Transportation Research Part A 155 (2022) 501–518

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Towards sustainable transport in developing countries: Preliminary findings on the demand for mobility-as-a-service (MaaS) in Metro Manila

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ARTICLE INFO

Keywords:
Mobility as a service
Travel behavior
Public transport
Urban mobility
Binary probit
Developing countries

ABSTRACT

Mobility as a Service (MaaS) is a recent concept that is gaining momentum in both the scientific world and the private sector. First studies and field trials – essentially conducted in developed countries – suggest that MaaS can influence people's mobility behavior and create more efficient and sustainable transport systems for the future. We intend to contribute to the existing knowledge about MaaS by extending the scope to the context of developing countries where MaaS could be a potential strategy to address existing transport problems. Our case study focuses on Metro Manila (Philippines), an emerging Asian megacity. We analyzed its citizens' (N = 238) readiness for and attitude towards MaaS, and how a MaaS-system could influence users' mobility behavior. Considering mobility-related and socio-demographic characteristics, our statistical models give preliminary insights about the potential MaaS users and how a MaaS system would create value for them. While the vast majority (84%) of respondents stated they were likely to use a MaaS app, the main reasons for adoption appear to be reliability and cost savings. In addition, we found evidence that MaaS could shift users' mobility behavior towards more sustainable transport modes (i.e., from private and low-capacity modes towards public transport). Policy implications and future research paths for MaaS in developing countries are also discussed. Considering the novelty and complexity of this research area, we call for additional research in this field.

1. Introduction

Many countries of the developing world are greatly affected by mobility problems induced by prevailing global mega trends such as population growth and urbanization (Detter, 2015; Hayashi et al., 2004). In the Philippines, the National Capital Region – also referred to as Metro/Metropolitan Manila (MM) – is experiencing what in the media is frequently described as a 'transport crisis'. In this 13-million population metropolitan area, urban sprawl, lack of coordinated transport policies at the Metropolitan level, absence of adequate infrastructure and mass transit solutions, and rapid pace of motorization, amongst various other reasons, have led to an inefficient transport system which continuously collapses under growing demand (Andong and Sajor, 2017). As is common in large

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https://doi.org/10.1016/j.tra.2021.11.024
Received 2 September 2020; Received in revised form 28 November 2021; Accepted 30 November 2021
Available online 24 December 2021
0965-8564/

developing cities, this resulted in premature traffic congestion, deterioration of the environment, safety and security issues, and declining mobility of the poor (Gwilliam, 2003).

With traffic jams and gridlocks currently belonging to the region's everyday picture, a recent report by the Asian Developing Bank ranked MM as the most congested developing Asian city (ADB, 2019). Based on comprehensive navigation system data for 2019, MM even experienced the second highest daily congestion worldwide (TomTom, 2020). Logically, this situation has led to increased calls for transport reforms and changes in mobility behavior, which are urgent also for environmental reasons.

Indeed, transport and human mobility play a crucial role in the current climate debate (Wynes and Nicholas, 2017). We are currently experiencing widespread protests around the world as part of the 'Fridays for Future' movement with millions of people demonstrating for more climate action. During the global climate strike on September 20, 2019, the organizers counted 260,000 people in New York City, 230,000 people in Berlin, and 120,000 people in Melbourne. Their concerns and call for a rapid reduction of greenhouse gas emissions (GHG) are supported by the majority of the scientific community who for a long time have warned about the threats of global warming (Hagedorn et al., 2019; Ripple et al., 2019). As part of that, it has led large parts of the general public to understand that we need to fundamentally change behavioral and consumption patterns. Taking into account that the transport sector is one of the largest GHG emitters worldwide and that transport-related energy use continues to grow faster than in most other sectors (IEA, 2019; IPCC, 2014), this also refers to our travel habits. Consequently, sustainable transport has not only become a major domain in academic research (e.g., Gillis et al., 2016; Greene and Wegener, 1999), but also a frequent subject in the public discourse.

While these developments have mainly been observed in the Global North, elsewhere the status quo differs significantly (Lee et al., 2015). In the Philippines, for example, it appears that climate change has not appeared yet as a crucial topic on the public agenda (Franzen and Vogl, 2013; Reyes, 2014) even though more environmental and sustainability awareness are imperatively needed. Not only is the Philippines currently one of the countries suffering the most from climate hazards (IEP, 2019), but is also one of the countries most affected by the projected sea-level rise in the future (Kulp and Strauss, 2019). Cities that are located on the coastline are highly vulnerable and could face drastic consequences (Meerow, 2017). Considering a relatively conservative scenario of expected changes in global carbon emissions, by 2050 large parts of MM are expected to be permanently threatened by inundation[1].

A potential solution often promoted by academic researchers and policymakers to tackle both transport and environmental problems is the shift towards more efficient/sustainable transport modes (e.g., Creutzig et al., 2012; Nykvist and Whitmarsh, 2008). In this context, several policy directions have been suggested and implemented. They encompass measures such as restrictions, bans, taxation, pricing and subsidization, information campaigns to create awareness, and integrated transport and land-use planning. They also encompass the improvement of services as well as the provision of adequate infrastructure (e.g., Banister, 2008; Hayashi et al., 2004; Pojani and Stead, 2015). We would like to emphasize the role of the last types of measures, given their historical contribution to the diffusion of transport systems (Leibowicz, 2018) and the results of case studies, for example, on biking infrastructure (Marqués et al., 2015) and BRT systems (Wright and Fulton, 2005). Simply put, this means that providing the necessary infrastructure and improving services precede and stimulate the change of mobility behavior.

Mobility as a Service (MaaS) is a promising new transport solution that, according to first results from field tests and studies in developed countries, could follow a similar rationale. For example, during a 6-month MaaS field trial in Sweden, it has been found that "over time the participants became less positive towards private car and more positive towards alternative modes" (Karlsson et al., 2016, p. 3269). As such, many users of a service called *UbiGo* changed their mobility behavior and increased patronage of bus/tram (50% of participants) or bicycle sharing (23% of participants), while 48% claimed to have used private cars less frequently than prior to the trial.

For this study, we collected online survey data in the Philippines from residents and commuters in MM. The questionnaire surveyed respondents' mobility-related and socio-demographic characteristics. Two binary response models have been specified with the objective to investigate preliminary demand for MaaS in developing countries and how it differs compared to findings in developed contexts.

Specifically, we have addressed the following research questions:

- (RQ1) How strong is the willingness to use MaaS in developing countries? Who are the potential adopters and what are their motives to use MaaS?
- (RQ2) By integrating different transport services and making them accessible on demand, does MaaS have the *potential* to promote a shift towards public transport and more sustainable mobility in developing countries?

This article complements the emergent literature on MaaS adoption and explores MaaS' potential beyond the developed world. Developing countries – which are home to the majority of the world's population, are growing rapidly, and often face severe transport-related problems – have so far been overlooked in existing studies. By focusing on a megacity that presents many of the prevalent transport characteristics in developing countries, this study offers first insights into MaaS in the context of the developing world – which we consider a promising field of research.

The remainder of the article is structured as follows. Section 2 provides the background for this study. Our research methods are presented in Section 3 and the study results in Section 4. We discuss policy recommendations in Section 5. Finally, Section 6 presents concluding remarks and an agenda for future research.

[1] We are referring to the Coastal digital elevation model (CoastalDEM) estimation by Kulp and Strauss (2019). A map for the area in MM threatened by inundation can be generated with the Climate Central's Coastal Risk Screening Tool available at https://coastal.climatecentral.org.

2. Background

This section contains the relevant background information for this study. Section 2.1 summarizes recent developments in the context of the emerging MaaS concept. Section 2.2 contains the case study presentation of Metro Manila, a developing megacity in Southeast Asia.

2.1. Mobility as a service (MaaS)

Mobility as a Service (MaaS) is a very recent concept. While a universal definition has yet to be developed, in the most prevalent view, it describes a new transport solution that integrates public and private transport services from different transport operators and service providers on a single platform (Jittrapirom et al., 2017).

MaaS springs from the 'Everything as a Service' (XaaS) paradigm, a huge stream known from cloud computing, where products, processes, data, information, and so forth, are being provided as a service (Duan et al., 2015). It thus translates the XaaS-concept into the context of transport, by promoting a shift from buying/owning means of transport towards servitized transport modes.

The MaaS concept originates from Finland where – since Hietanen (2014) – it has been strongly pushed and promoted by public and private actors. Nowadays, it is a widely used term in the scientific and grey literature comprising several publications by academic researchers (for recent reviews, see Calderón and Miller, 2019; Utriainen and Pöllänen, 2018), government agencies (e.g., Finnish Transport Agency FTIA, Transport Committee - UK Parliament, Dutch Ministry of Infrastructure and Water Management, and Swiss Federal Office of Transport BAV), international organizations (e.g., ITF/OECD, UNECE), research, tech, and consulting firms (e.g., Accenture, Cisco Systems, Deloitte, KPMG), and interest and industry associations (e.g., AARP, EMTA, IET, UITP) – pointing to its expected impact and market potential (see Appendix A for a comprehensive list of MaaS white papers and reports).

While integrated transport has been a goal of transport authorities for decades, MaaS leverages on recent developments in digital technologies as well as societal changes such as the sharing economy to bring this idea into reality. MaaS incorporates new mobility services (NMS) such as ride-hailing and car- and bike-sharing, makes services accessible on demand and on a single payment channel, and converts them into so-called mobility packages (also MaaS plans, mobility plans, or bundles) (Jittrapirom et al., 2017).

As the number of MaaS schemes and trials are rapidly increasing, it remains a difficult task to frame and categorize relevant MaaS providers. We note that the presumed MaaS schemes differ greatly in terms of business models, service features, and the number and types of integrated transport modes. One way to classify MaaS schemes refers to the degree of integration (Kamargianni et al., 2016) distinguishes between partial/advanced integration and (Sochor et al., 2018) classifies them based on integration levels ranging from 0 to 4 (Table 1).

There are several operating MaaS schemes in different parts of the world that fall under the advanced integration category or the MaaS level 2 type/class, respectively, including *Free2Move*[2], *moovel*[3], and *Jelbi*[4]. However, to the authors' best knowledge, the only provider offering advanced integration with mobility packages (or MaaS level 3) is the Finnish start-up *MaaS Global*. Its service *Whim*[5] has been officially launched in the Helsinki region in November 2017. Meanwhile, they have expanded internationally, for example, to Birmingham/West Midlands (UK), Antwerp/Flanders (Belgium), and Vienna (Austria).

Due to the limited number of real-world applications, several scientific studies have focused on (possible) implications as well as conditions for MaaS in the context of selected regions and countries – mainly in the developed part of the world. They include the Alpine regions (Signorile et al., 2018), the UK (Enoch, 2018), Germany (Hasselwander, 2019), Australia (Mulley et al., 2020), and the application of MaaS in rural areas (Eckhardt et al., 2018, Geurs et al., 2018).

The scientific community perception of the potential of MaaS to solve transport-related problems is rather positive. However, many studies consist of reviews, theoretical discussions, and qualitative studies. Possibly because of the novelty of MaaS and the paucity of available data, few studies provide empirical evidence about MaaS (expected) market potential, outcomes, and benefits.

Many of the available quantitative studies so far have addressed the potential users of a MaaS system mainly through stated choice/preference analyses (Table 2). A central issue of these articles refers to mobility packages and the question of how to bundle services, which is therefore obviously considered as a relevant leverage point for MaaS providers. Guidon et al. (2020) found that once public transport is offered in a bundle, it is valued higher compared to when valued individually. Matyas and Kamargianni (2019), in addition, highlight mobility packages' potential to introduce users to services they have not used before. Together with the results from the *Ubi-go* trial (Karlsson et al., 2016; Sochor et al., 2016) these findings therefore support the idea that MaaS could loosen people's reliance on private cars and increase the use of more sustainable transport modes (i.e., public transport and shared services). Notwithstanding, other studies leave some doubt as to whether MaaS can appeal to avid car users (e.g., Alonso-González et al., 2020; Fioreze et al., 2019; Ho et al., 2020).

A study commissioned by *Maas Global* examined the outcomes and effects of *Whim*'s first year of operation. Its results indicate that *Whim* increased the use of public transport and promoted intermodal travel, and that the integration of NMS enabled the substitution of private car trips (Ramboll, 2019). Other attempts to quantify outcomes and benefits of MaaS have been conducted through micro-simulation. Djavadian and Chow (2017) used data from Oakville, Ontario (Canada), to model MaaS as a solution to tackle public

[2] https://us.free2move.com/app
[3] https://www.moovel.com/en/our-products/for-public-transit-agencies-operators/mobility-app
[4] https://www.jelbi.de/
[5] https://whimapp.com/

Table 1
Typology of MaaS schemes according to the level of integration.

Integration Categories (Kamargianni et al., 2016)	Integration Levels (Sochor et al., 2018)	Examples
-	4 - Integration of societal goals	
Advanced Integration with mobility packages	3 - Integration of service offers (bundles)	Whim, UbiGo (pilot)
Advanced Integration	2 - Integration of booking & payment	Free2Move, moovel, Jelbi
Partial Integration	1 - Integration of information	Moovit, Qixxit, Google maps
-	0 - No integration	Lyft, Hertz

Table 2
Overview of literature on MaaS adoption.

Article	Author	Year	Case study	Research method	Main findings
Developing the 'Service' in Mobility as a Service: experiences from a field trial of an innovative travel brokerage	Karlsson et al.	2016	Gothenburg, Sweden	Mixed-methods approach based on field test (trial)	Participants of the trial reported decreases in private car use and increases in alternative mode use (particularly car sharing and public transport).
Trying out mobility as a service: Experiences from a field trial and implications for understanding demand	Sochor et al.	2016	Gothenburg, Sweden	Mixed-methods approach based on field test (trial)	Participants reported curiosity as the main motivation to adopt MaaS.
Potential uptake and willingness-to-pay for Mobility as a Service (MaaS): A stated choice study	Ho et al.	2018	Sydney, Australia	Stated preference survey data analysis	Car non-users and infrequent users are most likely to adopt MaaS. However, frequent car users seem to be interest in subscribing to mobility packages.
Public preferences for mobility as a service: Insights from stated preference surveys	Ho et al.	2019	Tyneside, UK	Stated preference survey data analysis	Young smartphone users are likely to adopt MaaS. MaaS could be a substitute for the second household car, but not the only car in the household.
The potential of mobility as a service bundles as a mobility management tool	Matyas and Kamargianni	2019	Greater London, UK	Stated preference survey data analysis	User, particularly those with lower household incomes, prefer mobility packages that include public transport.
Mobility as a service in community transport in Australia: Can it provide a sustainable future?	Mulley et al.	2019	NSW and Queensland, Australia	Stated choice experiment with survey data	The willingness to pay for bundled mobility services are substantially lower than the unit costs of provision.
Exploring motivational mechanisms behind the intention to adopt mobility as a service (MaaS): Insights from Germany	Schikofsky et al.	2019	Germany	Partial least squares analysis with qualitative interview data	Psychological needs play a crucial role in the acceptance of MaaS, such as anticipated advantages of autonomy, competence, and the feeling of being related to a social peer group.
Transportation service bundling–for whose benefit? Consumer valuation of pure bundling in the passenger transportation market	Guidon et al.	2019	Zurich, Switzerland	Discrete choice experiment with survey data	Transport services offered in a bundle may increase (e.g., public transport, car sharing) or decrease (e.g., bicycle sharing, taxi) its perceived value compared to the stand-alone service.
Bundling, pricing schemes and extra features preferences for mobility as a service: Sequential port-folio choice experiment	Caiati et al.	2019	Netherlands	Sequential portfolio choice experiment	The price of the monthly subscription is a key adoption factor. Public transport is the most preferred mode for bundles.
On the likelihood of using Mobility-as-a-Service: a case study on innovative mobility services among residents in the NL	Fioreze et al.	2019	Netherlands	Mixed-methods approach based on survey/focus group data	Residents show a significant interest in trying out MaaS but are not likely to use it in the long run. Unlike demographics, attitudes (e.g., environmental awareness) determine adoption of MaaS.
Drivers and barriers in adopting Mobility as a Service (MaaS)–A latent class cluster analysis of attitudes	Alonso-González et al.	2020	Netherlands	Latent class cluster analysis of attitudes	The cluster of individuals with multimodal weekly mobility patterns is most likely to adopt MaaS.

transport's first/last mile problem at a train station. Results from a case study of the Greater Zurich area, Switzerland, suggest that the integration of various transport services leads to efficiency gains and reduction of energy consumption (Becker et al., 2020). Kamargianni et al. (2019), in addition, have proposed a framework to simulate the entire MaaS ecosystem incorporating the decision makers and the interaction of involved stakeholders in the short- and long-term. The application of this framework could deliver first insights on the long-term impact of MaaS on transport systems and user behavior.

However, many of the aforementioned findings are likely not transferable – or are transferable only to a certain degree – to the context of developing countries, considering significant variations in available transport infrastructure and citizens' travel behavior (Gwilliam, 2003).

Indeed, the literature in the context of developing countries is yet incipient. Singh (2019) reports insights from the *Kochi One*[6] scheme in Kochi, India, and the city's transition towards MaaS which provides preliminary evidence about the feasibility of MaaS in developing countries. Adjustments to the MaaS model in Kochi involve the use of smart cards (along with the Kochi One app) and the integration of informal transport services. In the context of Phuket, Thailand, Khaimook et al. (2019) studied the potential of MaaS not only to contribute to more efficient and sustainable transport, but also to increase road safety. They concluded that MaaS, indeed, can break travel habits and encourage people to make safer travel choices (e.g., using public transport instead of traveling by motorcycle).

Nevertheless, little is known about potential users' intentions and preferences and how MaaS can be established in developing countries. The success and rapid diffusion of ridesharing and other internet-enabled services provides an analogy that underlines the potential and demand for NMS (including MaaS) in the developing world (Hasselwander et al., 2022). Several case studies found that socio-demographic characteristics – such as age and income level – are decisive adoption factors in developing context (e.g., Acheampong et al., 2020; Lesteven and Samadzad, 2021). Experience from ride-hailing, moreover, provides evidence for the mode-substitution effect of NMS (Tirachini, 2020).

However, with public transport trips often being substituted, it is argued that many NMS rather increase negative transport externalities and do not contribute to a sustainable transition in developing cities (Suatmadi et al., 2019; Tirachini, 2020).

With regards to implementing MaaS in developing cities, the literature suggests that the translation of transport policies settings – especially from a developed to a developing context – remains a difficult task (Canitez, 2020). Pojani (2020) argues that rather than policy transfer, putting the acquired knowledge into practice and implementing it locally is the critical step. This would require the consideration of local socio-cultural heritage, traditions, and citizens preferences, amongst others (Sharmeen et al., 2021).

Hence, the lack of insights regarding demand side peculiarities in the developing world causes a significant knowledge gap in the MaaS literature, also leaving many issues for policy and practice unanswered.

2.2. *Case study presentation: Metro Manila*

The Philippines is an archipelagic country in Southeast Asia with a population of well over 100 million. Ranked by the World Bank as a lower-middle income country, it is one of the fastest growing economies in the world. Metro Manila (MM), located on the island of Luzon in the Northern part of the country, represents the Philippines' center of culture, economy, education, and the seat of government. It comprises 16 cities and one municipality, and occupies an area of about 620 km^2 (Fig. 1). The urbanization process, however, has spilled out of MM borders into the adjoining provinces (also referred to as Mega Manila) from which a huge number of common trips are generated. With a population of around 13 million (and a daytime population reaching up to 15 million), MM is one of the most crowded and dense urban areas in the world. According to the latest census data from the Philippine Statistics Authority (PSA), the population is very young (in 2010, 58.9% were younger than 30 years) and is growing extremely fast (1.58% annually during the period 2010–2015).

In MM, vast social and spatial inequalities are observed, as well as an increasing gap between rich and poor. This development can be read off by a comparison of the current urban transformation with, at both extremes, locally disembedded wealthy enclaves on one side and low-income, informal settlements on the other (Kleibert, 2018). Also, citizen's mobility characteristics and travel behavior are very diverging (Hickman et al., 2017). Abad et al. (2019) found that low-income neighborhoods in the periphery lack adequate access to transport services, while locations with high housing prices (e.g., in proximity to the CBDs) provide the best accessibility. In addition, Andong and Sajor (2017) highlight a long-term trend that employees move farther away from their workplaces and that commuting distances are increasing accordingly. Vehicle ownership in MM, according to Rith et al. (2019), correlates to socioeconomic characteristics and land use patterns. Given the positive impact of income on car/vehicle ownership and motorization (Dargay and Gately, 1999; Kutzbach, 2009), it is not surprising that rising per capita income in recent years has boosted private car sales in MM. Unlike in most Western countries, however, the private car is not the most dominant transport mode in MM. In fact, its modal split share is still relatively low (20.4%) (JICA, 2015) and yet accounts for 72% of road traffic (NEDA, 2014). Due to the rapid pace of motorization and declining occupancy levels, car trips have increased by 69% between 1996 and 2012 (NEDA, 2014). Nevertheless, 88.6% of households do not own a car. More than two-thirds of the estimated 12.8 million daily trips in MM are, therefore, made by public transport (NEDA, 2014). According to different classification frameworks, there are numerous developing cities around the globe with similar transport characteristics and conditions to MM (Table 3).

The public transport system in MM includes buses (regular and P2P buses), jeepneys (a country-specific paratransit service – the cheapest and most popular mode of transport in the Philippines), UV Express (a point-to-point service with air-conditioned utility vehicles), a rail transit network with three lines (LRT1, LRT2, MRT3), and a commuter rail line (PNR Metro Commuter Line). In addition, more than 21,000 taxis ply the streets of MM, while tricycles (the local auto rickshaw version operated as shared taxis or private hire) and pedicabs (nonmotorized three wheelers) are readily available as first/last mile options.

Shortly after the launch of the first transport network companies (TNCs) in MM in 2014, the Philippines' government created a regulatory framework for these companies to legally operate in the country. Since then, several internet-enabled ridesharing services (i.e., taxi-hailing, ride-hailing, and carpooling) gained great popularity. Grab[7], the leading TNC in Southeast Asia, for example, claims that it occupies 60,000 active driver-partners in the country and that one out of six Filipinos has installed the Grab app (Grab, 2019). Yuana et al. (2019) explain that the insufficient provision and access to public transport in MM forces commuters towards the use of

[6] https://kochimetro.org/kochi-1-card/
[7] https://www.grab.com/sg/

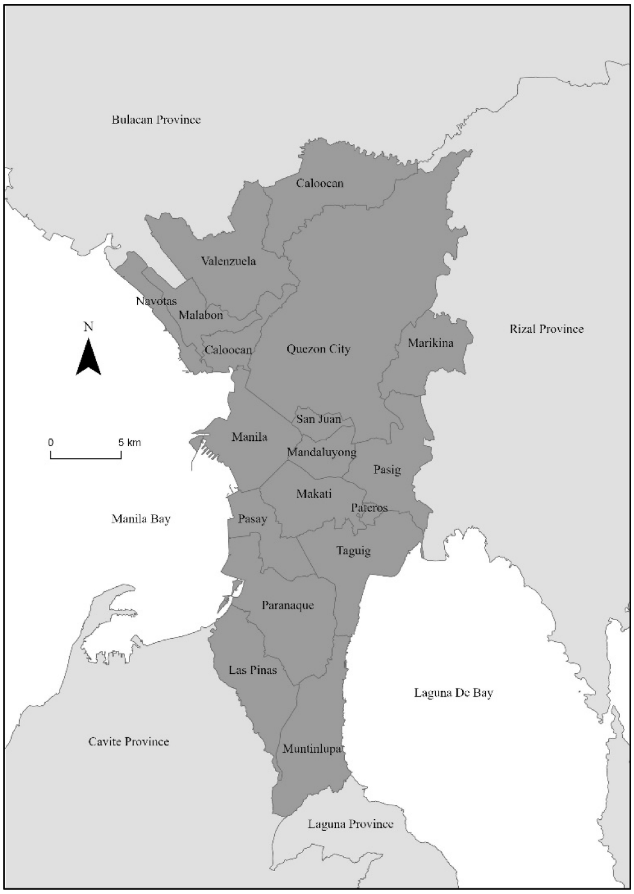

Fig. 1. Map of Metro Manila (dark grey) and its adjoining provinces (light grey). Outside the map section but part of study area: Pampanga Province in the north and Batangas Province in the south of the metropolitan area. Data from PhilGis.org.

Table 3
Transport- and mobility-related city typologies and categorizations.

Framework	Variables/Indicators	Comparable Cities to MM [Category]
Categorization of City Circumstances (Gwilliam, 2002)	Income (Motorization); Size and size distribution; Political history; Population growth rates	Bangkok, Hong Kong
Global urban typology framework for sustainable mobility futures (Oke et al., 2019)	Metro propensity; BRT propensity; Bikeshare propensity; Development; Sustainability; Population; Congestion; Sprawl; Network density	Bangalore, Delhi, Dhaka, Lagos, Lahore, Karachi, Kinshasa, Kolkata, Pune, etc. [Congested Boomers]
Megacity Clusters (Priester et al., 2013)	General city characteristics; Transport supply indicators; Mobility indicators	- [MM identified as an outlier]
Urban Transport Development Paths (Barter, 2004)	Ownership of passenger modes; Urban mobility level	Bangkok, Jakarta [Traffic-saturated bus cities]

ridesharing services, which in turn increases private vehicle utilization and traffic congestion.

The overall transport system in MM, with a railway network of only 75.2 km and a road network operating at capacity limit, is considered very inefficient and not able to accommodate the citizen's mobility needs. Thus, several measures have been implemented and even more proposed to ease the metropolis' transport woes (Boquet, 2013). Many of these measures center around the Epifanio de los Santos Avenue (EDSA) – the main north–south artery and most important and frequented road in MM. Aiming to reduce the number of cars on the streets, the Unified Vehicular Volume Reduction Program (UVVRP) came into force in 1995. This program, also known as 'number coding', bans certain vehicle types (based on the last digit of the license plate) from EDSA and other major public roads at certain times. In 2018, the Metropolitan Manila Development Authority (MMDA) proposed the implementation of a high-occupancy vehicle (HOV) lane, which after a short trial phase, however, has been discarded. Other policies target buses, which – while striving for passengers along EDSA – contribute to traffic congestion. In this context, the 'Yellow Lane Policy', which allows buses to occupy only certain lanes, and the ban of provincial buses have recently been tested on EDSA.

Other attempts refer to the construction and expansion of transport infrastructure, particularly as part of the current administration's 'Build! Build! Build!' infrastructure plan. This includes the Metro Manila Subway and the Southeast Metro Manila Expressway projects as well as the LRT1 Cavite extension and other projects aiming to increase the transport system's overall capacity.

In addition to planned short-term improvements and longer-term infrastructure projects increasing the efficiency of the public transport system could provide a remedy (Batalla, 2005). MM currently lacks a centralized and holistic plan for the road public transport network. The operator landscape is very fragmented. Buses, jeepneys, and tricycles are all privately owned and operated without subsidies. The provision of services depends on private sector initiatives and is not subject to any quality control, while franchises are issued in a rudimentary manner without considerations of road capacity constraints or changes in demand. These conditions result in a poorly managed public transport system with inadequate intermodal integration, high transport-related GHG emissions, and major traffic safety concerns. Operators have established competitive practices that disrupt vehicle flow, while commuters complain about declining service levels (increasing waiting and travel times, overcrowded means of transport, train breakdowns, etc.) and political failure.

Parallel to the ongoing Public Utility Vehicle Modernization Program (PUVMP) (Sunio et al., 2019), institutional and regulatory reforms could address the lack of rationalization and planning. The Department of Transportation (DOTr) commissioned the Metro Manila Road Transit Rationalisation Study completed in 2014. Research initiatives such as the government funded PUBFix[8] project, in addition, propose optimal schedules, routes, and integration schemes for public transport.

3. Research methods

This section describes the research methods used in this study. The following subsections detail the survey design (3.1.), variables and data (3.2.), model estimation and analysis (3.3.), and research limitations (3.4.).

3.1. Survey design

With support from the University of the Philippines - National Center for Transportation Studies (UP-NCTS), we conducted a small-scaled pre-survey with face-to-face interviews on two days in January 2019 at the Mall of Asia in Pasay City, MM. We used the inputs of the small sample to identify weaknesses regarding the formulation and comprehensibility of our questions as well as the response options to improve the survey design.

The final survey has been conducted online. Online surveys have become a popular tool for researchers from different scientific areas, including the field of transport research, as well as for different study purposes. Compared to other survey methods (e.g., face-to-face interviews and telephone surveys), their cost advantage and time saving benefits, the opportunity to address respondents from distant locations, as well as lower socially desirable responding bias are pointed out (Lindhjem and Navrud, 2011). On the other hand, uncertainty over the validity of the data and sampling issues remain as common shortcomings (Ilieva et al., 2002). This also applies to our study, as we discuss in more detail in Section 3.4.

The questionnaire was created using the Google Forms tool. We used a convenience sampling and snowballing technique - during a research stay of the first author at the UP-NCTS, the survey link was shared in social media networks and respondents were asked to share it with their contacts. The survey targeted respondents residing within MM (relating to 87.4% of the sample) or living in one of the adjoining provinces and commuting regularly to MM (e.g., for work or school) (12.6%). Answers have been accepted between February and July 2019, resulting in a total of 238 completed questionnaires.

3.2. Variables and data

The final questionnaire included a total of 20 questions. It first addressed transport- and mobility-related characteristics such as the number of available cars/motorcycles in the household (Table 4). We also surveyed the total distance and time the respondents have traveled on the *previous* day. We deliberately referred to the previous day, which we expected to be easier to answer rather than asking for abstract typical or average travel distances and times. While this could potentially bias the observed modes, we note that the mode distribution in our dataset is comparable to the numbers that are reported in a recent large-scale transport study in MM. That is, about half of all trips in MM are covered by public modes, followed by walking (about 30%), and private modes (about 20%) (JICA, 2015). With the same rationale, we asked about the respondent's *last* trip (instead of a *typical* trip) and the number of required transfers (considering the use of public transport even if the respondent used other modes). In order to record the degree of multimodal travel behavior, we asked which types of transport modes the respondent is using regularly (i.e., at least once a week). Finally, we also asked the respondents for the factors they valued most when choosing a transport mode for a trip (e.g., the availability of travel information[9]) as well as their main trip purpose.

In addition, we surveyed the respondents' socio-demographic characteristics as summarized in Table 5. This also covered

[8] http://pubfix.transfix.ph/about.php

[9] Note that in the Philippines, public transport is mostly informal, without timetables and detailed route information available. On the other hand, internet-enabled alternatives such as ride-hailing provide detailed information on travel and arriving times.

Table 4
Descriptive statistics for respondent's transport- and mobility-related aspects (N=238).

Variable	Description (Measurement and value)	Category	Observations (percentage)	Mean (SE)
RESID	Respondent's residence (=1 if he/she resides in MM, otherwise = 0)	–	203 (87.4)	–
HCARS	Number of cars available in the household	–	–	1.27
				(1.42)
HMOTOS	Number of motorcycles available in the household	–	–	.42 (.86)
MODES	Number of different transport modes used at least once a week	–	–	3.42
				(2.09)
PRICE	Factors that determine respondent's transport mode choice. Respondents could select up to	Price/Costs	148 (62.2)	–
TIME	three *unweighted* factors.	Time	179 (75.2)	–
COMFORT	(=1 if the respondent chose the respective factor, otherwise = 0)	Comfort	129 (54.2)	–
SAFETY		Safety	99 (41.6)	–
TRAVELINFO		Avail. Travel	20 (8.4)	–
ENVIRON		Info.	5 (2.1)	
RELIABILITY		Environm.	40 (16.8)	–
		impact		
		Reliability		
TRIPS-PV	Number of single trips per transport mode made on the *previous* day	Private vehicle	–	.99
TRIPS-PT		Public transport	–	(1.47)
TRIPS-TX		Taxi	–	1.15
TRIPS-RH		Ride-hailing	–	(1.34)
TRIPS-SM		Soft modes	–	.15 (.60)
				.63
				(1.15)
				1.33
				(1.60)
TOTDIST	Total distance in km travelled on the *previous* day (business day/weekend) (1–4)	[1] <15	107/12	–
		[2] 15–35	(50.0)	–
		[3] 36–55	73/11 (35.3)	–
		[4] >55	16/3 (8.0)	–
			15/1 (6.7)	
TOTTIME	Total time in hours spent travelling on the *previous* day (continuous variable)	Business day	–	2.36
		Weekend		(1.67)
				2.55
				(1.53)
WORK	Main purpose for the last trip made	Work/School	176 (73.9)	–
BUSINESS	(=1 if the respective trip purpose is the respondent's main trip purpose, otherwise = 0)	Business	31 (13.0)	–
FF		Family/Friends	12 (5.0)	–
PERSONAL		Personal	13 (5.5)	–
SHOPPING		Shopping	6 (2.5)	–
TRANSFERS	Number of transfers required for the *last* trip	–	–	1.13
				(1.29)

smartphone availability and whether the respondents had any transport applications installed on their mobile device. We assume that when respondents are already using a similar app (e.g., a ride-hailing or carpooling app), it is more likely that they would use a MaaS app as well.

The questionnaire included a written explanation of the MaaS concept, an explanatory image (Fig. 2) and a link to a short video[10] about MaaS. It described an app that would suggest the best (multi- and intermodal) travel alternative and would also provide real-time travel information before and during the trip. It also explained that all available transport modes and services would be included, and that it would only require a single payment for the entire journey. Moreover, it referred to the possibility of subscriptions and to pre-purchase limited or unlimited services on a monthly basis (mobility packages).

After this background information was provided, the participants were asked whether they would use a MaaS app and how a MaaS system would influence their mobility behavior. The answers contained the following options with the respective frequencies in parentheses:

- I would probably use this app and use public transport more often (61%)
- I would probably use this app, but wouldn't increase the use of public transport (23%)
- I would probably NOT use this app, because I don't find it useful (3%)

[10] https://www.youtube.com/watch?v=WXkJSppY5XU

Table 5
Descriptive profiles of the sample compared with Metro Manila census data.

Variable	Description	Sample (N=238)	Metro Manila*
SEX	Male	.46	.49[a]
	Female	.54	.51[a]
AGE	Age Group		
	-Under 20	.04	.39[a]
	-20–29	.58	.20[a]
	-30–39	.24	.16[a]
	-40–49	.08	.12[a]
	-50–59	.03	.08[a]
	-60 and above	.03	.06[a]
EDU			
	Highest education	.00	.00[c]
	-No Grade Completed	.00	.09[c]
	-Elementary	.06	.44[c]
	-Highschool	.75	.42[c]
	-College	.19	.05[c]
	-Post Secondary		
OCCUP	Occupation		
	-Student	.21	n/a
	-Working (full-time)	.68	n/a
	-Working (part-time)	.04	n/a
	-Unemployed	.03	n/a
	-Retired	.02	n/a
	-other	.03	n/a
HINCOME	Household annual income		
	-less than 40,000	.05	.00[b]
	-40,000 – 59,999	.07	.00[b]
	-60,000 – 99,999	.08	.00[b]
	-100,000 – 249,999	.18	.14[b]
	-more than 250,000	.61	.85[b]
HSIZE	Household size	4.4	4.1[b]
PHONE	Smartphone availability	.99	n/a
APPS	Number of transport apps	1.4	n/a
	Sample size	238	12,877,253[b]

*Source: PSA; [a] Data from 2010; [b] Data from 2015; [c] Data from 2016.

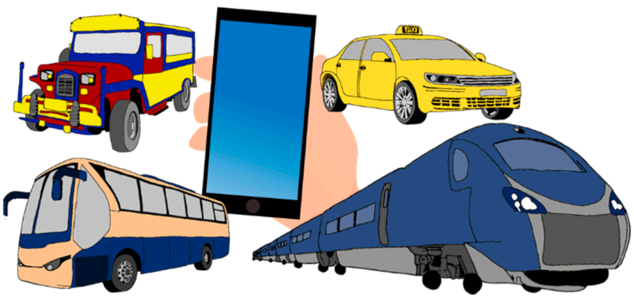
Fig. 2. Explanatory image about the integration of different transport modes in a MaaS scheme.

- I would probably NOT use this app, because I don't have a smartphone/mobile internet (0%)
- I would probably NOT use this app for other reasons (5%)
- I'm not sure (7%)

3.3. Model estimation and analysis

Utility theory and discrete choice analysis are frequently used in transport research to explain choices between two or more discrete alternatives (e.g., mode choice). For comprehensive presentations on this subject the reader is referred to Ben-Akiva and Lerman (1985), Train (2009), and de Dios Ortuzar and Willumsen (2011). In this study, we conduct a binary choice analysis in which exactly two discrete alternatives are available.

First, we model the overall willingness to use MaaS (Model 1). For this purpose, we consider two groups: those willing to use a MaaS system (84%) and all others (16%). Note that we therefore initially do not take note of potential changes in mobility behavior (i.e., using public transport more often). At this point, we also do not account for the respondents' underlying reasons not to use MaaS (e.g., because they do not find it useful).

In the second part of our analysis, we take a closer look on the respondents willing to use MaaS. We therefore draw on a subset of the sample consisting of the 84% that responded accordingly (i.e., N = 199). Here, we intend to model the potential MaaS-users' likelihood to use more public transport (PT) in a MaaS system (Model 2). We again consider two groups: those who would use PT in a MaaS system more often (73%) and those who would not (27%).

We relate the respondents' willingness to use MaaS (Model 1) or the likelihood of using PT more often (Model 2) to their individual mobility, socio-demographic, and household characteristics:

$$y_j^* = \beta x_j + \varepsilon_j, \tag{1}$$

where y^* is an unobserved latent variable, β a vector of estimated coefficients, x_j a vector of the values of the j-th observation, and ε_j the unobserved error term. The relation between the unobserved latent variable y^* and the observed binary variable y indicates whether the relative perceived utility of respondent j to use MaaS (Model 1) or more public transport in a MaaS system (Model 2) is positive:

$$y = \begin{cases} 1 & if\ y^* > 0 \\ 0 & otherwise \end{cases} \tag{2}$$

In short, Model 1 relates a stated intention to use MaaS with individual, household, and mobility-related characteristics. The latent variable y^* measures the perceived utility that each user associates with using MaaS (following a written explanation about the MaaS concept and characteristics, a visualization, and a video presentation). This utility is not directly observable. What we observe is the stated intention to adopt MaaS, that we denote by the dichotomous variable $y = 1$ if the perceived benefit of using MaaS (as opposed to not using) is positive. Similarly, Model 2 relates the stated intention of using more public transport (PT) in a MaaS-system with individual, household, and mobility-related characteristics of the respondents.

We use the software package NLOGIT 4.0 to perform the maximum likelihood estimation of both a standard probit model (equation (3)) and a heteroscedastic probit model (equation (4)). The latter accounts for possible heteroscedasticity – which is frequently encountered in micro-level data – and allows the error variance to depend on some of the independent variables in the regression model (Alvarez and Brehm, 1995). The key difference, therefore, is the inclusion of the variance model in the denominator of the latter equation.

$$ln\mathscr{L}(\beta|x_i, y_i) = \sum_{i=1}^{n}(y_i ln\phi(x_i\beta) + (1 - y_i)ln(1 - \phi(x_i\beta))) \tag{3}$$

$$ln\mathscr{L}(\beta, \gamma|x_i, y_i, z_i) = \sum_{i=1}^{n}\left(y_i ln\phi\left(\frac{x_i\beta}{exp(z_{i\gamma})}\right) + (1 - y_i)ln\left(1 - \phi\left(\frac{x_i\beta}{exp(z_{i\gamma})}\right)\right)\right) \tag{4}$$

For the selection of variables in the model, we follow the purposeful selection process which is a widely used approach to identify significant covariates and confounders (Bursac et al., 2008). For the univariate analysis, it recommends a p-value cut-off point of 0.25. For our models, we use a slightly higher value (0.28) to be able to include relevant variables for this study (e.g., the respondents' residence).

The McFadden Pseudo R^2 is frequently used as a goodness-of-fit metrics in logistic regression and reflects the degree of improvement over a base model. Here, we rely on the adjusted version to penalize for the number of predictors in the model. Note that this index can yield negative values, and that regarding its interpretation, it cannot be compared to the (adjusted) R^2 of linear models.

Finally, we validate the results of the models. We note that while a structured approach towards model validation is not frequently applied in the transport literature (Parady et al., 2021), the models' effectiveness should indeed be analyzed before the models can be used. Besides the common interpretation of the models' parameters (that provide initial insights about the accuracy of the models' specification), cross validation is used to detect overfitting. As no other similar data is available, we use the k-fold method to split the original data into k mutually exclusive data sets. Considering the small size of our sample, we define $k = 3$ to ensure there remain full representation of conditions in all data sets. Each data set is once defined as a hold out (validation data set), while the remaining data is used for the model estimation (training data set). We then regard the model evaluation scores to summarize and compare the skill of the model on new data. In addition to the percentage of correct predictions (actual 1 s and 0 s correctly predicted), we also report the negative predictive value (predicted 0 s that were actual 0 s) to account for the fact that our samples are rather skewed (e.g., recall that 84% stated that they would likely adopt MaaS) and that a trivial model that always predict "1" would thus obtain a high correct prediction score. The interpretation of the negative predictive values, therefore, helps to further evaluate that the models can really discriminate actual 1 s and actual 0 s (due to the explanatory variables included in them).

3.4. Research limitations

As we noticed during the pre-survey, a MaaS scheme in MM and especially the introduction of mobility packages[11] would be a novel

[11] Note that nowadays in MM there do not even exist seasonal tickets of any kind (e.g., monthly passes, etc.).

and revolutionary scenario. While we have made every effort to describe the MaaS concept as aptly as possible – given the fact that MaaS is still a near to unknown phenomena in the Philippines – we cannot guarantee that the respondents fully understood the MaaS concept and what it could mean to them. Note that we therefore included the "I'm not sure" option in the survey.

The online data collection implies that we could not reach citizen without internet access (and smartphones). Instead, the online survey primarily reached internet-affine individuals ('digital natives') which might have skewed the results towards positive views for MaaS. However, under consideration of the current conception of MaaS which requires smartphone possession and internet coverage, the potential user target group for MaaS is de facto restricted (Schikofsky et al., 2019). Hence, while our sample is not representative of the MM population, it is a subset of a potential user segment for MaaS wherein digital natives and so-called choice-riders might be overrepresented. Choice-riders can and do afford motorized private vehicles and they therefore need to be addressed when promoting a paradigm shift – which corresponds to one of the research questions that we explored in this study.

There are also some biases that we cannot control for, which is why the results of this study should be considered as preliminary. First and foremost, this relates to the use of a small sample size, which typically leads to higher variability. Another potential issue relates to endogeneity. In discrete choice models, endogeneity arises when some explanatory variables are correlated with the error term. This is almost unavoidable in transport modeling and can occur due to omitted variables, measurement or specification errors, and/or self-selection (Guevara, 2015). In our study, one can expect that particularly the mode choice indicators (travel cost, travel time, reliability, comfort, safety, etc.) are prone to endogeneity (Guevara, 2015).

Since there is currently no operational MaaS scheme in MM, our modeling approach is based on a stated intention to use MaaS, which does not necessarily align with the respondents' actual behavior. This is due to, for example, hypothetical biases (e.g., respondents overreport "desirable" behaviors), changes in explanatory variables (e.g., unanticipated income shifts), and the imperfect correlation between intentions and actions (Sun and Morwitz, 2010). Also, even though the concept of mobility packages was explained, we did not explicitly asked respondents whether they in fact would subscribe to a MaaS-plan and how much they would be willing to pay.

Nevertheless, since we analyze a premature market (i.e., MaaS in a developing country), we argue that these limitations are not critical at this point and, instead, should be addressed in future research (as discussed in Section 6).

4. Study results

This section describes the study results. Results of the first model are provided in section 4.1. and those of the second model in section 4.2.

4.1. Model 1: Willingness to use MaaS (whole sample)

The first model includes eight independent variables: the respondents' residence (RESID), Number of modes (MODE), ride-hailing trips (TRIPS-RH), distance traveled (DISTAN), number of transfers (TRANSF), price and reliability factors (PRICE, RELIABILITY), and gender (SEX) (Table 6).

For the heteroscedastic probit model, we include the respondents' gender and age in the variance model which are frequently detected with heteroscedasticity for many kinds of behavioral variables (Goldstein, 2014). Considering the log likelihood for the standard probit (-90.37) and the heteroscedastic probit model (-90.17), we can use the likelihood ratio test to validate whether the error variances are homoscedastic. The value of 0.4 (distributed chi-squared) with 2 degrees of freedom is clearly below the critical value of 9.21 (at $p < .01$). We can therefore not reject the null hypothesis and conclude that heteroscedasticity is likely not an issue in our data and that the standard probit model is sufficient.

Model 1 gives insights about the potential MaaS users in MM considering mobility-related and socio-demographic characteristics. The variables PRICE and RELIABILITY are both significant and have a positive coefficient, which indicates that price-sensitive citizens are a potential target group. For them, MaaS would be an opportunity to plan trips, compare travel alternatives, and choose the best option. The significance of TRIPS-RH suggests that frequent ride-hailing users are willing to use MaaS. Ride-hailing services are typically used for short social and leisure trips (Rayle et al., 2016), for which MaaS could provide suitable and more sustainable travel alternatives. The negative coefficient of the SEX variable shows that females in our sample are more likely to adopt MaaS, which aligns with studies related to public and soft modes suggesting that males attach a higher psychosocial value to cars and drive more often (Vance and Peistrup, 2012).

The number of transport MODES used regularly has a slight positive impact (though not statistically significant), while TOTDIST traveled shows a negative correlation. Taken together, the model therefore provides some (weak) evidence that MaaS attracts citizens that already rely on multiple transport modes and that MaaS is seen as an opportunity to facilitate multimodal travel on short distances. Citizens living in MM (which corresponds to RESID = 1), furthermore, show a greater interest to adopt MaaS compared to those living in the adjoining provinces. A possible explanation relates to the main trip purpose of respondents. Those living in the provinces typically travel to MM for work/business or school (94.3%) suggesting that they use the same daily routes. MM residents show a higher variety in trip purposes including those related to social and leisure activities (11.6%), which often implies that they travel to varying destinations and may be willing to use MaaS as a trip planner.

Interestingly, the willingness to use MaaS did not correlate to the responds' age. We report strong interest in MaaS across all age groups – the lowest percentage of respondents that stated that would probably use MaaS was as high as 74% for the age group 40–49 years old. The highest percentage (86%) was recorded for respondents between 20 and 29 years of age. This contrasts with what has been observed in previous studies, for example in Germany and the UK, where the older segments showed a significantly lower interest

Table 6
Estimated results of the standard probit model on the decision to use MaaS (Model 1).

Variable	Description	Coefficient	SE
(Constant)		.48069	.49185
RESID	Place of Residence	.34267	.30899
MODES	Number of modes	.07761	.05504
PRICE	Price (Mode choice)	.62325***	.22402
RELIABILITY	Reliability (Mode choice)	.81071**	.35258
TRIPS-RH	Ride-hailing trips	.39262**	.17911
TOTDIST	Distance travelled	−.20023*	.11784
TRANSFERS	Number of transfers	−.04058	.07882
SEX	Gender	−.47887**	.21663
Model Summary Statistics			
Number of observations:		238	
Number of model parameters:		9	
LL($\widehat{\beta}$)		−90.36884	
LL(c)		−106.1539	
McFadden Adjusted Pseudo R-squared:		.0733374	

* 90% Confidence Level; ** 95% Confidence Level; *** 99% Confidence Level.

in MaaS (Ho et al., 2018; Schikofsky et al., 2019). We further note that there was no correlation found with regards to the household's vehicle ownership or income levels.

With regards to the cross validation, the estimated models of the training data set provide an average predictive accuracy of 83.82% which is comparable to the predictive performance of Model 1 (83.61%) and a model without predictors (83.61%). Similar results are obtained for the validation data sets (83.18%, on average). The negative predictive values show robust results for both the training (46,20%, on average) and validation data sets (48,33%, on average), which are roughly comparable to the results of Model 1 (50,00%) and a significant improvement over a constant model (0,00%). We conclude that the variables contribute to the predictive performance of Model 1 and that overfitting is not an issue.

4.2. *Model 2: Likelihood of increasing the use of public transport (among MaaS adopters)*

The independent variables included in the second model are the following: the respondent's residence (RESID), modal choice factors such as PRICE and RELIABILITY, the number of trips by PT and taxi (TRIPS-PT, TRIPS-TX), the trip purposes PERSONAL and BUSINESS, gender (SEX), and the number of transport applications installed on the respondent's smartphone (APPS) (Table 7).

Among the respondents that would adopt MaaS (84% of the total sample), almost three forth stated that they would use PT more often. The significance of PERSONAL implies that trip purpose is relevant, and its negative coefficient further indicates that additional PT trips are expected to be made for motives other than personal trips. Based on the variable RESID, we further find strong evidence that citizens living in the adjoining provinces are willing to use more PT. This could relate to the current lack of adequate access to PT in the periphery and in the provinces (Abad et al., 2019). This suppressed/latent demand could be addressed by MaaS through the integration of shared and on-demand services (as a feeder to the mass transit hubs). Additionally, we find that price-sensitive citizens (PRICE) and females (SEX) are not only more willing to adopt MaaS (recall Model 1 above), but they also refer to the users who would use PT more often. In contrast, users seeking for RELIABILITY would likely not increase the use of PT. Another important finding refers

Table 7
Estimated results of the standard probit model on the decision to use public transport more often in a MaaS-system (Model 2).

Variable	Description	Coefficient	SE
(Constant)		1.12008**	.45470
RESID	Place of Residence	−.95301**	.39062
PRICE	Price (Mode choice)	.37428*	.22129
RELIABILITY	Reliability (Mode choice)	−.57037**	.26736
TRIPS-PT	Public transport trips	−.03972	.08347
TRIPS-TX	Taxi trips	.30441	.31494
PERSONAL	Trip purpose "personal"	−1.00121**	.41405
BUSINESS	Trip purpose "business"	.32823	.36389
SEX	Gender	−.39427*	.21341
APPS	Number of transport apps	.35247**	.15282
Model Summary Statistics			
Number of observations:		199	
Number of model parameters:		10	
LL($\widehat{\beta}$)		−92.81975	
LL(c)		−106.1539	
McFadden Adjusted Pseudo R-squared:		.040829	

* 90% Confidence Level; ** 95% Confidence Level; *** 99% Confidence Level.

to the number of transport apps (APPS) that the respondents have installed on their device. We find evidence that with increasing number of installed apps, the willingness to use more PT increases. MaaS could therefore be a solution to consolidate the growing number of NMS and different service providers and reduce barriers to use PT for 'digital natives' who prefer to plan, book, and pay services online.

The different model specifications in the cross validation show a roughly comparable predictive accuracy (78.36%, on average) compared to Model 2 (77.39%), and an improvement over a constant model without predictors (72.86%). However, while we observe that the results for the validation data sets are rather unstable, we argue that they are reasonably close to the predictive performance of Model 2 (within 3–10%). With regards to the negative predictive values, the average results for the training (68,94%) and the validation data sets (65,65%) are roughly comparable to Model 2 (64,52%). If compared to the result of a model without predictors (0,00%), it suggests that the variables contribute to the predictive performance of Model 2. We again conclude that overfitting is not an issue.

5. Policy implications

In our sample, half of the respondents traveled less than 15 km in MM on the previous day while the average travel time corresponded to 2.39 h. This describes the current traffic situation in MM very accurately and stresses why citizens (who can afford it) rely on private cars and low-capacity for-hire services such as taxis and ride-hailing. Yet, we found evidence that both the willingness to use MaaS (84%) and the willingness to increase PT usage in a MaaS-system are high (61% of the total respondents which corresponds to 73% of the potential MaaS users). This indicates that MaaS has the potential to be an effective strategy to promote public (and non-motorized) transport modes and tackling GHG emissions and other car-related social costs (e.g., traffic congestion, accidents, and noise) through modal shifts.

Accordingly, the study results provide important implications for public policy and practice, and influence how MaaS can be implemented in the developing world.

The most important question, in this context, relates to who should plan and implement the MaaS scheme. Essentially, previous research suggests two scenarios: a public or a private pushed development (or a combination of both) (Smith et al., 2018).

Findings from ride-hailing show that the private sector usually follow economic rather than sustainability objectives and thus contribute to increases in traffic congestion and overall vehicle-miles traveled (VMT) (Tirachini, 2020). These findings have been confirmed in the developing world, particularly in the context of Southeast Asian megacities (Suatmadi et al., 2019; Yuana et al., 2019). Under a private pushed MaaS development, therefore, the risk could be that the MaaS operator compel occasional PT users towards the use of less sustainable (and more expensive) transport modes of the MaaS-mix (e.g., carsharing or ride-hailing).

Thus, we argue that transport agencies should anticipate and address the existing demand for multimodal transport. Ambrosino et al. (2016) highlight the crucial role of transport agencies with regards to the integration and co-ordination of different modes and operators, which is urgently needed in cities such as MM. Ideally, we therefore envision a scenario in which the public sector plans and governs the MaaS scheme under consideration of sustainability goals. The available levers (e.g., pricing and bundling techniques), hereby, should be used to promote and favor environmentally friendly transport modes.

Nevertheless, the question arises as to whether emerging cities in developing countries, such as MM, can implement a complex project of this kind. Existing research has pointed out that the institutional setup in MM is extremely slow and convoluted, which has hampered the implementation of previous sustainability transport projects (e.g., cycling networks, BRT, etc.) (Pojani, 2020). Experts additionally point to barriers related to technology (e.g., available ICT infrastructure, the need for standardized open data) and the external environment (e.g., highly fragmented operator landscapes, auto-centric developments) that developing cities have to face (Hasselwander and Bigotte, 2021).

A window of opportunity for MaaS implementation, however, could lay in the current COVID-19 crisis. It is believed that pandemic response measures, amongst others, propel digital transitions and a shift towards sustainable transport (Megahed and Ghoneim, 2020). Indeed, despite the overall decrease in travel demand, several transport policies in favor of MaaS have recently been introduced in MM (Hasselwander et al., 2021). In Resolution No. 69 dated September 7, 2020, for example, the Inter-Agency Task Force for the Management of Emerging Infectious Diseases (IATF-EID) ordered the establishment of an interoperable automatic fare collection system and the promotion of cashless payments. Whereby the National Transport Policy (NTP) and its Implementing Rules and Regulations

Table 8
User motivations and reasons to adopt MaaS.

Findings based on trials and research in Developed Countries	New user perspectives for MaaS in Developing Countries (Metro Manila)
– Curiosity (Sochor et al., 2016)	– Expectation of a more reliable service (e.g., through the integration of different services, travel information, and identification and comparison of travel alternatives)
– Convenience/flexibility and (re)discovery of alternative modes (Karlsson et al., 2016)	– Expectation of cost-savings
– Increased accessibility (Fioreze et al., 2019; Sochor et al., 2016)	– Mobility solution for all age groups
– Environmental awareness (Fioreze et al., 2019)	– Consolidation of different services in a single app

(IRR) stipulate efficient data collection and an open database system for all governmental transport agencies.

For the successful implementation of MaaS in developing countries, it is important to notice that different user motivations and reasons to adopt MaaS compared to findings in developed countries have been identified (Table 8). For example, citizens in MM would not adopt MaaS for environmental reasons but rather for reliability and cost saving reasons. Accordingly, the MaaS providers should leverage on users' practical concerns and economic motivations.

Indeed, MaaS delivers much potential to make user travel more reliable. ICT integration would enable the provision of all relevant travel information (e.g., travel and arriving times, transfer points, and costs) and would always suggest suitable, multi-modal travel alternatives. This could potentially also deliver an improved travel experience as users would have the chance to avoid overcrowded transport means, long waiting/loading times, and traffic jams.

With regards to the potential of cost savings, it is argued that MaaS could significantly reduce costs as a substitute to private cars (i. e., by eliminating the sunk cost of vehicle ownership), even though it is not clear whether car owners would really dump their cars for MaaS. Through the introduction of mobility packages, also households without cars could potentially undercut their current mobility costs. This depends very much on the design of the mobility packages and potential subsidies of services, which should therefore be the subject of future studies.

6. Conclusion and future research

MaaS is still a developing concept and academic research on MaaS is in its early stages. From both practical and theoretical standpoints, findings regarding developing countries are particularly limited. We addressed this knowledge gap with an analysis on the demand side in Metro Manila, Philippines.

Two binary probit models have been estimated that help transport authorities and MaaS stakeholders (operators, aggregators, etc.) identifying (i) who the potential MaaS users are, and (ii) whether they would be willing to use more public transport in a MaaS scheme. The models were validated using a cross-validation approach.

In our study, the vast majority (84%) stated that they would probably use a MaaS-app. Even though this percentage appears surprisingly high, the fact that more than 90% of respondents already have at least one transport app installed on their device relativizes this number. Many citizens in MM are familiar with transport apps, especially ride-hailing (e.g., *Grab* and *Angkas*), and are aware how to plan, book, (and pay) trips online using smartphones. We need to emphasize that in order to reduce complexity, however, we only asked users if they would generally use MaaS – be it a 'pay-as-you-go' or a subscription-based alternative.

While environmental awareness does not appear to be a relevant aspect in the adoption process, we conclude that MaaS could provide added value to users by increasing reliability, reducing costs, and facilitating multimodal trips. In addition, we found evidence that MaaS has the potential to shape more sustainable transport systems in developing countries as it could help to make PT more attractive and induce a modal shift. MaaS could furthermore promote more inclusive mobility by addressing latent demand in the periphery and in adjoining provinces that often lack adequate access to PT.

The results of this study provide preliminary insights for transport planners and policymakers on how MaaS can promote sustainable transport and are replicable in the context of comparable developing cities. We conclude that MaaS can be a potential strategy to tackle both mobility and environmental issues. In face of the diverse transport problems that developing cities such as MM are currently facing, we highlight the upmost importance of these preliminary findings.

In order to build a future with MaaS in developing countries where it can deliver on its full promises, we stress that comprehensive research is still very much needed. While our research gives initial insights about MaaS in developing countries, it is also meant to be as a door opener for additional research.

More attention on MaaS in the media landscape and additional pilots and trials in the region would contribute to the dissemination of the MaaS concept, which would facilitate a more profound investigation of MaaS adoption in developing countries. A larger and more representative sample is needed to obtain fully conclusive results. We recommend stated choice/preference experiments (as well as other suitable methods, see Table 2) to investigate the demand and the willingness to pay (WTP) for different mobility packages. As is crucial for quality forecasting, future research should also address the endogeneity problem and (if necessary) correct this possible bias – for example, using instrumental variable techniques.

As our sample is skewed towards rather young (20–39 years) and tech-savvy adults, the particular needs of children and teenagers (Casadó et al., 2020), elderly citizens (Mulley et al., 2020), and the lower-income groups merit additional attention. Considering that in social terms the current transport systems in many developing cities are disproportionately affecting lower income groups (Hickman et al., 2017), one of the most important research questions relate to how these groups (that often do not have access to the internet) can benefit from MaaS.

Other promising lines of future research relate to governance, the supply side, and how MaaS can be implemented in developing countries. In this context, scholars should identify suitable governance approaches, optimal business models, and necessary adaptations of the MaaS concept.

Finally, large-scale simulation studies that quantify MaaS-related benefits and costs (under different scenarios) could deliver additional knowledge to promote MaaS schemes in developing countries.

CRediT authorship contribution statement

Marc Hasselwander: Conceptualization, Methodology, Formal analysis, Writing – original draft. **Joao F. Bigotte:** Conceptualization, Methodology, Writing – original draft, Supervision. **Antonio P. Antunes:** Validation, Writing – review & editing. **Ricardo G.**

Sigua: Resources, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The research has been carried out under the framework of the doctoral thesis of the first author, funded by the Portuguese Foundation of Science and Technology (FCT) with research grant PD/BD/143184/2019 under the MIT Portugal Program. An early version has been selected as one of the top 12 submissions for the ITF/OECD Young Researcher of the Year Award. We acknowledge the evaluation feedback given which helped to improve this article. Findings from this research have also been presented at a special session on "MaaS in developing countries" at the 2021 ITS World Congress. The authors thank Michel Arnd and four reviewers for providing valuable comments on the manuscript as well as Raymark Lapitan Sebastian for designing the Manila MaaS graphic. The first author expresses his gratitude to Prof. Ricardo Sigua and the staff of UP-NCTS for hosting him for a research stay and supporting the realization of this work.

Appendix A. . MaaS in the grey literature: Overview of white papers and reports

Organization	Title	Year
Dutch Ministry of Infrastructure and Water Management	Blueprint for an Application Programming Interface (API): From Transport Operator to MaaS Provider	2019
Finnish Transport Agency FTIA	MaaS Services and Business Opportunities	2015
Transport Committee - UK Parliament	Mobility as a Service (Eighth Report of Session 2017–19)	2018
Urban Redevelopment Authority of Singapore URA	How Mobility-as-a-Service Will Change Urban Mobility	2019
Switzerland Federal Office of Transport BAV	Literaturrecherche Handlungsempfehlungen «Mobility as a Service (MaaS)» (*in German*)	2018
Accenture	MOBILITY AS A SERVICE: Mapping a route towards future success in the new automotive ecosystem	2018
Arcadis	Mobility as a Service: Navigating the challenges of a MaaS data sharing future	2018
Arup	The Future of Mobility and MaaS: Governance and Orchestration	2019
Atkins	Exploring Mobility as a Service	2016
Cisco Systems	Enabling MaaS Through a Distributed IoT Data Fabric, Fog Computing and Network Protocols.	2018
Cubic Transportation Systems	Mobility as a Service: Putting Transit Front and Center of the Conversation	2018
d-fine	Mobility-as-a-Service: Creating mobility platforms for tomorrow	2019
Deloitte	The rise of mobility as a service: Reshaping how urbanites get around	2017
Dornier Consulting	Mobility as a Service – Challenges and Opportunities for Airports	2017
KPMG	Reimagine Places: Mobility as a Service	2017
L.E.K. Consulting	Mobility as a Service: The next transport disruption.	2017
Lynxx	Mobility as a Service (Maas): Government, Provide the Right Rules for the Game!	2017
Juniper Research	Why Mobility-as-a-Service is the Future of City Transport	2018
Juniper Research/moovel	Exploring Mobility-as-a-Service (MaaS) – The New Era of Urban Mobility	2018
PhocusWire/ SilverRail	How Mobility as a Service is bringing rail to the forefront	2019
Teradata	Optimizing Mobility as a Service to Drive Smart City Initiatives: Leveraging Teradata for First-to-Last Mile Traveler Insights	2018
AARP Public Policy Institute	Universal Mobility as a Service: A Bold Vision for Harnessing the Opportunity of Disruption	2018
APTA – American Public Transportation Association	Being Mobility-as-a-Service (MaaS) Ready	2019
Austroads	Opportunities in Mobility as a Service (MaaS)	2019
Bitkom	White Paper MaaS – Mobility-as-a-Service: Chancen für Mobility-as-a-Service-Geschäftsmodelle (*in German*)	2018
Calypso	Ticketing for MaaS, best practices for durable systems	2019
CERRE – Centre on Regulation in Europe	Mobility as a Service (MaaS): A digital roadmap for public transport authorities	2021
EMTA – European Metropolitan Transport Authorities	Mobility as a Service: A perspective on MaaS from Europe's Transport Authorities	2019
ERTICO – ITS Europe	Mobility as a Service (MaaS) and Sustainable Urban Mobility Planning	2019
IET – Institution of Engineering and Technology	Could Mobility as a Service solve our transport problems?	2019
ITF/OECD	Pricing and Efficient Public Transport Supply in a Mobility as a Service Context (Discussion Paper)	2020
ITF/OECD	Integrating Public Transport into Mobility as a Service	2021
ITS AUSTRALIA	Mobility as a Service in Australia: Customer insights and opportunities	2018
NADTC – National Aging and Disability Transportation Center	Bringing Mobility as a Service to the United States: Accessibility Opportunities and Challenges	2017
Polis Network	Mobility as a Service: Implications for urban and regional transport	2017
Transport Data Initiative	Mobility as a Service (MaaS) for Local Authorities	2019
UITP	READY FOR MAAS? EASIER MOBILITY FOR CITIZENS AND BETTER DATA FOR CITIES	2019

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Organization	Title	Year
United Nations Economic Commission for Europe UNECE	Transport Trends and Economics 2018–2019: Mobility as a Service	2020
Urban Transport Group	MaaS MOVEMENT? – ISSUES AND OPTIONS ON MOBILITY AS A SERVICE FOR CITY REGION TRANSPORT AUTHORITIES	2019

References

Abad, R.P., Fillone, A.M., Banister, D., Hickman, R., Biona, J.B.M.M., 2019. Investigating the relationship between housing affordability and mobility in Metro Manila Philippines. *Philippine Transport. J.* 2 (1), 1–13.

Acheampong, R.A., Siiba, A., Okyere, D.K., Tuffour, J.P., 2020. Mobility-on-demand: An empirical study of internet-based ride-hailing adoption factors, travel characteristics and mode substitution effects. Transportation Research Part C: Emerging Technologies 115, 102638. https://doi.org/10.1016/j.trc.2020.102638.

Alonso-González, M.J., Hoogendoorn-Lanser, S., van Oort, N., Cats, O., Hoogendoorn, S., 2020. Drivers and barriers in adopting Mobility as a Service (MaaS)–A latent class cluster analysis of attitudes. Transportation Res. Part A: Policy Practice 132, 378–401. https://doi.org/10.1016/j.tra.2019.11.022.

Alvarez, R.M., Brehm, J., 1995. American ambivalence towards abortion policy: Development of a heteroskedastic probit model of competing values. Am. J. Political Sci. 39, 1055–1079. https://www.jstor.org/stable/2111669.

Ambrosino, G., Nelson, J.D., Boero, M., Pettinelli, I., 2016. Enabling intermodal urban transport through complementary services: From Flexible Mobility Services to the Shared Use Mobility Agency: Workshop 4. Developing inter-modal transport systems. Res. Transport. Economics 59, 179–184. https://doi.org/10.1016/j.retrec.2016.07.015.

Andong, R.F., Sajor, E., 2017. Urban sprawl, public transport, and increasing CO 2 emissions: The case of Metro Manila, Philippines. Environ. Dev. Sustain. 19 (1), 99–123. https://doi.org/10.1007/s10668-015-9729-8.

Asian Development Bank, 2019. Asian Development Outlook (ADO) 2019 Update: Fostering Growth and Inclusion in Asia's Cities. ADB, Mandaluyong City, Metro Manila. Available from https://doi.org/10.22617/FLS190445-3.

Banister, D., 2008. The sustainable mobility paradigm. Transp. Policy 15 (2), 73–80. https://doi.org/10.1016/j.tranpol.2007.10.005.

Barter, P.A., 2004. A Broad Perspective on Policy Integration for Low Emissions Urban Transport in Developing Asian Cities (Draft paper). International workshop Policy Integration towards Sustainable Energy Use for Asian Cities: Integrating Local Air Pollution and Greenhouse Gas Emissions Concerns. Institute for Global Environmental Strategies, Kanagawa.

Batalla, E.V.C., 2005. Metro Manila traffic regulation and the public bus industry. Asia-Pacific Soc. Sci. Rev. 5 (1), 69–82.

Becker, H., Balac, M., Ciari, F., Axhausen, K.W., 2020. Assessing the welfare impacts of Shared Mobility and Mobility as a Service (MaaS). Transport. Res. Part A: Policy Pract. 131, 228–243. https://doi.org/10.1016/j.tra.2019.09.027.

Ben-Akiva, M.E., Lerman, S.R., 1985. Discrete Choice Analysis: Theory and Application to Travel Demand. MIT Press, Cambridge (MA).

Boquet, Y., 2013. Battling congestion in Manila: the EDSA problem. Transport Commun. Bull. Asia Pacific 82, 45–59.

Bursac, Z., Gauss, C.H., Williams, D.K., Hosmer, D.W., 2008. Purposeful selection of variables in logistic regression. Source Code Biol. Med. 3 (1), 17. https://doi.org/10.1186/1751-0473-3-17.

Caiati, V., Rasouli, S., Timmermans, H., 2020. Bundling, pricing schemes and extra features preferences for mobility as a service: Sequential portfolio choice experiment. Transp. Res. Part A: Policy Pract. 131, 123–148. https://doi.org/10.1016/j.tra.2019.09.029.

Calderón, F., Miller, E.J., 2020. A literature review of mobility services: definitions, modelling state-of-the-art, and key considerations for a conceptual modelling framework. Trans. Rev. 40 (3), 312–332. https://doi.org/10.1080/01441647.2019.1704916.

Canitez, F., 2020. Transferring sustainable urban mobility policies: An institutional perspective. Transp. Policy 90, 1–12. https://doi.org/10.1016/j.tranpol.2020.02.005.

Casadó, R.G., Golightly, D., Laing, K., Palacin, R., Todd, L., 2020. Children, Young people and Mobility as a Service: Opportunities and barriers for future mobility. Transp. Res. Interdisciplinary Perspectives 4, 100107. https://doi.org/10.1016/j.trip.2020.100107.

Creutzig, F., Mühlhoff, R., Römer, J., 2012. Decarbonizing urban transport in European cities: four cases show possibly high co-benefits. Environ. Res. Lett. 7 (4), 044042. https://doi.org/10.1088/1748-9326/7/4/044042.

Dargay, J., Gately, D., 1999. Income's effect on car and vehicle ownership, worldwide: 1960–2015. Transp. Res. Part A: Policy Practice 33 (2), 101–138. https://doi.org/10.1016/S0965-8564(98)00026-3.

de Dios Ortuzar, J., Willumsen, L.G., 2011. Modelling transport. John Wiley & Sons, London.

Detter, H., 2015. Satisfying transportation needs in fast-growing metropolitan areas: mobility solutions for mega-cities in developing countries. OPEC Energy Rev. 39 (4), 418–444. https://doi.org/10.1111/opec.2015.39.issue-410.1111/opec.12068.

Djavadian, S., Chow, J.Y., 2017. An agent-based day-to-day adjustment process for modeling 'Mobility as a Service' with a two-sided flexible transport market. Transp. Res. Part B: Methodol. 104, 36–57. https://doi.org/10.1016/j.trb.2017.06.015.

Duan, Y., Fu, G., Zhou, N., Sun, X., Narendra, N.C., Hu, B., 2015. Everything as a service (XaaS) on the cloud: origins, current and future trends. IEEE, pp. 621–628.

Eckhardt, J., Nykänen, L., Aapaoja, A., Niemi, P., 2018. MaaS in rural areas - case Finland. Res. Transportation Business Management 27, 75–83. https://doi.org/10.1016/j.rtbm.2018.09.005.

Enoch, M. (2018). Mobility as a Service (MaaS) in the UK: change and its implications. London: Foresight, Government Office for Science, Future of Mobility: Evidence Review.

Fioreze, T., De Gruijter, M., Geurs, K., 2019. On the likelihood of using Mobility-as-a-Service: a case study on innovative mobility services among residents in the Netherlands. Case Studies Transport Policy 7 (4), 790–801. https://doi.org/10.1016/j.cstp.2019.08.002.

Franzen, A., Vogl, D., 2013. Two decades of measuring environmental attitudes: A comparative analysis of 33 countries. Global Environ. Change 23 (5), 1001–1008. https://doi.org/10.1016/j.gloenvcha.2013.03.009.

Geurs, K.T., Gkiotsalitis, K., Fioreze, T., Visser, G., Veenstra, M., 2018. The potential of a Mobility-as-a-Service platform in a depopulating area in the Netherlands: An exploration of small and big data. Academic Press, pp. 57–79.

Gillis, D., Semanjski, I., Lauwers, D., 2016. How to monitor sustainable mobility in cities? Literature review in the frame of creating a set of sustainable mobility indicators. Sustainability 8 (1), 29. https://doi.org/10.3390/su8010029.

Goldstein, H. (2014). Heteroscedasticity and complex variation. *Encyclopedia of Statistics in Behavioral Science*. Chichester, UK: JohnWiley&Sons. https://doi.org/10.1002/9781118445112.stat06249.

Grab (2019). 7 years of Grab in Southeast Asia: Grab announces significant milestones across its super app services. Available at https://www.grab.com/ph/press/business/7-years-of-grab-in-southeast-asia-grab-announces-significant-milestones-across-its-super-app-services/ Accessed: 19.11.2020.

Greene, D.L., Wegener, M., 1997. Sustainable transport. J. Transp. Geogr. 5 (3), 177–190. https://doi.org/10.1016/S0966-6923(97)00013-6.

Guevara, C.A., 2015. Critical assessment of five methods to correct for endogeneity in discrete-choice models. Transp. Res. Part A: Policy Practice 82, 240–254. https://doi.org/10.1016/j.tra.2015.10.005.

Guidon, Sergio, Wicki, Michael, Bernauer, Thomas, Axhausen, Kay, 2020. Transportation service bundling–for whose benefit? Consumer valuation of pure bundling in the passenger transportation market. Transp. Res. Part A: Policy Practice 131, 91–106. https://doi.org/10.1016/j.tra.2019.09.023.

Gwilliam, K., 2002. Cities on the move: A World Bank urban transport strategy review (Technical report). World Bank, Washington, DC.
Gwilliam, K., 2003. Urban transport in developing countries. Transport Rev. 23 (2), 197–216. https://doi.org/10.1080/01441640309893.
Hagedorn, G., Kalmus, P., Mann, M., Vicca, S., Van den Berge, J., van Ypersele, J.-P., Bourg, D., Rotmans, J., Kaaronen, R., Rahmstorf, S., Kromp-Kolb, H., Kirchengast, G., Knutti, R., Seneviratne, S.I., Thalmann, P., Cretney, R., Green, A., Anderson, K., Hedberg, M., et al., 2019. Concerns of young protesters are justified. Science 364, 139–140. https://doi.org/10.1126/science.aax3807.
Hasselwander, M., 2019. MaaS in Deutschland. *Internationales Verkehrswesen* 71 (2), 59.
Hasselwander, M., & Bigotte, J. F. (2021). Transport Authorities and Innovation: Understanding Barriers for MaaS Implementation in the Global South. *24th Euro Working Group on Transportation Meeting (EWGT 2021)*, Virtual Event.
Hasselwander, M., Bigotte, J.F., Fonseca, M., 2022. Understanding platform internationalisation to predict the diffusion of new mobility services. Res. Transp. Bus. Manage. In press.
Hasselwander, Marc, Tamagusko, Tiago, Bigotte, Joao F., Ferreira, Adelino, Mejia, Alvin, Ferranti, Emma J.S., 2021. Building back better: The COVID-19 pandemic and transport policy implications for a developing megacity. Sustainable Cities Soc. 69, 102864. https://doi.org/10.1016/j.scs.2021.102864.
Hayashi, Y., Doi, K., Yagishita, M., Kuwata, M., 2004. Urban transport sustainability: Asian trends, problems and policy practices. European J. Transp. Infrastructure Res. 4 (1), 27–45. https://doi.org/10.18757/ejtir.2004.4.1.4255.
Hickman, R., Cao, M., Mella Lira, B., Fillone, A., Bienvenido Biona, J., 2017. Understanding capabilities, functionings and travel in high and low income neighbourhoods in Manila. Social Inclusion 5 (4), 161–174. https://doi.org/10.17645/si.v5i4.1083.
Hietanen, S., 2014. 'Mobility as a Service' - the new transport model? Eurotransport 12 (2), 2–4.
Ho, C.Q., Hensher, D.A., Mulley, C., Wong, Y.Z., 2018. Potential uptake and willingness-to-pay for Mobility as a Service (MaaS): A stated choice study. Transp. Res. Part A: Policy Practice 117, 302–318. https://doi.org/10.1016/j.tra.2018.08.025.
Ho, Chinh Q., Mulley, Corinne, Hensher, David A., 2020. Public preferences for mobility as a service: Insights from stated preference surveys. Transp. Res. Part A: Policy Practice 131, 70–90. https://doi.org/10.1016/j.tra.2019.09.031.
Ilieva, J., Baron, S., Healey, N.M., 2002. Online surveys in marketing research: Pros and cons. Int. J. Market Res. 44 (3), 361–376. https://doi.org/10.1177/147078530204400303.
Institute for Economics and Peace, 2019. Global Peace Index 2019: Measuring Peace in a Complex World. IEP, Sydney.
International Energy Agency, 2019. Energy Efficiency 2019. IEA, Paris. Available from: https://www.iea.org/reports/energy-efficiency-2019.
IPCC, 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland, p. 151.
Japan International Cooperation Agency (JICA), 2015. The Project for Capacity development on Transportation Planning and Database Management in the Republic of the Philippines. Available from, MMUTIS Update and Enhancement Project (MUCEP) http://open_jicareport.jica.go.jp/pdf/12247615.pdf.
Jittrapirom, P., Caiati, V., Feneri, A.M., Ebrahimigharehbaghi, S., Alonso González, M.J., Narayan, J., 2017. Mobility as a service: A critical review of definitions, assessments of schemes, and key challenges. Urban Planning 2 (2), 13–25. https://doi.org/10.17645/up.v2i2.931.
Kamargianni, M., Li, W., Matyas, M., Schäfer, A., 2016. A critical review of new mobility services for urban transport. Transp. Res. Procedia 14, 3294–3303. https://doi.org/10.1016/j.trpro.2016.05.277.
Kamargianni, M., Yfantis, L., Muscat, J., Azevedo, C.M.L., Ben-Akiva, M., 2019. Incorporating the mobility as a service concept into transport modelling and simulation frameworks. Transp. Res. Board (TRB) 98th Annual Meeting.
Karlsson, I.M., Sochor, J., Strömberg, H., 2016. Developing the 'Service' in Mobility as a Service: experiences from a field trial of an innovative travel brokerage. Transp. Res. Procedia 14, 3265–3273. https://doi.org/10.1016/j.trpro.2016.05.273.
Khaimook, S., Yoh, K., Inoi, H., Doi, K., 2019. Mobility as a service for road traffic safety in a high use of motorcycle environment. IATSS Research 43 (4), 235–324. https://doi.org/10.1016/j.iatssr.2019.10.002.
Kleibert, J.M., 2018. Exclusive development (s): Special economic zones and enclave urbanism in the Philippines. Critical Sociol. 44 (3), 471–485 https://doi.org/10.1177%2F0896920517698538.
Kulp, S.A., Strauss, B.H., 2019. New elevation data triple estimates of global vulnerability to sea level rise and coastal flooding. Nat. Commun. 10 (1), 1–12. https://doi.org/10.1038/s41467-019-12808-z.
Kutzbach, M.J., 2009. Motorization in developing countries: Causes, consequences, and effectiveness of policy options. J. Urban Economics 65 (2), 154–166. https://doi.org/10.1016/j.jue.2008.10.002.
Lee, T.M., Markowitz, E.M., Howe, P.D., Ko, C.Y., Leiserowitz, A.A., 2015. Predictors of public climate change awareness and risk perception around the world. Nat. Clim. Change 5 (11), 1014–1020. https://doi.org/10.1038/nclimate2728.
Leibowicz, B.D., 2018. Policy recommendations for a transition to sustainable mobility based on historical diffusion dynamics of transport systems. Energy policy 119, 357–366. https://doi.org/10.1016/j.enpol.2018.04.066.
Lesteven, G., Samadzad, M., 2021. Ride-hailing, a new mode to commute? Evidence from Tehran Iran. *Travel Behaviour Soc.* 22, 175–185. https://doi.org/10.1016/j.tbs.2020.09.006.
Lindhjem, H., Navrud, S., 2011. Are Internet surveys an alternative to face-to-face interviews in contingent valuation? Ecol. Econ. 70 (9), 1628–1637. https://doi.org/10.1016/j.ecolecon.2011.04.002.
Marqués, R., Hernández-Herrador, V., Calvo-Salazar, M., García-Cebrián, J.A., 2015. How infrastructure can promote cycling in cities: Lessons from Seville. Res. Transport. Economics 53, 31–44. https://doi.org/10.1016/j.retrec.2015.10.017.
Matyas, M., Kamargianni, M., 2019. The potential of mobility as a service bundles as a mobility management tool. Transportation 46 (5), 1951–1968. https://doi.org/10.1007/s11116-018-9913-4.
Meerow, S., 2017. Double exposure, infrastructure planning, and urban climate resilience in coastal megacities: A case study of Manila. Environ. Planning A: Economy Space 49 (11), 2649–2672 https://doi.org/10.1177%2F0308518X17723630.
Megahed, Naglaa A., Ghoneim, Ehab M., 2020. Antivirus-built environment: Lessons learned from Covid-19 pandemic. Sustainable Cities Society 61, 102350. https://doi.org/10.1016/j.scs.2020.102350.
Mulley, Corinne, Ho, Chinh, Balbontin, Camila, Hensher, David, Stevens, Larissa, Nelson, John D., Wright, Steve, 2020. Mobility as a service in community transport in Australia: Can it provide a sustainable future? Transp. Res. Part A: Policy Practice 131, 107–122. https://doi.org/10.1016/j.tra.2019.04.001.
Nykvist, B., Whitmarsh, L., 2008. A multi-level analysis of sustainable mobility transitions: Niche development in the UK and Sweden. Technol. Forecast. Soc. Chang. 75 (9), 1373–1387. https://doi.org/10.1016/j.techfore.2008.05.006.
National Economic and Development Authority (NEDA), 2014. Available from Roadmap for Transport Infrastructure Development for Metro Manila and its Surrounding Areas (Region III and Region IV-A). http://www.neda.gov.ph/wp-content/uploads/2015/03/FR-SUMMARY.-12149597.pdf.
Oke, Jimi B, Aboutaleb, Youssef M, Akkinepally, Arun, Azevedo, Carlos Lima, Han, Yafei, Zegras, P Christopher, Ferreira, Joseph, Ben-Akiva, Moshe E, 2019. A novel global urban typology framework for sustainable mobility futures. Environ. Res. Lett. 14 (9), 095006. https://doi.org/10.1088/1748-9326/ab22c7.
Parady, Giancarlos, Ory, David, Walker, Joan, 2021. The overreliance on statistical goodness-of-fit and under-reliance on model validation in discrete choice models: A review of validation practices in the transportation academic literature. J. Choice Modelling 38, 100257. https://doi.org/10.1016/j.jocm.2020.100257.
Pojani, D., 2020. Sustainable Urban Transport in Southeast Asia: Making It Happen. In *Planning for Sustainable Urban Transport in Southeast Asia*. Springer, Cham, pp. 117–121.
Pojani, D., Stead, D., 2015. Sustainable urban transport in the developing world: beyond megacities. Sustainability 7 (6), 7784–7805. https://doi.org/10.3390/su7067784.
Priester, R., Kenworthy, J., Wulfhorst, G., 2013. The diversity of megacities worldwide: Challenges for the future of mobility. In: Megacity Mobility Culture. Springer, Berlin/Heidelberg, pp. 23–54.
Ramboll (2019). WHIMPACT: Insights from the world's first Mobility-as-a-Service (MaaS) system. Available from https://ramboll.com/-/media/files/rfi/publications/Ramboll_whimpact-2019.pdf.

Rayle, L., Dai, D., Chan, N., Cervero, R., Shaheen, S., 2016. Just a better taxi? A survey-based comparison of taxis, transit, and ridesourcing services in San Francisco. Transp. Policy 45, 168–178. https://doi.org/10.1016/j.tranpol.2015.10.004.

Reyes, J.A.L., 2014. Environmental attitudes and behaviors in the Philippines. J. Educational Soc. Res. 4 (6), 87. https://doi.org/10.5901/jesr.2014.v4n6p87.

Ripple, W.J., Wolf, C., Newsome, T.M., Barnard, P., Moomaw, W.R., 2019. World Scientists' Warning of a Climate Emergency. Bioscience. https://doi.org/10.1093/biosci/biz088.

Rith, Monorom, Fillone, Alexis, Biona, Jose Bienvenido M., 2019. The impact of socioeconomic characteristics and land use patterns on household vehicle ownership and energy consumption in an urban area with insufficient public transport service–A case study of metro Manila. J. Transp. Geogr. 79, 102484. https://doi.org/10.1016/j.jtrangeo.2019.102484.

Sharmeen, Fariya, Ghosh, Bipashyee, Mateo-Babiano, Iderlina, 2021. Policy, users and discourses: Examples from bikeshare programs in (Kolkata) India and (Manila) Philippines. J. Transp. Geogr. 90, 102898. https://doi.org/10.1016/j.jtrangeo.2020.102898.

Schikofsky, J., Dannewald, T., Kowald, M., 2019. Exploring motivational mechanisms behind the intention to adopt mobility as a service (MaaS): Insights from Germany. Transp. Res. Part A: Policy Practice 131, 296–312. https://doi.org/10.1016/j.tra.2019.09.022.

Signorile, P., Larosa, V., Spiru, A., 2018. Mobility as a service: A new model for sustainable mobility in tourism. Worldwide Hospitality Tourism Themes 10 (2), 185–200. https://doi.org/10.1108/WHATT-12-2017-0083.

Singh, M., 2019. India's shift from mass transit to MaaS transit: Insights from Kochi. Transp. Res. Part A: Policy Practice 131, 219–227. https://doi.org/10.1016/j.tra.2019.09.037.

Smith, Göran, Sochor, Jana, Karlsson, I.C. MariAnne, 2018. Mobility as a Service: Development scenarios and implications for public transport. Res. Transp. Economics 69, 592–599.

Sochor, J., Karlsson, I.M., Strömberg, H., 2016. Trying out mobility as a service: Experiences from a field trial and implications for understanding demand. Transp. Res. Rec. 2542 (1), 57–64 https://doi.org/10.3141%2F2542-07.

Sochor, J., Arby, H., Karlsson, I.M., Sarasini, S., 2018. A topological approach to Mobility as a Service: A proposed tool for understanding requirements and effects, and for aiding the integration of societal goals. Res. Transp. Business Manage. 27, 3–14. https://doi.org/10.1016/j.rtbm.2018.12.003.

Suatmadi, Anissa Yuniashaesa, Creutzig, Felix, Otto, Ilona M., 2019. On-demand motorcycle taxis improve mobility, not sustainability. Case Studies Transp. Policy 7 (2), 218–229.

Sun, B., Morwitz, V.G., 2010. Stated intentions and purchase behavior: A unified model. Int. J. Res. Mark. 27 (4), 356–366. https://doi.org/10.1016/j.ijresmar.2010.06.001.

Sunio, V., Gaspay, S., Guillen, M.D., Mariano, P., Mora, R., 2019. Analysis of the public transport modernization via system reconfiguration: The ongoing case in the Philippines. Transp. Res. Part A: Policy Practice 130, 1–19. https://doi.org/10.1016/j.tra.2019.09.004.

Tirachini, Alejandro, 2020. Ride-hailing, travel behaviour and sustainable mobility: an international review. Transportation 47 (4), 2011–2047. https://doi.org/10.1007/s11116-019-10070-2.

TomTom (2020). Traffic Index 2019. Available from https://www.tomtom.com/en_gb/traffic-index/ranking/ Accessed 14.02.2020.

Train, K.E., 2009. Discrete choice methods with simulation. Cambridge University Press.

Utriainen, R., Pöllänen, M., 2018. Review on mobility as a service in scientific publications. Res. Transp. Business Management 27, 15–23. https://doi.org/10.1016/j.rtbm.2018.10.005.

Vance, C., Peistrup, M., 2012. She's got a ticket to ride: gender and public transit passes. Transportation 39 (6), 1105–1119. https://doi.org/10.1007/s11116-011-9381-6.

Wright, L., Fulton, L., 2005. Climate change mitigation and transport in developing nations. Transp. Rev. 25 (6), 691–717. https://doi.org/10.1080/01441640500360951.

Wynes, Seth, Nicholas, Kimberly A, 2017. The climate mitigation gap: education and government recommendations miss the most effective individual actions. Environ. Res. Lett. 12 (7), 074024. https://doi.org/10.1088/1748-9326/aa7541.

Yuana, S.L., Sengers, F., Boon, W., Raven, R., 2019. Framing the sharing economy: A media analysis of ridesharing platforms in Indonesia and the Philippines. J. Cleaner Prod. 212, 1154–1165. https://doi.org/10.1016/j.jclepro.2018.12.073.