SHARED MOBILITY: CURRENT ADOPTION, USE, AND POTENTIAL IMPACTS ON TRAVEL BEHAVIOR

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Abstract

Shared mobility services have experienced significant growth in adoption since the introduction of Uber, a ride-hailing service, in 2010. Although business models to support the sharing of vehicles (e.g., carsharing) have been present in the United States for more than 15 years, their adoption has been somewhat limited to niche markets in dense, urban cities or college campuses. To date, carsharing has attracted over 1.5 million members in North America and close to 5 million globally *(1)*. Conversely, new models of 'shared mobility,' are estimated to have grown to more than 250 million users within five years *(2)*.

The rapid adoption of these new mobility services poses significant challenges for transportation researchers, policymakers, and planners, as there is limited information and data about how these services may affect travel decisions and usage patterns. Given the long-range business, policy, and planning decisions that are required to support transportation infrastructure (including transit, roads, and vehicles), there is an urgent need to collect data on the adoption of these new services, and in particular, their potential impacts on travel choices.

This paper presents findings from a comprehensive travel and residential survey deployed in seven major U.S. cities that included questions on the adoption and use of carsharing and ride-hailing services. The findings suggest that early adopters of ride-hailing services tend to be younger, more highly educated, have higher incomes, and are more likely to reside in dense urban areas.

Although we find that ride-hailing adopters have lower levels of vehicle ownership than non-adopters, they are more likely to own a vehicle than core transit users. Given that ride-hailing services are relatively new, the majority of individuals report few changes in travel behavior. However, we do find preliminary evidence that these services support the disposal of a personal vehicle (9% of ride-hailing adopters reported having doing so) and a reduction in personal driving (26% of ride-hailing adopters). Reported changes in transit use by adopters are minimal; however, here we find early evidence that ride-hailing serves as a substitute for bus services, and may serve as a complement for commuter rail. While further research is needed, this study presents early findings on the potential impacts that emerging shared mobility services may have on travel behavior.

Keywords: shared mobility, carsharing, ridesharing, ride-hailing, Uber, travel behavior

INTRODUCTION

Many academic researchers, policymakers, and planners have acknowledged that the emergence of shared mobility services, such as Uber and Zipcar, are disrupting established transportation business models. The notion of ‘shared mobility’ is part of a broader concept termed the “sharing economy’ through which information technology has enabled the shared use of assets and services, ranging from housing (Airbnb) to small jobs and tasks (TaskRabbit). In this paper, we focus on the sharing of automobiles through carsharing services (Zipcar, car2go) and ride-hailing services (Uber, Lyft), the adoption of these services, and their potential impacts on travel behavior.

Shared Mobility: A Changing Landscape

First, we describe the evolution from ‘traditional carsharing’ programs to ‘ride-hailing’ services, and the distinct features of various shared business models. Traditional carsharing models, such as Zipcar, emerged in the United States in the late 1990s. Through carsharing, individuals or households typically joined a member-based program through which they gained as-needed access to a vehicle that they then drove themselves. Two strategic advantages of early carsharing programs included the following: 1) carsharing vehicles were typically located in accessible locations throughout a dense, urban region; and 2) members were able to borrow the vehicles on a short-term hourly basis *(3)*.

Although traditional carsharing programs have been somewhat popular in major cities and on college campuses, total North American carsharing members in 2014 was estimated to be 1.6 million *(1)*, less than 0.5% of the current U.S. population. Based on these figures, we suggest that traditional carsharing services continue to serve a fairly niche market. However, the initial disruption of carsharing programs has spurred the development of similar programs by rental car companies (Hertz 24/7) and major automakers (Daimler’s car2go in 2008, BMW’s DriveNow in 2011). An interesting new feature of the latter carsharing models is the ability to pick up a car at one location and drop it off at another spot or service area (one-way or free-floating carsharing).

The widespread adoption of smartphones embedded with GPS, combined with the availability of digital road maps through APIs, provided the necessary enabling technologies for ride-hailing services. Uber was one of the first services to emerge in 2010, however several similar companies have also entered (and some departed) this new market in subsequent years (Sidecar, Hailo, Lyft, Didi Kaudi). The common feature of ride-hailing services is the ability for a traveler to request a driver and vehicle through a smartphone app whereby the traveler’s location is provided to the driver through GPS. With the support of GPS technology, digital maps, and routing algorithms, users are provided with real-time information about waiting times. Proponents of these services argue that they provide a more safe, reliable, efficient transportation experience. However, others argue that they essentially operate as illegal taxis. While the regulation of these services continues to evolve, there is agreement on one issue: ride-hailing services have begun to disrupt traditional transportation systems in cities across the globe.

When ride-hailing services were first launched, they were commonly referred to as ‘ridesharing’ or ‘peer-to-peer mobility’ services. Many experts initially argued that this label was a misnomer because drivers and passengers did not share the same destination *(4)*, but rather, the drivers provided services analogous to limousines or taxis. In 2013, a California Public Utilities Commission ruling officially defined these services as transportation network companies (TNCs), although they are still often colloquially referred to as ridesharing, and more recently, ride-hailing services. In 2014, both Uber and Lyft announced the pilot of new products that harness algorithms to match passengers who request service along similar routes in real-time, enabling them to share rides (UberPool, LyftLine). Although the paid drivers of UberPool and LyftLine rides typically do not share the same destinations as their passengers, other business models and apps are emerging in an attempt to enable traditional carpooling – where the driver does indeed share a similar route (Waze's Rider).

While both carsharing services and ride-hailing services both reflect a shift away from vehicles as a product to vehicles as a mobility service, the service models and rates of adoption are quite different, with ride-hailing services attracting a much larger and broader segment of the total population. The remainder of this paper is organized as follows. First, we elaborate on the academic and industry research on shared mobility adoption and their potential impacts. Second, we describe our survey design methodology and data on shared mobility and travel behavior. Third, we present results on shared mobility adoption and travel behavior indicators, including vehicle ownership, driving, and transit use. We conclude with a discussion of this study's results, potential policy implications, and directions for future research. The findings presented here represent one study of a series of evaluations on future urban mobility trends based on these datasets.

LITERATURE REVIEW

This section presents a summary of the academic literature on shared mobility and recent industry figures on the adoption of shared mobility. As noted in a special issue on shared-mobility research in *Transportation* by Le Vine and Polak, the innovation in business models has outpaced the speed at which researchers can converge around a common lexicon *(5)*. Furthermore, we posit that the speed of innovation in mobility *business models*, as well as distinct mobility *products* (uberX, UberPool, UberAssist), presents significant challenges for transportation researchers to develop new data collection methods and methodologies that can effectively measure the potential impacts of these new mobility services on our transportation systems. Hence, in this review we draw on recent industry reports on the adoption and reported use of shared mobility.

Adoption of Carsharing and Ride-Hailing Services

Given the recent emergence of ride-hailing services (Uber, Lyft), the majority of academic studies on shared mobility to date have focused on the adoption and impacts of *carsharing* programs. Some of the earliest carsharing studies date back to 2001, when City CarShare was first launched in San Francisco. Based on surveys of members and non-members three months, nine months, and two years into the program, Cervero reported on the demographics of early adopters *(6) (7) (8)*. Cervero found that carsharing served a fairly distinct and unique market – young, moderate-income, non-traditional households without cars (over three-quarters of the surveyed carshare members had no household vehicles).

Similar studies deployed through carsharing organizations in North America found that members tended to be young, well-educated, and of moderate income levels *(9)*. However, a recent study by Clewlow using regional travel survey data from a representative sample suggests that not only are carsharing members more educated, they often have higher incomes than their non-carshare member counterparts *(10)*. Although global carsharing membership had grown to approximately 5 million user by 2014, after becoming commercially available 15 years ago *(1)*, it continues to represent a somewhat niche market – particularly compared to the rapid, and widespread growth of ride-hailing, which, according to news reports, has reached well over 250 million members globally *(2)*.

The neighborhood characteristics that support carsharing programs are generally similar to those of emerging ride-hailing services. Several studies have identified common factors that contribute to successful carsharing programs, including limited parking, availability of good public transportation, walkability, high density, and mixed-use neighborhoods *(3) (11) (12) (13)*. Numerous theoretical studies found that dynamic ride-sharing models, the core enabling concept of ride-hailing, are more likely to work in cities with high population density, where lead (or wait) times can more easily be reduced for both drivers and passengers *(14) (15)*. As commercial ride-hailing services have expanded, they have initially targeted major, metropolitan cities around the globe.

Due to the competitive market for ride-hailing, there is limited data on the adoption of Uber, Lyft, and other similar services. However, very recently, new reports have emerged which find that ride-hailing users tend to be younger, more educated, have higher incomes, and live in more urban areas *(16)*. Based on this Pew study released in May 2016, one in five urban Americans (21%) had used ride-hailing services. While it may still be early in the adoption of ride-hailing services, it seems clear that the adoption ride-hailing has already far out-paced the growth of traditional carsharing services of the past.

Impacts of Shared Mobility on Travel Behavior

Previous empirical research examining the possible impacts of shared mobility on travel behavior focuses almost entirely on carsharing. Cervero's initial studies indicated that carsharing appeared to induce travel by automobile among early adopters *(6)*. However, subsequent research revealed that as carsharing adoption spread, members were 12% more likely to shed a vehicle, and on average experienced a net reduction in vehicle miles traveled (VMT) *(7)*. Martin and Shaheen found that joining carsharing reduced the number average vehicles per household from 0.55 to 0.29 (a reduction of 0.26 vehicles) *(9)*. More recently, Firnkorn and Muller estimated vehicle reductions of 0.05 to 0.11 *(17)*.

Another dimension of travel behavior explored in previous carsharing studies is the potential impact of carsharing on public transit and non-motorized travel (walking and bicycling). Martin and Shaheen found that there was a slight net decrease in public transit use, and a significant increase in walking, bicycling, and carpooling after individuals joined carsharing *(9)*. However, there were significant variations in travel behavior across the different carsharing organizations whose members were surveyed. Another study by Stillwater et al examined the relationship between carsharing and public transit use, finding ambiguous results *(18)*.

Almost all of the previous studies used before-and-after or retrospective questioning of carsharing members to establish a relationship between carsharing and travel behavior (vehicle holdings, VMT, and transit use). However, a critical issue that has largely been unaddressed is the likely spurious relationship between the built environment, carsharing adoption, and travel behavior. While previous studies have observed that carsharing members tend to own fewer vehicles and drive less after joining carsharing, what is less well understood is the extent to which the observed travel decisions can be attributed to carsharing adoption itself, as opposed to the prior self-selection of individuals into urban neighborhoods that are consistent with their travel preferences. By design, shared vehicle services are generally placed in high-density, transit-accessible neighborhoods where vehicle ownership and vehicle miles traveled (VMT) are known to be lower than average *(19)*. Hence, it is unknown whether the true "effect" of carsharing or ride-hailing (or some portion of the effect) may simply be due to the prior residential and travel preferences of carsharing members. Previous studies control for residential changes *after* joining carsharing *(9)*; however, residential changes immediately *prior* to joining carsharing have not been measured.

In an attempt to control for built environment effects, Clewlow conducted a study comparing the travel behavior indicators of carshare adopters and non-adopters with residential locations in the same U.S. Census tracts using a statistically representative sample *(10)*. Carsharing members living in very dense, urban neighborhoods owned significantly fewer vehicles: 0.58 versus 0.96. However, there was no difference in vehicle holdings among suburban carshare members versus non-members. This recent work suggests that the core neighborhood characteristics that make carsharing successful (limited parking, good transit availability, walkability) may also play a role in previously estimated 'effects' of carsharing on vehicle holdings. As adoption of shared mobility becomes more widespread, continued attention to the relationship between the built environment and travel behavior is critical.

Only very recently have reports emerged that feature the potential travel behavior impacts of ride-hailing services, including an American Public Transportation Association (APTA) report released in March 2016 *(20)* and a Pew Research Center report released May 2016 *(16)*. The APTA analysis found that the more people used shared modes (including carsharing, ride-hailing, and bike-sharing), the more likely they were to use public transit and own fewer vehicles. Similarly, the Pew study found that frequent ride-hailing users were less likely to own a vehicle and more likely to use a range of transit options. The latter acknowledged that this trend carries a significant geographic component – that is, those Americans who live in an urban center are much more likely to have greater access to ride-hailing services, alongside a range of transportation alternatives that allow them to live a car-free (or car-light) lifestyle.

METHODOLOGY

The objectives of this study were to examine the adoption of shared mobility services (carsharing and ride-hailing) in the United States, including the demographics of adopters, reasons for non-adoption and attrition, and potential differences in travel behavior between adopters and non-adopters. An internet-based survey was deployed in major metropolitan regions in the United States, gathering demographic, travel, and residential choice data as described in detail in the sections below.

Survey Design

We developed an extensive self-administered travel and residential choice survey, drawing on questions commonly used in the American Community Survey, regional transportation surveys (e.g., California Household Travel Survey), and previous travel behavior research by the authors. The survey was deployed in two phases, first between September 2014 to March 2015, and second between August 2015 and December 2015. Table 1 summarizes the differences in sampling methodology and question focus between surveys A and B.

The surveys were comprised of five sections organized as follows: 1) attitudes towards travel, neighborhoods, technology, and environment; 2) household demographics, 3) current and previous residential decisions, 4) travel behavior including use of shared mobility services, and 5) vehicle ownership and preferences. In survey B, a section on life stage events was added. A broader objective of the survey design and deployment was to gather extensive data on urban populations' current, past, and potential future travel, residential, and vehicle ownership choices.

TABLE 1 Overview of survey deployment

	Survey A	Survey B
Dates administered	September 2014 – March 2015	August 2015 – December 2015
Survey question focus	1) attitudes towards travel, neighborhoods, technology, and environment; 2) household demographics; 3) current and previous residential decisions; 4) travel behavior including use of shared mobility services, with a focus on traditional carsharing; and 5) vehicle ownership and preferences	In addition to the focus areas in survey A, survey B covers life stage events
Metropolitan areas sampled	Boston, Chicago, New York, Seattle, and Washington, D.C	Boston, Chicago, New York, Washington, D.C., San Francisco, and Los Angeles
Sampling method	Urban and transit-oriented suburban zip codes were targeted; oversampling of carsharing members based on a targeted zip code list located in neighborhoods with a significant presence of carsharing vehicles, as well as a specified quota	Stratified sampling of urban and suburban neighborhoods in major metropolitan regions based on the population distribution across population density quartiles

Sampling

We selected seven major metropolitan areas in the United States for our survey: Boston, Chicago, Los Angeles, New York, San Francisco/ Bay Area, Seattle, and Washington, D.C. Due to constraints in survey deployment, the San Francisco Bay Area and Los Angeles regions were excluded from survey A, but included in survey B.

Using data from the 2011-2013 American Community Survey (ACS) 3-Year Statistics, we screened potential neighborhoods to vary systematically on population density and housing density. For survey A, we also utilized data from Zipcar's website to oversample zip codes with the availability of carsharing vehicles. Specific quotas for the number of respondents from urban neighborhoods, suburban neighborhoods, and carsharing members (for survey A) were provided to a commercial sampling firm through which we purchased responses. Based on the 2011-2013 ACS, the age and income distributions of survey respondents were also constrained to match the reported distributions of each metropolitan region sampled.

We built our survey on an internet-based survey platform that enabled complex survey logic and branching. The survey was pre-tested on faculty and researchers with expertise in travel survey design, transportation modeling, and shared mobility, as well as a snowball sample of the general population. Through the sampling firm employed for this study, the survey was pre-tested on 50 respondents from five metropolitan regions. Between each pre-test, the survey was refined based on expert feedback, general feedback, and analysis of the survey data.

The survey was administered by the sampling firm using a targeted email approach to adult respondents (18 and older) pre-identified as residing within the major metropolitan zip codes selected for this study. The sampling firm incentivizes members based on "completed" responses by providing gift cards from online shopping firms like Amazon. To identify "bad" responses, we included a number of tests and filtering criteria. Validity questions to prevent robo-responses were included at different stages of the survey. In order to identify false, albeit completed responses, we added filtering questions to the survey (e.g., non-existent zip codes were included to reject respondents who likely did not actually reside within the target cities). Two additional quality checks were used – zero variation in responses to the attitudinal questions, and nonsensical responses in free text inputs (e.g. vehicle make/model, residential address, and school/workplace address). We excluded survey responses that failed in at least two of the filtering criteria listed above.

A total of 4,094 completed responses were collected, with 2217 from respondents residing in dense, urban neighborhoods and 1877 from more suburban locations. By design, the responses were evenly distributed between the five metropolitan regions, Boston, Chicago, New York, Seattle, and Washington, D.C. for survey A, and with an oversampling of respondents for the San Francisco and Los Angeles regions for survey B.

RESEARCH RESULTS

In this section, we present key findings from the survey data including an analysis of shared mobility adoption and potential impacts on travel behavior. First, we provide an overview of the demographics of the survey respondents and shared mobility adoption. Second, we examine the personal vehicle use and transit use of shared mobility adopters. Third, we compare differences in mode choices for various activities between shared mobility adopters and non-adopters.

Adoption of Shared Mobility Services

There are 2098 completed responses from survey A (60% urban) and 1966 completed responses from survey B (47% urban). The demographic distributions of the survey respondents, including a breakdown of ride-hailing adoption, are presented in Table 2. As mentioned in the previous section, survey A purposefully oversampled carsharing members, and thus ride-hailing adoption results are only presented for the respondents of survey B, for which sampling was designed to be representative of the general population in metropolitan regions.

Based on the results of survey B, we find that 92% of total respondents had heard of ride-hailing services and 29% had used ride-hailing services. We note that this adoption figure is slightly higher than that found in a recent Pew study (where 21% of urban Americans had used ride-hailing) *(16)*; a significant difference between our sampling method and theirs is that we focused specifically on the seven major cities listed above, which included a larger portion of what one might consider "early adopter" cities. The demographic results presented in Table 2 suggest that ride-hailing service adopters tend to be younger and more highly educated than the general population. The average age of the non-adopter sample population (no ride-hailing use) is 50.5, as compared with the average age of ride-hailing users (37.0). Shared mobility adopters are also significantly more likely to be employed, as compared with their non-adopter counterparts; however, differences in age distributions may partially explain differences in employment status.

TABLE 2 Demographic Distributions by Shared Mobility Service

Demographic Attribute	Total	Non-shared mobility users	Ride-hailing users*	Carsharing members	Supersharers
Age	N = 4,094	N = 2741	N = 911	N = 784	N = 237
18 to 29	16%	9%	34%	26%	36%
30 to 49	38%	33%	47%	49%	59%
50 to 64	27%	31%	14%	18%	5%
65 and older	19%	25%	5%	6%	0%
Household income					
$24,999 or less	7%	8%	6%	5%	5%
$25,000 to $74,999	31%	31%	32%	30%	33%
$75,000 to $149,999	36%	35%	35%	39%	38%
$150,000 to $199,999	9%	9%	10%	10%	10%
$200,000 and $300,000	6%	6%	7%	7%	5%
$300,000 and over	7%	7%	8%	8%	8%
Decline to state	3%	4%	2%	1%	2%
Education level					
HS graduate or less	7%	8%	4%	4%	1%
Some college	15%	18%	10%	9%	6%
Assoc. degree	6%	7%	4%	3%	1%
Bachelor's degree	39%	36%	45%	41%	42%
Master's degree or higher	34%	31%	38%	44%	49%
Employment					
Employed full-time	52%	44%	70%	71%	81%
Employed part-time	9%	9%	7%	7%	3%
Self-employed	8%	8%	7%	7%	5%
Out of work	4%	5%	3%	2%	2%
Homemaker/ caregiver	5%	6%	2%	2%	1%
Student	4%	3%	6%	5%	7%
Retired	17%	23%	4%	5%	2%

* Due to the oversampling of carsharing adopters in survey A, adoption of ride-hailing is only presented for survey B respondents. The sampling procedures for survey B were designed to collect a representative sample of the general population in metropolitan areas.

Adoption of Ride-Hailing Amongst Urban and Suburban Americans

Similar to carsharing business models, ride-hailing services tend to be offered primarily in more urban neighborhoods, where higher population density enables higher frequency of use and utilization rates of vehicles. In Figure 1, we present the adoption rate of ride-hailing services, segmented by demographics, as well as by residential neighborhood type. Not surprisingly, we found that 29% of urban Americans had used ride-hailing services, as compared with 13% of those living in suburban neighborhoods.

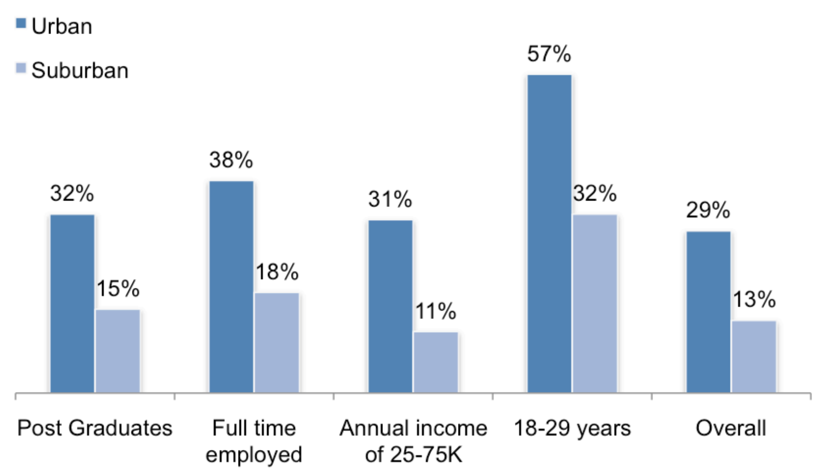

FIGURE 1 Ride-hailing adoption by demographics and geography.

Restricting our sample to survey B, we found that the vast majority of respondents in metropolitan areas had heard of these services: 93% of urban respondents and 91% of suburban respondents. However, both use and awareness of these services varied significantly by age, education, and income. While 45% of 18-29 year-olds had installed a ridesharing app and used these services, only 27% of 30-49 year-olds and 10% of respondents above 50 years had used these services. Considering income – among the lowest annual household income category of $25,000 or less, we observed an adoption rate of 16%. The figure rises monotonically to 27% among those with annual income of $150,000-200,000 and 31% among those with higher than $200,000.

Reasons for Ride-Hailing Use

Survey respondents were asked to select the top reason that they might use ride-hailing services instead of driving themselves (see Figure 2). Among both urban and suburban respondents, we found that the top reason adopters cited that they use these services is to avoid drinking under the influence. Uber itself and Mothers Against Drunk Driving (MADD) jointly released a study in 2015 that demonstrated that drunk-driving crashes fell among drivers under the age of 30 in markets where Uber operates following the launch of their uberX service *(21)*. Similarly, another study found that drunk driving deaths fell by 3.6-5.6% following the availability of Uber in California markets *(22)*. Based on the results of this survey, our findings do suggest that avoiding drunk driving is a strong reason for adopters to use these services.

Difficulties and the price of parking were cited as the second and third most common reasons that adopters use ride-hailing services instead of driving themselves. 23% of respondents in urban regions identified either the expense or difficulty associated with parking as the top reason they prefer to use ride-hailing. As a combined factor, parking represents the number one reason that urban ride-hailing users substitute a ride-hailing service in place of driving themselves.

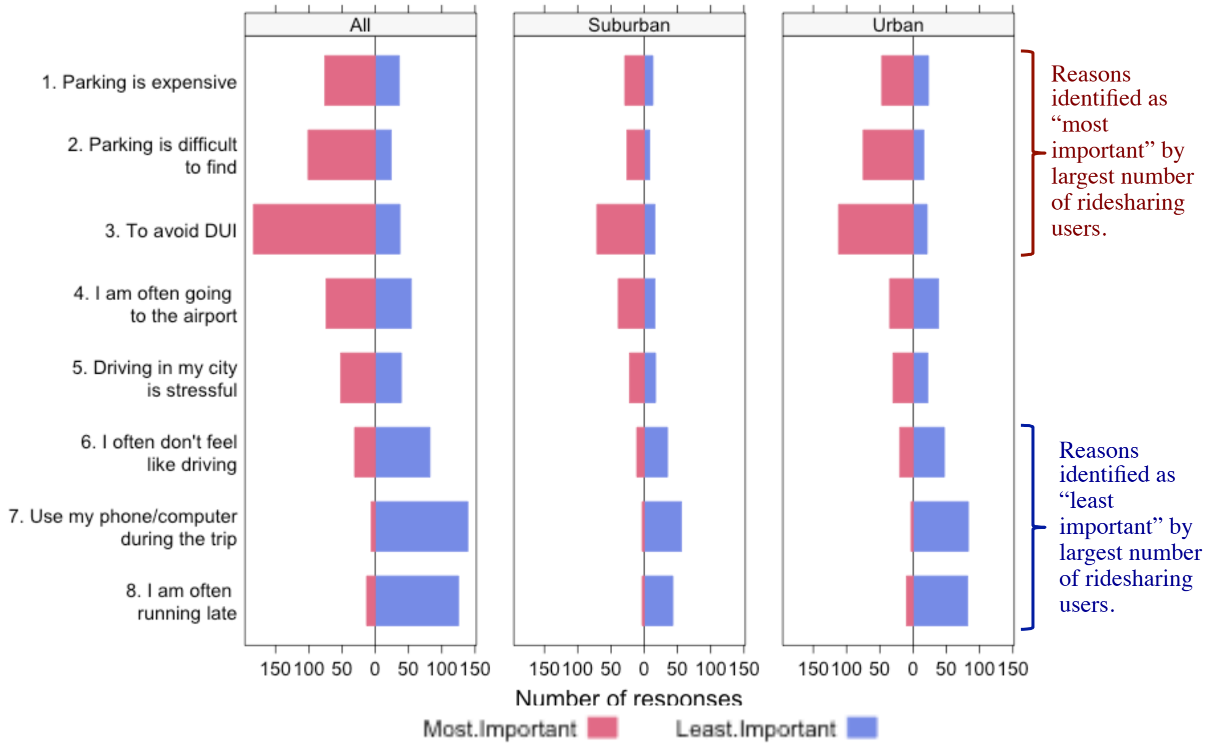

FIGURE 2 Reasons for using ride-hailing services instead of driving oneself.
Notes: (a) Results based on survey B only; (b) Survey question: What would you consider the most important versus least important reason you use on-demand mobility services such as Uber or Lyft instead of driving yourself? ; (c) Only ride-hailing adopters shown in graph.

Vehicle Ownership and Driving Habits of Ride-Hailing Adopters

Vehicle Ownership among Shared Mobility Adopters

Previous studies on shared mobility (primarily focused on carsharing) find that those who adopt shared services tend to have lower rates of household vehicle ownership, although it is unclear to what extent the built environment and self-selection play a role. In Figure 3, we present household vehicle ownership rates among ride-hailing-only users, transit-only users, "supersharers" – a term recently coined by an APTA report to includes those who use a combination of shared services, and those who use none of these services *(20)*. The supersharers below include survey respondents who indicated that they use public transit, ride-hailing, and carsharing services.

Contrary to the recent APTA report on shared mobility, we find that although so-called supersharers have lower vehicle ownership rates than the non-sharing population, on average they have higher vehicle ownership rates as compared to transit-only users. This applies to both those sampled in urban as well as suburban regions. However, unsurprisingly, we also find that the more significant differences in vehicle ownership rates are between urban and suburban adopters of these services.

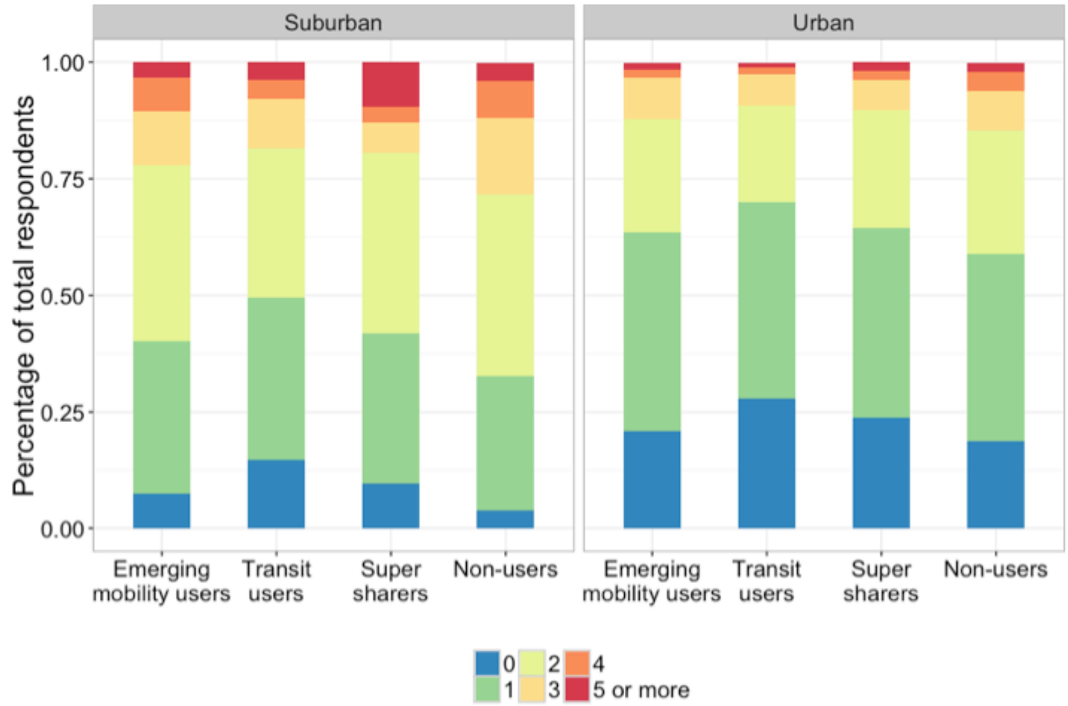

FIGURE 3 Household vehicles by residential neighborhood and shared mobility adoption.

Potential Driving and Vehicle Reductions

Two important questions facing policymakers are whether the adoption of ride-hailing services can reduce vehicle ownership and total vehicle miles traveled (VMT). When asked whether they had made any decisions to get rid of a vehicle, the vast majority of ride-hailing respondents (91%) had made no changes in their vehicle ownership, with 16% indicating that they had no vehicle to begin with. However, 9% respondents indicated that they had made a decision to dispose of one or more household vehicles, and this trend in vehicle shedding increased with ride-hailing use. That is, the more frequently an adopter used ride-hailing services, the more likely they were to have shed a vehicle (see Figure 4). Similarly, while the vast majority of individuals (62%) indicated that there was no change in their personal driving habits, there was a strong correlation between increased frequency of ride-hailing use and reported reduction in personal driving (see Figure 5).

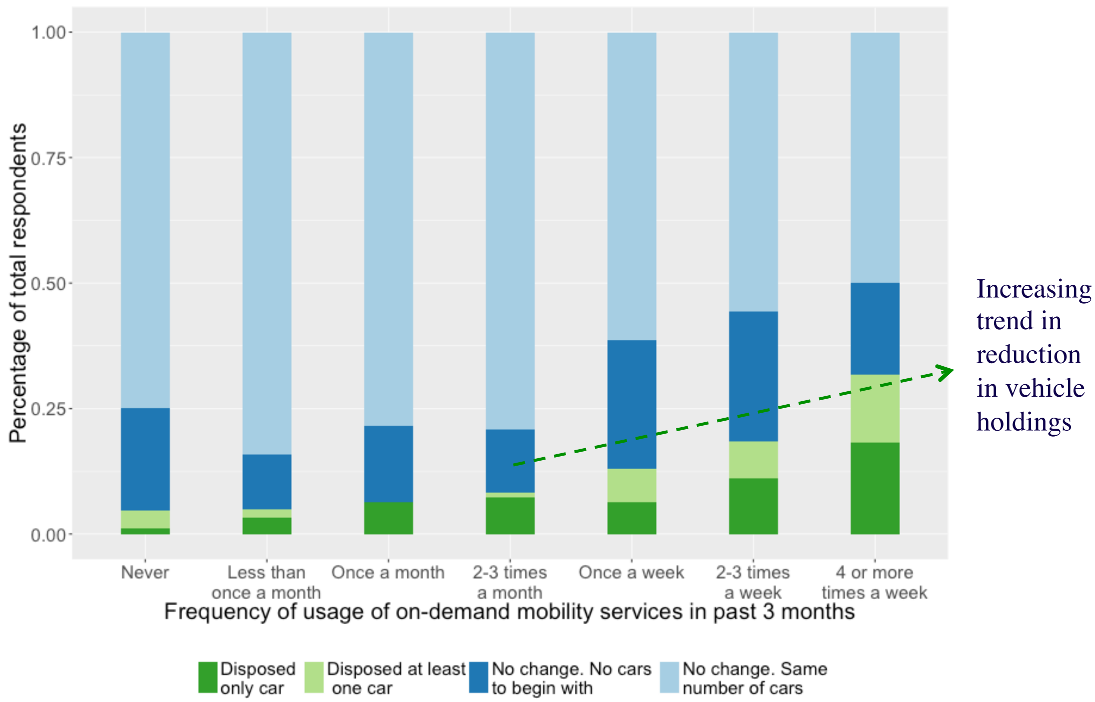

FIGURE 4 Changes in vehicle holdings by frequency of ride-hailing use.
Notes: (a) Results based on survey B only; (b) Survey question: Since you started using on-demand services like Uber or Lyft, have you reduced the number of vehicles that you own or lease? (c) Only ride-hailing adopters shown in graph.

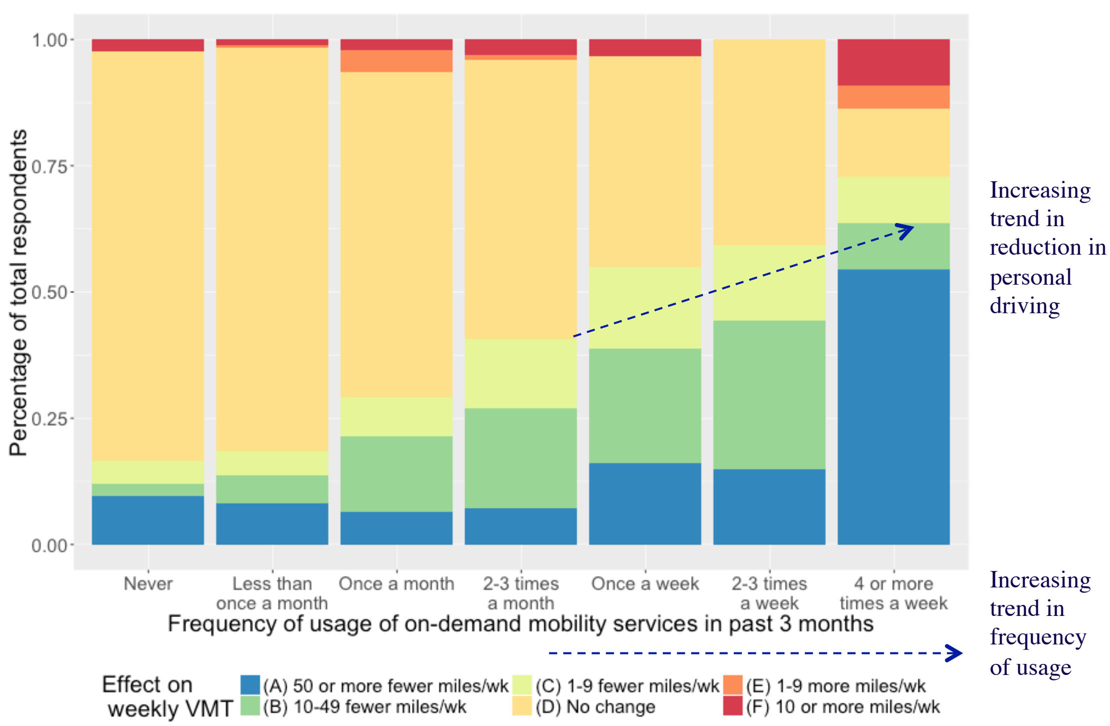

FIGURE 5 Change in vehicle miles traveled (VMT) based on frequency of ride-hailing use.
Notes: (a) Results based on survey B only; (b) Survey question: During the past three months, on average how often have you used the following mobility services? (c) Only ride-hailing adopters shown in graph

Based the survey results (Figure 5), 26% of individuals indicated that they reduced their driving by 10 or more miles per week since they started using these services. Given that these adopters also use ride-hailing services quite frequently, their net change in VMT must account for both the total reduction in personal driving plus their VMT increase in a shared vehicle service.

Transit Use and Alternative Modes of Ride-Hailing Adopters

Another important policy question that these results address is the extent to which ride-hailing complements or substitutes for public transit services. Survey respondents were asked whether they use various transit services more or less after they began using ride-hailing services (see Figure 6). Similar to the results on vehicle ownership, there were notable differences in results depending on whether a respondent lived in a primarily urban or a suburban neighborhood.

The vast majority of respondents indicated that there was no change in their transit use. Based on the results of those who did change their behavior, we find that shared mobility may attract urban Americans away from bus services, and serve as a complementary mode for commuter rail. Among urban respondents, 19% indicated that they rode the bus less after using ride-hailing, while only 11% indicated that they rode the bus more. Among suburban respondents, 16% rode commuter rail more after they began using ride-hailing services, while 7% rode commuter rail less.

As compared with previous studies that have suggested shared mobility services complement transit services, we find that based on the demographics of the respondent, availability of transit services, and type of transit service in question, the substitutive versus complementary nature of ride-hailing services is likely to vary. In the survey, we further explored why individuals might use ride-hailing instead of public transit services. Results are highlighted in Figure 7.

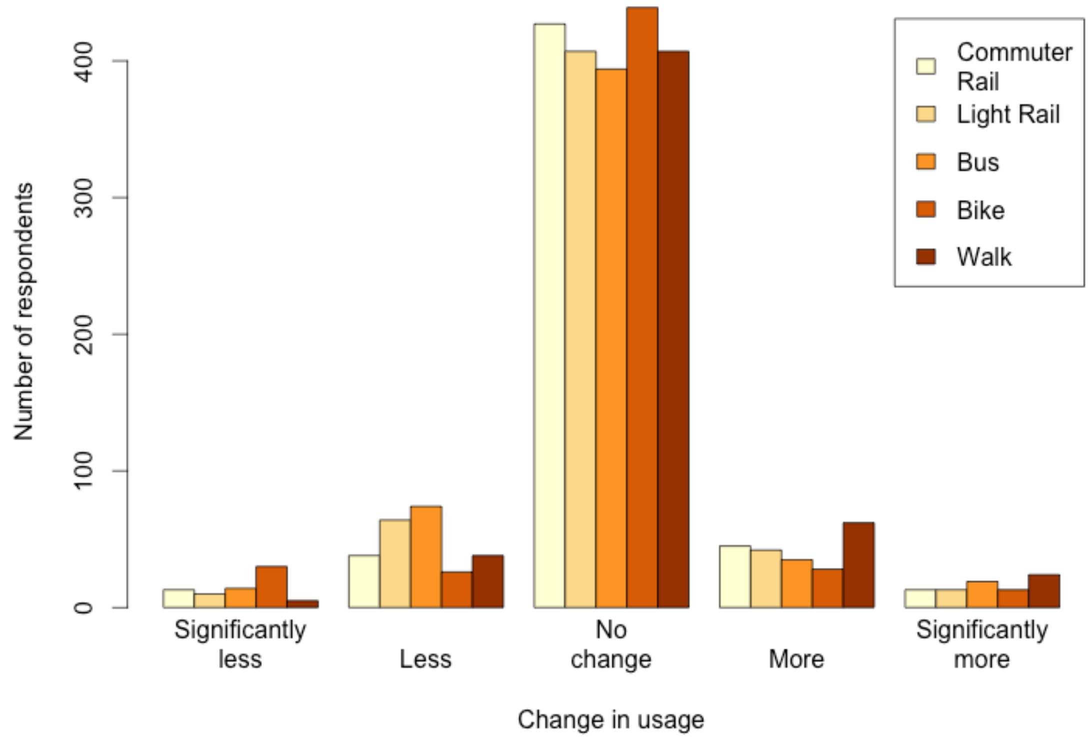

FIGURE 6 Changes in transit use after adoption of ride-hailing services
Notes: (a) Results based on survey B only; (b) Survey question: *Since you started using on-demand mobility services such as Uber and Lyft, do you find that you use the following transportation options more or less?* (c) Only ride-hailing adopters shown in graph

When asked explicitly why one might substitute ride-hailing for public transit, suburban respondents cited that the most important reason was that there were not "enough stops/ stations" to meet their transportation needs, while urban respondents cited that "services are too slow" (see Figure 7). Two other top reasons that urban respondents might substitute ride-hailing for public transit included the lack of availability and infrequency of transit service, as well as the unreliability of transit service. A critical policy question is whether and how on-demand ride-hailing can serve as a complementary mode (e.g. for first- and last-mile solutions) and/ or a substitute for transit services (e.g. where fixed-route services are impractical or unreliable).

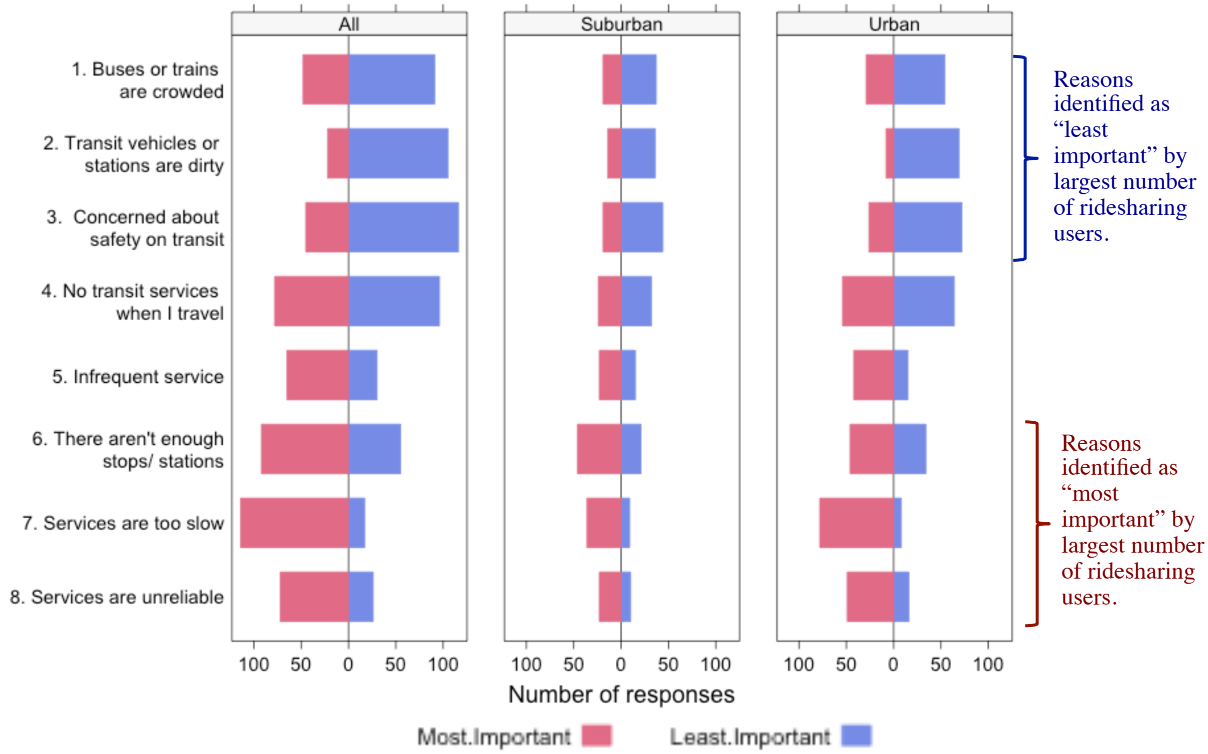

FIGURE 7 Reasons for substituting ride-hailing for transit services

Notes: (a) Results based on survey B only; (b) Survey question: What would you consider the most important versus least important reason you use on-demand mobility services such as Uber or Lyft instead of public transit? ; (c) Only ride-hailing adopters

CONCLUSIONS

By collecting data through a representative panel in seven major U.S. metropolitan areas, this study presents initial evidence on the adoption and use of shared mobility services, including carsharing and ride-hailing, and their potential impacts on travel behavior. As anticipated, we find that ride-hailing adopters tend to be younger, more educated, have higher incomes, and live in more densely populated urban areas than the rest of the population. Similar to previous studies produced by ride-hailing companies themselves, we find that avoiding driving under the influence of alcohol is a top reason for using ride-hailing instead driving oneself. The other top reason that adopters use these services over driving themselves is to avoid the costs and pain of parking.

Although we also find that ride-hailing adopters have lower levels of vehicle ownership than non-adopters, contrary to recent work on this topic, we find that so-called "supersharers" (those who use ride-hailing, carsharing, and public transit) and ride-hailing users own more vehicles than individuals who only use public transit. However, in this early study, we do find evidence that the adoption of ride-hailing may lead to a car-free lifestyle: 9% of respondents indicated that they had disposed of a vehicle since using these services, and 26% of individuals reported having reduced their driving by 10 or more miles per week. The reported a reduction in personal driving is highly correlated with reported frequency of ride-hailing use. Hence, the question of whether vehicle miles traveled will increase or decrease with these services is an open question, as the net effect of driving oneself (versus being driven in a vehicle) is uncertain.

Furthermore, it is unclear how these services fit into long-range lifecycle decisions (residential location) that also have strong linkages to travel behavior.

Finally, we find mixed evidence of the complementary versus substitutive nature of ride-hailing services and transit use. The vast majority of individuals report no change in their transit behavior. However, given individuals who did report a change, a significantly larger portion reported a reduction in their use of bus services, and a significantly larger portion reported an increase in their use of commuter rail. When asked further about why they might substitute ride-hailing for transit services, respondents cited limited stops/ stations, slow service, and lack of reliability as the primary reasons for using ride-hailing. As ride-hailing adoption continues to grow in popularity, new models for the provision of transit services in urban and suburban areas should be explored. This analysis of this early data suggests that the substitutive versus complementary nature of ride-hailing for public transit will be highly dependent on geography (urban/ suburban), as well as the prevalence and quality of existing transit services.

Given the rapid growth of shared mobility services in cities around the world, it is critical to begin collecting data on their potential impacts on travel behavior, including vehicle ownership, vehicle miles traveled, and mode shares. While future research harnessing user data from ride-hailing service providers and transportation service providers may shed light on utilization, demographics, and miles traveled, the more complex decisions that individuals and households make over time may require continued data collection efforts through traditional research methods (e.g., focus groups and representative surveys).

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