SHARED MOBILITY:
An Overview, with Highlights from the United States and Germany

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INTRODUCTION

For a variety of socioeconomic, demographic, technological, and environmental reasons, an increasing number of people are using shared mobility services to travel. These shared mobility services include carsharing, bikesharing, and transportation network companies (TNCs) such as Uber and Lyft, as well as more traditional services such as taxis and limousines. Both in terms of the number of providers and in terms of the trips provided, these services have been increasing rapidly in recent years. These technologies and systems are becoming more widely deployed, more reliable, and more convenient. The shared modes may therefore continue to increase their modal share, reducing single-occupancy vehicle trips. While these services provide very few trips relative to the total amount of motor vehicle travel, they provide essential transportation services in certain circumstances, particularly for a variety of disadvantaged populations. If the rapid growth of private innovation in transportation continues, it may have long-term effects on traveler behaviors, which would result in mobility, economic, and environmental consequences.

The varieties of new business models are continuing to mature, but their eventual role in the transportation world remains to be seen. They may be only a partial replacement for traditional taxi, limousine, and transit services; on the other hand, if they help enough people to meaningfully change their travel patterns, they may be an integral part of a deeper transformation of transportation. Features of shared use services affect the cost, convenience, and security of available transportation options. In turn, these characteristics affect trip-making rates, mode choices, and trip destinations. In the long run, these travel behavior changes can influence not only personal mobility, but also, the safety and capacity and the economic and environmental impacts of the transportation system. For example, a direct impact of TNCs may be to reduce personal vehicle trips, but the TNC pickup/drop-off mileage may result in more total travel. On the other hand, if TNCs enable or encourage higher vehicle occupancies or skew overall travel behavior away from single-occupant vehicle travel by reducing personal vehicle ownership, they may have positive impacts in terms of minimizing vehicle miles traveled (VMT).

The truly shared-ride aspects of these new services have the potential to increase average vehicle occupancies, leading to significantly reduced carbon footprints per passenger. Aggregating trips and increasing vehicle occupancy can improve both the energy efficiency and the capacity of existing transportation systems, allowing cities and regions to accommodate growth in population and travel demand without proportional increases in infrastructure.

Existing services, particularly Uber and Lyft, are likely to continue to promote shared rides. In addition, existing and yet-to-develop services may be able to provide first- and last-mile service for traditional fixed-route transit lines, making it easier for travelers to use transit regularly. If these new services create options that simplify traveling without a private vehicle, car ownership

rates may decline. Carsharing services have already resulted in some car ownership declines, but as the innovative service options expand, the declines may occur on an even greater scale.

If vehicle ownership rates are reduced, a positive feedback loop results in even larger VMT reductions. Car owners see very low marginal costs in taking an additional trip; they see the marginal costs only as the cost of gasoline, parking, and any applicable tolls. Evidence has long been overwhelming that vehicle owners do not consider the full cost of their trips when making their travel choices. Shared mobility services charge travelers the actual cost of each individual trip, but in return, the user to have no upfront costs, such as the purchase, insurance, and maintenance of a private vehicle. If travelers own fewer cars and instead make greater use of the array of shared use services, they may become more used to calculating the actual cost of each trip, perhaps making fewer discretionary trips.

If private vehicle ownership declines, parking requirements can be reduced throughout many cities. These reduced parking needs could in turn allow for increased density, depending on both zoning and community support for land use changes, and this could make transit, walking, and bicycling into more appealing and realistic transportation options. The combination of more rational trip-making and the wide availability of shared ride services has the potential to dramatically reduce vehicle miles traveled, which would thereby also reduce pollution, greenhouse gas emissions, and road and parking infrastructure needs.

However, it is entirely possible that these new services will not have these positive effects but instead result in the opposite. Transit riders may be attracted to these convenient and inexpensive shared rides, drawing passengers away from much more space- and energy-efficient buses and trains. Also, the reduced costs and increased convenience of traveling by for-hire vehicles may induce increased trip making and/or longer trips. These would therefore contribute to increases in vehicle miles traveled, congestion, and greenhouse gas emissions.

It is impossible to know which direction these services will go. However, planners and policy makers can take an active role in shaping the future by creating regulatory and policy structure that encourage growth in a positive direction. Shared use mobility services currently exist in a variety of business models and vehicle types, and the services are continually evolving, blurring the lines between types of services. Planning and policy considerations for these myriad services will need to be flexible, allowing for growth in currently-unimagined directions, while still encouraging outcomes that result in environmental, economical, and safety benefits. The remainder of this paper describes some of the key shared mobility services and their key issues.

TRANSPORTATION NETWORK COMPANIES

Transportation network companies (TNCs) are on-demand ride services offered through a smartphone app. They have seen a great deal of growth worldwide in recent years and are the most visible face of shared mobility. Smartphone apps connect a traveler with a driver and his or her personal vehicle. The drivers available through the app may be either licensed vehicle-for-hire drivers or private individuals without a commercial license. As with taxis, fares are based on both distance and time, but the fares are paid from the traveler's credit or debit card account, which is registered with the TNC. The fares are charged automatically when the trip is

completed; the driver does not engage the passenger regarding payment. As of 2016, the two largest TNCs were Uber and Lyft, with Uber being by far the largest. Data on these companies are difficult to obtain, but as of June 2015, Uber alone provided more than 1 million rides daily worldwide (Geier 2015), operating in 311 cities on six continents with more than 162,000 drivers (Shaheen 2015). At the same time, Lyft operated only in the United States, although it had relatively good penetration; the service operated in 60 cities with more than 100,000 drivers. The more than 262,000 total drivers represent approximately 80 percent of the number of taxi and limousine drivers worldwide, but TNC drivers work mainly part-time, sometimes only a few hours a month. TNCs are being regulated to wildly varying degrees internationally (and sometimes even within a country), but generally much more lightly than traditional taxi and other for-hire transportation services.

The largest TNC is Uber, which launched in March 2009 and is headquartered in San Francisco. Uber is currently in hundreds of cities in dozens of countries and is rapidly expanding; it has also notoriously become the target of numerous lawsuits from taxi companies, advocacy groups for the disabled, cities, countries, the families of individuals hurt or killed by Uber drivers, and its own drivers and customers. Uber provides a variety of service options. The first service, what is now called Uber Black, enables a customer to use an app to summon a black car and licensed driver. The company has since developed a number of other services, including UberX, which allows private individuals (or community drivers) to use their private vehicles to drive the traveler around. This service has expanded fastest and has been the focus of much of the taxi and regulator concern. Other services include Uber SUV, which calls SUVs that seat six or more people; Uber Lux, which uses premium vehicles ("the finest cars with prices to match" according to Uber); and Uber Taxi, in which Uber partners with local taxi fleets to provide standard taxis through their app. In August 2014, Uber also unveiled UberPool, which allows a user to share a ride and split the cost with another person "who just happens to be requesting a ride along a similar route" (Uber.com 2014).

The largest competitor to Uber is Lyft, which is also headquartered in San Francisco. Like UberX, it pairs riders with non-professional drivers who use their own vehicles. Also like UberX, Lyft claims that the substantial majority of its drivers are part-time (Saitto 2014). Similar to UberPool, the firm launched LyftLine as a ridesharing option in 2014 (Lyft 2014). (The two companies launched their ridesharing options within twenty-four hours of one another.)

One feature of Uber and Lyft that differentiates it from traditional taxis is that fares vary with consumer demand and vehicle supply. This type of pricing is the norm in hotel and rental car industries, but in the traditional taxi industry, pricing is highly regulated and therefore variations in pricing are very limited. When demand for rides is high, such as at a stadium after a sports event or when the weather is particularly foul, Uber implements "surge pricing," which multiplies the standard rate by some factor greater than one. Lyft has a similar policy they refer to as "Prime Time Pricing." This both tempers demand and encourages an increase in supply; drivers are more likely to come out and drive if they know they can make additional income during these periods of increased prices.

TNCs have seen incredibly rapid growth over the last five years. However, because they are subject to limited public regulation and are private firms, little concrete information is known

about their scale and performance. Data is largely limited to short reports produced by the firms themselves, most of which paint the companies in extremely complimentary lights. However, the amount of known information is growing. As of March 2015, after four years of operating in New York City, the number of Uber vehicles in that city alone had overtaken the number of medallion cabs (Licea et al. 2015). The total number of TNC vehicles overtook the number of cabs prior to March 2015, considering that other companies, including Lyft, also operate in the city. However, yellow cabs still make ten times the number of trips of Uber cars, per New York Taxi and Limousine Commission reports (Licea et al. 2015), reflecting the highly part-time nature of TNC driver behavior. At approximately the same time, Uber reportedly had 2 million customers in New York City (Badger 2015).

As they carry these millions of passengers, the companies also bring in large revenues. In January 2014, the taxi market in San Francisco (the birthplace of TNCs) was about $140 million per year, while the gross revenues of Uber alone were reported $500 million and growing at 500 percent per year (Blodget 2015). At the same time, Uber reported that San Francisco trips were increasing more than threefold each year while New York trips were increasing fourfold. At least part of this growth is likely attributable to service quality. Rayle and colleagues (2015) found that 90 percent of TNC rides in San Francisco began within 10 minutes of the request no matter the time of day the request was made. In comparison, the same was true with only 35 percent of daytime taxi rides and 16 percent of nighttime and weekend taxi rides.

Valuations can and do change rapidly and significantly. However, in late 2015 Uber was valued at about $63 billion (Newcomer 2015), while Lyft was valued at approximately $5.5 billion (Newcomer 2016). Uber's valuation puts it above that of Ford, General Motors, Delta Airlines, Netflix, and FedEx (Verhage 2015).

The rise of TNCs and other innovative services has changed long-standing beliefs about the total potential size of the shared ride market. Although it has grown substantially in recent years, the global taxi and limousine market generally saw relatively little change for decades. TNCs seem to have led to a rapid acceleration of the recent growth, although it is difficult to determine how many rides are simply being shifted from other modes. However, given the very rapid growth in TNC revenues and drivers, many of the rides are likely new to the for-hire transportation market. If true, this may well result in an overall increased market size for all for-hire rides. It could also reduce the share of other modes such as private vehicles and transit.

TNCs do not own the vehicles, contract with the employees, or directly provide a dispatch service. At times, they have therefore claimed not to be in the transportation business (Reindl 2014; Velotta 2014). Uber and Lyft have begun operating in a wide variety of cities around the world, occasionally without complying with local vehicle-for-hire licensing laws. As a result, they have been subject to many cease-and-desist and temporary restraining orders. Because they (indirectly) provide rides to passengers in exchange for a fare, governments from federal to local levels have generally viewed them as subject to licensing requirements. The companies have expanded rapidly, and found themselves waging contentious battles not only with regulatory agencies and regulated taxi companies (Graham 2015), but also with one another. Because of their convenience and availability, TNCs have become quite popular with the public. This is especially true in areas where traditional taxi companies lack these attributes.

Initially, TNCs strongly resisted regulatory demands to comply with any state or local licensing requirements for limousine and sedan services. These requirements included having commercial auto liability insurance policies and conducting fingerprint-based background checks on drivers. These issues have been the central points of disputes between the companies and regulatory authorities. Compounding these challenges is the sheer number of authorities who may be overseeing these services. In the United States, the regulation may be at the city, county, metropolitan, or state level, with regulations at different levels occasionally conflicting. In Europe, most taxi regulation is at the national level, but these companies operate across the continent, leading to potential European Union (EU)-level regulations and coordination issues. In an attempt to simplify matters, the Philippines was the first country to issue nationwide regulations for app-based transportation services (Alba 2015). To date, there is no such movement from the United States federal government or from the EU, although the EU is considering whether existing taxi regulations violate EU regulations concerning competition.

TNCs in Germany
While shared mobility services have begun (and often gained notoriety) first in the United States, they operate worldwide. As context for the shared mobility services, particularly TNCs, in Germany, it is important to consider the travel behavior and vehicle ownership characteristics of the German population. Car ownership among 18 to 29 year olds in Germany dropped by 44 percent between 2000-2010, from 424 to 239 cars per person. The average German spends 95 minutes per day traveling: 50 minutes in a car, 20 walking, 25 on local transport, and 10 on trains. About one-third of the country's population lives in cities with populations of at least 100,000, and 2.5 percent of these urban inhabitants currently use carsharing. Thirty-eight percent of urban-dwelling Germans aged 18 to 39 think they will use carsharing more in ten years, as do 26 percent of those over 40 (McKinsey & Company 2012).

Shared mobility operators are particularly prolific in Berlin, in large part because the demographics of the city are nearly ideal for successful operations. The share of zero-car households in Berlin is 40 percent overall, but that is significantly higher in denser inner neighborhoods (LSE Cities 2015). The city also has an umweltzone (low-emission zone), begun in 2008, restricting inner city neighborhoods to certified low emission vehicles. Berlin has 324 cars per 1000 inhabitants (compared to a national average of approximately 540) and 721 bikes, and the number of single person households has risen 34 percent in 15 years. On average, each Berliner makes 3.4 journeys per day and in the process spends about 70 minutes traveling (Senate Department 2015); nonetheless Berlin's motorization rate per thousand people has actually dropped by nearly 9 percent since 2000. As of 2012, free-floating cars outnumbered standard carsharing vehicles in Berlin by three to one (most of these were owned by the operator car2go). The overall strength of these demographics is reflected in the 3.4 percent of city residents who report being carsharing members (LSE Cities 2015).

Uber first entered Germany with a service it called UberPop, the equivalent of the low-cost unlicensed driver service. German courts banned this service in a series of decisions throughout 2014 and 2015 (Rawlinson 2014; BBC 2015); Taxi Deutschland, a taxi company coop, filed a suit against Uber which led to the UberPop ban (Geiger 2015).German regulations

make entry into the taxi market difficult, requiring drivers to obtain a chauffer's license and to adhere to a set fare structure. On May 19, 2015, Germany launched a new version of UberX, which complies with German laws. This version of UberX uses licensed drivers who must return to the company's local headquarters after every trip.

As of Friday, October 30, 2015, Uber closed down in Hamburg, Frankfurt, and Dusseldorf, remaining only in Berlin and Munich. The company announced that the retreat was only temporary (Hawkins 2015). After the federal government required that Uber drivers obtain the same licenses as normal taxi drivers, Uber ran into a major supply shortage, even after offering to pay for the fees associated with the licenses. These fees range from €100 to 200 for a license and an additional €150 to 200 for a permit from the county's Chamber of Commerce (D'Orazio 2015).

Because of Uber's complaint that German's laws on taxis violate EU rules on competition, the EU is reconsidering Germany's rules. One of the rules under contention is that car-hire services cannot accept a new order while the passenger is in the car. German courts have also said that Uber must hold a taxi operator's license, but as it often has, Uber has argued that it is a tech company, not a transportation company. Uber would rather be regulated at the EU level by Brussels than deal with individual regulators in each of the EU's 28 countries (Robinson 2015).

Insurance for TNCs

While there are dozens of issues involved in the operations of these services, in both the United States and Germany, insurance concerns are one of the key issues. Taxis carry commercial insurance, which is rated and priced assuming nearly constant use of the vehicle for transporting others in exchange for money. TNC vehicles, on the other hand, are primarily private vehicles, with the owners occasionally using them to transport others for money. Private vehicle insurance, which most jurisdictions require owners to carry, does not cover use of the vehicle for commercial purposes. When the private vehicle becomes a TNC vehicle, insurers view this as a violation of the policy and have often revoked the policies of the owner, a major concern in both the United States and in Germany (Rawlinson 2014). Insurance companies are unwilling to issue a policy without properly being able to evaluate the risks associated with its issuance, and the TNC services are too new to have a databank appropriate for this analysis.

Nonetheless, some insurance companies, primarily in the United States, are beginning to offer hybrid insurance policies to fill the gap between private and commercial insurance. These hybrid policies allow the policyholder to pay a bit more for a policy covering occasional TNC use without needing to upgrade to a far more expensive commercial policy. Metromile, Farmers Insurance, MetLife, GEICO, the United Services Automobile Association (USAA), Liberty Mutual, Travelers Insurance, Progressive, and Erie Insurance all began offering some sort of insurance policy that either removes the "livery exemption"[1] from existing policies or transforms the TNC driver's personal policy into an excess policy for the period of TNC activity (NAIC 2015).

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[1] A livery exemption excludes the transporting of people and/or goods for hire, such as by a taxi service, motor carrier, or delivery service, from being covered under an automobile insurance policy.

While they were initially reluctant to do so, TNCs themselves now offer insurance coverage for both passengers and drivers during the time that the ride occurs. Most jurisdictions with TNC insurance regulations have based their requirements on California's; California was the first jurisdiction to define periods of TNC service and require varying insurance levels for each, which reflected compromises between the insurance industry and TNCs. Period 1 is the time during which the driver has the app open and is waiting for a match. In period 2, the driver has accepted a match and is on his/her way to pick up the passenger. Period 3 consists of the time when the passenger is in the vehicle. Periods 2 and 3 require much more significant primary commercial insurance coverage than does Period 1. Many jurisdictions followed the lead of California in enacting similar regulations outlining specific coverage requirements for TNCs (PFHT Task Force 2015; Salazar 2015).

TAXIS

Taxis are usually seen, rightly so, as the primary competitor of TNCs. Taxi use constitutes just 0.2 percent of all person trips, but this is about 738,000,000 annual trips in the United States alone.[2] Taxis clearly have a share of all person trips; also, given that taxi trips tend to be shorter than trips made by other modes, taxis represent an even smaller share of person-miles of travel.[3] Despite these small proportions, taxis are an important component of an overall transportation system. In some cases, they may be the only available transportation option, particularly for those who do not own a car, and taxis can provide out-of-town travelers with flexible and relatively standardized door-to-door service.

In the United States alone, 7,500 companies with employees provided taxi and limo service in 2012. These companies had revenues of nearly $6 billion and approximately 76,000 employees (Transportation Research Board 2015). However, these companies are only one part of the taxi industry, as most taxi drivers are independent contractors. Taxi and limo businesses without employees accounted for additional revenue of $7.5 billion. Overall, the industry saw $14.1 billion in revenue. There were about 300,000 taxi and limo drivers who provided 890 million trips each year (Transportation Research Board 2015).

The German Association of Taxis and Hire Cars estimates that the country has about 260 million taxi passengers per year, a market that is about one-third the size of the United States market. These passengers form the basis of a $3.4 billion industry (Kistner 2012). Nearly 60 percent of all German taxis are Mercedes Benz, predominantly the E-class, which retails at about $51,800 (Behrmann et al. 2014), making the German taxi fleet one of the most comfortable and luxurious in the world. Daimler also manufacturers a taxi version of its top-of-the-line S-class, although these are less commonly used (Behrmann et al. 2014).

Germany has strict regulations for new entrants into the taxi market, requiring drivers to get special passenger-transportation licenses and adhere to fare structures set by municipalities. As described above, taxi companies and authorities have accused Uber and its drivers of violating these rules, while Germany's Monopoly Commission, an advisory body to the government, has recommended deregulating the country's taxi market. German legislators and even various

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[2] Data on taxi use are generated from the United States 2009 National Household Travel Survey (NHTS).
[3] NHTS data.

ministries have expressed differing views on the matter (Dauer 2014), making the point that regulating such services is not a simple matter.

Taxi Apps

The convenience advantage that is most often held by Uber and Lyft is not particularly new or proprietary technology. The taxi industry has also developed its own apps to eliminate this advantage; these apps offer cashless payment and app-based dispatching. They work with existing and taxi companies, resulting in all vehicles in use being locally licensed and regulated taxis. Hailo, based out of London, was one of the first taxi apps. It charged a $1.50 fee per trip in addition to the taxi fare, both of which the rider paid. All fares were collected through credit cards connected to the user's app and were passed along to the taxi company within 24 hours (Overly 2013). Hailo was available in seven North American cities by October 2014, but that month it shut down North American operations. The company cited "astronomical" marketing costs due to competition from other applications, especially the TNCs (Weber 2014). The company still operates in Britain, Ireland, Spain, Singapore, and Japan (Hailo.com 2016).

Hamburg-based mytaxi launched in 2009 and was acquired by Daimler in 2014, but has yet to establish much foothold in the United States (Mamiit 2014). It has approximately 45,000 drivers, half of which are in Germany (Scott 2016), and approximately 40 percent of German taxi rides now are initiated through the app (mytaxi.com 2016). Taxi.eu is another smartphone application relying solely on licensed drivers. It also began in Germany but has expanded in 12 countries, ranging from Brussels to Turkey (Scott 2016).

Other taxi apps currently available worldwide (with varying penetration rates) include Flywheel and Curb (rebranded from Taxi Magic in 2014). All of these companies contract with individual cab companies/fleets in each city. The contracting process and the need to integrate the business processes and computer systems of a large number of relatively small fleets have resulted in these apps having a slower expansion rate than the TNCs (especially Uber), which are single integrated businesses.

From the German perspective, in addition to acquiring mytaxi, Daimler has made other inroads into the shared mobility world. Daimler's subsidiary Moovel acquired United States-based RideScout and Germany-based Intelligent Apps (owner of the MyTaxi app) in September 2014. Moovel also has a holding in Blacklane, a limo booking service, and owns Park2gether, a parking app (Mamiit 2014). In addition, the automaker is considering launching an on-demand limo service, which they announced at the 2015 Frankfurt auto show (Wile 2015). And, of course, Daimler owns car2go, a carsharing operator discussed in the later section on carsharing.

TNCs, TAXIS, AND PUBLIC TRANSIT

Federal regulations in both the United States and Germany make it clear that transit must serve all, and the 1990 Americans with Disabilities Act made access to transportation a civil right in the United States. Sometimes people cannot be served by traditional bus or rail transit vehicles, or by access to the routes themselves (the stops are inaccessible, there are no elevators to platforms, etc.). As a result, nearly every transit agency has a paratransit division to serve this select group of passengers. These systems usually do not run on regular routes with regular

schedules as do standard transit operations. Instead, users generally have to request these rides, often 24 hours in advance, and are typically given a two hour window for pickup. The advance notice and large pickup windows make what would otherwise be simple trips to the grocery store or doctor into a potentially all-day ordeal.

Not only are paratransit operations often less than convenient for their users, but they are often enormous money drains for the parent transit agency. In Washington DC, for example, each paratransit trip costs nearly $50 per passenger (Di Caro 2016), and NYC Transit's trips cost about $72 each (Sullivan 2015). These high paratransit costs account for specialized vehicles and trained operators and extremely low passenger load rates and dispatchers. Meanwhile, paratransit fares are generally capped as a social benefit; in many places the cap is twice what the standard fare would have been, or some similar multiple. For comparison, the Washington DC standard transit fare ranges from $1.75 to $5.90 per trip and NYC Transit's flat fare is $2.75. Clearly, paratransit fares come nowhere near covering the costs of the trip.

In an attempt to control and reduce their costs, many transit agencies globally currently contract with taxi companies to handle some of their paratransit needs. The passenger pays the paratransit rate to the taxi service, the transit agency makes up the difference in the fare through its regular contracting process, and the net effect is a far less expensive ride. TNCs have made it clear that they are interested in this market as well. Given their (to date) track record of improved convenience and widespread availability, TNCs may provide a great advantage to paratransit users. Transit agencies could provide prepaid credit or debit cards to users who can then independently call/use a TNC. Instead of making the vehicle request the previous day and having an hours-long window for a potential pickup time, a user can make the request at the time the ride is needed and face the average TNC wait of approximately four to seven minutes. The customer would receive far more convenient service, and the cost to the transit agency would be far less than the cost of owning, maintaining, and operating a fleet of wheelchair-accessible vehicles, along with employing and training their operators.

However, there are a number of hurdles before a TNC and paratransit alliance could be established and effective. In the United States, 36 percent of Americans do not have a smart phone (Pew Research Center 2015), and nearly 1 in 10 do not have a credit card (FDIC 2014); both of these items are prerequisites for TNC use; they are also very helpful, if not mandatory, to use bikesharing and carsharing. These groups have strong overlap with paratransit users, and the proportions of paratransit users without a smart phone or credit card are even higher.

In Germany, the number of residents without bank accounts is in the "high six figures," according to the European Commission – a number that is expected to rise with the country's influx of migrants (Copley 2015). Germany has long been a country that is highly predisposed to using cash for transactions, both due to social norms about living within one's means and also because of concerns about privacy and data tracking. More than 80 percent of transactions in Germany are conducted with cash, and only 32 percent of Germans own a credit card, as compared to more than half of all Americans. Even among those with a credit card, only 39 credit card transactions occur per person each year, far below averages in other highly developed countries (Yohannes 2015). In addition, smartphone usage is not as pervasive as it is in the United States, as only 37 percent of respondents own a smartphone (compared to

nearly two-thirds of Americans).Given these social and financial norms, along with the markedly better availability and usability of public transit in Germany, coordination between app-based shared transportation services and public transit is likely to develop much more slowly in Germany than in the United States.

CARSHARING

Carsharing is the short-term rental of vehicles to individuals who drive themselves. While traditional car rentals last for days or weeks, most carsharing rentals are for minutes or hours. Carsharing services reduce the need for personal vehicle ownership by providing members access to vehicles on an on-demand basis. There are many variants of these services, but the two most common are round-trip carsharing, where the vehicle is returned to a "home" parking space at the end of each trip, and free-floating carsharing, where a vehicle can be parked anywhere within a large service area.

Carsharing began in Europe in the 1940s, in part as a response to the challenges households faced in acquiring their own vehicle in the post-war years. However, it did not become popular until the 1990s. It was slower to develop in North America, but today North America is the largest carsharing region in the world when measured by number of members (Shaheen et al. 2015). 45 carsharing operators provided service in the Americas as of January 2015, with approximately 1.6 million members and more than 22,000 vehicles (Shaheen and Cohen 2015). Dozens more operated in Europe, and these worldwide operators ranged from for-profit, non-profit, and cooperative business models. As of early 2015, Zipcar and car2go were the largest carsharing companies in the world (PR Newswire 2014).

Most operators charge their members an annual fee (on the order of $25-60, depending on the market and level of membership) and an hourly rate for vehicle rentals. The hourly rates vary depending on the market, the day of the week, and the type of car, but generally range from about $6 to $15 and cover vehicle use, fuel, parking fees, insurance, and maintenance. Members have automated access to the fleet of vehicles with access cards that are shaped and sized like a credit card, which they wave over a reader in the car's dash. Keys are kept inside the vehicle. Depending on the specifics of the service, members can reserve cars in advance on the internet or using a mobile app or they can simply walk up to a vehicle with an available light flashing on its dashboard.

In a roundtrip carsharing such as Zipcar, the member drives the vehicle as needed and returns the vehicle to its assigned parking spot at the end of the rental. Cars are stored either in off-street garages under arrangements between the carsharing operator and the garage, or on-street under arrangements with the carsharing operator and the local government.

One-way carsharing is both an alternative and complement to roundtrip carsharing. In the roundtrip model, vehicles must be returned to their "home" parking space, making the vehicles unsuitable for one-way trips. The first large-scale carsharing operation to introduce one-way rentals was car2go, a subsidiary of Daimler; DriveNow, a subsidiary of BMW, followed. Both services operate throughout Europe, with large fleets in many German cities, but only car2go has successful operations in North America. Car2go uses a fleet of all Smart ForTwos, which are manufactured by Daimler, and DriveNow uses a fleet of Minis and small BMWs, both of

which are manufactured by BMW. The two systems each allow a user to access the vehicle by the minute, beginning the rental wherever the vehicle is located and ending the rental when the vehicle is parked in any legal space within a large geographic or "geo-fenced" area. Renters can drive the vehicle outside of the geo-fence, but the vehicles must be parked within the fence to end the rental. Otherwise, the vehicles can be parked anywhere, resulting in a much more free-floating fleet than traditional systems with assigned home locations for the vehicles. The tradeoff to providing travelers with the flexibility of one-way travel is that the spatial distribution of the vehicles in the geo-fenced service area must periodically be "re-balanced," or moved to bring the supply of vehicles in line with consumer demand.

As in roundtrip carsharing systems, members wave an access card over a windshield reader to unlock the car, and the keys are kept inside the vehicle. Car2go also now provides users the option to open the vehicle remotely using the smartphone app (Blanco 2014). One-way carsharing rentals tend to be more spontaneous than roundtrip rentals, as a user can walk up to a vehicle on the street and rent it on the spot as opposed to having to make a reservation in advance. Members can determine vehicle locations either online or using an app, and they can also reserve the vehicle through the app. One-way systems are made possible through coordination between cities and carsharing operators over parking agreements.

Traditional car rental companies have also begun operating as carsharing providers, with Enterprise (Enterprise Carshare) and Hertz (Hertz on Demand) as the largest of these. Traditional rental companies are well-suited to carsharing, given that they already own large fleets of vehicles and have systems in place to arrange for individuals to rent the vehicles. In order to expand from traditional rentals to carsharing, they expand their business model and software systems to allow them to rent the vehicles on a shorter-term basis with automatic smartcard access. These services have, to date, acted solely as roundtrip carsharing providers.

In addition to vehicle manufacturers, traditional car rental companies, and Zipcar, carsharing service models also exist in nonprofit form, generally based in particular metropolitan areas. One of the first large nonprofit systems was San Francisco's City CarShare, and there are many others, including eGo (Denver and Boulder), and CarShare Vermont. Many of these have since been bought out by private companies, particularly Enterprise and Hertz.

In general, in the United States, these services are almost entirely disconnected from public sector involvement. The public role in carsharing generally includes only the leasing of street-level or other convenient parking to the services. Many carsharing programs have agreements with municipalities to allow for free on-street parking; the companies pay the city for the value of the spaces, essentially leasing the parking. The companies also have agreements with cities that provide a number of dedicated spaces, indicated by city signs, paint, or other markings, for which the carsharing company pays the city a fee which can generate significant revenues. Depending on the agreement the carsharing company may also pay for other costs to operate that include insurance, pilot evaluation, or vehicle removal in cases of parking restriction violations.

In Germany, however, there is much greater public involvement in carsharing, given that several of the large carsharing operators are owned and/or operated by public entities. The largest

example of these is Flinkster, unique among carsharing operators in that it is a government-sponsored carsharing option. The service, originally called DB Carsharing, is operated by Deutsche Bahn (DB) and has cars available in Germany, Italy, Austria, the Netherlands, and Switzerland. More than one 1,000 in over 200 towns provide more than 3,600 cars. The cars can be rented by the hour, day, or week. A potential members registers online, then visits a sales center (such as a DB travel center in a train station) to show a driver license. Holders of Bahn cards (frequent traveler passes) have no registration costs. A flat usage fee includes unlimited mileage and fuel. Trips in Flinkster vehicles also earn Bahn points, which can be redeemed for train travel (Flinkster.com 2016).

Of course, other carsharing operators are also widely available in Germany, including car2go, Drive Now, and multicity (only in Berlin), all of which are operated by vehicle manufacturers (Daimler, BMW, and Citroen, respectively).

BIKESHARING

Bikesharing, like carsharing, consists of members who pay daily, weekly, or annual fees in return for access to a fleet of bicycles. Members are able to pick up a bicycle from any station (or "dock") and return them either to the same dock or any other. As a result, bikesharing is much more similar to one-way carsharing than it is to round-trip carsharing. In most systems, dues-paying members can rent the bikes for up to 30 minutes for no charge (beyond their membership fee), and hourly rates begin to apply after the first half-hour. Like carsharing, bikesharing originated in Europe. It faced a series of notable failures, however, until Paris implemented the Vélib program in 2007, which featured more than 19,000 bikes at over one thousand stations. Since the debut of Vélib, bikesharing has grown rapidly both throughout Europe and the rest of the world.

Several public bikesharing business models have evolved to date. These models include (1) nonprofit, (2) privately owned and operated, (3) publicly owned and operated, (4) publicly owned/contractor operated, and (5) vendor operated. Occasionally distinctions among these models become blurry based on variations on ownership, system administration, and operations (Shaheen et al. 2014). Cities also encourage bikesharing through the provision of public space for the bikeshare stations.

As of May 2015, nearly 850 communities worldwide had a bikesharing system that was technology-enabled. These systems provided almost one million bikes at more than 37,000 stations (Stein 2015). In the United States alone, there are about 25,000 bikes available in 72 cities for nearly 900,000 members of bikeshare systems. The largest systems include New York's CitiBike, Washington DC's Capital Bikeshare, and Chicago's Divvy.

China represents by far the largest bikesharing market in the world, with 80 percent of all bikeshare bikes located there (Shaheen 2015). In 2014, 150 new bikesharing programs began operating worldwide; 70 of these systems were in China (Shaheen 2015). Wuhan and Hangzhou, both in China, have the world's largest bikesharing operations; more than 50,000 bikes are available in each city (Guilford 2014).

Multiple bikesharing systems exist in Germany. For example, Deutsche Bahn offers Call a Bike, which provides more than 8500 bikes at stations and city centers around Germany (multicity 2016). Nextbike is another German bikesharing system which began with 20 bikes in Leipzig; today the service operates in more than 30 German cities and several nearby countries with more than 20,000 bicycles. The system is sponsored in part by Germanwings and has 300 bicycles available in Berlin. Nextbike costs one euro per thirty minutes of use, or nine euros per 24 hours. For a longer-term option, nextbike also offers the RadCard, which costs 48 euros per year and allows unlimited 30 minute trips (nextbike 2015).

CONCLUSION

Carsharing, bikesharing, and more recently TNCs, have emerged as important and growing components of passenger transportation, especially in urban areas. These are in addition to the many long-standing taxi and limousine companies. For several decades, policies designed to reduce reliance on the private automobile and its associated contributions to congestion and emissions have proven largely unsuccessful. In contrast, private companies offering shared vehicles and rides—particularly TNCs but carsharing and bikesharing as well—have recently emerged and appear to be experiencing rapid expansion and success.

What form the new shared mobility services will take as they evolve, as well as whether and how they will affect travel behavior and demand, the use of all other modes (including taxis and limousines), and private vehicle ownership – answers to these questions all remain to be seen as shared mobility services grow and expand into different market segments and geographic areas. Shared mobility services will continue to evolve and mature with or without public sector guidance, and planners, policy makers, and the research communities will need to react quickly without being restrictive or reactive. Use of existing and yet-to-be-developed technology-enabled services is likely to continue transforming passenger travel. The many stakeholders will need to cooperate to ensure that the mobility, economic, and environmental consequences of these changes improve both the transportation system and traveler quality of life for the better.

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