
<th>Monthly fee</th>
<th>Pay-as-you-Go</th>
<th>Fifty50</th>
<th>Saver25</th>
<th>GreenPass</th>
<th>SuperSaver25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public transport discount</td>
<td>-</td>
<td>50% per trip</td>
<td>25% per trip</td>
<td>100% (unlimited)</td>
<td>25% per trip</td>
</tr>
<tr>
<td>Ride-sourcing discount</td>
<td>-</td>
<td>AUD$3 per trip</td>
<td>15% per trip</td>
<td>AUD$3 per trip</td>
<td>AUD$3 per trip</td>
</tr>
<tr>
<td>Taxi discount</td>
<td>-</td>
<td>AUD$3 per trip</td>
<td>15% per trip</td>
<td>AUD$3 per trip</td>
<td>AUD$3 per trip</td>
</tr>
<tr>
<td>Car sharing discount</td>
<td>-</td>
<td>-</td>
<td>15% per trip</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Car rental discount</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

(1) 15% per trip during Feb.
(2) Plus, an AUD$3 cap for ≤ 5km trips to and from public transport stations

In addition to the technical features and the mobility plans, the Tripi service offering to the participants encompassed a significant level of support from the trial team. Core support activities included introducing the participants to Tripi (and MaaS), supporting them during the on-boarding process, and checking in with them throughout the trial. The support was provided via face-to-face meetings as well as via digital platforms. Furthermore, at the end of each month, the participants did not only receive a monthly bill, but also a breakdown of the cost per mode during the past month as well as individualized information on how each of the available mobility plans could reduce these costs the following month.

In terms of participants, it was decided to focus on IAG employees based in Sydney. Since the trial team had well-established communication channels (and trust) with this group, it lowered the marketing challenge. Moreover, as IAG has a workforce of over 8,000 who reside and work throughout Greater Sydney, the group was judged to be large and diverse enough for finding the targeted 150 participants to invite to the trial. While the trial focused on everyday travelling, business travel was also eligible for travel discounts if these business trips were taken and paid for using the participants’ personal Tripi accounts.

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115 All mobility services were not fully integrated in the app. For instance, a linked smart card (opal) was included in the trial starter pack, which the participants used to pay for public transport trips during the trial. See chapter 5.1. in Hensher et al. (2021) for further details.
Data collection and analysis

In July and August 2019, participants were recruited via several e-mails and posts at IAG’s internal communication system (Yammer) as well as via flyers, seminars and in-person advertising at the lobbies of IAG’s offices. These efforts resulted in 226 IAG employees registering interest for participating in the trial by completing an online questionnaire. This (ex-ante) questionnaire comprised two sections. The first section, which had 15 questions, aimed at establishing who the respondents were, including household data and how they currently travelled. In the second section, the respondents were first asked to watch a video introducing the MaaS concept. Then, they were queried to what extent different features of MaaS appealed to them, as well as how interested they were in joining the trial, and why. This section had six questions in total.

The residential locations, as retrieved from the responses to the ex-ante questionnaire, were plotted against the Sydney public transport network (see Ho et al. 2021a). Insights from this activity, and from the ex-ante questionnaire in general, were in the early stages of the trial used to identify suitable participants and to design the first mobility plan. A summary of the responses to the ex-ante questionnaire is provided in Appendix 1.

Of the people that filled in the ex-ante questionnaire, 184 were deemed eligible for the trial, based on which IAG office they worked at and what type of phones they used. Following trial invitations and significant onboarding support, 91 of them entered the trial, and used the included mobility services at least once during the trial period. The characteristics of the participant group are described in more detail in section 4.1.1.

Statistical analyses were performed in SPSS to determine if there were differences in the responses to the ex-ante questionnaire between participants and eligible non-participants (n=93). For the dichotomous variables (n=4), the chi-square test of homogeneity was used to analyse the differences in proportions. For the variables that did not have the minimum sample size required for this test to provide a valid result (n=1), the Fisher’s exact test was used instead. For the nominal variables (n=4), the independent-samples t-test was performed to determine if a statistical difference existed between the means of the two sub-groups. For the variables that had heterogeneity of variances, the Welch t-test was performed instead. For the ordinal variables (n=13), the Mann-Whitney U test was run to determine if there were differences in the sub-groups’ responses. The distributions of the ordinal data for the sub-groups were similar, as assessed by visual inspection. The results of these analyses are provided in section 4.1.2.

During the course of the trial, the participants reported their experiences to the trial team through two principal tools: an online pulse questionnaire and short interviews116. Both tools aimed at capturing the current mood of the participants and to guide refinement of the trial offering. The pulse questionnaire contained four questions about the trial experiences and was pushed out to the participants through the Tripi app once a month during the trial. In total, it received 111 responses, which were read through and coded. The short interviews (n=27) were conducted at the beginning of February. The interviewees were selected to mirror the participants’ choices of mobility plans. Thus, six interviewees had only used the Pay-as-you-Go option, twelve had subscribed to a mobility plan, and four had switched between several bundles (see Wong 2021 for a detailed description of the sampling strategy and the semi-structured interview guide). The interviews were audio recorded and automatically transcribed through the use of software called Otter. The transcriptions were then analysed in order to identify recurring themes in relation to the trial, the trialled service and its effects on the participants’ travel behaviour.

Following the early closure of the trial in mid-March 2020 due to the onset of COVID-19 related travel restrictions, the participants were invited to fill in an online (ex-post) questionnaire. An AUD$50 gift card was offered as an incentive. The 24 questions covered the participants’ general experiences of the trial as well as their views on specific components of the trialled service. Moreover, it investigated how the trial had influenced the participants’ travel behaviour, and how these were likely to change in the future. 70 of the participants filled in the ex-post questionnaire. A summary of these responses is provided in Appendix 2.

The results from the ex-post questionnaire were linked with the results from the ex-ante questionnaire as well as with the participants’ choices of mobility plans. This enabled an analysis of relationships between ex-ante statements, behaviour during the trial, and ex-post statements. Insights from this exercise were compared with the insights from the interviews and the pulse questionnaire, in order to determine who participated in the trial, and why (RQ1), how the participants used the trialled service (RQ2), and what experiences they reported (RQ3). These findings are outlined in the next section.

116 During the trial, the behaviour of the participants was moreover recorded via multiple other means, such as sales statistics and GPS-tracking devises (see Hensher et al. 2021 for details). These data sets are not used as primary data in the analysis reported in this paper.
Results and analysis

Who participated in the trial, and why?

The gender ratio for the participant group was fairly evenly split between females and males (52% females), which resembles the distribution in Greater Sydney (Australian Bureau of Statistics, 2016). 70% of the participants were between 25 and 54 years old, whilst no one was above 64 years. In contrast, the proportion of the Greater Sydney population aged 65 years and older is 14% (ibid.). Furthermore, none of the participants had any disabilities that affected their ability to use public transport, whilst 18% of Australians have a disability (Australian Bureau of Statistics, 2018). Thus, one can assume that the participants were less constrained in their mobility choices than the population as a whole.

With regard to household composition, the bulk of the participants lived in households with more than one adult (90%). Of these, about half of the households (53%) also included children. In Greater Sydney, 74% of all households are defined as family households117. Of these, 33% are couples without children, whilst 50% are couples with children (Australian Bureau of Statistics, 2016). Thus, there seems to have been a small overrepresentation of multiple adult households without children among the participants.

95% of the participants had a driver’s license valid in Australia (provisional or full), and all but one participant lived in a household in which at least one person was allowed to drive. As only 83% of the population aged over 16 in New South Wales held a driver’s licenses in 2010 (Raimond & Milthorpe, 2010), non-license holders might have been underrepresented among the participants. 80% had daily access to a car owned by them, their family, or their business. Furthermore, 30% lived in households that typically used multiple cars. In Greater Sydney, 85% of occupied private dwellings have at least one registered motor vehicle garaged or parked at their address, whilst 49% have several registered vehicles (Australian Bureau of Statistics, 2016). Thus, the participant group’s access to private cars seems to have been slightly smaller than what the Greater Sydney population has on average.

Regarding travel behaviour, 45% of the participants reported that they used a private car 3-5 times a week or more frequently. The corresponding number for public transport was 90%. This can be contrasted with the general commuting practices of the Greater Sydney population; 60% of employed people in Greater Sydney aged 15 years and older travel to work by car as driver or passenger, whilst 23% travel to work by public transport (ibid.). Thus, it seems that the participants on average used their private cars less than the general population. A large majority of the participants (82%) used both private cars and public transport on a weekly basis, whilst the use of other modes was fairly limited. 76% rode a bicycle less than once a month or never. The corresponding number for taxi, car share, and car rental were 64%, 90%, and 99%, respectively. The exception was ride-sourcing (sometimes referred to as ride-hailing), which 62% used on a monthly basis. In total, 24% of the participants used both public and at least one type of car services on a weekly basis, see Table 2.

<table>
<thead>
<tr>
<th>Table 2. Characteristics and travel behaviour of the participants</th>
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<tbody>
<tr>
<td><strong>Personal characteristics</strong></td>
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<tr>
<td></td>
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<tr>
<td>Male</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Male</td>
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<tr>
<td>Female</td>
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<tr>
<td><strong>Household composition</strong></td>
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<tr>
<td></td>
</tr>
<tr>
<td>No children</td>
</tr>
<tr>
<td>One adult</td>
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<tr>
<td></td>
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<tr>
<td>Several adults</td>
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<td></td>
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<tr>
<td><strong>Private car use</strong></td>
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<td></td>
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<tr>
<td>Do not use private car weekly</td>
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<tr>
<td>No daily access</td>
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<td></td>
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<tr>
<td>Daily access</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Mobility service behaviour</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Do not use car services weekly</td>
</tr>
<tr>
<td>Do not use PT weekly</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Use PT weekly</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

117 22% of the households are defined as single person households and 5% as group households.
The comparative analysis of the participants and the eligible non-participants indicate that the two sub-groups were quite similar, see Table 3. No statistically significant differences were found when it came to the dichotomous variables. In contrast, the analysis of the nominal variables identified two statistically significant differences. The mean number of adults within the household among the participant group was 0.307 ± 0.154 (mean ± standard error) lower than among the eligible non-participants. Relatedly, the mean number of car drivers within the household among the participant group was 0.140 ± 0.1147 (mean ± standard error) lower than among the eligible non-participants. Regarding the ordinal data, the only statistically significantly difference that was identified, regarded the sub-groups’ interest in the multimodal travel planner feature of MaaS. The median interest score was statistically significantly higher among participants (5 out of 5) than among eligible non-participants (4 out of 5), U = 4875.5, z = 1.968, p = .049.

Table 3. Differences between participants (n=91) and eligible non-participants (n=93)

<table>
<thead>
<tr>
<th>Dichotomous variables</th>
<th>Statistical test</th>
<th>N</th>
<th>Part.</th>
<th>Diff</th>
<th>p</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Chi-square test</td>
<td>183</td>
<td>.484</td>
<td>.016</td>
<td>.824</td>
<td>Retain null hypothesis</td>
</tr>
<tr>
<td>License</td>
<td>Chi-square test</td>
<td>184</td>
<td>.956</td>
<td>.031</td>
<td>.370</td>
<td>Retain null hypothesis</td>
</tr>
<tr>
<td>Car access</td>
<td>Chi-square test</td>
<td>184</td>
<td>.802</td>
<td>.015</td>
<td>.795</td>
<td>Retain null hypothesis</td>
</tr>
<tr>
<td>Disability</td>
<td>Fisher’s exact test</td>
<td>184</td>
<td>.000</td>
<td>.001</td>
<td>1.00</td>
<td>Retain null hypothesis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nominal variables</th>
<th>Statistical test</th>
<th>N</th>
<th>t</th>
<th>df</th>
<th>p</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td>Welch t-test</td>
<td>184</td>
<td>-.516</td>
<td>177.196</td>
<td>.607</td>
<td>Retain null hypothesis</td>
</tr>
<tr>
<td>Adults</td>
<td>Welch t-test</td>
<td>184</td>
<td>-1.996</td>
<td>164.524</td>
<td>.048</td>
<td>Reject null hypothesis</td>
</tr>
<tr>
<td>Drivers</td>
<td>Standard t-test</td>
<td>184</td>
<td>-.515</td>
<td>182</td>
<td>.607</td>
<td>Retain null hypothesis</td>
</tr>
<tr>
<td>Cars</td>
<td>Welch t-test</td>
<td>184</td>
<td>-.271</td>
<td>167.826</td>
<td>.224</td>
<td>Reject null hypothesis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ordinal variables</th>
<th>Statistical test</th>
<th>N</th>
<th>U</th>
<th>z</th>
<th>p</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age group</td>
<td>Mann-Whitney U test</td>
<td>184</td>
<td>4339.5</td>
<td>-.312</td>
<td>.755</td>
<td>Retain null hypothesis</td>
</tr>
<tr>
<td>Private car frequency</td>
<td>Mann-Whitney U test</td>
<td>184</td>
<td>4474.5</td>
<td>.695</td>
<td>.487</td>
<td>Retain null hypothesis</td>
</tr>
<tr>
<td>Bicycle frequency</td>
<td>Mann-Whitney U test</td>
<td>184</td>
<td>3884.0</td>
<td>-.1130</td>
<td>.259</td>
<td>Retain null hypothesis</td>
</tr>
<tr>
<td>Public transport frequency</td>
<td>Mann-Whitney U test</td>
<td>184</td>
<td>3717.0</td>
<td>-.1584</td>
<td>.113</td>
<td>Retain null hypothesis</td>
</tr>
<tr>
<td>Ride share frequency</td>
<td>Mann-Whitney U test</td>
<td>184</td>
<td>3953.0</td>
<td>-.789</td>
<td>.430</td>
<td>Retain null hypothesis</td>
</tr>
<tr>
<td>Taxi frequency</td>
<td>Mann-Whitney U test</td>
<td>184</td>
<td>4212.5</td>
<td>-.055</td>
<td>.956</td>
<td>Retain null hypothesis</td>
</tr>
<tr>
<td>Car share frequency</td>
<td>Mann-Whitney U test</td>
<td>184</td>
<td>3937.5</td>
<td>-.1034</td>
<td>.301</td>
<td>Retain null hypothesis</td>
</tr>
<tr>
<td>Rental car frequency</td>
<td>Mann-Whitney U test</td>
<td>184</td>
<td>4116.5</td>
<td>-.365</td>
<td>.713</td>
<td>Retain null hypothesis</td>
</tr>
<tr>
<td>Interest in booking feature</td>
<td>Mann-Whitney U test</td>
<td>184</td>
<td>4875.5</td>
<td>1.968</td>
<td>.049</td>
<td>Reject null hypothesis</td>
</tr>
<tr>
<td>Interest in pay portal feature</td>
<td>Mann-Whitney U test</td>
<td>184</td>
<td>4473.0</td>
<td>.906</td>
<td>.365</td>
<td>Retain null hypothesis</td>
</tr>
<tr>
<td>Interest in bundle feature</td>
<td>Mann-Whitney U test</td>
<td>184</td>
<td>4365.5</td>
<td>.548</td>
<td>.583</td>
<td>Retain null hypothesis</td>
</tr>
<tr>
<td>Interest in trial</td>
<td>Mann-Whitney U test</td>
<td>184</td>
<td>4308.5</td>
<td>.235</td>
<td>.814</td>
<td>Retain null hypothesis</td>
</tr>
</tbody>
</table>

In terms of why they participated, 43% of the participants that filled in the ex-post questionnaire reported a desire to contribute to an IAG initiative as their main motive. This was followed by curiosity (24%), more streamlined access to transportation (15%), and potential cost savings (15%)118. A more detailed understanding of the motives can be traced from the ex-ante questionnaire in which 63 of the participants offered further reasoning.

Regarding the desire to contribute to an IAG initiative, a few participants mentioned that they specifically wanted to help IAG succeed in this new potential business area. Still, many also reported a will to support an initiative that might improve the transport system more generally — “I would love to be part of a project that can ease some congestion, save some money for the family and save the environment.” Thus, the participants’ desire to contribute by participating in the trial seemed to stretch beyond just helping their employer. Moreover, a few participants mentioned that they wanted to reduce carbon dioxide emissions from their own traveling as well.

On the subject of curiosity, the participants mentioned that they were interested in new technologies and MaaS in general as well as about how different features of MaaS would work in practice. Yet, they were even more curious as to whether the trialled service could help them identify new ways to travel and how it might influence their travel habits — “I’m intrigued and curious to see what new options there are for me. I rarely use my car but need it for certain events. I want to see how this app could change the way I get around.” Some participants even stated that they were hoping that the trial would disprove the assumptions that currently guided their travel choices.

Many participants also wrote about being tired of juggling several mobility apps simultaneously — “App swapping is annoying, comparing prices between Uber and Ola is annoying, checking Google Maps then making sure I have my Opal card then making sure I check Google Maps again then ordering an Uber because I became late through so many apps is annoying. I would really like a place to combine all of my travel services, costs and directions.” In general, the

118 3% picked the option “other”.

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participants were intrigued by the potential of added convenience with regards to choosing between and paying for different modes of transport and appeared to find it more important than the potential of reduced travel expenses “cost savings are nice, but the convenience is much more valuable.” Nonetheless, some participants brought forward the appeal of potential cost savings too – “transport costs in Sydney are only increasing. I'm keen to look at new ways of transporting myself and my family to try and keep costs down”.

In summary, the participant group mostly consisted of working age individuals in Greater Sydney that used a combination of private cars and public transport to solve most of their travel needs. Compared to the average population in Greater Sydney, they used private cars less, and public transport more. Their participation in the trial was primarily motivated by a will to contribute to the development of a novel service that might help their employer excel while, at the same time, making the transportation system more sustainable. The participants were also keen to learn about how MaaS could improve their traveling, frustrated with juggling several mobility apps, and interested in finding new ways to reduce their travel-related expenses.

How did the participants use the trialled service?

On average, the participants were active on the Tripi platform 16.2 days per month (std 7.8 days) (Ho et al. 2021b). Each month, a participant typically spent AUD$338 (std AUD$363), which was split between public transport (72.7%, std 31%), taxi and ride-sourcing (23.5%, std 27%), and car sharing (3.7%, std 15%) (ibid.). In other words, all included modes attracted significant use, except for the car rental service that was used by only six participants Three of these were frequent users though (their average monthly spending was more than AUD$200).

The mobility plans (other than the Pay-as-you-Go option) were introduced and refined throughout the trial. Consequently, the uptake of mobility plans grew gradually month by month. In the final month, a shy majority of the participants (57%) subscribed to one of the three then available mobility plans that encompassed an upfront monthly fee and trip discounts, see Table 4.

<table>
<thead>
<tr>
<th>Month</th>
<th>Pay-as-you-go</th>
<th>Fifty50</th>
<th>Saver25</th>
<th>GreenPass</th>
<th>SuperSaver25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov-19</td>
<td>100%</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Dec-19</td>
<td>83%</td>
<td>17%</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Jan-20</td>
<td>74%</td>
<td>16%</td>
<td>11%</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Feb-20</td>
<td>53%</td>
<td>16%</td>
<td>16%</td>
<td>15%</td>
<td>NA</td>
</tr>
<tr>
<td>Mar-20</td>
<td>43%</td>
<td>19%</td>
<td>NA</td>
<td>24%</td>
<td>15%</td>
</tr>
</tbody>
</table>

Note: NA = Not applicable (bundle was not available during that month)

Hensher et al. (2021b) found that the male participants were more likely to stick with the Pay-as-you-Go option than the females, while Ho et al. (2021b) reported that older participants were less inclined to do so, compared to younger participants. The participants that lived in households with multiple drivers were more likely to choose one of the other mobility plans over the Pay-as-you-Go option (Hensher et al. 2021b). Interestingly, the participants that lived in households which owned two or more cars also had a lower probability of sticking with Pay-as-you-Go (Ho et al. 2021b). These findings contradict the assumptions that car owners and license holders would be less inclined to subscribe to mobility plans. Moreover, Ho et al. (2021b) found that participants that stuck with the Pay-as-you-Go option were less multi-modal (from the outset) than the ones that opted into one of the other mobility plans. The Pay-as-you-Go users were also active fewer days per month (ibid.). Furthermore, a 1 percent increase in monthly public transport trips resulted in a 0.82 percent increase in the probability of choosing another mobility plan than Pay-as-you-Go, while a 1 percent decrease in monthly private car trips resulted in a 1.25 percent increase (Hensher et al. 2021b). In other words, there was a positive correlation between frequent travelling, multi-modality, and public transport use and willingness to subscribe to a mobility plan, while the correlation to private car use was negative.

With regard to the other features of the service, the mobility wallet function was not used much; only 27% of the participants that filled in the ex-post questionnaire used it weekly or more frequently. Regarding the multi-modal trip planning function, the mid-trial interviewees revealed that many participants hardly used it either; competing products were preferred, partly due to habit, but also due to not liking the design and/or the functionality of the Tripi journey planner (Wong 2021). In the ex-post questionnaire, the participants reported that they mostly consulted it when travelling to and from work (43%) and for leisure trips (29%).

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In summary, the participants used the Tripi service significantly during the trial period mainly to gain access to public transport, but also to purchase taxi, ride-sourcing, and car sharing trips. Still, most participants did not use the mobility wallet and multi-modal journey planner features of the trialled app regularly. About half of the participants had opted into a mobility plan by the last month of the trial. Gender and age influenced the probability of opting into a mobility plan, as well as travel behaviour, car ownership, and the household composition (see Hensher et al. 2021b and Ho et al. 2021b for further details).

**What experiences did the participants report?**

In the pulse questionnaire, the participants were (among other things) asked to name what they liked the most and the least with the trialled service. In terms of likes, the three most common themes were: having everything in one place — “I like being able to have an app that looks at a range of different transport methods to my destination. I have discovered new bus routes I didn’t know about”; one monthly bill that makes paying for transport easier and provides a better overview of transport costs — “even though I got ‘sticker shock’ when I started, I now appreciate the total view of my transport”; and the provided discounts — “I have tried to use as many of the services as possible and got a great discount when using Thrifty recently.” The participants, moreover, said that they liked the convenience of the service and that it helped themselves and others “saving petrol and saving [the] environment”.

The mid-trial interviews further deepened the understanding of what the participants liked about the trialled service. The interviewees were generally very happy about their trial experience (up until that point) and explained that they were proud of participating in the trial and how the Tripi service constitutes the “future of transport”. This was also reflected in the post-trial questionnaire; 82% of the participants stated that they would have purchased the trialled product would it become available after the trial. In particular, the mid-trial interviewees were full of praise for the onboarding process. They appreciated the time that the trial team spent on onboarding each participant (in many cases one-by-one), as opposed to more generic emails and instructions as they envisioned beforehand (Wong 2021). The support from the trial team seemed to add to the positive trial experience. Furthermore, the interviewees were happy about how the monthly bill (and the attached information) brought greater clarity to them of their transport costs. Overall, the participants identified feedback on travel costs as a positive feature of the trial, revealing cost outlays that many had never realized they made (Hensher et al. 2021b). Equally so, however, the interviewees felt that aggregating by month made individual trip costs less transparent.

In terms of dislikes, the most frequently recurring areas of complaint in the pulse questionnaire regarded: the monthly bill that had to be manually handled and that did not match their pay cycles — “I also find paying the invoice separately annoying, again, it’s another step I don’t have normally with my transport. I missed the Feb one cause I was on holidays”; the lack of mobility plans that matched their needs — “The plans are heavily geared towards public transport users. I rarely use public transport so they don’t appeal to me at all”; that some modes were either missing or not fully integrated — “I dislike having to use the Opal card instead of having a digital wallet”; and various shortcomings of the Tripi app — “The trip planning function doesn’t include all possible options”. Many participants were, moreover, disappointed about the lack of behaviour change, unhappy about the credit card surcharge fee, and annoyed over that they kept forgetting to use the app (and thus sometimes missed out on discounts). A few also said that they did not think that the service offered much added value and/or that they found it untrustworthy — “I’m still a bit uncomfortable with my travel data all in one place - if this was an external app, I would want to be very clear on who has access to my data and for what purpose”.

The disappointment over the lack of behaviour changes expressed in the pulse questionnaire was also mirrored in the mid-trial interviews. The interviewees usually could not recall any significant changes in their travelling, and a few said that they were “very sceptical” in how much of a difference MaaS could make to their travelling, given the limited number of service options available in their area (Wong 2021). Yet, the interviews revealed a few interesting impacts on the participants’ travel habits that they might have overlooked themselves. Especially, the trial seemed to have influenced how the participants used public transport. The standard public transport payment system (Opal) has daily, weekend, and weekly caps. It also prices different modes as well as on- and off-peak trips differently. The GreenPass mobility plan (which included unlimited public transport use) effectively eliminated these policies. The subscribers to the GreenPass mobility plan therefore self-proclaimed to be able to “relax a bit” in their choice of public transport mode and time of travel. A couple of interviewees that used to rely only on riding as a passenger in others’ private cars also said that they had done so less often during the course of the trial, switching to Uber or public transport instead (ibid.). Furthermore, in contrast to the insights from the mid-trial interviews and the pulse questionnaire, 22% of the participants that filled in the ex-post questionnaire thought that the trial had decreased their carbon dioxide emissions (39% picked maybe). 34%, moreover, said that they would maintain the transport behaviour adopted during the trial going forward (33% were not sure yet) and 18% noted that the trial had influenced their position on car ownership.

The participants stated that the trip planning function hardly had contributed to their behaviour changes during the trial; the median score for its contribution was 4 on a five-point scale that stretched between “a great deal” (1) and “not at all” (5). Similarly, the median score for the mobility plans’ contribution was 3. Still, quite a few of the
participants that had opted into a mobility plan (39%) said that this had caused them to use the discounted modes more frequently. Furthermore, 41% said that the mobility plans had made them more cost aware.

41 of the participants that filled in the ex-post questionnaire had subscribed to a mobility plan. They reported potential cost savings (76%) and simplified payment procedure (15%) as the main reasons for doing so. On the other side of the spectrum, low usage of the discounted modes (21%), not being able to estimate travel needs (20%) and price (11%) were reported as reasons for not opting into a mobility plan.119 During the mid-trial interviews, the interviewees mentioned working from home regularly, relying exclusively on either public transport or walking for the journey to work, and not wanting to subscribe to services that they previously had had access to on an on-demand basis as main reasons for why a multi-modal subscription plan did not seem worthwhile (Wong 2021). Other reasons brought forward were the irregularity of travel patterns during the holiday season and that it would take too much effort to review the selection of mobility plans. Of the participants that filled in the ex-post questionnaire, 58% would have opted into a mobility plan if the Tripi service would have continued.

In the ex-post questionnaire, the participants offered several ideas on changes that would have made the mobility plans more appealing. Next to more extensive discounts, and the inclusion of more services or suppliers, the most frequent comment referred to designing mobility plans suited for other types of travel patterns. In particular, the participants requested a plan for those who do not travel every day, but some also wanted more locally adjusted plans - “Most of the plans got their value from the public transport discounts but I rarely use public transport due to living inner city”. A few participants thought that weekly or fortnightly plans would have suited their salary and household budget timelines better120, and in general the participants sought a higher degree of flexibility - “Having flexibility to pause/change mid-month might be nice, when circumstances change, like when COVID happened and no one was traveling”. The wish for better feedback about cost savings as well as ideas about how to incentivize carbon dioxide reductions were also recurring121. Finally, some comments regarded lower or no upfront fee, family plans, capping, and better use of artificial intelligence for the trip planning function.

In summary, the participants were, on average, happy about their trial experiences. Although it did not produce the behaviour changes they were hoping for, it helped them explore new travel options, get a better overview of their transport costs, and, in some cases, reduce their spending. The participants especially appreciated all the support from the trial team and the feedback and advise that was attached to their monthly bills. Still, a few participants struggled with understanding how to fit the trialled service and its components to their own circumstances. The mobility plans did not match all participants’ needs, and as noted in Wong (2021), many aspects, exogenous to the trial (and to MaaS products in general), favour sticking to established travel behaviours.

Discussion and conclusion

The contribution to the literature on MaaS from this paper is three-fold. Firstly, the majority of the people that signed up for the trial were frequent users of both public transport and private cars. This supports the notion that multi-modal travellers are more interested in MaaS than others (e.g., Alonso-González et al. 2020), and contradicts the fear that MaaS does not appeal to car owners and frequent car users (e.g., Ho et al. 2018). Rather, 82% of the people that registered interest for the trial had daily access to private cars. Moreover, 17% of the participants reported that the experience of the trial changed their view of car ownership and 82% would have purchased the trialled offering if it became available after the trial. This indicates that the trialled service has potential to reduce car ownership, although the behaviour change was limited during the trial.

Secondly, a will to support the development of a service that might help their employer and make the transportation system more sustainable was the participants’ main motivation for signing up for the trial, followed by a curiosity about MaaS and how the trialled MaaS service could improve their traveling. This reinforces earlier findings on MaaS users’ motivations (e.g., Sochor et al. 2014; Smith et al. 2019). Thirdly, the participants struggled with making the service work for them. They seemed to value the support and feedback functions higher than the functions included in the trialled app (the multi-modal travel planner and the mobility wallet). This speaks to the novelty of MaaS, compared to existing transport services, and reiterates the notion that (much) more than an app and a set of subscription plans is needed to put together and disseminate MaaS offerings (e.g., Hensher et al. 2020; Karlsson et al. 2016; Smith et al. 2019; Smith 2020; Smith & Hensher 2020). As with previous studies of the user perspective on MaaS, this work has several limitations. The sample size was limited and hardly representative of the general population, the trial was confined to Greater Sydney area, and the trialled service embodied only one example of how the MaaS concept can be realized. Subtle changes to either service design, target group and/or context could significantly alter the users’ perception of and experience with MaaS. Thus, one must be careful in generalising the findings reported herein. Rather, this paper should be interpreted as an entrée into understanding MaaS users that highlights aspects to investigate further. Furthermore,

119 44% picked “other”, indicating that the fixed choices were mismatched with the actual reasons for sticking with Pay-as-you-Go.
120 Conversely, some participants also asked for half-year plans.
121 An emission busting challenge was introduced in March. See Hensher et al. (2021) for further details.
while it draws upon multiple data sources, analyses, and modelling techniques, the paper is primarily based on questionnaire data and interviews – data sources that are subject to self-reporting bias and known to have limitations in estimating travel behaviour changes since people tend to under-report short trips while exaggerating other aspects such as the time spent walking or on public transport (e.g., Gerike et al., 2015). To further improve the understanding of MaaS users and MaaS use, the findings reported in this paper should be complemented with comparable analyses of distinct MaaS services trialed in other contexts as well as with use-centered analyses that in addition to self-reported data also draw on objective data sources, such as passively collected tracking data.

Acknowledgements

We would like to thank the IAG employees that participated in the trial, filled in the questionnaires, and agreed to be interviewed. We are also grateful for the contributions of the other members of the trial project team, especially John Nelson, Corinne Mulley, Yale Wong, Andre Pinto, Cecilia Warren, Sam Lorimer, Ivy Lu, David Worldon, Brandon Liew, Corinne Liew, Amanda Meier, David Duke, Brian Huang, Tim Doze, and Claus von Hessberg.

References


Sochor J., Karlsson, I.C.M. and Stromberg, 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. https://doi.org/10.3141/2542-07


Wong (2021, forthcoming) MaaS Mid-Trial Interviews Report, to be included as an appendix in Hensher et al. (2021a)
Appendix 11 Results from the ex-ante questionnaire

Table 5. Personal and household characteristics

<table>
<thead>
<tr>
<th></th>
<th>All respondents (n=226)</th>
<th>Trial participants (n=91)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>What is your gender?</td>
<td>50 % (112) Male</td>
<td>48% (44) Male</td>
</tr>
<tr>
<td></td>
<td>49% (110) Female</td>
<td>52% (47) Female</td>
</tr>
<tr>
<td></td>
<td>2% (4) Other/prefer not to answer</td>
<td>0% (0) Other/prefer not to answer</td>
</tr>
<tr>
<td><strong>Age group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>What is your age group?</td>
<td>7% (15) 24 or under</td>
<td>5% (5) 24 or under</td>
</tr>
<tr>
<td></td>
<td>30% (68) 25 to 34</td>
<td>32% (29) 25 to 34</td>
</tr>
<tr>
<td></td>
<td>38% (87) 35 to 44</td>
<td>37% (34) 35 to 44</td>
</tr>
<tr>
<td></td>
<td>21% (47) 45 to 54</td>
<td>20% (18) 45 to 54</td>
</tr>
<tr>
<td></td>
<td>4% (9) 55 to 64</td>
<td>5% (5) 55 to 64</td>
</tr>
<tr>
<td><strong>Smartphone</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Usually, which kind of mobile device do you use?</td>
<td>84% (189) iPhone</td>
<td>100% (91) iPhone</td>
</tr>
<tr>
<td></td>
<td>16% (37) Android</td>
<td>0% (0) Android</td>
</tr>
<tr>
<td><strong>Disability</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you have any conditions or disabilities that affect your ability to use public transport?</td>
<td>100% (226) No</td>
<td>100% (91) No</td>
</tr>
<tr>
<td><strong>Driver’s license</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you hold a valid Australian driver's license?</td>
<td>89% (202) Yes</td>
<td>90% (82) Yes</td>
</tr>
<tr>
<td></td>
<td>5% (11) Learner's license</td>
<td>5% (5) Learner's license</td>
</tr>
<tr>
<td></td>
<td>6% (13) No</td>
<td>4% (4) No</td>
</tr>
<tr>
<td><strong>Car access</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you have daily access to a car owned by you, your family or your business?</td>
<td>83% (187) Yes</td>
<td>80% (73) Yes</td>
</tr>
<tr>
<td></td>
<td>17% (39) No</td>
<td>20% (18) No</td>
</tr>
<tr>
<td><strong>Adults</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How many adults live in your household?</td>
<td>10% (23) 1</td>
<td>11% (10) 1</td>
</tr>
<tr>
<td></td>
<td>65% (146) 2</td>
<td>67% (61) 2</td>
</tr>
<tr>
<td></td>
<td>15% (33) 3</td>
<td>13% (12) 3</td>
</tr>
<tr>
<td></td>
<td>6% (13) 4</td>
<td>5% (5) 4</td>
</tr>
<tr>
<td></td>
<td>3% (7) 5</td>
<td>3% (3) 5</td>
</tr>
<tr>
<td></td>
<td>2% (4) 6-8</td>
<td>0% (0) 6-8</td>
</tr>
<tr>
<td><strong>Children</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How many children live in your household?</td>
<td>49% (110) 0</td>
<td>51% (46) 0</td>
</tr>
<tr>
<td></td>
<td>24% (54) 1</td>
<td>22% (20) 1</td>
</tr>
<tr>
<td></td>
<td>21% (47) 2</td>
<td>23% (21) 2</td>
</tr>
<tr>
<td></td>
<td>5% (12) 3</td>
<td>4% (4) 3</td>
</tr>
<tr>
<td></td>
<td>1% (2) 4</td>
<td>0% (0) 4</td>
</tr>
<tr>
<td><strong>Drivers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How many people in your household can drive a car?</td>
<td>3% (6) 0</td>
<td>1% (1) 0</td>
</tr>
<tr>
<td></td>
<td>21% (47) 1</td>
<td>22% (20) 1</td>
</tr>
<tr>
<td></td>
<td>56% (127) 2</td>
<td>58% (53) 2</td>
</tr>
<tr>
<td></td>
<td>13% (29) 3</td>
<td>15% (14) 3</td>
</tr>
<tr>
<td></td>
<td>4% (9) 4</td>
<td>1% (1) 4</td>
</tr>
<tr>
<td></td>
<td>3% (7) 5</td>
<td>2% (2) 5</td>
</tr>
<tr>
<td></td>
<td>0% (1) 6</td>
<td>0% (0) 6</td>
</tr>
<tr>
<td><strong>Cars</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How many private cars are typically used or owned by your household?</td>
<td>8% (18) 0</td>
<td>9% (8) 0</td>
</tr>
<tr>
<td></td>
<td>54% (122) 1</td>
<td>62% (56) 1</td>
</tr>
<tr>
<td></td>
<td>26% (59) 2</td>
<td>21% (19) 2</td>
</tr>
<tr>
<td></td>
<td>8% (17) 3</td>
<td>8% (7) 3</td>
</tr>
<tr>
<td></td>
<td>3% (7) 4</td>
<td>1% (1) 4</td>
</tr>
<tr>
<td></td>
<td>1% (2) 5</td>
<td>0% (0) 5</td>
</tr>
<tr>
<td></td>
<td>0% (1) 6</td>
<td>0% (0) 6</td>
</tr>
</tbody>
</table>

Table 6. Travel behaviour prior to the trial

<table>
<thead>
<tr>
<th></th>
<th>All respondents (n=226)</th>
<th>Trial participants (n=91)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public transport</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How often do you use public transport (train, bus, light rail, ferry)?</td>
<td>47% (107) Almost daily</td>
<td>58% (53) Almost daily</td>
</tr>
<tr>
<td></td>
<td>38% (86) 3-5 times a week</td>
<td>32% (29) 3-5 times a week</td>
</tr>
<tr>
<td></td>
<td>8% (17) 1-2 times a week</td>
<td>9% (8) 1-2 times a week</td>
</tr>
<tr>
<td></td>
<td>1% (3) Once a fortnight</td>
<td>0% (0) Once a fortnight</td>
</tr>
<tr>
<td></td>
<td>2% (4) Once a month</td>
<td>1% (1) Once a month</td>
</tr>
<tr>
<td></td>
<td>3% (6) Less than once a month</td>
<td>0% (0) Less than once a month</td>
</tr>
<tr>
<td></td>
<td>1% (3) Never</td>
<td>0% (0) Never</td>
</tr>
<tr>
<td>Car</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How often do you use your private car?</td>
<td>28% (64) Almost daily</td>
<td>22% (20) Almost daily</td>
</tr>
<tr>
<td></td>
<td>24% (55) 3-5 times a week</td>
<td>23% (21) 3-5 times a week</td>
</tr>
<tr>
<td></td>
<td>31% (71) 1-2 times a week</td>
<td>38% (35) 1-2 times a week</td>
</tr>
<tr>
<td></td>
<td>3% (6) Once a fortnight</td>
<td>2% (2) Once a fortnight</td>
</tr>
<tr>
<td></td>
<td>1% (2) Once a month</td>
<td>1% (1) Once a month</td>
</tr>
<tr>
<td></td>
<td>3% (6) Less than once a month</td>
<td>3% (3) Less than once a month</td>
</tr>
<tr>
<td></td>
<td>10% (22) Never</td>
<td>10% (9) Never</td>
</tr>
<tr>
<td>Taxi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How often do you use taxi?</td>
<td>0% (1) 3-5 times a week</td>
<td>0% (0) 3-5 times a week</td>
</tr>
<tr>
<td></td>
<td>9% (20) 1-2 times a week</td>
<td>1% (1) 3-5 times a week</td>
</tr>
<tr>
<td></td>
<td>12% (27) Once a week</td>
<td>15% (14) Once a fortnight</td>
</tr>
<tr>
<td></td>
<td>12% (27) Once a month</td>
<td>12% (11) Once a month</td>
</tr>
<tr>
<td></td>
<td>40% (90) Less than once a month</td>
<td>42% (38) Less than once a month</td>
</tr>
<tr>
<td></td>
<td>26% (59) Never</td>
<td>22% (20) Never</td>
</tr>
<tr>
<td>Service</td>
<td>How often do you use...</td>
<td>All respondents (n=226)</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td><strong>Ride share</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uber, Ola</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Almost daily</td>
<td>0% (0)</td>
<td>0% (0)</td>
</tr>
<tr>
<td>Almost daily</td>
<td>0% (0)</td>
<td>0% (0)</td>
</tr>
<tr>
<td>3-5 times a week</td>
<td>0% (0)</td>
<td>1% (1)</td>
</tr>
<tr>
<td>1-2 times a week</td>
<td>17% (39)</td>
<td>20% (18)</td>
</tr>
<tr>
<td>Once a fortnight</td>
<td>18% (40)</td>
<td>25% (23)</td>
</tr>
<tr>
<td>Once a month</td>
<td>15% (35)</td>
<td>14% (14)</td>
</tr>
<tr>
<td>Less than once a month</td>
<td>31% (70)</td>
<td>29% (26)</td>
</tr>
<tr>
<td>Never</td>
<td>16% (36)</td>
<td>11% (10)</td>
</tr>
<tr>
<td><strong>Car share</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GoGet, CarNextDoor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Almost daily</td>
<td>0% (0)</td>
<td>0% (0)</td>
</tr>
<tr>
<td>Almost daily</td>
<td>0% (0)</td>
<td>0% (0)</td>
</tr>
<tr>
<td>3-5 times a week</td>
<td>0% (0)</td>
<td>0% (0)</td>
</tr>
<tr>
<td>1-2 times a week</td>
<td>1% (2)</td>
<td>2% (2)</td>
</tr>
<tr>
<td>Once a fortnight</td>
<td>1% (3)</td>
<td>2% (2)</td>
</tr>
<tr>
<td>Once a month</td>
<td>4% (8)</td>
<td>5% (5)</td>
</tr>
<tr>
<td>Less than once a month</td>
<td>23% (52)</td>
<td>21% (19)</td>
</tr>
<tr>
<td>Never</td>
<td>71% (161)</td>
<td>69% (63)</td>
</tr>
<tr>
<td><strong>Car rental</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thrifty, Hertz, Europcar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Almost daily</td>
<td>0% (0)</td>
<td>0% (0)</td>
</tr>
<tr>
<td>Almost daily</td>
<td>0% (0)</td>
<td>0% (0)</td>
</tr>
<tr>
<td>3-5 times a week</td>
<td>0% (0)</td>
<td>0% (0)</td>
</tr>
<tr>
<td>1-2 times a week</td>
<td>0% (0)</td>
<td>0% (0)</td>
</tr>
<tr>
<td>Once a fortnight</td>
<td>0% (1)</td>
<td>1% (1)</td>
</tr>
<tr>
<td>Once a month</td>
<td>2% (5)</td>
<td>0% (0)</td>
</tr>
<tr>
<td>Less than once a month</td>
<td>44% (100)</td>
<td>47% (43)</td>
</tr>
<tr>
<td>Never</td>
<td>53% (120)</td>
<td>52% (47)</td>
</tr>
<tr>
<td><strong>Bicycle</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shared or personal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Almost daily</td>
<td>2% (4)</td>
<td>3% (3)</td>
</tr>
<tr>
<td>3-5 times a week</td>
<td>4% (9)</td>
<td>7% (6)</td>
</tr>
<tr>
<td>1-2 times a week</td>
<td>5% (11)</td>
<td>7% (6)</td>
</tr>
<tr>
<td>Once a fortnight</td>
<td>4% (8)</td>
<td>3% (3)</td>
</tr>
<tr>
<td>Once a month</td>
<td>16% (36)</td>
<td>13% (12)</td>
</tr>
<tr>
<td>Less than once a month</td>
<td>65% (146)</td>
<td>63% (57)</td>
</tr>
<tr>
<td>Never</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7. Perceived appeal of MaaS features prior to the trial
Appendix I2 Results from the ex-post questionnaire

### Table 8. General trial experiences and impacts

<table>
<thead>
<tr>
<th>Reason to participate in trial</th>
<th>Trial participants (ex-post questionnaire)</th>
</tr>
</thead>
<tbody>
<tr>
<td>What was your main reason for participating in the Maas Trial? (n=67)</td>
<td>24% (16) Curiosity 15% (10) Potential cost savings 15% (10) More streamlined access to transportation 43% (29) Desire to contribute to an IAG initiative 3% (2) Other122</td>
</tr>
</tbody>
</table>

| Future travel behaviour | |
| Will the experience you’ve had with the Maas trial, change the way you travel in future? (n=67) | 33% (22) No, I will travel the same way I did before the trial 34% (23) Yes, I will maintain my new travel behaviours 33% (22) Not sure yet |

| Mobility plan contribution | |
| How much did the subscription plans contribute to your behaviour change? (n=67) | 18% (12) 1 – A great deal 18% (12) 2 18% (12) 3 18% (12) 4 28% (19) 5 – Not at all |

| Journey planner contribution | |
| How much did the journey planner contribute to your behaviour change? (n=67) | 6% (4) 1 – A great deal 10% (7) 2 24% (16) 3 22% (15) 4 37% (25) 5 – Not at all |

| Impact on car ownership | |
| Has participating in the Maas Trial changed the way you view car ownership? (n=70) | 6% (4) Yes, I would consider giving up my primary car 6% (4) Yes, I would consider giving up my secondary car 6% (4) Yes, I will reconsider purchasing a car 27% (19) No, I will continue to own cars 39% (27) No, but I may consider changes in future 17% (12) Other |

| Carbon dioxide emissions | |
| Overall, do you think the Maas trial decreased your CO2 emissions? (n=67) | 22% (15) Yes 39% (26) No 39% (26) Maybe |

| Willingness to become a customer | |
| If the MaaS trial offering was to become a commercially available product, would you purchase it? (n=67) | 82% (55) Yes 18% (12) No |

### Table 9. Experiences of the smartphone application

| Journey planning | |
| For what trip types did you consult the Tripi journey planner? (n=67) | 43% (29) Travel to or from work 3% (2) Business travel 4% (3) Child commitments 0% (0) Shopping 29% (19) Leisure 21% (14) Other123 |

| Mobility wallet | |
| How often did you use the wallet feature in the Tripi app? (n=67) | 0% (0) Several times a day 3% (2) Once a day 10% (7) Several times a week 13% (9) Once a week 15% (10) Several time a month 21% (14) Once a month 37% (25) Less than once a month |

| Tripi app after the trial | |
| How likely would you continue to use the Tripi app if it was available to the public after the trial? (n=70) | 13% (9) 1 – Very unlikely 14% (10) 2 – Unlikely 20% (14) 3 – Neutral 16% (11) 4 – Likely 37% (26) 5 – Very likely |

### Table 10. Experiences of the mobility plans

| Mobility plan | |
| Did you opt-in to any of the mobility plans? (n=70) | 59% (41) Yes 41% (29) No |

| Reason to choose a mobility plan | |
| What was your main reason for opting into a mobility plan? (n=41) | 5% (2) Curiosity 76% (31) Potential cost savings 15% (6) Simplified payment (set and forget) 5% (2) Other124 |

| Reason to not choose a mobility plan | |
| | 11% (8) Price |

122 The other responses were: “trying to reduce my carbon footprint”; and “potential cost savings and a desire to contribute to an IAG initiative”.
123 The majority of the other responses were comments on limited or no use of the journey planning function.
124 The other responses were: “to motivate myself to use more public transport as I was feeling guilty”; and “novelty, a feeling of choice re what suited my travel and perception of bundling [incl potential saving]”.

193
Why did you choose not to opt into a mobility plan? (n=70)

20% (14) Could not estimate my travel usage
21% (15) Don’t usually use the discounted modes of transport
3% (2) Don’t like upfront/subscription costs
44% (31) Other

Behaviour change due to mobility plans
Did being on a mobility plan change the way you travelled during that month? (n=41, multiple choice)

12% (5) Yes, I travelled more frequently
39% (16) Yes, I used discounted modes more often
41% (17) Yes, I was more conscious of my travel costs
44% (18) No change
10% (4) Other

Mobility plan after the trial
If the MaaS Trial had continued, which mobility plan would you have selected for April? (n=67)

15% (10) Fifty50
22% (15) Super Saver 25
21% (14) Green Pass
42% (28) Pay as you go

Pay-as-you-Go after the trial
How likely would you be to purchase Pay-as-you-Go if it was available after the trial? (n=41)

20% (8) 1 – Very unlikely
15% (6) 2 – Somewhat unlikely
15% (6) 3 – Neutral
29% (12) 4 – Somewhat likely
22% (9) 5 – Very likely

Fifty50 after the trial
How likely would you be to purchase Fifty50 if it was available after the trial? (n=41)

2% (1) 1 – Very unlikely
12% (5) 2 – Somewhat unlikely
22% (9) 3 – Neutral
24% (10) 4 – Somewhat likely
39% (16) 5 – Very likely

Super Saver 25 after the trial
How likely would you be to purchase Super Saver 25 if it was available after the trial? (n=41)

0% (0) 1 – Very unlikely
7% (3) 2 – Somewhat unlikely
27% (11) 3 – Neutral
20% (8) 4 – Somewhat likely
46% (19) 5 – Very likely

Green Pass after the trial
How likely would you be to purchase Green Pass if it was available after the trial? (n=41)

24% (10) 1 – Very unlikely
12% (5) 2 – Somewhat unlikely
17% (7) 3 – Neutral
5% (2) 4 – Somewhat likely
41% (17) 5 – Very likely

Saver 25 after the trial
How likely would you be to purchase Saver 25 if it was available after the trial? (n=24)

8% (2) 1 – Very unlikely
13% (3) 2 – Somewhat unlikely
25% (6) 3 – Neutral
29% (7) 4 – Somewhat likely
25% (6) 5 – Very likely

Table 11. Prospects for future travel behaviour changes

<table>
<thead>
<tr>
<th>Mode choice and costs</th>
<th>Trial participants (ex-post questionnaire)</th>
</tr>
</thead>
<tbody>
<tr>
<td>How important are costs when choosing a mode of transport? (n=67)</td>
<td>28% (19) 1 – Most important</td>
</tr>
<tr>
<td></td>
<td>25% (17) 2</td>
</tr>
<tr>
<td></td>
<td>21% (14) 3</td>
</tr>
<tr>
<td></td>
<td>16% (11) 4</td>
</tr>
<tr>
<td></td>
<td>9% (6) 5 – Least important</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mode choice and convenience</th>
<th>How important is convenience when choosing a mode of transport? (n=67)</th>
</tr>
</thead>
<tbody>
<tr>
<td>43% (29) 1 – Most important</td>
<td>30% (20) 2</td>
</tr>
<tr>
<td></td>
<td>0% (0) 3</td>
</tr>
<tr>
<td></td>
<td>7% (5) 4</td>
</tr>
<tr>
<td></td>
<td>19% (13) 5 – Least important</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mode choice and sustainability</th>
<th>How important is sustainability when choosing a mode of transport? (n=67)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7% (5) 1 – Most important</td>
<td>22% (15) 2</td>
</tr>
<tr>
<td></td>
<td>36% (24) 3</td>
</tr>
<tr>
<td></td>
<td>27% (18) 4</td>
</tr>
<tr>
<td></td>
<td>7% (5) 5 – Least important</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mode choice and safety</th>
<th>How important is safety when choosing a mode of transport? (n=67)</th>
</tr>
</thead>
<tbody>
<tr>
<td>22% (15) 1 – Most important</td>
<td>13% (9) 2</td>
</tr>
<tr>
<td></td>
<td>36% (24) 3</td>
</tr>
<tr>
<td></td>
<td>18% (12) 4</td>
</tr>
<tr>
<td></td>
<td>10% (7) 5 – Least important</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Obstacles for behaviour change</th>
<th>What is the main obstacle for you to reduce transport-related CO2 emissions? (n=67, multiple choice)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6% (4) Not interested in CO2 reductions</td>
<td>19% (13) Public transport not available</td>
</tr>
<tr>
<td></td>
<td>24% (16) Public transport is slower</td>
</tr>
<tr>
<td></td>
<td>12% (8) Out-of-pocket costs of alternative modes</td>
</tr>
<tr>
<td></td>
<td>21% (14) Difficulty accessing alternative modes</td>
</tr>
<tr>
<td></td>
<td>45% (30) Convenience of private car</td>
</tr>
<tr>
<td></td>
<td>37% (25) Other</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Public transport post COVID-19</th>
<th>In a post Covid-19 world, how will your use of public transport change now the trial is over? (n=67)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3% (2) Didn’t use</td>
<td>12% (8) Decrease</td>
</tr>
<tr>
<td></td>
<td>57% (38) No change</td>
</tr>
<tr>
<td></td>
<td>28% (19) Increase</td>
</tr>
<tr>
<td></td>
<td>0% (0) Won’t use</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Taxi post COVID-19</th>
<th>In a post Covid-19 world, how will your use of taxi change now the trial is over? (n=67)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25% (17) Didn’t use</td>
<td>22% (15) Decrease</td>
</tr>
<tr>
<td></td>
<td>46% (31) No change</td>
</tr>
</tbody>
</table>

125 Four respondents picked “no” as well as one or several of the other alternatives.
<table>
<thead>
<tr>
<th>Service/Category</th>
<th>Answer Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uber post COVID-19</td>
<td>In a post Covid-19 world, how will your use of Uber change now the trial is over? (n=67)</td>
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<td></td>
<td>3% (2) Increase</td>
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<tr>
<td></td>
<td>3% (2) Won’t use</td>
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<td></td>
<td>10% (7) Didn’t use</td>
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<td></td>
<td>16% (11) Decrease</td>
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<td></td>
<td>64% (43) No change</td>
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<td></td>
<td>7% (5) Increase</td>
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<tr>
<td></td>
<td>1% (1) Won’t use</td>
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<tr>
<td>GoGet post COVID-19</td>
<td>In a post Covid-19 world, how will your use of GoGet change now the trial is over? (n=67)</td>
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<td>55% (37) Didn’t use</td>
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<td>3% (2) Decrease</td>
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<td></td>
<td>31% (21) No change</td>
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<td></td>
<td>3% (2) Increase</td>
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<td>7% (5) Won’t use</td>
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<td>Thrifty post COVID-19</td>
<td>In a post Covid-19 world, how will your use of Thrifty change now the trial is over? (n=67)</td>
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<td>57% (38) Didn’t use</td>
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<td>0% (0) Decrease</td>
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<td></td>
<td>30% (20) No change</td>
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<td></td>
<td>6% (4) Increase</td>
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<td></td>
<td>6% (4) Won’t use</td>
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<tr>
<td>Personal vehicle post COVID-19</td>
<td>In a post Covid-19 world, how will your use of personal vehicles change now the trial is over? (n=67)</td>
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<td>13% (9) Didn’t use</td>
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<td>15% (10) Decrease</td>
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<td></td>
<td>60% (40) No change</td>
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<td>10% (7) Increase</td>
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<td>1% (1) Won’t use</td>
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<td>Ola post COVID-19</td>
<td>In a post Covid-19 world, how will your use of Ola change now the trial is over? (n=67)</td>
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<td>58% (39) Didn’t use</td>
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<td>31% (21) No change</td>
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<td>4% (3) Increase</td>
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<td>3% (2) Won’t use</td>
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<td>Didi post COVID-19</td>
<td>In a post Covid-19 world, how will your use of Didi change now the trial is over? (n=67)</td>
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<td>61% (41) Didn’t use</td>
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<td>31% (21) No change</td>
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<td>3% (2) Increase</td>
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<td>3% (2) Won’t use</td>
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<td>CarNextDoor post COVID-19</td>
<td>In a post Covid-19 world, how will your use of CarNextDoor change now the trial is over? (n=67)</td>
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<td>63% (42) Didn’t use</td>
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<td>1% (1) Decrease</td>
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<td></td>
<td>27% (18) No change</td>
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<td>0% (0) Increase</td>
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<td>9% (6) Won’t use</td>
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<td>Other hire cars post COVID-19</td>
<td>In a post Covid-19 world, how will your use of other hire cars change now the trial is over? (n=67)</td>
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<td>57% (38) Didn’t use</td>
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<td>34% (23) No change</td>
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<td>6% (4) Won’t use</td>
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Appendix J: Mobility bundling and cultural tribalism - might passenger mobility plans through MaaS remain niche or are they truly scalable?

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Abstract

This short note is a topical issues paper focusing on the role that mobility as service (MaaS) might play in the future with a question as to whether it can grow to become a scalable product offer in the mobility market or whether it is destined to a niche offering. We consider arguments that may enable MaaS to be more than a niche product and have a supporting business case with the key element being a move beyond multi-modality to multi-services.

Keywords: Mobility as a service (Maas), niche product, scalable, multi-service, multi-product, ambiguity and redundancy

It is becoming popular in the transport sector to promote the packaging of multi-modal services, facilitated by digital platforms that offer the capability to coordinate services offered by many different suppliers. There has been a proliferation of reports and grey material praising the opportunities that bundling (or packaging) can have in achieving broad sustainability goals such as reduced emissions, and in the context of passenger transport through Mobility as a Service (MaaS), the reduction in private car ownership and use. The jury is still out as to whether MaaS will be a game changer or an interesting niche product for a limited population who can gain benefit from a one-stop approach to accessing mobility services – the topic explored by this topical issues paper.

Bundling or packaging is predicated on the ubiquitous development of digital applications which has allowed new ways of delivering and accessing services, as well as underpinning the development of the MaaS concept. This technology has been growing since the turn of the century with early day applications being smart cards (plastic cards with ‘chips’) initially used for payment systems in the transport domain. Research into the non-priced or soft benefits in the early days of these smart cards showed that there is value (and a positive willingness to pay) from multiple applications on a single smart card rather than multiple separate cards or multiple smart cards (Edwards and Mulley, 2004). This suggests that contemporary ideas of extending bundles beyond mobility to include a combination of services may well have buy-in from citizens. Telecommunications providers (often called Telcos) are an obvious service to combine with mobility, but utilities are also a good match, sharing the same characteristic of non-storeability with mobility. These also have the advantage of being necessary rather than discretionary purchases. The degree of similarity with Telcos is worth emphasising: user uptake for a mobile phone package may consider both the service package as well as the benefit of paying by instalment for their

126 An alternative position is that the marginal costs differ significantly, with telecommunication providers or utilities in general having a low marginal cost. In contrast, providing some extra mobility services, such as taxi or car-rental, is associated with a much higher marginal cost but other additional mobility services, such as an extra seat on a train service, is associated with a low marginal cost if there is spare capacity. Some have suggested that once car owners have acquired a car, they will use it more than they should? While true, the car, once purchased, has a low marginal use cost. The position taken in the text is that utilities share the same characteristics, but not the MC characteristics in all cases.
choice of phone (hardware); but in the case of MaaS there is no hardware involved, only an App which is accessible under a subscription plan.

There is no doubt that some sort of partnering will be helpful for MaaS to develop out of the niche bracket, especially if it is all centred on the single item to carry around as with the smart phone. This is entirely possible, with even bank cards becoming superfluous with the take up of Apple pay\textsuperscript{127}. The big question is what sort of service bundles might emerge? Some commentators suggest that the types of service bundles that emerge may be a combination of various services, what we call multi-service in contrast to multi-modal and not restricted to mobility, such as a mobile phone contract, with data, a streaming package and mobility options (e.g., first and last mile (micro-mobility), ride-hail and public transport) together with utility or other household related essential services (e.g., television packages such as Amazon Prime, Netflix). Retail discounts and other rewards have been favoured for inclusion, but these additions are likely to be more marginal, based as they are on discretionary purchases, unless retail reads food and groceries. This could, for those to whom it may appeal, capture all the behaviour of customers from the moment they wake until they sleep, where they go, what they like to look at, and what their willingness to pay is for an extended set of one-stop services and items. It is suggested by some commentators that most of the Telcos are pretty close to full customer capture at the moment (purely due to smart phone capabilities). If this is the case, then it may be just a matter of time before they transition to partnering with organisations to offer mobility. This could be the much needed shot in the arm for MaaS as the importance of getting non-mobility service providers involved becomes ever more apparent. Indeed, it is likely to be of more importance to MaaS than to the services with which it partners, as it provides the opportunity to create a different business model for MaaS, especially if the aim is commercial, which has more opportunity for cross subsidy than hitherto. To support this idea, consider the business cases in other settings: Telcos for example are increasingly offering more bespoke arrangements to keep their customers interested and grow their market share, including 'choose your own plan' and 'bring your plan with you' options. The blurring of the price of a subscription may well be key for these organisations to disguise the real way that the Telcos make their money, through on-selling aggregated data and the broader commercial value in their partnering arrangements. Obtaining the customer is essentially marginal. Might this apply to MaaS in the future?\textsuperscript{6}

While we have shown, through the Sydney MaaS trial, that offering subscription bundles compared to Pay-as-you-go has appeal to nearly 50% of the market who are interested in MaaS (Hensher, Ho and Reck 2020, Ho et al. 2020), the big question remains as to whether the majority of the population really want such a tailored approach to accessing transportation? Hence the real question is whether 50% of a very small market of trial participants scales up to 50% of the broader population?\textsuperscript{128} The outcome may well depend on the governance arrangements (see Hensher et al. 2020b). If we have what is increasingly being called regulated utility MaaS, where there is competition between the aggregators in meeting demand, then there can, in theory at least, be a proliferation of MaaS packages where they are suitably differentiated to meet the needs of different people. This also applies to an extent with the walled garden type arrangement where the aggregators make contracts with selected mobility operators and create offerings to the customer based on these contracts. This is what has happened with the mobile phone/internet market where people have chosen their provider on the basis of liking the plan they offer. Other governance arrangements where there is only one demand facing aggregator (which arguably is what the Sydney trial mirrored) may not be able to provide enough packages to sufficiently differentiate and appeal to everyone. All of this suggests the need to be more focussed on mapping potential outcomes to potential governance arrangements, and to push in a direction where the MaaS bundles help create the greater sustainability that MaaS could offer, but is very unlikely to be the case if it remains niche.

In working through the arguments to support MaaS, there has always been one issue that has been a significant source of concern to us. It is that, if the packaging of mobility services is not sufficiently flexible,

\textsuperscript{127} However, there may be a significant percentage of population who have not been, and will never be, seeing the benefits of such a technology, despite that they are technologically capable. While true, it depends on what is meant by 'significant'. The soft benefits study showed there was a benefit in having only one card to carry around and we suspect that for some people, just carrying their phone is desirable

\textsuperscript{128} One of the crucial experiences many people had with the Sydney MaaS trial was that they saw their monthly mobility "consumption" in dollars per mode the first time. Once consumers get more used to this, acceptance for bundles might increase, especially with marketing as the secure, easy, "not to worry about" option (mobile phone plans) as they offer a ceiling in the case of flat rates.
which may require too many variations to be of value to mobility providers (noting that to date the few MaaS products such as Whim and Ubigo rarely exceed four bundles), then there is likely to be significant build-in redundancy from a potential users position that they will not be interested in the uptakes of such offers. In a recent book by James Mumford (2020a) called Vexed, he is suggesting that we must be very wary of packaging, and that bundling may have significant concerning issues, since with few variants it constrains rather than expands choice. Within the passenger transport context, the one stop shop for all mobility that is claimed to be mobility needs, may in fact contain many non-needs and missing some relevant needs, creating ambiguity, confusion and resulting lack of interest. The best way to minimise ambiguity and redundancy might instead to offer only Pay as you Go options rather than a package of services. If this is true, then even if bundling may appeal to a small niche market, it is likely that scalability of MaaS is a dream. If simplicity as a pre-condition to other benefits is what most people want, this might be best provided through a digital platform that is single service focussed, exactly what we have at present for each mode (e.g., Opal for public transport in NSW, Uber, Ola, Didi etc.). Are people complaining about this? Generally, no is the response.

How important is bundling to MaaS? If, as currently the case, bundles are limited to a few options in a dominant multi-modal only setting, MaaS will not grow beyond the niche. The talk of multi-service bundles is still hypothetical and unexplored. To help understand potential mobility opportunities for MaaS, it will be important to start with a full month of detailed travel activity by all modes of transport for potential users, capturing travel times, service frequency, reliability, costs, crowding, kilometres etc. as well as what non-transport packaging offers have appealed. This would allow the identification of changes that benefit specific individuals and use this to see if some possibly needs-based bundles could emerge. This is likely to reveal the importance of transport service level improvements and not just financial savings opportunities to travellers, thus underwriting the importance of service quality. However, this process will not be straightforward since MaaS offers are unlikely to differ in terms of transport service levels as compared to other ways of accessing transport, and financial incentives associated with mobility services may be the only way to attract interest in a mobility-only based package. This is where the multi-service setting comes into play, and the addition of the non-transport services are what just might sway individuals to subscribe to a bundle that offers very little benefit associated with travel but benefits with being bundled with the other services (Hensher 2020). Importantly, multi-service contracts offer greater opportunities to cross subsidise, and the combination of mobility and other services may provide an overall financially beneficial package, not only to subscribers but to suppliers or brokers. However, if this is the case, one wonders how MaaS (with multi-service bundles) brings the societal benefit in terms of helping to meet sustainability goals. So it would seem the dilemma for MaaS is picking the bundle winners out of a very large stable of combinations of possibilities and developing a business case, commercial or otherwise, that can support the preferred set, where the preferences are those of potential customers in a way that makes all the services more appealing, and desirably passes the test of relevant sustainability key performance indicators which one would hope matter to the commitment of government to MaaS. An alternative to the package-type MaaS is the marketplace-type MaaS in which users pick and mix themselves, or what is called co-creation between users and suppliers via the aggregator. This has implementation challenges which appear to be more complex than the current examples in marketplace platforms such as eBay or Amazon.

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129 In the sense of managing such a quantity of offers by one mobility providers, which in turns increases the operating cost. However in a governance arrangement where there is more than one aggregator, one may expect to see a proliferation of bundles in much the same way as with Telcos.

130 The answer to this question also depends not only on the number of bundles one offers, but also the level of service guaranteed, and how these are compared against the options, notably the private car that the user has. In the current shared-mobility market, the MaaS LOS, in utility or monetary terms, is still worse than what the private car can offer in many locations. In the future, if and when AVs are included in the MaaS offer, that could change dramatically and that is when MaaS has a greater prospect for scalability. For example, as the moment, if one wants to use a shared-car, they have to book it in advance, and have to go to the pad to get it and then return it after every use. When a shared-car is AV, the hassles of booking, getting and returning the car should be eliminated changing the dynamic on using shared-car instead of owning a car.

131 Outside of the transport sector, there is evidence of a growing area for organisations to have a 'social licence to operate'. This concept is prevalent in the resources sector. As consumers become more environmentally conscious, this type of concept may translate into other sectors with a growing number of companies wanting to be certified as carbon neutral. We might expect that 'culturally' the environmental benefits of MaaS is one of the reasons that the Scandinavian countries embraced the concept of MaaS earlier than other countries. Of course, there is a role for regulators in this space too, in setting the broader societal outcomes that we expect from service operators. (Personal communication with Natasha Hinrichsen).
Understanding bundling means understanding the behaviour of citizens towards this practice. Underlying much of the thinking about the concerns surrounding bundling is what is sometimes called tribalism, or behaviour and attitudes that stem from strong loyalty to one’s own tribe or social group. This needs to be placed in a cultural setting, and so it might best described as cultural tribalism, where national culture is understood as a multi-faceted concept which fits with the different approaches taken by MaaS operators in different countries (Hofstede132). Tribalism in this context also has synergies with the segmentation of markets into behaviourally sensitive segments (Anable, 2005) as Figure 1 illustrates with a segmentation or type of tribalism that could be evolving in the MaaS space. This, however, has the real risk of pigeonholing people, with profound implications for MaaS. In the words of Mumford (2020b), to let alliances fall where alliances fall. The implication for MaaS is profound.

![Figure 1. Five mobility tribes (Alonso-González et al. 2020)](image)

There is a lot of evidence to suggest that (degrees of) integrated services are good and are what people would like to have, but cultural tribalism is a reminder that there are many built in prejudices that are challenging to break if sustainable outcomes are to be achieved. Perhaps another route might be to accept these cultural differences and use improved relevant information and opportunities to experience alternative ways of doing things, so that what we see in different contexts will be different. This is commonly seen through phrases such as ‘I always tend to do what my friends do’, ‘If it is alright for other elderly people than it will work for me’, and ‘the world is becoming too complicated and the cost of finding out is not worth the likely benefits’133. It is also illustrated by the take-up of new mobility services, such as on-demand transport, being best advertised by the users themselves. This focus aligns well with ideas of herding behaviour, where we have leaders and followers and through example, individuals see the merit of new mobility ideas and come on board. This can be achieved by participation from both government and industry associations.

For some, if not most cultural tribes, change will be slow, very slow, and the extent to which MaaS in particular can benefit by change will be inextricably linked back to how well it can demonstrate that the benefits significantly outweigh the costs (including effort) for many cultural tribes or segments. In the Telco context, customers appear to be happy with bundling as long as the increases are minor and incremental (so they are easy to comprehend and digest), and they can see ‘value’ in the service being offered. If not, we may, in ten years time, or even sooner, talk about a program of historical interest that failed: MaaSively impactful may become MaaSively oversold! We hope we are wrong because MaaS has the opportunity to deliver on this promise.

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132 see https://geerthofstede.com/culture-geert-hofstede-gert-jan-hofstede/6d-model-of-national-culture/)
133 It is noteworthy that less than 4% of household disposable income (HDI) is spent on mobile and fixed-line telephone rent, calls and internet charges (Source. The Household Income and Labour Dynamics in Australia (HILDA) Survey, Release 15.). If we exclude the cost of owning a car (~12% of HDI), then we have a similar percentage outlay on transport as on telecommunications.
opportunity to add significantly to sustainable outcomes, but time will tell; and with Covid-19 imposing an even more challenging future, that may be a very long time.

Acknowledgements. We especially thank Natasha Hinrichsen (Policy Director, Mobility as a Service Program Management, Department of Transport and Main Roads Queensland) for many useful comments on earlier drafts; as well as Chinh Ho and John Nelson (ITLS) and Daniel Reck (ETH Switzerland) for discussions. All view, however, are ours alone. We also thank two referees.

References


Appendix K: Mobility as a Service (MaaS) – Going Somewhere or Nowhere?

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10 February 2021

Abstract
Noting the continuing lack of agreement as to how the concept of Mobility as a Service (MaaS) should be defined, this short paper offers an evaluation of the extent to which MaaS faces a very uncertain future. While MaaS remains a compelling concept, without evidence of MaaS contributing to sustainability goals the multimodal future may be one of contactless deep linked customer-oriented Apps with no provision for bundling mobility services. A MaaS Champion with a proactive approach, led by government, seems essential for any future positive outcomes.

Keywords: Mobility as a Service (MaaS); definition; journey planner; multimodal; sustainability

Acknowledgements
We thank Chinh Ho, Daniel Reck and Natasha Hinrichsen for useful comments. The views expressed in this short piece are solely those of the authors, who are responsible for all errors and omissions.

The pandemic has not led to a decline in the interest in Mobility as a Service (MaaS) despite many aspects of transport worldwide suffering a considerable decline. Despite this, using the Gartner hype cycle, MaaS was probably at the ‘peak of inflated expectations’ a couple of years ago and now is somewhere in the ‘trough of disillusionment’. The pandemic has led to the question as to whether MaaS will sink or swim (Hensher, 2020) and/or if in some ways the COVID-19 recovery might provide an opportunity for MaaS to become more centre stage.

The commentary on MaaS is often unfocussed because of a lack of agreed definition. We recently offered a clarifying definition of what constitutes MaaS (and what does not) to use as a reference benchmark to decide if a MaaS solution is being offered:

“MaaS is a framework for delivering a portfolio of multi-modal mobility services that places the user at the centre of the offer. MaaS frameworks are ideally designed to achieve sustainable policy goals and objectives. MaaS is an integrated transport service brokered by an integrator through a digital platform. A digital platform provides information, booking, ticketing, payment (as PAYG and/or subscription plans), and feedback that improves the travel experience. The MaaS framework can operate at any spatial scale (i.e., urban or regional or global) and cover any combination of multi-modal and non-transport-related multi-service offerings, including the private car and parking, whether subsidised or not by the public sector. MaaS is not simply a digital version of a travel planner, nor a flexible transport service (such as Mobility on Demand), nor a single shared transport offering (such as car sharing).‘Emerging MaaS’ best describes MaaS offered on a niche foundation. This relates to situations where MaaS is offered on a limited spatial scale, to a limited segment of society or focused on limited modes of transport.
The MaaS framework becomes mainstream when the usage by travellers dominates a spatial scale and the framework encompasses a majority of the modes of transport.”

Herrlin (2021) in an opinion piece titled ‘MaaSive fail’ focusses on part of this definition and wonders if there is too much focus on the system and not enough on problem-solving, listing a number of issues that raise fundamental concerns about the virtues of MaaS. His comment has prompted an evaluation by the authors of the extent to which MaaS may not just be experiencing Herrlin’s ‘failure’, but just going nowhere.

The first key issue relates to traditional public transport as the central supplier (or “backbone”) to MaaS. It is of course true that public transport is unprofitable in the normal way of things and requires significant subsidy. However, any attempt to innovate to be more customer-focused has in the main still required subsidy with private demand-responsive solutions failing at a significant rate. The ride share and e-scooter suppliers are struggling although backed by increasing amounts of venture capital with little evidence of a profitable solution on the horizon, a situation made more acute by COVID-19. In general, this applies to all individual shared mobility services, and there appears to be little prospect of a public transport authority cross-subsidising these services alongside heavy subsidy-requiring mainstream public transport given the on-going need to deliver more with less funds. This is likely to continue to be true into the immediate future whilst the cost of supporting public transport through the pandemic takes its toll.

Although a MaaS offer run by the public sector is more likely to be put in place, given the increasing uncertainty in establishing a commercially viable business case, will the required subsidy be worth it? This is only likely if the take-up is such that sustainability goals and objectives will be met. This would require a significant scaling up of the services on offer (from a fragmented market of suppliers) with enough of a discount or convenience to attract users that convert to an acceptable margin. It is clear that there remain important issues of governance in the emerging MaaS future to resolve, as highlighted by Hensher et al (2020). Fostering a healthy MaaS ecosystem environment requires the identification of a “MaaS Champion” whose role, amongst others, is to influence the development of MaaS to align with broader societal goals.

A “MaaS Champion” would have a considerable task. On one level, the champion would need to push for a change in the way that MaaS is considered. Moving away from thinking of a MaaS ecosystem as a collection of vertically integrated services based on providing mobility with each supplier aiming to maximise their market share, to a world where the suppliers co-operate to service the market and users are encouraged or incentivised to consume mobility and other services in order to promote sustainable outcomes. For this reason and under this scenario, the most likely candidate for this role would seem to be government.

Secondly, while the idea of a broker or aggregator is acknowledged as good sense, it is unclear who might take up this challenge. Both private and public operators are keen to protect their one-to-one relationship and brand with end use customers and so are unwilling to share degrees of loss and profitability within a MaaS model where a commercial business case is yet proven (Mulley and Nelson, 2020). If there is no profit, how can its spoils be shared? This is especially the case where it matters to operate to service the market and users are encouraged or incentivised to consume mobility and other services in order to promote sustainable outcomes. For this reason and under this scenario, the most likely candidate for this role would seem to be government.

Secondly, while the idea of a broker or aggregator is acknowledged as good sense, it is unclear who might take up this challenge. Both private and public operators are keen to protect their one-to-one relationship and brand with end use customers and so are unwilling to share degrees of loss and profitability within a MaaS model where a commercial business case is yet proven (Mulley and Nelson, 2020). If there is no profit, how can its spoils be shared? This is especially the case where it matters to promote the sustainability outcomes (which are unlikely to be financially attractive). It may be though that future generations of users are attracted by the possibility of a “sustainability contribution” as part of their mobility bundle. MaaS promotion appears to forget that while potential markets are already being well serviced there is still more to be done to improve the customer experience. Travel agents book online for longer trips, attractive discounts exist for public transport in the commuting market with increasingly available smart account-based Apps for contactless payment which are almost universally available for both public and private transport. In this market, the value of MaaS is for travellers who do not only want to access public transport, but to regularly combine other modes of transport such as car clubs (e.g. Car Next Door), taxis, and micromobility schemes. Why would this segment of travellers sign up for a MaaS offer? This is only likely if they save money by using the MaaS platform or if they are willing to pay for greater seamlessness and convenience than a contactless travel solution is already providing? The question this raises is how much would customers be willing to pay for convenience and seamlessness? We suspect, not much, even when motivated by personal sustainability goals and objectives, although we acknowledge that the growing emphasis on the “as a service” sector is redefining the perception of
convenience. In another recent critique of MaaS which calls for a more subjective evaluation Ditmore (2020) asserts: “the industry has a messaging problem, but it is rooted in the fact that the general public does not see their life mirrored in the product”. If she is correct, then the future could indeed be interpreted as bleak for MaaS.

Thirdly, perhaps it is telling that Herrlin (2020) does not mention bundling given the misuse of the term MaaS. He has a point when he talks about existing solutions (Journey Planners and contactless payment) working well for travellers. The [good] Journey Planner vs. MaaS debate, once we have an agreed benchmark definition, is pivotal to the future debate since the former, if coupled with contactless payment, will keep most travellers happy (although a single truly intermodal journey planner is, we believe, yet to exist). Anecdotally we know that many are happy to travel around using their credit card for infrequent use in their home city and everywhere internationally. So, have we, in promoting MaaS, overestimated what passengers really want?

So what does MaaS offer over good journey planners? Journey planning apps such as Google or Apple Maps now allow users to navigate transport systems and get turn-by-turn directions, facilitating, through deep linking, most transactions for most modes through Google Pay and Apple Pay. What this suggests is that a private MaaS offer will need to offer much more if it is to be profitable, let alone to gain respect and social licence support more broadly. Within the convenience space of existing digital facilities, there may be a price that busy people are prepared to pay for MaaS solutions driven by superior convenience (while being a “good corporate citizen”) but whether this is enough to appeal to providers remains an open question.

In the words of Herrlin (2021), “Great journey planners highlight available options and guide passengers through the experience of using various modes of transport, eliminating confusion along the way. If payment for local transport is contactless and other modes are easily accessed and/or paid for via deep links, then the main obstacle is to continue working on delivering a great multimodal journey planning experience that suggests the appropriate mode based on preferences, weather, journey time, cost and so on.” Unless other developments make MaaS more desirable, such as bundling mobility services with non-mobility utility services providing a more convenient way to live beyond only tackling mobility, we suggest that MaaS, defined as above, is unlikely to be going anywhere.

Against this evidence is the rather more encouraging evidence from trials that underpins our fourth key issue. The experience with subscription plans and discounts in the Sydney trial (Hensher et al. 2021) suggests that there is the potential to gain subscribers and reduce private car use, but there is little in a business model to turn this into a profitable activity. The Sydney Trial demonstrated the potential of selling MaaS as a monthly or periodic bundle, with or without non-mobility services, suggesting MaaS products (cf. apps) present value-adding for users, with over 36% of the participants taking up a bundle in preference to Pay as you Go. But, this was achieved with a subsidy to users. We believe that without a (monetary) incentive or without taking a gamified approach (whereby benefits have been seen through incentivised collaboration between friends) (Yen et al, 2019), travellers will see very little value in MaaS in the presence of existing services that are improving all the time with improved technical platforms that facilitate payment in addition to searching and planning (for example, in Sydney, the smart card became contactless and then provided the ability to use a credit card), and hence not enough buy-in to make a currently niche product scalable. The trial did not deliver enough evidence on the scalability of an attractive niche product (Hensher and Mulley 2020).

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134 https://www.itsinternational.com/its17/feature/dignity-should-be-key-measure-maas-success
135 It is interesting to note the recent statement by Iomob that “we no longer self-identify as a MaaS company, but rather a Mobility on Demand Platform which supports a range of use cases for our enterprise companies, including but not limited to MaaS”. This could be taken as illustrating both the lack of clarification around the definition of MaaS and the lack of an obvious business case. See https://www.iomob.net/iomob-the-worlds-first-interoperable-mobility-on-demand-platform-boyd-cohen-ceo-iomob/

136 In a personal communication with Natasha Hinrichsen (9 February 2021), Natasha comments that “What do you think the results would look like if all the participants were born after 2001? Globally this is when the world shifted towards uncertainty. The children born after 2001 have been raised in a different world. SARS in 2002. Then 2008 saw the Global Financial Crisis, people losing their jobs or their retirement funds. Then we had COVID-
However, the Sydney trial did show some potentially positive sustainability outcomes associated with reduced private car use and emissions, including the potential to include electric cars to support sustainable solutions. How much will the public sector be willing to support MaaS if it brings sustainability benefits? And would this support be a good use of resource? It would seem to have merit where the sustainability outcomes align with government objectives (discussed in detail in Hensher et al. 2020, chapter 8, Section 8.9)\textsuperscript{137}. All this suggests that without evidence of contributing to sustainability goals, a real challenge for government in particular, we see a bleak future for MaaS, leaving the multi-modal future as one of contactless deep linked customer-oriented Apps designed to be interoperable between different jurisdictions.

Mulley and Nelson (2020) at the International Transport Forum (ITF) round table on Integrating Public Transport into MaaS asked the question “Is MaaS in crisis?” and gained an impression that the audience did not want to discuss this! Conceptually, we still believe that MaaS is a compelling concept especially if delivered with the sustainability aspects of the definition; however, there is much groundwork still to be done. We are not sure whether bundles will ever become mainstream as we increasingly come to believe many people would be just as happy with a public transport season ticket with capped weekly fares plus the occasional pay-per-use bikeshare/carshare/… ride.

References


\textsuperscript{19} These generations have a greater view of social responsibility, particularly towards climate change. They’re also digital natives. They will adopt a MaaS solution, particularly if it’s gamified."

\textsuperscript{137} The MaaS book ITLS wrote is #2 on best technology and mobility books: https://skedgo.com/our-top-ten-must-reads-on-business-tech-and-transport/
Appendix L: MaaS bundle design and implementation: Lessons from the Sydney MaaS Trial

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Abstract

A central feature of Mobility as a Service (MaaS) is the design of subscription plans, also known as mobility bundles. Despite the recognition of the importance of MaaS bundles compared to the Pay as you Go (PAYG) option, there is very little guidance in the literature on what a bundle that is attractive for users and financially viable for the operator might look like. With very few actual MaaS offers in real markets, and a lack of transparency in sharing how successful the few MaaS offers have been, the call for trials has grown throughout the world. The Sydney MaaS trial is the first in Australia to introduce MaaS bundles, using an incremental strategy of adding a bundle each month after a PAYG familiarity period. This paper sets out a framework within which we designed and introduced five bundles, using a co-creation and data-driven approach to bundle design. We present the findings on how successful bundles were in attracting MaaS users away from PAYG, and what this uptake might mean for achieving goals such as reduced transport emissions, notably those associated with private car use.

Keywords: Mobility as a Service (MaaS), Bundle design, Mobility plans, Bundle uptake, Co-creation, Sydney MaaS trial, sustainability outcomes.

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Introduction

The interest in Mobility as a Service (MaaS) has garnered support from many stakeholders who see it as offering a way to connect greater mobility choices for travellers with an attractive information-laden framework. Powered by digital technology, mobility suppliers and those who bring them together through some aggregation structure (typically acting as a broker) deliver the extended set of mobility choices. MaaS is seen as an ecosystem that can, through appropriate incentive-based regulation, offer a way forward for government and other interested parties to achieve a wide range of sustainability objectives such as reducing transport emissions and private car ownership (Hensher et al., 2020, Smith and Hensher, 2020). The Sydney MaaS trial, the first in Australia, has a number of objectives of which sustainability in terms of private car usage and a test of commercial viability are prominent.

A necessary but not sufficient condition for achieving MaaS sustainability objectives is a digital platform, typically in the form of a smart-phone app and its back-end database. This digital platform provides a multi-modal journey planner capability but also offers information on ways of achieving mobility outcomes that align well with customer preferences. Some digital platforms allow the users to specify their preferences in terms of individual priorities of different travel attributes such as time, cost, hassle, and emission. The last piece of evidence contributes to sustainability outcomes which may or may not appeal to users.

At the centre of the MaaS ecosystem is a recognition that although an appropriate digital platform is required, this is not enough to move MaaS beyond being an improved journey planner with a potentially convenient one-stop shop for all mobility services a traveller may want. We argue that this is the case even when the MaaS app can offer payment integration, but with a pay as you go (PAYG) option only, with or without a personal mobility wallet function through which an integrated payment mechanism may be available.\textsuperscript{138} There is emerging evidence that MaaS offering PAYG option only which is the only option in the majority of digital platforms promoted as MaaS, is not enough to attract potential users, and where it has, it is unlikely to change travel behaviour in ways that can benefit individuals and society as a whole (Ho et al., 2018, Ho et al., 2020, Matyas and Kamargianni, 2018).

What is missing is a way to co-create different ways to make MaaS offers attractive in a way that it can impact traveller behaviour and deliver desirable aggregate changes of the performance of the mobility network. MaaS requires some structure that can be adjusted to respond to such opportunities. This structure is a suite of subscription bundles that offer varying combinations of mobility services for a given subscription fee. The subscription bundles can be designed and adapted to accommodate the preferences and travel habits of potential subscribers while also achieving gains in key sustainability goals of government and other socially committed groups. In addition, the way in which MaaS might be delivered to the market must recognise the need for a structural outcome that aligns with the set of objectives set by interested stakeholders, notably the business case in terms of a commercial outcome or a net benefit outcome to society that is supported by public subsidy.

This paper sees subscription design, through the development and implementation of a range of bundles, as the linchpin in testing various MaaS offerings on a journey to establish a business case in line with agreed objectives. The Sydney MaaS trial, undertaken in 2019-2020, was designed to develop a way to identify financially viable bundles and to test them in a revealed preference setting. The trial monitors impacts and revises the bundle offers through a sequential incremental addition of complementary bundles as more insights into travel behaviour and bundle uptake are obtained. Based on the growing knowledge through data analysis and qualitative interviews as the trial progressed, further opportunities are identified and additional bundles introduced to satisfy customer needs beyond that available under PAYG and the existing bundles. While business factors and other instructional aspects are also relevant to the development and implementation of MaaS (Karlsson et al., 2020), we focus on revealed consumer preferences to design subscription bundles that improve uptake so that the trial objectives in terms of sustainability and commercial viability can be evaluated. This paper describes this co-creation and data-driven approach to bundle design in detail such that other trials may benefit from the lessons learnt from the MaaS trial in Sydney, Australia.

\textsuperscript{138} Payment integration could be in the form of an account based payment tool or a digital smart-card stored on the user’s smart-phone. An example of the latter is the digital Opal card in Sydney where the former is typically in a form of a digital credit-card payment such as Apple Pay and Google Pay.
Reflecting on the experience of designing and implementing bundles prior to the trial through stated preference (SP) surveys (Ho et al 2018, 2020) and for the Sydney MaaS trial, we recognise that designing bundles in an SP setting is relatively easier than in a revealed preference setting. Despite the learnings from SP surveys on potential interest in bundle take up, the transition to real market implementation is complex and challenging. The transition is not simply the offer of appealing bundles but the entire infrastructure required in integrating all facets of MaaS. To date there is very little in the literature and reported real experience to guide us. For example, the most widely promoted MaaS offer with bundles, Whim in Finland, has no publicly available documentation on the underlying theory and methodology objectives, and assessment of how successful these bundles are, and why these bundles were designed in the way they were. This paper provides first-hand knowledge on how to design and implement MaaS bundles, taking into consideration the spatial and technical settings of the MaaS offers.

This paper is structured as follows: Section 2 discusses the range of issues that need careful consideration in bundle design and implementation. Section 3 summarises the practical challenges of implementing bundles, while Section 4 outlines approaches to bundle design. Section 5 discusses mechanisms and levers available to design MaaS bundles. This is followed by Section 6 that details the design of specific bundles and the uptake of such bundles with a focus on the extent to which such bundles align with customer preferences and broader societal goals. Section 7 summarise implementation experience in areas such as platform design, customer enrolment, and invoicing, while Section 8 provides an overview of bundle uptakes. We conclude the paper with a summary of lessons learnt and challenges going forward.

Literature review

The literature on MaaS bundle design is dominated by studies employing stated preference methods, while only a few studies employ revealed preference methods or indeed any other methods, and only a few trials have been transparently reported upon. Here, we provide an overview of the main contributions to identify the research gap we address, and refer the reader to a recent review on MaaS bundle design (Reck et al., 2020) for further details.

Several authors have recently conducted stated preference studies to investigate the willingness to pay (WTP) and potential uptake of MaaS bundles (e.g., Caiati et al., 2020; Feneri et al., 2020; Guidon et al., 2020; Ho et al., 2018; Ho et al., 2020; Matyas and Kamargianni, 2019a; Mulley et al., 2020; Polydoropoulou et al., 2020). Methodologically, most authors present their study participants with a number of choice situations where bundle configurations vary (e.g., by included transport modes or allowances) and subsequently model bundle uptake using discrete choice models. One common finding is that uptake intention is correlated with current mobility tool usage (Ho et al., 2018; Ho et al., 2020; Matyas and Kamargianni 2019b; Polydoropoulou et al., 2020). While public transportation is preferred by most participants, heterogeneity is much higher for shared modes. In particular, bundles containing taxi or ridesourcing budgets only appeal to their current users (which are often in the minority of the samples resulting in overall negative coefficients for these modes). While there appears to be a high general interest in buying MaaS bundles and using MaaS apps (Ho et al., 2018; Matyas and Kamargianni, 2019a), only participants in Zurich appear to be willing to pay for an app per se (Guidon et al., 2020; Ho et al., 2020). Methodologically diverting from previous studies, Caiati et al. (2020) conducted a portfolio choice experiment (Wiley and Timmermanns, 2009) where participants could design their own bundles containing variations of modes, pricing schemes, geographical validity and extra features. They found that price and social influence variables had a substantial effect on bundle uptake. Finally, taking a more macroscopic approach, Esztergár-Kiss and Kerényi (2020) related city characteristics to bundle contents and levels.

While SP studies were very useful early explorations of MaaS bundle design, they are subject to hypothetical bias (Hensher, 2010). Thus, real-world trials are needed to test previous findings and

139 To clarify in a little more detail, we argue that designing bundles in terms of specifying what to include in a bundle in an SP setting is probably as challenging as it is in an RP setting; however obtaining relevant information from users is very different. This may be easier / more straightforward in an SP setting, however limited at the same time due to the hypothetical bias. Collecting relevant RP data is much more challenging / complex but has the potential to yield greater insight.

140 What is out there is in many ways arbitrary and appears to be ‘suck it and see’ in real applications.
generate further insight. The earliest and probably most thoroughly documented MaaS trial is the UbiGo trial conducted in Gothenburg in 2013/2014 (Sochor et al., 2015; Sochor et al., 2016; Strömberg et al., 2016; Strömberg et al., 2018). 83 households participated in the trial and could subscribe to customizable MaaS bundles. Strömberg et al. (2016) and Sochor et al. (2015) conclude that the trial helped participants to try out new transport modes and made multimodal travel less expensive and more convenient. By means of interview analyses, the trial was found to promote usage of public transport and active modes over private car use and induced changes in mode choice behaviour for 42% of the participants.

Once issue that researchers and practitioners face when planning a new trial is how to design MaaS bundles. Previous trials and studies have either used customizable portfolio choice approaches (Ubigo, Caiati et al., 2020) or relied on pre-designed plans following the authors’ intuition. In a recent study, Reck et al. (2020) synthesized ten fundamental design dimensions of MaaS bundles, providing researchers and practitioners a framework within which to design new bundles. An open question, however, is of a procedural nature: how to design MaaS bundles using revealed preference data?

To date, only two studies have started research in this direction. Liljamo et al. (2020) directly related current mobility costs to willingness to pay for MaaS bundles using linear regression analysis. Reck and Axhausen (2020) use tracking data to fit MaaS bundles to the mobility traces of a panel of Danish students. In line with previous SP studies, they find that public transportation season tickets are a viable core for MaaS bundles, fitting the majority of the samples’ travel patterns, while usage of shared modes (carsharing, bikesharing, taxi) is too infrequent to include as recurring credit in MaaS plans.

While these studies provide first guidance for how to design MaaS bundles, they also remain hypothetical, as participants in those studies never actually had to buy them. Hence, to our knowledge, no one so far has designed and tested uptake in a real-world trial setting.

Factors to consider in bundle design and implementation

In designing and implementing MaaS bundles, an obvious starting point for MaaS integrators is a mix of transport modes they can offer to their customers (i.e., MaaS users). This is because MaaS operates on the concept of uniting existing transport modes to provide a better service to travellers. In this context, Reck et al. (2020) offers a master design framework which distinguishes necessary design dimensions from complementary design dimensions. Choosing which modes to include is the most important dimension of a MaaS bundle design, in addition to other necessary dimensions including metrics (how to measure quantity/entitlement), targeted customers (individuals or groups), subscription cycle (fortnight, month, quarter, or year), and spatial coverage (or valid area).

Mix of transport modes

In the context of SP experiments, selecting a mix of transport modes to offer in a bundle is typically driven by two factors: the availability of different modes in the study area, and the roles of these modes in the local setting (e.g., trunk services vs. first and last mile services, transport modes for everyday travel vs. weekend outings). There is, however, a marked difference between designing MaaS bundles for SP experiments and designing bundles for real-world subscriptions. This is because an SP design does not need to justify the ‘cost’ of including these modes against the marginal benefits of their inclusions, whether this benefit is financial (e.g., improving the attractiveness of the bundle and hence uptake) or societal (e.g., encouraging sustainable behaviour and hence reducing greenhouse gas emissions).

Conversely, in real-world experiments or operation, the process of selecting which modes to include in a MaaS bundle involves trade-offs and often long negotiations. First, negotiations with transport service providers (TSP) must take place for each mode to be included in the MaaS platform. This negotiation could mean obtaining an agreement with TSPs to resell their transport tickets in the case of public transport to end-users, or require TSPs to provide a special arrangement for business-style accounts so that bookings and payments for transport services made by MaaS users can be done automatically and in bulk by a MaaS integrator. However, the negotiation may also require TSPs to provide a discount from the standard fare for bulk purchase such that financial levers are available to create attractive and commercially viable MaaS bundles for subscription.
Once agreement has been obtained, TSP’s technical readiness presents a second hurdle to be addressed before the corresponding mode could be included in the MaaS (bundle) offers. The required level of technical readiness depends on the targeted level of technical and operational integration. For example, the basic level of integration associated with informational integration across some transport modes does not require much technical setup beyond an access to the TSP’s service timetable database or app through, for example, an API gate (Application Programming Interface). Travellers in many cities/countries have already enjoyed informational integration through free apps such as Moovit and Google Maps. Aiming to offer MaaS users a fully integrated experience, however, requires significant technical setup, and hence cost, to achieve not only informational integration but also operational and transactional integrations across all modes of transport included in a MaaS offer (Lyons et al., 2019).

The highest level of integration additionally allows users to pre-pay for their travel by subscribing to a mobility bundle that best suits their travel needs (Reck et al., 2020). These subscription bundles could either be pre-defined by the MaaS integrator (e.g., Whim) or be co-created with the customers (e.g. UbiGo). Also, mobility bundles can be designed with or without an integration of societal goals such as reducing CO2 emissions (Sochor et al., 2018). In all forms and shapes, a fully integrated version of MaaS should allow its users to search for the services they want, but also to book, pay, and manage their account almost in real-time or near real-time, depending on how often the transaction database is updated. We argue that only through this full integration with built-in bundles does MaaS become a mainstream product, and hence can realise its potential to change travel behaviour towards more sustainable travel (i.e., MaaS is used to achieve societal goals as promoted in Hensher, Ho, Mulley et al. 2020).

Putting the above-mentioned considerations into practice, the Sydney MaaS trial starts with a long list of transport modes that the participants are interested in using as part of the MaaS offers. These include all public transport services available in Sydney (i.e., bus, train, ferry, light rail, metro, and on-demand transport services accessible via Opal smartcard), taxi, ride-hailing/ride-sharing (Uber/Uber Pool), car-sharing (GoGet, Car Next Door), car-rental (Thrifty, Hertz), bike-sharing (e-Lime/Mobike), and even the private car. Since the Sydney MaaS trial aims to reduce the negotiation time and cost by leveraging existing relationships between Insurance Australia Group (AIG), the mobility integrator, and a wide range of transport service providers, this long list of transport modes is shortlisted for inclusion in the trial, with a focus on the modes where the trial has real prospects of being able to offer them to the participants. The aim is to give the trial participants a ‘smorgasbord of transport options’ (Strömberg, Karlsson and Sochor, 2018) for their travel needs, covering not only day-to-day travel such as commuting but also first/last mile travels, regular weekend outings and shopping, and irregular trips (e.g., returning home late at night, running late to a meeting).

The shortlisted modes include all public transport services accessible via the Opal smart-card system, private car, Uber, Taxi, GoGet, Thrifty car-rental, and Lime-E bike-sharing. IAG has existing relationships with all TSPs, except for Opal, Lime-E, and private car. As public transport appears to be the backbone of MaaS offers (Ramboll, 2019, Caiati et al., 2020, Guidon et al., 2019, Ho et al., 2020), alternative methods to allow trial participants access to all PT services were discussed, including directly involving Transport for NSW (the local transport authority), and Cubic (provider of the Opal ticketing system) in the trial. After lengthy discussions, it was decided that the most feasible approach to including PT services in MaaS offers was that IAG create a corporate Opal account, issues Opal cards to the participants, and link all those cards to the corporate account so that all PT trips made by the trial participants were paid by the IAG corporate card (see payment integration below). As for bike-share, negotiations were commenced with Lime-E but not Mobike. Unfortunately, the timing for Lime-E was not good since the trial

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141 Long negotiations and willingness to resell and the point on readiness are so important and probably take longest to solve in real-world trials (and indeed can break them). For the Swiss MaaS trial, for example, the technical implementation and deep integration of existing TSPs has taken more than a year which stands in stark contrast with the dynamics of the market (i.e., one of the e-scooter providers went out of business in the meantime).

142 While the private car is typically out of scope in the MaaS definition, it may have a new role post-Covid-19 in what Hensher describes as a ‘familiar sharer’ setting (Hensher 2020).

143 The point to emphasise is the huge gap between simple bundle design concepts (i.e., choose a couple of TSPs) and practice. The negotiation process is lengthy and subject to failure with a number of suppliers.
was scheduled to launch just a couple of months after Lime-E launched their services in Sydney. As a result, apart from walking and ride share, the Sydney MaaS trial was not able to include in the offers an affordable micro-mobility mode of transport for the participants to access and egress from PT services. This first and last mile issue is addressed by designing appropriate MaaS bundles targeting participants who would use PT but being deterred by the distance to/from PT services (see more details in Section 0).

Like PT services, private car use makes up a major part of everyday travel, and thus it was deemed important to capture private car use during the trial so that the trial can answer one of the most critical questions about MaaS; namely how MaaS may change private car use. Put it differently, should MaaS be positioned as a complementary or supplementary service to the private car? Again, alternative arrangements were considered, including incentivising car-owning participants to share their cars through a car-sharing platform of Car Next Door for the duration of the trial, and reimbursing the sunk cost of car ownership if the participants send the car keys in – the latter being similar to the Ubigo trial (Sochor et al., 2016). Given the 6-month trial period, these arrangements did not appear to have much appeal and hence were abandoned.

The adopted approach to including private car use in the trial relies on a complementary program called Safer Journeys run through IAG before the MaaS trial was launched. Although the private car is not part of the MaaS offering, data on its use is crucial in assessing the impact of MaaS on private car use. Safer Journeys is a car-based program with GPS tracking technology installed to make car journeys safer, by for example deploying an ambulance to the accident location if the driver did not answer the phone from the call centre who recognises some sudden incidents that may have happened with the trip, based on the tracking data. A by-product of this program is that private car use can be tracked and used as a complementary data source to assess the success of the MaaS trial in terms of reducing emissions through reduced car kilometres. All car-owning participants to the MaaS trial were asked whether they were a member of the Safer Journeys program, and if not whether they would be interested in joining. All safer journeys users who participated in the Maas trial consented to sharing their Safer Journeys data with the Trial.

The final transport providers for integration and experiment during the trial are Opal (i.e., an integrated ticket for all public transport services in Sydney, including bus, train, ferry, light rail, BRIDJ), Uber, Taxi (Cabcharge), GoGet, and Thrifty car hire. Before these services could be included in bundle offers for the participants to subscribe to, users must be provided with a means to search for their availability, book, and pay for these services. The next section describes the tasks required to integrate these services into the digital platform developed for the trial, the Tripi app to obtain the desired levels of search, booking, and payment integrations. Before turning to the technical setup, however, it is worth discussing briefly the other necessary dimensions associated with designing a MaaS bundle.

**Other necessary design dimensions**

Once the mix of transport modes/services to be included in a MaaS bundle has been finalised, we need to consider other necessary dimensions of the MaaS bundle design. These include metrics, targeted customers (individuals or groups), subscription cycle (fortnight, month, quarter, or year), and spatial coverage (or valid area). Of these dimensions, choosing the appropriate metric to define subscriber’s entitlements to each mobility service included in a MaaS bundle is most challenging because this decision depends on not only the local context (e.g., how public transport fares are charged such as distance-based, zone-based, flat fare, with or without daily/weekly cap) but also the mechanisms and levers that the MaaS operator may have at their disposal to define a MaaS bundle. These are discussed in detail in Section 0.

The design for the remaining necessary dimensions is much simpler as they are more or less defined by the objectives of the trial and how it is run. Specifically, to obtain payment integration, the trial relies on the corporate accounts that IAG has with various TSPs. To add the participants as members to these corporate accounts, and hence obtaining payment integration, the participants must be IAG employees. That is, the targeted customers are individuals instead of groups (the terms and conditions of the trial

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144 Lime-E was too busy to set up their own business and had little interest in joining the trial, given that it lasts for only six months with a small number of participants.
detail this eligibility criterion and usage agreement). With respect to the subscription cycle, we chose a monthly subscription to reduce the administration cost (i.e., processing data and issuing invoices) and to simplify the payment for participants. Since all participants are IAG employees and the trial target is to obtain a minimum of 100 participants, the monthly budget required from the trial to pay for all trips made by the entire sample every month is not too large. Thus, a monthly cycle is chosen as a compromise between the budget and administration costs. Finally, while the trial is offered to Sydney IAG employees, the spatial coverage of the service is defined by the availability of each service with no spatial boundary defined. For example, the spatial coverage of public transport services is defined by the validity area of the Opal cards, which includes urban and inter-city travel by all public transport modes. Similarly, participants can access GoGet car-share, Uber, Taxi and Thrifty rental car from anywhere they find these services (i.e., Australia wide, except for Uber which is international and could also be accessed in the trial).

Technical setup for desired levels of integration

To offer MaaS users an integrated experience, technical setup is required to integrate search, booking, and payment into the same digital platform (i.e., Tripl) that MaaS users interact with. Search integration means that when a user requests a trip between point A and point B, the app is able to check the location of services from a provider and their estimated costs and time taken for the trip, and map out a route for the user. This function can be described as a journey planner that many travellers have experienced with and hence, typically considered as the most basic function of any MaaS app. Booking integration means the user is able to seamlessly book a service (once found through the search function or through a different method) to complete a trip from the app. Booking integration can be achieved via different levels, in order of decreasing complexity as summarised in Figure 1, with a recognition of the extensions that the trial has made highlighted in Figure 2 through extending previously reported frameworks on MaaS integration levels by providing more detail in the booking and payment categories.

Increasing level of booking integration

<table>
<thead>
<tr>
<th>No integration</th>
<th>Public / Anonymous linking</th>
<th>Deep linking</th>
<th>API integration</th>
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<tbody>
<tr>
<td>• A user might be prompted with a phone number to call, or other means of ‘offline’ booking for a trip outside the MaaS app</td>
<td>• Still no information is passed on to the transport providers’ app / website, however links are provided</td>
<td>• Some information such as a start and end point for a journey is passed on to each transport providers’ app / website</td>
<td>• Booking takes place completely inside the MaaS app which handles all communication between transport providers and users from planning through booking to payment</td>
</tr>
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<td></td>
<td>• The user has to re-enter trip details and log in to each providers’ app / website separately to complete the booking outside the MaaS app</td>
<td>• The user needs to complete the booking outside the MaaS app</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: Booking integration options
Payment integration means the user is able to pay for the service they use in various ways (see Table 1 and Figure 1). Depending on the desired level of payment integration, this could be undertaken inside or outside the MaaS app. Also, a payment may be required for every trip taken by the user; however, from a user perspective, periodical payments such as weekly, fortnightly or monthly invoices may improve user experience at the expense of billing shock. Table 1 summarises the levels of integration that the TripGo app, which was used as the basis for the trial app, already provided for the services to be included in the Sydney MaaS trial app, Tripi. As can be seen, while search integration was well advanced, booking and payment integration were not offered via the TripGo app, except for Uber booking. This meant that resources and technical setups were required to facilitate booking and payment via the Tripi app. The next section describes the technical design implemented for the integration.

### Increasing level of payment integration

<table>
<thead>
<tr>
<th>Increasing level of payment integration</th>
<th>Single trip</th>
<th>All (monthly) trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single provider</td>
<td>No integration (each provider bills trips separately)</td>
<td>Aggregated billing by month but separate for each provider</td>
</tr>
<tr>
<td>All providers</td>
<td>MaaS broker bills for all providers</td>
<td>Single monthly billing through MaaS broker for entire mobility consumption</td>
</tr>
</tbody>
</table>

Figure 3: The increasing levels of payment integration

![Table 1: Extending previously reported frameworks on MaaS integration levels](image)
<table>
<thead>
<tr>
<th>Provider</th>
<th>Search integration</th>
<th>Booking integration</th>
<th>Payment integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opal</td>
<td>Yes</td>
<td>Not applicable (not required)</td>
<td>No</td>
</tr>
<tr>
<td>Uber</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Cabcharge</td>
<td>Yes</td>
<td>No (deep link to GoCatch app)</td>
<td>No</td>
</tr>
<tr>
<td>GoGet</td>
<td>Yes</td>
<td>No (opens public GoGet website)</td>
<td>No</td>
</tr>
<tr>
<td>Thrifty</td>
<td>No</td>
<td>No (Opens generic hire-car aggregator website)</td>
<td>No</td>
</tr>
</tbody>
</table>

Integration designs and implementations

Search integration design
Search integration is required for all providers except Thrifty car hire which is excluded from Tripi because the trial participants may occasionally rent a car for long distance travel, and thus it does not make sense to show this transport mode and its attributes for every search they may do. As for other modes, integration already exists in the TripGo app (see Table 1). This allows users to see a list of possible methods for a given trip from point A to point B via each provider, by knowing locations of the services and their cost estimates for the trip.

Booking integration design
For this trial, we prioritised deep linking as the preferred method of providing bookings, as it maintains a relatively seamless user experience without the high-cost and technical complexity involved with creating and maintaining a direct integration to a transport provider’s booking stack. For public transport, all participants were provided with an Opal card for all their public transport travel which does not required bookings. For Uber booking, the TripGo app currently has a direct integration with Uber but it does not support Uber Ride Profiles, which can be described as the ability of users to select the appropriate account they have more than once (e.g., personal vs. business profile). The trial replaced the direct integration with a deep link to the Uber app, where the destination is pre-populated, and the MaaS Trial Ride Profile can be left as the default method of payment for participants. As for Taxi, Tripi offered an anonymous linking to the GoCatch app for taxi bookings, in addition to a phone number which the users can click to call a taxi. To book a GoGet car-shared, Tripi users simply open the GoGet website or app and logs into their membership account. Finally, for car-rental booking, a web link is provided from the Profile section for the participant to make a booking by filling out the information required by Thrifty.

Payment integration design
For the trial, IAG is acting in the MaaS operator role, meaning all payments are facilitated via IAG. The aim is to provide a seamless experience to participants where all of their trips with associated costs are able to be shown to them via a mobility wallet function of Tripi, and they only need to make a single payment to IAG to access all modes. The wallet tab of the app enables users to track all trips taken as well as costs, mode use, date and time of trip start, start location, as well as the current credit/debit balance (see Figure 4). Payments to private transport providers (i.e., Uber, Taxi, GoGet, Thrifty) are facilitated by IAG holding the master account with each provider and passing on costs on a monthly basis to participants via separate invoice during the live trial period.
To pay for all public transport trips, Opal cards were procured by IAG for each participant and linked to several Opal accounts controlled by IAG. To capture and reflect these trips in the mobility wallet, the app developer provided an automated mechanism which logs in and reads all new trips taken by each Opal card linked to these accounts and updates the back-end portal on a regular basis. The study team has the capability to manually add and edit trips in the back-end portal as well.

The system architecture for the integration of information, booking, payment, and contracting elements of the Sydney MaaS trial is summarised in Figure 5. The integration of information, typically in the form of timetable data, allows users to use the journey planner function of Tripi to search for mobility services. For services that require booking, Tripi uses a deep linking method to facilitate booking integration, while all payments are integrated through several master accounts held by the MaaS operator, which allows centralised billing for all trips taken by the users. The trial integrates mobility services through subscription contracts, where users can subscribe to a monthly bundle or stay with PAYG.

![Figure 5: System architecture for the integration of information, booking, payment, and contracting elements in Tripi](image-url)
Approaches to MaaS bundle design

Very little knowledge exists to guide the real world design of MaaS bundles, especially when these are offered to participants for subscription. However, emerging evidence from SP and RP studies (e.g., Reck and Axhausen 2020) suggests that understanding travel demand is critical to obtain a certain level of acceptance of MaaS bundles amongst the targeted customers. Without much understanding of the targeted participants’ transport needs for everyday travel, we can adopt one of the following two approaches to designing MaaS bundles.

The first approach requires a survey of the targeted customers to understand their transport needs and their personal circumstances, including socio-demographics and the environmental setting (availability of different transport modes, existing memberships with mobility service providers, and their levels of services). The survey can preferably include SP choice tasks so that user’s preferences and willingness to pay for various MaaS bundles can be estimated, and the ones with highest potential can be selected to offer for subscription. This approach works pretty much in the same way as an SP survey method but with a decision support system that helps MaaS operators design bundles and estimate the demand for a given population (see Ho et al., 2020). The second approach allows the targeted customers to construct their own bundles. This approach requires no prior knowledge about the targeted customers because the operator effectively hands over the design of the bundles to the customers, who understand their travel needs best. This second approach was adopted by the UbiGo trial (see Sochor et al., 2016) and previous research by Caiati et al. (2020).

Both approaches to bundle design have pros and cons. The first approach, referred to as a data-driven approach, in which bundles are pre-designed by analysts, is time-consuming and always subject to hypothetical bias (Hensher 2010). On the positive side, this approach gathers valuable data, which can be used to segment the population and target the potential segments to minimise resources and maximise uptake. The second approach, referred to as a customer-centred approach, whereby customers choose the elements they like and provide input into building their own bundles, does not necessarily require any survey or model, and hence no prior investment is required. The downside, however, is that many bundles will be created by the customers because their transport needs are likely to significantly vary. This results in a high administrative cost to manage many different bundles.

For the trial, the targeted customers are IAG employees living in the Sydney Greater Metropolitan area. IAG is one of the biggest insurance groups in Australia, with more than 10,000 employees in Sydney, and thus the targeted customers are expected to have varying travel needs. Adopting the data-driven approach to designing MaaS bundles means that before the trial is officially launched, we must (i) identify potential participants, defined as IAG employees who are most likely to participate in the MaaS trial and have a high potential of actively using mobility services offered via the monthly bundle, and (ii) specify (or speculate) what the participants can do and the associated benefits of buy-in to MaaS. Given the prior knowledge from previous SP studies in Sydney (Ho et al., 2018) and Tyneside UK (Ho et al., 2020), we know the critical role of the following aspects in identifying early adopters of MaaS:

a. Current travel patterns (how much a person uses different modes of transport and how much they pay, on average, per month)
b. Personal and household characteristics (socio-demographics) such as car-ownership, age group, and employment status (part time or full time)
c. A MaaS bundle that tailors to each individual/segment’s travel needs
d. The benefit of using MaaS (e.g., discounted price, unlimited use of public transport, access to cars)

Thus, the first task requires a pre-trial survey, covering all points a – d above, plus any other items that are unknown at this stage in deciding bundle acceptance such as the form and/or level of incentive (financial vs. non-financial). The pre-trial survey should include a stated bundles choice experiment to help design mobility bundles that are more attractive to each segment, while also interesting for the mobility broker/operator (i.e., IAG) to test, considering the budget and the potential of commercialising these after the trial is completed.
To design the SP survey, we need to know the mobility services, cost, and non-mobility service that will be included in the MaaS in-field trial. Note that section 0 identified the transport services Tripi ended up offering, but at the stage of the pre-trial survey, it was far from clear if we would be able to include bike-share and car-share in the field trial. Note also the possibility that IAG as a MaaS operator, but also an insurer in this case, would want to bundle non-mobility offers (such as home insurance, car insurance, or any other products/services) into a MaaS bundle to make the products more attractive, and indeed add some value to a potential commercial business case by broadening MaaS to be multi-service rather than just multi-modal (Hensher 2020).

Initially, the Sydney MaaS trial was planned to go down this path to collect SP data and identify a limited number of MaaS bundles and the people who are most likely to subscribe to these bundles. Once the targeted participants have been identified, we then planned to recruit and interview 100 participants to the MaaS field trial. However, discussions amongst the study team and the progress of app development shifted the approach towards a new and innovative method to design MaaS bundles.

The proposed method uses the first month of the field trial as a learning period to collect necessary data and to seek qualitative feedback from the participants for the implementation of the data-driven approach to bundle design from the second month onwards. After the first bundle is introduced to participants for subscription, additional data can be collected, and monthly informal qualitative interviews can be conducted with a few participants to collect input for the design of bundles in the next and subsequent months. We term this approach an incremental and co-design approach, which leverages the strengths of both the data-driven approach and the customer-centred approach.

Using the incremental and co-design approach means that we do not need to design all MaaS bundles prior to the field trial, nor undertake a pre-trial SP study. Thus, we can simplify the pre-trial survey to a much parsimonious and more manageable form which acts as an ‘Expression of Interest’ to participate in the MaaS field trial. Before the first bundle is introduced to participants for subscription, additional data can be collected, and monthly informal qualitative interviews can be conducted with a few participants to collect input for the design of bundles in the next and subsequent months. We term this approach an incremental and co-design approach, which leverages the strengths of both the data-driven approach and the customer-centred approach.

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**Mechanisms and levers available to design MaaS bundles**

MaaS bundles define subscriber’s entitlements to various services based on some ‘operational rules’. These rules act as technical mechanisms for the MaaS operator to update user accounts every time a transaction happens. Operational rules also create a platform for MaaS operators to use various levers when combining multiple services and their entitlements into a bundle that has the potential to attract targeted segments. Using the MaaS bundle design framework developed by Reck et al. (2020), exemplary mechanisms are:

- **Discounts**
  - a. A fixed discount percentage per mode of transport on a bundle, applied per trip. For example, 10% off each Uber trip.
  - b. A fixed discount amount per mode of transport on a bundle, applied per trip. For example, $5 off every Uber trip. A mechanism must be built in to avoid a trip having a negative balance (a $8 trip taken with a $10 discount costs $0, instead of -$2) or to combine with constraints, such as trips connect to PT.

- **A cap per mode** of transport on a bundle. For example, subscribers are entitled to 5 taxi trips up to 5 km per month, and 200 km car car-sharing per month where they can use them all at once or across multiple hires. A mechanism must be built to allow the subscribers to use up to these amounts every month without additional fees. A different treatment (e.g., pay per ride) is required for every service beyond the caps.

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145 We also felt that a focus on getting used to Tripi under PAYG had much merit, and that introducing bundles would be better undertaken once some familiarity and experience with Tripi under PAYG had occurred. A recognition that subscription bundles would be subsequently introduced was mentioned.
• A **subscription fee that a participant is charged up-front** each month they are on a bundle.
For example, a $50 subscription fee each month on a bundle which could offer discounts and/or entitlements as defined above. A mechanism must also be built to debit from the participant's credit the specified subscription fee each month they are on the bundle.

• A **minimum purchase/pre-payment cost** that a participant must pay up-front to spend on transport that month. For example, a $200 minimum purchase cost means at the start of the month a participant must add $200 to their credit. Once paid, this amount should be added to a participant’s credit to spend each month they remain on the bundle.

• A **reset / roll-over of credit balance at the end of every subscription cycle**. This rule governs what happens to credit, in monetary or entitlement terms, at the end of each month when the subscriber may effectively switch bundles. Under a “use it or lose it” mechanism, the credit balance will return to zero at the start of a month. Under a “roll-over” mechanism, the only rules that applies are (i) every $1 of payment received from a participant will increase their credit balance by $1, and (ii) any unused credits will be added to the next month entitlements. That is, the balance will always continue to flow over to the next month and MaaS operators do not penalise subscribers by removing an unused positive balance.

Overall, these mechanisms enable the MaaS operator to define various bundles and manage a user account balance. Once the mechanisms have been built, the operator can pull the corresponding levers to design mobility bundles. Table 2 summarises the various levers and their corresponding mechanisms that MaaS operators may want to have at their disposal to define and implement MaaS bundles.

It is worth noting that some mechanisms are easier to implement than others. We identify in Table 2 the preferred levels and their corresponding mechanisms to design bundles for the Sydney trial. Our preferences for these levers are driven by three desires. First, monthly bundles must be easy for the trial participants to understand. Second, the levers are useful to alter subscriber’s behaviour towards more sustainable choices of transport modes while are not too labour-intensive to manage. Finally, time and resources required to develop the corresponding mechanisms so that these levers can be used in defining bundles must be within the timeline of the trial. The Sydney trial settled on using the upfront cost, billed cost, fixed unlimited cost, fixed discount, percentage discount, and credit roll-over as levers to design month bundles. The next section describes the process of designing monthly bundles in detail.
## Design Bundles for the Sydney MaaS Trial

The Sydney MaaS trial used an incremental and co-design approach to designing monthly bundles. Over the trial period, four monthly bundles were designed and introduced incrementally, plus a PAYG option, as shown in Figure 6 (from Hensher, Ho and Reck 2020). This section describes the process of designing these bundles.

<table>
<thead>
<tr>
<th>Lever</th>
<th>Description</th>
<th>Mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upfront cost*</td>
<td>Participant puts money into their 'Mobility Wallet' to spend on services</td>
<td>Minimum purchase/pre-payment</td>
</tr>
<tr>
<td>Billed cost*</td>
<td>Participants accrue a cost over the month, and pay at the end of the month</td>
<td>Roll-over of credit balance</td>
</tr>
<tr>
<td>Ticket cost</td>
<td>Participants pay for singular trips, when necessary</td>
<td>Fixed discount (inc. 0%) applied per trip</td>
</tr>
<tr>
<td>Fixed unlimited cost*</td>
<td>Fixed cost to gain unlimited access to a mode</td>
<td>Fixed discount (100%) and subscription fee</td>
</tr>
<tr>
<td>Fixed access cost*</td>
<td>Fixed cost to gain access to other discounted prices (like subscription cost)</td>
<td>Fixed discount + subscription fee</td>
</tr>
<tr>
<td>Fixed ticket cost</td>
<td>Single modal tickets at a fixed cost</td>
<td>Flat fare per mode</td>
</tr>
<tr>
<td>Capped trips **</td>
<td>Pay $x for trips costing up to $y (x&lt;y)</td>
<td>Capped fare per mode</td>
</tr>
<tr>
<td>Capped discounts allowance **</td>
<td>Users have a capped amount per month to use at a discounted rate (with PAYG rates after)</td>
<td>Capped allowance per mode</td>
</tr>
<tr>
<td>Capped surcharging</td>
<td>Surge prices capped to a limit or removed completely (specific to modes of transport)</td>
<td>Capped discount per mode</td>
</tr>
<tr>
<td>Fixed discount*</td>
<td>Take a fixed amount off the cost per mode/trip</td>
<td>Fixed discount amount per mode</td>
</tr>
<tr>
<td>Percentage discount*</td>
<td>Take a percentage amount off the bill per mode</td>
<td>Fixed discount percentage per mode</td>
</tr>
<tr>
<td>Time-based incentives</td>
<td>Apply discounts based on the time the trip is taken</td>
<td>Fixed discount percentage by time period</td>
</tr>
<tr>
<td>Multimodal incentives**</td>
<td>Apply discounts based on the number/type of modes used in one journey</td>
<td>Multiple modal discount (fixed or percentage)</td>
</tr>
<tr>
<td>Volume discounts</td>
<td>The more money converted into 'mobility credits', the more discounts applied</td>
<td>Quantity discounts</td>
</tr>
<tr>
<td>Ratio discounted credits</td>
<td>Convert $x dollars into credits based on a ratio</td>
<td>Ratio discount</td>
</tr>
<tr>
<td>Travel tokens</td>
<td>Token has an equivalent value for a transport mode</td>
<td>Token values + subscription fee</td>
</tr>
<tr>
<td>Credits roll-over*</td>
<td>Any unused credits (points, tokens, allowance) are transferred to the next subscription cycle</td>
<td>Roll-over of credit balance</td>
</tr>
<tr>
<td>Unlimited access</td>
<td>Upfront cost of $x allows unlimited access (partial access) to all modes</td>
<td>Fixed discount (inc. 100%) + subscription fee</td>
</tr>
</tbody>
</table>

Note: * indicate the levers desired and used in the Sydney MaaS Trial. ** indicate desired levers but too manual to use.
PAYG as a default bundle for the first month (November 2019)

The incremental approach to bundle design uses PAYG as a default option when the participant joined the trial, whenever this would be. While the trial aims to recruit and onboard about 100 participants, it is impossible to onboard all participants at once, since the onboarding process takes the boarding team about 30 – 40 minutes per participant. Onboarding tasks include explaining the purpose of the trial, seeking the participant’s consent for collecting and using their travel-related data, explaining terms and conditions of the trial, setting up accounts, familiarising the participants with the Tripi app, and taking the participant through each step of the trial so that they know what to expect around invoicing and bundles. Figure 7 shows the progress of onboarding the participants to the in-field trial, with most participants being onboarded in November and December 2019. The onboarding process ended on 20th January 2020 with a total of 93 participants, very close to the target of 100 participants.
Using PAYG as a default option for the first month of joining MaaS is justified from both user’s and operator’s viewpoints. From the user’s perspective, there are many things that the participants may not be familiar with when they were onboarded to the trial. Examples are how to use the Tripi app to search for mobility services, compare the alternatives, book the services they want, and pay for them. Thus, using PAYG option for the first month means that the participants can experience the Tripi app and learn how MaaS works before they have to make a choice between paying as they go or subscribing to a monthly bundle.

From the operator’s viewpoint, the incremental approach to bundle design, starting with a PAYG option, is desired for two reasons. First, while some data on individual participant’s demand for various transport services were collected in the pre-trial survey, the insights gained from analysing this dataset were limited to the desired features of a MaaS digital platform and socio-environmental context of the potential participants. Thus, pre-trial data are not sufficient to form an accurate basis for how much of different transport services each participant would require for their monthly travel. The PAYG period is useful for estimating individual transport needs and segmenting the participants so that an appropriate bundle for each segment can be designed. Second, participants were onboarded gradually, and thus introducing all monthly bundles at once would risk missing some emerging segments and creating unnecessary administrative and technical work in the back-end to implement and manage these bundles. The timeline in Figure 8 provides an overview of the different bundles and a guide to the structure for the following sections that discuss each bundle.

The Fifty50 bundle for the festive season (December 2019)

Guided by previous SP studies (Ho et al., 2018, Ho et al., 2020), the study team believe that discounting is a highly desirable characteristic to engage participants with monthly bundles. Given the scale of the trial, we decided not to push to get a reduction in price, either per trip or per hire, from any TSP and use them as levers to monthly bundle design. Rather, a budget of $100 per participant per month was allocated for this via the project to “artificially” offer some discounting in bundles as well as to be used as a guide as to how much the project could afford for financial incentives. As the months progressed and bundle offers were taken up, we would then be able to revisit the budget allocation and decide on changes that were deemed desirable to change behaviour as well as being affordable, given the spend to date.
Figure 9: Process of designing the first monthly bundle: Fifty50

Figure 9 illustrates the process of designing the first monthly bundle, which has three additional inputs/constraints. First, very limited data were available because the trial was launched for only a week, with about 30 participants starting to generate data (see Figure 7). Second, once introduced, bundles cannot technically be withdrawn during the trial unless no one subscribes to them. Third, the first bundle is offered in December when individual transport need is expected to be different from that of a typical month.

Given that the trial goal is to reduce travel emissions, and that the December bundle should account for the seasonal effect, the initial design split the incentive budget evenly between PT ($50) and Taxi/Uber ($50), the latter facilitating short taxi and Uber trips, which are popular during the holiday periods. As IAG shut down their business for one week over the Christmas period, the participants, who are all AIG employees, are expected to use PT at most three weeks in December, and hence a 75% discount for PT (3 weeks out of a 4-week month) is deemed more attractive than unlimited use of PT. Offering 75% discount for PT in Sydney costs us a maximum of $150 per month per person, given the $200 Opal monthly cap. Charging the subscriber a subscription fee of $100 per month means that this initial design requires a $50 incentive budget for PT. In addition, the initial design offers a $3 discount for every Uber/taxi trip. With a $50 incentive for taxi/Uber, this is a conservative design that enables about 17 rides per month, which is about the maximum one would do per month. The design used the fixed discount lever instead of the percentage discount lever for taxi and Uber trips because the former creates more value for short Taxi/Uber trips than for long trip, and this may encourage participants to use taxi/Uber to access PT services instead of using taxi and Uber, both being carbon-heavy modes, for door-to-door travel.

The initial design was subject to a co-design process in which the business co-design (BCD) team at IAG suggested charging a $50 subscription fee and an offer of a 50% PT discount instead, while keeping a $3 discount for every Uber/taxi trip. This does not change the incentive required (still $50 for PT and $50 for Uber/Taxi), while lowering the subscription fee to $50 (i.e., a lower barrier-to-entry mentally) and making it easier to digest a half-price discount than a 75% one. Finally, the $50 with 50% off makes it easy to sell with a catch holiday plan name like “Fifty50”.

The BCD team did a very quick poll of some current participants via an internal messaging tool and asked: “Which plan would you be most likely to select for the December period? Of the 9 participants taking the poll, 2 chose PAYG, 1 chose the initial design bundle, and 6 chose the co-design bundle. The study team settled on the co-design bundle, called Fifty50. Figure Figure 10 shows the email introducing the Fifty50 bundle to all participants, together with instructions on how to subscribe.

Of the 66 participants who were onboarded by the end of November 2019, 11 participants subscribed to the Fifty50 bundle in December, with the balance staying with the default PAYG option. It is noted that the study team recommended each participant to use Tripi as a PAYG user for at least two weeks in order to have a better understanding of their travel needs before subscribing to any bundle on offer; however, the participant is allowed to take up a monthly bundle when it is on offer, regardless of how long they have been onboarded to Tripi under the default PAYG option. It appears that in December
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2019, all participants followed the recommendation, with all 11 subscribers to the Fifty50 bundle being onboarded and made their first trip via Tripi before the 15th November 2020 (i.e., having at least two weeks of travel records before taking up the bundle). Put it differently, all the 26 participants who were onboarded after the 15th November 2020 stayed with PAYG in December.

The Saver25 bundle for the New Year (January 2020)

In contrast to the design of the first monthly bundle, Fifty50, which was mainly based on a conservative and co-design approach, the design of the second bundle for January 2020 starts to be data driven because 80 participants have been onboarded, and have started using Tripi and generating data. The new monthly bundle for January 2020 must be released by the 12th December 2019 so that the participants have enough time to clarify details and consider subscribing or not (given the Christmas and New year shutdown between 20 December 2020 and 5 January 2020 inclusive). This means that usage data are available, but this varies across participants, ranging from 2 days to 5 weeks. Figure 11 illustrates the process of designing the January bundle.
Considering the data limitation, the study team invited all onboarded participants to a ‘ChristMaaS’ morning tea, held in the IAG city office on the 3rd December 2019, to share their experience and upcoming January activities to help co-design a bundle for January 2020. We gathered feedback and information via informal chats from seven participants, which largely confirmed our hypothesis: January is a typical holiday period in Sydney with a different travel pattern. A few participants revealed that the $50 subscription fee of the Fifty50 bundle is rather high, particularly during the irregular work months of December and January.\(^{146}\) Despite all the irregularity, most participants will likely work regularly for approximately three weeks in January.

We surveyed the booking data collected up to 2nd December 2019 to learn about participants’ travel patterns and used these as input in our data-driven approach to bundle design. An analysis of data on regular work weeks suggested two things. First, most trips that the MaaS participants booked were PT, which can be regarded as the sustainable “backbone” of mobility provision in the trial. Most people, however, have PT outlays less than the weekly Opal cap (i.e., $50 per week, with an average weekly cost of $35). Second, Uber is most popular among the remaining modes (24 users, 75 trips), followed by taxi (8 users, 13 trips) and GoGet is least (3 participants, 8 trips) between 4 Nov and 2 Dec 2019.

Building on the insights on participants’ anticipated activities for January obtained through the ChristMaaS morning tea (i.e., the co-design approach) and regular travel patterns of transport mode usage obtained from analysing Tripl booked trip dataset (i.e., the data-driven approach), the study team agreed that an attractive January bundle should: (i) support sustainable travel, especially regular commutes, and (ii) support flexible, daily outings without a private car. Given that we want to decrease the bundle entry barrier in January (i.e., subscription fee), we address objective (i) with a 25% discount for public transport (maximum monthly cost $50/person = incentive budget). As for (ii), the January bundle aims to promote more car-sharing. While one might initially think that encouraging car-based modes does not support a sustainability agenda, it must be linked to both short-term and long-term impacts. Accordingly, the trial emphasised an aim to differentiate the roles of car-sharing in the short-term (i.e., emissions) from the long-term effects (i.e., intent not to buy or sell the/a second/third private car). The latter could be measured by asking about buying/selling intentions now and when the trial is concluded (i.e., through the exit survey).

Following this logic, MaaS offers in January detail a **one-off discount** of $20 for the first GoGet trip of users within the trial, which aims to encourage participants to experience car-sharing for the first time so that they can assess its potential of replacing their (second) private car. January is particularly good for testing out GoGet car-sharing since a few people would hire GoGet ute/truck for moving furniture and other large items. The $20 GoGet credit offer is enough to cover the cost of a 2-hour hire of a typical GoGet car, which the participants can use any time during January. GoGet further offers 20% discount of the first GoGet trip in January for all trial participants.

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\(^{146}\) Only seven participants were present during the ChristMaaS morning tea. Thus, the bundle design is not based entirely on this feedback.
For the complementary services in the MaaS offer, we can, in principle, choose between discounts for car sharing, Uber and taxi. Designing a bundle around car-sharing and public transports risks only being attractive to a small subset of frequent car-sharing users. To mitigate this risk, we opt to offer all three flexible modes and use a discount metric other than the fixed dollar discount off each trip so that the January bundle will not be superior to the Fifty50 bundle. We therefore use the percentage discount lever on all three remaining modes (GoGet, Taxi, Uber). We do not include discount for Thrifty car rentals as all IAG employees have automatically received a lower rate (about 40%) than market prices.

The remaining issues in finalising the January bundle relates to the level of discount (at what %) and bundle price (i.e., subscription fee). To this end, a data-driven approach is used in which a sensitivity analysis is conducted to compare the appeal of the January bundle with the Fifty50 bundle and PAYG. The sensitivity analysis uses a $25 subscription fee (make it easy to sell $25 for 25% PT discount, drawing parallel to the Fifty50 bundle) and assumes that most people will likely work three weeks in January, with some additional demand for taxi, Uber and GoGet expected. It is noted that the sensitivity analysis is limited to participants who have at least a full week of data (i.e., having onboarded for 7+ days). Table 3 shows the estimated split of these participants among the three options in January by the percentage discount on Uber, Taxi, and GoGet, assuming that these participants slightly increase their demand for flexible modes in January as compared to their own travel record in December, and that they would choose the option that has the highest value-for-money (i.e., lowest travel costs, including the subscription fee).

Table 3 shows that using a 15% discount for Uber, Taxi, and GoGet modes for the January bundle, 11 participants would continue to subscribe to the Fifty50 bundle, 23 participants would continue with PAYG, and 14 participants would subscribe to the January bundle. Increasing the discount levels for all these three modes to 20% does not change the split, mainly because the savings from these flexible trips is small (~$2.25 to $3.15 saving per trip with a 15% discount). Thus, the bundle for January requires a $25 subscription fee in return for a 25% discount on every public transport trip, and a 15% discount on every car-share, Uber and taxi trip. We name this bundle Saver25, with the key marketing points being a lower subscription fee and additional flexibility by including car-share. Communication emails that summarise the January offers are shown in Appendix D.

The GreenPass bundle for regular public transport users (February 2020)

By the middle of January 2020 when the February bundle needs to be designed, we have 2-months of Tripi data, representing which bundle the participants subscribed to and how much of each transport modes they used so far. Thus, a fully data-driven approach is used to design the new bundle for February 2020, which is illustrated in Figure 12.

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147 Here we assume that people are strictly rational, which is not necessarily the case (see Lambrecht and Skiera, 2006, for an overview on the different tariff-choice biases).
The data-driven approach to bundle design relies on an in-depth analysis of booking and subscription data from all participants. The main aim is to segment the market and verify factors (e.g., potential cost saving, usage pattern) that motivate users to subscribe to a bundle in the presence of PAYG. Such segmentation analysis helps identify market segment for the new bundle. Figure 13 compares the monthly cost estimate for January 2020 that each participant was informed about via a communication email in mid-December 2019 (see Appendix D for an example email). The graph is limited to the monthly subscribers, with Appendix E investigating why participants stay with PAYG. The top panel of Figure 13 shows that all participants, except for P027, have the lowest estimated cost in January under the bundle they subscribed to (i.e., Fifty50). Thus, there is a strong correlation between the decision to subscribe to the Fifty50 bundle and the potential monies saved. By contrast, those who subscribed to the Saver25 bundle for January travel (the bottom panel) do not necessarily have this bundle as the lowest monthly cost estimate (e.g., P066, P177), although many participants do. Thus, while monies saved may have influenced the participant’s decision to take up the Saver25, the lower entry cost (i.e., subscription fee – see below) may have been appealing too. As for PAYG users (see Appendix E), an analysis of cost saving and booked trips reveals that many participants were on holiday, and hence prefer PAYG.

![Figure 13: Estimated monthly cost of travel in January by bundle subscribers in January 2020](image)

Why did the participants subscribe to the MaaS bundles: chosen bundle vs estimated monthly cost for Jan 2020

- Fifty50
- Saver25
- PayGo

- $100 incentive budget/person
- 2 months usage data (93 participants)
- Bundles remain available onwards
- Quarterly month

- Input
- Data analysis
- Data-driven design
- Sensitivity Analysis

- Cost savings
- Usage patterns
- Market segments
- Market for new bundle
- -100% PT fare (max monthly cost $200)
- -$3 Uber/Taxi (max monthly cost $25)
- Subscription fee: $125
- PAYG: 22 persons
- Fifty50: 24 persons
- Saver25: 22 persons
- GreenPass: 22 persons

Figure 12: Process of designing the February bundle: GreenPass
The data-driven approach to bundle design lies partly in our understanding of the value that subscribers derive from each monthly bundle, including how subscribers use different transport modes on offer, compared to those who have always been on PAYG. Appendix F presents a comparative analysis of subscribers vs. PAYG users in terms of modal utility. Overall, this analysis found that those who subscribed to the Fifty50 bundle showed a much higher average number of PT trips than those who have always been on PAYG since being onboarded. By contrast, Saver25 subscribers showed a lower level of PT use while a higher level of Taxi/Uber travel during the period up to 1 January 2020 when this bundle was first available to the participants. As for other modes (GoGet, car rental), usage patterns were remarkably similar between the subscribers and PAYG participants.

In summary, analysis evidence suggests that we have two good bundles in place to cater for different segments of the 90 participants to date (mid-January 2020). The Saver25 bundle is more attractive to participants with a lower level of PT use (around 4 – 5 trips per week) and one or two weekly Uber/Taxi trips. The Fifty50 bundle is appealing to participants with a higher level of PT use (around 8 – 10 trips/week in November 2019). What we need for February 2020 is a bundle that serves relatively heavy PT users, either in terms of trips or fare.

In February, we expected all participants would go back to work, and hence, February is the good month to introduce an ‘all you can ride public transport’ bundle, called GreenPass, which offers unlimited travel on PT for a subscription fee. Again, sensitivity analysis was used to design a subscription fee such that this bundle is attractive to current PAYG users while it does not reduce the attractiveness of the two existing bundles (Fifty50 and Save25).

Table 4 shows the split of users by monthly bundle that is most financially appealing to them, assuming their historical and regular travel patterns are to be repeated in February 2020.\(^\text{148}\)

<table>
<thead>
<tr>
<th>Most financially attractive bundle</th>
<th>$100 subscription fee for GreenPass</th>
<th>$125 subscription fee for GreenPass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fifty50</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>PAYG</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Saver25</td>
<td>17</td>
<td>22</td>
</tr>
<tr>
<td>GreenPass</td>
<td>51</td>
<td>22</td>
</tr>
</tbody>
</table>

Note: as of 20 January 2020, there are 90 Tripi participants: 14 on Fifty50 and 10 on Saver25 with the balance on PAYG.

With a $100 subscription fee, the proposed GreenPass bundle is likely to dominate severely the Fifty50 bundle. A $125 subscription fee results in a nice even split of users amongst the bundles. An estimate of the incentive budget required to offer the GreenPass bundle to everyone confirms that the trial has the budget to afford this level of incentive (see Figure 14 with few participants receiving $75 incentive per month, while many participants receiving between $25 - $50 per month under the GreenPass).

\(^{148}\) Note that each participant has their own travel record, with some having onboarded earlier than others, and some being more active on Tripi than others.
Thus, the new bundle for February 2020 offers unlimited use of public transport, a 15% discount for every Taxi and Uber trip while requiring a subscription fee of $125 per month. Note that the GreenPass bundle excludes GoGet car-sharing from the mix because the generous GoGet offers in January (see section 0) did not result in any significant increase in GoGet trips. We only observed two more participants using the $20 GoGet credit + 20% discount to try out the GoGet car-sharing in January (i.e., one GoGet trip per new user).

The onboarding process was completed on the 20th January 2020 with a total of 93 participants. Of these, 12 participants subscribed to the GreenPass bundle in February, 12 participants subscribed to the Fifty50 bundle, and 14 participants subscribed to the Saver25 bundle, with the balance using PAYG. While the exact number of subscribers to each bundle differs from the estimate shown in Table 4, the three bundles obtain a balance of users as designed (one bundle for one segment of traveller).

Fine-tuning bundles (March 2020)

March was scheduled to be the last month of the incremental bundle design process, with the plan to switch everyone back to PAYG in the last month of the trial, in order to compare with the first month when they joined the trial as PAYG users. By the end of February when the new bundle for March was designed, the trial had collected an extensive amount of data for analysis to assist bundle design. Yet, there is still one critical question relating to bundle design that we have not yet been able to answer by analysing the trial data. That is, why a significant number of users have stayed with PAYG despite the financially attractive bundles which have been offered?

Data analysis suggests that many PAYG users are already multimodal users who have access to a private car and use PT, Taxi, and Uber much less often than bundle subscribers do. Monthly variability in travel demand indeed can be a hurdle to bundle uptake, particularly for modes that are not regularly used (i.e., Taxi, Uber) (Reck and Axhausen, 2020). Thus, it may be difficult to design financially attractive bundles for these participants and test how monthly subscription may change the way they travel. In addition, it is not clear at this point whether attracting these multimodal users to a bundle would reduce their carbon footprint, which is the ultimate goal of the MaaS trial. To investigate this in more detail, we conducted one-on-one semi-structured interviews with 22 participants in February, covering all bundle subscribers and PAYG users, as well as those who switched between bundles, and between a bundle and PAYG. The main aim of this qualitative survey is to provide additional insights as to what the trial can do (i.e., which levers to pull) to promote more sustainable travel and to reduce the cost of travel, both to the participants themselves (monetary, hassle) and to the environment (emissions).
With respect to bundle design, a few interviewed participants suggested removing from the monthly bundles the discounts for transport services they do not use (i.e., GoGet) and increasing the discounts for services that they use more often (e.g., Uber)\(^{149}\). Also, there is a dominating preference for fixed dollar discounts over percentage discounts. Overall, the interviewed participants agreed on the importance of PT services in monthly bundles and suggested a way forward to make PT use easier such as including bike-share and Ola in the MaaS offers to address the first and last mile issue associated with PT use.

Feedback from continuing PAYG users (i.e., participants who have always been using Tripi as PAYG users) suggests four common reasons why they stay with PAYG. These relate to value for money (e.g., do not use a certain mode often enough to find the bundle offers worth the subscription fees), spatial context (e.g., living close to work and could access to most activities on foot), varying travel patterns from one month to the next, and the need to commit to a certain bundle for one month (while they are used to paying per ride for all the services that the monthly bundle offers).

Given that the most affordable bundle (i.e., Saver25) costs $25 per month, the new bundle needs to add extra value if it aims to address the value-for-money feedback, since reducing the subscription fee below $25 appears to create little difference to travel budgets of the participants, who are regarded as middle or high income earners. Apart from adding more value, it appears that the trial has limited options in responding to the qualitative feedback from the continuing PAYG users, except for further promoting MaaS bundles through, for example, better communications implemented by using bespoke visualisations in communication with the participants (see below).

In responding to the preferences for fixed dollar discount, in March we fine-tuned the Saver25 and the GreenPass bundles by replacing the 15% discount for Taxi and Uber with a fixed $3 discount as in the Fifty50 bundle. Given that taxi and Uber trips are short in nature, the $3 discount was deemed preferable than the 15% discount for most trips, albeit the difference is small. Regarding the suggestion of removing the GoGet mode from monthly bundles, an analysis of booked trip data shown in Figure 15 identifies six GoGet users, with two users using GoGet every month (P001, P176). In January, it cost the trial more than $100 to subsidy a heavy GoGet user (P176) while the generous GoGet offer ($20 credit + 20% discount for first trip) was taken by three other participants (P024, P027, P035). Only one of these participants is a new GoGet user (P024). A decision was made to remove GoGet from all March bundles since offering it in monthly bundles costs money for little impact on the participants’ choices of transport modes.

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\(^{149}\) This finding aligns with Guidon et al. (2020) evidence that discounts a user does not want are perceived as negative value (i.e., decreasing WTP).

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To address the PT first/last mile issues, the trial investigated possibilities to cap taxi and Uber fares at a certain price to make these modes more affordable for participants who would use these modes to access PT but being discouraged by the high fare. A spatial analysis reveals that up to 80% of PAYG users live within 5 km of a train station (see Figure 16), and thus capping fares for taxi and Uber trips that are up to 5 km has a great potential to attract PAYG users, in addition to the Saver25 subscribers.

Figure 16: Distribution of distance from participant’s home to nearest train station by MaaS user type

Applying a capped fare for eligible taxi/Uber trips effectively means we use a cap per mode mechanism, which is not available for the trial, to create monthly bundles and apply discounting/allowance rules automatically. Thus, using this lever necessarily requires an analytical method to identify eligible trips and process them manually within a timeline that is acceptable to the users. To reduce the analytical burden, the flat fare offer is limited to Uber only (because Uber distance is readily available, whilst taxi distance requires network analysis) and allows a 60-minute changeover between PT and Uber. The fares of eligible Uber trips that connect to/from PT are capped at $5, informed by a regression analysis of booked Uber/Taxi trips which suggests a formula to estimate Uber fare ($6.00 + 2.50 \times \text{km})$. Capping Uber fares at $5 is associated with a risk of Fifty50 and GreenPass subscribers substituting walking or bus for Uber as an access mode to train services, and hence the $5 Uber flat fare offer is limited to the Saver25 bundle only.

In summary, the bundles offered in March 2020 are similar to those in February, with some fine-tuning. Removing GoGet and changing a 15% discount to a $3 dollar discount are minor changes which have a little effect on a few participants. The only significant change in March relates to the Saver25 bundle, which adds a $5 flat fare offer for all Uber trips that connect to/from PT. We therefore rebranded this bundle to the SuperSaver25 bundle and personally called all existing Saver25 subscribers to inform about this significant change before sending a notification about March bundles to all participants (see Appendix E for details). Figure 18 summarises all monthly bundles offered by the Sydney MaaS trial.
Bundle implementation

The monthly bundles described above were implemented via the wallet portal where the trial administrator can specify the bundle details (i.e., modes, entitlements, subscription fee). Figure 18 shows the user-interface of the Tripi wallet portal, with the Fifty50 bundle used as an example.

Figure 17: Monthly bundles offered to MaaS participants from December 2019 to March 2020

Figure 18: Implementing monthly bundles via the Tripi wallet portal
Once bundles are available for subscription, users can view all current active bundles, or a selection thereof, via the Tripi app, plus the bundle they are currently on. A user’s view of available bundles via the Tripi app is shown in Figure 19. Users can choose from this selection a single bundle they would like to have for the next period. For the Sydney trial, participants can change their bundle selection as often as they like, but the one selected on the 1st of every month is the one which will be activated.

![Figure 19: Tripi user’s view of monthly bundles](image)

In the first week of each month, each participant received a summary of their activities and their closing balance for the previous month. Where this is negative, it prompts them to pay this amount, using the Tripi payment function or a bank transfer. All information shown in the invoice comes from the actual trips taken and costs incurred as per the wallet view, but shown in the participants’ view (i.e., they see all the credit adjusted prices and credit balance, not raw prices). Figure 20 shows a redacted invoice sent to a participant who was on the GreenPass bundle for the invoicing period (reflected in the $0 price for the $104.91 worth of Opal use).
Bundle uptake

A summary of the take up of bundles by month is given in Figure 21. The evidence on take up of bundles is very encouraging, at 46 percent in March. The percentage of participants subscribed to the Fifty50 bundle in the final month of the trial (i.e., March 2020) is 15%, and the equivalent statistics for the SuperSaver25 and Green Pass bundles are 12% and 19%, respectively. This aggregate share from real preference evidence is similar to what has been found in SP studies such as Ho et al. (2018) and the first tangible evidence on the validity of the SP approach to study Maas uptake. Table 5 summarises the transition between bundle subscriptions and PAYG as of March 2020 when all bundles, except for the Fifty50, are fine-tuned following participants’ feedback and an extensive data analysis. Four participants from PAYG joined the SuperSaver25, while another four participants who were on Saver25

A comparison with available known evidence from stated preference studies such as Ho et al. (2018) is very encouraging. To make the comparison we must ignore the status quo respondents in the SP study. We never ever asked and accounted for in the trial those who did not participate (stayed with status quo). 37% in the SP study choose a bundle for those who effectively participated like the trial, and 36.4% in trial choose a bundle.
in February switched to PAYG in March. Nobody on GreenPass was tempted by moving to another bundle, which saw the most growth and is also the one promoting the most sustainable travel, and the only one with a hard cap ($125 for "all you can ride" public transport). Modelling the drivers of these bundle subscriptions and month-to-month switching is reported in Ho et al. (2021).

![Monthly bundle subscription: Nov 2019 - Mar 2020](image)

*Figure 21: Summary of bundle take up by month: November 2019 – March 2020*

<table>
<thead>
<tr>
<th>February bundle</th>
<th>Fifty50</th>
<th>Green Pass</th>
<th>PAYG</th>
<th>SuperSaver25</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fifty50</td>
<td>8</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>GreenPass</td>
<td>12</td>
<td>4</td>
<td>43</td>
<td>4</td>
<td>54</td>
</tr>
<tr>
<td>PAYG</td>
<td>4</td>
<td>3</td>
<td>43</td>
<td>4</td>
<td>54</td>
</tr>
<tr>
<td>Saver25</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>Total users</td>
<td>14</td>
<td>18</td>
<td>50</td>
<td>11</td>
<td>93</td>
</tr>
<tr>
<td>Percentage</td>
<td>15%</td>
<td>19%</td>
<td>54%</td>
<td>12%</td>
<td>100%</td>
</tr>
</tbody>
</table>

#### Conclusions

What might we have done differently? A trial, by its very nature with a typically constrained set of resources and the technical constraints (see section 0), can only design and test a few levers to create a limited set of bundles that attract different travel segments, and consequently altering their travel behaviour towards more sustainable choices. It should be noted, however, that real world MaaS offerings such as Whim and Ubigo have four bundles available. The constraints mean that we were unable to provide a customised bundle that suits individual needs, such as removing discounts for modes the participant does not use as the qualitative feedback suggested, because this necessarily creates many bundles to manage. While it is difficult to do a completely custom co-creation with technical and resource limitations in the trial, indeed real world MaaS offerings have not achieved this to date, seeing the similarities among individual preferences through data analysis and qualitative feedback is useful to refine the bundles to better match individual transport needs. One thing we had planned to do if the trial had not come to a sudden stop in April 2020 due to COVID-19, is to vary the fixed discount for taxi and Uber across the monthly bundles so that the participants can sort themselves into different bundles according to their preferences for these services. This would have provided more quantitative data to test the role of discounting for these flexible modes in improving the attractiveness of monthly bundle offers.
Reflecting on the technical-rational model that Marsden and Reardon (2017) highlights with a number of limitations (including “little attention paid to the goals, setting and objectives”, “static or context-free reflection on policy tools rather than process”, “lack of engagement with real world policy example”, leading to), we believe that our paper has followed the “calls for notions of ‘communicative rationality’ and ‘exogenous’ variables such as decision maker preferences to be better built into models in order to make their predictions stronger.” (Marsden and Reardon, 2017 p.245). Indeed, this is the motivation for us to document the geographical and institutional setting within which the trial takes place, as well as adopting a co-design approach in designing mobility bundles. Retrospectively, we believe that our approach effectively uses the “communicative rationality” and engages with the real-world complexities by accounting for not only the contextual setting of the trial, but also decision maker preferences, which in this case is the trial participants’ preferences for subscription bundles they would like to see in the subsequent offers. Drawing parallels to what Marsden and Reardon (2017) described as “impactful policy research”, we believe that this paper provides not only “better information and tools to aid policy makers, but also about developing a body of knowledge that […] understands why decisions come to be made in the way they are.” (Marsden and Reardon, 2017 p.246).

A post-trial survey of all participants (see Hensher, Ho, Reck et al 2020) revealed that a greater number of participants would have been preferred a longer period to test and refine bundles, and to ensure we have appropriate tests of ways to reduce private car use. The most notable lesson learnt is the ability to be more flexible in the design of the digital platform in order to test new ideas that arise such as caps on the amount of travel that can be subject to even larger discounts for specific modes, and the ability to allow for bundle design during any time that is appropriate when new evidence is identified. While the trial was able to implement this cap via data analysis and post-processing of trips booked, it would provide better customer experience and require less administrative support if the caps could have been implemented via the back-end setup such that trips that are eligible for capped fares could be identified and treated accordingly.

During the start-up period of the in-field trial, it was recognised that not all participants will be ready through the onboarding program to commence the PAYG period at the beginning; that is on Monday November 4, 2019. While collecting a full month of PAYG data (elapsed month strategy) and only offering bundles subsequently is preferred, Tripi was designed for what we refer to as a calendar month condition as distinct from elapsed period, resulting in some participants having a limited time under the November month to get used to Tripi and PAYG. This was not ideal for participants who needed more time to get used to the digital platform before having to choose between PAYG and a bundle. However, one has to be careful in allowing too much flexibility and revision since this has resource implications throughout the entire MaaS program as well as risks confusion for participants with too much change. On balance, we are confident that the progress made in the Sydney trial can offer a rich informative starting point for any future trials or indeed a market role out of a MaaS product. The logistics of rolling out MaaS beyond a trial has been tested and we now are confident as to the operational requirements, and associated resources, as distinct from the more challenging marketing and take up tasks that ultimately determine the business case.

On-going work involves data analysis and modelling is progressing in three directions: modelling monthly bundle uptake to identify key drivers of bundle subscription, assessing the impact of bundle uptake on travel behaviour, particularly private car use, and modelling mode choice at the trip/journey level conditioned on a bundle subscribed to. Hensher, Ho and Reck (2020) have analysed the sub sample who also participated in Safer Journeys program and find encouraging evidence of a reduction in car use when a bundle is taken up. There may also be an opportunity to see how the revealed preference data collected by this trial might be used to calibrate the SP models developed for Sydney outside of the trial setting.
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