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Mobility as a Service (MaaS) in the UK: change and its implications

Future of Mobility: Evidence Review

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Mobility as a Service (MaaS) in the UK: change and its implications

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1. Introduction

What is MaaS?

Mobility as a Service (MaaS) is a term used to describe digital transport service platforms that enable users to access, pay for, and get real-time information on, a range of public and private transport options. These platforms may also be linked to the provision of new transport services (UK Parliament, 2017).

In scientific terms, MaaS is defined as a 'digital interface to source and manage the provision of a transport related service(s) which meets the mobility requirements of a customer' (The Transport Systems Catapult, 2016).

The key point about MaaS is that it envisages users buying transport services as packages based on their needs instead of buying the means of transport (Kamargianni et al., 2016). Current UK examples of MaaS include the app Whim in the West Midlands, and MaaS Scotland. Whim has been designed by Helsinki-based MaaS Global and offers a range of monthly plans, bringing in National Express, Transport for West Midlands, Gett, Nextbike and Enterprise rent-a-car as transport providers. MaaS Scotland is a joint venture operated by Technology Scotland and ScotlandIS, and has pilots starting this year in Highlands, Island and Cities areas.

MaaS can be perceived as a one-stop online ICT interface comprising:

- an intermodal journey planner (providing combinations of different transport modes: car-sharing, car rental, underground, rail, bus, bike-sharing, taxi, etc.) that operates in real-time
- a single payment portal like that for smartphones, whereby users can pay as they go or else buy a 'service bundle' in advance
- a booking system incorporating the entire end-to-end journey stages

MaaS providers generate revenues in two ways (The Transport Systems Catapult, 2016):

1. When a traveller buys a service bundle of transport journeys through the MaaS provider, the MaaS provider would take a fee before passing on those revenues to the transport operators that delivered the service.

2. MaaS providers can generate income through the data that their Digital Service Platform generates. Other transport operators and/or software service providers may be able to use this data to help further enhance their service offerings.

How did MaaS come about?

MaaS has emerged from two main sources:

1. From the transport side it is derived from a long-standing desire by policymakers to deliver 'total journey solutions' (Potter and Skinner, 2000), by seamlessly integrating:

    - public transport routes (e.g. Tabassum et al., 2017)
    - timetables (e.g. Ibarra-Rojas et al., 2015)
    - information (e.g. Tavares et al., 2015)
    - ticketing (e.g. Puhe, 2014)

In particular, much good work stemmed from small-scale Dial-a-Ride (DaR) and Demand Responsive Transport (DRT) service trials in Scandinavia, Germany, the Netherlands, North America and the UK (e.g. Ambrosino et al., 2016). Related to this, the evolution of car- and bicycle-sharing solutions since the 1970s has become blended within this picture (e.g. Shaheen et al., 2012).

2. From the computing side, 'Mobility' is one of dozens of 'as-a-Service' concepts (e.g. Software, Ontology, Routing, Monitoring) now being marketed (Sharma, 2016), and this revolution in data processing capability is now transforming the transport sector.

In simplistic terms, this joint heritage has led to two main forms of MaaS-type schemes:

- there are the relatively local/regional-level, multimodal and often local authority or public agency 'transport or society-led' solutions, such as Ubigo, SHIFT, EMMA, Mobility Mixx, HannoverMobil, Moovel, Chariot or Qixxit, (Kamargianni et al., 2016; Ambrosino et al., 2016)
- there are the internationally focused, larger-scale, uni-modal and private-sector 'commercially led' solutions, such as Lyft and Uber (and formerly Bridj), which though possibly not strictly MaaS as currently defined, are currently by far the most significant actors in this space (Watanabe et al., 2016)

2. The changing mobility system

Pre-MaaS transport

Traditionally, mobility systems have comprised fixed assets (such as rail tracks or road ways, power and control equipment, storage and maintenance depots, and passenger stations and stops) and mobile units (vehicles) which, when combined together with a set of (often extremely strict) rules for their operation, enabled the movement of goods and people (Ortuzar and Willumsen, 2011). This means that:

- users have very little direct ability to influence the type/level of public transport service they receive, certainly in the immediate term, unless they can access a lift, or else pay significantly more to opt for a taxi or minicab
- operators are legally required to provide the services they are registered to, whether or not anybody actually uses them on a particular day
- services are initially introduced based on limited amounts of historic customer needs/preference data, which is then aggregated and averaged across the day/week/year and the route network, using ticketing data where available

In practice, this approach was likely 'good enough', because the economic and regulatory reality dictates that an operator is heavily constrained in terms of the size of vehicle that can be operated, the route characteristics, and the timetable over the course of a normal day. Also key is that the operators or service providers must be licensed and so are clearly identifiable and tightly regulated.

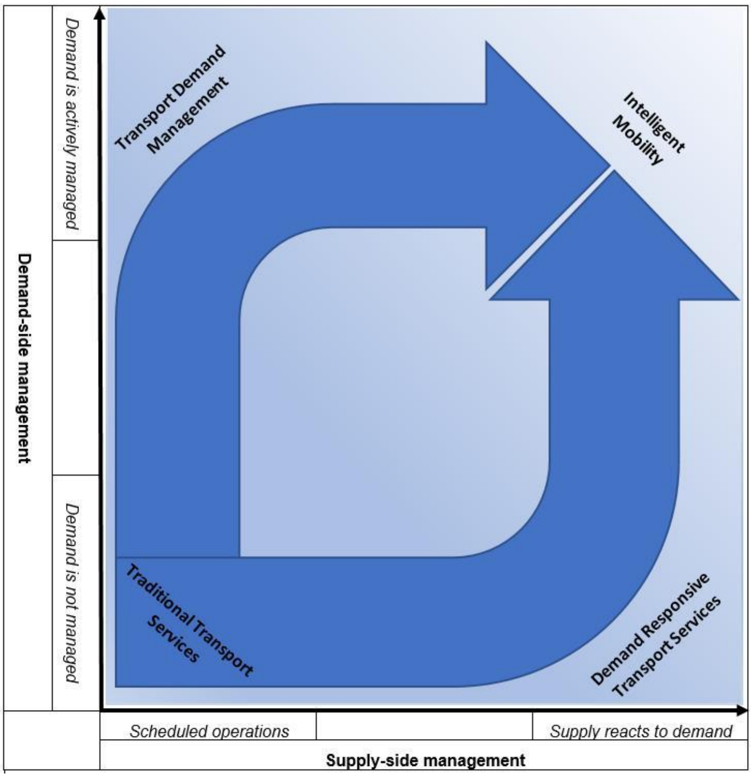
MaaS transport

With Mobility as a Service the first key change is that transport users and providers now communicate their needs instantaneously via Digital Service Platforms (DSPs) – i.e. two-sided markets or brokers – which, for a suitable charge, make the most appropriate journey match (Djavadian and Chow, 2017). The second key change is the emergence of a whole new suite of shared services (e.g. lift sharing, bike sharing, micro-transit, car club schemes) (Shaheen, 2016). These changes theoretically mean that:

- users can now tell (multiple) operators of (multiple types of) transport service exactly the attributes they want from a transport service: time of arrival, origin and destination points, degree of flexibility, type/level of comfort required, and price they are prepared to pay
- providers, which are growing in number and offer a broader range of services than before, can choose to respond or not
- users, providers and regulators can readily monitor service availability and hence adjust their travel behaviour, market strategy, or policy decisions accordingly

In principle, this should result in services that are essentially customer-led and tailored to the actual conditions in the market at any given time to the benefit of all – not least because suppliers can 'dip in and out' of the sector as they like. This 'paradigm shift' from the traditional operator-led public transport environment described earlier is illustrated in Figure 1. Effectively, MaaS is able to actively manage both supply and demand in near-real-time and in parallel – something which was not possible before (Hensher, 2017).

Figure 1: Transition pathways: Provider-led to user-led paradigm (bottom left to top right)



Current MaaS research areas

The goal of actively managing supply and demand is clearly a worthy one, not least from a commercial perspective, and consequently there is a significant amount of work underway in the sector (Shaheen, 2016) – much of which is likely to be confidential. Specific **areas of operational focus** include:

- improvements to the Digital Service Platforms (e.g. Ruutu et al., 2017)
- how best to optimise vehicle dispatch locations (Dimitriou et al., 2016)
- surge pricing and labour supply (Zha et al., 2017)
- research on exploring demand dynamics (Kourti et al., 2017)

Payment and ticketing systems are another topic. For instance, the idea of using electronic fare coupons for public transport has been explored as a means of developing a revenue stream that is suitable for MaaS (Chow, 2014).

There is also research into **potential MaaS markets**. Thus, Zha et al. (2016) conducted an economic analysis of ride-sourcing markets, and Harding et al. (2016) examined the impact of Uber-type solutions on the taxi market.

Privacy and security of MaaS systems is another area that has been studied (e.g. Belletti and Bayen, 2017), while papers have been written about the legal and institutional issues around MaaS; e.g. Flores and Rayle (2017) presented a case study of the regulatory approach around Uber and Lyft in San Francisco.

Relatively little has been written so far about the **vehicle to infrastructure interface** in MaaS, though there is a significant amount about the technological workings of vehicular ad hoc networks (VANETs) which enable vehicles to communicate with each other (V2V), as well as with roadside infrastructure units (V2I), for instance (Benslimane, et al., 2011). One exception is where MaaS features in an article on slot booking systems (Lamotte, et al., 2017). Interestingly, very few references using the terms ‘Freight’ or ‘Logistics-as-a-Service’ were found, and these were focused very much on the technology of the Digital Service Platforms involved (e.g. Nowicka, 2014; Niharika and Ritu, 2015). Instead, terms such as ‘Smart Logistics’, ‘Smart City Logistics’, ‘Smart Connected Logistics’, and various others are used. Grazia Speranza (2016) gives some ideas as to how these concepts are likely to evolve in the future.

3. Drivers of change in personal and societal demand for mobility services

Technology drivers

Perhaps the most important driver of change is technology. Digitalisation, and the generation and sharing of data, incorporating the internet of everything (IoE) and including sensors, mobile devices and consumer electronics, provide 'the most significant technological trend faced globally' (Leviäkangas, 2016). This is especially true once the devices are combined with internationally integrated telecommunication infrastructure and advanced programming algorithm methodologies. In future, not only transport, but the reasons why people travel (employment, leisure, shopping) will be affected, and in ways that are very difficult to predict. For MaaS, crowdsensing – whereby transport and other personal-level data is collected from sensing devices such as smartphones from a large number of users and analysed using a common ICT platform in order to enhance community wellbeing – is one especially interesting developing technology (Heiskala et al., 2016). In addition, the shift towards increasingly autonomous vehicles (Alessandrini et al., 2015) represents a major change in how transport will be delivered in future.

Political drivers

The global economic recession has led to significant cuts to public transport subsidies in many countries (Stiglitz, 2010). This has had the effect of making bus and rail services less attractive and less viable in many areas. Similar effects have arguably also been a by-product of political moves to deregulate certain policy sectors (such as planning, for example), and the ideal of promoting 'choice' as a means of driving up service quality (for example, in schools and healthcare). On the other hand, concerns about climate change, energy security and poor air quality have pushed governments towards 'encouraging' people not to use their cars wherever possible, by increasing fuel taxes or banning vehicles from city centres, for example.

Institutional drivers

Change is also taking place within companies that supply intermediate transport modes (i.e. those which fill the gap between public and private transport). One aspect is that the previously distinct car leasing and rental sectors are becoming 'increasingly blurred', which is important because nearly 55% of all new cars sold in the UK in August 2017 were leased (see SMMT, 2018). Additionally, multinational transport corporations are now investing in the new intermediate modes. For instance, in recent years rental car provider Avis Budget bought out car sharing operator Zipcar to expand its market reach, and car manufacturer BMW launched DriveNow, a point-to-point car sharing service, in partnership with car rental firm Sixt.

Social drivers

Social influences include the rising proportion of elderly people who will no longer be able to drive, and younger people who are likely to continue to be increasingly excluded from car ownership and use through more demanding driving tests and rising insurance premiums, as well as attitudinal factors (Delbosc and Currie, 2013). There is also a new culture of 'collaborative consumption', whereby material possessions such as power tools, as well as houses and cars (e.g. see Cheng, 2016), are being lent and borrowed. Meanwhile, attitudes to issues such as privacy are also continuing to develop (Cruickshanks and Waterson, 2012).

Economic drivers

Economic factors (not least the global economic recession) have also heavily impacted economic growth, affecting the demand for goods and services, employment levels, and purchasing power (Stiglitz, 2010). This has not only had an effect on overall travel demand, but rising transport costs could also well be a core driver in pushing shared mobility options.

All these factors have important implications for how people and goods are moved.

4. Research findings: Mobility trends, MaaS and the user, and societal impacts

Mobility trends

One (as yet unpublished) study output from the New Zealand Ministry of Transport's PT2045 project devised four scenarios, of which two – 'Mobility Marketplace' and 'Competitive Commons' – involve MaaS elements.

- Mobility Marketplace assumes a low population density setting and that while sharing will be common, the private car remains important

- the Competitive Commons speculates that car ownership will be less important in a high-density environment and that more sharing options will be available

Another future is proposed in Enoch (2015), which suggests that current trends could lead to a convergence of modes towards a universally used, driverless 'dial-a-pod' taxi service.

In bringing these findings together, Snellen and de Hollander (2017) suggest that the increasing choice of transport options will lead to a more informed demand for mobility services. At the same time, more reliable, personalised and dynamic information about alternative available transport services will mean that the need to drive one's own car will decrease. In addition, travel time will become more productive, the geography of destinations will change, and the mobility system will become yet more complex, especially with the advent of self-driving vehicles.

Taking a similarly broad view, Figure 1 suggests how the design of the 'public' transport' service may begin to evolve in the future as a result of the changing circumstances mentioned, and how the operational mindset may need to adjust.

MaaS and the user

On one of the rare studies of a small-scale MaaS operation undertaken so far, on **Ubigo** in Gothenburg, the key service attributes identified by users included the 'transportation smorgasbord' concept, simplicity, improved access and flexibility, convenience, and economy (Karlsson et al., 2016).

Other research directions include:

- studies on the growth and development of **Uber** (e.g. Watanabe, et al., 2016; Harding, et al., 2016; Watanabe et al., 2017)

- a report on the importance of personalisation settings in shared vehicle environments (Kuemmerling et al., 2013)

While the Transport Systems Catapult (2016) called for more research to determine the impact of MaaS on people's travel behaviour, reporting that the effects were 'unknown', in the same year the American Public Transport Association reported the following findings on the shared transport sector:

1. people who used shared transport modes tended to own fewer cars than users of public, but not shared, transport

2. shared modes complement public transport use: they are used most often when public transport is not an attractive alternative

3. shared modes will continue to grow in significance

4. there is a need for institutional changes if the sector is to mature in a desirable way

MaaS operations

Taking a market perspective, success for MaaS providers depends on 'gaining a critical mass of end users, developers, and service providers and achieving self-sustaining growth and scalability' (Ruutu et al., 2017).

A successful pricing structure is key to this, as is the size of the competitor 'ecosystem', as well as the degree of interoperability and level of standardisation between the different platforms. These may be quite difficult to achieve in practice, given the wide variety of local and regional operational contexts in which MaaS will need to develop.

Having a single integrated provider can prove problematic: the Ubigo system in Gothenburg was found to rely on a transport system that was not only blurred between modes (in terms of services, infrastructure, information, and payment), but also between public and private operators – which in the end proved challenging due in part to the regulations and institutional barriers (Karlsson et al., 2016).

MaaS societal impacts

The sharing of autonomous vehicles (AVs) is seen as an important way to limit the potentially negative externalities of rapid AV adoption, such as additional vehicle use, congestion and sprawl (Gruel and Stanford, 2016).

In fact, simulations of autonomous shared taxi solutions in Lisbon (Martinez and Viegas, 2017) reported a 45% per kilometre discount on current public transport fare levels; and a significant land saving in cities (if properly 'locked in'). As a result, it may be desirable for shared fleets to directly compete with (and possibly even replace) taxi and bus services – although this would require changes to public governance.

In other studies:

- the Transport Systems Catapult (2016) found that societal impacts could potentially be significant and will need to be carefully managed

- Hensher (2017) found that that MaaS provides a real opportunity to match customer needs more closely to service supply and to reveal the real contribution of conventional public transport services, but this is likely only if institutional frameworks can be modified to allow them to work

- Rio (2016) looked at the influence of Uber on ethnicity in Baltimore

- Cheyne and Imran (2016) explored the effects of MaaS on energy use in small towns in New Zealand

5. Implications for decision makers

Key challenges

MaaS is still at a very early stage in its development, as highlighted by the recent failures of two high-profile examples, both for financial reasons (Djavadian and Chow, 2017):

- **Kutsuplus** in Helsinki failed because large scale was needed to make the economics work, but the significant cost of doing that was too much for the local authorities that were subsidising the service

- **Bridj** in the USA ceased operating when it could not find a major investment partner to scale up its operations

These examples show that a great deal more research (and no small amount of investment) is plainly needed. In particular, key policy challenges will focus on the accessibility, availability, (cost) efficiency and acceptability of transport, while policymakers will need to switch from a reactive mode to be more proactive (Snellen and de Hollander, 2017).

The reliance of MaaS platforms on real-time information means that data sharing is critical for successful MaaS trials. Transport providers' unwillingness to share data would clearly act as a barrier to achieving a minimum level of MaaS that works. Many of the data challenges are not unique to the transport sector but are pertinent to it: lack of common standards; commercial sensitivities and vested interests; lack of clear business models; issues around privacy and security to name but a few (UK Parliament, 2017).

Clearly, to enable MaaS to work between users, public and private providers, agreed data protocols and data sharing are needed. Government has an important role to play in setting open data policies and frameworks and creating the right ecosystem and conditions to attract business and users to use and share data. Industry too has a key role to play; for example, in developing open standards with government and in promoting the value of data that can extracted by sharing data (Department for Transport, 2017). Both government and industry must cooperate and collaborate to overcome these challenges and unlock the benefits from new innovations, which have been estimated to be £14bn by 2025 (Transport Systems Catapult, 2017).

Policy options

The American Public Transport Association (2016) proposes that public transport agencies become Mobility Agencies, and that they form partnerships and collaborations with (a wider range of) service providers. It adds that data and payment application programming interfaces (APIs) need to be standardised, and that administrative subsidy and investment programmes should be more targeted and transparent.

Similarly, Miles and Potter (2014) suggest that the role of local authorities will need to become less directive (e.g. as project managers/clients, funders, and service providers). Rather, they will need to become more facilitative and supportive of the 'new' sector in making connections and leveraging access to finance and other resources as a partner agency. In this respect there could be lessons to be learnt from the travel plan sector, where the most successful examples typically benefit from partnership working between non-traditional transport actors, transport operators, and local authorities (Enoch, 2011). One expectation might also be that subsidy provision shifts from the current dominant paradigm of supplier subsidies, to one where deserving users (e.g. young, unemployed, low income, senior citizens) making socially valuable journeys (e.g. health-related, commuting, business, education) are financially supported instead.

Walker and Marchau's 2017 study, on the uncertainties of implementing automated vehicle taxis, focused on the need for an adaptive or flexible approach to policymaking, so as to limit the potential for errors.

One approach could be to regulate the day-to-day aspects of each transport operator (driver licensing, subsidy allocation, etc.) almost as they are now, but then to classify operators by their level of specialism (e.g. occasional, regular, specialist), whereby the more specialist the operator, the tighter the regulations but the greater the operational benefits and opportunities (Enoch and Potter, 2016). This would mean that 'new' modes would no longer be forced into operating pre-conceived service patterns (constrained, for example, by limitations on number of seats, timetable schedules, route/area restrictions); and should allow for occasional providers to 'safely' join the transport market as the opportunity arises.

A need for flexibility

The above insights suggest that a great deal of uncertainty still pervades the future of MaaS, which suggests policymakers need to consider options of how to better deal with uncertainty.

There is also a feeling that a significant re-alignment process is already well underway. This will require serious consideration and the Government may wish to take positive action as soon as possible to effectively influence how this new transport paradigm ultimately develops.

In squaring this circle, the best approach would seem to be as open and flexible as possible to the opportunities that arise, while being careful not to become locked into particular paths too early. It is likely that the transport policy landscape will look quite different in the years to come as MaaS becomes both more mainstream, and potentially more complex and difficult to manage than many transport practitioners and policymakers currently imagine.

6. Conclusion

This report finds that MaaS does not yet have a major presence in either the research arena or in society more generally, though this could well change very quickly. This is because MaaS potentially offers a paradigm shift from transport being fundamentally provider-led (i.e. where fixed capacity is provided to serve a predictable demand), to being a fully user-led system whereby the level and type of transport supply continually adjust in response to the specific desires of individual travellers.

Accordingly, major challenges exist for policymakers, who will need to balance the promised benefits with issues such as safety, data security and privacy, equity and the threat of marketplace distortion by dominant unscrupulous suppliers.

7. References

Alessandrini, A., Campagna, A., Delle Site, Paolo, Filippi, F., Persia, L. (2015). Automated Vehicles and the Rethinking of Mobility and Cities. *Transportation Research Procedia, 5, 145–160*. doi: http://dx.doi.org/10.1016/j.trpro.2015.01.002.

Ambrosino, G., Nelson, J. D., Boero, M., & Pettinelli, I. (2016). Enabling intermodal urban transport through complementary services: from Flexible Mobility Services to the Shared Use Mobility Agency: Workshop 4. Developing inter-modal transport systems. *Research in Transportation Economics*, *59*, 179-184. doi: http://dx.doi.org/10.1016/j.retrec.2016.07.015.

American Public Transport Association (2016). *Shared mobility and the transformation of public transit* (March), p. 39. Available at: https://www.apta.com/resources/reportsandpublications/Documents/APTA-Shared-Mobility.pdf.

Belletti, F. and Bayen, A.M. (2017). Privacy-preserving MaaS fleet management. *Transportation Research Procedia*, 23, 1000–1019. doi: 10.1016/j.trpro.2017.05.055.

Benslimane, A., Barghi,S., Assi, C., (2011). An efficient routing protocol for connecting vehicular networks to the Internet. *Pervasive and Mobile Computing*, 7(1), 98–113. doi: 10.1016/j.pmcj.2010.09.002.

Cheng, M. (2016). Sharing economy: A review and agenda for future research. *International Journal of Hospitality Management*, 57, 60–70. doi: 10.1016/j.ijhm.2016.06.003.

Cheyne, C. and Imran, M. (2016). Shared transport: Reducing energy demand and enhancing transport options for residents of small towns. *Energy Research and Social Science*, 8, 139–150. doi: 10.1016/j.erss.2016.04.012.

Chow, J.Y.J. (2014). Policy analysis of third party electronic coupons for public transit fares. *Transportation Research Part A: Policy and Practice*, 66(1), 238–250. doi: 10.1016/j.tra.2014.05.015.

Cruickshanks, S. and Waterson, B. (2012). Will Privacy Concerns Associated with Future Transport Systems Restrict the Public's Freedom of Movement?. *Procedia – Social and Behavioral Sciences*, 48, 941–950. doi: 10.1016/j.sbspro.2012.06.1071.

Delbosc, A. and Currie, G. (2013). Causes of Youth Licensing Decline: A Synthesis of Evidence. *Transport Reviews*, 33(3), 271–290. doi: 10.1080/01441647.2013.801929.

Department for Transport (2017). *Scoping Study into Deriving Transport Benefits from Big Data and the Internet of Things in Smart Cities.* Available at https://www.gov.uk/government/publications/transport-benefits-from-big-data-and-the-internet-of-things-in-smart-cities

Dimitriou, L., Kourti, E., Christodoulou, C., Gkania, V., (2016). *Dynamic Estimation of Optimal Dispatching Locations for Taxi Services in Mega-Cities based on Detailed GPS Information.* IFAC-PapersOnLine, 49(3), 197–202. doi: 10.1016/j.ifacol.2016.07.033.

Djavadian, S. and Chow, J.Y.J. (2017). An agent-based day-to-day adjustment process for modeling 'Mobility as a Service' with a two-sided flexible transport market. *Transportation Research Part B: Methodological*, 104, 36–57. doi: 10.1016/j.trb.2017.06.015.

Enoch, M.P. (2011). *Sustainable transport, mobility management and travel plans*, Transport and mobility, Ashgate.

Enoch, M.P. (2015). How a rapid modal convergence into a universal automated taxi service could be the future for local passenger transport*. Technology Analysis & Strategic Management*, 27(8), 910–924. doi: 10.1080/09537325.2015.1024646.

Enoch, M.P. and Potter, S. (2016) Paratransit: the need for a regulatory revolution in the light of institutional inertia, in *Paratransit: Shaping the Flexible Transport Future*, Emerald.

Flores, O. and Rayle, L. (2017). *How cities use regulation for innovation: The case of Uber, Lyft and Sidecar in San Francisco.* Transportation Research Procedia. 25, 3760–3772. doi: 10.1016/j.trpro.2017.05.232.

Grazia Speranza, M. (2016). *Trends in transportation and logistics.* European Journal of Operational Research, 264, 3, 830-836. doi: 10.1016/j.ejor.2016.08.032.

Gruel, W. and Stanford, J.M. (2016). *Assessing the Long-term Effects of Autonomous Vehicles: A Speculative Approach.* Transportation Research Procedia, 13, 18–29. doi: 10.1016/j.trpro.2016.05.003.

Harding, S., Kandlikar, M., and Gulati, S. (2016). Taxi apps, regulation, and the market for taxi journeys*. Transportation Research Part A: Policy and Practice*, 88, 15–25. doi: 10.1016/j.tra.2016.03.009.

Heiskala, M., Jokinen,J-P., and Tinnilä,M. (2016). Crowdsensing-based transportation services – An analysis from business model and sustainability viewpoints*. Research in Transportation Business and Management*, 18, 38–48. doi: 10.1016/j.rtbm.2016.03.006.

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

Ibarra-Rojas, O.J., Delgado, F., Giesen, R. and Muñoz, J.C. (2015). Planning, operation, and control of bus transport systems: A literature review. *Transportation Research Part B: Methodological*, 77, 38–75. doi: http://dx.doi.org/10.1016/j.trb.2015.03.002.

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

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

Kourti, E., Christodoulou,C., Dimitriou,L., Christodoulou,S., and Antoniou, C. (2017) Quantifying Demand Dynamics for Supporting Optimal Taxi Services Strategies. *Transportation Research Procedia*, 22, 675–684. doi: 10.1016/j.trpro.2017.03.065.

Kuemmerling, M., Heilmann, C. and Meixner, G., (2013). *Towards seamless mobility: Individual mobility profiles to ease the use of shared vehicles.* IFAC Proceedings Volumes (IFAC-PapersOnline). IFAC. doi: 10.3182/20130811-5-US-2037.00029.

Lamotte, R. de Palma, A. and Geroliminis, N. (2017). On the use of reservation-based autonomous vehicles for demand management. *Transportation Research Part B: Methodological*, 99, 205–227. doi: 10.1016/j.trb.2017.01.003.

Leviäkangas, P. (2016). Digitalisation of Finland's transport sector. *Technology in Society*, 47, 1–15. doi: 10.1016/j.techsoc.2016.07.001.

Martinez, L.M. and Viegas, J.M. (2017). Assessing the impacts of deploying a shared self-driving urban mobility system: An agent-based model applied to the city of Lisbon, Portugal. *International Journal of Transportation Science and Technology*, 6(1), 13–27. doi: 10.1016/j.ijtst.2017.05.005.

Miles, J. and Potter, S. (2014). Developing a viable electric bus service: The Milton Keynes demonstration project. *Research in Transportation Economics*, 48, 357–363. doi: 10.1016/j.retrec.2014.09.063.

Niharika, G. and Ritu, V. (2015). Cloud architecture for the logistics business. *Procedia Computer Science*, 50, 414–420. doi: 10.1016/j.procs.2015.04.013.

Nowicka, K. (2014). Smart City Logistics on Cloud Computing Model. *Procedia – Social and Behavioral Sciences*, 151, 266–281. doi: 10.1016/j.sbspro.2014.10.025.

Ortuzar, J. D. and Willumsen, L. G. (2011). *Modelling Transport*. Wiley. doi: 10.1002/9781119993308.

Potter, S. and Skinner, M.J. (2000). On transport integration: A contribution to better understanding. *Futures*, 32(3–4), 275–287. doi: 10.1016/S0016-3287(99)00097-X.

Puhe, M. (2014). Integrated Urban E-ticketing Schemes – Conflicting Objectives of Corresponding Stakeholders. *Transportation Research Procedia*, 4, 494–504. doi: 10.1016/j.trpro.2014.11.038.

Rio, M. (2016). Black Mobility Matters: An Exploratory Study of Uber, Hacking, and the Commons in Baltimore. *Architecture_MPS*, 10(4), 3–29. doi: 10.14324/111.444.amps.2016v10i4.001.

Ruutu, S., Casey, T. and Kotovirta, V. (2017). Development and competition of digital service platforms: A system dynamics approach. *Technological Forecasting and Social Change*, 117, 119–130. doi: 10.1016/j.techfore.2016.12.011.

Shaheen, S.A. (2016). Mobility and the sharing economy. *Transport Policy*, 51, 141–142. doi: 10.1016/j.tranpol.2016.01.008.

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

Sharma, S. (2016). Expanded cloud plumes hiding Big Data ecosystem. *Future Generation Computer Systems*, 59, 63–92. doi: 10.1016/j.future.2016.01.003.

SMMT (2018). *Car vehicle registrations*. Available at: https://www.smmt.co.uk/vehicle-data/car-registrations/

Snellen, D. and de Hollander, G. (2017). ICT'S change transport and mobility: mind the policy gap! *Transportation Research Procedia*, 26, 3–12. doi: https://doi.org/10.1016/j.trpro.2017.07.003.

Stiglitz, J.E. (2010). *Freefall: America, free markets, and the sinking of the world economy.* WW Norton & Company. doi: 10.1111/j.1468-2346.2008.00711.x.

Tabassum, S., Tanaka,S., Nakamura, F., and Ryo, A. (2017). Feeder Network Design for Mass Transit System in Developing Countries (Case study of Lahore, Pakistan). *Transportation Research Procedia*, 25, 3129–3146. doi: http://dx.doi.org/10.1016/j.trpro.2017.05.343.

Tavares, A.S., Gálvez, G., de Albuquerque, L.W.N., Almeida, A.L, Barros, R.Q, Soares, M., and Villarouco, V. (2015). Information on Public Transport: A Comparison Between Information Systems at Bus Stops. *Procedia Manufacturing*, 3, 6353–6360. doi: 10.1016/j.promfg.2015.07.958.

The Transport Systems Catapult (2016). *Mobility as a Service*, TSC.

The Transport Systems Catapult (2017). *The case for Government Involvement to Incentivise Data Sharing in the UK Intelligent Mobility Sector*.

UK Parliament (2017). Written Evidence submitted by the Department for Transport (MAS0003) for Transport Select Committee Mobility as a Service Inquiry. Available at: https://www.parliament.uk/business/committees/committees-a-z/commons-select/transport-committee/inquiries/parliament-2017/mobility-as-a-service-17-19/publications/

Walker, W.E. and Marchau, V.A.W.J. (2017). Dynamic adaptive policymaking for the sustainable city: The case of automated taxis. *International Journal of Transportation Science and Technology*, 6(1), 1–12. doi: http://dx.doi.org/10.1016/j.ijtst.2017.03.004.

Watanabe, C., Naveed, K., Neittaanmäki, P., & Fox, B. (2017). Consolidated challenge to social demand for resilient platforms – Lessons from Uber's global expansion. *Technology in Society*, 48, 33–53. doi: 10.1016/j.techsoc.2016.10.006.

Watanabe, C., Kashif, N., and Neittaanmäki, P. (2016). Co-evolution of three mega-trends nurtures un-captured GDP – Uber's ride-sharing revolution. *Technology in Society*, 46, 164–185. doi: 10.1016/j.techsoc.2016.06.004.

Zha, L., Yin, Y. and Yang,H. (2016). Economic analysis of ride-sourcing markets. *Transportation Research Part C: Emerging Technologies*, 71, 249–266. doi: 10.1016/j.trc.2016.07.010.

Zha, L., Yin, Y. and Du, Y. (2017). Surge Pricing and Labor Supply in the Ride-Sourcing Market. *Transportation Research Procedia*, 23, 2–21. doi: 10.1016/j.trpro.2017.05.002.

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