Behavioral and Sociodemographic Impacts of Carsharing

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INTRODUCTION

Carsharing services give users short-term, on-demand access to a fleet of shared vehicles, allowing users to gain the benefits of vehicle ownership without having to take on the additional costs and responsibilities. Since the launch of carsharing services in North America in 1998, three models have emerged: (1) roundtrip carsharing (users pick up and drop off vehicles at the same location); 2) one-way carsharing (users can pick up and drop off vehicles at different designated locations); and (3) peer-to-peer (P2P) carsharing (operators facilitate short-term rentals between vehicle owners or hosts and guests or drivers) (Shaheen et al., 2019).

As of October 2018, the global carsharing market was active in 47 countries across six continents, with approximately 32 million members sharing over 198,000 vehicles. The largest carsharing region was Asia with 22.7 million members, accounting for almost three-quarters of the market, followed by Europe, accounting for 21% of carsharing members and 31% of vehicle fleets. From 2016 to 2018, the number of carsharing members worldwide increased by 238%, while the carsharing vehicle fleet grew by 103% (Shaheen & Cohen, 2020).

Carsharing shifts the conventional cost structure of driving from fixed costs (e.g., monthly car payments and insurance payments) to variable costs (e.g., paying by time or distance of use). Carsharing also increases the efficiency of vehicle use by employing a fleet of shared vehicles rather than personally owned vehicles, which are used on average only 4.6% of the time (Fraiberger & Sundararajan, 2017). As a result, carsharing has been shown to impact the travel behavior of users, including transportation mode choice and vehicle ownership. These travel behavior impacts have broader implications on transportation sustainability through reducing vehicle miles traveled (VMT) and shifting users to other, more sustainable modes (e.g., public transit or active transportation, such as cycling). While numerous studies have investigated the impact of roundtrip carsharing on travel behavior, comparing their findings can be difficult due to differences in data collection, methodologies, and analysis models, as well as limited survey sample sizes and data aggregation (Cohen & Shaheen, 2016).

In this chapter, we focus on the findings from user surveys of: (1) roundtrip carsharing; (2) one-way carsharing; and (3) P2P carsharing. User surveys attempting to measure changes in travel behavior often rely on self-reported data, which has validity issues such as inaccuracies in reporting travel extent and frequency and sample bias. Furthermore, user surveys may contain response bias, and therefore are not necessarily representative of the population. Nevertheless, user surveys still provide an important source of understanding of the impacts of carsharing on user travel behavior (Cohen & Shaheen, 2016).

Prior research has analyzed the travel behavior impacts of carsharing with numerous different metrics, including the following:

1. Number of vehicles sold or shed by carsharing members;
2. Number of vehicle purchases avoided, postponed, or suppressed by carsharing members;
3. Change in vehicle miles or kilometers traveled (VMT/VKT); and
4. Change in use of other transportation modes (e.g., walking, biking, public transit).

In this chapter, we summarize and discuss findings from studies using these metrics for each of the three carsharing models (roundtrip, one-way, and P2P). In addition to travel behavior impacts, we also summarize the demographics of carsharing members. The cost structure of carsharing may present a more affordable alternative to personal vehicle ownership. However, research has found that the demographics of carsharing users are not necessarily reflective of the general population and overrepresent high-income, highly educated individuals. We conclude with future directions for carsharing.

ROUNDTRIP CARSHARING

Roundtrip carsharing models provide members access to a fleet of shared vehicles on an hourly or daily basis, and they require that members pick up and return their vehicles at the same location. As of October 2018, roundtrip carsharing accounted for about half of global carsharing membership and 58% of global carsharing fleets. There were approximately 16 million roundtrip carsharing users worldwide. Roundtrip carsharing membership was higher than one-way carsharing membership in Asia, with almost 13 million members. In Europe, there were 1.8 million roundtrip carsharing members, less than half of one-way carsharing membership. In North America, roundtrip and one-way carsharing services had about 1 million members each (Shaheen & Cohen, 2020).

Travel Behavior Impacts of Roundtrip Carsharing

In this section, we summarize the travel behavior impacts of roundtrip carsharing through: (1) vehicle ownership impacts; (2) modal shift; (3) VMT/VKT impacts; and (4) greenhouse gas (GHG) emission impacts.

Vehicle ownership impacts

Numerous studies have found that roundtrip carsharing reduces vehicle ownership, both through members selling or getting rid of a car after joining carsharing and postponing or suppressing future vehicle purchases. Table 18.1 summarizes findings from studies completed in North America, Europe, Asia, and Oceania. We track the following vehicle ownership metrics:

1. Percentage of members selling a personal vehicle;
2. Percentage of members avoiding future vehicle purchase; and
3. Number of vehicles removed from the road per carsharing vehicle.

These metrics are based on survey questions that asked carsharing users to report whether they had sold or gotten rid of a vehicle after joining carsharing, and whether their vehicle purchasing plans had changed for the future. Many studies calculate the net impact of vehicle ownership changes by comparing the number of vehicles sold or vehicle purchases suppressed to the total number of vehicles in the carsharing fleet. This is reported as the number of vehicles removed per carsharing vehicle; see Table 18.1 for a summary of studies of roundtrip carsharing and their impacts on vehicle ownership.

Table 18.1 Summary of vehicle ownership impacts of roundtrip carsharing

Operator *Location*	Period	% Selling Personal Vehicle	% Avoiding Vehicle Purchase	# of Vehicles Removed per Carshare	Source
			North America		
Short-Term Auto Rental (STAR) *San Francisco, CA*		15	43		Walb & Loudon (1986)
CarSharing Portland *Portland, OR*	Year 1	26	53		Katzev (1999)
	Year 2	23	25		Cooper et al. (2000)
City CarShare *San Francisco, CA*	Year 2	29	68	6.8	Cervero & Tsai (2004)
	Year 4	24			Cervero et al. (2007)
PhillyCarShare *Philadelphia, PA*		25	29	10.8*	Lane (2005)
Nine + carsharing companies *U.S. and Canada*		55	70	15	Millard-Ball et al. (2005)
Flexcar and Zipcar *Arlington, VA*	2005	25	68		Price & Hamilton (2005)
	2006	29	71		Price et al. (2006)
Zipcar *Baltimore, MD*		18	46		Auto Rental News (2011)
Eleven carsharing companies *U.S. and Canada*		33	25	9–13	Martin & Shaheen (2011b)
AutoShare and Zipcar *Toronto, Canada*		29	55		Engel-Yan & Passmore (2013)
Modo *Vancouver, Canada*		35	42** 62***	5	Namazu & Dowlatabadi (2018)
Two operators *New York City*		0.6	7	4	Martin et al. (2021)

Table 18.1 (continued)

Operator *Location*	Period	% Selling Personal Vehicle	% Avoiding Vehicle Purchase	# of Vehicles Removed per Carshare	Source
			Europe		
Two providers *Frankfurt am Main, Germany*		14	27		Lichtenberg & Hanel (2007)
Mobizen *France*		67		7	6t bureau de recherche (2014)
Flinkster *Berlin and Munich, Germany*		15			Giesel & Nobis (2016)
Annual Survey of Car Clubs *London, UK*		16	34	11	Gleave (2017)
			Asia and Oceania		
FunCarsharing *Hangzhou, China*			49		Hui et al. (2019)
Carsharing service *Seoul, South Korea*	2014 2018	2 4	29 28	3.2 13.2	Kim et al. (2019)
Five providers *Melbourne, Australia*		26			Jain et al. (2022)

Notes: *Among members who gave up a car; **among respondents who did not change vehicle ownership after joining carsharing; ***among respondents who decreased vehicle ownership after joining carsharing.

Source: Modified and updated from Shaheen et al. (2019).

In general, the percentage of members postponing or suppressing vehicle purchase is higher than the percentage of members selling a vehicle. These findings are consistent across the three regions (i.e., North America, Europe, and Asia and Oceania).

In North America, the majority of studies found that between 20% and 30% of car-owning members sold or otherwise got rid of a personal vehicle after joining carsharing. These findings have been consistent over time, from the earliest study we tracked (1986) to more recent studies conducted in 2018. Similarly, over that same period, most studies found 40–60% of carsharing members avoided purchasing a personal vehicle in the future after joining the service. Overall, some researchers have calculated that each carsharing vehicle can remove 4–15 personal vehicles from the road. One study conducted with two operators in New York City found much less vehicle shedding and vehicle purchase avoidance compared to prior studies: 0.6% of members sold a vehicle and 7% avoided buying one (Martin et al., 2021). However, this study represents a unique case due to the lower vehicle ownership rates in New York City, as many carsharing members did not own or lease a vehicle prior to joining carsharing.

In Europe, Asia, and Oceania, the number of carsharing members selling a personal vehicle is smaller, with most studies finding 14–26% of members sold a personal vehicle and 27–49% postponed a future vehicle purchase. These percentages are smaller compared to North America, and they may be due to lower vehicle ownership rates in these countries in general than in the U.S. and Canada. In summary, researchers calculated that 1–13 personal vehicles were removed per carsharing vehicle in these regions.

Overall, carsharing users have fewer vehicles per household compared to national averages. Three studies reported that about two-thirds of carsharing users are in a zero-vehicle household, with 22–31% having one vehicle and 8.5–10.5% having two or more vehicles (Cervero et al., 2007; Cooper et al., 2000; Martin et al., 2010). The latter study also found that 80% of vehicle shedding came from one-vehicle households (i.e., households went from having one vehicle before joining carsharing to zero vehicles after joining), and 4% came from two-vehicle households (i.e., households went from two vehicles to one vehicle).

Modal shift

In addition to vehicle ownership, researchers have investigated how carsharing has impacted the use of other transportation modes, and they have taken two approaches to investigate mode shift. First, some studies asked survey respondents to report directly how their use of transportation modes has changed as a result of carsharing use (Table 18.2), measuring the impact that carsharing has had on travel behavior more generally. Second, studies have assessed how members report how they would make trips if carsharing was not available, measuring what modes carsharing is replacing or substituting (Table 18.3).

In Table 18.2, these studies find that carsharing members overall walk and cycle more often compared to before they joined carsharing. For public transit, the findings are mixed, with some studies showing that carsharing members use public transit more often, while others indicate members use it less or about the same. Members also drive their personal vehicles less often after joining carsharing. Note that the studies summarized in this table reflect North American carsharing companies.

In Table 18.3, the relevant studies find that carsharing most often replaces public transit, taxi, and personal vehicle trips. A survey of roundtrip carsharing members in Vancouver found that 41% of members would take public transit if carsharing was not available, 32% would take a taxi, and 24% would drive their personal vehicle (Namazu & Dowlatabadi, 2018). Interestingly, about a quarter of respondents indicated that they would take fewer trips if carsharing was not available. This shows that carsharing may be providing some additional mobility for these respondents, enabling them to make more trips than they would have been able to otherwise. A survey of carsharing members from nine companies across North America similarly found that 39% of members would use public transit and 34% would take a taxi, with another 36% responding that they would use carpooling or vanpooling (Millard-Ball et al., 2005). In Hangzhou, carsharing members were most likely to use their personal vehicle in the absence of carsharing, followed by public transit, taxis, and carpool or shared-ride services (Hui et al., 2019).

VMT/VKT impacts

The cost structure of carsharing may impact the amount that carsharing members drive as users shift from the fixed costs of vehicle ownership to the variable costs of carsharing. Car owners tend to view the fixed cost of their cars as a sunk cost, and therefore perceive the cost of each car trip as based only on variable costs such as fuel and parking. However,

Table 18.2 Summary of changes in frequency of use of other modes due to roundtrip carsharing

Operator *Location*		Drive (%)		Walk (%)		Bike (%)		Public transit (%)		Carpool/ rideshare (%)		Taxi (%)		Source
		More	Less	More	Less	More	Less	More	Less	More	Less	More	Less	
CarSharing Portland *Portland, OR*				26	2	10	7	14	8					Cooper et al. (2000)
PhillyCarShare *Philadelphia, PA*	Members who reduced car ownership	8	77	37	0	19	6	37	2			37	2	Lane (2005)
	Members who gained access to a car	48	14	6	2	3	6	4	12			2	27	
Nine+ companies *U.S. and Canada*	All members			37	28			40	32					Millard-Ball et al. (2005)
	Members who reduced car ownership			32	31			33	36					
Flexcar and Zipcar *Arlington, VA*	2005		50	49				54						Price & Hamilton (2005)
	2006			47				47						Price et al. (2006)
Eleven operators *U.S. and Canada*		4*	15*	12	9	10	4	8** 12***	9** 13***	5	2			Martin & Shaheen (2011a)

Notes: *Change in mode use for commuting; **change in mode use for bus; ***change in mode use for rail.

Source: Modified and updated from Shaheen et al. (2019).

Table 18.3 If roundtrip carsharing was discontinued, what modes would you use instead?

Operator *Location*	Personal vehicle (%)	Walk (%)	Bike (%)	Public transit (%)	Carpool/ rideshare (%)	Taxi (%)	Take fewer trips (%)	Source
Nine+ companies *U.S. and Canada*		15		39	36	34		Millard-Ball et al. (2005)
Modo *Vancouver*	24	15	13	41	16	32	27	Namazu and Dowlatabadi (2018)
FunCarsharing* *Hangzhou*	32			25	20	22	1.1	Hui et al. (2019)

Note: * Respondents were asked what mode they would use if carsharing was not available.

Source: Modified and updated from Shaheen et al. (2019).

as fixed costs account for at least 80% of the total cost of the car, this means that drivers often underestimate driving costs. Carsharing costs encapsulate more of the fixed costs of car ownership in the price that users are charged, leading to the perception that driving is more expensive. As a result, carsharing members are more mindful of the cumulative costs of driving (Millard-Ball et al., 2005).

Researchers have measured VMT/VKT impacts by asking survey respondents to report their monthly or annual vehicle mileage and change in use of other transportation modes. Reductions in VMT/VKT may also come from the modal shifts, summarized in the previous section, as carsharing members shift from driving to other modes such as walking, cycling, and public transit. Trips taken on foot, by bike, and on public transit are reported as trips with zero VMT/VKT; therefore, shifting trips toward active and public transportation has the overall effect of reducing VMT/VKT. Martin and Shaheen (2011a) found that carsharing members who increased their public transit usage were from households that had owned a car prior to using carsharing, which resulted in an overall decrease in VKT. Combining the impacts of driving reduction and mode shift on VMT, several studies in North America and one study in Europe found that carsharing leads to an overall reduction in VMT/VKT driven by members. A full summary of these studies is shown in Table 18.4, with reductions in VMT ranging from 3% to 63%.

Surveys of City CarShare members (now part of Getaround) in San Francisco between 2001 and 2005 may illustrate the impacts of "judicious" car use on VMT. In a survey from the first year of City CarShare, Cervero (2003) found that its carsharing members reduced their VMT, but these reductions were less than those of the general population of non-carsharing members (3% decrease in VMT by members vs. 58% decrease by a comparable group of non-members). The author suggests that the relatively higher VMT of members may have been due to giving car access to a large group of non-car owners (approximately two-thirds of City CarShare members surveyed in his study period did not own a car), and that carsharing induced car travel for these members. However, in subsequent surveys, researchers found that VMT continually decreased for members, by 47% in the second year of operation and by 67% in the fourth year (Cervero et al., 2007; Cervero &

Table 18.4 Summary of changes in VMT/VKT per member due to roundtrip carsharing

Operator *Location*		% VMT/VKT change per member	Avg VMT/ VKT per year	Source
Car Sharing Portland *Portland, OR*		−8	3,666 miles	Cooper et al. (2000)
City CarShare *San Francisco, CA*	Year 1 Year 2 Year 4	−3 −47 −67	2,178 miles* 4,314 miles*	Cervero (2003) Cervero & Tsai (2004) Cervero et al. (2007)
Flexcar and Zipcar *Arlington, VA*	2005 2006	−40 −43	8,125 miles 5,411 miles	Price & Hamilton (2005) Price et al. (2006)
Mobility Services for Urban Sustainability (moses) Project *Europe*		−28 to −45		Rydén & Morin (2005)
Philly CarShare		−42	6,852 miles	Lane (2005)
Nine+ companies *U.S. and Canada*		−63	6,111 miles	Millard-Ball et al. (2005)
Eleven companies *U.S. and Canada*		−27	8,064 miles/ 13,000 km**	Martin et al. (2010)
Two companies *New York City*		−7	4,313 miles	Martin et al. (2021)

Notes:
* The authors report a metric "Mode- and Engine Size-adjusted VMT" to represent overall transportation consumption. This reflects total miles traveled in motorized vehicles, and it is adjusted for vehicle occupancy and engine size (see Cervero, 2003 for more details).
** This number is reported only for vehicles that were shed by carsharing members.

Source: Modified and updated from Shaheen et al. (2019).

Tsai, 2004). In comparison, non-members *increased* their VMT by 73% over the second year and by 24% over the fourth year. VMT reduction occurs as members shed their personal vehicles and shift from driving to other modes such as walking, cycling, and public transit. The authors of these studies argue that the reductions in VMT seen in the second and fourth year of City CarShare operation show the effect of carsharing members becoming more judicious about car travel and more selective when it comes to deciding to shift from driving to another mode, or to forgo a trip altogether.

Impacts on greenhouse gas (GHG) emissions

Some researchers have studied the impact of roundtrip carsharing on GHG emission from transportation, and they found that overall roundtrip carsharing reduces it. These declines come from reductions in vehicle ownership and miles driven, as well as members shifting from driving to other modes such as walking, cycling, or public transit.

An early study of City CarShare in San Francisco found that approximately 30% of roundtrip carsharing members reduced their car ownership by shedding one or more vehicles, while about 67% postponed the purchase of a new vehicle (Cervero & Tsai, 2004). Using travel diary data over a 24-hour period, researchers found that some members began driving more, replacing carsharing for trips previously taken on public transit, on foot, or by bike. However, they observed that daily fuel consumption still fell among carsharing members compared to non-members due to reductions in vehicle ownership, switching to more fuel-efficient vehicles in the carsharing fleet, and increasing vehicle occupancy by carpooling. This resulted in a net reduction in carbon dioxide (CO_2) emissions from transportation, with carsharing members reducing their emissions by 0.75 lbs (0.34 kg) over two years of using carsharing compared to an estimated 0.25 lbs (0.11 kg) increase among non-members (Cervero & Tsai, 2004).

A case study of two carsharing operators in New York City (NYC) also considered the impacts of vehicle ownership changes and modal shift on GHG emissions. Although NYC users exhibited lower levels of vehicle shedding and suppression compared to users in other cities, modal shift and reduction in miles driven led to an average GHG reduction of 6% per carsharing member (Martin et al., 2021).

An extensive survey of 6,281 carsharing members from 11 operators across the U.S. and Canada found that 25% sold a vehicle and 25% postponed a vehicle purchase as a result of carsharing (Martin & Shaheen, 2011a). While public transit use of carsharing members declined, the authors found an increase in walking, biking, and carpooling. Overall, they documented that household annual VMT/VKT decreased by 27–43%, considering vehicles sold and postponed, resulting in a net decrease of 0.58 tonnes of GHGs annually per household (based on observed decreases in driving) and a net decrease of 0.84 tonnes of GHGs annually per household (including the effects of postponed vehicle purchases and mode shift).

Studies in North America have found that, overall, members of roundtrip carsharing drive their personal vehicles less, increase their use of public transit and non-motorized modes (e.g., walking and biking), and may sell a personal vehicle or postpone the purchase of a personal vehicle. As a result, roundtrip carsharing has the effect of reducing household GHGs from transportation by replacing personal vehicle use with more sustainable transportation modes.

Demographics of Roundtrip Carsharing Users

In this section, we outline and discuss the findings on roundtrip carsharing member demographics in North America, Europe, Asia, and Oceania. Table 18.5 provides a summary of the findings on age, gender, educational attainment, income, and race of carsharing members.

The studies in Table 18.5 indicate that the average age of carsharing members in North America is between 30 and 40 years, while one study in Europe found the average age to be 45 (Giesel & Nobis, 2016). In Asia and Oceania, it appears that carsharing members are younger: over 80% of members in South Korea are below 40 (Kim et al., 2019); and in Hangzhou, three-quarters are between 25 and 34 (Hui et al., 2019).

The gender distribution of users varies between operators and regions. In North America, many operators have relatively equal proportions of male and female members, while some operators had more female than male subscribers. Large surveys of members across multiple companies in the U.S. and Canada found that approximately 45% are male

Table 18.5 Summary of roundtrip carsharing member demographics

Operator *Location*		Age	Gender (%) (male/female)	Education (% Bachelor's or higher degree)	Income: %	% Caucasian/white	Source
North America							
CarSharing Portland *Portland, OR*	Year 1	Mean: 37.2	45/54		< \$35,000: 47 < \$50,000: 66		Katzev (1999)
	Year 2	Mean: 39.1		87	< \$35,000: 42 < \$50,000: 56		Cooper et al. (2000)
City CarShare *San Francisco, CA*	Year 1 Year 2	Mean: 30–40 Median: 36	38/62 43/57	90	Median: \$50,000 Median: \$57,000	88 81	Cervero (2003) Cervero & Tsai (2004)
PhillyCarShare *Philadelphia, PA*		25–39: 55%		99.6		89	Lane (2005)
Nine+ companies *U.S. and Canada*		Median: 35	45/55	83	< \$30,000: 13 < \$60,000: 50	87	Millard-Ball et al. (2005)
Eleven companies *U.S. and Canada*		< 40: 66%	45/55	81	< \$60,000: 43		Martin & Shaheen (2011a)
Two operators *New York City*		25–34: 29–36%	50–60/40–50	72–84	< \$35,000: 9–21	49–57	Martin et al. (2021)
Europe							
Mobizen *France*				72			6t bureau de recherche (2014)
Flinkster *Berlin and Munich, Germany*		Mean: 45	80/20	78			Giesel & Nobis (2016)

			Asia and Oceania		
FunCarsharing *Hangzhou, China*		25–34: 76%	89/11	72	Hui et al. (2019)
Carsharing service *Seoul, South Korea*	2014 2018	< 40: 88% < 40: 85%	83/17 77/23		Kim et al. (2019)
Five providers *Melbourne, Australia*		25–34: 44%	52/48	83	Jain et al. (2022)

and 55% female (Martin & Shaheen, 2011a; Millard-Ball et al., 2005). In Europe, Asia, and Oceania, these trends were different, with much higher percentages of male than female members. In Seoul and Hangzhou, female members comprised only 20% of carsharing members (Hui et al., 2019; Kim et al., 2019). However, a survey of five providers in Melbourne showed a fairly even distribution of male and female members (Jain et al., 2022).

Across all operators and regions, carsharing members reflect high educational attainment, with 70–90% holding a Bachelor's degree or higher, which results in their relatively higher incomes. Studies from the early 2000s show a median income of around $50,000 or $60,000 (Cervero & Tsai, 2004), while later studies have smaller percentages of users earning less than $35,000 or $60,000 (Martin et al., 2021; Martin & Shaheen, 2011a). For studies in North America that reported users' race and ethnicity, four from the early 2000s indicate that over 80% of carsharing members identified as Caucasian/white (Cervero, 2003; Cervero & Tsai, 2004; Lane, 2005; Millard-Ball et al., 2005). A more recent study of members in NYC found more diversity, with only 49–57% identifying as Caucasian/white (Martin et al., 2021).

The demographics of carsharing members also differ slightly by region and operator, and there are some indications that these demographics have changed since the early 2000s. Recent studies in North America have found that carsharing members are more racially diverse and more evenly split between males and females. However, in Europe, Asia, and Oceania, most studies show that a large majority are male. Consistent across all operators and regions is the high educational attainment of members, with at least 70% having a Bachelor's or post-graduate degree.

ONE-WAY CARSHARING

One-way carsharing services enable users to pick up and drop off vehicles at different locations within a geofenced area. In comparison to roundtrip carsharing, where users must return the vehicle to the same pick-up location, one-way users may have more flexibility when deciding when and how to use carsharing, and they may more easily combine carsharing with other modes (Shaheen et al., 2019). One-way carsharing services grew quickly around the world; and in Europe, one-way had even surpassed roundtrip carsharing prior to the global pandemic. As of October 2018, there were approximately 15.8 million one-way carsharing members worldwide, with 9.8 million in Asia, 4.9 million in Europe, and 1 million in North America (Shaheen & Cohen, 2020).

Travel Behavior Impacts of One-Way Carsharing

Because of the potentially more flexible nature of one-way carsharing and increased ability to take multimodal trips, its impacts on travel behavior may differ from those on roundtrip or other forms of carsharing. This section explores the travel behavior impacts of one-way carsharing through: (1) vehicle ownership; (2) modal shift; (3) VMT/VKT; and (4) GHG emissions.

Vehicle ownership impacts

To evaluate the impacts of one-way carsharing on vehicle ownership, researchers used similar methods to those described in the section on roundtrip carsharing. Table 18.6 summarizes various studies that have evaluated vehicle ownership impacts of one-way carsharing in North America, Europe, and Asia.

Table 18.6 Summary of vehicle ownership impacts of one-way carsharing

Operator *Location*	% Selling Personal Vehicle	% Avoiding Vehicle Purchase	# Vehicles Removed per Carshare	Source
		North America		
Car2go *U.S. and Canada*	2–5	7–10	7–11	Martin & Shaheen (2016)
Car2go *Vancouver, Canada*	12	30* 55**	6	Namazu and Dowlatabadi (2018)
GIG Car Share *Oakland, CA*	2	7		Martin et al. (2020)
		Europe		
Car2go *Ulm, Germany*		14***		Firnkorn & Müller (2011)
Autolib *France*	23		3	6t bureau de recherche (2014)
DriveNow *Berlin and Munich, Germany*	7			Giesel & Nobis (2016)
Annual Survey of Car Clubs *London, UK*	19	27	11	Gleave (2017)
Free-floating Carsharing Service *Basel, Switzerland*	6			Becker et al. (2017)
Free-floating Carsharing Service *London, UK*	4	30		Le Vine & Polak (2019)
SHARE NOW *Europe*	3–16	14–41		Jochem et al. (2020)
		Asia		
Evcard *Shanghai, China*	0.8	30	4.6	Ye et al. (2021)

Notes: *Among respondents who did not change vehicle ownership since joining carsharing; **among respondents who decreased vehicle ownership since joining carsharing; ***expected impact based on intentions to forgo a future purchase

Source: Modified and updated from Shaheen et al. (2019).

Compared to roundtrip carsharing, fewer one-way carsharing users reduce their vehicle ownership. In North America, 2–12% of members sold a personal vehicle (compared to 20–30% of roundtrip carsharing members) and 7% to 55% of members avoided a future vehicle purchase (compared to 40% to 60% of roundtrip carsharing members). A slightly higher percentage of one-way users in Europe reduced their vehicle ownership: 3–23% of users sold a personal vehicle and 14–41% avoided future purchase. The impacts of one-way carsharing in Asia are smaller, with 0.8% of users in Shanghai selling a vehicle and 30% avoiding a future vehicle purchase (Ye et al., 2021). Although the proportion of users selling a vehicle is low, the higher percentage of users suppressing a future vehicle purchase results in a net reduction of 4.6 personal vehicles per carsharing vehicle. This value is similar to findings in France by the 6t bureau de recherche (three vehicles removed per carsharing vehicle) and by Namazu & Dowlatabadi in Vancouver (six vehicles removed per carsharing vehicle). A study of one-way carsharing across the U.S. and Canada found that, on average, each carsharing vehicle removed between seven and 11 personal vehicles (Martin & Shaheen, 2016).

Modal shift

Three studies in North America investigated the modal impact of one-way carsharing, summarized in Table 18.7. Like roundtrip carsharing, one-way carsharing users walk and cycle more often and drive a vehicle less often, although these findings vary between regions. For example, in a survey of car2go members in the U.S. and Canada, users in some cities drove more frequently as a result of joining one-way carsharing (Martin & Shaheen, 2016). Unlike roundtrip carsharing, where changes in public transit use differed among operators and cities, one-way users generally reduced their use of public transit. Three relevant studies, in our review, also assessed the impact of carsharing on transportation network companies (TNCs) such as Uber and Lyft. Studies of car2go in the U.S. and Canada and of GIG Car Share in Oakland, CA found that one-way carsharing reduces TNC use, with the GIG study finding that ride-alone TNC use decreased more than pooled TNC use (Martin et al., 2020; Martin & Shaheen, 2016). However, car2go users in San Diego used TNCs more due to one-way carsharing (Shaheen et al., 2018a).

Rather than asking about how mode use would increase or decrease due to one-way carsharing, one study asked respondents what modes they would employ in place of carsharing if the service were discontinued (Namazu & Dowlatabadi, 2018). The authors found that the most common modes respondents would use in place of carsharing were public transit (57%), personal vehicle (46%), and taxi (44%); about a quarter of respondents would walk instead of carsharing, while 15% would take fewer trips.

Studies on modal shift due to one-way carsharing find similar results to roundtrip carsharing, except for public transit. Namazu & Dowlatabadi (2018) surveyed car2go users in Vancouver and asked respondents what mode they would use if carsharing were discontinued, with 57% of choosing public transit. This study asked the same question of roundtrip carsharing users, with 41% of respondents choosing public transit. The authors argue that these findings indicate that one-way carsharing is used more frequently as a complement to other modes or as an additional option in multi-modal trips. One-way carsharing has also been found to enable multi-modal trips with public transit from a study of GIG Car Share in Oakland. This study found that 44% of respondents made a

Table 18.7 Summary of changes in frequency of use of other modes due to one-way carsharing

Operator *Location*	Drive (%)		Walk (%)		Bike (%)		Public transit (%)		Taxi (%)		TNCs (%)		Source
	More	Less	More	Less	More	Less	More	Less	More	Less	More	Less	
Car2go *U.S. and Canada*	11–47	10–27	10–34	9–12	3–7	2–8	3–11* 3–8** 0–6***	3–24* 21–48** 1–5***	1–3	42–65	6–22	16–37	Martin & Shaheen (2016)
Car2go *San Diego, CA*	11	26	33	9			12	24	2	59	22	17	Shaheen et al. (2018a)
GIG Car Share *Oakland, CA*	<1	15	2	11	<1	9	<1* 2**	13* 20**	0	4	0† <1‡	43† 33‡	Martin et al. (2020)

Notes: *Urban rail; **bus; ***intercity rail; †ride-alone TNC; ‡pooled TNC

Source: Modified and updated from Shaheen et al. (2019).

multi-modal trip combining one-way carsharing and public transit that they would previously have made with a personal or borrowed vehicle (Martin et al., 2020).

These findings suggest that, although one-way carsharing does not have the same impacts on vehicle ownership as roundtrip carsharing, one-way users are still shifting their behavior toward more sustainable transportation modes such as walking, cycling, and multi-modal public transit trips.

VMT/VKT impacts

Fewer studies have quantified the impact of one-way carsharing on miles/kilometers driven. However, some relevant studies have used activity data from carsharing operators to supplement survey analysis, a methodological approach that was not taken in roundtrip carsharing studies. Activity data from operators include trip distance, duration, and frequency for carsharing members. In a study of car2go users in the U.S. and Canada, activity data were used to account for survey bias, with more respondents being active users (i.e., those using carsharing more than once per month) of carsharing compared to the overall carsharing population. The trip frequency distribution generated from the activity data was used to re-weight the responses of heavy carsharing users to be representative of the overall population.

In addition to accounting for survey bias, activity data were used to estimate the overall VMT/VKT impacts in cities where carsharing was operational. Activity data were used to estimate the total distance driven by all carsharing users. Survey data provided estimates of reduction in miles/kilometers driven, reduction in vehicle ownership, miles/kilometers driven in personal vehicles, and estimated miles/kilometers that would have been driven on vehicle purchases that had been avoided due to carsharing. These data were re-weighted based on frequency of carsharing use and extrapolated for the entire population of carsharing users. Using this methodology, Martin & Shaheen (2016) found that car2go users reduce their household VMT/VKT by 6% to 16%. Survey respondents reported driving an average of 5,800 to 7,800 miles per year in vehicles that were sold as a result of joining carsharing. A study of GIG Car Share in Oakland found that 42% of respondents changed the amount that they drove as a result of one-way carsharing, with a median change of 35 fewer miles per month. For the surveyed population, approximately 9.3% of all members would reduce miles driven in their personal vehicles by an average of 67 miles per month as a result of GIG. Using activity and survey data and extrapolating this to the overall population of one-way carsharing users, Martin et al. (2020) estimate that GIG Car Share results in a net decrease of between 881,716 and 2,830,533 miles driven annually in Oakland.

Impacts on greenhouse gas emissions

Martin and Shaheen (2016) estimated the overall impact of one-way carsharing on GHG emissions from changes in vehicle ownership and reduction in miles driven. Their survey of car2go users in the U.S. and Canada found that, on average, each company vehicle displaces 10–14 metric tons of GHGs per year, which corresponds to an average decrease of 10% across five North American cities. Although this study did not include additional GHG reductions that would result from modal shift, it still indicates the potential of one-way carsharing to reduce GHG emissions from transportation.

Demographics of One-Way Carsharing Users

An overview of the demographics of one-way carsharing users in North America, Europe, and Asia is provided in Table 18.8. In Europe, their mean age was found to be around 34 to 36 years (Giesel & Nobis, 2016; Le Vine & Polak, 2019). A study in Oakland found that one-way carsharing users are younger, with almost half being between 25 and 34 years of age (Martin et al., 2020), and one study in China found that 90% of users were under the age of 40 (Ye et al., 2021).

The gender distribution of this group was more skewed toward male users in Europe and Asia, where they comprised over three-quarters of the user population. Meanwhile, the study conducted in Oakland found a higher percentage of female users. Similar to roundtrip carsharing, one-way users reflected a high educational attainment: over 90% of users in the Oakland and London studies had a Bachelor's degree or higher, together with two-thirds of users in Germany and China (Giesel & Nobis, 2016; Ye et al., 2021). These findings on educational attainment result in less representation from low-income users: in Oakland, only 15% of users reported an annual household income of less than $35,000; and in London, the mean household income was £49,000 (approximately US$65,000) (Le Vine & Polak, 2019; Martin et al., 2020).

PEER-TO-PEER (P2P) CARSHARING

In the P2P carsharing model, service providers broker transactions between vehicle owners (hosts) and vehicle users. Owners list their vehicles on a platform and users can view and book these vehicles. Members access vehicles by directly receiving and returning keys to

Table 18.8 Summary of one-way carsharing user demographics

Operator *Location*	Age	Gender (%) male/ female)	Education (% Bachelor's or higher)	Income	Source
			North America		
GIG Car Share *Oakland, CA*	25–34: 48%	42/53	90	< $35,000: 15%	Martin et al. (2020)
			Europe		
DriveNow *Berlin and Munich, Germany*	Mean: 36	74/26	71		Giesel & Nobis (2016)
Free-floating Carsharing Service *London, UK*	Mean: 33.6	89% / 11%	93%	Mean: £49,000	Le Vine & Polak (2019)
			Asia		
Evcard *Shanghai, China*	< 40: 90%	82% / 18%	66%		Ye et al. (2021)

the vehicle owner or the P2P operator may provide and install in-vehicle technology that enables remote access. Pricing is determined by the vehicle owner, and the P2P operator often takes a commission for facilitating the transaction between owner and user (Shaheen et al., 2019). As of January 2017, there were approximately 2.9 million P2P members in North America sharing 131,336 vehicles (Shaheen et al., 2018b). P2P carsharing is also operational in Europe. In a study of P2P and business-to-consumer carsharing in 177 European cities, Münzel et al. (2020) found that all but two cities had shared cars, and that the average number of P2P cars in each city was 187, with 35 cars per 100,000 residents.

Travel Behavior Impacts of Peer-to-Peer Carsharing

Compared to roundtrip and one-way carsharing, there have been fewer studies on the travel behavior impacts of P2P carsharing. In this section, we summarize the vehicle ownership and modal shift impacts of P2P carsharing.

Vehicle ownership impacts

Two studies of P2P carsharing users in the U.S. have estimated the vehicle ownership impacts of P2P carsharing, with their findings summarized in Table 18.9. In one study in Portland, Dill et al. (2019) found that approximately 44% of users avoided a future vehicle purchase. The other study, of users across three operators, found a smaller percentage of users avoiding vehicle purchase (19%), and 14% of users sold their personal vehicle as a result of using P2P carsharing (Shaheen et al., 2018b). Based on these findings, P2P carsharing appears to have a smaller impact on vehicle ownership than roundtrip and one-way carsharing.

Modal shift

The impact of P2P carsharing on use of other travel modes is also similar to roundtrip and one-way carsharing. The two studies included in this chapter measure mode shift differently: Shaheen et al. (2018b) asked survey respondents whether P2P carsharing increased or decreased their use of other modes, while Dill et al. (2019) asked respondents how they would have made their last trip if P2P carsharing were not available.

P2P carsharing users in the U.S. used active transportation more often: 15% walked more often, 10% cycled more often with their own bike, with 3% using bikesharing more

Table 18.9 Summary of vehicle ownership impacts of P2P carsharing

Operator *Location*	% Selling Personal Vehicle	% Avoiding Vehicle Purchase	Source
Getaround, RelayRides (Turo), and eGo Carshare *U.S.*	14	19	Shaheen et al. (2018b)
Getaround *Portland, OR*		44	Dill et al. (2019)

Source: Modified and updated from Shaheen et al. (2019).

often; and 11% used carpooling and ridesharing services more often. P2P carsharing also increased the amount of travel, with over one-third of users taking trips more frequently due to carsharing. The impacts on public transit, including urban rail and bus, were split: 7% to 9% of respondents used public transit more often and 8% to 10% less often. TNC use (i.e., Uber and Lyft) was also split, with 9% of users taking them more often and 9% less often (Shaheen et al., 2018b).

In Portland, if P2P carsharing was not available, about one-third of users would not have taken their last trip, and 20% would have used public transit (Dill et al., 2019); about a quarter of users would have taken a personal, borrowed, or rented vehicle; and 12% would have used another carsharing service. The findings from these two studies indicate that P2P carsharing is increasing the mobility of some users by increasing the number of trips they are taking, as well as supplanting some trips in private or borrowed vehicles and some public transit trips.

Research on P2P carsharing has not quantified its overall impacts on VMT/VKT or GHG emissions. However, research found some reduction in vehicle ownership, albeit less than roundtrip and one-way carsharing, as well as increases in active transportation, which were seen in the other service models.

Demographics of P2P Carsharing Users

An overview of the demographics of P2P carsharing users from two U.S. studies is shown in Table 18.10. Both studies had similar findings. About half of P2P carsharing users are between 25 and 34 years old, and more than three-quarters have a Bachelor's degree or higher. Slightly more users in Portland reported a household income of less than $35,000 compared to the study of three operators in the U.S. (31% vs. 21%). Shaheen et al. (2018b) found a higher percentage of male users than female users (56% vs. 44%). They also tracked the race/ethnicity of users, finding that two-thirds identify as Caucasian/white, 20% as Asian, and 3% as Black/African American. This work on P2P carsharing users found that users are more diverse compared to earlier studies of roundtrip carsharing.

Table 18.10 Summary of P2P carsharing user demographics

Operator *Location*	Age (between 25 and 34)	Gender (%) (male/female)	Education (% Bachelor's or higher)	Income less than $35,000	Source
Three P2P operators *U.S.*	55%	56/44	86	21%	Shaheen et al. (2018b)
Getaround *Portland, OR*	53%		76	31%	Dill et al. (2019)

Source: Modified and updated from Shaheen et al. (2019).

CONCLUSION AND FUTURE OUTLOOK

This chapter summarized research findings on the travel behavior impacts and user demographics of three carsharing service models – roundtrip, one-way, and peer-to-peer (P2P) – focusing on surveys of users in North America, Europe, Asia, and Oceania. These studies report travel behavior impacts in terms of vehicle ownership changes, miles/kilometers driven changes, and modal shift. Some studies also estimate the impact of travel behavior changes on GHG emissions from transportation.

Overall, the majority of studies find that carsharing reduces vehicle ownership and GHG emissions from transportation. Roundtrip carsharing results in the biggest reductions in vehicle ownership, with 20% to 30% of members selling a personal vehicle and a further 40% to 60% avoiding the purchase of a future vehicle because of roundtrip carsharing membership. Although one-way carsharing had smaller impacts on vehicle ownership, its flexibility enabled users to make more multi-modal trips, in particular trips that combined carsharing and public transit. The effects of reductions in vehicle ownership, reductions in VMT/VKT, and shifts toward active and public transportation led to overall reductions in the GHG emissions of carsharing users. Although studies have not estimated the impacts of P2P carsharing on GHG emissions, P2P carsharing has been shown to also reduce vehicle ownership on a smaller scale and cause some modal shift to active transportation.

While these studies have shown that carsharing services have the potential to significantly reduce vehicle ownership and GHG emissions, these impacts are limited by the small share of carsharing members in the general population. For example, in the United States in 2018, only 0.6% of licensed drivers were members of carsharing organizations.[1] Even though carsharing represents only a small share of all licensed drivers, carsharing membership grew – by over 200% from 2016 to 2018. As carsharing continues to evolve with technological advancements (such as electric carsharing and vehicle automation) and a growing focus on low-income carsharing models in the U.S., the environmental impacts of carsharing could expand.

Additionally, there are few longitudinal studies of carsharing members that show the long-term travel behavior impacts of carsharing. An exception is by Cervero et al. (2007), who employed five waves of surveys of City CarShare users in the San Francisco Bay Area to analyze long-term impacts on VMT and fuel consumption. The authors found that carsharing members reduce VMT over time, although the largest reductions occurred in the early years of joining carsharing. The long-term impacts of carsharing on the use of other transportation modes, such as public transit and active travel, have not been explored. Further research is needed to better understand the long-term travel and environmental impacts of carsharing.

Research on the demographics of carsharing users show some differences between operators and regions. The majority found that users were between 30 and 40 years old, with some studies showing a high percentage of younger users (aged 25–34). In North America and Oceania, the gender distribution of users was even, although some studies showed a higher percentage of female users. However, in Europe and Asia, the vast majority of carsharing users were male.

Early studies in the U.S. indicated that over 80% of users identified as Caucasian/white; however, more recent studies from 2018 and 2021 showed that this proportion had fallen to around 60%, a sign that carsharing users are becoming more diverse. At the same time, even with this increased diversity, carsharing users were still not racially or ethnically representative of the general population in the cities where carsharing operates. For example, while only 50% to 57% of roundtrip carsharing users in NYC identify as Caucasian/white – a decrease from earlier studies, where over 80% of users were Caucasian/white – only 32% of the city's population is Caucasian/white. Similarly, in Oakland, 62% of one-way carsharing users identified as Caucasian/white, compared to just 27% of its general population.

While demographics such as age, gender, and race/ethnicity differed between operators and regions, levels of educational attainment were consistent among carsharing users. In the majority of studies that included demographic information, over 70% of users held a Bachelor's degree or higher, and in some studies, high educational attainment translated to higher overall income of users. Although there are some indications that the demographics of carsharing users are increasing in diversity since the introduction of carsharing in the 1990s, there are still persistent gaps in the educational attainment, income, and race/ethnicity of users compared to the general population.

The issue of social equity in carsharing has been addressed in several studies. Researchers believe that carsharing can be effective in providing low-income individuals with access to cars at a reduced cost compared to car ownership; yet the demographics of carsharing users were not representative of the general population, and low-income individuals are underrepresented (Espino & Truong, 2015). Several barriers to carsharing exist for low-income and other underserved populations. These barriers may be structural (i.e., vehicles are not available in low-income neighborhoods); financial (i.e., carsharing operators require credit card and bank account information); and informational and cultural (i.e., social status attached to car ownership, low-income individuals have less information about carsharing and its benefits) (Kodransky & Lewenstein, 2014a).

Some operators have taken actions to address these barriers, including: setting up short-term pilot programs in neighborhoods to gauge demand (e.g., eGo in Denver, CO); opening storefronts in low-income neighborhoods to help new users sign up and learn how to use carsharing (e.g., City CarShare in San Francisco and Buffalo CarShare in New York state); and providing additional payment options for unbanked populations (e.g., Ithaca CarShare in New York and iGO in Chicago) (Kodransky & Lewenstein, 2014b). The program directors for Buffalo CarShare reported that success with low-income members was a result of intentional expansion into low-income neighborhoods and marketing campaigns that targeted low-income individuals on public transit (Randall et al., 2011). Ithaca CarShare found that 25% of users earned less than $10,000 per year, with the program directors indicating that the organization's emphasis on providing access to local low-income residents played a role in its success with low-income users (Blair & Dotson, 2011).

Given the potential benefits of carsharing for low-income individuals and other underserved populations, as well as the continued equity gap in carsharing users, ongoing work should consider policy strategies that specifically target these populations (e.g., EV carsharing for underserved populations, which has been piloted in California). Researchers can also contribute to addressing transportation equity issues in carsharing by conducting rigorous, longitudinal evaluations of social equity programs to assess their effectiveness in generating lasting impacts on the adoption and use of carsharing among low-income populations.

Future Outlook

The carsharing sector has continued to evolve since the launch of the first service in North America in 1994. More widespread vehicle electrification has the potential to increase reductions in GHG emissions that have already been reported for roundtrip and one-way carsharing. Anecdotal evidence suggests that electrification of carsharing fleets is increasing, with one-way carsharing services in Europe adding more electric vehicles to their fleets and EV one-way programs in California cities (e.g., Los Angeles, Sacramento). While electric carsharing pilots have been conducted in the U.S., charging infrastructure has been identified as a persistent barrier to overcome (Ferguson & Holland, 2019; Shaheen et al., 2018a).

Further advances in vehicle automation may also have a transformative effect on carsharing. Early research modeling fleets of shared, automated, electric vehicles (SAEVs) has shown the potential of such fleets to reduce vehicle ownership and GHG emissions from transportation. Furthermore, anecdotal evidence indicates that SAEVs could enable more multi-modal connections through facilitating first- and last-mile connections to other modes. Together, electrification and automation have the potential to increase the vehicle ownership and GHG reduction impacts of carsharing. Nevertheless, the early stages of growth from carsharing and other shared mobility services indicate that users from underserved communities and certain sociodemographic groups are often left out. As the carsharing industry continues to evolve with advances in electrification and automation, future research and policy strategies are needed to maximize the social and environmental benefits of carsharing, keeping in mind the transportation needs and barriers of historically underserved populations.

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NOTE

1. The number of licensed drivers was taken from https://www.fhwa.dot.gov/policyinformation/statistics/2018/dv1c.cfm, and the number of carsharing members from Shaheen and Cohen (2020).

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