Network Economics of Shared Mobility[1]

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ICT innovations are the key drivers for a paradigm shift from traditional intramodal transportation markets to intermodal shared mobility markets. The changing necessities of regulations regarding market entry, public subsidies, and technical regulations are identified, and the potentials of pilot projects, as well as the impact of shared mobility on congestion and pollution, are analyzed.

The evolution of markets for shared mobility services

Shared mobility services provide transportation services without requiring individual ownership of the vehicles for exclusive use. Shared mobility services can be non-commercial (for example, reciprocal ride sharing organized by a peer group) or commercial. There are many forms of commercial provision of shared mobility services, either by small-scale vehicles (such as cars, minibuses, and bicycles) or mass transit of large capacity transportation (trains, subways, etc.). The owner of a car may rent his or her vehicle out for others to use for limited periods of time, or offer taxi services organized by a ride-sourcing company. Alternatively, vehicles may be owned by a platform operator organizing on-demand transportation services or may be in shared ownership organized on a peer-to-peer basis, or vehicles may provide rail and bus transit: "…rail and bus transit were the most frequently used shared modes, followed by bikesharing, carsharing, and ridesourcing …" (Feigon and Murphy 2016: 7). On-demand mobility can be provided via self-service concepts or for-hire service concepts. For fully automated (driverless) vehicles, the concept of self-service is changing, as the real-time driving activity is no longer performed by the driver and has shifted to a platform (Transportation Research Board 2015: 1–22; US Department of Transportation, Federal Highway Administration 2017, chapters 1, 2).

An important consequence of shared mobility is the convergence of intramodal transportation markets towards intermodal shared mobility markets. An evolving multiplicity of combinations between shared mobility services provides substitutes for individual private car trips, such as taxis, car rentals, car sharing, minibuses, buses, and high-capacity public transit with trains, subways, or tramways. The smaller bundling advantages of shared cars and minibuses may be combined with the greater bundling advantages of buses and the even greater bundling advantages of high-capacity public transit by providing seamless shared mobility service networks. Boundaries are beginning to blur between shared on-demand mobility services (such as bus-on-demand services) with flexible stops and routes, and public transit with scheduled (timetabled) services with fixed stops and routes. Shared mobility can extend the scope of public transit, providing feeder services for public transit by tackling the first-and-last-mile problem (US Department of Transportation, Federal Highway Administration 2017: ix).

Virtual networks for shared mobility services

Although there are different types of shared mobility services with heterogeneous information and communication technologies (ICT) requirements, they typically rely on real-time, location-based information to enable app-based operating platforms coordinating and organizing the on-demand provision of mobility services. Examples are bicycle sharing, car sharing, ride sharing, ride sourcing, minibus-on-demand with virtual stops and flexible routes, driverless shared mobility services, and (high-capacity) public transit. On-demand mobility services require real-time, location-based mobile communication services combined with mobility apps. App-based mobility services result in a convergence of transportation services provided by taxis, private hire vehicles, and ride-sourcing platforms (commercial transport apps) (OECD/ITF 2016c).

From a network economic perspective, the complementary role of virtual networks for the design of smart physical networks is important, combining a required QoS bandwidth capacity with other virtual components (Knieps 2018). Virtual networks for shared mobility services are based on combinations of real-time mobile communications, global navigation system services (geopositioning), and sensor-generated data processing (OECD/ITF, 2015b, 2016b). Infrastructure-generated data are increasingly replaced by sensor-generated data via mobile phones, on-

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board navigation devices, and vehicle-to-vehicle communications. ICT for shared mobility services are based on multi-platform sensoring technologies as well as data storage and transmission capacity in vehicles that are able to precisely locate and track people and vehicles supported by global navigation satellite systems (GNNS). Examples of location-based data services include taxi-hailing apps and ride-hailing apps, road navigation and multi-modal routing services, and multi-modal big data processing (OECD/ITF 2016b; GNNS 2017).

Shared mobility markets and the challenges for regulations

The necessity for institutional reforms, including free entry into shared mobility markets, competition for subsidies, and technical regulations, are considered below.

- Free entry and competition in shared mobility markets

The abolition of legal entry barriers and regulatory market splits is unavoidable. Prosumer peer-to-peer activities as well as business-oriented market activities providing shared mobility can only flourish if all legal entry barriers in the markets for transport services are abolished. Market entry regulations with licenses and public price fixing, as in the German taxi market, serve to establish cartels. Such market regulation not only interferes with price competition and market-driven entry and exit decisions, but also obstructs the search for new innovative mobility concepts. Due to app-based ICT innovations, services provided by taxis, private-hire vehicles, and ride sourcing services are converging and belong to the same relevant market for individualized mobility. Entry regulations via licenses, geographic restrictions, and fare setting for taxis are not only contrary to the general principles of open markets but also cause artificial regulatory market splits compared to private-hire vehicles and ride sourcing services (OECD/ITF 2016c: 6). Moreover, competition between individualized mobility services and shared on-demand mobility services with shared taxis, taxi buses and bus-on-demand services should not be disturbed by regulatory market splits.

- Competition for subsidies of public non-cost covering shared mobility services

The comparative advantages of different forms of shared mobility services are relevant in densely populated urban areas, but also in rural areas with low population density. A major change is that the concept of "public transport" is no longer limited to scheduled services, but can also include on-demand mobility services (OECD/ITF 2015c). If demand is so low during certain periods of the day that offering a scheduled train or bus services would result in large deficits, the publicly desired transport service could be provided by a shared minibus or shared taxi service; even individual ride-sourcing trips should not be excluded. In the context of a transparent bidding procedure, the most cost-efficient public mobility service can be chosen, exhausting the comparative advantages of scheduled mobility services versus on-demand mobility services depending on the local/regional demand circumstances and thus minimizing public subsidies.

- Technical regulations and consumer protection

Technical regulations in shared mobility markets focusing on health and safety, as well as insurance and consumer protection through adequate laws and technical standards, are gaining increasing relevance and have raised controversial debates regarding the extent to which additional rulings are necessary (Transportation Research Board 2015: 62–71). Other issues regarding the interaction of public and private spheres are parking and access to public space, both for private businesses and for non-profit purposes, with competing operators and transportation services as well as taxation on shared mobility. Data sharing (open data), data privacy protection, and cybercrime protection are also gaining relevance. Of particular importance is safeguarding privacy in the context of location-based mobility data (OECD/ITF 2016b:21–26; OECD/ITF 2015b: 33–58).

Get the bandwagon rolling: The role of pilot projects

"Kutsuplus", the world's first pilot project providing a fully automated, real-time on-demand public minibus service with flexible routes and virtual stops, started in 2012 in Helsinki. The project was initiated by Helsinki Regional Transport Authority (HSL) to provide incentives to substitute private car trips with an on-demand minibus service, thereby reducing congestion and air pollution. Routes were optimized on the basis of real-time trip orders from customers using a GPS-enabled smartphone. Passengers with roughly the same pick-up and end-point locations were allocated to the same vehicle. The platform bundled all requests with similar routes and informed users about the closest virtual stop. The transportation service of Kutsuplus offered a flexible, real-time-based choice of routes without fixed departure times or fixed entry and exit points, comparable to a shared taxi service. The goal was to assess the technical feasibility of the project and to get experience on user acceptance over a three-year period. The Kutsuplus pilot project gained worldwide attention as an innovative forerunner ICT project that could provide new impulses to public transit with a real-time on-demand service that strongly reduced private individual car traffic. It was considered a success due to strongly growing demand

and customer requests to extend the service areas. A further expansion of the service network would have required a significant increase from 15 minibuses to 45 in 2016 and to more than 100 in 2017, but the necessary investments could not be realized.[2] Nevertheless, the goal is to develop further shared mobility services based on more extended Kutsuplus-type services (Helsinki Regional Transport Authority (HSL), 2016). Although the minibuses in the Kutsuplus pilot project were able to choose demand-oriented virtual stops and virtual routes on a fully automated basis, they still involved drivers, which were a high cost factor. Therefore, the start of a regular bus line in Helsinki with a driverless bus in 2017[3] is opening up interesting new perspectives for the future. In the meantime, the potential for Kutsuplus-type bus-on-demand services are also being considered in other towns; examples include the American city of St. Louis, Missouri[4] and a ride-pooling-project in Hamburg starting in January 2019.[5]

Shared mobility markets as driver to reduce congestion and pollution

The future role of shared mobility markets in reducing congestion and environmental problems within cities is a challenging problem worldwide. The question of the extent to which shared on-demand mobility services such as shared taxis, taxi-buses, or bus-on-demand should replace private car traffic is highly controversial. Moreover, the interaction between shared on-demand mobility services and high-capacity public transit by train, subway, ferry, and tramway plays an important role.

In recent years, the International Transport Forum at the OECD has conducted several simulation studies to investigate the impact shared on-demand mobility services would have on replacing other forms of travel and thus reducing traffic congestion and air pollution. Within a real urban context under the application of real mobility and network data, different reform scenarios have been analyzed, with particular focus on the complete or partial replacement of private car traffic by shared on-demand mobility services. It is assumed that a central mobility dispatcher coordinates the matching of shared vehicles to passengers, centralizing all real-time information and optimizing routes and stops to fit the transportation requirements of each passenger, according to a set of time-minimizing rules. Depending on heterogeneous travel requirements, different quality standards regarding travel time and travel duration may be offered. Shared mobility simulations were carried out for Auckland, New Zealand's largest city (OECD/ITF 2017a); for Lisbon, a mid-sized European city (OECD/ITF 2015a, OECD/ITF 2016a); a follow-up study for the greater Lisbon Metropolitan Area (OECD/ITF 2017b); and for the Helsinki Metropolitan Area in Finland (OECD/ITF 2017c). Different scenarios are considered, differentiating, for instance, according to whether all private cars are being replaced or only a subset, whether all public transit trips with busses and rail continue or whether bus trips also are replaced by shared on-demand mobility services. Different shared mobility services are considered, typically with shared taxis (six passengers) and taxi buses (8–16 passengers); only the first Lisbon study (OECD/ITF 2015a) also considered sequential individual transport ("AutoVots"). There is also differentiation regarding whether the shared on-demand mobility service is provided with fully automated (driverless) vehicles or with a human driver.

In a scenario where all private car trips are replaced by shared taxi or taxi bus and all other trips are taken via public high capacity transit, walking and cycling, the simulation studies all arrive at the same conclusion: congestion is strongly reduced or disappears completely, and pollution is also drastically reduced. For Lisbon, the simulation showed if all cars and bus trips were replaced by a fleet of six-seat vehicles (shared taxis) that offer on-demand door-to-door shared rides in combination with a fleet of eight- and 16-person minibuses (taxi buses), the car fleet would only be 3 percent of the current fleet and total vehicle-kilometers would be reduced by 37 percent (OECD/ITF 2016a: 8). The benefits of shared mobility even increase when greater Metropolitan areas are considered, due to the greater importance of shared mobility services in providing feeder services to public transit. Even if only 50 percent or 20 percent of private car trips were replaced by on-demand shared mobility services and the bus services continued, there would still be a significant reduction of congestion and CO_2 to be expected for the Helsinki Metropolitan Area (OECD/ITF 2017c: 53). For Auckland, it was found that if all trips currently being made by private car were made by shared mobility services, congestion and emissions as well as distance driven would be cut in half. Even if the switch to shared mobility services was only partial, a significant effect on congestion and CO_2 could be observed (OECD/ITF 2017a:6).

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