Economic Commission for Europe

Inland Transport Committee

Working Party on Transport Trends and Economics

Thirty-first session
Geneva, 2–4 September 2019
Item 11 (a) of the provisional agenda
Review of the transport situation, transport trends and economics in ECE region:
Transport Trends and Economics 2018–2019: Mobility as a Service

Mobility as a Service

Note by the secretariat

Background

This document contains an advance version of a paper on Mobility as a Service. The Working Party is invited to review this paper and to provide its comments and suggestions. The Working Party may wish to request the authors to finalise the paper in view of comments made.

This MaaS paper was prepared by:

Dimitris Dimitriou (University of Thrace) – parts of Chapter 1

Athena Roumboutsos (Prof., Dr., Dipl. Eng.), together with Amalia Polydoropoulou (Prof., Dr., Dipl. Eng.), Ioanna Pagoni (Dr., Dipl. Eng.), and Athena Tsirimpa (Dr.) (University of the Aegean, Greece) – parts of Chapters 1 and Chapter 5

Stefanie Pichler (Fluidtime) – parts of Chapter 1 and Chapter 2

Juhi Verma and Dr Claire Gregory with the team of Department for Transport (Department for Transport, United Kingdom of Great Britain and Northern Ireland) – Chapter 3

Manuel Marsilio (CONEBI and WBIA) – Chapter 4

Andrzej Maciejewski – Chapter 6

This paper was developed under coordination of Lukasz Wyrowski and Konstantinos Alexopoulos (ECE), who also prepared Chapter 7.

Chapter 1

Mobility as a Service: concept, objectives, actors, models and development

1.1 Introduction

Mobility as a Service (MaaS) is a new mobility concept gaining pace in many cities around the world. Its value proposition concerns integration of mobility services which is realized by providing trip planning and one-stop fare purchase for the user through a single platform.

Since MaaS is only emerging, the analysis of real-life demonstrations is still limited and, thus, evidence on the potential benefits of MaaS implementation is scarce and fragmented. However, there is a growing amount of literature which documents that MaaS is a promising mobility concept and it is expected to deliver several economic, societal, transport-related and environmental benefits.

Three groups of stakeholders are expected to benefit from MaaS (Hietanen, 2014), namely: end users (travellers), businesses and the public sector.

Travellers may benefit from seamless, easy-accessed, high-quality and value-for-money mobility. In addition, if both public and private transport operators/providers join a MaaS scheme, then there is potential to provide customised mobility options and better accessibility to people with disabilities or reduced mobility.

Businesses identify new markets and new business opportunities, while active transport operators may ensure cost reduction in individual operations.

The public sector, with the implementation of MaaS may expect the creation of new jobs, resource allocation efficiency and improvement in transport system reliability. Also, environmental and societal benefits are feasible (Polis, 2017), should MaaS be designed so as to promote low energy consumption and environmentally friendly mobility solutions. Finally, reduced dependence on private vehicles has been documented as a potential benefit of MaaS (Cole, 2018).

1.2 Definitions

As an emerging concept, MaaS has been widely debated by researchers but a unique definition for MaaS is still pending. Most consider as key feature the potential to deliver integrated mobility to enable end-to-end trips by offering services combining different transport modes provided by different transport service providers under a single platform and a single service provider for trip planning, scheduling, ticketing and payment. This reflects the first comprehensive definition of MaaS "a mobility distribution model in which a customer's major transportation needs are met over one interface and are offered by a service provider" (Hietanen, 2014).

Later, Kamargianni and Matyas (2017) and MaaSLab (2018) describe MaaS as "a user-centric, intelligent mobility management and distribution system, in which an integrator brings together offerings of multiple mobility service providers and provides end-users access to them through a digital interface, allowing them to seamlessly plan and pay for mobility". Depending on the feature of MaaS considered most important, researchers focus on customization and user-centric features of MaaS (Jittrapirom et al., 2017; König et al., 2016), or envision MaaS as an opportunity to deliver a more sustainable transport system by the reduction of private car usage and the use of electric vehicles (Gould et al., 2015; König et al., 2016).

This paper adopts a broad definition of MaaS as *a user-centric transportation management system, using intelligent mobility distribution systems and IoT applications, in which all transport modes service operators and infrastructure providers are connected under a single platform, which supplies mobility options to travellers providing real time traffic*

information, service conditions and operator arrangements, and delivering on-line ticketing and payment options.

1.3   MaaS objectives and Target Groups

Hence, as promoted in the definition of MaaS, there are four key objectives of the development of MaaS as transportation system:

- Seamless and efficient flow of information, goods, and people both locally and on long distances;

- Globally scalable door-to-door mobility services without using a private car;

- A better level of service than the private car; and

- An open ecosystem for information and services in intelligent transportation.

MaaS can be established for specific target groups. MaaS can thus respond to different mobility demands providing different mobility solutions. Among them:

(a)   Business-to-customer (B2C) solution – MaaS is designed for travellers being commuters and residents of cities and region to meet their mobility needs, such as seamless travel from A to B, easy booking and payment for all integrated services and saving of either money or time while traveling on the modes recommended through the MaaS platform.

(b)   Business-to-employee (B2E) solution – MaaS is designed to serve employees of an enterprise taking their expectations and preferences into account while reducing the costs of employee's mobility.

(c)   Business-to-business (B2B) solution – MaaS is designed to combine various mobility service operators/providers with various MaaS providers to create a networking platform aimed at fostering MaaS in general.

1.4   MaaS typology

Notably, the definition of MaaS as well as its objectives suggests that its various features may be achieved at various levels, which imply a progression or advancement in goals. To this end, Sochor et al (2017) have developed a typology that distinguishes four stages of MaaS integration, and a basic step of no integration.

Stage Zero: There is no MaaS integration. Separate services are provided for different means of transport. A traveller must access various websites, apps or interfaces to plan and pay for an A-to-B trip that consists of multiple segments and modes.

Stage One: There is a loose integration of information into one interface (one-call/one-click centres or information apps). There are several examples of one-call/one-click sites to explore, many of which were developed by the local transport authorities. State one integration facilitates the traveller's decision for selecting the route and the mode of transport for a trip at a specific time of day.

Stage Two: It builds upon the information aggregators (platforms) by allowing travellers to find, book and pay for their trip without having to navigate away from the platform. In this stage, travellers are able to pay for their A-to-B trips that use services from multiple operators with just one ticket or pass.

Germany's moovel or moovit, for example, have introduced multimodal ticketing in multiple cities, and continue to grow their offerings across the continent. For example, moovel's customers can now book and pay for a train ride on Deutsche Bahn, Germany's national train service, and then cover the last stretch of their trip with car-sharing or bike-sharing.

Stage Three: It builds upon Stage Two integration, adding a layer of service through bundling. Travellers can still choose to pay per single trip, just as in Stage Two, but they also have the option to purchase a subscription to different packages of services, offered at

different price levels depending on what is included in the package. At this stage, travellers can purchase packages for a defined amount of travel with selected transport modes.

Whim's app in Helsinki, for example, includes two subscription levels which show the range of what can be offered: €49 per month buys unlimited transit use, and discounted taxi rides, car rentals, and bikesharing trips within the city, whereas €499 per month allows unlimited use on all modes. (Whim compares the cost of this unlimited package to the cost of owning a car, but with far more options than traditional car ownership provides). With UbiGo, a subscription-based MaaS service in Stockholm, the focus is on mobility packages that can be shared between family members.

The up-front payment model versus a pay-as-you-go model, makes it even easier for people to make decisions to use alternatives to private car since the only thing one has to do is "unlock" their trip with a ticket or app. In this way, people are incentivized to use the modes that they have already paid for. In addition, the true cost of moving around is made more visible to travellers and helps them to compare the value of what they have purchased with other options, such as car ownership.

Stage Four: This stage goes beyond the link between supply and demand for mobility. MaaS role is to correct transport issues, enhance the exchange of transport services and reach the mobility-related, economic or societal goals the city or region has. This stage requires the involvement of public authorities of cities and regions in a MaaS scheme.

This stage of MaaS remains theoretical for the most part, with few if any examples. At January's 2018 TransportationCamp DC in Arlington, Virginia, Jim Baker of the California Integrated Travel Program introduced a program in which California's Department of Transportation (CalTrans) aims to integrate travel planning and fare payment across as many modes and providers as possible in the state. When the program fully forms, travellers should be able to figure out their travel from one end of the state to the other using one interface and making one payment.

1.5 Understanding the MaaS innovation

MaaS bears the characteristics of an innovation that could be disruptive, as defined by Christensen et al. (1997, 2015), or destructive, as defined by Schumpeter (1942/ 2010). More specifically, MaaS could develop addressing a niche market (disruptive innovation) or produce a radical change of the mobility concept (modus operandi – creative destruction) depending on the existing urban mobility market and user characteristics.

As already stated, the key value proposed by MaaS is the integration of mobility services by providing seamless trip planning and one-stop fare purchase for the user through a single platform. Should the urban transit system (UTS) be characterized by a high level of integration (fare, schedule, information etc.), then MaaS might have little added value, if at all, for the UTS user within this system. It does, however, provide an alternative to the non-UTS user, who might prefer to exchange the private car with other personalized mobility schemes within the city limits or the UTS user addressing gaps in the UTS through personalized mobility schemes. In this case, MaaS could represent a disruptive innovation taking advantage of a niche in the market (Christensen et al., 1997). Of course, a highly integrated UTS is the outcome of a highly regulated urban transit market.

On the other end of the spectrum, a highly deregulated market faces issues of transport integration. In this case, MaaS allows users to fully appreciate urban transit services and, also, potentially exploit more personalized mobility options addressing fragmentation. Younger generations, environmentally sensitive users, and people who choose to live in cities rather than the traditionally suburban areas are expected to combine public transit with the many new transport service provisions that have entered the market, such as bike-sharing, car-sharing and ride sharing. There are studies predicting a favourable evolution in this direction, particularly in high income countries (Gao et al.,2016). The millennial generation appears to have a different cultural view of personal car ownership and increased use of virtual media (on-line shopping, social media) (Mulley, 2017; Klein and Smart, 2017). Owning a car might no longer be a "must have" lifestyle choice. In this case, a creative

destruction is anticipated as the traditional modus operandi is expected to be replaced by a totally different one. Experts agree that the younger generations will be the early adopters of the MaaS innovation (Jittrapirom et al, 2018).

The above line of thinking suggests a continuum between a fully regulated and fully deregulated UTS. In fact, regulatory reform of urban public transport has been a major world trend, due to concerns about the economic performance of public transport. Escalating government public transport subsidies have driven many governments to explore private operation or involvement in the management of UTS (Currie, 2016). However, while these reforms have not always resulted in the anticipated economic savings, in some countries they resulted in more fragmented transport operations (O'Sullivan and Patel, 2004; Van de Veldeand and Wallis, 2013) requiring state/public authority interventions. Therefore, even in highly deregulated public transport environments, the public regulator is still present (Currie et al., 2018). Furthermore, there is considerable evidence (Standing et al., 2018) that (over)-regulation is a key barrier in the development of shared transportation services or the introduction of the "Fifth Mode" as MaaS was initially described (Schade et al., 2014).

Hence, formal institutions and regulation will define the innovation type (disruptive vs destructive) and its potential evolution based on emerging governance (regulated/deregulated market) and the business models.

1.6   MaaS actors, enablers and challenges

Among the key actors are:

- MaaS operator/provider: It is an entity managing the MaaS platform through which it faces the mobility user (traveller) to whom the mobility service is sold.

- Public and private transport/mobility service operators/providers: These are operators of the physical transport service such as for example public transport, car-sharing, taxi or demand responsive transport but also parking operators. Polydoropoulou et al. (2019), who examined the importance of several stakeholders in the deployment of MaaS in three European regions, concluded that the mobility service operators/providers tend to be regarded as the most important actors in MaaS; especially the public transport operators (i.e. bus, metro, tram, rail).

- Public authorities: These are city, state government or public transport authorities responsible for transportation in a city or region. With the interests of public authorities in MaaS, public authorities may join a MaaS scheme as a partner to a MaaS partnership. They may initiate such partnership bringing and incentivizing various partners to work together. They may however only orchestrate MaaS through rules and regulations for transport and mobility market. In this case, the emphasis is on policy intervention, where public authorities set the conditions and orchestrate MaaS to correct transport issues, enhance the exchange of transport services and reach the mobility-related, economic or societal goals the city or region has. Such orchestration may be important, as MaaS innovation might bring disruptive changes to urban mobility, which, if simply left to market forces, may not bring the expected benefits for all.

Other actors, who support or enable MaaS, hence act as Enablers, are:

- Data providers;
- IT companies;
- Ticketing and payment service providers;
- Telecommunication companies;
- Financing companies and/or investors.

Considering the working definition adopted in this document, there have been advances in intelligent systems, the internet of things, cloud technology and big data management

enabling the vision of MaaS and also introducing new actors into the transportation market or giving them new roles.

More specifically, MaaS requires a unique platform to integrate the mobility and other services facilitating for travellers to plan and purchase their trips. The platform is a digital MaaS enabler. Chapter 2 discusses what this digital platform is, what functionalities it needs to provide, which are the challenges in developing the platform and what advantages it offers. It also provides case studies on MaaS development in two cities with focus on the creation of a MaaS unique platform.

MaaS also requires the provision of various mobility services in addition to public transport so that travellers find the most suitable, when necessary multimodal, mobility service at a right price for their A-to-B trips. In this multimodal service cars will continue to be important means for addressing mobility needs. They may offer the best overall value on certain legs of trips or for specific trips. Such value may be maximised when a traveller has the possibility to use a car in such situations without owning it. Chapter 3 of this paper speaks about car-sharing, its models, business case, good practices and challenges and trends. It alludes how car-sharing can become an important component of MaaS.

Like cars, bicycles will continue, and may even gain on importance as means for addressing mobility needs. Bicycles may offer the best overall value on certain legs of trips or for specific trips. This value can be further maximised when the traveller can use a bike-sharing service. Chapter 4 of this paper speaks about bike-sharing, its models, business case, good practices and challenges and trends. It alludes how bike-sharing can become an important component of MaaS and foster the mobility of tomorrow.

The MaaS development depends then on creation of conditions allowing for mobility service innovation, favouring integration and preventing fragmentation of mobility services and creation of transparent and fair transport and mobility markets. These conditions should also allow to embrace benefits from sharing economy by all as well as to offer framework for the development and financing of an appropriate transport infrastructure.

The MaaS innovation is not only about benefits. Form a perspective of a potential MaaS actor, especially MaaS provider and mobility service operators/providers, there are also costs and risks that need to be carefully considered. These costs and risks are related to integration and complexity of coordination also in the context of local transport market regulations. They are linked to service deployment and market uptake. They create the revenue challenge and revenue allocation challenge. Chapter 5 discusses the various transport market regulations, costs and risks and the revenue challenges in more detail.

The MaaS innovation is taking place on transport infrastructure that for many years has been developed with the focus on facilitating travel by a private car. Moreover, a great source for financing infrastructure has been from the taxes and fees imposed on the travel by private car. If MaaS innovation is to progress, the development and financing of transport infrastructure of today and tomorrow need to be addressed differently. Chapter 6 therefore discusses [work in progress]

Chapter2

Digital enablers of Mobility as a Service

2.1 Digital mobility platform and its functionalities

MaaS requires a unique platform, as MaaS digital enabler, to integrate the mobility and other services facilitating for travellers to plan and purchase their trips. The platform offers uniform and standardized access to the products and services from all mobility service operators/providers integrated in it. In effect, the platform plays a role of standardization layer for MaaS. It harmonizes data from various mobility service operators/providers.

The MaaS platform delivers four main functionalities, relevant for MaaS Stage 2 and above:

    (a)   information and availability

    (b)   routing

    (c)   booking, ticketing and payment, and

    (d)   reporting.

2.1.1 Information and availability

MaaS platforms provide static and dynamic data to travellers. Static data includes, for example, public transport lines and stations, public transport schedules, location data including points of interests (POI), be it parking, charging station, taxi ranks, etc.. Dynamic data includes, for example, availability of shared vehicles, pricing schemes, real-time traffic information, etc..

This functionality is intended to provide travellers with all the necessary information and the availability of the means of transport to plan their journey. Table 2.1 contains the information on different modes of transport processed by the MaaS platform:

Tables 2.1
Information and service availability in the MaaS platform from different mobility service providers and other providers

Mode of transportation	Information
General data	Third-party information about services with locations
Car/Bike/Scooter Sharing	Location, vehicle information (type, engine, fuel/ charge state), station details, availability, price schemes
Public Transport	Routes, trips, stops, arrival and departure times, service intervals, real-time incidents and delays, tickets,
Ride Sharing	Locations, vehicle and driver info, price schemes
Ride Hailing	Locations, vehicle and driver info, price schemes
Car/Bike/ Scooter Renting	Locations, hours, available vehicles, additional info (e.g. pricing, insurance)
Taxis	Locations, vehicle and driver info, pick-up and arrival times, price schemes

Mode of transportation	*Information*
Demand-Responsive Transport (DRT)	Locations, vehicle and driver info, pick-up and arrival time, price schemes
Parking & Charging	Car and parking lot location, capacity, availability, price schemes

Source: Fluidtime 2018

The information is provided by each mobility service operator/provider participating in the mobility ecosystem and integrated within the MaaS platform Typically, it is imported into the MaaS digital platform via technical interfaces (APIs). At the same time, import of data can be quite challenging and lead to costs. This can be caused by insufficient or incomplete APIs or invalid certificates, which needs to be fixed before data import.

Generally, the more the data environment is heterogenic, i.e. there is a multitude of interfaces with different data standards, technologies and supporting capabilities, the more costly it becomes to integrate the data into the MaaS platform. Experience shows that depending on mobility service operators/providers' existing systems and their specification, costs for integration can range between Euro three- to five-figure numbers.

In addition it should be evoked that before it comes to the data import, a considerable amount of work is usually put into negotiating terms and conditions of MaaS cooperation, for example, between the platform operator and the mobility service providers, and before that, depending on the business model, the investment to convince a critical number of on mobility service operators/providers to join or partner in the MaaS scheme, so as to make the mobility service offering in that MaaS interesting to travellers.

2.1.2   Routing

The MaaS platform enables the calculation of intermodal and multimodal travel routes via external routing providers tailored to specific modes of transport. The platform will propose routes with the most suitable combination – as per the traveller's preferences – of modes from different mobility service operators/providers to be used for the trip, even if each of the modes could be used for the full trip (see Figure 2.1.a). The platform can also combine modes operating in different zones (see Figure 2.1.b)

Figure 2.1
Different forms of intermodal routing (a) within the same zone, and (b) across different zones.

Source: Fluidtime 2018

Table 2.2 provides an overview of routing data used in MaaS platform.

Tables 2.2
Routing data used in the MaaS platform

Mode of transportation	Routing
General data	Third-party info such as weather, traffic, etc. comprised in route results
Car/Bike/Scooter Sharing	Sharing options are considered in route results, i.e. walk to bike sharing station
Public Transport	Routing information (routing & monitor service), trips, stops
Ride Sharing	Pick-up and arrival times
Ride Hailing	Pick-up and arrival times
Car/Bike/ Scooter Renting	Routing based on these transport modalities
Taxis	Pick-up and arrival times
Demand-Responsive Transport (DRT)	Vehicle, driver and pickup point are route-specific
Parking & Charging	Lot location is considered for routing, i.e. walk to the car park

Source: Fluidtime 2018

2.1.3 Booking, ticketing and payment

The MaaS platform enables the booking of different mobility services, choosing from various offers, through one single sales channel. For this purpose, the platform uses various booking workflows, in particular route- and product-related booking.

Bookings are performed through the standardized APIs, which allows full integration of products and services from mobility service operators/providers. A product-catalogue can be put together and consolidated across all mobility service operators/providers.

Four types of products are supported by the platform, namely:

- Vehicle-based: car-/bike-/scooter- sharing/rental, etc.
- •   Route-based: taxi, hailing, DRT, public transport, etc.
- Tickets: public transport, etc.
- Parking and charging services

Table 2.3 provides an overview of operations and information related to booking in MaaS platform.

Tables 2.3
Operations and information related to booking in the MaaS platform

Mode of transportation	Booking
General data	-
Car/Bike/Scooter Sharing	Booking, cancellation, access service (to unlock a vehicle), tariff scheme, pricing
Public Transport	Booking/ ticketing (reservation and cancellation), tariff schemes, lists of provided tickets

Mode of transportation	Booking
Ride Sharing	Booking, cancellation, tariff scheme, pricing, booking info
Ride Hailing	Booking, cancellation, tariff scheme, pricing, booking info
Car/Bike/ Scooter Renting	Booking, cancellation, tariff scheme, pricing, booking info
Taxis	Booking, cancellation, tariff scheme, pricing, booking info
Demand-Responsive Transport (DRT)	Booking, cancellation, tariff scheme, pricing info
Parking & Charging	Booking, cancellation, tariff schemes, pricing

Source: Fluidtime 2017

The MaaS platform permits booking cancellation. A request for cancellation is forwarded to mobility service operator/provider. A refund is done in accordance with the rules and conditions for refund and cancellation fees. Existing bookings as well as boking history are listed and managed via the mobility platform's back office. To ensure that bookings are always up to date, the booking details are retrieved from the database and synchronized with the system of the mobility service operator/provider.

The platform's pricing engine makes it possible to create new prices for mobility services and products. Such a price can be based on the price provided by the mobility service operator/provider, including mark-ups and deductions, or result from an individual price calculation, e.g. a new calculated price, based on product-related attributes such as duration, length or service category.

For ticketing, the MaaS platform uses ticketing APIs which enable integration with existing ticketing solutions from the mobility service operator/provider or new ticketing solutions are developed and integrated. NFC, QR validation codes and other validation features are supported by the MaaS platform

Depending on the data availability from the MaaS integrated mobility service operators/providers and the degree to which they meet the technological requirements, a MaaS provider can choose from different extension depths for its MaaS platform, which vary specifically in the different payment modalities.

(a) Information and routing: On this basic level, no payment option is available. The MaaS platform lists locations, products and offerings of mobility service operators/providers. For example, the locations of free-floating shared cars are available. Locations and services are used for creating intermodal routes. For example, upon sending a routing request, the mobility customer receives an intermodal route using the shared cars combined with other transport means.

(b) Direct booking and payment: mobility offer can be booked from the options listed through routing. The payment is made directly to mobility service operator/provider.

(c) Pay-as-you-go: mobility service is paid on the go by the traveller. The traveller is charged a one-time payment on the go e.g. when unlocking the shared car booked for the trip.

(d) Account-based billing and payment: mobility offers are paid through bills coming at pre-determined time intervals to the traveller. For example, the traveller gets a monthly invoice for all the free-floating car sharing services she/he used in a month. Such invoice can also comprise the amount due for other mobility services used during that month.

(e)   Subscription-based billing and payment: subscriptions and mobility packages from mobility service operators/provider are made available on the MaaS platform. For example, the traveller can purchase a 10-hour car sharing package to be used in a specific time period.

The payment option levels build on each other, i.e. pay-as-you-go is only possible if direct booking is also enabled by the mobility service operators/provider.

Ideally, each mobility service operators/provider should offer deep integration levels.

. 2.1.4 Reporting

The MaaS platform enables comprehensive reporting. Its logging and reporting framework allow tracking all data it handles, e.g. mobility service data, processing and enrichment of mobility information, transactions, bookings, traveller's behaviour etc. This includes all information regarding requests, bookings and transactions it processes. A dashboard for the most relevant KPIs together with charts and diagrams support facilitates data comprehension and analysis.

Moreover, all data can be exported to allow further processing and in-depth analysis by partners (e.g. investors, cooperation partners, public authorities) or integration into existing analytics and business intelligence services. Both real time and historical analyses can be conducted, since all data flowing through the platform is logged. In addition, all demand and supply related data, including a traveller's full routing, booking and service history as well as provided services from mobility service operators/provider for the individual requests are logged. This complete base of information allows the creation of any demand/supply reports. As an example, KPIs such as those presented in Figure 2.2 for the MaaS service UbiGo – see also case study 2.3.1 – can be established.

Figure 2.2
Reporting options
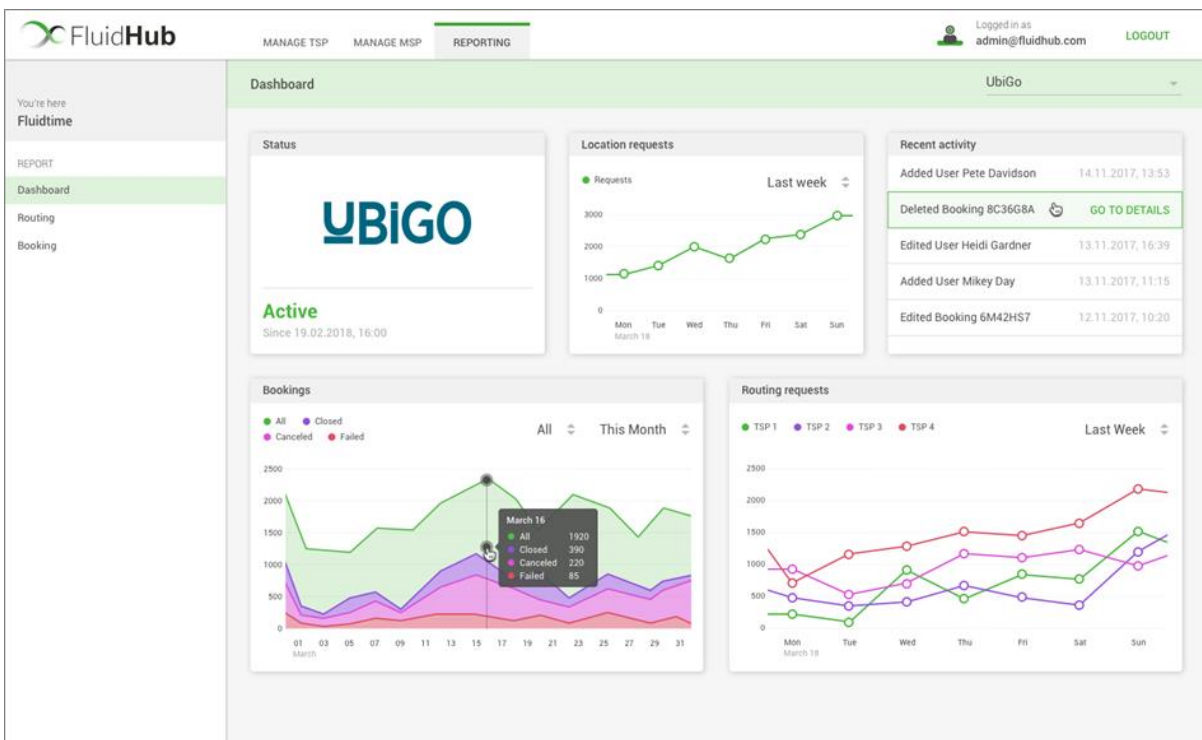
Source: Fluidtime 2018

2.2 Advantages from a MaaS platform

The MaaS platform, thanks to its functionalities, offers various advantages to its users (travellers) but also to MaaS actors.

The reporting functionality offers analytical information that can be useful to mobility service operator/provider to further adjust its mobility products and services. The public authorities can better understand mobility patterns and further facilitate or reverse them depending on mobility goals set for a region or area.

Mobility service operator/provider is visible on a MaaS platform (information and availability functionality), and depending on the scope of its operation, can be available to multiple MaaS providers. MaaS platforms thus promote mobility service operator/providers' products and services, which may help them to reach out to new customers and target groups (e.g. in new geographical zones).

Presence in one MaaS scheme would allow mobility service operator/provider to faster integrate in a new MaaS, thus would help save on integration costs.

Travellers benefit from tailored-made offers based on their preferences for high-quality and value-for-money mobility compared to owning and using a private vehicle.

Moreover, MaaS can be seen not only as bridging the gap between mobility service operators/providers in the same city, but also between different cities and initiate the idea of "roaming" in the transport sector. (Kamargianni/Matyas 2017).

Figure 2.3
The Role of MaaS providers
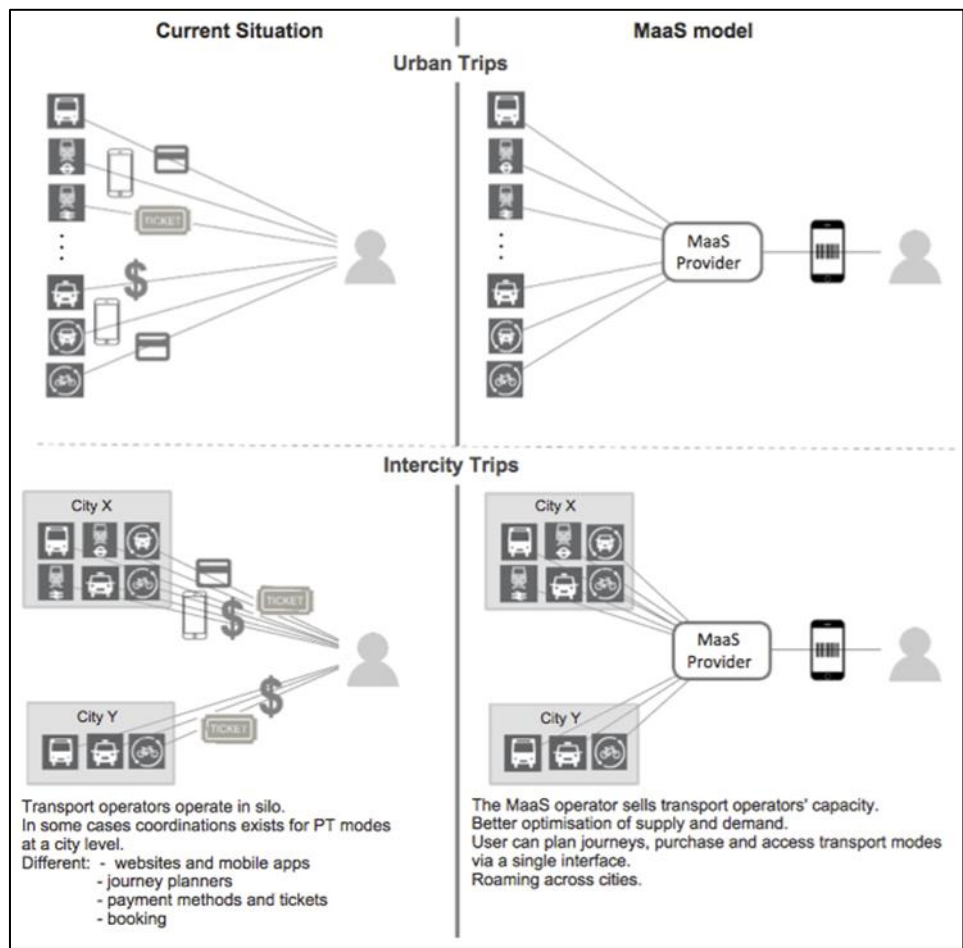
Source (Kamargianni/Matyas 2017)

Should MaaS platform integrate mobility offers going beyond one city (as shown in Figure 2.3), ie. include intercity trip options and trips in other cities, the traveller would be in position to use the same MaaS platform to travel in multiple cities or between them. At the same time, monopolies should be prevented.

2.3 Case studies

2.3.1 Stockholm

A B2C MaaS solution called UbiGo has been launched in Stockholm to provide Stockholmers with a true MaaS experience for their daily travel. This MaaS solution combines public transport, car-sharing, rental car services and taxi to one intermodal on-demand mobility service. It is based on a flexible monthly subscription for mobility. The mobility subscription can be shared within the family. For example, parents can choose to share bike sharing points with their children but decide to limit taxi points. Each month a new mobility budget can be selected to suit arising mobility needs. The larger the chosen package, the lower the basic price per hour for rental cars. If points have not been used at the end of the month, they can be taken into the following month. If all points have been used before the end of the month, mobility offers can still be used at the normal rate and the booked trips are listed in addition on a monthly invoice.

Figure 2.4
UbiGo – Profile, Balance, Subscription and Mobility packages
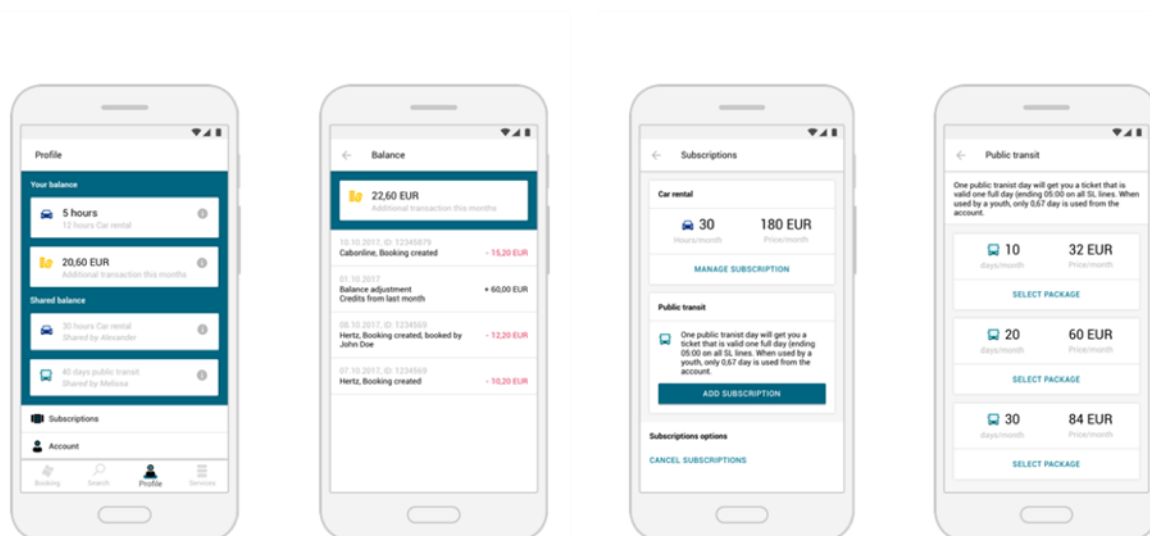
Source: Fluidtime, 2018

As a digital MaaS enabler within this project, the Austrian IT company Fluidtime Data Services GmbH offered its complete technology service stack including frontend (profile, balance, subscription and mobility packages – see Figure 2.4) for the travellers, its platform technology FluidHub for the standardization of the integration process and simplification of the data management as well as the commercial back office for the administration of accounts, subscriptions and associated payments (see Figure 2.5). UbiGo thus benefited from the full integration with multiple mobility service providers and was able to profit from a quick time to market and a carefree rollout.

Figure 2.5
UbiGo Back office
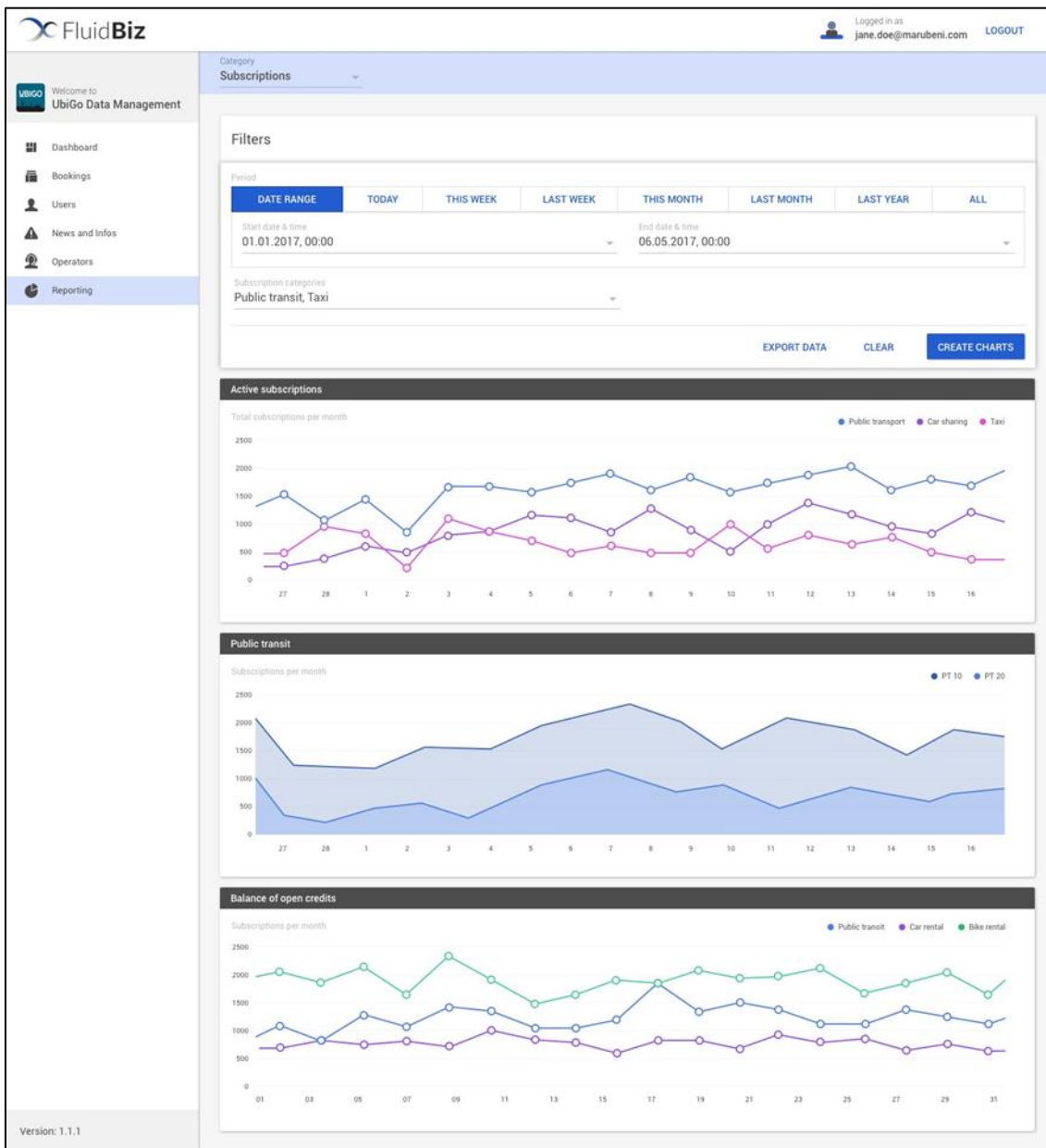
Source: Fluidtime, 2019

UbiGo in Stockholm is based on the experiences gained within the very successful and thoroughly evaluated Go:Smart/UbiGo MaaS pilot project with 70 paying households (180 users) in 2014 in Gothenburg. These results and user experiences were incorporated into the further development of the MaaS solution, which has been implemented together with Fluidtime since 2017. After a test phase in summer 2018, UbiGo was launched in Stockholm in autumn of that year. The MaaS service was introduced for around 200 external households in the city and was expected to be fully operational in 2019 after evaluation and fine-tuning. UbiGo will use Fluidtime's mobility platform on an ongoing basis. This will enable the roll-out of UbiGo in Stockholm as well as its international and national expansion based on a franchise concept. In the future, it will be possible to use a private UbiGo account including mobility credit in other UbiGo regions internationally.

2.3.2 Aarhus

In view of mobility challenges, the city authorities of Aarhus together with the authorities of its surrounding communities embarked on a MaaS project to enhance collective transport in

order to reduce pollution and CO_2 emissions, solve congestion problems in the region and increase the occupancy rate of private vehicles. In 2018, they launched the first phase of the MaaS project – a demonstration area for mobility services and mobility service providers. The aim was to analyse and develop an innovative solution for a multimodal data platform that would support both public and private mobility service providers/operators. Another part of the project was the development of a pilot test for a MaaS service. As digital MaaS enabler within the project, Fluidtime has provided the city of Aarhus with its MaaS platform to facilitate and accelerate the implementation of a MaaS solution.

As a first step, a mobility solution with an integrated planning platform and private peer-to-peer ridesharing was established. This solution is to contribute to minimizing the number of single occupied vehicles in traffic and thus congestion. At the same time, the expanded service offering will help travellers change their mobility behaviour over the long term. After a test phase in spring 2018, the web client presented in Figure 2.6 integrating public and private transport companies was launched in the summer of that year.

Figure 2.6
Web client of Aarhus' mobility platform
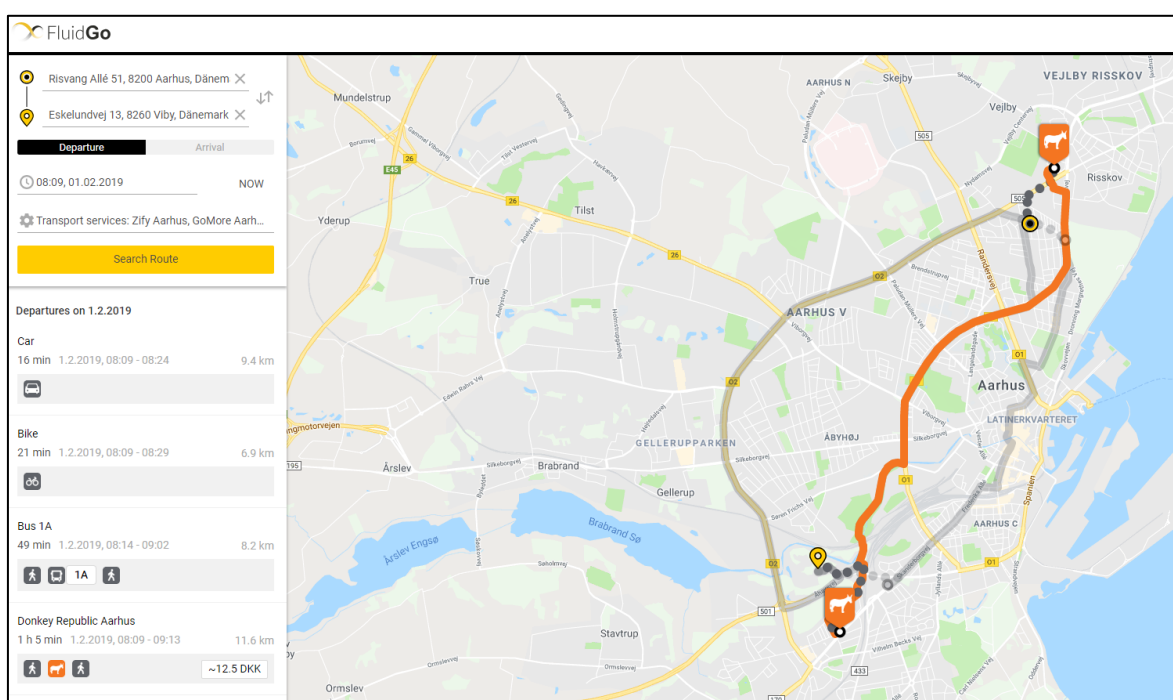
Source: Fluidtime, 2019

The web client of Aarhus' new mobility platform shows Denmark's public transport Midtrafik, the carpooling service GoMore, the bike-sharing service Donkey Republic as well as the carpooling service Zify in one interface. Users can plan their route from A to B, choose between different route recommendations that include all integrated mobility service options, and book the desired option via the web client.

This intelligent MaaS platform enables easier interaction between public and private actors and facilitates access to the mobility market. To do so, the MaaS enabler Fluidtime ensures that the mobility platform's data is easily accessible to other transport services if they meet the requirements set by the city. The Danish Automobile Association (FDM) is the first MaaS provider to use and expand the MaaS platform provided by the city of Aarhus to offer open access to transport services via a MaaS app.

Chapter 3

Car-sharing

3.1 Car-sharing development

Car-sharing provides consumers with access to vehicles for short-term rental. The vehicles within the sharing operation may be owned by individuals and lent through a peer-to-peer platform, or as part of a fleet owned by a single organisation (Department for Transport, 2019). Usually, operators are responsible for ensuring that the vehicles are maintained and meet vehicle safety requirements, and are responsible for the costs of storage, parking, fuel and insurance (where applicable) (Innovative Mobility, 2015). Typically, internet application based platforms are used to match travellers with available vehicles and enable user-payments by them.

It is very important to distinguish between car-sharing and ride sharing, also known as car-pooling. Whilst car-sharing is usually when a vehicle itself is shared amongst many people, ride sharing refers to sharing the route of a journey. Ride sharing tends to indicate more on-demand services and doesn't require individuals to be the driver. Ride-sharing platforms charge a fee for bringing together drivers and passengers, and drivers share trip costs with passengers rather than making a profit. (Department for Transport, 2019).

Car-sharing provides alternative means of access to a vehicle for consumers, reducing the need for individual vehicle ownership. Offering flexible access and use of a vehicle can aid integration with the wider mobility system (Department for Transport, 2019), where shared cars can be used to provide links to other modes.

The concept of car-sharing emerged in the 1940s. These systems used key boxes, reservations were made by phone call, with paper recording of usage. These low-tech systems meant that they were difficult to scale, and therefore it did not emerge as a common service. As IT systems developed and fell in price sufficiently for the automated booking and billing of cars to be commercially efficient, the consumer experience improved and these systems were more effectively able to scale (RAC Foundation, 2012).

Following this development, car-sharing has been increasing over recent years. In 2007, there were 32,000 car-sharing club members in the UK, this has risen almost eight-fold to nearly 250,000 members (Commission on Travel Demand, 2018). Other parts of the world have shown a larger increase, for example figures from Germany demonstrate around 1.7 million members in 2017 (Commission on Travel Demand, 2018). However, these are still relatively small numbers: data from the UK's Department for Transport show a low proportion of full driving licence holders reporting they were a member of a car club. Looking across the 5 years surveyed (2013-17), only 0.5 per cent of full driving licence holders in England reported being a member of a car club. Similarly, data from the Departments' Public Attitudes Tracker found that, in December 2017, 1 per cent of respondents used a car club service (and 1 per cent used an internet-arranged or app-based ride-sharing) (Department for Transport, 2018).

Figure 3.1
Awareness and use of transport services, UK Department for Transport's Transport and Technology: Public Attitudes Tracker, December 2017
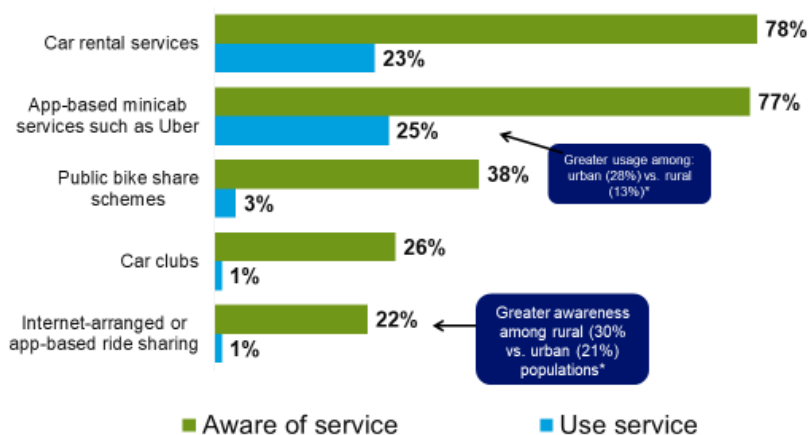
Q23. Which of the following types of travel services have you heard of?/ Q.24 Do you personally use any of these travel services nowadays?
Base: Q23 asked to all respondents (3,499). Q24 asked to all aware of service but re-based on all respondents
Subgroups: Urban (2,935); Rural (517)

3.2   Car-sharing models

Three main models of car-sharing have emerged across Europe and Northern America: traditional (or back-to-base), one-way car-sharing, and peer-to-peer sharing. There is also emerging evidence of what future models could look like with the advent of automated vehicles. These models are explored in more detail below.

Traditional or back-to-base

Within this model, a vehicle is returned to the same location that it was picked up from. Vehicles are rented on a short-term basis, commonly in 30-minute increments (RAC Foundation, 2012). The vehicles are typically owned by the 'car club', which is frequently a private company. Fleets are located in dedicated parking spaces throughout neighbourhoods. Consumers are required to subscribe to the car club service. Through the subscription process, relevant required driving licences are verified, and driving record checks are undertaken by the car club. When members then wish to use a car, they are able to book a specific vehicle through a web interface or smartphone application. Typically, reservation periods are specified before the use of the vehicle begins, but there are some services which provide open-ended reservations where the consumer will only pay for the time used. Vehicles are normally accessed by swiping a smartcard on a windscreen. Once the consumer has finished their journey, they are required to return the vehicle to its original location (RAC Foundation, 2012).

One-way car-sharing

One-way models are similarly structured to the traditional model, with consumers required to subscribe to a car club. However, instead of being required to return the vehicle to the same location as it was picked up, one-way journeys can be undertaken within a defined geographic area. Consumers pay by the minute and only for the time they are driving (RAC Foundation, 2012).

Providing this flexibility renders this model more complex for operators. First, fleet management is more difficult compared with fixed location vehicles. With a free-floating fleet, it is not known in advance where vehicles will be. Therefore, commonly a consumer will notify the provider that they wish to use a vehicle in a given area, and then the provider will then notify the consumer where the nearest vehicle is available. Secondly, flexibility in location of the vehicles requires agreements with car parking operators to use parking spaces

in non-standardised ways (for example, allowing parking without infringement) (RAC Foundation, 2012).

Peer-to-Peer sharing

The key difference of this model compared to the traditional and one-way models is that the vehicles are owned privately, rather than by a central organisation. An intermediary peer-to-peer platform will facilitate the market by matching available vehicles with those who wish to hire a vehicle and will arrange aspects of the hire such as insurance. This peer-to-peer model is commonly used in lower density areas where there is insufficient population to support the service (RAC Foundation, 2012).

Potential future models

Looking towards the deployment of automated vehicles, models of car-sharing may integrate with ride sharing models. As a driver will no longer be required, consumers could be provided with the option of sharing a vehicle for their journey with other travellers with similar origin and destination locations (MERGE Greenwich, 2018).

Initial aspects of such a service were explored through the MERGE Greenwich project, which ran between 2017 and 2018 in Greenwich, London. This trial modelled consumers booking a vehicle coupled with specialised dispatch and allocation software optimising the route, enabling other travellers to share the journey if it involved similar locations (MERGE Greenwich, 2018).

3.3 Car-sharing business case

There are a number of purported benefits of car-sharing which underpin their business cases, which are outlined below.

Improved efficiency of resources

Car-sharing enables more efficient use of vehicles. It is estimated that most vehicles are not utilised 96 per cent of the time (RAC Foundation, 2018). Car-sharing has been shown to increase the efficiency of vehicle use, with one car-sharing vehicle replacing 9-13 privately owned vehicles (Innovative Mobility, 2015).

An increase in car-sharing could also help alleviate congestion, as personal car ownership declines alongside miles driven and public transport utilisation increases. A London based case study reflected that 28 per cent of car club members have reduced the number of vehicles owned by their household since joining a car club, of which 53 per cent report that the car club was the main factor (CoMo, 2018).

Wider economic impacts

Car-sharing can also contribute to wider economic impacts. By increasing access to vehicles, more people can travel to locations previously inaccessible to them and take part in new activities. For those that had previously owned a vehicle, car club members spend less on buying and maintenance of their own vehicle, meaning that their disposable income increases. In the UK, this has been estimated at £7,000 per car club vehicle (CoMo, 2018).

Increasing fuel efficiency and lowering emissions

Vehicles within car-sharing fleets tend to be smaller and newer compared with those in the average household (Intelligent Energy Europe, 2009). The higher turnover of car-sharing fleets mean that newer vehicles can take advantage of technology improving fuel efficiency along with developments in zero carbon technology (CoMo, 2018). This has also shown to be important in the adoption of new technology, for example, consumers who may not have been willing to depend on electric vehicles as private cars can be willing to use them if they are available through a car club (CoMo, 2018).

The travel behaviour of members of car clubs has also shown to change in favour of shared models, which lead to lowering overall emissions of the transport system. As journeys tend to be better planned when shared cars are used, more journeys are shared. In the UK, the average car occupancy of shared cars is 2.3 people per trip, compared to 1.5 people for private cars, leading to lower emissions per person kilometre (CoMo 2018). The cost transparency of a shared car compared to a private vehicle has also been shown to lead to increased use of public transport or active journeys (Intelligent Energy Europe, 2009).

Social inclusion

The expense of owning a vehicle can be prohibitive for some, and car-sharing can assist in providing access to a vehicle. This is particularly important in rural communities where access to a vehicle provides vital links to key services where public transport is not an option (CoMO, 2018) and can help reduce isolation and loneliness rates, especially amongst older people.

There is also some evidence that car-sharing can lead to a reduction in the total of number of vehicles on the road, thereby reducing road space requirements for parking. This space can in turn be provided for other purposes, such as green space for communities (CoMo, 2018).

3.4   Good practices and case studies

The way in which people commute in cities and between urban areas is changing drastically, with new mobility services and innovations providing consumers with more choices that complement the existing public transport networks. Local authorities need to take this into account, ensuring that existing market access and operational rules do not hamper the uptake of car- or ride sharing. Local governments will also have a major role to play in supporting the integration of shared mobility services into MaaS platforms, allowing citizens to have a sustainable alternative to private car use.

Case studies

Car-sharing is becoming a global phenomenon, with Europe representing 50 per cent of the global car-sharing market and well-known providers such as DriveNow and car2go operating across the region (Deloitte, 2017). However, the phenomenon varies between individual countries.

Currently, Germany has the largest car-sharing market in Europe with 150 providers and supportive authorities who are open to collaboration. However, strict regulations in the taxi industry have made it difficult for ride-hailing/ride-sharing services like Uber.

In the UK, London is the centre for car-sharing although the focus is beginning to shift to other regions. Parking is a prominent issue in London as all 32 boroughs need to be approached individually for permits and this could be a significant barrier for car club operators.

France, has the most successful market for peer-to-peer car-sharing in Europe. Its strict regulations enforce all free-floating vehicles to be electric or hybrid, which enhances the environmental benefits of car-sharing schemes (Deloitte, 2017).

Open access to public data

For over ten years, Transport for London (TfL) has been releasing a significant amount of data (timetables, service status and disruption information) in an open format for anyone to use. The provision of this free, accurate and real-time open data by TfL is helping London's economy by up to £130 million a year.

More than 650 apps are now being powered specifically using TfL's open data feeds, used by 42 per cent of Londoners. In addition to its own data sources, TfL also receives crowdsourced anonymous traffic data to get an even better understanding of journeys in London to improve its operations.

Citymapper, one of the first journey-planning apps in London, was enabled by Transport for London's (TfL) open data. Other businesses which use TfL data to improve customer information include Apple, Google, BusChecker, BusTimes, and Moovit. (Department for Transport, 2019)

Sustainable car-sharing

ZipCar is a car club with 250,000 members in London and almost 3000 vehicles of varying sizes. Car-sharing is a fast-growing concept and ZipCar estimates that 800,000 Londoners (15 per cent of those who drive) could be active car club members by 2025.

ZipCar partnered with Volkswagen in 2018 to introduce 325 electric vehicles in to its fleet, and hopes this will help drive investment in London's rapid charging network. The company's vision is for its fleet to be fully electric across all vehicle types by 2025, helping keep Londoners moving while reducing the impact of cars on the urban environment. (Department for Transport, 2019).

Self-driving vehicles

StreetWise aims to develop and demonstrate the technology, safety validation methods, insurance and service models for a mobility solution replacing the urban commuter car with shared self-driving vehicles. Trials will start on London roads in 2019.

Part funded by the UK Government, the project consortium is led by FiveAI, a company specialising in perception and artificial intelligence technologies. Other partners include the University of Oxford, Direct Line Group, McLaren Applied Technologies and Transport for London. (Department for Transport, 2019).

Employers encouraging car-sharing

Heathrow has an exclusive car share scheme for airport workers, which was created in 2002 and is administered by Liftshare via automated software that matches members of the scheme to each other based on home location and commuting patterns. Active members are entitled to priority parking in Heathrow managed car parks and access to a 24-hour emergency ride home.

Quantitative research on Heathrow employees' travel choices suggests that 61 per cent of drivers were interested in car-sharing, and 41 per cent of drivers would be encouraged to car share if they could be helped with finding someone with similar shift patterns (Department for Transport, 2017).

3.5 Challenges and trends

3.5.1 Trends

There are a number of trends, both within the automotive sector and more broadly across the economy that are supporting the movement towards more shared use of cars.

Design of vehicles for sharing

The automotive industry's scepticism to car-sharing schemes and its perceived threat to sale volumes has begun to diminish. We're seeing this through the rise of strategic partnerships, such as that of Ford and Zipcar to the outright ownership of car club schemes, including the likes of Daimler's car2go (RAC Foundation, 2012) and Volkswagens' We Share in Berlin.

At present vehicles in car club fleets are often standard models fitted with aftermarket telematics. However, this is changing as car manufacturers are acknowledging the requirements needed for car club operations and are beginning to design vehicles suited to this purpose.

Research conducted by MERGE Greenwich reflected on concerns users had with ride-sharing, particularly around sharing with strangers in a small vehicle (MERGE Greenwich, 2018). The UK's Department for Transport-commissioned Future Roads Public Dialogue,

also found resistance to ride-sharing in smaller vehicles, where close proximity to other passengers was seen as a risk to personal comfort and safety. Accommodating other passengers' needs was seen to compromise convenience, and there was a willingness to pay a premium for private self-driving services to avoid the inconvenience and discomfort of having to share routes and personal space (Department for Transport, Future Roads, 2018). When considering other forms of shared mobility, vehicle design will play a key role in overcoming barriers regarding personal safety and privacy.

Challenging use of personal car

People own a car for a combination of practical and emotional reasons. A study conducted by the RAC Foundation on car dependence highlighted the key reasons for personal attachment to cars including: the ability to be spontaneous, the psychological economics, privacy, desire for control and enjoyment of driving (RAC Foundation, Car Dependence, 1995). In most cases, owning and using a personal car is still the rational choice when the alternatives are of poor quality (Transport for London, Road Task Force, 2012).

Similarly, the UK Department for Transport's transport and technology tracker survey demonstrated that people have a strong attachment to their car. Car owners were very likely to agree with the statements "*I enjoy the freedom and independence I get from my car or van*" (94 per cent) and "*My current lifestyle means I need to own a car or van*" (87 per cent) (Department for Transport, 2018). These findings are reinforced in the Future Roads Public Dialogue, which explored views on sharing in the context of automated vehicles. People instinctively compared sharing options unfavourably against familiar forms of transport. In particular, car owners saw them as inconvenient when compared to personal ownership, especially so for those with complex trips or trip chains (e.g. combining commute, school drop offs, shopping) (Department for Transport, Future Roads, 2018).

However, with the global movement towards clamping down on diesel vehicles and declining car sales the status held by private-car ownership is declining. (McKinsey, 2013) In cities such as Beijing, data shows that car use has reduced absolutely with an increase in the use of public transport, whilst its GDP has continued to grow. This transition can be explained in terms of changing government policies, increased investment in urban rail and emerging cultural trends alongside significant growth in electric vehicles and bikes (Gao and Newman, Urban Planning, 2018). Similarly, the Rocky Mountain Institute forecasts that annual personal light-vehicle sales in the US could fall from 17m currently to 7m by 2035. (Rocky Mountain Institute, Peak Car Ownership Report, 2016).

Integration with other services

Shared modes of transport can play a fundamental role in encouraging the integration of existing transport networks and services. Car hire and car club services to some extent have encouraged this type of integration by linking consumers to commercial aviation and inter-city rail networks, whilst also addressing the first and last mile issue related to public transit access. (University of California, Berkeley, Shared Mobility, 2015). This has come in the form of privileged access to parking, integrated rail-car-club ticketing and bundled subscriptions. (RAC Foundation, 2012).

Several economic benefits arise from the integration of services, including cost-savings, increased economic activity through creation of trips that have not been accessible by public transport before, and enabling new one-way (or point-to-point) options previously unavailable. (University of California, Berkeley, Shared Mobility, 2015).

Broader trends towards personalised services

Increasingly personalised services have become more common and, at times, an expectation from consumers. Research conducted by Deloitte highlights that 1 in 4 consumers are willing to pay more for a personalised product or service (Deloitte, 2015.) Car clubs have also expanded into new markets to diversify the services they offer, from including a variety of pricing plans and vehicle types to flexibility in reservations (RAC Foundation, 2012). Given the variety of users that car clubs tend to serve, it is likely that a number of different personalised services will continue to develop and compete with each other.

Automated Vehicles

Existing technologies, such as the increasing smartphone penetration, will continue to be a key enabler for the growth of the car-sharing market. However, innovations in transport technologies will continue to unfold and change the dynamic for shared mobility.

Automated vehicles have the potential to significantly impact consumer behaviour and the way in which cars are utilised. They could erase the distinction between car-sharing and ride sharing and offer consumers a significant edge in the total cost of ownership (Boston Consulting Group, 2016).

3.5.2. Challenges

There are also a number of challenges that can be foreseen that may limit the use of shared vehicles.

Reliance on technology

Car-sharing operations would work very differently at scale, in comparison to the current prevailing system of personal car ownership. If demand is greater than available capacity, a car club's reservation system could allocate to some users whilst others may lose out. The reliance on technology for such a system to operate at scale is significant. Car clubs rely on wireless communications and back-office IT systems that could also be vulnerable to system-wide disruptions (RAC Foundation 2012).

It is also hard to assess whether new innovations and technologies will help revolutionise the car club industry or disrupt its ability to operate at scale. An influx of automated vehicles may have contradictory effects both on shared mobility, travel demand and congestion if these technologies are not adopted through the means of ride-sharing.

Cost competitiveness

The Government Office for Science in the UK published a report exploring the human factors in shared use of transport, which suggested that car-sharing is likely to be adopted by those who already travel flexibly, live where public transport is easily available and accessible, and seek to optimise their journeys on a case-by-case basis (Government Office for Science, 2019). Currently, car-sharing is only cost competitive for low mileage drivers (ING Economics Department, 2018) and it may require government intervention to increase its competitiveness compared to personal car ownership.

3.6 Car-sharing and MaaS

The trend towards car-sharing gives an indication that car-sharing should play an increasing role in the future mobility. The MaaS potential can only increase this role with more integrated services encouraging more specific, targeted use of a vehicle that is more suited to shared ownership. For the latter to accelerate, physical infrastructure supporting car-sharing and data integration challenges need to be addressed. Moreover, local authorities should set out clear visions for increasing car-sharing competitiveness vis-à-vis private car ownership.

Chapter 4

Bike-sharing

4.1 Bike-sharing systems

Bike-sharing systems represent an important option in the repertoire of traveller choice, which have been shaped by the introduction of Information and Communication Technologies with regard to – for instance - urban analytics and digital integration in multimodal transport networks. Alongside that, electrically powered assisted cycles have started to open up a remarkable new vision that re-frames cycling as a realistic opportunity for most people and, in doing so, help transform the vehicle-based priority of our streets: bike-sharing schemes, all over the world, will definitely receive a significant boost from the increasing presence of electrified bicycles.

In practical terms, bike-sharing schemes are short-term bicycle rentals available at unattended urban locations and mainly used for transit purposes. Nowadays there are more than 1,000 schemes in place globally:

Figure 4.1
Global presence of bike sharing systems 2017
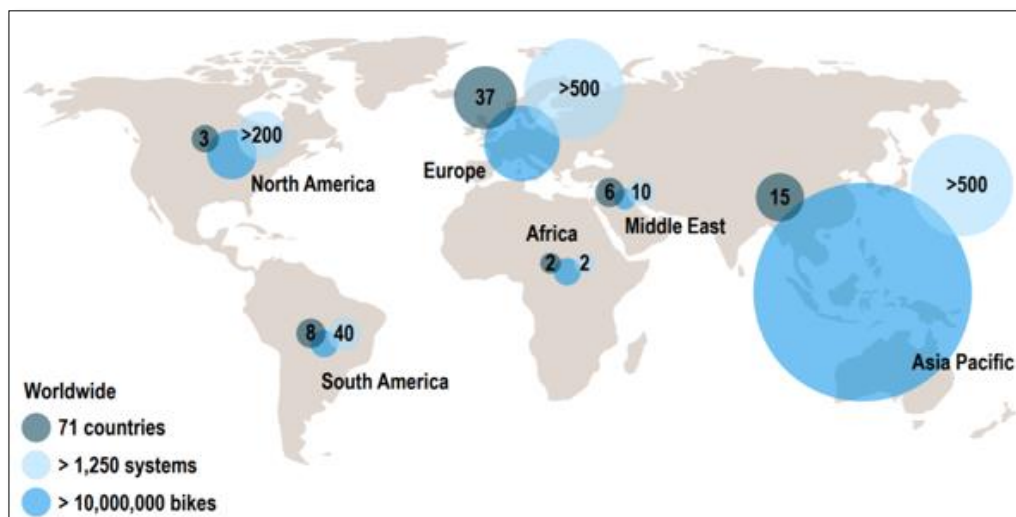
Source: Roland Berger, ''Bike-Sharing 5.0, Market Insights and Outlook 2018''

4.2. Bike-sharing models & business cases

The First Generation of Bike-Sharing (Mid-1960s): the free-use model

In the mid-1960s, Amsterdam was the city where the first generation of bike-sharing systems was introduced (Parkes et al. 2013). 10,000 bicycles, painted in white, were distributed throughout the city so that anyone could use them for free. The initiative did not originate because public institutions wanted to offer a service to city residents: on the contrary, it was generated by a popular protest against pollution, fatal accidents caused by motor vehicles, and the inferior quality of public transport. Conceived as a symbol of protest, the white bikes received much media attention, but the City rapidly acted to ban bicycles left in public places without security measures.

The Second Generation (Early to late 1990s): the introduction of docking stations

From the early 90's onwards, Denmark shows a structured evolution of the free-use model. The most significant example is that of Copenhagen, where the city – supported by other public administrations and the participation of the private sector – implemented a bike-

sharing system for mass use. Docking stations were installed across the city designed to park bicycles when they were not in use. As in Amsterdam, the service was free, but users had to put a coin in the docking stations as a form of deposit in order to undock bikes. The deposit was given back when the bicycle was returned to a docking station, thus it was a free service aimed at reducing the use of motor vehicles, but without seeking to be self-financing. The model did not include any penalty in case of non-return of a bike, so once it had been undocked, there was nothing to prevent or discourage theft.

The second-generation bike-sharing schemes were operated and initially funded by local authorities, but, in order to provide the service in the long term, a search for external sources of funding was crucial. The solution came through the incorporation of advertising on the bicycles: something new that helped finance the service without the need to charge users, even though not sufficient to cover all costs.

The Third Generation (from late 1990's): restructuring of Public-Private Partnerships, profitability and introduction of digital technologies

At the end of the 90's new developments included: the standardization of bicycle models (to reduce costs), and the restructuring of traditional PPP (Public-Private-Partnership) contracts, in which private companies started to take on both CAPEX and OPEX, obtaining advertising concessions in return. There have also been instances where CAPEX was provided by structural funds (i.e. in the EU) or from national environment taxation (i.e. the USA), while OPEX was a responsibility of private sponsors.

In comparison with the past, users began to pay for using the bike-sharing systems: third-generation models proved to be more profitable and financially sustainable due to the widening of the revenue streams, which was possible thanks to the modernization of bicycle fleets and docking systems as part of a more competitive proposition.

Taking that proposition as a trigger that would make users pay for such a service, at the end of 1990's digital technologies entered the ''value chain'' to complement a business & operations model that could then focus on upgrading the complex interaction between bicycles, infrastructure and logistics. That is why in 1998, the city of Rennes decided to incorporate IT solutions to create a technologically sophisticated system that worked with fixed docks and magnetic smartcards for the check-out and return of the bicycles. The racks contained a controller, which consisted of a GSM modem, a CPU (Central Processing Unit), a card reader and a power supply. The bicycles were equipped with microchips, and a central computer downloaded information stored in each docking station.[1] From a logistical point of view, this made it easier to transport bicycles from full docks to empty ones (or to a repair centre). Rennes was the first example, which has been followed by many other cities all over the world. Nowadays technology has improved further and users can access a website to check the status of the service, inquire about the availability of bicycles in a specific docking station, or manage their user accounts and interact with the operating company.

In the last years, one of the most visible expressions of digital technology – smartphones – have supported the re-proposition of bike-sharing schemes without any docking stations: specifically the combination of dockless bikes available almost everywhere, accessible by paying for their use through apps on mobile devices. Such a mix was foreseen as providing optimal user availability but, in some cases, has faced logistical issues related to the management of public space, and the lack of a balanced fleet deployment. In consequence, municipalities have taken the decision to create regulatory frameworks to tackle the negative externalities.[2]

The next generation: the introduction of Electrically Power Assisted Cycles and the inclusion of Bike-sharing systems in MaaS platforms

In coming years new business models will appear, based on a substantial electrification of the shared bikes (Barcelona is an example), and on a higher degree of digitalization. Electrification provides a solution for longer distance travels as well as for riding in cities

---

[1] www.eltis.org/discover/case-studies/velo-la-carte-public-bicycles-rennes-france
[2] www.ieseinsight.com/doc.aspx?id=2212&ar=15

that present difficult terrain: Importantly, electrification will also enhance the cross-generational accessibility that bikes can give in terms of commuting.

In addition, more advanced digitalization will bring the introduction of geofencing - such as virtual parking slots - and a closer integration of bike- and e-bike-sharing systems in MaaS platforms. There will be two levels of integration: one that relates to the concept of continuity from the pure mobility perspective (full integration of all means of transportation within one digital platform that enables data-sharing for best ad-hoc mobility solutions) and the one that is linked to the concept of continuity from the usage point of view (the same digital platform that is available in different cities and even countries).

4.3. Benefits, challenges and trends

Cycling and bike-sharing have important positive externalities on health, environment and urban mobility, along with socio-economic growth.

Health benefits

The World Health Organization reports that physical inactivity has been identified as the fourth leading risk factor for global mortality (6 per cent of deaths). Moreover, physical inactivity is estimated to be the main cause for approximately 21–25 per cent of breast and colon cancers, 27 per cent of diabetes and approximately 30 per cent of ischaemic heart disease burden.[3]

A recent study carried out by the Specialist Center on Public Private Partnership in Smart & Sustainable Cities of IESE business School[4], analyzed the investment and operation data of 13 municipal services of bike-sharing in Europe[5] and calculated the related health benefits by using the WHO's Health Economic Assessment Tool: the result is that these 13 bike-sharing services prevented more than 90 premature deaths between 2014 and 2016 and the aggregated socio-economic value of the effects of each euro invested in the programs had an average effect that ranges from €1.37 to €1.72. With a conservative estimation of 1.000 programs in place worldwide, about 7.000 premature deaths might be avoided every year.

Environmental benefits

From an environmental perspective, cycling is a significant element in the fight against climate change and air pollution. In Europe, urban mobility accounts for 40 per cent of all CO_2 emissions and up to 70 per cent of other pollutants from road transport[6]: Reducing emissions through cycling can have a remarkable impact on the overall dependence on fossil fuels. In such a context, bike-sharing schemes are not only one of the solutions to urban commuting, but also act as a promotional tool to encourage more cycling. They provide access to bicycles for all those who do not own a bicycle themselves, and thereby increase further the level of transport decarbonization: a 2018 study entitled ''Environmental benefits of bike-sharing: A big data-based analysis'' shows that bike-sharing in Shanghai saved 8,358 tonnes of petrol usage and decreased CO_2 emissions by 25,240 tonnes in 2016.[7]

Mobility benefits and trends

Bike-sharing has an important role in the development of sustainable and smart urban transport networks: it reduces road congestion, especially during peak hours[8], it brings

---

[3] www.who.int/dietphysicalactivity/pa/en/

[4] www.ieseinsight.com/doc.aspx?id=2212&ar=15

[5] The 13 cities in the scope of the study were Barcelona, Madrid, London, Berlin, Paris, Vienna, Bilbao, Cologne, Milan, San Sebastian, Hamburg, Copenhagen and Turin

[6] urbact.eu/sites/default/files/import/general_library/19765_Urbact_WS5_MOBILITY_low_FINAL.pdf

[7] www.sciencedirect.com/science/article/pii/S0306261918304392

[8] Bike-sharing systems and congestion: Evidence from US cities https://media.rff.org/documents/RFF-DP-15-39-REV.pdf?_ga=2.143379772.848596912.1558798079-1933688875.1558798079

tourists to sightsee with an active mobility approach and improves accessibility to public transportation by supporting the tram, bus and metro systems.

In the United States, bike-sharing has grown considerably, with 35 million trips taken in 2017 (representing 25 per cent more than in 2016): since 2010, 123 million trips have been done on shared bikes[9] (figure 2)

Figure 4.2
Growing ridership

SOURCE: NACTO.ORG
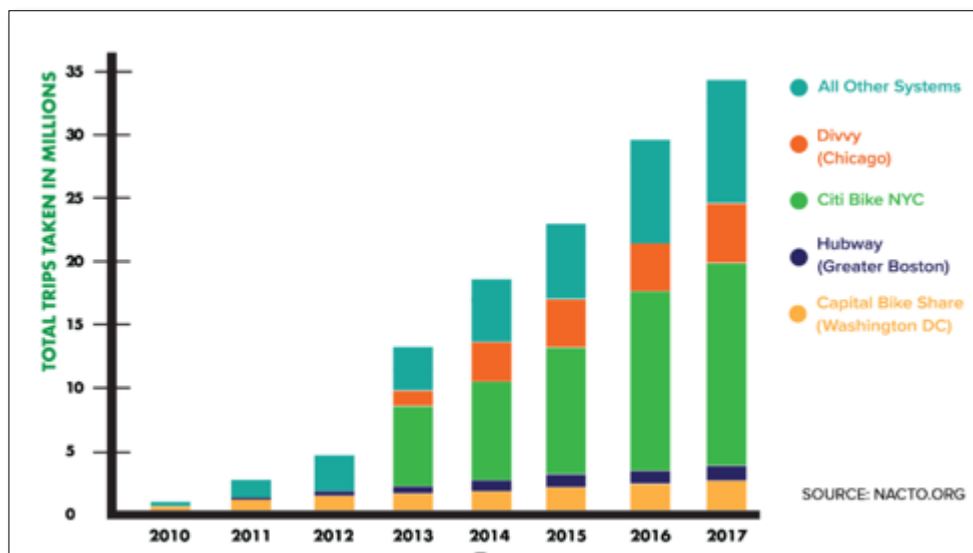
The study ''Bicycle infrastructure and traffic congestion: Evidence from DC's Capital Bikeshare'' quotes an estimate on national congestion costs arising from time loss and wasted fuel that amounted to more than $120 billion in 2011, while indicates a 4 per cent reduction in congestion due to the presence of bike-sharing in metropolitan Washington between 2011 and 2012.[10] A 2016 report of New York City's Department of Transport states that in New York City's congested Midtown Manhattan, average trips between 1 and 1.5 miles were more than 5 minutes faster and $10 cheaper by bike-sharing than by taxi.[11]

China has 400 million registered bike-sharing users and the daily number of riders peaked at 70 million in 2018 according to the Ministry of Transport, with 23 million bikes deployed in cities, towns and villages. 400 million hours of time spent in traffic were saved, equal to the work hours of 240,000 people a year in the country.[12] In addition, under a scenario where 75 per cent of vehicle-kilometres are replaced by bicycle travel in Beijing, fuel consumption should reduce by 225.06 thousand tons.[13]

In 2016 in Japan, there were 100 cities with public bicycle systems. According to the Ministry of Land, Infrastructure and Transport (MLIT), those systems have been growing rapidly: at the time, Tokyo was the city in Japan with most public bicycle systems[14] and bicycles were used about 1.8 million times in 2016, up from 20,000 times in 2012.[15]

Economic and societal benefits

Bike-sharing generates positive externalities that are linked to both economy and society: it creates jobs and growth, with significant direct, indirect and induced effects that, in some

---

[9]   nacto.org/bike-share-statistics-2017/

[10] media.rff.org/documents/RFF-DP-15-39-REV.pdf?_ga=2.143379772.848596912.1558798079-1933688875.1558798079

[11] www.nyc.gov/html/dot/downloads/pdf/mobility-report-2016-print.pdf

[12] en.people.cn/n3/2018/0208/c90000-9425354.html

[13] ideas.repec.org/a/gam/jsusta/v10y2018i4p1145-d140514.html

[14] www.itf-oecd.org/sites/default/files/docs/bike-share-deployment-strategies-japan_0.pdf

[15] www.japantimes.co.jp/news/2017/05/01/reference/urban-japan-trying-hand-bicycle-sharing/#.XNflgOgzY2w

cases, have been translated into economic terms. The high number of systems that have spread across the world in the last decades, and even more in the last years, have supported employment in - among others - manufacturing, research & innovation, marketing, logistics, maintenance and infrastructure construction.

Bike-sharing demonstrates as well a revival of local economies by connecting people to retail and other places where economic activities take place, while the breakthroughs in our digital era have seen tech companies entering the bike-sharing business with the consequent creation of Information Technology-related jobs.

The study conducted by the Specialist Center on Public Private Partnership in Smart & Sustainable Cities of IESE business School[16] - mentioned above - shows that the total estimated economic impact of 13 bike-sharing systems in the European Union ranged from €718 million to around €860 million in 2016, out of which the derived economic impact ranged from around €316 million to almost €459 million (Figure 4.3). Every euro invested in the 13 bike-sharing programs generated an average impact between €1.37 and €1.72. At the same time, around 3,400 jobs were created directly and indirectly as a result of the investment in the 13 bike-sharing systems, with an induced effect by those new jobs on final household consumption that amounts to more than 142 million Euro.

Figure 4.3
Estimated economic impact from bike sharing in the European Union
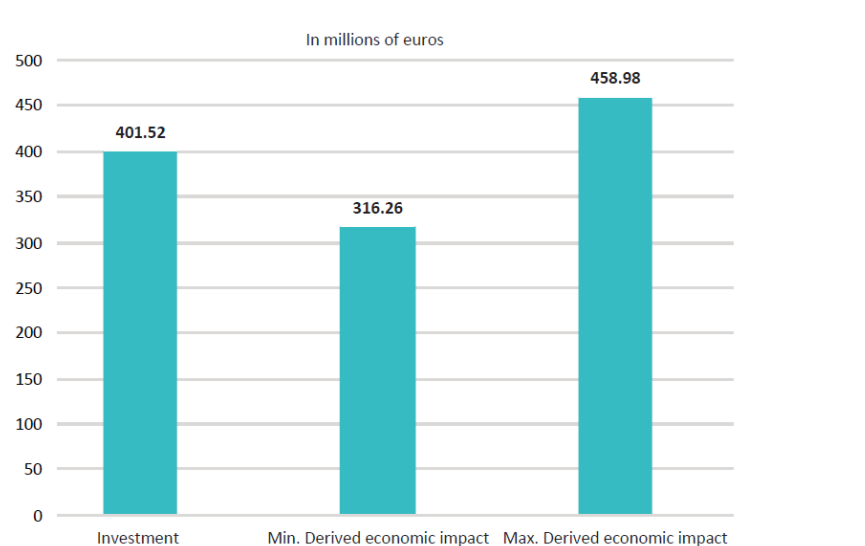
Source: IESE study on the economic impact of bike sharing, 2019

A study conducted in Beijing entitled ''Bike Sharing and the Economy, the Environment, and Health-Related Externalities'' estimates the supplementary effect of bike-sharing as a link to other modes of urban transport: results show that bike-sharing in China's capital can help each worker save an average of 8 minutes per day. This additional time can increase the total GDP of Beijing by about RMB1.20 billion (176 million USD).[17]

Another worth-noting economic externality is that proximity to bike-sharing stations augments property values, similarly to a metro station or a bus stop nearby that increase the market value of an apartment or a house. Researchers in Canada studied house sales in central Montreal before and after the city bike-sharing system was launched in 2009. They found that a typical home in the central Montreal area with bike-sharing stations nearby, had increased its value by 2.7 per cent on average.[18]

Local business is also part of the positive picture that links bike-sharing with economic growth: for example, restaurants closer to bike-sharing stations do more business than those

---

[16] www.ieseinsight.com/doc.aspx?id=2212&ar=15

[17] www.ieseinsight.com/doc.aspx?id=2212&ar=15

[18] phys.org/news/2015-06-proximity-bike-stations-augments-property.html

farther away. Researchers from the New York University[19] tracked retail sales volumes in the period after bike-sharing stations were installed in Brooklyn (New York) and Jersey City between 2013 and 2016 and found out that food retailers (typically restaurants) in the Brooklyn neighbourhood closest to bike-sharing stations saw their total volume of business increase between 2 and 5 percent in the years after bike-sharing stations were added. In Jersey City, the results were also very positive, with restaurants closest to bike-sharing stations seeing 4 percent increases.

The impact of bike-sharing on society is broad and benefits go beyond job creation: indeed, cities are more liveable, accessible and socially connected after they have introduced bike-sharing schemes. It is not surprising that many of the cities that score a high-rate in terms of liveability have invested in cycling promotion, bicycle infrastructure and good networks of bike-sharing stations. A study by the Netherlands Institute for Transport Policy Analysis shows that cycling scores well in terms of annual infrastructure costs: per traveller kilometre 0.03 euros are spent for bicycles, 0.10 euros for cars and 0.14 euros for buses.[20]

Challenges

Nevertheless, bike- and e-bike-sharing schemes have also faced some challenges. Dockless bike-sharing schemes are not new in the shared mobility scenario and have been re-proposed massively in the last years in many cities worldwide. The fact of not having docking stations has been seen as an advantage in getting more people to use publicly available bicycles, but lack of coordination with local authorities (which unfortunately happened in several situations) has clouded the good intentions of promoting cycling by some service providers.

Existing urban infrastructure has objective limitations, and guidelines agreed upon by all stakeholders are necessary in order to avoid either the saturation of public parking spaces and the unsuitable parking of dockless bicycles. In addition to that, thefts and vandalism by irresponsible users, may damage - to a certain extent - the image of bike- and e-bike-sharing.

A 2018 survey[21] looked into the solutions proposed by some cities to tackle the negative aspects of dockless bike-sharing schemes: a shared opinion among the public authorities was that a set of regulations was needed to address those negative effects.

Most of the measures proposed are cross-disciplinary:

- Enhanced cooperation between service providers and local authorities;
- Preparation of specific regulations on the obligations of both the provider and the customer;
- Better understanding of the terms and conditions of the service;
- Creation of specific parking areas for dockless bicycles;
- Promotion of a licensing systems

Through a clear legal framework, dockless service providers would be required promptly to collect broken bicycles from public spaces, and to be penalized for lack of maintenance. Codes of conduct on how they should interact with users and the urban environment would support the cooperation with local authorities, while the usage data collected could be shared with municipalities (in compliance with data protection legislation). Specifically, municipalities could also introduce a licensing system to limit the number of bicycles per operator, granting licences according to the municipalities' criteria. However, to determine how many licences would be appropriate, municipalities would have to conduct studies to estimate the potential demand of dockless bicycles.

Dockless bike- and/or e-bike-sharing schemes offer a very significant opportunity if properly managed, and must be positively contextualized within the picture of MaaS platforms. Wrong

---

[19] peopleforbikes.org/blog/closer-bike-share-better-business/ and
arxiv.org/ftp/arxiv/papers/1712/1712.00659.pdf
[20] Cycling Facts, Netherlands Institute for Transport Policy Analysis
english.kimnet.nl/publications/publications/2018/04/06/cycling-facts
[21] www.ieseinsight.com/doc.aspx?id=2212&ar=15

practices should be taken as examples for improvement, without compromising the overall benefits that are linked with increased levels of cycling through publicly available bicycles.

4.4.   Bike-sharing and MaaS

The attention that bike- and e-bike-sharing schemes have attracted, especially in the last years, represents an indication of how crucial cycling and cycling services are in shaping the future mobility in cities, possibly as part of MaaS. In that perspective, public-private collaboration models are decisive to neutralize the negative effects that have been noticed in several cases.

The density and quality of cycling infrastructure have a very important impact on cycling and bike-sharing uptake. In cities that have built safe cycling lane networks, cycling is increasing and the risk of injury is decreasing: the link between appropriately-implemented bike-sharing schemes and high-quality bike lanes fosters ridership.[22] Density, on the other side, is a relevant factor of cohesion: the smaller the distance between cycling routes, the more the cyclist has the choice to use share bikes, while the cohesion with other transport networks plays a key role in MaaS with regard to the overall intermodal connections.[23]

The digital world is bringing mobility to a new dimension by providing simple and immediate information related to localization, routes and prices, while influencing a behavioural change that regards the way users have access to share bicycles and e-bikes. Smart solutions via Big Data analytics and artificial intelligence are enabling operators to optimize their networks, supporting fleet deployment and improving the multimodal offer to the community. Indeed, the mentioned solutions underpin the rationale behind MaaS platforms.

The combination of bicycles and e-bikes with other means of transportation adds value. By approaching urban mobility with such a holistic mindset – meaning through efficient integration rather than counter-productive fragmentation of mobility offer –cycling can be and will be an important mode in a successful deployment of MaaS.

---

[22]   usa.streetsblog.org/wp-content/uploads/sites/5/2016/07/NACTO_Equitable-Bike-Share-Means-Building-Better-Places-To-Ride.pdf

[23]   https://ec.europa.eu/transport/sites/transport/files/cycling-guidance/presto_policy_guide_cycling_infrastructure_en.pdf

Chapter 5

# MaaS cost, risk and revenue challenges

5.1. Business models, assumed risks and the revenue challenge

Participation in a MaaS scheme may take on various forms resulting from the appetite for risk taking by the various MaaS actors. As stated in the introduction, the MaaS provider could be a single entity taking the role of MaaS Champion/Leader and operating as a "broker" as it buys services from the (other) mobility service operators/providers and resells in MaaS packages. In this configuration, all risks and, consequently, all benefits are collected by the "broker". All other operators assume no risks. On the contrary, they have presold tickets (secured revenues).

The MaaS provider can be a partnership of actors of the MaaS ecosystem not necessarily all. The partnership can include varying levels of independence. In an "Alliance", mobility service operators/providers formulate a loose partnership supporting and promoting each other services. Each mobility operator/provider remains a fully independent entity and assumes minimum, if any, risk. More complexity is found when the governance model is characterized by a MaaS operator functioning as "coordinator".

Figure 5.1 maps the potential business partnerships and their scope. It also, suggests governance models and respectively assumed risk by the business champion/leader and the other "participants".

Figure 5.1:
Potential business models and respective risk uptake
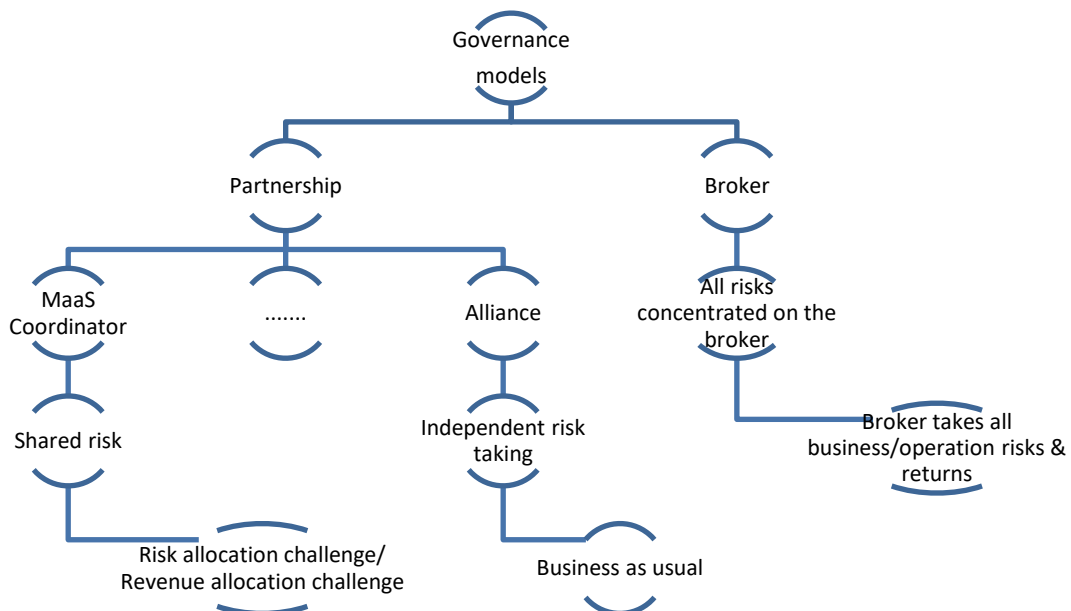
Source: Roumboutsos et al, Currently under review

The MaaS "broker"

As a MaaS broker, the MaaS operator/provider undertakes the full risk of the activities while all other stakeholders involved provide services to the broker creating bilateral "buyer-seller" (principal-agent) relations. The broker assumes the entire business risk and enjoys all profits. Depending on the broker's risk appetite (or assessment of the mobility opportunities), the implemented business model may range from the provision of travel/trip planning services to realizing the full potential of MaaS.

The level of payment options is representative of the complexity of the business model and the level of risk undertaken by the broker, while mobility service providers/operators assume minimum risk and have no stake in the endeavour (see Figure 5.2).

Figure 5.2
Benefits and Risks Levels for the Broker and the Mobility Providers under payment option levels

		Broker		Mobility Operator/Provider	
		Benefits	Risks	Benefits	Risks
Level 5 Subscription-based billing & Payment	• Mobility Packages • Subscriptions	• User Profile • Portfolio of risks	High	• Pre-sale of availability	Low
Level 4 Account-based Billing & Payment	• Monthly invoicing	• User Profile • Crowdsourcing of mobility data	Medium	• Reduction in sales costs	Low
Level 3 Pay-as-you-go	• Invoicing	• User Profile • Crowdsourcing of mobility data	Medium	• New sales outlet	None
Level 2 Direct payment	• Booking • Direct Payment	• User Profile • Crowdsourcing of mobility data	Low	• New sales outlet	None
Level 1 Information	• Schedules • Routing		Low		None

In all cases, the broker establishes with each mobility service operator/provider a bilateral agreement. The content of the agreement ranges from providing schedules, booking and ticketing to describing the arrangement for the data exchange/interface compatibility and provision of availability as well as the related fare pricing formulae. However, in all cases mobility service providers continue to operate independently in the mobility market.

The broker may negotiate the price, for example, based on availability bought, which in any case would need to be below market prices offered. Greater price reductions are expected in situations where the seller (agent) has excess capacity. Negotiated reduced mobility service prices might be passed on to the customer and/or used to cover broker operating costs and respective profits. The broker would then undertake losses in full. The model becomes viable when including most, if not all mobility providers and offering subscription packages, which could balance the broker's, risk portfolio. Hence, the revenue issue is addressed as in the case of the Mobile Communications Sector.

Partnerships and the MaaS "coordinator"

As MaaS "coordinator", the MaaS operator/provider coordinates the activities of partners, who form a partnership. Operating costs are assigned to the legal entity representing the "partnership" and revenues are allocated to partners. The "partnership" requires multilateral agreements, interoperability and faces the challenge of revenue allocation. "Partnerships" strive on their ability to provide multiple mobility options leading, when considering revenues, to the "museum pass problem". Notably, the complexity involved in delivering a service that spans multiple modes of transportation, with multiple providers, for a single fare is not straightforward, as each mode needs to be appropriately compensated.[24] Notably, in this case the coordinator and the mobility service providers share the same risks (see Figure

---

[24] Of course, a "pay-as-you-go" option might also be available, which works like most route planner apps: A trip can be organized as a single trip chain, but the user would then pay separately for each leg.

5.3). Equally so, benefits for the mobility providers exist when Level 5 payment option is included in the MaaS offer.

Finally, under this governance model, Public-Private-Partnerships might emerge as public mobility providers might be directly included in the partnership.

Figure 5.3
Benefits and Risks Levels for the Coordinator and the Mobility Providers under payment options

		Coordinator & Mobility Providers		
		Costs	Benefits	Risks
Level 5 Subscription-based billing & Payment	• Mobility Packages • Subscriptions	• Coordination • Sharing of information • Revenue allocation challenge	• Reduction in sales costs • New markets	High
Level 4 Account-based Billing & Payment	• Monthly invoicing	• Coordination • Sharing of information	• Reduction in sales costs • New markets	Medium
Level 3 Pay-as-you-go	• Invoicing	• Coordination • Sharing of information	• New sales outlet	Medium
Level 2 Direct payment	• Booking • Direct Payment	• Coordination	• New sales outlet	Low
Level 1 Information	• Schedules • Routing			None

5.2   Lessons learned from existing MaaS applications

MaaS is a novel concept and, as such, many efforts are underway following different business models and navigating through institutional systems which are not always supportive or favourable (see Polydoropoulou et al., 2019).

Table 5.1 lists 13 MaaS applications. Amongst them, only two (Whim and UbiGo) offer a MaaS scheme reflecting the full notion of MaaS including a considerable range of transport modes and Level 5 payment options. Whim constitutes a "broker" governance model and may be described as an investment project. It includes most mobility modes (public and private) and three payment options: pay-as-you-go; a monthly subscription with limited use of on-demand services and an annual subscription with unlimited usage of on-demand services. As a "broker" model, all risks are concentrated on the broker, consequently on the investors, as due losses and profits. UbiGo is a spin-off financed by Vinnova. The Gothenburg application, despite meeting project expectations (increased transport options, easier payment, tracking expenditures, and reduced need for private car ownership) folded with the completion of the project. The effort was confronted with low revenues due to less than expected car rental and car-sharing services demand and the cost of purchasing public transport services as regulation prevented the reselling of the public trasnport services at reduced cost. Furthermore, the introduction of a registration fee or a minimum amount in advance was not well received by the users (Jittrapirom et al, 2017).

From an environmental point of view, MaaS is expected to provide respective benefits by supporting the use of e-vehicles. SHIFT was an ambitious investment project (Project 100) in Las Vegas planning to combine Uber and autonomous vehicles (had placed an order for 100 Tesla vehicles) closed down considering the investment that still needed to be placed

before the project could take-off. Moovel, in Germany, is a partnership between Daimler AG and the BMW Group providing in combination three applications: Carsharing, taxi-hailing, and rail, along with a trip planner application. Their key scope is to promote e-vehicle usage. However, the payment option they offer is low (Level 2) by which they avoid the revenue allocation challenge. Hannovermobil, funded by the public, is also an application in support of e-mobility reverting to separate bookings.

Of the remaining applications listed: one is purely a trip planning app (TransitApp) and six (Qixxit, Switchh, Mobility Mixx, NS-Business Card, Radiuz Total Mobility, Tuup) address different target users providing respective flexibility but with payment options that are either based on pay-as-you-go (or charge-as-you-go) schemes or redirecting to separate bookings. Again, these are low risk applications of MaaS avoiding the revenue/demand risk and setup as broker schemes.

Finally, interesting is the case of the partnership between STIB (public transport and rail operator) and Cambio (and also other ride-sharing, bike-sharing and park & ride services). The scope of the alliance is to extend STIB services and network using on-demand services. The scheme consists of promoting each other's services and positive results (increase in public transport ridership, decrease in car usage, etc.) have been reported. However, each partner in the alliance, despite promotions on own services offered in favour of the other partners, continues to receive separate revenues from usage.

Table 5.1
MaaS initiatives reviewed

MaaS Schemes	Coverage Area	In Operation Y/N	MaaS Operator Type	Urban Public Transport	Bike Sharing	Car-Sharing	Car Rental	Taxi	Rail	Parking	Flights	Coach	Governance Model	Revenue Allocation
STIB+ Cambio	Brussels	Y	PU	X	X	x		X	X	x			Alliance	Not required. Independent service.
Qixxit	Germany	Y	PR						X		x	X	Broker/Level 2	Not required
Moovel	Germany	Y	PR			x	X	X	X				Broker /Level 2	Not required
Switchh	Hamburg	Y	PR		X	x							Partnership/Level 2	Not required
Hannove-rmobil	Hannover	Y	PU			x		X	X				Partnership/Level 2	Not required
Mobility Mixx	Netherlands	Y	PR	X	X	x	X	X	X	x			Broker /Level 2 & 3	Not required
NS-Business Card	Netherlands	Y	PR	X	X	x	X	X	X	x			Broker /Level 3	Not required
Radiuz Total Mobility	Netherlands	Y	PR	X	X	x	X	X	X				Broker /Level 3	Not required
TransitApp	US, Canada, Europe, Australia	Y	PR	X	x	x		X					Broker/Level 1	Not required
Tuup	Finland (Turku region)	Y	PR	X	x	x	X	X		x			Broker/Level 1 & 2	Not required
Whim	Helsinki, Antwerp, Birmingham	Y	PR	X	x	x	X	X	X				Broker/Level 3 & 5	Not required
SHIFT	Las Vegas	N	PR		x	x	X						Broker/Level 3 & 5	Not required
UbiGo	Gothenburg	N	PR	X	x	x	X						Partnership/Level 5	Pilot project with public support

The reflection on the current practice suggests that the emphasis of current efforts is on setting up the applications, manoeuvring regulatory and other institutional issues and addressing revenues through minimum profit configurations, which are not sustainable in the long-run.

A final point of interest is that in the United States most applications are orchestrated by the private sector (Pöllänen, 2018; Buehler and Pucher, 2012) and emerging mobility service operators/providers are more likely to be the champions of MaaS (House, 2018). However, Polydoropoulou et al. 2019 identified that the MaaS actors expect a leading role by public transport authorities in Europe. This is considered critical by relevant actors for a successful deployment of MaaS.

5.3   Lessons learned on bundling services and goods from other sectors

The bundling of services and goods is a known marketing strategy that has been applied for several years in a variety of sectors (e.g. finance, tourism, health care, telecommunication, museums) in order to attract demand and achieve economies of scale (Guiltinan, 1987; Cataldo and Ferrer, 2017; Fanga et al., 2017). Initially, companies concentrated on tying goods and services (tie-in sales or pure bundling), while over time, especially in the sectors which considered to be competitive, they begun to use mixed bundling strategies, where goods and services, are available both individually as well as part of a package (Guiltinan, 1987; Venkatesh and Mahajan,1996).

Bundling can be applied either by one company, which offers as a package a combination of its goods and services, or by different entities which choose to bundle their services and goods and offer them as a package to potential customers. The former is mostly observed in the telecommunication industry, where companies offer "double" or "triple" packages, which includes landline telephony, Internet and digital/satellite television (Klein and Jakopin, 2014), while the latter has become quite popular recently in the hospitality sector. Online travel aggregators such as Expedia offer vacation packages that include a variety of products and services from different companies (e.g. hotels, plane tickets, car rentals), while several museums around the globe have created passes (i.e Paris Museum Pass, Berlin Museum Pass) granting access to their facilities for a certain period of time (i.e. 48 hours, 3 days, etc.) at a discounted price. The main challenge when different companies choose to bundle their services and products is how the generated revenues will be distributed among them.

The use of Shapley value (Sharpley, 1953), where the revenues generated by the bundled services/goods are equally distributed between the service/goods providers has been proposed by Ginsburgh and Zang (2003) for the Museum pass challenge. An extension of this approach would also consider the relative "power" that each service provider brings to the package by taking into consideration additional factors, such as the reputation of the museum or the importance of its collection. Nevertheless, this approach has been questioned by Fernandez, Borm and Hamers (2004), on the ground that it does not take into account the asymmetries that usually exists, considering the regular tickets prices and the number of visits a pass holder may conduct.

From the above discussion, it has become evident that other sectors have been dealing with similar problems and a number of potential solutions to each of them already exist.

5.4   The Revenue Allocation Challenge

The revenue allocation challenge is profoundly related to the Revenue Challenge. As a new innovation concept, MaaS is primarily faced with the issues of deployment and market uptake. It is faced with integration costs and the complexity of coordination (see Chapter 2), governance and the subsequent agreements between partners; all within the uncertainty of users' willingness-to-pay for services.

The overview of current applications reflects the aforementioned uncertainty, which is addressed through a very conservative approach to the implementation of the MaaS concept. This approach is neither supportive of a disruptive nor destructive innovation.

In order to address the uncertainty, factors such as demand, revenues and search for breakeven point are discussed in this section. As every effort in support of integration, MaaS is also faced with three potential outcomes that need to be considered as part of risk assessment:

- Synergy, when the result is greater than the individual outcomes before the effort;

- Additivity, when the result is equal to the individual outcomes before the effort; and

- Substitutability, when the result is less than the individual outcomes before the effort.

5.4.1   Demand

5.4.1.1   *The risk of additivity*

There is significant uncertainty with respect to demand for MaaS services and offers. However, the demand for each individual modality offer is known to the respective operators. The fact that seamless travel might introduce a shift from the use of the private car to on-demand or public transport services is of considerable certainty. Therefore, the key risk operators are faced with is "additivity" as a result of MaaS, expressed as demand shifting from one modality/operator to another. This risk is of particular importance to public transport operators, where modal shift may manifest towards more personalized mobility options such as car-sharing (Le Vine and Adamou, 2014).

5.4.1.2   *Attractiveness in the number of options*

Mobility users are faced with the multiple mobility options and their respective applications. They need to combine, evaluate and assess information and then carry-out multiple transactions to complete their door-to-door trip. The result is usually to revert to the most comfortable means of transport, i.e. often their own private car. The MaaS offer becomes all the more attractive when all possible modes of transport are included in the same platform. Reasonably, Kamargianni et al (2016) propose an index for Mobility integration, which is principally weighted on the number modes/operators included.

However, while users are attracted by the number of available mobility options not all services will be used. The prevailing issue, in this case, is whether these operators will be compensated. Notably, the question is directly relevant for level 5 payment options, it is of equal interest also for lower level payment options.

Researchers of the Museum Pass problem, addressing the above issue, propose a flat rate in addition to revenue allocated according to revenue allocation rules. This approach might apply equally to accommodate the needs of each case either in an "partnership" formation of partners or as a basis for negotiation the pricing of time or tickets if a "broker" is championing the MaaS endeavour.

5.4.2.   Revenues

5.4.2.1   *Customers*

Revenues are, of course, the result of demand, costs and price paid. Related to the payment options, it is evident that Level 1 to 3 payment options (trip planner, separate bookings/payment, pay-as-you-go) do not provide significant viability as they might only achieve a reduction in customer services costs for mobility providers and minimum returns to MaaS operators, through possibly, site advertisements or other website generated revenues. The risk of additivity is also present even for lower level payment options. Risks increase for higher level payment options, where subscription packages are offered. Pricing packages and identifying a balance between user willingness-to-pay and package cost is not always straightforward. For example, a study undertaken by Ho et al (2018), revealed that half of their survey respondents would take up a MaaS offer but their willingness-to-pay in many cases was below the current market price of services. On the contrary, Polydoropoulou et al (2019) found travellers to be willing to pay more than the current market price of services. Also, travellers are hesitant in pre-paying for services or even a minimum advance (Jittrapirom, 2017).

Consequently, implementing payment options of lower level, allows for traveller confidence and trust to be built but does not eliminate the risks mobility operators/providers are facing nor provides the grounds to create risk portfolios nor increase operational efficiency leading to lower operational costs.

5.4.2.2 Subsidies

MaaS should extend the "sustainable" characteristics of a public transport system. Considering social benefits and welfare, public transport is most often subsidized to compensate for low ridership and/or price/fare reductions needed and assumed socially important. In the same context, these subsidies to public transport might extend to public transport within the MaaS offer.

Building on this approach, one questions whether MaaS also contributes to the same sustainability goals as public transport and in this context, if MaaS should be subsidized. In many cases, MaaS applications today constitute funded projects or investment projects (where investors are probably seeking long-term returns). Hence, alternatives to subsidization are already present. However, a more structured approach would benefit the MaaS operational efforts and could, possibly, be related to improved levels of sustainability achieved through an extended "public mobility service". Currie et al (2018) based on a framework proposed by De Gruyter et al. (2017) provide a methodology and scores for public transport sustainability performance for 88 cities in the world. These are based on indicators reflecting apart from economic, environmental and social sustainability as well as system effectiveness. Subsidies could be attached to agreed sustainability goals.

Despite the potential benefits, there is increasing evidence that support through subsidies is not favoured, as in many cases respective regulation is limiting (Jittrapirom, 2017). This translates in the MaaS service buying public transport fares at a price higher than these are sold to the public and the public authorities requesting that private on-demand mobility providers subsidize public transport services.

5.4.3 Seeking the breakeven point

In any cost and returns function capital expenses (CAPEX) and operational/maintenance costs (OPEX) need to be balanced by the revenues. The simple cost and returns function for a MaaS endeavour at the breakeven point might be described as below (Polydoropoulou et al, 2018):

$$CAPEX(t)+OPEX(t)=\sum_n P_n\ S_n(t)-\sum_m \left[\sum_n C_n\ R_m(t)\right]$$
(1)

Where:

CAPEX is the amortization of the initial investment (capital cost) in year t

OPEX is the operational and maintenance (O&M) costs of the MaaS in year t

P_n and S_n is the nth promotional package and its sales of year t,

R_m are the returns to the mth operator participating in the MaaS offer in year t, and

C_n is the consumption of the P_n package sold. C_n is assumed to follow a normal distribution, which over time and as users become more aware of their usage patterns, the standard deviation will decrease, and C_n will tend to 100 per cent consumption.

Figure 6.4
Figurative representation of Cn (Polydoropoulou et al., 2018)

Cn→ 100%
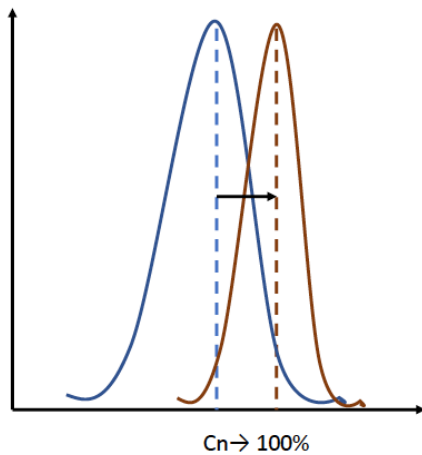
5.4.3.1 *Breakeven for the Broker*

In this configuration, the MaaS operator/provider "buys" availability through bilateral agreements from the other mobility service operators/providers at reduced prices. The reduction offered will be based on:

- Current excess capacity of the provider

- Provider profit margins

The scope of the negotiation would be to reduce the value of the term $\sum_m \sum_n C_n R_m(t)$.

Mobility providers with no excess capacity or with marginal profit margins (e.g. Public Transport Operators) will not be able to offer reductions. As noted previously, total risk is allocated to the "broker", who will need to strive on demand (n) in order to break even.

5.4.3.2 *Breakeven for the Partnership*

In this configuration, the initial breakeven equation places emphasis on the term $\sum_m \sum_n C_n R_m(t)$, i.e.

$$\sum_m \sum_n C_n R_m(t) = \sum_n P_n S_n(t) - CAPEX(t) - OPEX(t)$$

Revenues to be shared result after MaaS CAPEX and OPEX are covered. Once again, there are variants to be considered. Notably, the remaining revenue to be allocated to operators is a function of package underusage $(1\text{-}C_n)$ in combination with demand (n). Revenues may then be allocated to mobility providers following the Kalal-Smorodinsky rule or other relevant revenue allocation rule, which also applies in cases of bankruptcy when the value of assets is lesser than the value demanded by creditors.

The above approach may have variants to accommodate for mobility providers, of whom services were present in packages sold but not consumed by the user. In this case, for each package a minimum flat rate could be initially agreed upon per package independent of the services consumed, while the remaining sum is allocated following the overall agreed rule.

In both approaches, in an underdeveloped market where demand for MaaS services is still building up, economic viability is achieved through the under-consumption of subscriptions packages. This is neither sustainable nor fair for the user and could have negative ramifications for MaaS deployment.

5.5 Addressing the revenue allocation challenge

Economic sustainability is a primary goal, also attached to the MaaS concept primary objective: the reduction of private car usage and, potentially, ownership in favour of MaaS. This goal requires time in order to address the key barriers of over-regulation, inconsistent

quality of service and the need for recommendation (trust building). It also requires information on the new travel behavioural patterns to be collected so as mobility packages suited to travellers needs and supporting a profitable portfolio to be structured and, appropriately, promoted. In other words, while the personal communication market as well as other markets might serve as an example in addressing the revenue allocation challenge, their usefulness can only be exploited at a future stage when the MaaS market has matured.

In the meantime, mobility service providers wishing to entry a MaaS endeavour need to assess a number of issues and address them in cooperation with peers competing in the same and for the same market. Figure 6.5 describes the decision points leading the assessment and formulating the MaaS governance, business and revenue allocation model.

Figure 6.1
Decision points leading the revenue allocation challenge
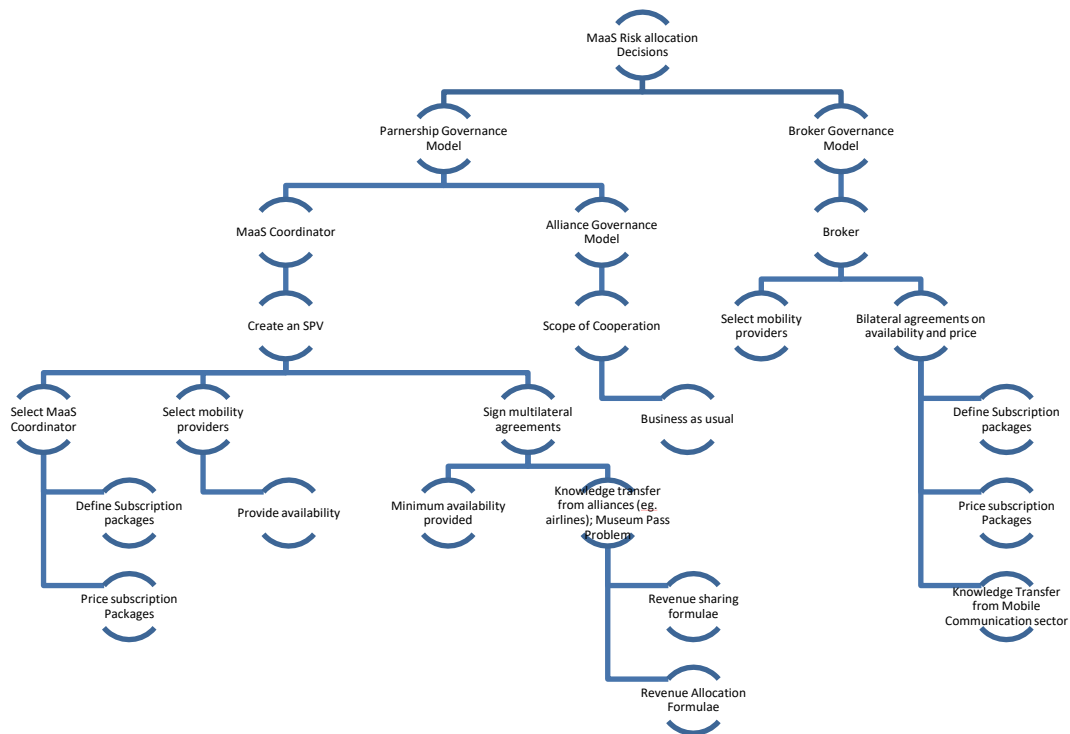
It is worth noting that, to-date, no "partnership" model has emerged corresponding to "MaaS Coordinator", while only the STIB+Cambio case to be considered as an "Alliance" model.

Chapter 6

MaaS infrastructure challenges

[work in progress]

Chapter 7

Conclusions and Recommendations

7.1 Conclusions

MaaS relies on the bundling of services and products, a marketing strategy that has been widely used in other sectors. Although there is a great interest on its development and usage worldwide, only a small number of MaaS schemes have been successfully deployed, most of them being the outcome of demonstrations as part of research funded projects.

In terms of MaaS platform, its development and bundling of a good number of services to make the offer interesting from the perspective of travellers can create a major challenge due to different technology and information standards (data integration challenge).

For car- and bike-sharing, their accelerated development, potentially bundled with other mobility service through MaaS, to compete against private car ownership requires that, in addition to addressing the data integration challenge, also physical infrastructure challenge is addressed, i.e. adequate infrastructure is available to make the services easily accessible. For bike-sharing, also safe and dense infrastructure in terms of cycling dedicated lanes needs to be provided. MaaS has the potential to enhance the growing transition of the sharing economy, but it relies on public-private collaboration models to prevent maldevelopment.

When it comes to MaaS business models, currently, the vast majority of MaaS business models is based on the broker model, where the MaaS provider bears all the risks and the mobility service providers/operators obtain an additional selling point. In such cases, the revenues generated by MaaS do not need to be distributed among the mobility service providers/operators, which are compensated for their participation through the: (a) potential increase of their market share and (b) any price difference that may exist between actual price of the product/service (when the product is sold individually) and the price that the product/service is sold to the MaaS provider (in order to be offered as a bundled product/service).

The observed preference of the MaaS providers towards the broker model compared to the partnership and alliance governance models, can be attributed to the trial nature of these MaaS schemes; where involved actors are mostly interested on testing this new mobility concept and validating its viability, benefit and potential impacts.

Generating revenues, as well as allocating them to the different parties do not appear to be of interest at this early stage of MaaS. It is anticipated that in the coming years, as MaaS evolves and actual data from demonstrations and existing commercial efforts, such as WHIM, becomes available, more complex governance models, such as the partnership model, will be adopted.

The main challenge of the latter models is to identify the most appropriate revenue allocation approach, to ensure that the interests of all the involved entities are accomplished.

7.2. Recommendations

MaaS deployment can be accelerated with supportive actions and policies. It is recommended to:

[work in progress]

- Local authorities set out a clear vision and strategy on how to integrate car sharing into a MaaS platform in a way that is cost competitive and reduces private car ownership.

Local authorities should consider appropriate methods of sharing data in a way that is fair to consumers and businesses to increase opportunities of integrating into a MaaS platform.