Chapter 13
Sharing strategies: carsharing, shared micromobility (bikesharing and scooter sharing), transportation network companies, microtransit, and other innovative mobility modes

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1 INTRODUCTION

While sharing is not a new concept, economic models have emerged in the last two decades that are based on sharing or collaborative consumption of resources. Trust generated through online social networks and the proliferation of GPS-enabled mobile technology have been cited as factors that have enabled transactions rooted in the sharing economy (Hickman, 2011). There is not yet agreement on the nomenclature used to describe this phenomenon, which includes the “sharing economy,” “collaborative economy,” and “peer-to- peer economy.” This new form of resource sharing is present in many sectors including: lodging (e.g., Airbnb); labor (e.g., TaskRabbit, Handy); equipment (e.g., EquipmentShare); food (e.g., Nommery); and the transportation (e.g., Zipcar, Citibikes, Lyft). Hamari, Sjoklint, and Ukkonen (2015) classified 254 collaborative consumption platforms into two exchange modes: (1) access over ownership and (2) transfer of ownership. They found that access over ownership was the most common mode of exchange; it was found in 191 of the studied platforms. Botsman and Rogers (2010) explain that in collaborative consumption users access goods without the burden of fixed ownership costs and the greater environmental impacts of personal ownership.

While many of these services originated in the United States (US), they are in use across the world including in Europe and Asia. Forbes estimated that in 2013 that the sharing economy in the US was valued at US$3.5 billion (Geron, 2013). PricewaterhouseCoopers (PwC) estimated that five sectors of the sharing economy (i.e., equipment, housing, books, movies, and cars) generated US$15 billion in global revenue in 2014, and it is poised to grow to US$335 billion in 2025 (PwC, 2014). Research continues to emerge on this fast-changing and rapidly growing segment of the economy.

2 EMERGING SHARED MOBILITY SERVICES

During the latter half of the 20th century, the North American passenger transportation system emphasized personal vehicle ownership and usage and, to a lesser extent, the use of other modes such as bus, rail, bicycles, and taxis. However, recent sharing economy and information technology innovations have expanded beyond traditional transportation and ownership models. Travelers can: (1) request a private driver and vehicle via an app (e.g., Lyft, Uber); (2) access a car, bicycle, or scooter for a short trip (e.g., Zipcar, Lime); (3) ride a private shuttle on a crowd-sourced route or on-demand (e.g., Via); and (4) have groceries or take-out food delivered in someone’s personal vehicle (e.g., Instacart, Postmates, UberEATS)—all using internet-enabled smart- phones and tablets. Such innovative mobility services fall under the umbrella term of shared mobility.

Shared mobility is the shared use of a vehicle, bicycle, or other mode that enables users to have short-term access to transportation modes on an “as- needed” basis. It includes carsharing, personal vehicle sharing (PVS, including peer-to-peer [P2P] carsharing and fractional ownership); scooter sharing; bike- sharing; transportation network companies (TNCs, also known as ridesourcing or ridehailing); ridesharing (i.e., carpooling, vanpooling); microtransit; and courier network services. Fig. 13.1 categorizes these key areas of shared mobility. Carsharing, scooter sharing, and bikesharing (Fig. 13.1, left) are services that enable vehicle sharing. Ridesharing (carpooling and vanpooling), on-demand ride services, and microtransit (Fig. 13.1, middle) facilitate the sharing of a passenger ride. Lastly, courier network services (Fig. 13.1, right) allow for the sharing of a delivery ride (i.e., a ride for cargo).

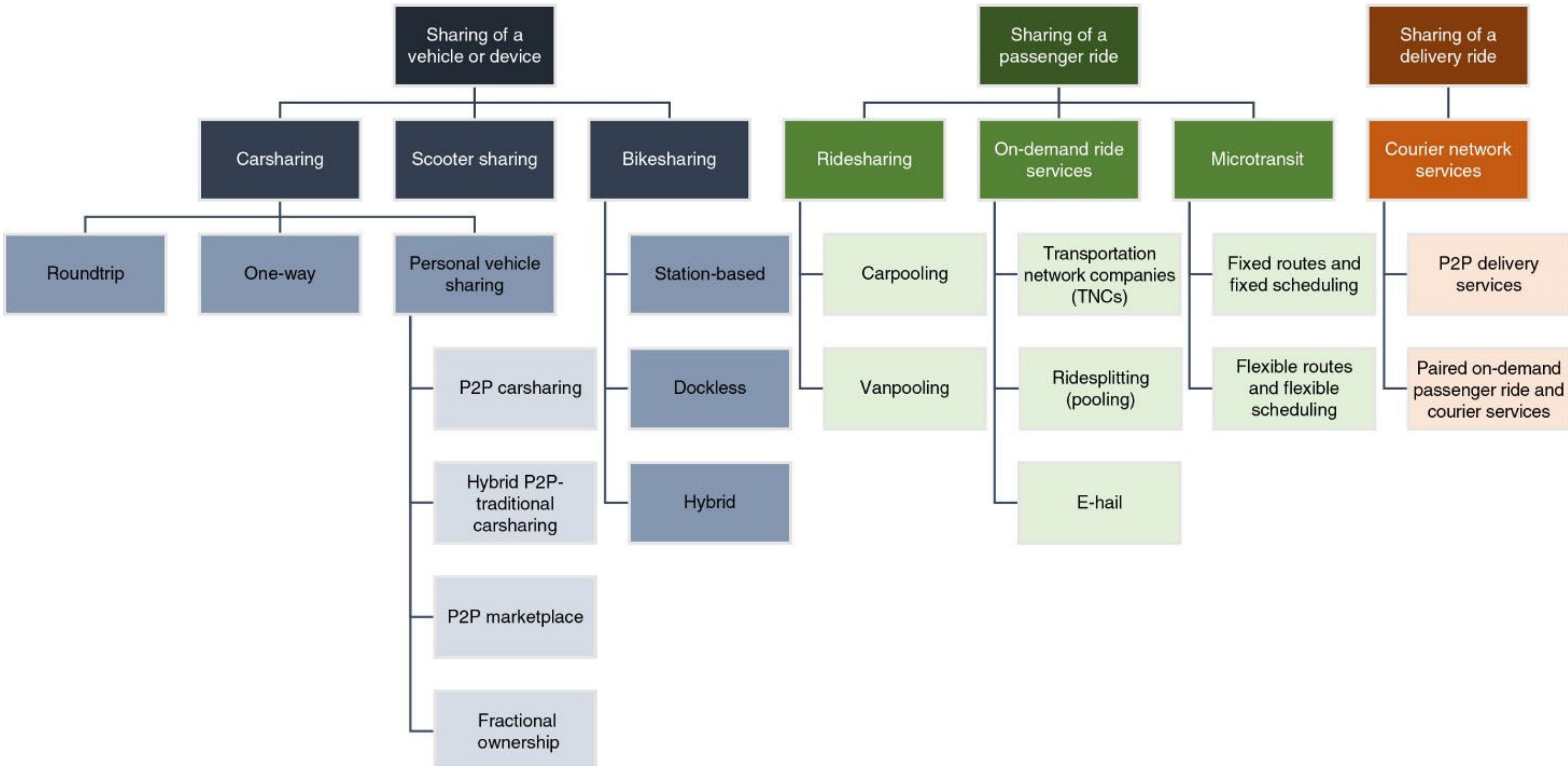

Figure 13.1 Key areas of shared mobility.

Many studies have documented the impacts of shared mobility in numerous global cities with respect to cost savings and convenience, reduced personal vehicle ownership and vehicle miles traveled (VMT)/vehicle kilometers traveled (VKT), which can translate to greenhouse gas (GHG) emission reductions. Nevertheless, more research is needed on a city or regional basis and on emerging services, such as microtransit, dockless bikes and scooters, and courier network services. There is also the need to study Mobility as a Service and Mobility on Demand platforms, which are beginning to link mobility services on an integrated multi-modal platform in regions across the globe. As the private sector innovates and the menu of shared mobility options grows, it is important for the public sector to not only respond with appropriate legislation to protect public safety but also to provide guiding policies to maximize benefits.

This paper presents an overview of the following elements of the shared mobility ecosystem: (1) carsharing, (2) scooter sharing, (3) bikesharing, (4) ridesharing, (5) TNCs, (6) microtransit, (7) courier network services, and (8) trip planning apps.

3 CARSHARING

The principle of carsharing is simple: individuals can gain the benefits of private vehicle use without the costs and responsibilities of ownership. Rather than owning one or more vehicles, a household or business accesses a fleet of shared autos on an as-needed basis. Since private vehicles stand idle for an estimated 95% of the time, carsharing can increase the efficiency of automobile use (Fraiberger & Sundararajan, 2015).

The first carsharing program was launched in the US in 1994, and the industry has grown rapidly ever since. As of January 2017, there were 49 carsharing operators (roundtrip, one-way, and P2P carsharing) in the Americas with over 4.8 million members and over 156,470 vehicles (Shaheen, Cohen, & Jaffee, 2018a). In October 2016, there were approximately 15 million carsharing members worldwide out of which Asia had 8.7 million members, Europe had 4.4 million, and North America had 1.8 million (Shaheen, Cohen, & Jaffee, 2018b). There are various carsharing models in existence, the earliest of which was the roundtrip model. More recently, different carsharing models have emerged, including one-way and P2P carsharing.

3.1 Roundtrip Carsharing

Roundtrip carsharing provides its members access to a fleet of shared vehicles on an hourly basis. Users must return the shared vehicle to the same location from where it was accessed. In October 2016, there were approximately 10.3 million roundtrip carsharing members worldwide, including 7.8 million members in Asia, 1.5 million members in Europe, and 1.0 million members in North America (Shaheen et al., 2018b). The cost of carsharing is a combination of annual or monthly fees, as well as time and distance costs; fuel and insurance are typically included in these costs. In the United States, annual fees for membership can range from US$0 to $300, although most fall between US$30 and $70. For periods lasting under 24 hours of use and distances under 50 miles (~80 km), time costs can range from US$3 to $11 per hour of use, and distance costs range between US$0 and $0.49 per mile/km driven.

Numerous studies have documented that roundtrip carsharing reduces the number of vehicles on the road, VMT/VKT, GHG emissions, and individual transportation costs. Cervero and Tsai (2004) found that 30% of City CarShare (a San Francisco Bay Area service acquired by Carma in 2015 and now defunct) members shed one or more of their own personal cars, and two-thirds decided to postpone purchasing another vehicle after using the service for 2 years. A North American study of 6,281 people who participated in roundtrip carsharing programs in the United States and Canada documented the following impacts:

- One quarter of the study participants sold a vehicle due to carsharing, and another quarter postponed a vehicle purchase;
- One carsharing vehicle replaced 9 to 13 vehicles among carsharing members;
- Household annual VMT/VKT declined 27% to 43% (considering vehicles sold and purchases postponed); and
- Household annual GHG emissions declined 34% to 41% (0.58 to 0.84 metric tons/household) (Martin & Shaheen, 2011).

It is important to note that aggregate-level data cannot necessarily be generalized on a city or regional basis, as this analysis reflects the combined impacts across US and Canadian study populations.

Roundtrip carsharing also has had a notable impact on modal shift. Martin and Shaheen (2011) examined the impact of carsharing on public transit and nonmotorized travel. While they noted an overall decline in public transit use among carsharing members, they also found a significant increase in walking, bicycling, and carpooling. A case study in Montreal, Canada found that carsharing members had significantly lower auto use than non-carsharing members (Sioui, Morency, & Trépanier, 2013). Further, Shaheen, Mallery, and Kingsley (2012a) compiled numerous studies of roundtrip carsharing in North America and found that members saved an average of US$154 to $435 per month per carsharing household when compared to their private vehicle-use expenses.

Roundtrip carsharing has not only been deployed in neighborhoods but also at employers and on college campuses, thereby providing mobility options for employees and students. Shaheen and Stocker (2015) conducted a study of Zipcar for business members and found 40% of members sold or avoided buying a vehicle due to Zipcar access through their employers. Aggregate-level carsharing impacts for North America are summarized in Fig. 13.2.

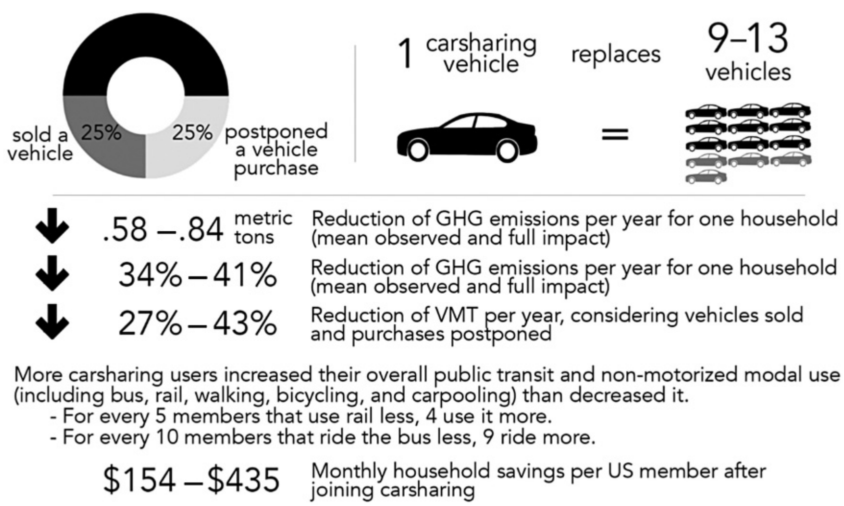

Figure 13.2 Impacts of roundtrip carsharing in North America. *(With permission from Shaheen and Chan, 2015)*

Carsharing fundamentally changes the cost structure of driving from a fixed to a variable cost. The service provides consumers with sufficient (sometimes better) mobility at reduced cost. This drives most of the emission and fuel-use reductions with travel substitutions replacing private vehicle use. As this involves substituting "driving with driving" (i.e., private auto with fixed costs vs. shared vehicle with variable costs), the magnitude of these changes must be measured to assess the fundamental impact of carsharing. This is challenging as we do not know who will join carsharing until after they have enrolled. Among the carsharing member population, we need to know: (1) how individuals traveled before and what modal behaviors they changed due to carsharing and (2) how individuals would have traveled in the absence of carsharing (e.g., postponed vehicle purchase). These effects are difficult to measure without a survey conducted among carsharing members, as the best way to understand these shifts is to ask members how carsharing impacted their behavior. Further, as carsharing becomes more established in the mobility ecosystem, it will likely become more challenging to ask users to assess what their travel behavior would have been in a hypothetical world without these shared mobility options.

3.2 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 park it at another. One-way carsharing enables increased flexibility and has the potential to further enhance first- and last-mile connectivity. In 2012, a rapid expansion of one-way carsharing began worldwide in 7 countries, which grew to 26 nations in 2016 (Shaheen & Cohen, 2012; Shaheen et al., 2018b). In October 2016, there were about 4.7 million one-way carsharing members globally, out of which 2.9 million were in Europe and 812,440 were in North America (Shaheen et al., 2018b). As of January 2017, 38.1% of North American carsharing fleets allowed one-way trips, and 48.9% of members had access to such fleets (Shaheen et al., 2018a). As of January 2017, six carsharing companies in the US offered one-way functionality: BlueIndy; Maven; ShareNow (formerly car2go and ReachNow/DriveNow); WaiveCar; and Zipcar. BlueIndy offers several membership plans, but its one-day plan costs US$8 for the first 20 minutes of use and US$0.40 per minute thereafter. ShareNow, which is currently integrating car2go and ReachNow, has pricing that varies by operator and market. Car2go previously charged an annual fee of US$35 and US$0.41 per minute of use, and ReachNow charged US$12 for the first 30 minutes of vehicle use and US$0.32 per minute thereafter. Zipcar charges US$0.20 per minute of use in addition to its annual fee. In September 2016, Maven began offering one-way carsharing in its Metro Detroit market starting at US$8 per hour.

A study of car2go users in five North American cities by Martin and Shaheen (2016) found that each carsharing vehicle removed between 7 and 11 vehicles from the road (sold and purchases forgone). About 2% to 5% of members sold a vehicle, and 8% to 10% postponed a vehicle purchase. Moreover, the authors estimated that net VMT/VKT declines due to carsharing ranged from −6% to −16% per car2go household, and net GHG emissions were lowered by −4% to −18% (see Fig. 13.3).

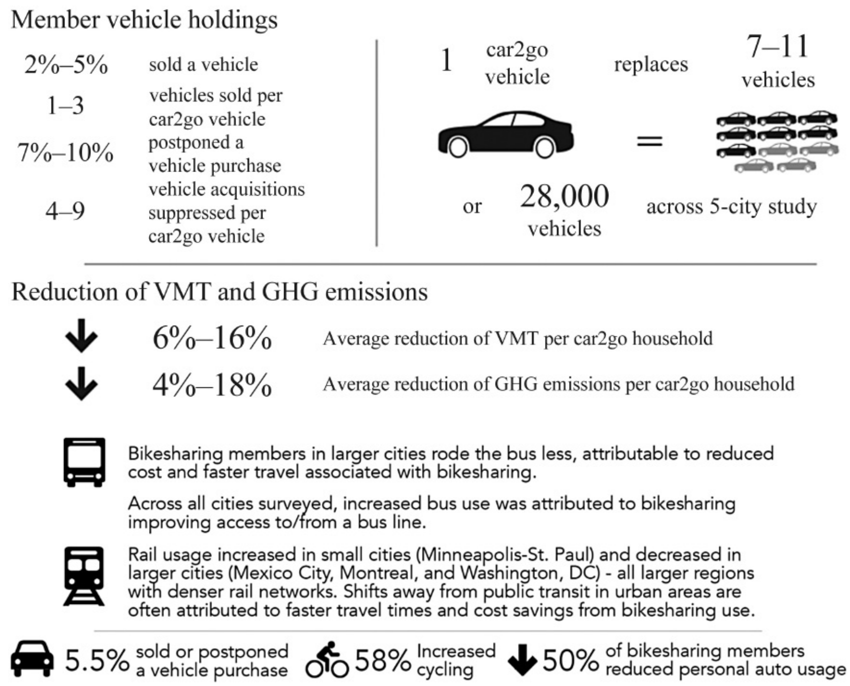

Figure 13.3 Impacts of one-way carsharing in North America.

3.3 Personal vehicle sharing (PVS)

PVS is another carsharing service model characterized by short-term access to privately owned vehicles (in contrast to an operator-owned vehicle fleet). PVS companies broker transactions among car owners (hosts) and guests by providing the infrastructure needed to make the exchange possible, including: an online platform, customer support, auto insurance, and vehicle technology. Members can access vehicles either through a direct key transfer from the host to the guest or through operator-installed in-vehicle technology that enables unattended access. There are four distinct models of PVS: (1) P2P carsharing, (2) hybrid P2P-roundtrip carsharing, (3) P2P marketplace, and (4) fractional ownership (Shaheen et al., 2012a).

3.3.1 P2P carsharing

P2P carsharing employs privately owned vehicles made temporarily available for shared use by an individual or members of a P2P company. While still heavily focused in urban areas, P2P carsharing operations are not as geographically confined as other types of carsharing because the owners/hosts provide the vehicle fleet. In addition, P2P carsharing appears to serve a more diverse population than roundtrip carsharing services. As of January 2017, 2.9 million members shared 131,336 vehicles as part of a P2P carsharing program in North America (Shaheen et al., 2018a). A study of P2P carsharing use in Portland, Oregon found that 37% of families in poverty live in a census block group that contains at least one P2P vehicle, but only 13% live in a census block that has a roundtrip carsharing vehicle. In parts of East Portland, which is a lower-income area of Portland, P2P vehicles are the only type of carsharing automobiles available (Dill, 2014). Further, Fraiberger and Sundararajan (2015) project that P2P car- sharing will have more pronounced impacts on below-median income consumers than above-median income users. Examples of P2P carsharing operators in the US include: Turo (formerly RelayRides) and Getaround. Pricing and access terms for P2P carsharing services vary, as they are typically determined by vehicle hosts listing their vehicles. The P2P carsharing operator generally takes a portion of the P2P transaction amount in return for facilitating the exchange and providing third-party insurance. For example, Turo takes a 25% commission from the host along with 10% from the guest, and Getaround takes 40% from the host for its services.

As of January 2017, there were six active P2P operators in North America, and interviews with operators and users indicate several advantages (such as a large variety in vehicle types offered), as well as challenges (e.g., hassle of in- person key exchange). Additionally, the ridership of P2P carsharing was found to be younger, more likely male, liberal, highly educated, and white than the national average. Large changes in public transit use were not detected among members (bus and rail) or for TNCs, but there were significant net declines in taxi use. Three percent of surveyed users indicated that they sold a vehicle because of their carsharing membership, and 14% held off from purchasing a vehicle since beginning membership. While P2P carsharing has had success in urban markets, operators voiced difficulty with launching networks in rural areas. P2P carsharing operators have established agreements with insurers and state regulators (in every jurisdiction but New York State), which prevents vehicle hosts from losing their insurance or having their premiums spike. P2P car- sharing operators, such as Getaround and Turo, have created a hybrid insurance model in which the same vehicle is covered by different policies based on whether it is being used by the vehicle owner (host) or a member of the carsharing system (guest) (Shaheen, Martin, & Bansal, 2018).

3.3.2 Hybrid P2P-roundtrip carsharing and P2P marketplace

Hybrid P2P-roundtrip carsharing is where individuals access vehicles by joining an organization that maintains its own dedicated fleet, along with privately owned vehicles, throughout a network of locations. The P2P carsharing marketplace enables direct vehicle exchanges among individuals via the internet, including pricing agreements. Terms are generally decided among parties to a transaction, and disputes are subject to private resolution.

3.3.3 Fractional ownership

In the fractional ownership model, individuals sublease or subscribe to a vehicle owned by a third party. These individuals have "rights" to the shared-vehicle service in exchange for taking on a portion of the operating and maintenance expenses. This enables access to vehicles that individuals might otherwise be unable to afford, and it results in income sharing when the vehicle is rented to non-owners. Fractional ownership could be facilitated through a dealership or a partnership with a carsharing operator. Often, fractional ownership employs luxury cars and recreational vehicles. At present, this segment of the industry is small, and it remains to be seen whether fractional ownership can compete with existing carsharing models and personal vehicle ownership.

Automakers have tested fractional ownership and co-leasing of their vehicles. In December 2014, Audi launched its "Audi Unite" fractional ownership model in Stockholm, Sweden. Audi Unite offers multi-party leases with its pricing based on the vehicle model, yearly mileage, and the number of drivers (ranging from two to five). For example, an Audi Unite A3 sedan can be leased among five drivers for approximately 1,800 kronor per month (approx US$208 per driver per month) for 2,000 annual Scandinavian miles (20,000 km) on a 24-month lease. In 2018, Ford launched "Ford Credit Link" in Austin, Texas that enables three to six people to share a lease of a new Ford. Orto in London is testing co-leasing, as well.

4 SHARED MICROMOBILITY (BIKESHARING AND SCOOTER SHARING)

Shared Micromobility—a broad term used to describe the shared use of a bicycle, scooter, or other low-speed mode—is an innovative transportation strategy that enables users to have short-term access to a transportation mode on an as-needed basis. Shared micromobility includes various service models and transportation modes that meet the diverse needs of travelers, such as station-based bikesharing (a bicycle picked-up from and returned to any station or kiosk) and dockless bikesharing and scooter sharing (a bicycle or scooter picked up and returned to any location).

4.1 Scooter sharing (standing electric and moped-style scooters)

There are several scooter sharing systems (both standing electric and moped- style scooters) across the globe. This includes many companies, such as: (1) Bird, which operates standing electric scooters in approximately 50 metropolitan areas across the US, 14 cities in Europe, and 3 cities in the Middle East; (2) Scoot Networks (acquired by Bird in Spring 2019) operates in San Francisco, Barcelona, and Santiago and offers standing electric scooter sharing, moped-style scooter sharing, and bikesharing; (3) Skip operates standing electric scooters in Washington, DC, San Diego, and San Francisco; (4) Zapp (formerly Scootaway) operates in Tempe, Arizona and offers standing electric scooters, moped-style, and electric-assist bikesharing; (5) Lime (formerly known as Limebike) offers standing electric scooters, bikesharing, and carsharing (in some markets) in over 100 cities in North America, Europe, Southeast Asia, South America, and Australia; and (6) Spin operates in more than 40 cities across the US. In Europe, Motit launched in 2013 in Barcelona and has expanded to Milan and Paris. This system offers one-way and roundtrip short- term moped-style scooter sharing, which includes insurance and helmets. Other moped-style scooter systems in Europe include: CityScoot in Paris and emmy in Berlin, Hamburg, Munich, and Dusseldorf (formerly eMio).

Pricing models vary, for example, Scoot users in San Francisco have two pricing options: (1) US$4 for the first 15 minutes and $.10 a minute after that for mopeds or (2) US$1.00 to unlock a standing scooter and $.29 after that. Renting a Bird standing electric scooter costs US$1 to unlock and US$0.15 per minute of use. Fleets have continued to grow. For example, in 2018, Scoot had over 500 moped-style scooters in its network in San Francisco, including 43 charging station. As of Spring 2018, Bird had deployed over 1,000 scooters in Santa Monica and close to 200 in San Francisco (Edelstein, 2018; Kerr, 2018).

4.2 Bikesharing

Bikesharing has emerged as one of the fastest growing transportation innovations in many cities. Bikesharing users access bicycles on an as-needed basis for one-way (point-to-point) or roundtrip travel using one of three bikesharing models: (1) station-based bikesharing, (2) dockless, and (3) hybrid bikesharing systems. These systems currently operate with both traditional (motorless) bicycles and electric bicycles or “e-bikes.” There are also closed campus and P2P bikesharing systems (Shaheen & Christensen, 2014). Closed-campus bikesharing systems are deployed at university and office campuses, and they are only available to the particular campus community they serve (e.g., students).

The majority of bikesharing systems in the world are public, with anyone able to access a bicycle for a nominal fee (and a credit/debit card on file). In a station-based bikesharing system, users access bicycles via unattended stations offering one-way service (i.e., bicycles can be returned to any station). In a dockless bikesharing system, users may access (unlock) a bicycle and park it at any location within a predefined geographic region. In a hybrid bikesharing system, users can check out a bicycle from a station and end their trip by either returning it to a station or a non-station location or users can pick up any dockless bicycle and either return it to a station or a non-station location. Most bikesharing operators are responsible for bicycle maintenance, storage, and parking costs.

As of May 2018, there were over 1600 information technology-based public bikesharing systems worldwide with over 18.17 million bicycles (Russell Meddin, unpublished data). Of those bikes, approximately 6.1 million bicycles are located in China across more than 640 bikesharing programs. The US had 261 operators with more than 48,000 bicycles (Russell Meddin, unpublished data). As of 2017, dockless bikesharing bicycles accounted for about 44% of all bikesharing bikes in the US and approximately 4% of bikesharing trips (NACTO, 2018). Between 2010 and 2017, 123 million bikesharing trips had been completed in the US, with 35 million trips completed in 2017 alone (NACTO, 2018).

Shaheen, Martin, and Cohen (2012b) and Shaheen, Martin, Cohen, and Pogodzinski (2014) conducted a two-part study of public bikesharing pro- grams 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). A 2012 survey of 20 US public bikesharing programs found the average cost for a day pass to be US$7.77, which includes the first 30 minutes of each trip. At present, day passes in Chicago, New York, and San Francisco range from US$10 to $15. JUMP Bikes (acquired by Uber in 2018) charges US$3 to unlock and $0.15 a minute after that in San Francisco. Lime charges a fixed rate to unlock its bikes and scooters and a per minute fee after that; rates vary based on location. Aggregate-level impacts of docked bikesharing are summarized in Fig. 13.4 based on a number of cities analyzed in North America.

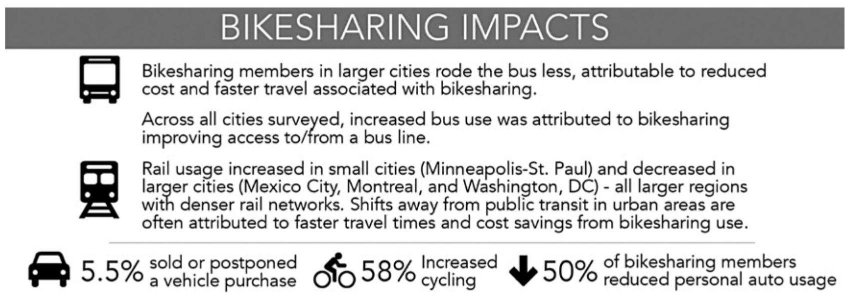

Figure 13.4 Impacts of docked bikesharing in North America. *(With permission from Shaheen and Chan, 2015)*

5 RIDESHARING

Ridesharing facilitates shared rides among drivers and passengers with similar origin-destination pairings. Ridesharing includes vanpooling and carpooling, which have been in use for decades. Vanpooling is classified by the US Federal Highway Administration (FHWA) as a grouping of 7 to 15 persons commuting together in one van, whereas carpooling involves groups smaller than 7 traveling together in one car. Ridesharing can be classified under several 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 and coworkers). Organization-based carpools require participants to join the ser- vice either through membership, employment, or by visiting a website. Ad hoc ridesharing involves more unique forms of ridesharing, including casual car- pooling—also known as "slugging" (Chan & Shaheen, 2012). Ridesharing's modal share in the US has declined from 20.4% in 1970 to 9% in 2016. However, it still remains the second largest travel mode in the US after driving alone (Social Explorer, 2016).

Carpooling and vanpooling have the added benefit of reducing driver costs. A vanpool could cost between US$100 and $300 per person per month, although this varies considerably depending on gas prices, local market conditions, and government subsidies (Elliot Martin, unpublished data). Flexible carpoolers could save two-thirds the cost of commuting alone in a single-occupancy vehicle (Dorinson, Gay, Minett, & Shaheen, 2009).

6 ON-DEMAND RIDE SERVICES

On-demand ride services have experienced notable growth in the last few years, but they face an uncertain regulatory and policy climate. They include TNCs, ridesplitting (or pooling) within TNC services, and e-Hail services for taxis with medallions (as well as taxi splitting).

6.1 Transportation network company (TNC) services

TNCs use smartphone apps to connect community drivers with passengers. There are various terms used for this emerging transportation option including: TNC, ridesourcing, ridehailing, and ride booking. Examples of for-hire vehicle services include: taxis, Lyft, and Uber, as well as specialized services such as 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. As of early 2018, Lyft operated in over 600 US cities with over 1.4 million drivers, and Uber operated in 81 countries in over 700 cities. Prices are generally based on time and mileage, although many TNCs provide flat rates for their economy services. In addition, prices across these companies tend to increase with demand, often called "surge pricing" (e.g., in an area of a city where a sporting event is taking place).

One specialized for-hire vehicle service is HopSkipDrive, which provides rides for children either to or from school or after-school activities. The drivers are either parents or those with a background in childcare. As of February 2018, HopSkipDrive was available in Los Angeles, Orange County, and the San Francisco Bay Area, and they charged US$10 to $18 for rides.

There are a number of studies documenting TNC impacts. Work commissioned by New York City found that many residents are using TNCs in lieu of public transit (Schaller, 2017a), although Uber and Lyft argue their services complement public transit. Rayle, Dai, Chan, Cervero, and Shaheen (2016) conducted an early analysis of 380 TNC users in San Francisco, California during Spring 2014. Using an intercept survey approach, researchers found that TNC users were generally younger and more 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 8%. Lyft provided 30% of trips, Sidecar (suspended operations and was acquired by General Motors) at 7%, and the remainder of trips were provided by other ser- vices. Forty percent of TNC users who owned a car stated that they had reduced their driving due to the service. This early study focused on limited areas in San Francisco and may not be representative of tripmaking at that time and since the portfolio of mobility options (including bikesharing) and scooter sharing have expanded significantly. Approximately 30% of TNC trips would have been taken by public transit in this study.

In addition, more recent studies have focused on TNC impacts on driving and public transit (Gehrke, Felix, & Reardon, 2018; Henao, 2017). An important nuance to these findings is the degree to which a modal shift away from public transit takes place is tied to city density. From these early studies, denser cities appear to be drawing more people from public transit and into TNCs. In less dense cities, TNCs more often replace individuals driving private cars. To date, there have been two aggregated studies that have examined modal shift across 7 cities (Clewlow & Mishra, 2017; Feigon & Murphy, 2016). Both found that the mode being replaced most often was driving. It is important to note that aggregated cross-city studies run the risk of obscuring city-specific differences in TNC impacts. The findings of these recent studies are summarized in Table 13.1.

Three studies have examined the effect of TNCs on vehicle ownership. All detected that TNCs encourage the sale of a private vehicle, while two studies found that new vehicle purchases were lowered. In one study of the city of Austin, Texas, Lyft and Uber briefly ceased operations due to a contentious local ballot issue. Following the withdrawal of these TNCs from the city, 9% of survey respondents indicated that they had acquired a vehicle, and another 9% had considered doing so (Hampshire, Simek, Fabusuyi, Di, & Chen, 2017).

TABLE 13.1 TNC mode replacement impacts in the United States.

Study authors Location Survey year	Rayle et al.[a] San Francisco, CA, 2014	Henao[a] Denver and Boulder, CO, 2016	Gehrke et al.[a] Boston, MA, 2017	Clewlow and Mishra[b] Seven US Cities[e] Two Phases, 2014–16	Feigon and Murphy[c] Seven US Cities[e] 2016	Hampshire et al.[d] Austin, TX 2016	Alemi et al.[f] California 2015
Drive (%)	7	33	18	39	34	45	66
Public transit (%)	30	22	42	15	14	3	22
Taxi (%)	36	10	23	1	8	2	49
Bike or walk (%)	9	12	12	23	17	2	20
Would not have made trip (%)	8	12	5	22	1	—	8
Carsharing/car rental (%)	—	4	—	—	24	4	—
Other/other TNC (%)	10	7	—	—	—	42 (another TNC) 2 (other)	6 (van/ shuttle)

[a]*Survey question: "How would you have made* ***your last trip,*** *if TNC services were not available?"*
[b]*Survey question: "If TNC services were unavailable,* ***which transportation alternatives would you use for the trips*** *that you make using TNC services?"*
[c]*Survey crosstab and question: For respondents that use TNCs most often compared to other shared modes: "How would you make* ***your most frequent (TNC) trip*** *if TNCs were not available?"*
[d]*Survey question: "How do you currently make the last trip you took with Uber or Lyft, now that these companies no longer operate in Austin?"*
[e]*The impacts in both of these studies were aggregated across: Austin, Boston, Chicago, Los Angeles, San Francisco, Seattle and Washington, DC.*
[f]*This study allowed multiple responses to the question: "How would you have made your most recent TNC trip (if at all) if these services had not been available?" This is why the percentages add up to more than 100%, making it challenging to directly compare to the other studies.*

Furthermore, many studies indicate an increase in VMT due to TNCs (Schaller, 2017a,b; SFCTA, 2017). The report commissioned by New York City found that TNCs added 600 million additional VMT to the roads between 2013 and 2016 (Schaller, 2017a). Likewise, the San Francisco County Transportation Authority determined that TNCs comprised 15% of the average weekday intra- city vehicle trips in San Francisco (SFCTA, 2017). "Deadheading," or the time/miles during which a taxi or TNC vehicle drives without a passenger, is another important metric. A paper released in late 2017 indicated that the number of taxis and TNC vehicles that were unoccupied increased by 81% between 2013 and 2017 (Schaller, 2017b), while the number of taxis dropped significantly. The findings are summarized in Table 13.2. Schaller's two studies are largely based on TNC activity data (and SFCTA's on data scraped from a TNC API), which do not reflect additional understanding from passenger surveys. Moreover, none of these studies assess the impact of pooled services provided by Uber and Lyft [uberPOOL and Lyft Shared rides (formerly Lyft Line), respectively], although more recent work, noted later, does examine pooling.

TABLE 13.2 TNC key VMT and trip metrics in the United States.

City *Study author* Data time period	Key trip metrics	Key mileage metrics
San Francisco, CA *SFCTA* 1 month, late-2016	*TNC trips comprise* • **15% of vehicle trips** (intra-SF, avg.weekday) • **9% of person trips** (intra-SF, avg. weekday)	*TNC mileage comprises...* • **20% of intra-SF VMT** (avg. weekday) • **6.5% of total VMT** (avg. weekday) • **10% of total VMT** (avg. Saturday)
New York City, NY *Schaller Consulting* Full year, 2016	*TNC trips comprise* • **80 million vehicle-trips** (in 2016) • **133 million person-trips** (in 2016)	*TNC mileage comprises* • 7% of total VMT (in 2016) *TNC mileage equates to an estimated increase of* • **3.5% citywide VMT** (in 2016) • **7% VMT in Manhattan, western Queens, and western Brooklyn** (in 2016)
New York City, NY *Schaller Consulting* June 2013 and June 2017	*TNC/taxi trips increased by* • **15% between June 2017 and June 2013** (Manhattan CBD, avg.weekday) • **133 million person-trips** (in 2016)	*TNC/taxi mileage increased by* • **36% between June 2017 and June 2013** (Manhattan CBD, avg.weekday)

According to several studies, TNC use peaks on Fridays and Saturdays (Feigon & Murphy, 2018; SFCTA, 2017). In terms of trip variance over the course of each day, there are slight peaks during the morning and evening commutes. These results support research on TNC trip purpose, which has shown that a large percentage of passengers take TNCs to commute (Hampshire et al., 2017; Rayle et al., 2016). Studies of TNC trip length have been less conclusive, with average trip distances ranging from just over 2 miles to just under 6, leaving this topic ripe for future study. Moreover, there has also been limited study of the connection between TNCs and GHG emissions and vehicle occupancy, as well as standardized methodologies for measuring impacts on modal shift, personal vehicle ownership impacts, and VMT/VKT.

6.2 Ridesplitting (also known as pooling)

Ridesplitting (or pooling) involves splitting a TNC-provided ride with another passenger taking a similar route. Lyft and Uber match riders with similar origins and destinations together, who split the ride and the cost. Recent examples of ridesplitting are Lyft Shared rides (formerly Lyft Line) and uber- POOL. In December 2017, uberPOOL was available in 36 cities globally. This includes over 14 US cities, Toronto (Canada), Latin America (7 cities), and Europe (London and Paris). Twenty percent of Uber trips are pooled in those cities (Paige Tsai, personal communication). As of December 2017, Lyft Line was available in 16 US markets, and it accounts for 40% of Lyft rides in those locations (Peter Gigante, personal communication). However, polling of Lyft and Uber riders in the Boston area (Gehrke et al., 2018) indicated that only 20% of all rides are shared, and the majority of rides only serve a single passenger.

These shared services entail dynamic changing of routes, as passengers request pickups in real time. Lyft 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 tested "Smart Routes," where passengers 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). In May 2018, Uber Express POOL (formerly "Smart Spots") was available in 12 US markets and costs about 30% to 50% less than POOL (Nickelsburg, 2018). Uber Express POOL offer rides as low as US$2 in locations when users walk a few blocks to join other riders at a common pickup and drop-off spot in San Francisco and Boston (Constine, 2017). In New York City, Uber is also incorporating driver and rider feedback into its algorithms to improve matching and minimize walking (Perez, 2017).

6.3 E-hail services

In the wake of the rise in TNCs, the taxi industry has also been modernizing. Taxis can now be reserved by an "e-Hail" internet or phone application maintained either by the taxi company or a third-party provider. In some cases, even pedicabs can be hailed through a mobile application (e.g., St. Pete Pedicab). There has been a dramatic increase in US taxi use via e-Hail services, such as Arro, Bandwagon, Curb, Flywheel, Hailo, and iTaxi. For example, as of October 2014, the e-Hail service Flywheel claimed 80% of San Francisco taxis (1,450 taxis) were using their app, which has brought taxi wait times closely in line with those of TNCs (Steinmetz, 2014). Increasingly, taxi and limousine regulatory agencies are developing e-Hail pilot programs and mandating e-Hail services. As of February 2018, Curb was operating in 65 cities with over 50,000 cabs and 100,000 drivers. Bandwagon matches riders going a similar direction in taxis and provides a platform for splitting the fare (or taxi splitting). All of the aforementioned e-Hail services charge locally regulated taxi rates and do not use "surge pricing" during periods of high demand as TNCs. In San Francisco, licensed taxis charge a base fare of US$3.50, US$0.55 per minute of traffic delay, and US$2.75 per mile regardless of high demand times. However, Flywheel, similar to TNCs, charges its users US$5, if they cancel a ride request more than 2 minutes after placing it. Flywheel also charges a US$1 service fee in addition to each fare.

7 MICROTRANSIT

Many transportation options exist in parallel to established public transit networks including: jitneys, dollar vans, paratransit, and employer or public-transit feeder shuttles. A more technology-enabled type of on-demand transit service has emerged called microtransit, which can incorporate flexible routing, flexible scheduling, or both (Shaheen, Cohen, & Zohdy, 2016a). These services operate much like jitneys of the past but are enhanced with information technology (Cervero, 1997). Existing microtransit operators target commuters, primarily connecting residential areas with downtown job centers. However, there are opportunities for microtransit services to either expand into the paratransit space or for paratransit to innovate along similar lines. Microtransit's use of smartphone technology avoids traditional and costly methods of booking rides, such as call centers or even booking websites. The use of advanced technology has the potential to lower operating costs for services that target special populations, such as: disabled, older adults, and low-income groups.

Microtransit services typically include one or more of the following service characteristics [these are a variation of the characteristics attributed to "flexible transit services" by TCRP (2014)]:

- Route deviation (vehicles can deviate within a zone to serve demand-responsive requests);
- Point deviation (vehicles providing demand-responsive service serve a limited number of stops without a fixed route between spots);
- Demand-responsive connections (vehicles operate in a demand-responsive geographic zone with one or more fixed-route connections);
- Request stops (passengers can request unscheduled stops along a predefined route);
- Flexible-route segments (demand-responsive service is available within segments of a fixed-route); and
- Zone route (vehicles operate along a route corridor whose alignment is often determined based on user input, with fixed departure and arrival times at one or more end points).

Microtransit services can include either: (1) fixed route or dynamic (flexible route services) and (2) fixed schedule or dispatch (on-demand) operations. A former microtransit service provider, Bridj (now defunct in the US but operating in Australia), used millions of data points to deploy dynamic transportation routes that change based on user demand (Matthew George, personal communication). Bridj previously operated in Boston and Kansas City, the latter through a partnership known as "RideKC" with the Kansas City Area Transportation Authority. Researchers conducted an evaluation of the RideKC program (Shaheen, Stocker, Lazarus, & Bhattacharyya, 2016b). The pilot project offered on-demand rides within 2 areas of the city (down- town, as well as surrounding the KU Medical Center) during certain hours of the day (AM and PM commutes). This was problematic given many hospital workers have shifts that fall outside of the normal workday. Fares started at US$1.50 per ride, and the first 10 rides were free. Through a combination of online and intercept surveys, researchers surveyed riders and registered users (the latter group consisting of users who signed up for the service but had not completed a trip at the time of the survey). Respondents who used the service were overwhelmingly younger, upper income, highly educated, and vehicle owners. Fifty-five percent of respondents were Millennials between the ages of 19 and 35. Eighty-three percent owned one or more private vehicles. Half of the respondents had a gross annual income of US$100,000 or greater. All respondents had a 4-year college or graduate degree. Eighty-nine percent of respondents identified as Caucasian.

The pilot project evaluation found that only 6% used the RideKC:Bridj microtransit service as their main commuting mode. Forty-four percent employed RideKC:Bridj to commute, and 33% used the service for work-related travel. Price affordability (compared to other modes) and convenience were reported as the most common motivations for using microtransit at 56% and 39%, respectively. One-third indicated that greater flexibility was a key motivation for using the service. More than half of the respondents noted using microtransit in the afternoon exclusively. Twenty-five percent noted driving alone less often as a result of microtransit, and 29% of users reported riding the bus less often due to the service (Shaheen et al., 2016b). Seventy-one percent who had signed up but had not used the service reported driving alone as their primary commute mode. Sixty percent downloaded the app to try the service, and 50% of riders did so out of curiosity. Seventy-six percent did not use the microtransit service because of geographic coverage limitations. Sixty-seven percent said they were interested in the mictrotransit service, if the service area was expanded (Shaheen et al., 2016b). The results of the two surveys suggest that geographic service coverage may have been a key factor limiting microtransit ridership. This study represents early exploratory research and is based on user surveys, which could reflect a sampling bias. Not surprisingly, more research is needed to better understand the impacts of microtransit services on the transportation system and user behavior.

Another example of a microtransit service is Chariot (now defunct and formerly owned by Ford Smart Mobility LLC), which operated similar to public transit by running 15-seater vans, typically along predefined routes. However, customers could also make requests for new "crowd sourced" routes based on demand. Chariot operated in Austin, Chicago, Denver, Detroit, the San Francisco Bay Area, and London before it ceased operations in February 2019. Fares ranged from US$3 to $6 on select routes.

While these services are somewhat similar to vanpools, microtransit vehicles employ drivers (whereas vanpool passengers often share driving responsibilities). Because of their more rigid nature (fixed routes and schedules), these services more closely mirror public transit and could represent more direct competition. It is important to note, however, that while Chariot's fleet and ridership were growing, San Francisco's public buses transport an order of magnitude more people each day (Fehr and Peers, 2015). Thus, the impact of many microtransit services is still limited.

Finally, another microtransit service, Via, allows customers to request a ride within a geo-fenced area typically from minivans, 10 to 14-seater vans, and shuttles. Via users can request rides in real time and expect a shared vehicle to pick them up within minutes along with other travelers going in a similar direction. Via operates in Arlington (Texas), Chicago, New York City, Washington, DC, and West Sacramento. The service has also announced partnerships with public agencies in Berlin and Los Angeles. The service is fully dynamic, as it does not have any static routes or schedules, and reroutes its vehicles based on traffic and demand. Via charges riders based on the trip distance and provides a guaranteed fare before customers confirm each trip. Currently, a ride on Via in Chicago ranges from under US$5 to $25 (excluding trips to airports). In New York, for example, a trip from lower Manhattan to Harlem costs US$15.

8 COURIER NETWORK SERVICES

Courier network services (CNS) (also referred to as flexible goods delivery) provide for-hire delivery services for monetary compensation using an online application or platform (such as a website or smartphone app) to connect couriers using their personal vehicles, bicycles, or scooters with freight (e.g., packages, food). Although the business models in this realm are evolving, two general models appear to have emerged: (1) P2P delivery services and (2) paired on-demand passenger ride and courier services.

8.1 P2P delivery services

With a P2P courier service, anyone who signs up can use their private vehicle or bike to conduct a delivery. Among P2P delivery services, there are a variety of business models. Postmates couriers, for example, deliver groceries, takeout, or goods from any restaurant or store in a city. They charge a delivery fee in addition to a 9% service fee based on the cost of the goods being delivered. Instacart is similar to Postmates, but it is limited to grocery delivery and charges a delivery fee between US$4 and $10, depending on the time given to complete the delivery. DoorDash is a service in which a courier can be paid a flat delivery fee of US$7 in return for going to a restaurant and delivering to the requester's home or office. Roadie is another courier service, but it is used more for intercity goods movement rather than same-day, intra-city deliveries. Finally, Shipbird is a shipping service that connects everyday commuters with individuals seeking couriers. Couriers provide the Shipbird app with their availability, commuting route, and the distance they are willing to deviate from their commute route to complete a delivery. The algorithm then matches these couriers with the requested delivery jobs. The proliferation of P2P delivery services, where couriers use their personal vehicles or travel modes, could reduce the need for delivery companies to maintain their own fleet for operations.

8.2 Paired on-demand passenger ride and courier services

The second CNS model that has emerged is one in which for-hire ride services (e.g., TNCs) also provide package deliveries. Deliveries via these modes can either be made in separate trips or with mixed-purpose trips (e.g., for-hire drivers can transport packages and passengers in the same trip).

Uber has also entered the food delivery service market with UberEATS (food). UberEATS charges a US$3 flat delivery fee (US$4 in New York City) in addition to the food cost. Uber had released a goods delivery product called UberRUSH, but they discontinued it in June 2018. Uber is also experimenting with UberCARGO in Hong Kong for moving and delivery needs (e.g., mattress delivery to a new house) (Russell, 2015). For one day in June 2015, Lyft ran a promotion with Starbucks in which they delivered free iced coffee. Three major TNC operators have in some form tried to expand their ride services to include package/item delivery, food delivery, or both (i.e., Lyft, Sidecar, and Uber).

In the next section, smartphone or trip planning apps are featured, as they often play a key role in enabling shared mobility.

9 TRIP PLANNING APPS

Trip planning apps can assist travelers in identifying their preferred travel route and mode based on cost, environmental impact, and time considerations (Shaheen, Cohen, Zohdy, & Kock, 2016c). They can also provide step-by-step assistance as users navigate their chosen route. In this way, they can act as an enabling technology for shared mobility. Initial research indicates that 80% of such app users took modes other than their personal cars, mostly opting for public transit (Gossart & Whitney, 2014).

Trip planning apps can be grouped into two general categories: (1) single mode trip planning and (2) multi-modal trip aggregators. The vast majority of trip planning apps, including those discussed later, can be downloaded and used free of charge.

9.1 Single-mode trip planning

Trip planning apps that are designed for a particular mode include public transit and driving route-assistance apps. Increasingly, most mobility apps are using real-time information. Transit trip planning apps augment maps and timetables with real-time information about delays. For example, the Embark iBART app provides real-time information about the San Francisco Bay Area regional rail system, although it does not provide information about other connecting modes. The Washington DC Metro also has its own app that provides real-time delay information about its trains. Driving-related single mode apps include: Waze and Metropia. These apps use real-time traffic congestion and incident data to generate optimal travel routes, and they also give turn-by-turn assistance during the journey. The turn-by-turn guidance is similar to Google Maps and Apple Maps, although those applications also show modes other than driving when generating user routes.

9.2 Multi-modal trip aggregators

Multi-modal trip aggregators offer a single platform for planning trips involving different modes including: public transit, taxi services, carsharing, bikesharing, scooter sharing, ridesharing, on-demand ride services, bicycling, walking, and personal vehicles. Travelers can quickly view the time, cost, and even calories burned while using different modes and routes. These apps also use real-time information to provide accurate departure and arrival times. A few examples of trip aggregation apps include: Citymapper, Nimbler, and TripGo.

Citymapper consolidates real-time information for public transit, walking, biking, ridesharing, and bikesharing in the cities it covers. The app allows users to set arrival and departure times and provides suggestions based on travel time, cost, mode choice, and calories burned. *Nimbler* is another trip planning app that provides turn-by-turn directions, taking into account real-time traffic and delays when traveling by bike, train, bus, and walking. For bicyclists, the app also allows users to set preferences related to the fastest, safest, or flattest route (Anderson, 2013).

TripGo allows the user to set their relative priorities among cost, travel time, GHG emissions, and convenience. The app integrates public transit, ridesharing, carsharing, personal vehicle driving, bikesharing, etc. and allows the user to select desired modes.

Another development in mobile trip aggregator apps is gamification to incentivize more environmentally friendly travel modes and reduce traffic congestion.

9.3 Gamification

Some mobile apps have developed incentives to reduce congestion. These apps employ gamification to incentivize more environmentally friendly travel modes. Waze gives its users points for providing traffic data and warnings of road hazards (construction, police, cameras) for other drivers. *Metropia*, shown in Fig. 13.5, provides commuting routes, but it also offers incentives for people to take alternative routes and departure times to reduce traffic on certain routes (Metropia, 2015). Incentives include online music and gift cards to local and online shops. The app also tracks how many pounds of carbon dioxide the user saves. A Metropia pilot study of its users in Los Angeles found that after 6 weeks of use, 86% of commuters reported saving time, and over 60% of users changed their regular departure time. Users who changed their departure time and route experienced between a 20% and 30% reduction in commute times (Hu et al., 2014).

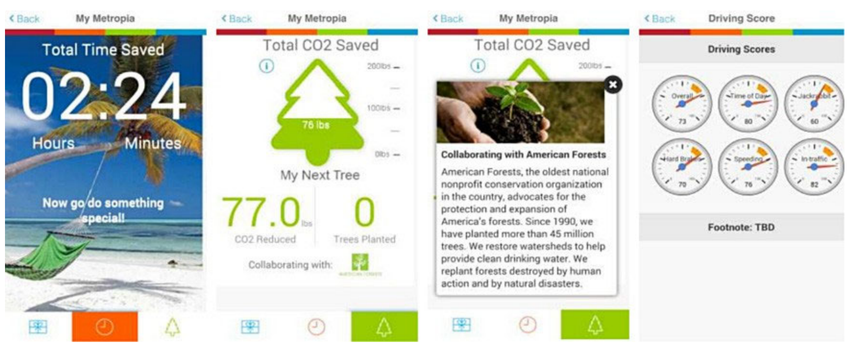

FIGURE 13.5 Screenshots of the Metropia Gamification App.

10 CONCLUSION

Shared mobility, a subset of the larger sharing economy, is an innovative transportation strategy that enables users to gain short-term access to transportation modes on an as-needed basis for either passenger trips or goods delivery. The advent of carsharing, bikesharing, scooter sharing, TNCs, microtransit, and other innovative mobility services is changing how urban travelers, in particular, access transportation. In the future, these options could spread more to suburban and rural locations, particularly with the arrival of connected and automated vehicle technology.

Urban transportation is on the verge of rapid transformation. The convergence of mobility services, shared modes, electrification, and automation will undoubtedly transform how people travel and how cities are planned and built (Cohen & Shaheen, 2016). While the impacts of this convergence and other transformative technologies on auto ownership, parking, and travel behavior remain to be seen, what is clear is that policymakers will need to rethink traditional notions of access, mobility, and auto mobility. The advent of shared automated vehicles will allow us to reimagine how we use and interact with automobiles. The integration of transportation modes, real-time information, and instant communication and dispatch—all possible with the click of a mouse or a smartphone app—will continue to redefine "auto mobility." Rather than rendering cars obsolete, the convergence of on-demand shared travel, automation, and electric drive technology could ensure that vehicles retain their fundamental importance by making the car more cost effective, efficient, and convenient—especially when pooled. While the impacts are not fully known, innovative technologies will likely have a disruptive impact on cities and established business models. In the future, additional research is needed to understand the longer-term impacts of these emerging and fast-growing services on society and the environment, how they interact with public transportation, and how they may be situated in a larger cultural shift.

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