MOBILITY AND THE SHARING ECONOMY: POTENTIAL TO OVERCOME FIRST- AND LAST-MILE PUBLIC TRANSIT CONNECTIONS

Susan Shaheen, Ph.D.
Adjunct Professor, Civil and Environmental Engineering
Co-Director, Transportation Sustainability Research Center
University of California, Berkeley
408 McLaughlin Hall
Berkeley, CA 94720
510-642-9168
sshaheen@berkeley.edu

Nelson Chan
Survey Researcher
Transportation Sustainability Research Center
University of California, Berkeley
1301 46th St, Bldg 190, Richmond, CA 94804
(510) 665-3524
ndchan@berkeley.edu

MOBILITY AND THE SHARING ECONOMY: POTENTIAL TO OVERCOME FIRST- AND LAST-MILE PUBLIC TRANSIT CONNECTIONS

ABSTRACT
Shared mobility—the shared use of a motor vehicle, bicycle, or other mode—enables travelers to gain short-term access to transportation modes on an as-needed basis. The term "shared mobility" includes the modes of carsharing, personal vehicle sharing (peer-to-peer carsharing and fractional ownership), bikesharing, scooter sharing, traditional ridesharing, transportation network companies (or ridesourcing), and e-Hail (taxis). It can also include flexible transit services, including microtransit, which supplement fixed-route bus and rail services. Shared mobility has proliferated in global cities not only as an innovative transportation mode enhancing urban mobility but also as a potential solution for addressing first- and last-mile connectivity with public transit. It can extend the catchment area of public transportation, potentially playing a pivotal role in bridging gaps in the existing transportation network and encouraging multimodality for first- and last-mile trips rather than driving alone. While public transit is often constrained by fixed routes, driver availability, and vehicle scheduling, shared mobility's "on-demand" access provides the flexibility that travelers need to access or egress from a bus or rail "trunk line." Moreover, shared mobility provides an alternative to costly feeder bus services and land-intensive parking infrastructure. This paper discusses the history of shared mobility within the context of the urban transportation landscape, first in Europe and Asia, and more recently in the Americas, with a specific focus on first- and last-mile connections to public transit. The authors discuss the known impacts of shared mobility modes—carsharing, bikesharing, and ridesharing—on reducing vehicle miles/kilometers traveled (VMT/VKT), greenhouse gas (GHG) emissions, and modal splits with public transit. The future of shared mobility in the urban transportation landscape is discussed, as mobile technology and public policy continue to evolve to integrate shared mobility with public transit and future automated vehicles.

KEYWORDS: shared mobility, sustainable transportation, sharing economy, first-last mile, public transit, multi-modal integration, automated vehicles

INTRODUCTION
Shared mobility—the shared use of a vehicle, bicycle, or other mode—is a growing sector of the sharing economy. The concept of sharing is far from new, yet economic models have emerged, particularly since the 1990s, that are based on peer-to-peer sharing or the collaborative consumption of resources. Other names for the sharing economy include the "collaborative economy" and "peer-to-peer (P2P) economy." Factors that facilitate sharing among strangers include online social networking platforms and global positioning systems (GPS)-enabled mobile technology. Sharing economy business models include the sharing of lodging (e.g., Airbnb, Couchsurfing); labor (e.g., Handy, TaskRabbit); equipment (e.g., NeighborhoodGoods); food (e.g., Social Dining Network), and the transportation sector (e.g., Uber, Vélib', Zipcar). Botsman and Rogers (2010) explain that consumers are opting for accessing goods without the cost, burden, and greater environmental impacts often associated with personal ownership. PricewaterhouseCoopers (PwC, 2014) estimated that five sectors of the sharing economy (e.g., equipment, housing, books, DVDs, and cars) currently generated US$15 billion in global revenue in 2014, which is poised to grow to US$335 billion in 2025.

Shared Mobility and The Sharing Economy

While the latter half of the 20th century in North America and even Europe emphasized personal vehicle ownership and usage in passenger transportation, innovations in information communication technology (ICT) and business models have brought forth various modes beyond the traditional automobile and public transit. Travelers can now hail a driver and vehicle (e.g., Lyft, Uber); rent a car or bicycle for a short trip (e.g., Zipcar, car2go, and Santander Cycles); ride a private shuttle on a crowdsourced route or on-demand (e.g., Bridj, Chariot, Via); and have groceries or takeout food delivered in someone's personal vehicle (e.g., Instacart and Postmates)—all using Internet-enabled smartphones, tablets, and other mobile devices. There remains some controversy over whether some services should be considered part of the sharing economy (Eckhardt and Bardhi, 2015), but the majority of the literature and popular press attribute these to the sharing economy. Moreover, it is undisputed among transportation agencies and planners that innovative mobility services fall under the umbrella term of shared mobility (Cohen and Shaheen, 2016; Shaheen, Cohen, and Zohdy, 2016).

Shared mobility is the shared use of a vehicle, bicycle, or other low-speed mode that enables users to have short-term access to transportation modes on an "as-needed" basis, often serving as a first- or last-mile connection to other modes, such as public transit. It includes carsharing; personal vehicle sharing; scooter sharing; bikesharing; on-demand ride services (including taxi e-Hail and ridesourcing or transportation network companies (TNCs)); ridesharing (i.e., carpooling, vanpooling); and microtransit; and courier network services (CNS).

Figure 1 categorizes these key areas of shared mobility depending on what is being shared. Carsharing, scooter sharing, and bikesharing (Figure 1, left) are services that enable the sharing of a vehicle. Ridesharing, on-demand ride services, and microtransit (Figure 1, middle) facilitate the sharing of a passenger ride. Finally, CNS, Figure 1, right, enable the sharing of a delivery ride (i.e., a ride for cargo). CNS is not a focus in this paper (thus, it has been darkened in Figure 1), as we are not aware of such services directly linking to public transit.

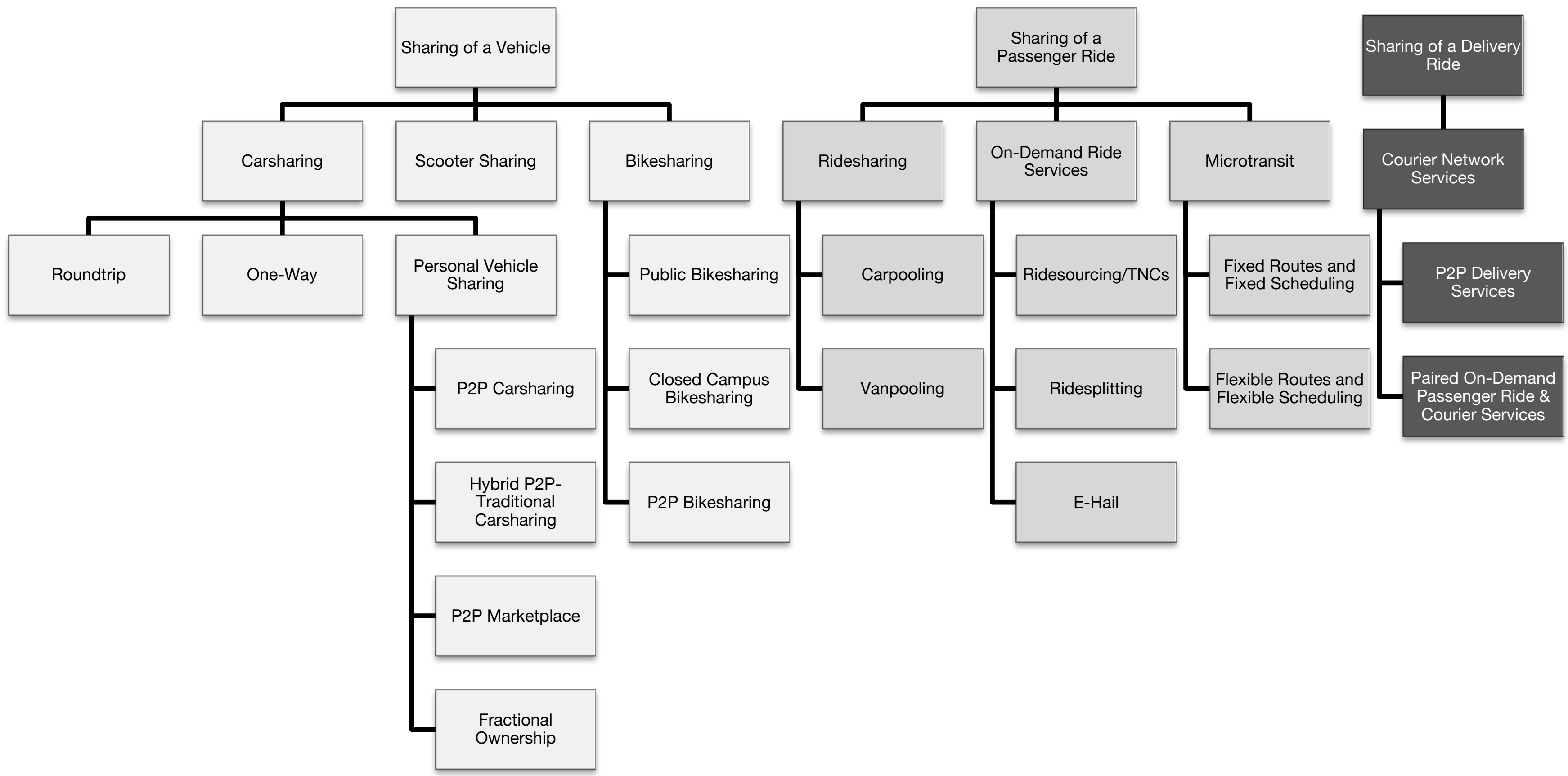

Figure 1 Key areas of shared mobility.

The impacts of shared mobility have been documented in cities worldwide, including cost savings and convenience, reduced vehicle miles traveled (VMT)/vehicle kilometers traveled (VKT), and reduced personal vehicle ownership, as well as reduced greenhouse gas (GHG) emissions. Moreover, there are often economic benefits to shared mobility, such as increased economic activity near multimodal hubs and commercial areas (Wang et al., 2016; Buehler and Hamre, 2015). Yet, there remains to be sufficient research on a municipal and regional level, particularly with innovative forms of shared mobility, such as on-demand ride services, microtransit, and CNS. Social issues, such as equity of such services, still remain unanswered. As shared mobility options grow in the future, it is important for the public sector to enact or revise appropriate legislation to protect public safety and equity and to provide guiding policies to maximize benefits.

This paper presents an overview of the sharing of a vehicle and sharing of a passenger ride. Within each section, we present the history and current understanding of each shared mobility mode, with a focus on impacts to other modes and the potential for connections to public transit as first- and last-mile solutions. Lastly, the paper discusses the future of urban transportation as technology and shared mobility become more integrated into a multi-modal transportation system.

SHARING OF A VEHICLE

Carsharing

Through carsharing, individuals can gain the benefits of private vehicle use without the cost and burdens of ownership (e.g., fuel, maintenance, insurance). Carsharing members instead are able to access a fleet of shared vehicles on an as-needed basis and pay a usage- and/or membership-based fee. The first carsharing program can be traced back to Switzerland in 1948. More popularized European programs launched in the 1980s. Since then, the industry has grown worldwide. As of October 2014, there were 4.8 million carsharing members worldwide, 2.2 million of which were in European programs, and 1.6 million in North American programs (Shaheen and Cohen, 2016).

These are various carsharing business models in existence, the earliest of which is the roundtrip model. More recently, one-way carsharing and personal vehicle sharing (PVS) have emerged. While each model can provide first- and last-mile connections to other modes, one-way carsharing allows for the most flexibility to provide linkages to public transit and are discussed in the most detail.

Roundtrip Carsharing

Roundtrip carsharing provides its members access to a fleet of shared vehicles on an hourly basis, and it requires the vehicle be returned to the same location from where it was accessed. Because roundtrip carsharing has the longest history, there have been several studies on its impact on VMT/VKT, vehicle ownership, GHG emissions, and individual transportation costs. Cervero and Tsai (2004) found that 30% of members of a San Francisco Bay Area carsharing operator, City CarShare, shed one or more of their personal vehicles, and two-thirds postponed purchasing a vehicle after using the service for two years. Martin and Shaheen (2011) conducted a study of over 6,000 members of carsharing in the U.S. and Canada and documented the impact of roundtrip carsharing on modal shift. They found an overall decline in public transit use among carsharing members, but they also found a notable increase in non-motorized travel—walking, bicycling, and traditional carpooling. Moreover, Le Vine et al. (2014) developed a model for forecasting carsharing impacts. They found that employing carsharing (both roundtrip and one-way) in London would reduce the number of public transit trips. They also noted that while one-way carsharing was found to be a substitute for public transit, roundtrip carsharing was complementary.

Le Vine et al. (2014) also argued that innovative mobility modes are being used by travelers in ways that cannot be adequately understood with current activity-based methodologies, suggesting the use of multi-day travel diaries to better capture behavioral understanding. The member survey, although imperfect in its precision in measuring changes in big numbers, is an important instrument for obtaining a before-and-after measure of carsharing impact. For instance, Sioui et al. (2013) found that carsharing members in a case study in Montreal, Canada used private vehicles significantly less than non-carsharing members. Finally, Clark et al. (2015) conducted a study of business-to-business carsharing in Great Britain, and they found that 15% of employees commuted to work by private auto less than they did prior to joining carsharing. For this reason, surveys will likely and continue to play a fundamental role in assessing causes of change and providing critical inputs to its measurement--despite advances in technology that improve approaches to travel behavior measurement (i.e., activity data). A similar discussion is relevant to impact analyses of the other shared modes discussed in this paper.

One-Way Carsharing

One-way carsharing, also known as point-to-point or free-floating carsharing, allows members to pick up a vehicle at one location and drop it off at another. In 2012, a rapid expansion of one-way carsharing began worldwide in seven countries (Shaheen and Cohen, 2012). In October 2014, there were 851,988 one-way carsharing members globally, 372,466 of which were in Europe, 445,722 were in North America, 29,600 in Asia, 3.500 in South America, and 700 in Oceania (Shaheen and Cohen, 2016). As of January 2015, 35.7% of North American fleets allowed one-way trips, and 30.8% of members had access to such fleets (Shaheen and Cohen, 2015). As of September 2015, four carsharing companies in the U.S. offered one-way functionality (BlueIndy, car2go, DriveNow, and Zipcar) in 14 U.S. metropolitan regions.

One-way carsharing can allow increased flexibility and has the potential to further enhance first- and last-mile connectivity. Moreover, as one-way trips are short city trips, electric vehicles (EVs) can be used to reduce GHG emissions. To serve these mobility opportunities, companies and cities have launched experimental programs of one-way carsharing, beginning in Europe in the 1970s, East Asia in the 1990s, and continuing in the U.S. from the 1990s until today.

Procotip was the first recorded one-way carsharing experiment, launched in August 1971 in Montpellier, France with 35 cars and 19 stations. It closed in May 1973 due to technological and financial issues (Biau, 1991). Liselec launched in 1993 in La Rochelle, France with 50 EVs at seven stations. Liselec was successful and still exists today as Yelómobile. It is sponsored by Peugeot-Citroen and receives financial support from the government. European one-way carsharing schemes connected to public transit began with Praxitèle in 1997. Fifty EVs were placed in Saint-Quentin-en-Yvelines, a Paris suburb, allowing its 500 members to make one-way trips between 14 stations located in neighborhoods, near offices, and at public transit stations. By

March 1999, 90% of total trips were one-way trips (Massot, 2011). Although Praxitèle succeeded in its technical implementation, the program struggled with costs and ended in July 1999.

In Japan, automakers piloted mobility services with one-way carsharing at public transit stations. In 1998, Honda Motor Company deployed the Intelligent Community Vehicle System (ICVS) concept, which included both roundtrip and one-way carsharing with connections to public transit (Honda Motor Co., Ltd., 1998). Similarly, in 1999, Toyota Motor Company launched the Crayon System in Toyota City, Japan. Fifty EVs were placed at public transit stations and other locations for its 700 members. Both Honda and Toyota employed advanced technologies including: smartcards, automatic vehicle location, vehicle information and communication systems, and a management system for reservations and recharging (Barth et al., 2007).

One-way carsharing began in the U.S. as pilot projects for public transit connectivity. In 1999, CarLink I launched at the Dublin/Pleasanton Bay Area Rapid Transit (BART) station in the East Bay of the San Francisco Bay Area (Shaheen, 1999; Shaheen et al., 2000). Twelve compressed natural gas (CNG) Honda Civics were available to drive between the BART station and the Lawrence Livermore National Laboratory (LLNL). Similarly, CarLink II was based at the Caltrain station in Palo Alto, California with 27 Honda Civics and 100 users (Shaheen and Novick, 2005). The CarLink pilot programs facilitated one-way trips between rail stations and home- and work-side trips. Some who lived near the transit station took BART into the central business district (CBD). Others took public transit to their suburban workplace, using CarLink as the last-mile link from the transit station to work. These commuters then returned their vehicles to the station in the evening, and home-side users picked up these vehicles after taking public transit from the CBD. At the end of the CarLink II pilot, Flexcar took over the service in 2002. However, it ceased operations in 2003 due to concerns with cost recovery and its limited scale.

The University of California (UC) piloted several one-way carsharing projects with links to public transit. UC Irvine operates the Zero Emission Vehicle Network Enabled Transport (ZEV· NET) system. Launched in 2002, ZEV· NET facilitates trips between the Irvine Transportation Center commuter rail terminal, four employers, and the UC Irvine campus. Additionally, its fleet is entirely comprised of EVs. More recently, 30 Toyota iQ EVs were added in March 2013, and the system still operates today (UC Irvine News 2013). UCR Intellishare operated around the UC Riverside campus and the Downtown Riverside Metrolink station from 1999 to 2010 (Barth et al., 2000).

Since the 1970s, despite many successful one-way carsharing projects that were well received, many ceased operations. The main reasons include economic viability (e.g., CarLink), underuse (e.g., Praxitèle), and insufficient technology (e.g., Procotip). Yet, others have succeeded and still operate today (e.g., Yélomobile). Early one-way carsharing attempts established the foundation for existing carsharing services today.

At present, one-way carsharing reflects two main models: 1) free-floating carsharing and 2) station-based carsharing. Free-floating carsharing enables shared vehicles to be picked up and dropped off anywhere within a designated operating area. In contrast, station-based systems require users to return the vehicle to any designated station. Although this model may be perceived as less flexible, station-based carsharing limits vehicle search to select locations. One variation to station-based carsharing is the airport-based model, which facilitates one-way trips between airports (i.e., the "station") and destinations, such as the CBD.

Experts in carsharing forecast one-way systems to continue to grow. Shaheen et al. (2015) conducted interviews with the carsharing industry and found that a notable innovation linked to one-way carsharing's expansion was integration with public transit. Much of the recent literature has focused on vehicle and staff rebalancing and logistics management (e.g., Nourinejad, et al. (2015); Weikl and Bogenberger (2015)). Preliminary results from Martin and Shaheen (2016) of car2go users in five North American cities found that each carsharing vehicle removed between 7 to 11 vehicles from the road (sold and forgone). Two to 5% of members sold a vehicle and 7% to 10% postponed a vehicle purchase. Moreover, estimated VMT impacts due to carsharing ranged from -6% to -16% per car2go household, and GHG emissions changed by -4% to -18% (see Figure 2). Nevertheless, more research is needed to better understand one-way carsharing's potential impact on VMT/VKT, GHG emissions, and automobile ownership, particularly longer-term effects.

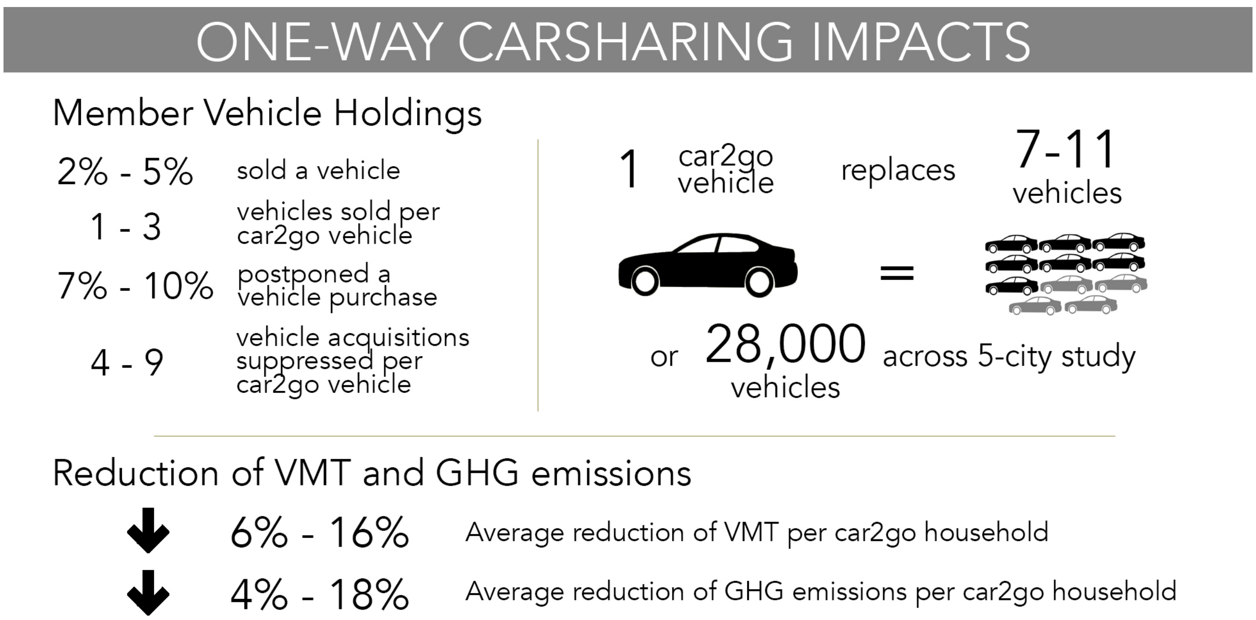

Figure 2 Impacts of one-way carsharing (Martin and Shaheen, 2016).

Scooter Sharing

Scooter sharing is a recent variation on the vehicle-sharing business model. As of September 2015, there were two scooter sharing systems in Europe: Motit in Barcelona and Enjoy in Milan—and two in the U.S.: Scoot Networks in San Francisco, California, and Scootaway in Columbia, South Carolina. All of these systems offer both one-way and roundtrip short-term scooter sharing, including insurance and helmets. Several other systems in Europe are in trial including: CityScoot in Paris, eMio in Berlin, and Scoome in Munich and Cologne. In addition to scooter sharing (classic and cargo models), Scoot Networks also offers electric motorcycle sharing and Scoot Quads (Renault's Twizy EV). From its launch in 2012 through April 2014, Scoot Networks increased from four to 12 stations and 20 to 50 scooters, respectively. As of October 2015, Scoot had over 400 scooters and 10 Quads in its network, and Scootaway's fleet was comprised of 350 scooters. At that time, Scoot's vehicles were being driven over 70,000 miles each month (Scoot, unpublished data).

Due to the lower speed of scooters, which must remain on city streets versus highways, scooter sharing systems have remained in urban areas. Although scooter sharing represents a smaller market relative to other shared modes, it also can provide first- and last-mile connections to public transit. Similar to public bikesharing, scooters require less parking space at public transit stations, which could potentially increase transit ridership. Future research could test multi-modal linkages, similar to station car and one-way carsharing pilots of the past.

Bikesharing

Bikesharing systems allow users to access bicycles on an as-needed basis from a network of unattended stations, typically concentrated in urban areas. Most bikesharing operators are responsible for bicycle maintenance, storage, and parking costs. Bikesharing can also be free-floating within a geo-fenced area either through a business-to-consumer (B2C) operator (e.g., Social Bicycles) or through P2P systems enabled through third-party hardware and applications (e.g., Bitlock, Spinlister). There are three main types of bikesharing systems: 1) public bikesharing, 2) closed campus bikesharing, and 3) P2P bikesharing (Shaheen and Christensen, 2014). The majority of bikesharing systems in the world are public, with anyone able to access a bicycle for a nominal fee (and with a credit/debit card on file). In order to serve low-income communities, some public bikesharing systems offer subsidies and cash memberships (Shaheen et al., 2014).

Bikesharing has emerged as one of the latest and fastest growing transportation innovations in many global cities. As of October 2015, there were 995 cities with information technology (IT)-based public bikesharing systems in the world comprising of 1,165,200 bikes, the majority of which were in China. The U.S. had 61 programs spread over 87 cities, with approximately 30,750 bikes and 3,200 stations. Europe had 433 cities with public bikesharing systems in 29 countries, out of which Italy led with 130 cities (Russell Meddin, unpublished data). Closed-campus bikesharing systems are increasingly being deployed at university and office campuses; they are only available to the particular campus community they serve. P2P bikesharing services are available in urban areas for bike owners to rent out their idle bikes for others to use and are also growing due to companies, such as Spinlister and Bitlock.

Bikesharing has the potential to impact public transit systems, serving as an effective and efficient first- and last-mile connection. Several studies in the literature have reached mixed conclusions, depending upon the city context in which bikesharing is located. Campbell et al. (2016) compared traditional bikesharing and electric bikesharing (e-bikeshare) in Beijing, China. They found that e-bikesharing use was less sensitive to longer trip distances, reduced air quality, and poor weather conditions. Due to these factors, the authors conclude that e-bikesharing acts more as a competitor to public buses rather than as a supplement. They were unable to conclude that bikesharing in Beijing was acting as a first-/last-mile connection. In North America, study conclusions are opposite. Kaufman et al. (2015) studied the Citi Bike system in New York City and found that almost 75% of its bikesharing stations are within a five-minute walk from a subway station, providing that first-/last-mile connection to public transit. Shaheen et al. (2011) conducted a survey of over 800 members of a large public bikesharing program in Hangzhou, China. Their understanding of modal shifts suggested that bikesharing acted as both a competitor and complement to public transit. Over 30% of its members incorporated bikesharing into their most common commute.

Shaheen et al. (2012 and 2014) conducted a two-part study of public bikesharing programs in North America to determine the program impacts on modal split. The results suggest that public bikesharing in larger cities takes riders off of crowded buses, while bikesharing in smaller cities improves access/egress from bus lines. Moreover, respondents reported that rail usage decreased in larger cities due to faster travel speeds and cost savings from bikesharing.

Half of all bikesharing members reported reducing their personal automobile use (Shaheen et al., 2014). Aggregate-level impacts of bikesharing are summarized in Figure 3, below, based on a number of cities analyzed in North America (n=6,168).

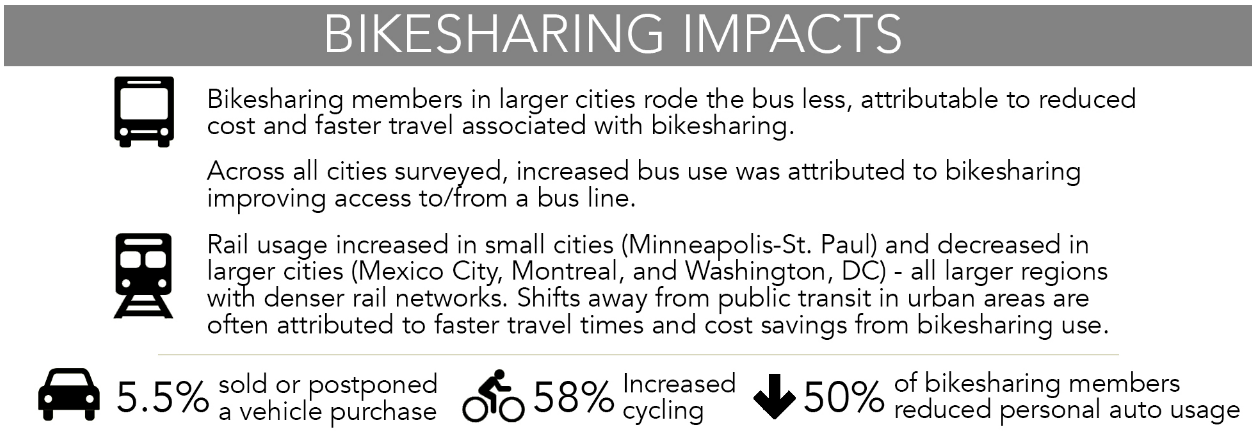

Figure 3 Impacts of North American public bikesharing (Shaheen and Chan, 2015).

SHARING OF A PASSENGER RIDE

While vehicle sharing has had a longer history of documented impact analysis, sharing of a passenger ride remains relatively new. Because innovations in the area of sharing a passenger ride have burgeoned only recently, the terminology remains unclear. To differentiate carpooling and vanpooling (ridesharing) from the emerging services, the terms “traditional ridesharing” and “on-demand ride services” are used.

Traditional Ridesharing

Traditional ridesharing facilitates shared rides among drivers and passengers with similar origin-destination pairings. Traditional ridesharing includes vanpooling (the grouping of seven to 15 persons commuting together in one van) and carpooling (groups of seven or less traveling together in one car), which have been in use for decades. Traditional ridesharing can be classified into the following categories: 1) acquaintance-based, 2) organization-based, and 3) *ad hoc*. Acquaintance-based ridesharing consists of carpools that are formed by people who are already acquaintances (i.e., carpools among family (“fampools”) and coworkers). Organization-based carpools require participants to join the service either through membership or by visiting a website. *Ad hoc* ridesharing involves more unique forms of ridesharing, including casual carpooling—also known as “slugging” (Chan and Shaheen, 2012). Although traditional ridesharing’s modal share in the U.S. declined from 20.4% in 1970 to 9.3% in 2013, it remains the second largest travel mode, after driving alone (U.S. Census Bureau, 2013).

Since the late-1960s, public agencies particularly in the U.S. and Canada have tried to increase traditional ridesharing’s modal share through policies (e.g., transportation demand management, trip reduction ordinances); high-occupancy vehicle (HOV) infrastructure (e.g., HOV lanes, park-and-ride facilities); and technology (computerized ridematching). The combination of those strategies proved successful. As of July 2011, there were 638 ridematching services in North America, with traditional ridesharing remaining the second largest travel mode (Chan and Shaheen, 2012). Yet as mobile technology has proliferated and improved in this decade, companies have increasingly targeted traditional ridesharing. Most recently, ridesourcing companies (discussed in more detail below) have launched services to target commuters and users of traditional ridesharing. Lyft began Driver Destination in 2014, and Uber launched uberCOMMUTE in China in 2015, which targeted drivers with longer commutes to pick up passengers along their commute. In March 2016, Lyft partnered with the Metropolitan Transportation Commission in the San Francisco Bay Area to pilot Lyft Carpool. Several other mobility companies have created similar platforms for traditional ridesharing, including Carma Carpooling, Carzac, and Ride. Most recently, in August 2016, Uber sold its China operations to competitor Didi Chuxing for an approximate 20-percent equity stake in the combined company, valued around US$35 billion (Mozur and Issac, 2016).

On-Demand Ride Services

On-demand ride services differ from traditional ridesharing, in that these services involve the passenger requesting a ride through a mobile device and a mobile app. On-demand ride services have experienced notable growth in the last few years, but they face an uncertain regulatory and policy climate. They include ridesourcing (also known as TNCs), ridesplitting within ridesourcing services, and e-Hail services for taxis with medallions.

Ridesourcing

Ridesourcing or TNC services use smartphone apps to connect community drivers with passengers. There are various terms used for this emerging transportation option—ridesourcing among transportation academics, TNCs among practitioners, and ride-hailing and ride-booking among the popular press. Examples of these services include: Lyft, Uber (specifically, uberX, uberXL, and UberSELECT), as well as specialized services such as Lift Hero and HopSkipDrive. These services can provide many different vehicle types including: sedans, sports utility vehicles, vehicles with car seats, wheelchair accessible vehicles, and vehicles where the driver can assist older or disabled passengers. While taxis are often regulated to charge static fares, ridesourcing often uses market-rate pricing, popularly known as "surge pricing"—when prices usually go up during periods of high demand to incentivize more drivers to take ride requests.

Lift Hero is a specialized ridesourcing service that caters to older adults and those with disabilities in the San Francisco Bay Area. The drivers are specially trained in caring for these riders. Similarly, Lyft has partnered with National MedTrans Network to deploy *Concierge*, a platform to provide non-emergency medical transportation in New York City. Another specialized for-hire vehicle service is HopSkipDrive, which provides rides for children either to or from school or afterschool activities. The drivers are either mothers or those with a background in childcare. At present, HopSkipDrive is only available in Los Angeles and the San Francisco Bay Area. A similar service, Shuddle, pioneered the service for children in the Bay Area, but it is now defunct.

Ridesourcing services have the potential to provide connectivity to public transit, as well as fill gaps in the public transit network. While reducing the need for additional parking at park-and-ride lots, this would increase the need for curb-space access. An exploratory study by Rayle et al. (2016) was conducted in 2014 with 380 ridesourcing users in San Francisco, California. Ridesourcing users were generally younger and more highly educated than the city average (84% had a bachelor's degree or higher). UberX provided the majority of trips (53%), while other Uber services (black car, SUV, etc.) represented another eight percent. Lyft provided 30% of trips, Sidecar (now defunct) 7%, and the remainder of trips were provided by other services. Forty percent of respondents who owned a car stated that they had reduced their driving due to the service. A summary of the study findings is provided in Figure 4 below.

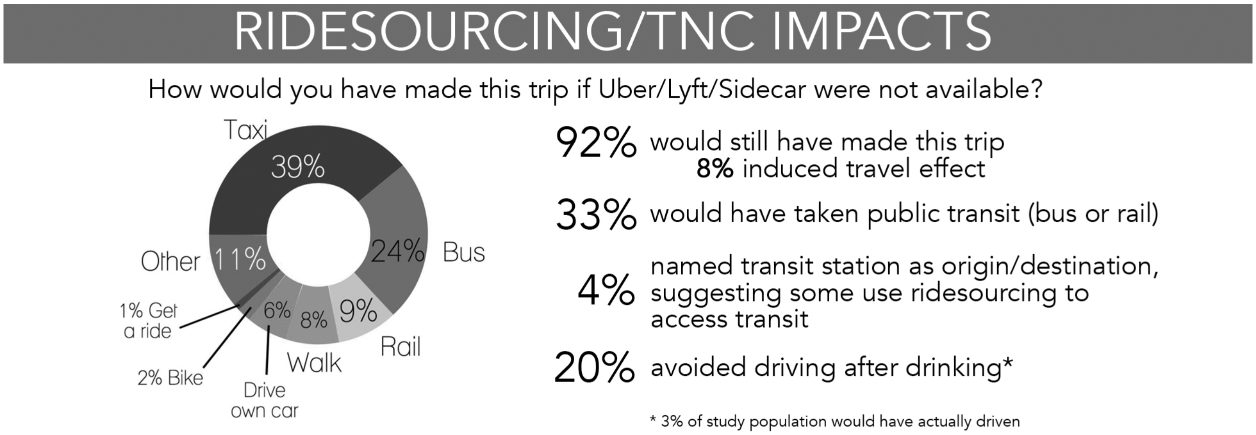

Figure 4 Impacts of ridesourcing/TNCs in San Francisco, CA (Shaheen and Chan, 2015).

Ridesourcing may also complement public transit, serving specific times when and areas where public transit is sparser. A 2016 study from the American Public Transportation Association found that ridesourcing is most popular between the hours of 10pm and 4am, when public transit is infrequent or even unavailable. Moreover, the study found that ridesourcing appeared to substitute for private auto trips rather than trips via public transit (APTA, 2016), based on a sample of 4,500 shared mobility users.

Ridesplitting

Ridesplitting is a variation on ridesourcing—it involves splitting a ride and fare with someone else taking a similar route. Ridesourcing companies operate ridesplitting services, such as Lyft Line and UberPOOL, which match riders with similar origins and destinations together. These shared services enable dynamic route changes, as passengers request pickups in real time. Lyft Line has experimented with "Hot Spots" in the San Francisco Bay Area that encourage passengers to congregate at select intersections in exchange for discounted fares as a means of consolidating operations and making them more efficient. Similarly, UberPOOL has recently been testing "Smart Routes," where users can get a discounted fare starting at US$1 off the normal UberPOOL price in return for walking to a major arterial street. This allows drivers to make fewer turns and complete ride requests faster (de Looper, 2015).

Uber has also launched uberHOP in Seattle, Washington, and Toronto, Canada—an on-demand ridesplitting service for peak-period travel. Travelers request their ride through the app and walk to a designated pickup location and share the ride with other commuters. The uberHOP service straddles ridesplitting and on-demand microtransit (discussed below). Like microtransit, it pools more riders together and uses predetermined pickup and dropoff locations, but it uses community vehicles and drivers, which is closer to ridesplitting.

E-Hail Services

The taxi industry has responded to the rising popularity of ridesourcing with its own mobile device apps. Travelers can use "e-Hail" apps to electronically hail a taxi, which are maintained either by the taxi company or a third-party provider. There has been a dramatic increase in the use of e-Hail services, such as Arro, Bandwagon, Curb, Flywheel, Hailo, and iTaxi, in the U.S.

For example, as of October 2014, Flywheel was used among 80% of San Francisco taxis (1,450 taxis), which has brought taxi wait times closely in line with those of ridesourcing (Steinmetz, 2014). Increasingly, taxi and limousine regulatory agencies are developing e-Hail pilot programs and mandating e-Hail app compatibility. In February 2015, Flywheel was operating in six cities with over 5,000 drivers, and Curb (acquired by Verifone) served approximately 60 U.S. cities with 35,000 cabs. The Bandwagon app combines ridesplitting with e-Hail to facilitate taxi splitting. It matches riders going a similar direction in taxis and provides a platform for splitting the fare. As of Spring 2016, Bandwagon operates at LaGuardia Airport and John F. Kennedy International Airport in New York City. Because regulated taxis charge static fares, e-Hail services similarly charge locally-regulated taxi rates and do not use “surge pricing” during periods of high demand as ridesourcing companies often do.

Microtransit

In addition to traditional fixed-route public transit, other transportation options have existed in parallel including: paratransit, jitneys, dollar vans, and feeder shuttles operated by employers or public transit agencies. Recently, a form of private transit enabled by technology has emerged, called microtransit, which incorporates flexible routing, flexible scheduling, or both. These services operate much like jitneys of the past but are enhanced with information technology (Cervero, 1997). Microtransit operators primarily target commuters, connecting residential areas with urban and suburban job centers. Microtransit’s use of smartphone technology avoids traditional and costly methods of booking rides, such as call centers or even booking websites, thus potentially lowering operating costs for services that target special populations, such as disabled, older adults, and low-income groups. Microtransit services can be categorized into the following two models: 1) fixed route, fixed schedule, and 2) flexible route with on-demand scheduling.

Fixed Routes and Fixed Scheduling

Fixed-route and fixed-schedule microtransit operates similarly to fixed-route public transit or even vanpooling. An example of such a service is Chariot, which runs 14-seat vans along predefined routes in San Francisco, California. Chariot allows its customers to request new routes through its mobile app as a way to determine new crowdsourced routes. While these services may appear like vanpooling, microtransit drivers are employed drivers rather than vanpool participants sharing driving responsibilities. To some public transit agencies, microtransit seems to directly compete with its bus routes. However, in some congested cities, microtransit can alleviate overcrowding on popular bus routes or provide feeder service to transit trunk lines. Research is needed to better understand this dynamic.

Flexible Routes and On-Demand Scheduling

Flexible-route, on-demand microtransit operates more similarly to ridesplitting and paratransit services. An example includes Bridj in Austin, Texas; Boston, Massachusetts; Kansas City (both Missouri and Kansas); and Washington, D.C. Its app enables users to request rides in select neighborhoods. Based on the requests received, Bridj selects a central meeting spot, which passengers walk to and share a ride with other passengers traveling along a similar route. According to Bridj, the service is able to transport 22 passengers per vehicle per hour. Notably, *Ride KC: Bridj* in Kansas City is the first public-private partnership among a shared mobility company (Bridj), an automaker (Ford Motor Company), and a public transit agency (Kansas City Area Transportation Authority).

Another on-demand microtransit service is Via in New York City. Via users request rides in real-time and share a ride with passengers going in a similar direction. Due to the one-way avenue design of New York City, passengers are often asked to walk to an adjacent one-way avenue to minimize route deviation and improve operational efficiency. Via has served 1.5 million rides since its launch in late-2013 and expanded to Chicago, Illinois. Similar to fixed-route microtransit, on-demand microtransit could provide first- and last-mile service for public transit. In fact, in August 2016, Chariot announced a variation on its microtransit service, called Chariot Direct. Rather than a fixed-route, fixed schedule service, Chariot Direct provides a last-mile service from public transit hubs in San Francisco to destinations in the city. Similar to Bridj, routes and scheduling are created on-demand based on travelers' requests. As microtransit continues to evolve, research is needed to understand its potential impacts.

FUTURE OF SHARED MOBILITY

This section focuses on shared mobility's future including use of trip planning mobile apps, multi-modal integration, and potential opportunities with automation.

Trip Planning Apps

It is evident that ICT, most recently in the form of personal, mobile devices, is shaping passenger mobility. One end-user form is trip planning apps (also known as "journey planners"), which assist travelers in identifying a particular travel mode and route based on cost, environmental impact, and time considerations (Shaheen et al., 2016). They can also provide turn-by-turn guidance as users navigate their chosen route. Trip planning apps are often an enabling technology for shared mobility use. Gossart and Whitney (2014) found that 80% of app users in the study took modes other than their personal cars, mostly opting for public transit. Trip planning apps can be grouped into two general categories: 1) single-mode trip planning and 2) multi-modal trip aggregators. We focus on the latter category. Most of these apps, including those discussed below, are free to download and use.

Multi-modal trip aggregators assist travelers planning trips involving different modes—public transit, carsharing, ridesharing, on-demand ride services, taxis, bicycling, walking, and personal vehicles—in a single app. Apps can display travel time, cost, and even calories burned while using different modes and routes. Moreover, these apps often use real-time information to provide accurate departure and arrival times. A few examples of trip aggregation apps are discussed below.

Citymapper consolidates real-time information for public transit, walking, biking and ridesourcing in over 30 cities in Europe, Asia, and the Americas. The app allows users to set arrival and departure times and provides route suggestions based on travel time, cost, mode choices, and calories burned. Similarly, *Nimbler* provides turn-by-turn directions, taking into account real-time traffic and delays when traveling by bike, train, bus, and walking. Nimbler also allows bicyclists to set preferences related to the fastest, safest, or flattest route. The *TripGo* app enables users to input their personal schedule and create routes based on that schedule. *Swiftly* is another trip-planning app launched in September 2015 in San Francisco. One unique feature is that it allows its users to input overcrowding and delay information to alert other Swiftly users in real time seeking to travel the same route or mode.

RideScout originally launched in November 2013 as a trip planning app, comparing different routes and modal options, with links to third-party apps to complete bookings. Since acquiring GlobeSherpa in 2015, RideScout shifted toward integrated payment across shared mobility modes. To provide this integration, RideScout launched its *RideTap* software development kit (SDK) to app developers in 2016. Moreover, Daimler's subsidiary moovel Group acquired RideScout in 2016 and relaunched it in the form of a mobile ticketing app, called *moovel Transit*, and a trip planning app called, *moovel*, that will replace RideScout.

Companies are also partnering with cities to create apps specific to public transit and shared mobility services available in the city or region. An example is *Go LA*, a collaboration between Xerox and the City of Los Angeles. This is a multi-modal transit app, which launched in January 2016. Xerox launched a similar app, *Go Denver*, in collaboration with the City of Denver in February 2016 (McKee and Palmeroni, 2016). Another development in mobile trip aggregator apps is gamification to incentivize more environmentally-friendly travel modes and reduce traffic congestion.

Mobile and payment apps can provide a platform for public transit agencies and shared mobility companies to collaborate, provide real-time travel information, and facilitate payment and incentives to enable multi-modal connectivity.

CONCLUSION: OPPORTUNITIES AND CHALLENGES TO OVERCOME FIRST- AND LAST-MILE PUBLIC TRANSIT CONNECTIONS

Shared mobility, a subset of the larger sharing economy, enables users to gain short-term access to transportation modes on an as-needed basis. Carsharing, bikesharing, on-demand ride services, and microtransit are changing how travelers, particularly in urban settings, access transportation, and make connections to other modes, such as public transit. Moreover, shared automated vehicles (SAVs) could facilitate such connections to public transit and contribute to a major shift in mobility from privatized transport to shared mobility. For more discussion on autonomous vehicles, refer to Ohnemus and Perl in this issue. Studies have found a number of environmental, social, and transportation-related impacts of shared mobility services, such as a reduction of vehicle miles/kilometers traveled, vehicle use, and vehicle ownership. This has been demonstrated for carsharing and public bikesharing, but more research is needed to better understand the impacts of on-demand ride services.

Seizing the opportunity to serve first- and last-mile trips, various shared mobility services have launched to serve as connections to public transit. Major pilots have included carsharing and bikesharing located at rail stations. Thus, public transit agencies have been increasingly interested and are planning and piloting multi-modal integration of shared mobility services. Bay Area Bike Share, a public bikesharing program in the San Francisco Bay Area, launched in August 2013 with a specific objective of providing connections to local and regional rail systems—Caltrain, BART, and MUNI. Similarly, the Los Angeles County Metropolitan Transportation Authority (Metro) launched a public bikesharing system in July 2016, with 1,000 bikes at 65 stations. The initial system focuses on connections to Metro Rail stations in Downtown Los Angeles, and it will expand to 4,000 bikes in ten communities in Los Angeles County. While other systems have launched through successful partnerships among municipalities, departments of transportation, air quality management districts, bikesharing operators, and other sponsors, Los Angeles's system is the first public bikesharing system in North America directly operated by a public transit agency.

In comparison to carsharing and bikesharing, there are mixed responses from cities and public agencies regarding the future of ridesourcing in urban areas. While some have attempted to prohibit ridesourcing operations, others are interested in its potential to complement the existing public transit system. In March 2016, a suburb of Orlando, Florida has begun a pilot to subsidize Uber rides within its city and to and from its commuter rail station.

Despite shared mobility's impacts and opportunities, challenges remain particularly in the area of public policy. Cities and states have had difficulty enacting and revising policy to keep pace with shared mobility innovations while addressing issues of public safety, insurance and liability, and fair labor practices. Equity remains an unanswered area—early anecdotal evidence has emerged stating that lower-income populations lack adequate access to certain shared mobility services. Additionally, labor issues have been raised regarding ridesourcing drivers, leading regulators and companies to question whether drivers should be considered independent contractors or employees. Monitoring public-private partnerships, such as the Ride KC: Bridj pilot that employs vehicles and drivers from the Kansas City Area Transportation Authority, may assist in answering such labor issues. As automated vehicles are poised to dramatically transform mobility, SAVs may too become a major public transportation mode, filling gaps in the existing fixed-route network and allowing first- and last-mile connectivity. Although research and development into AVs has increased, its impacts on travel and emissions remains speculation. Further research is needed to better understand the longer-term impacts of this nascent and rapidly-expanding industry as it intersects with public transportation.

ACKNOWLEDGEMENTS
The authors of this paper would like to thank the California Department of Transportation, the Federal Highway Administration, and the Transportation Sustainability Research Center at the University of California, Berkeley for funding the research, which led to this paper. The contents of the article reflect the views of the authors and does not necessarily indicate acceptance by the sponsors.

REFERENCES

APTA (2016). Shared Mobility and the Transformation of Public Transit. American Public Transportation Association, March 2016. Available at http://www.apta.com/resources/hottopics/Pages/Shared-Use-Mobility.aspx, accessed 17 March 2016.

Barth, M., Shaheen, S., Fukuda, T., and Fukuda, A. (2007). Carsharing and Station Cars in Asia: An Overview of Japan and Singapore. *Transportation Research Record: Journal of the Transportation Research Board*, No. 1986, pp. 106-115.

Barth, M., Todd, M., and Murakami, H. (2000). Intelligent Transportation System Technology in a Shared Electric Vehicle Program. *Transportation Research Record: Journal of the Transportation Research Board*, No. 1731, pp. 240-245.

Biau, V. (1991). Montpellier 1971-1974: une expérience de “transport individuel public” *Transports Urbains*, No. 72, pp. 21-25.

Buehler, R. and Hamre, A. (2015). Business and Bikeshare User Perceptions of the Economic Benefits of Capital Bikeshare. TRB 94th Annual Meeting Compendium of Papers, Transportation Research Board.

Botsman, R. and Rogers, R. (2010). *What's Mine Is Yours: The Rise of Collaborative Consumption*. New York: Harper Collins.

Campbell, A. A., Cherry, C. R., Ryerson, M. S., and Yang, X. (2016). Factors influencing the choice of shared bicycles and shared electric bikes in Beijing. *Transportation Research Part C: Emerging Technologies*, Vol. 67, pp. 399-414.

Cervero, R. (1997). *Paratransit in America: Redefining Mass Transportation*. Westport, CT: Greenwood Publishing Group.

Cervero, R. and Tsai, Y. (2004). City CarShare in San Francisco, California: Second-Year Travel Demand and Car Ownership Impacts. *Transportation Research Record: Journal of the Transportation Research Board*, No. 1887, pp. 117-127.

Chan, N. and Shaheen, S. (2012). Ridesharing in North America: Past, Present, and Future. *Transport Reviews*, Vol. 32, No. 1, pp. 93-112.

Clark, M., Gifford, K., Anable, J., and Le Vine, S. (2015) Business-to-business carsharing: evidence from Britain of factors associated with employer-based carsharing membership and its impacts. *Transportation*, Vol. 42, pp. 471-495.

Cohen, A. and Shaheen, S. (2016). Planning for Shared Mobility. American Planning Association, Report PAS 583, August 2016.

de Looper, C. (2015). Uber Testing Bus-Like 'Smart Routes.' *Tech Times*. Available at http://www.techtimes.com/articles/79084/20150824/uber-testing-bus-smart-routes.htm, accessed 14 March 2016.

Eckhardt, G. and Bardhi, F. (2015). The Sharing Economy Isn't About Sharing at All. *Harvard Business Review*, January 28, 2015. Available at https://hbr.org/2015/01/the-sharing-economy-isnt-about-sharing-at-all, accessed July 14, 2016.

Fagnant, D. J. and Kockelman, K. M. (2014). The travel and environmental implications of shared autonomous vehicles, using agent-based model scenarios. *Transportation Research Part C*, No. 40, pp. 1-13.

Greenblatt, J. B. and Saxena, S. (2015). Autonomous taxis could greatly reduce greenhouse-gas emissions of US light-duty vehicles. *Nature Climate Change*, Vol. 5, September 2015.

Greenblatt, J. B. and Shaheen, S. (2015). Automated Vehicles, On-Demand Mobility, and Environmental Impacts. *Current Sustainable Renewable Energy Reports*, Vol. 2, No. 3, pp. 74-81.

Gossart, J. and Whitney, A. (2014). RideScout T 76 IDEA Grant. Transportation Research Board of the National Academies, IDEA Program Final Report. Available at http://onlinepubs.trb.org/onlinepubs/IDEA/FinalReports/Transit/Transit76.pdf, accessed 14 November 2015.

Honda Motor Co., Ltd. (1998). Honda Announces the Development of Intelligent Community Vehicle System (ICVS) Management Technology and Vehicles. Honda Motor Co., Ltd., Tokyo, 10 September 1998. Available at http://world.honda.com/news/1998/c980910.html, accessed 1 March 2016.

Hu, X., Chiu, Y., Delgado, S., Zhu, L., Luo, R., Hoffer, P., and Byeon, S. (2014). Behavior Insights for an Incentive-Based Active Demand Management Platform. TRB 93rd Annual Meeting Compendium of Papers, Transportation Research Board.

Kaufman, S. M., Gordon-Koven, L., Levenson, N., and Moss, M. L. (2015). Citi Bike: The First Two Years. Rudin Center for Transportation, Robert. F. Wagner School of Public Service, New York University, June 2015.

Le Vine, S., Lee-Gosselin, M., Sivakumar, A., and Polak, J. (2014). A new approach to predict the market and impacts of round-trip and point-to-point carsharing systems: Case study of London. *Transportation Research Part D*, No. 32., pp. 218-229.

Martin, E. and Shaheen, S. (2010). Greenhouse Gas Impacts of Carsharing in North America. Mineta Transportation Institute, Report 09-11.

Martin, E. and Shaheen, S. (2011). The Impact of Carsharing on Public Transit and Non-Motorized Travel: An Exploration of North American Carsharing Survey Data. *Energies,* Vol. 4, No. 11, pp. 2094-2114.

Martin, E. and Shaheen, S. (2016). Impacts of Car2go on Vehicle Ownership, Modal Shift, Vehicle Miles Traveled, and Greenhouse Gas Emissions. Working paper, University of California, Berkeley, Berkeley, CA, July 2016. Available at http://innovativemobility.org/wp-content/uploads/2016/07/Impactsofcar2go_FiveCities_2016.pdf?platform=hootsuite, accessed 5 August 2016.

Massot, M-H. (2011). Praxitèle, un concept, un service, une expérimentation, bilan d'un prototype. *TEC, Transport, Environnement, Circulation*, No. 2000, pp. 25-32.

McKee, B. and Palmeroni, J. (2016). Los Angeles Commuters to Usher in New Era of Daily Trip Planning. Press Release, Norwalk, CT: Xerox Corporation, 27 January 2016. Available at http://news.xerox.com/news/City-of-LA-introduces-new-Xerox-Go-LA-app, accessed 20 March 2016.

Mozur, P. and Issac, M. (2016). Uber to Sell to Rival Didi Chuxing and Create New Business in China. *The New York Times*, 1 August 2016. Available at http://www.nytimes.com/2016/08/02/business/dealbook/china-uber-didi-chuxing.html, accessed 2 August 2016.

Nourinejad, M., Zhu, S., Bahrami, S., and Roorda, M. J. (2015). Vehicle relocation and staff rebalancing in one-way carsharing systems. *Transportation Research Part E: Logistics and Transportation Review*, Vol. 81, pp. 98-113.

PwC (2014). The sharing economy—sizing the revenue opportunity. PricewaterhouseCoopers. Available at http://www.pwc.co.uk/issues/megatrends/collisions/sharingeconomy/the-sharing-economy-sizing-the-revenue-opportunity.html, accessed 15 September 2015.

Rayle, L., Dai, D., Chan, N., Cervero, R., and Shaheen, S. (2016). Just a better taxi? A survey-based comparison of taxis, transit, and ridesourcing services in San Francisco. *Transport Policy*, Vol. 45, pp. 168-178.

Shaheen, S. (1999). Dynamics in behavioral adaptation to a transportation innovation: A case study of CarLink - A Smart Carsharing System. Institute of Transportation Studies, University of California, Davis, UCD-ITS-RR-99-16:232.

Shaheen, S. and Christensen, M. (2014). Shared-Use Mobility Summit: Retrospective of North America's First Gathering on Shared-Use Mobility. Transportation Sustainability Research Center, University of California, Berkeley, June 2014.

Shaheen, S., Chan, N. and Micheaux, H. (2015). One-way carsharing's evolution and operator perspectives from the Americas. *Transportation*, Vol. 42, No. 3, pp. 519-536.

Shaheen, S. and Chan, N. (2015). Mobility and the Sharing Economy: Impacts Synopsis. Shared-Use Mobility Definitions and Impacts, Special Edition. Transportation Sustainability Research Center, University of California, Berkeley, Spring 2015.

Shaheen, S. and Cohen, A. (2012). Innovative Mobility Carsharing Outlook: Carsharing Market Overview, Analysis, and Trends. Transportation Sustainability Research Center, University of California, Berkeley, Fall 2012.

Shaheen, S. and Cohen, A. (2015). Innovative Mobility Carsharing Outlook. Transportation Sustainability Research Center, University of California, Berkeley, Winter 2015.

Shaheen, S., Martin, E., and Cohen, A. (2012). Public Bikesharing in North America: Early Operator and User Understanding. Mineta Transportation Institute, Report 11-26.

Shaheen, S. and Cohen, A. (2016). Innovative Mobility Carsharing Outlook. Transportation Sustainability Research Center, University of California, Berkeley, Winter 2016.

Shaheen, S., Cohen, A., and Zohdy, I. (2016). Shared Mobility: Current Practices and Guiding Principles. U.S. Department of Transportation, FHWA-HOP-16-022, Washington, D.C., April 2016. http://www.ops.fhwa.dot.gov/publications/fhwahop16022/index.htm, accessed 26 July 2016.

Shaheen, S., Cohen, A., Zohdy, I., and Kock, B. (2016). Smartphone Applications to Influence Travel Choices. U.S. Department of Transportation, FHWA-HOP-16-023, Washington, D.C., April 2016. Available at http://www.ops.fhwa.dot.gov/publications/fhwahop16023/index.htm, accessed 26 July 2016.

Shaheen, S., Martin, E., Chan, N., Cohen, A., and Pogodzinski, M. (2014). Public Bikesharing in North American During a Period of Rapid Expansion: Understanding Business Models, Industry Trends and User Impacts. Mineta Transportation Institute, Report 12-29.

Shaheen, S. and Novick, L. (2005). Framework for Testing Innovative Transportation Solutions: Case Study of CarLink, a Commuter Carsharing Program. *Transportation Research Record: Journal of the Transportation Research Board*, No. 1927, pp. 149-157.

Shaheen, S., Wright, J., Dick, D., Novick, L. (2000). CarLink - A Smart carsharing system field test report. Institute of Transportation Studies, University of California, Davis Publication UCD-ITS-RR-00-4:182.

Shaheen, S., Zhang, H., Martin, E., and Guzman, S. (2011). China's Hangzhou Public Bicycle: Understanding Early Adoption and Behavioral Response to Bikesharing. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2247, pp. 33-41.

Sioui, L., Morency, C., and Trépanier, M. (2013). How Carsharing Affects the Travel Behavior of Households: A Case Study of Montréal, Canada. *International Journal of Sustainable Transportation*, Vol. 7, No. 1, pp. 52-69.

Steinmetz, K. (2014). Taxi Drivers Are Using Apps to Disrupt the disruptors. *TIME*. Available at: http://time.com/3119161/uber-lyft-taxis/, accessed 15 March 2016.

Thomopoulos, N. and Givoni, M. (2015). The autonomous car—a blessing or a curse for the future of low carbon mobility? An exploration of likely vs. desirable outcomes. *European Journal of Futures Research*, Vol. 3, No. 14, pp. 1-14.

UC Irvine News (2013) UC Irvine's car-sharing program charges ahead. University of California, Irvine. Available at http://news.uci.edu/press-releases/uc-irvines-car-sharing-program-charges-ahead/, accessed 21 March 2013.

U.S. Census Bureau (2013). Sex of Workers By Means of Transportation to Work. American Community Survey 1-Year Estimates, Table B08006, American FactFinder. Available at http://factfinder2.census.gov, accessed 5 April 2015.

Wadud, Z., MacKenzie, D., and Leiby, P. (2016). Help or hindrance? The travel, energy and carbon impacts of highly automated vehicles. *Transportation Research Part A*, Vol. 86, pp. 1-18.

Wang, X., Lindsey, G., Schoner, J. E., and Harrison, A. (2016). Modeling Bike Share Station Activity: Effects of Nearby Businesses and Jobs on Trips to and from Stations. *Journal of Urban Planning and Development*, Vol. 142, No. 1.

Weikl, S. and Bogenberger, K. (2015). A practice-ready relocation model for free-floating carsharing systems with electric vehicles – Mesoscopic approach and field trial results. *Transportation Research Part C: Emerging Technologies*, Vol. 57, pp. 206-223.