Chapter 4
Shared Mobility: The Potential of Ride Hailing and Pooling
Susan Shaheen

Shared mobility with pooled rides is the linchpin for leveraging vehicle automation and electrification to reduce congestion and emissions and to create livable urban communities.

The sharing of rides is older than horse-and-buggy travel. Recent innovations make sharing easier, more convenient, and more efficient. Innovative mobility services premised on pooling can lower travel costs, mitigate congestion, and reduce greenhouse gas emissions. They also offer travelers more mobility choices between the traditional bookends of auto ownership and public transit. While the realm of shared mobility is vast, including shared bikes, scooters, and cars, the focus of this chapter is on pooled services—placing more people in a single vehicle. Doing so unlocks huge economic, social, and environmental benefits.

The motivation for pooling is simple. First and foremost is economics. Cars are among the most underused capital assets in our economy, sitting empty 95 percent of the time and carrying one individual much of the remaining time. If a car were used more than 5 percent of the time, and if that car carried two, three, or four passengers, the cost per rider would drop dramatically. The benefits go well beyond cheaper mobility. Because the car would be carrying multiple riders who might otherwise be driving, there would also be fewer vehicles on the road, less parking space required, less air pollution, and reduced energy use and greenhouse gas emissions. Given that the world has more than 1 billion cars and light trucks, the potential for major reductions in pollution and greenhouse gases is huge—in the United States and also most other countries.

The transition to a future where many rides are shared is now possible. What remains to be seen is whether and under what conditions people will be willing to make the transition.

Historic Trends About to Be Disrupted

Shared mobility is a radical departure from the auto-ownership culture that became entrenched as a result of the post–World War II manufacturing shift from defense items to consumer goods. This culture spanned the industrialized world and was supported by the growth of interstates and auto-oriented service industries, such as drive-through restaurants and drive-in movie theaters. Almost everywhere, car ownership increased and public transit use declined, often in spite of efforts to boost transit ridership.

Since the late 1960s, public agencies, particularly in the United States and Canada, have tried to increase the use of carpooling and vanpooling through transportation demand management strategies. These strategies have included trip reduction ordinances, construction of carpool lanes and park-and-ride lots, and the use of telephonic and computerized ridematching. How well have they succeeded? In the United States, carpooling peaked during the energy crisis of the 1970s. The share of Americans carpooling to work dropped from 20 percent in 1970[1] to only 9 percent in 2014[2] (see Figure 4.1).

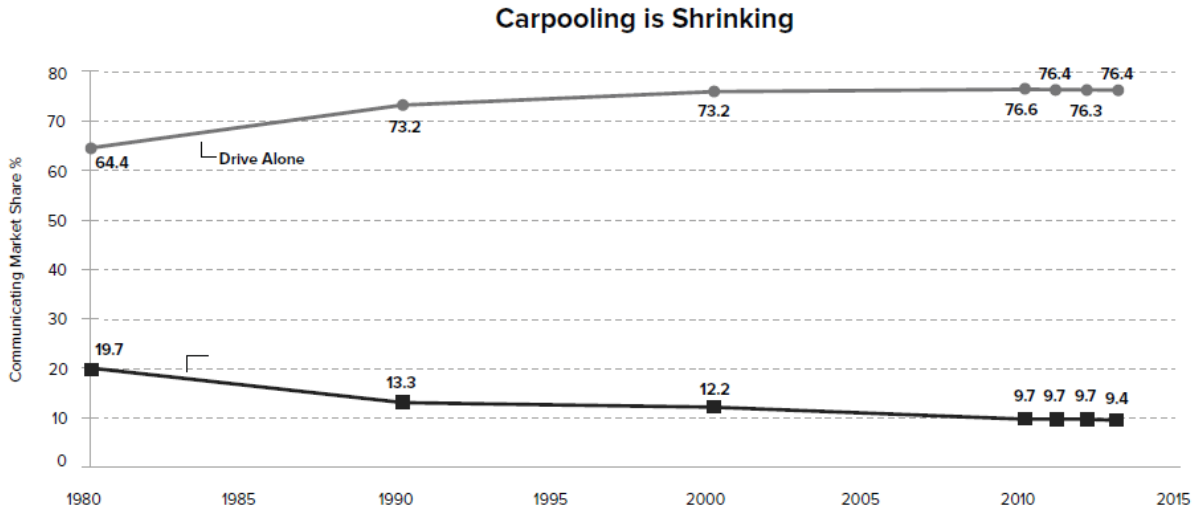

Figure 4.1. The decline in carpooling and the growth in commuters driving alone in the United States, 1980–2013. Source: Steven Polzin and Alan E. Pisarski, *Commuting in America 2013*, AASHTO, 2015, http://traveltrends.transportation.org/Pages/default.aspx

But new ways of facilitating shared rides, eventually aided by vehicle automation, may reverse historic trends. Smartphones, wearable technology, location-based services, social networking, and the mobile Internet are key enablers that make it easier for travelers to share rides. In the words of Lyft president and co-founder John Zimmer: "A full shift to 'Transportation as a Service' is finally possible, because for the first time in human history, we have the tools to create a perfectly efficient transportation network."[3]

Innovations in pooling are rapidly gaining market share, pushed by consumer demand. Around the world, on-demand transportation is booming. The number of trips served by this industry tripled globally every year through 2017, as shown in Figure 4.2 (though the China numbers are likely inflated). Aside from ride-hailing services, various shared, automated vehicle pilots are emerging across the globe.[4]

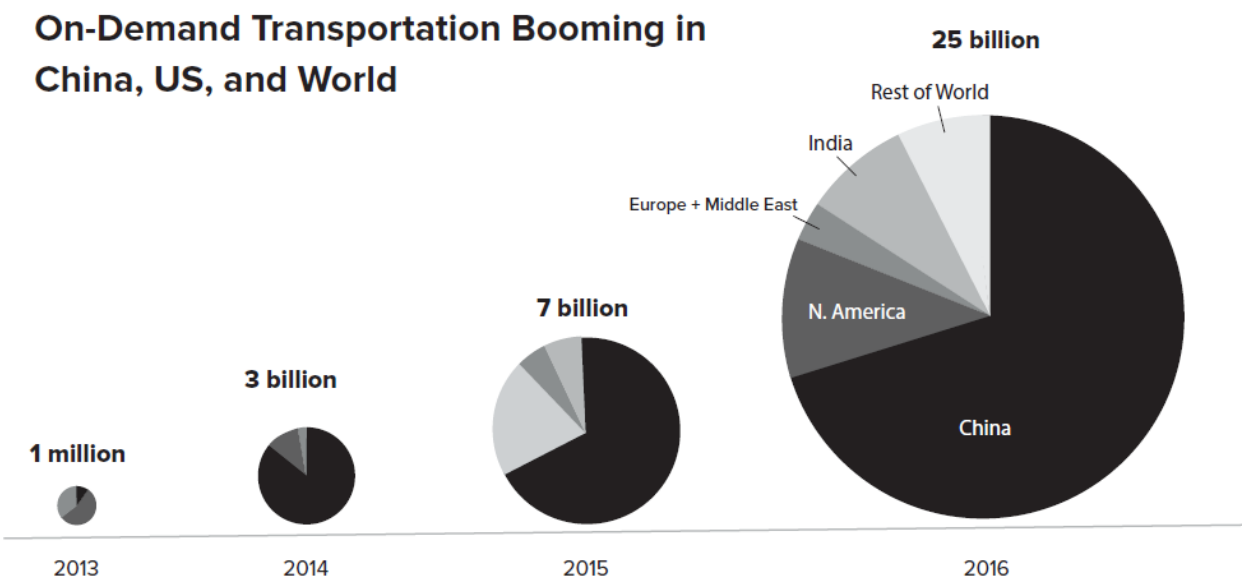

Figure 4.2. The number of trips made via on-demand transportation around the world, 2013–2016. Source: Adapted from a presentation by Mary Meeker (KPCB) at the 2016 Code Conference in Los Angeles, as reported in http://www.datenna.com/industry/internet-report-shows-chinas-lead-in-many-metrics/

Even automakers are beginning to realize that cars will be used differently in the future. Companies such as Ford, GM, Mercedes, Fiat Chrysler, BMW, PSA, and Volvo are openly discussing the need to evolve beyond manufacturing driver-centric cars to become mobility companies.[5] Google, Tesla, and Ford have all said that their plan is to put the first fully driverless vehicles into fleets for shared services. Ford's then-CEO Mark Fields, pushing back against assertions that private vehicle ownership is the very definition of freedom, asked at the 2016 Consumer Electronics Show: "But is sitting in traffic in LA really freedom?"[6]

This begs the question: Which provides more freedom, driving a private automobile or being chauffeured? Posing questions in this way is how fundamental change starts.

The Growth of Lyft and Uber

Ride-hailing services using smartphones got their start in 2010. UberCab (founded by Travis Kalanick and Garrett Camp and soon to become Uber) rolled out an iPhone app that provided a convenient way to hail a taxi in San Francisco. The app let travelers summon a black limo with the tap of a finger and pay for their ride seamlessly with a credit card. The service soon expanded to other cities and countries. In February 2013, Uber introduced UberX, a more affordable service using personally owned vehicles driven by their owners—a peer-to-peer-based platform. The company followed up with UberXL, offering a larger capacity SUV or minivan that carries up to six people, and UberSelect, using luxury cars.

Another market player, Lyft (formerly Zimride), has a slightly longer history. Its precursor was founded in 2007 by Logan Green and John Zimmer, who were motivated as much by social and

environmental aims as business goals. Zimmer has written that "ridesharing is just the first phase of the movement to end car ownership and reclaim our cities."[7] He points out that we have built our cities entirely around cars, and if we found a way to take most cars off the road, we would have a world with less traffic, less pollution, and more real community—a world built around people. Green's and Zimmer's initial company, Zimride, focused on matching riders for long-distance carpool trips. The service made the vast majority of its money from ridematching software that was run privately through individual schools and companies. Then in mid 2012, Green and Zimmer launched their Lyft ride-hailing app—described as a way to "unlock unused cars, create economic opportunities, and reduce the cost of transportation." By 2013, more than 130 university and corporate campuses were offering ridesharing and carpooling through Zimride, but the Lyft part of the business was growing much faster. In mid 2013, Green and Zimmer sold Zimride to Enterprise Rent-A-Car so that they could focus on Lyft.

Although Lyft and Uber, both headquartered in San Francisco, originally had very different values and approaches, they converged on the same business model—taking a transaction fee from individuals driving their own vehicles—at about the same time. They were not alone in this space. They were accompanied by San Francisco–based Sidecar, which also launched operations in mid 2012. Ultimately, Sidecar left the market, selling its assets to GM in 2015.

Lyft, Uber, and Sidecar had few capital assets. They were mostly agile computer companies that did not need to manage large inventories of equipment, facilities, and employees. Their principal innovation was computer algorithms that matched riders and drivers efficiently. The apps removed the exchange of money from the rider-driver relationship—with fares automatically calculated and billed through the apps—and applied basic principles of economics to balance supply and demand by raising prices when demand exceeded supply (called surge pricing by Uber). The companies established a system for passengers to rate drivers and for drivers to rate passengers, with the driver ratings displayed prominently to riders before they accept the ride.

Lyft and Uber were soon joined by other mobility companies, such as Ola Cabs in India, Grab in Southeast Asia, Chauffeur Privé in France, and Didi-Chuxing in China (which bought Uber's China subsidiary in 2016 and soon became the largest on-demand company in the world). All embrace the asset-light, peer-to-peer model of individually owned cars.

Also proliferating are specialized providers, such as Lift Hero (rides for older adults and those with disabilities) and HopSkipDrive and Kango (rides for children to and from school). These providers serve specific market segments (for example, youth, older adults, and passengers with disabilities) by using specially trained drivers who can assist riders with special needs and specialized vehicles that offer child seats and wheelchair accessibility.

Among the most transformative services are those that involve pooling—getting multiple riders into the same vehicle. Some have been more successful than others. Uber launched UberHop—an on-demand service for peak-period travel whereby travelers request their ride through the app, walk to a designated pickup location, and share the ride with other commuters—in cities around the world. Lyft piloted its Lyft Carpool service, whereby commuters pick up strangers along their route, in the San Francisco area. UberHop was eventually discontinued in all markets except for Manila, and Lyft Carpool was discontinued in less than a year due to low match rates.

In 2014, Lyft introduced Lyft Line and Uber launched UberPool. These services bring together previously unacquainted riders with similar origins and destinations. Computer algorithms assign additional riders to drivers in real time. The computer optimizes route changes as new pickups are requested, aiming to minimize the detours experienced by each rider. In return for the slight delay in getting to their destination, riders typically get a 40-to-50-percent discount on their fare, even if the driver never picks up another rider.

Lyft expanded Lyft Line to include Driver Destination, which lets drivers enter a destination into the Lyft app and receive ride requests from Lyft Line passengers along their commute. Uber also added the driver destination filter in 2015. Lyft Line experimented with encouraging passengers to congregate at select intersections ("hot spots") in the San Francisco Bay Area in exchange for discounted fares, as a means of consolidating operations and making them more efficient, but discontinued them. Similarly, UberPool has tested "smart routes," whereby users can get a discounted fare starting at a dollar 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.[8] In New York and London, this early pilot has since been adapted to allow passengers to walk to an arterial and pick up a pooled ride for a flat fare ($5 and £5, respectively).

In March 2017, Uber launched a pilot of UberCommute, which matches commuters traveling along major highways during commute hours, in the Washington DC area for a price of $5 to $10 per ride.[9] This experimental carpooling service was not new, having already been launched by Uber in Chicago (where it floundered)[10] and in Chengdu, China, in 2015, and in New Delhi and Bengaluru, India, in 2016.[11] Uber advertised the pilot as a lower-cost alternative to UberPool.

Pooling can be successful for longer intercity trips as well, as demonstrated by BlaBlaCar, the world's largest long-distance ridesharing service.[12] BlaBlaCar was founded in France in 2006 as a free platform for carpooling but transitioned in 2011 to a fee-based service that charges users a percentage of trip fees (between 7.9 and 12.5 percent), as well as a fixed amount (about $1) for each trip. It connects drivers and passengers willing to travel together between cities and share the cost of the journey. Passengers and drivers are connected through a website that combines social media and a reservations platform in a way that enables a feeling of trust and safety, which is key to the company's growth. By 2017, BlaBlaCar had more than 40 million members across twenty-two countries.[13]

App-based pooling is at an early experimental stage. The question is how to leverage these technologies to carry more passengers in more vehicles with the goal of companies generating profits and society benefiting from reduced emissions and traffic congestion. Executives at Lyft and Uber believe the key to their long-term success is lower prices, and even small price reductions will increase traveler use of their services. One way to lower prices is to increase passenger occupancies via pooling—in effect sharing costs across more riders. Another factor critical to success will be lowering travel times for pooled riders by having cities give priority access to pooled vehicles at curbs with pickup and drop-off access, as well as on roadways. However, more experimentation and public policies are needed to support these approaches.

Case Study: Pooling in the San Francisco Bay Area

In the San Francisco Bay Area, commuters often use casual carpooling to get from the East Bay to downtown San Francisco during the morning commute. Casual carpooling, also known as slugging, is an informal system where people line up in self-organized locations to catch a ride with drivers wanting to use a carpool lane or avoid bridge tolls. Slugging is especially attractive to many Bay Area commuters crossing the San Francisco Bay Bridge because cars and passengers can access carpool lanes and enjoy reduced travel times, shorter wait times at toll plazas, and reduced tolls. Some say that time and cost savings are the "secret sauce" of casual carpooling—in this case with average wait times for riders of just 2.5 minutes.[14] Casual carpooling got started in 1979 due to a ninety-day Bay Area Rapid Transit (BART) strike and has grown organically since. It carries more than six thousand people per day.[15]

Bay Area travelers who use ride-hailing services may also share rides. One university survey of 380 ride-hailing users in San Francisco found that half of the reported ride-hailing trips had more than one passenger (not including the driver), with an average occupancy of 2.1 passengers (in contrast to 1.1 in taxis). Close to 90 percent of respondents said they waited ten minutes or less for a vehicle to arrive after requesting one, and 67 percent waited five minutes or less.[16]

While the share of travelers using carpooling for commuting has been relatively stable at about 10 percent over the last decade,[17] congestion on the Bay Area's freeways and public transit is approaching near-record highs.[18] The Metropolitan Transportation Commission (MTC), the region's transportation agency, believes filling empty seats in private vehicles may be the most cost-effective way to increase capacity within the existing transportation network.[19] At present, MTC is engaged in a pilot program to determine if the private sector can enhance ridematching by leveraging a large match database.

Between May and November 2015, MTC issued two calls for partners among private sector app-based pooling providers. MTC executed pilot partnership agreements with four private-sector app-based services: Carma, Lyft, MuV, and Scoop. MTC's partners are testing marketing and incentive approaches that encourage commuters to use new app-based services to increase ridesharing.

If MTC determines this pilot program is successful, the agency may decide to phase out its public ridematching services. MTC estimates it could save $500,000 annually by transferring ridematching services to the private sector. MTC is considering a number of other future innovations including integrating app-based matching services with the region's call-in 511 services, establishing designated "hot spots" for casual carpooling, integrating app-based services with park-and-ride facilities, and leveraging pooled services to bridge first-and-last-mile gaps.[20]

End of Case Study

Why Is Pooling So Important?

When Uber unveiled UberPool, the company called it "a bold social experiment" and promised to get it right, "because the larger social implications of reducing the number of cars on the road, congestion in cities, pollution, parking challenges . . . are truly inspiring."[21] In a speech in London on UberPool's launch, CEO Travis Kalanick said his goal was to take a third of that city's three million cars off the streets, which he said would not only help congestion and reduce the capital's carbon footprint but also create 100,000 new jobs and dramatically expand the local economy.[22]

A study conducted by the Paris-based International Transport Forum in 2016 offers a glimpse into how shared mobility may change urban living in the future. This study modeled the impact of replacing all car and bus trips in Lisbon, Portugal, a mid-sized European city, with mobility provided by fleets of shared automated taxis and shuttle buses.[23] Among the key findings were that 97 percent fewer vehicles (cars, shuttle buses, and full-size buses) would be needed to serve all trips, 95 percent less space would be required for public parking, and 37 percent fewer kilometers would be traveled by the vehicles. The study also estimated that each vehicle would travel ten times the total distance traveled by current vehicles. The benefits of intensive use of vehicles are large: much lower cost per passenger (since depreciation and operating costs are spread over many more occupants) and more rapid turnover of vehicles, which results in accelerated adoption of cleaner vehicles.

A study of New York City by researchers at the Massachusetts Institute of Technology (MIT) came to similar conclusions: 3,000 four-passenger cars could serve 98 percent of taxi demand in New York City, with an average wait time of only 2.7 minutes.[24] The researchers also found that 95 percent of taxi demand would be met by just 2,000 ten-person vehicles, compared to the nearly 14,000 taxis that currently operate in New York City. They used an algorithm that reroutes cars in real time to serve incoming requests.

Finally, a study by researchers at the Lawrence Berkeley National Laboratory found that a fleet of shared automated electric vehicles, with right sizing of vehicles by trip (that is, smaller vehicles for fewer passengers and larger for more passengers), in combination with a low-carbon electricity grid (forecasted for 2030), could reduce per-mile greenhouse gas emissions by 63 to 82 percent by 2030 compared to a privately owned hybrid vehicle.[25]

As suggested by these studies, ride pooling may offer numerous transportation, infrastructure, environmental, and social benefits. Innovative one-way and peer-to-peer carsharing, which is typically one customer per trip and sequentially shared, represents a critical step toward creating more choice for travelers and making it easier for drivers to give up personal car ownership. But pooled rides have a far smaller carbon footprint, consume much less road space and parking space, and have the potential to serve far more trips. In short, pooling is critical to maximizing the benefits of shared mobility.

This point is brought home by an analysis of the app-based ride services in New York City. The analysis found that despite heavy promotion of pooled options, exclusive-ride trips still predominate, and that these services have added significantly to vehicular miles traveled on city

streets.[26] The report, released in February 2017, stated: "After accounting for declines in yellow cab, black car, and car service ridership, [app-based ride services] have generated net increases of 31 million trips and 52 million passengers since 2013," and this has increased vehicular travel on the city's roadway network by 600 million miles. This is clearly not a sustainable trajectory.

The Evolution of Other Shared Modes

Existing services, like taxis and public transit, naturally feel threatened when new competition emerges. Taxis are especially vulnerable, but public transit has many opportunities to partner and benefit. How are these services evolving to compete?

Taxis

The traditional taxi industry has seen an existential threat in the rising popularity of ride-hailing services. As just one example, the number of taxi rides in San Francisco fell by 65 percent between March 2012 and July 2014, and in January 2016 the city's largest taxi company, Yellow Cab, filed for bankruptcy.[27] From New York to Paris, taxis have been fighting to block Lyft and Uber, sometimes successfully but generally not. Governmental protection helps taxis survive, but more critical to their success will be enhancing service so that they can compete with the proliferation of shared-ride services—ride hailing, carsharing, and microtransit—around the world.

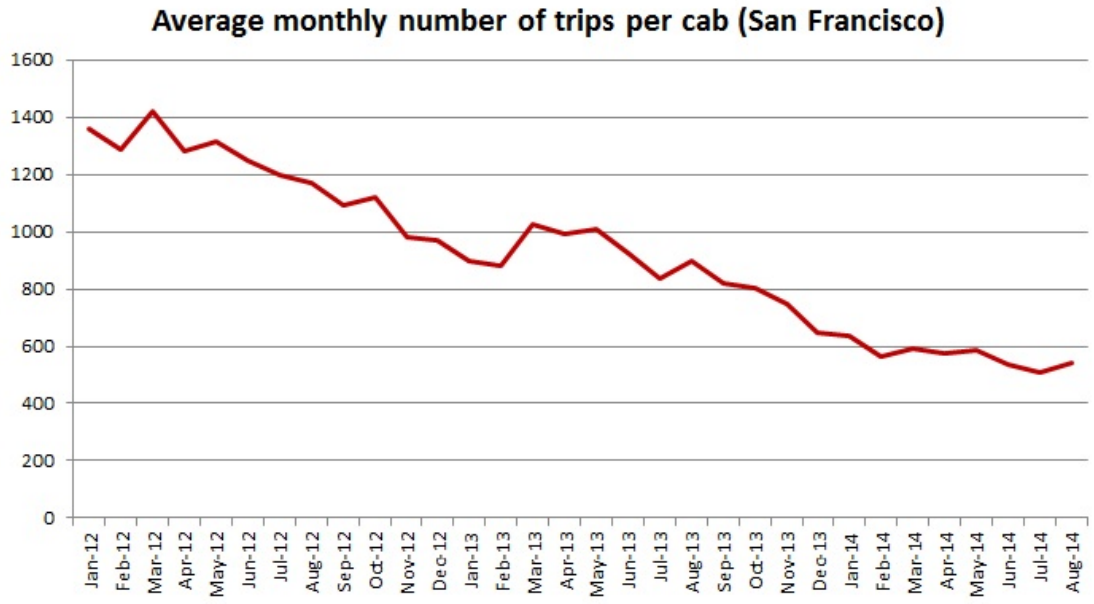

Figure 4.3. The impact of Uber on taxi ridership in San Francisco: average monthly number of trips per cab, January 2012 to August 2014. Source: https://eng.uber.com/wp-content/uploads/2016/09/Uber_City_Growth_-1024x601.jpg

Electronic hailing (e-hailing) services, such as Arro, Bandwagon, Curb, Flywheel, Hailo, and iTaxi in the United States, are a step in that direction. Travelers can use these mobile apps—

maintained by either the taxi company or a third-party provider—to digitally dispatch a taxi. These services have seen a dramatic increase in usage. As of October 2014, Flywheel was used by 1,450—or 80 percent—of San Francisco taxis. In September 2016, Flywheel expanded its operation to New York City, with six other cities already in its service area. In April 2017, Flywheel was acquired by taxi telematics provider Cabconnect, which hoped the deal would create a universal app for booking taxis.[28] By May 2017, Curb (acquired by Verifone) was serving sixty-five U.S. cities with fifty thousand cabs.[29]Increasingly, taxi and limousine regulatory agencies are developing e-hail pilot programs and mandating e-hail app compatibility.

This e-hail innovation, although in the works for many years, emerged largely in response to the success of Uber and Lyft. Where this innovation has been adopted, taxis have reduced their wait times close to those of their shared-ride competitors. But e-hail services still face market challenges, including matching supply and demand and the requirement to charge locally regulated taxi rates. Furthermore, taxis cannot employ surge pricing during periods of high demand, as ride-hailing companies often do.

Another innovation is taxi sharing. Pooling is desirable not only for expanding ridership but also to reduce fares so that more people can gain more access and mobility. But until now, few taxis were allowed to carry multiple unrelated passengers with different origins and destinations. Cities like Los Angeles, Burbank, and Boston have permitted sharing of taxi rides only in downtowns and at airports. New York City technically allows taxi sharing, but in practice it has been successful only at airports, some in-city taxi stands, and along one eastside corridor.[30]

Shared-ride taxis arose in different places for different reasons. In Washington DC, they were initiated during World War II to conserve scarce resources. In New York City, the Share-a-Cab service was started at LaGuardia Airport in 1979 to address the problem of long queues at the cabstands. A combination of good quality, reliable service, an open marketplace, aggressive marketing, and economies of scale resulted in cost-effective shared taxi services in places like Little Rock, Arkansas, where in 1977, shared-ride taxis were transporting more than 1.7 million passengers annually.[31] But since then, local regulations have curtailed and often eliminated these services. Increased competition from subsidized intra-city bus and rail services likely contributed to the decline.

In July 2013, Bandwagon re-introduced shared-ride taxis in New York City. In a partnership with the New York City Taxi and Limousine Commission, Bandwagon provides an iPhone app that lets riders share taxis at La Guardia Airport, JFK Airport, Newark Liberty Airport, New York Penn Station, and the Port Authority Bus Terminal. Waiting passengers text Bandwagon their destination and are paired with passengers with similar routes and destinations. Paired passengers are permitted to advance to the front of a taxi line, get into their cab, and split the fare. Bandwagon claims that the app contributes to shorter taxi lines, reduced wait times (when a user at the end of the line is paired with a passenger at the front of the line), and cost savings of up to 40 percent per taxi trip.[32]

More evidence for the potential benefits of taxi sharing comes from a 2010 experiment in New York City in which taxis transported up to four passengers at a reduced fare of three to four dollars.[33] The shared taxis picked up passengers at designated pickup locations and allowed

passengers to get off anywhere along the route during the morning commute. The experiment was credited with making taxi sharing more convenient, increasing taxi capacity during peak commute periods, providing cost savings to passengers, and lowering greenhouse gas emissions over single-fare-rider taxi use.[34] A subsequent study in 2014 quantified the impacts of taxi sharing in New York City and found that it could reduce taxi trips by an estimated 40 percent and carbon dioxide emissions by more than 50 percent.[35]

Public transit, microtransit, and paratransit

Public transit ridership has declined in most U.S. cities due to a number of factors, including low fuel prices, poor transit performance in some markets, and possibly competition with ride-hailing services.[36] Public transit operators are under tremendous pressure to improve the quality and quantity of service, as more cities focus on social equity, urban livability, air quality, and climate change initiatives, and suffer stifling congestion. Partnering with shared mobility operators may be one strategy to help local governments achieve some of these goals. A combination of nonprofit and for-profit services can provide pooled bus-like services and facilitate first-and-last mile connections, bridging gaps where the public transit network is sparse.[37] The evolution of these partnerships is examined in the next chapter.

Microtransit operators offer a broad mix of demand-responsive curb-to-curb services, using vans and small buses. These services tend to be less expensive than for-hire services, such as Lyft, Uber, and taxis but more expensive than public transportation. Typically, riders use mobile apps to pay for trips electronically and track the vehicles as they approach, although a few microtransit services use telephone dispatch and cash payment mechanisms.

Microtransit has evolved from jitneys in cities like San Francisco and New York City. Jitneys are common in many cities around the world in various forms, but in the United States they have largely disappeared as a result of increasing regulations to protect public transit, rising insurance costs, and competition from public transit services. They usually carry up to fifteen passengers in a van over a semi-fixed route, operating along busy streets and making numerous pickups and drop-offs. Some provide door-to-door service for an extra charge.

One jitney success is the “dollar vans” in New York City, which got their start in 1980 due to an eleven-day public transit strike. Dollar vans had a ridership of about 120,000 people per day in 2016.[38] They are a shadow transportation service that follows popular bus routes but also serves communities neglected by subways and buses. They often operate in low-income neighborhoods that have large immigrant populations. Since 1994, the city’s Taxi and Limousine Commission has been issuing permits to dollar vans in an attempt to regulate them, but most still operate illegally, without any formal regulations or oversight.[39] Because these services are well integrated into the community, regulators frequently condone them and enforcement has thus been intermittent.[40] In March 2107, 325 official (licensed) dollar vans were running,[41] down from more than a thousand just a few years ago. The decline probably reflects a lack of license enforcement rather than an actual decline in number of vehicles.[42]

In recent years, new microtransit services have been emerging, offering varying levels of demand responsiveness on a mix of fixed and flexible routes.[43] Microtransit services in the United

States include Chariot and Via. Chariot, which was acquired by Ford in September 2016, operates like a public bus service. It initially ran vans along predefined routes in Austin and San Francisco, with plans to expand to more cities. Customers can make requests for new "crowdsourced" routes that are created based on demand. Via, which operates in New York City, had approximately five hundred vehicles and provided more than 1.5 million rides from its system launch through October 2015. Bridj, a microtransit service that started in Boston in 2014, eventually extended limited service to Washington DC, Austin, and Kansas City but shut down in May 2017 after failing to strike a hoped-for deal with a major automaker.[44]

Microtransit has great potential, but considerable effort is required to make it successful. It may be particularly well suited to complement, enhance, or replace existing paratransit or dial-a-ride services, which are legislatively required to provide service to passengers with mobility limitations. They dispatch specially outfitted small buses and vans on request and operate door-to-door. Paratransit became common in the United States in the 1970s as requirements were imposed and subsidies provided to serve people with disabilities. Paratransit providers are typically embedded in larger transit bus operators or are small companies that contract with public transit operators, often outsourcing to taxis. More about microtransit and paratransit is discussed in the next chapter. The takeaway here is that these services are ripe for integration into a larger shared mobility system.

When Do People Choose Shared Rides?

Two big questions loom. When and at what price are people willing to share rides with strangers? And under what conditions are people willing to give up personal car ownership and replace those car trips with shared mobility services?

Early use of carpooling was motivated by the desire to conserve time, money, or fuel. In the United States, the government began to encourage carpooling in 1942 during World War II as a means of reducing costs and gasoline use. The OPEC oil embargo of 1973–74, which had cars waiting for gasoline in lines that snaked around the block, motivated many people to carpool. A survey of 197,000 employees during the energy crisis of the 1970s found that 15 percent of them became carpool commuters, resulting in a 23-percent reduction in vehicle miles traveled among survey respondents.[45]

Conserving money is certainly a motivator for those who cannot afford their own cars or meet the requirements for a driver's license. Indeed, sharing and pooling serve an important role in enhancing mobility in low-income and immigrant households where cost, driving skills, or legal status may be an issue.[46] Data from the National Household Travel Survey and the American Community Survey also indicate that ridesharing users generally have lower incomes, and some minorities (typically Hispanics and African Americans) carpool more than other racial and ethnic groups. This suggests that economics and culture can play a role in influencing attitudes about sharing.

A recent study of Bay Area casual carpooling—where people line up in self-organized locations to catch a ride with drivers wanting to use a carpool lane or avoid bridge tolls—revealed that many people are willing to share rides with strangers in exchange for time and money savings

and to reduce commute stress.[47] The study found that 75 percent of casual carpoolers were previous public transit riders, while approximately 10 percent previously drove alone.[48] An online survey of casual carpoolers in northern Virginia found similar motivations. The leading reason this survey found for riding with strangers was the desire to save on gasoline costs and do other things during the drive, while the primary reason given for driving instead of riding was departure time flexibility.[49]

The evidence is strong, from surveys and anecdotal evidence, that consumers share rides when it is both convenient for them and more affordable than private car ownership and driving alone. What is not known is how many people are willing to ride with strangers and under what conditions. And even less is known about how many people are willing to give up car ownership under what conditions. Because survey research is notoriously unreliable in predicting future acceptance of innovative services and products that are unfamiliar to the subjects, it will take a lot of real-world experience and research to gain an accurate assessment of the chances of future success for the proliferating variety of mobility services.

Adding Automation to the Picture

The attractions of shared mobility could be greatly expanded by integrating it with vehicle automation. Without a driver and with more intensive vehicle use, pooling could be even cheaper. Many companies are looking forward to this future. Indeed, Uber said as part of a legal proceeding in April 2017 that any injunction that blocked it from continuing work on automated cars could harm its ability to be a viable business.[50] CEO Travis Kalanick has already bet hundreds of millions of dollars that autonomous cars are the future. He says, "If we weren't part of the autonomy thing? Then the future passes us by."[51]

Indeed, by 2017 various small-scale shared automated vehicle pilots were emerging across the globe.[52] Uber's pilot in Pittsburgh and nuTonomy's in Singapore were joined by EasyMile's EZ10 driverless shuttle that covers short distances along predefined routes in Finland, France, Switzerland, and San Ramon, California. CityMobil2 launched small-scale automated road passenger transport demonstration projects in Italy and Finland, and they were planning to launch large-scale demonstration projects in France, Switzerland, and Greece. Local Motors in Phoenix, Arizona, unveiled Olli, a self-driving electric microbus designed to work on college and corporate campuses and to fill gaps in urban transit systems.

Considering that fully automated vehicles may initially cost anywhere from $10,000 to $50,000 more than an equivalent nonautomated vehicle,[53] some analysts predict that the first automated vehicles introduced to the public will be part of a shared-fleet service and not targeted at individual owners. Lyft, which received a $500 million investment from General Motors in January 2016, envisions a subscription model for a shared automated vehicle service.[54] In September 2016, Lyft co-founder John Zimmer boldly predicted that in five years the majority of Lyft rides would take place in automated vehicles and by 2025 private car ownership would be rare in major U.S. cities.[55] In October 2016, Tesla Motors described a future "Tesla Network" that will let its fully automated cars provide rides for a fee while the owner is not using the vehicle.[56] In Europe, Deutsche Bahn, the continent's largest railway company based in Germany, plans to

operate fleets of shared automated vehicles that could be used for trips to and from their regional rail stations.[57]

Not surprisingly, U.S. cities and public agencies have begun to examine possible ways to advance, test, manage, and regulate shared automated vehicle services. The federal government's Smart City Challenge sparked interest in emerging transportation technologies in cities across the United States, with seventy-eight cities completing the initial application for the $50 million award.[58] Automated vehicles were a key component of most proposals. Columbus, Ohio, won the challenge in June 2016 with a proposal that included a shared automated shuttle connecting public transit to retail districts. San Francisco proposed a plan for shared, electric, connected, automated vehicles to replace single-occupant-vehicle ownership and use.[59]

More research is needed to fully understand the array of deployment scenarios and impacts associated with automated vehicle ownership, sharing, and consumer behavior. What is clear is that the mainstreaming of shared automated fleets will likely vary by region and be heavily influenced by local factors, such as population density, urban form, local policies, and private vehicle ownership costs.

How Can We Create an Environment Conducive to Pooling?

Advancements in technology and mobile computing, along with widespread use of smartphone apps and tracking technologies, provide new opportunities for pooling. For decades, public policy has emphasized the construction of capital-intensive high-occupancy-vehicle (HOV) lanes and ramps along with park-and-ride lots—and still, overall carpool use has declined. While these HOV investments may provide the foundation for future pooling, digital infrastructure will likely be more important. Pooling that leverages modern information and communication technologies could increase vehicle occupancy and mitigate congestion on existing roadway infrastructure without the addition of HOV-specific facilities.

Public policy will play an influential role in accelerating pooling in conventional, electric, and eventually automated vehicles. In a complex federal system such as the United States, policy is multilayered. There are a multitude of relevant policy levers and many carrots and sticks. Cities and local governments can use their authority over land use and local infrastructure, including roads, parking, and curb space, to favor pooling. They own and subsidize public transit, and in many cases regulate and tax the taxi industry; they can also use those carrots to encourage partnerships and services that aid pooling.

To leverage pooling as a first-and-last mile connection to public transportation, it will be important for mobility providers to share data. Without access to travel data, local governments cannot effectively plan for and invest in transportation and parking infrastructure nor can they effectively manage traffic congestion, regulate competing services, design public transit routes, subsidize transit and paratransit, meet the needs of disadvantaged travelers, and plan for future public transportation funding. Open data are also needed to package mobility service choices for use in apps for travelers. There are alternative ways of getting data, including traveler surveys and new techniques of collecting "big data" from moving cell phones. But all those alternatives are expensive, slow, and/or unreliable.

To establish repositories for public and private sector data sets, the public sector needs to create firewalls that maintain confidentiality for mobility service providers and travelers. Government safety and environmental regulators do this routinely with automakers (who submit plans for future models and technology). The public sector can play a critical role in establishing and overseeing data standards, developing security protocols, and maintaining data exchanges. The National Highway Traffic Safety Administration's proposed policy on automated vehicles advocates sharing of data generated by testing and deployment "in a way that allows government, industry, and the public to increase their learning and understanding as technology evolves but protects legitimate privacy and competitive interests."[60]

Moving forward, it is clear that people and cities are on the cusp of rapid change as advancements in technology and services converge in the marketplace. The need to reduce congestion and emissions globally, coupled with the megatrends of population growth and urbanization, is contributing to a fundamental reimagining of transportation across the world. The convergence of shared mobility, fleet electrification, and vehicle automation is positioned to cause fundamental changes and disruption in how people live, work, shop, and travel every day. What is certain is that society and cities are entering a new era of mobility unlike anything we have seen since the introduction of the automobile more than a century ago.

Summary Box: Key Policy Strategies

The aim is to create a social and institutional environment that is conducive to pooling.

Providing incentives for pooling

- Give special parking and stopping privileges at airports and other congested areas.
- Give discounts for pooled cars and vans on toll roads and toll lanes.
- Give priority to pooled vehicles in urban areas, including designating curb space and shared mobility lanes.
- Offer free carsharing coupons and public transit passes for workers who use pooling, along with rewards such as express lines in the cafeteria.
- Provide tax breaks for companies that demonstrate a high level of pooling among employees.
- Offer tax deductions or reductions in vehicle registration taxes for car owners who use their vehicles for pooling (versus for single-passenger UberX-type services).
- Provide subsidies for low-income passengers using pooled services.
- Give tax credits to mobility service providers for achieving certain levels of pooling.
- Give permission for taxis to offer pooled services.

Safeguarding personal security

- Modify apps to include safety-related profiles of passengers, which are made available to fellow passengers and include a mandatory rating scheme (similar to ratings of drivers and passengers with Uber and Lyft)

Protecting personal and proprietary data

- Establish data security protocols.

- Develop guidelines on how and when data are to be made available, such as for travel demand modeling and program evaluation.
- Present data in accordance with laws prohibiting discrimination.

Regulating entry, exit, and tariffs

- Impose sufficient safeguards on innovative services to protect drivers and riders, while reducing onerous regulations on taxis so they can compete effectively.

End of Summary Box

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