

# Technical Appendix 7

## Information and Communications Technology

### in Support of Chapter 7

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## INTRODUCTION AND STRUCTURE

Technical Appendix 7 is divided into four main themes. Part One presents the empirical facts about who owns connected mobile devices and how they use them, including attitudes toward current communications devices. Part Two explores attitudes towards the importance of being connected and being productive during travel. Part Three looks at current attitudes and use of new services enabled by technology, such the services of Transportation Network Companies (TNC), like Uber and Lyft. Part Four explores various concepts about future roles for new services that might influence the future of transit markets, based on the results of the 2016 Project survey. In general, this Technical Appendix follows the logic of Chapter 7 of *TCRP Research Report 201*, but contains more information than the chapter, which was constrained by space and need for brevity.

## INTRODUCTION

In this study, the amount one values being ‘connected,’ being able to obtain real-time travel information, and the desire to be productive while in transit have been shown to influence travel choices.

More than 80% of our 2016 sample owns a smartphone. People used their smartphones to navigate, socialize, chat, and obtain news. Younger people used their phones more intensely and for a wider variety of purposes than older people. Over a third of market segments identified as ‘Urban commuters’ used their phones to help navigate transit or get transit directions. The phones are less used to obtain real-time transit information, and fewer young people use their devices for transit navigation than in the 2014 TransitCenter survey.

The use of smartphones to engage in activities like reading or texting that are illegal while driving may favor transit use. More evidence supports the hypothesis that “the growing dependence on personal electronic devices appears to have altered the perceived ‘disutility’ of spending time” in travel (Schwieterman *et al.* 2015). The data collected in the Project Survey adds support to this point of view.

While everyone in the sample was positive about staying connected, younger people in the Project Survey attached greater importance to being connected and being productive while traveling than older people. In fact, they would rather go without a personal vehicle than without a mobile device.

But, as the analysis will show, staying ‘connected’ means different things to different types of people, depending on age, life stage, and attitudes. In addition, we see that every market segment spends considerable amounts of their free time on the internet—but they do not all agree about how this may change their travel.

Younger groups were far more likely to say that the chance to be productive affects their choice of how they travel. As a result, in each category that we asked about the value of staying connected, being productive, or being able to multitask, respondents who felt that those were

important were more likely to take transit than those who replied that these factors were unimportant.

Over the last decade, the means of travel have become more varied. People in urban areas depend on TNCs like Uber/Lyft, car-sharing services, bike share, and other means for both work trips and other trips. This shift seems to enable selecting the means of travel based on daily circumstances rather than habit. It also may be the reason for the rise in occasional transit users, which is a growing market for transit (as noted in previous research from this team).

The Project Survey finds that younger people are more likely to use these new travel options, and to use them more often. Although trips using TNCs for non-work purposes were reported across all age groups, Millennials also reported using TNCs for commuting. Overall, the car ownership rate for people with access to car-share programs was about half of those without such access.

Looking forward, Millennials seem to be embracing technology and the changes in travel behavior. TNCs and share programs/services that offer options for multimodal travel are growing at unusual rates—fueled by younger travelers. And looking farther out, younger people tend to imagine a world where autonomous cars would replace transit, while older respondents do not. The future belongs to the young, and this Technical Appendix concludes with some thoughts about the future role of transit in the transportation ecosystem.

Roles in the future?

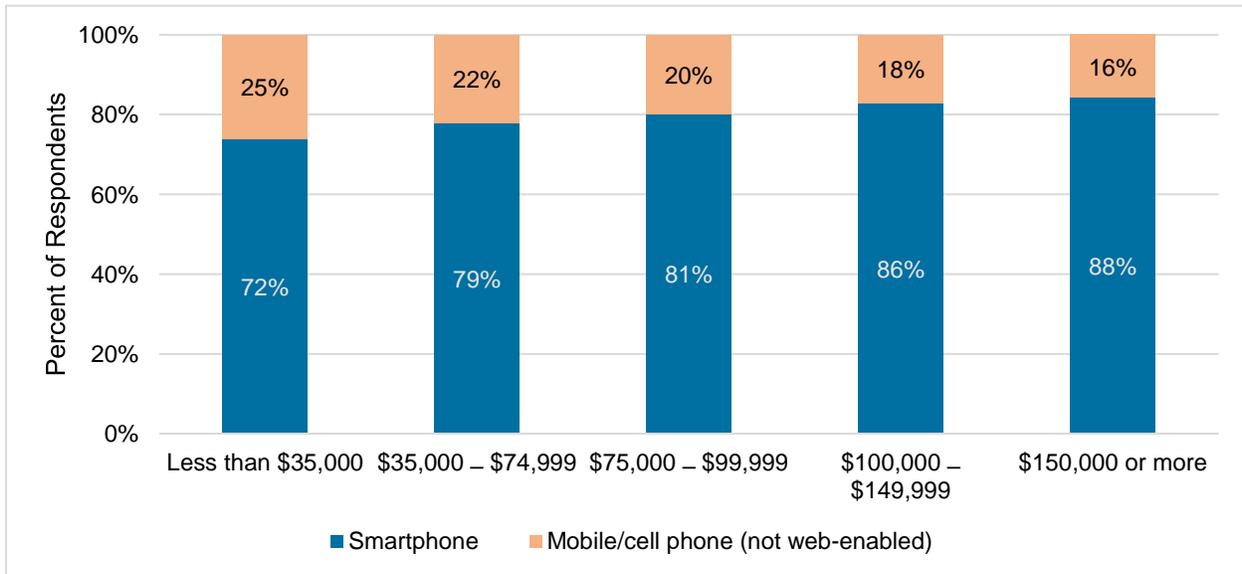
Information and Communications Technology (ICT) could affect the future market for public transportation in at least five functional areas.

1. By making the task of planning and undertaking an automobile trip easier and more efficient (e.g., with GPS navigation)
2. By making the task of planning and undertaking a public transit trips easier and more dependable (e.g. with real-time information, a role in its nascent phase in the US)
3. By influencing the decision to own a private vehicle by facilitating convenient car-share services (e.g. Zipcar)
4. By enabling a new generation of publicly available shared-ride services, whose evolution will either be integrated into packages of public mode services, or be seen as a threat to established fixed route and scheduled transit operations, or some of each
5. By disrupting current transportation paradigms with autonomous vehicles

## **PART ONE: OWNERSHIP AND USE OF CONNECTED DEVICES**

Income and age are the key factors that influence the ownership of smart devices. Overall in the project survey, 81% of the respondents said they owned a smartphone, while 20% owned a cell phone that was not web-enabled (there were a few who reported both, but virtually none reported

not owning either). The distribution by income is shown in Figure 1. Seventy-two percent of even the lowest income group—people making less than \$35,000—had a smartphone.



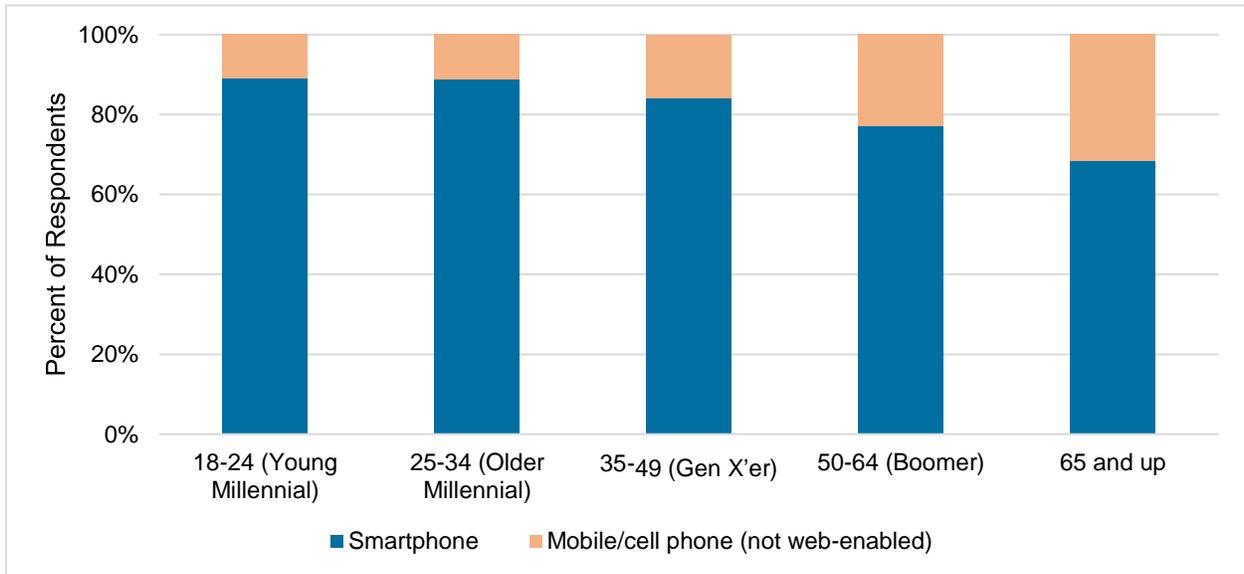
**FIGURE 1. SMARTPHONE OWNERSHIP, BY INCOME**

Source: 2016 Project Survey

While there was more divergence between income groups for tablets, landlines, and navigation devices, it is important to note that any expected “digital divide” *based on income* may be not be a major issue at this point; other ‘divides’ may be based on willingness to accept change, and location in rural areas.

According to recent Pew research (Raine 2017), 77% of all Americans have a smartphone—64% of those with incomes less than \$30K and 90% or more of those with incomes greater than \$75K. And whites, African-Americans, and Hispanics have similar rates of smartphone ownership—although minorities are more likely to use their smartphone to access to the internet (meaning they are less likely to have broadband at home).

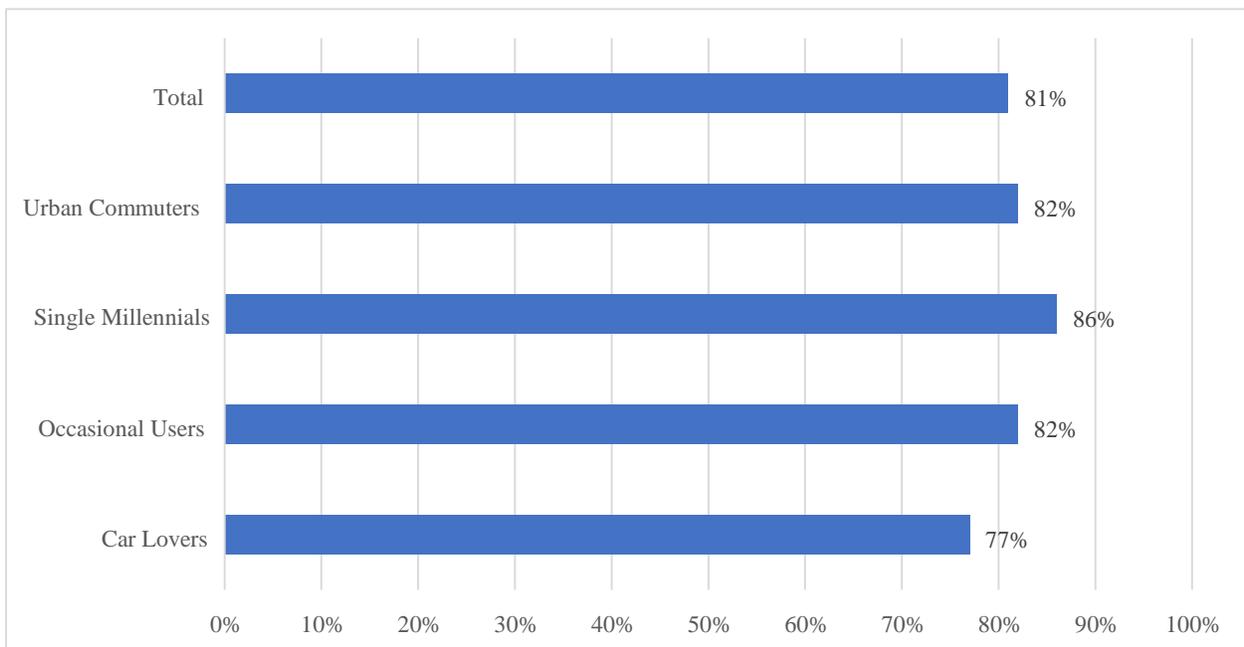
However, the same research indicates the people who were least likely to own a smartphone were older, rural, and poor. Over 90% of urban Millennials reported owning a smartphone in the Pew research. The Project Survey found similar distributions across age groups (Figure 2). Over 90% of the respondents 18-34 years old (the two youngest age groups) reported owning a smartphone.



**FIGURE 2. SMARTPHONE OWNERSHIP, BY AGE GROUP**

Source: 2016 Project Survey

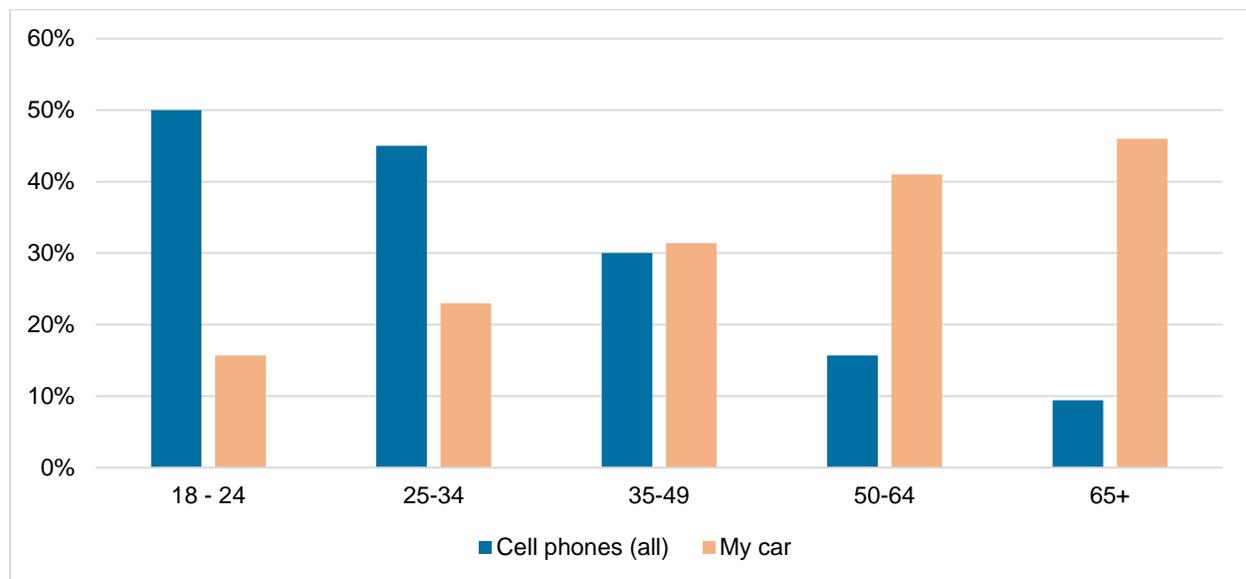
Looking at the project’s four market segments, the ownership of smartphones is highest for ‘Single Millennials’ as shown in Figure 3 with 86% owning a smartphone, in comparison to ‘Car lovers,’ of whom 77% owned a smartphone.



**FIGURE 3. SMARTPHONE OWNERSHIP (E.G., IOS OR ANDROID), BY MARKET SEGMENT**

Source: 2016 Project Survey

In the TransitCenter survey (2014) we asked our respondents what “device” would be most difficult to live without, with a broad definition of “device” to include not only one’s television, but also one’s car. The results show powerfully the effect of increasing age on personal priorities about staying connected. While fully half (50%) of those between 18-24 say the hardest device to live without is their phone, less than 10% of those over 65 say the same thing. The importance of the private auto has an almost inverse ratio with increasing age, with more than 45% of those over 65 stating it would be the hardest device to live without (Figure 4). Gender is also an important factor in attitudes about mobile technology with women placing a somewhat higher value on connected devices than men in every age category, as examined in the following section of this Appendix.

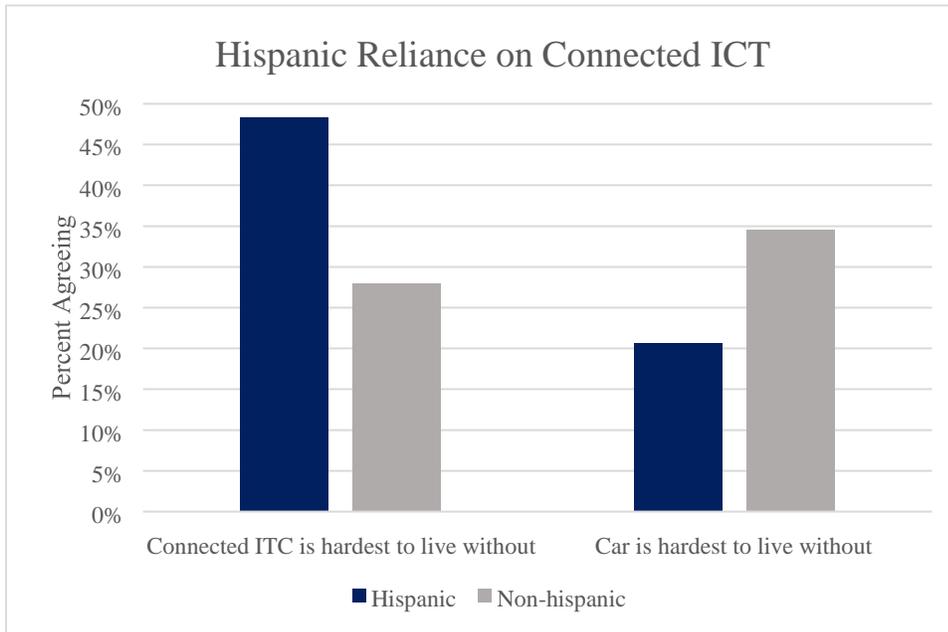


**FIGURE 4. MOST DIFFICULT TO LIVE WITHOUT-- CELL PHONE VS. CAR, BY AGE**

Source: TransitCenter 2014

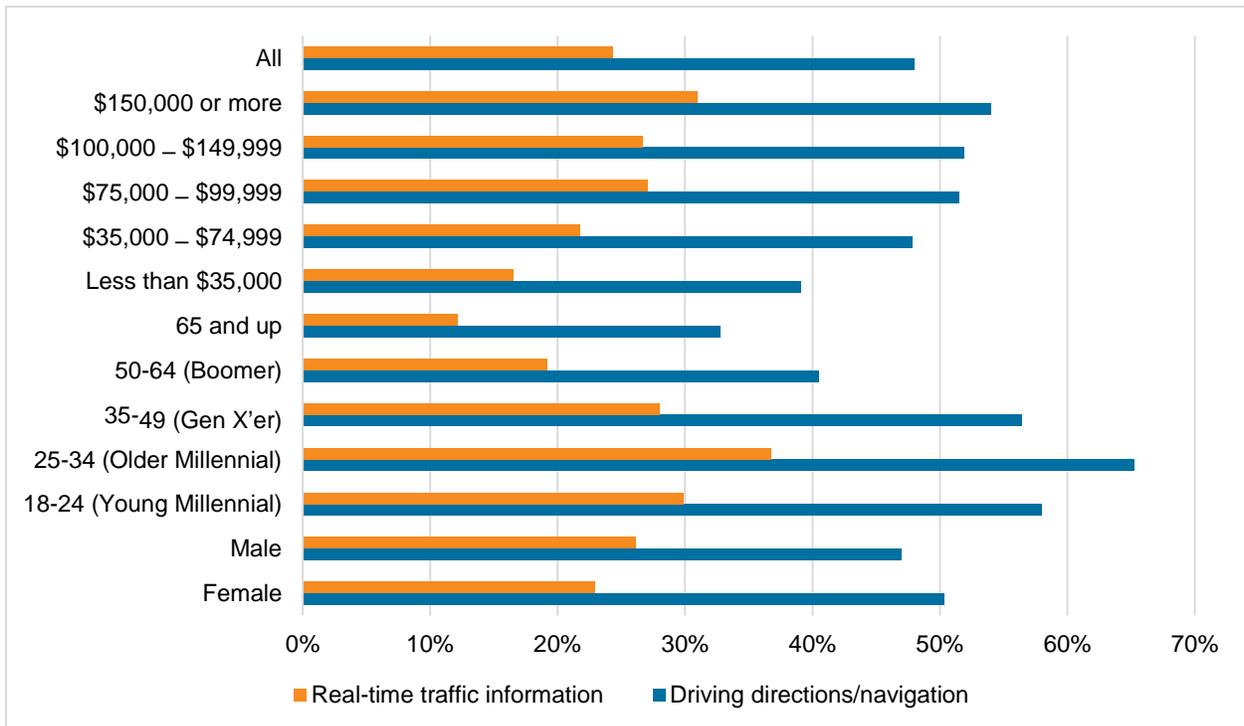
The importance of mobile technology varies significantly with other demographic factors, notably with Hispanic status, as shown in Figure 5.

Half of the Project Survey sample used a connected device to help with driving directions and a quarter to obtain real-time traffic information within the last week, as shown in Figure 6. A clear relationship exists between income and age—younger people were more likely than older people to use their device for information and navigation for auto travel, and individuals with higher incomes were more likely than individuals with lower incomes to use their device for assistance in auto travel.



**FIGURE 5. IMPORTANCE OF CONNECTED PORTABLE DEVICE, BY HISPANIC STATUS**

Source: TransitCenter, 2014



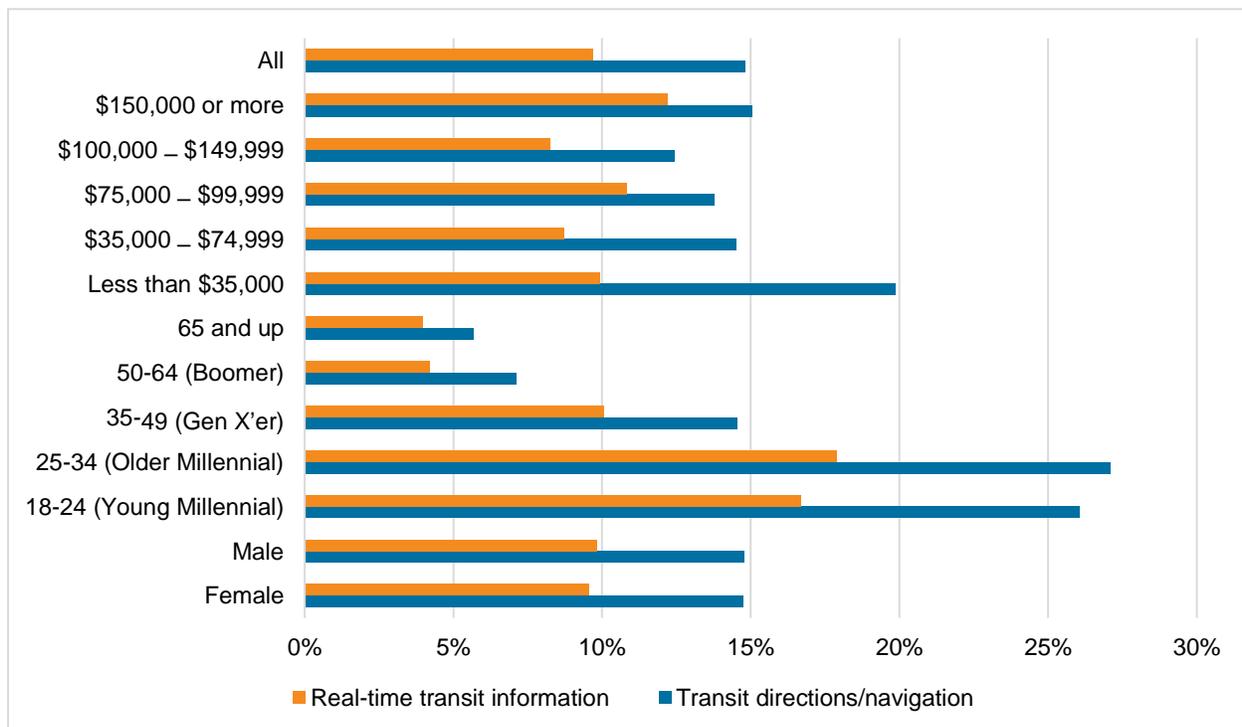
**FIGURE 6. DEVICE USE FOR DRIVING ASSISTANCE, BY AGE, INCOME, AND GENDER**

Source: 2016 Project Survey

Similarly, Figure 7 shows how the use of a connected device to assist with transit travel varies by age, income, and gender. Importantly, these devices reduce the burden of trip planning and uncertainty associated with the trip (one of the traditional ‘costs’ of travel). The efficacy provided via smartphone can be significant—one knows where to wait, which bus to board, how long the trip will take, and even some reviews of the cleanliness/friendliness of the driver and patrons. The Smartphone also removes barriers to transit use, such as the fear of getting on the wrong bus and ending up lost. And there is the added efficiency of knowing which route (e.g., subway or bus) has the fastest travel time in real-time. These advantages could encourage greater transit use.

Overall in the Project Survey, 15% of the respondents used a device to navigate transit or obtain real-time transit information in the last week. Younger people and individuals with lower incomes are more likely to use a connected device for assistance in navigating transit travel.

It should be noted that the percent of the sample using a device for auto directions is about the same as in the TransitCenter survey (2014), but there were changes in the percent of people by age using a device for transit directions. For the youngest age group, the percentage was considerably less in the most recent survey--in 2014 we found about 36% of 18- to 24-year-old respondents reported getting transit information from their device, but in the most recent survey only 26% of the youngest people said the same. However, for the 25- to 34-year-old respondents the percent stayed about the same.



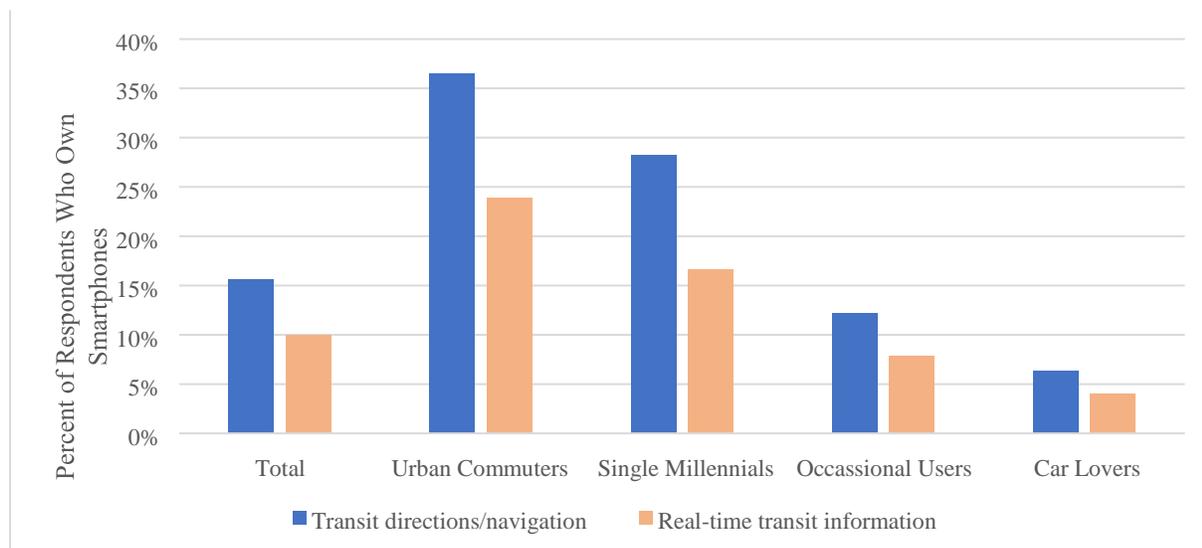
**FIGURE 7. DEVICE USE FOR TRANSIT ASSISTANCE BY AGE, INCOME, AND GENDER**

Source: 2016 Project Survey

Just looking at the people who reported owning a smartphone, 16% used a smartphone for transit directions in the last week, and 10% obtained real-time transit information (shown in Figure 8). However, over twice that average--36% of 'Urban Commuters'--used their smartphones in the last week to navigate transit, compared to a negligible percent of 'Car lovers.'

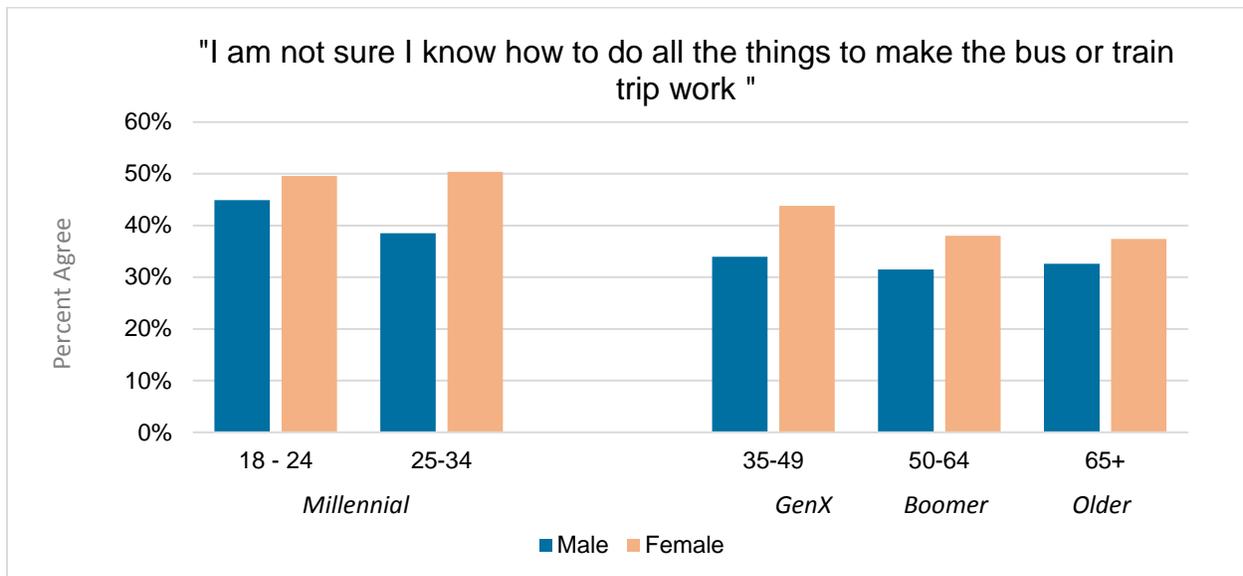
#### *Getting Transit Information to the Transit Rider*

ICT will improve the ability of traditional transit providers to give minute by minute directions to transit users, who are often involved in multi-segment and multimodal trips. In general, people are quite willing to admit that they simply do not know how to use public transportation. This sentiment is explored in Figure 9 where women and Millennials are more likely to report uncertainty with public transportation. About half of women under the age of 35 and 40% of women between the ages of 35 and 49 agree with the statement, "I am not sure I know how to do all the things to make the bus or train trip work." These troubling findings are critically important for the transit industry. Embracing provision of data to enable mobile apps could be a key way to overcome the barriers that a large percentage of people, especially young adults and women, face in how to get from here to there on local transit.



**FIGURE 8. % OF MARKET SEGMENTS WHO USE THEIR SMARTPHONE FOR TRANSIT TRAVEL ASSISTANCE**

Source: 2016 Project Survey



**Figure 9. VARIATION IN BELIEF THAT MORE INFORMATION IS NEEDED FOR METROPOLITAN TRIPS**

Source: TransitCenter, 2014

### Summary

The 2016 project sample was highly ‘connected’—over 80% of respondents had a smartphone (compared to 77% nationwide, according to Pew). About 15% of the sample obtained transit directions on their smart devices—and for the youngest age group that was a decline of about 10 percentage points from 2014. Making transit information available in real-time on smartphones apps may be a critical step in keeping transit competitive in the current market. Recent research by the FHWA (Office of Operations 2017) notes that:

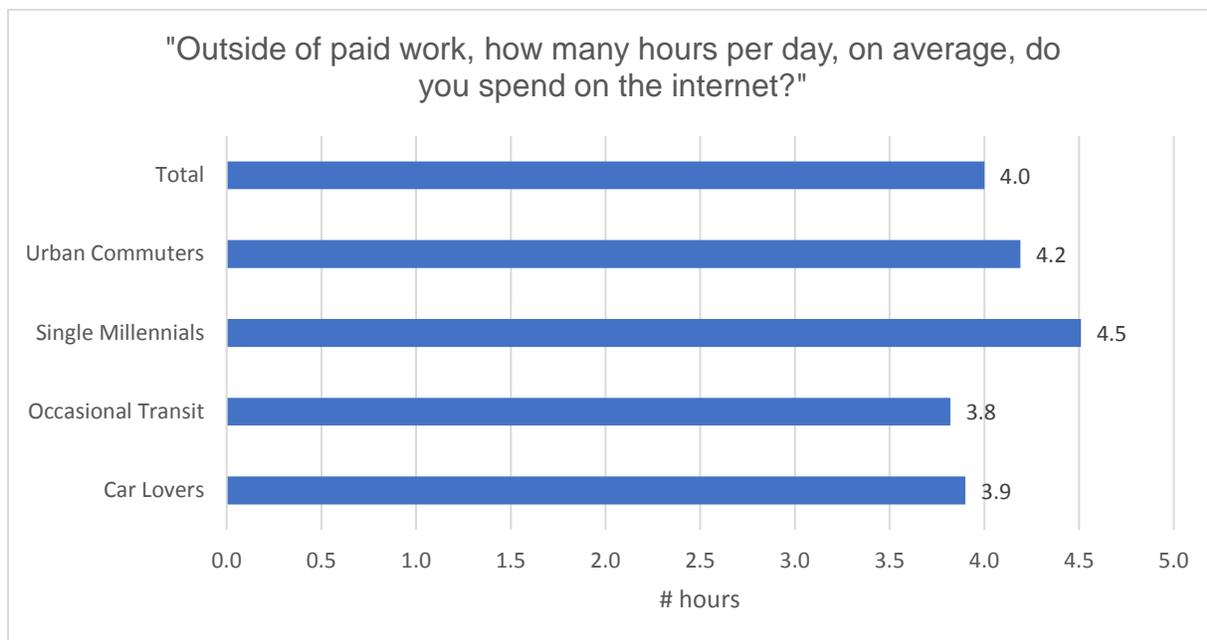
- Smartphone apps can reduce the cognitive effort required to make sense of complex situations
- Apps give the user important feelings of control: the more a user feels in control, the more satisfied and comfortable they are.
- To be effective, the app must deliver what is promised. This is particularly sensitive for transportation app providers, who may be fielding data on complex and unreliable public transit arrivals. Often, when there is a failure in real-time arrivals data (the purview of the serving agency), the party that is blamed is the transportation app, even if the app has no actual control over data quality
- Advances in mobile ticketing and access apps have impacted the norm of service access—the smartphone and its transportation apps are increasingly enabling seamless door-to-door travel on multiple modes (e.g., Moovel, formerly RideScout). This is creating new informational and transactional norms, with digital wallets and wireless communication capabilities changing expectations for how easy the process of booking and accessing a service might be.

It is a challenge—and perhaps a necessity—for the transit agencies to keep up with the need for real-time mapping and mobility data. Users expect directions and destination information on a real-time, as-needed basis, breaking the prior norm of having to use static sources of information like paper schedules or websites.

## PART TWO: ATTITUDES ABOUT STAYING CONNECTED WHILE TRAVELING

It is hard to measure the amount of time one spends ‘connected’—for example the American Time Use Survey separates playing computer ‘games’ from ‘socializing’ on the internet, but many people play games with friends achieving both. And there is a growing acceptance that because of the way we interact with our mobile devices, we are always ‘on the internet,’ whether listening to music, reading news, or hanging out with friends.

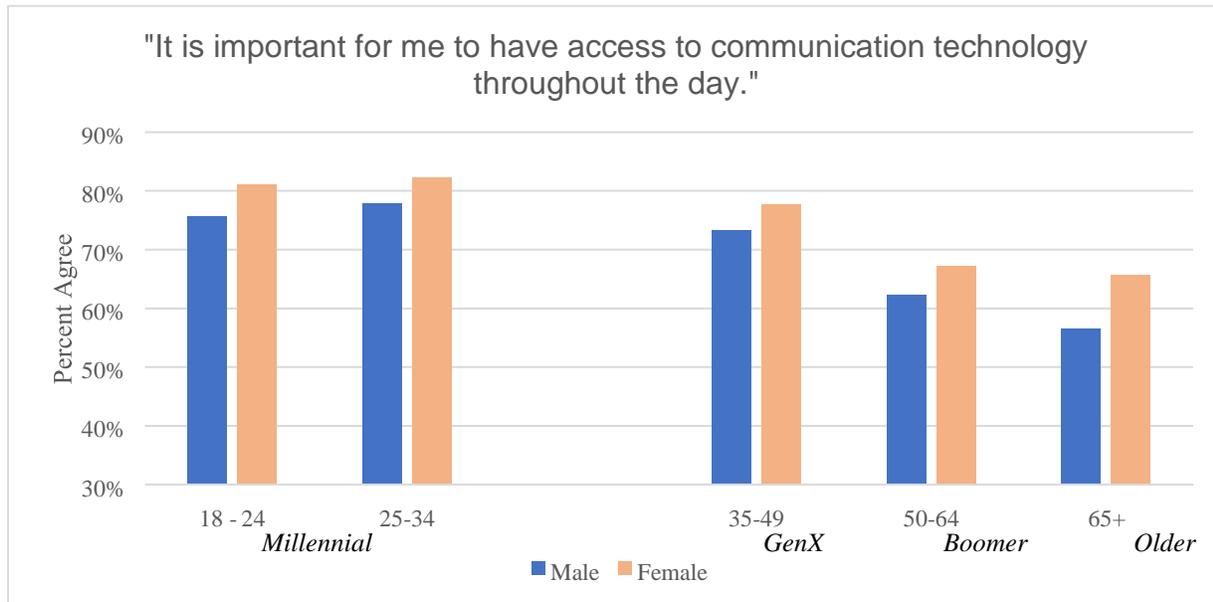
In the Project Survey the average respondent says they usually spend four hours a day outside of paid work on the internet. Figure 10 shows the small variance from that average between the market segments; the most connected spend just 15% more time on the internet than the least connected.



**FIGURE 10. OUTSIDE OF PAID WORK, HOURS PER DAY, ON AVERAGE, DO YOU SPEND ON THE INTERNET?**

Source: 2016 Project Survey

There are several questions about importance of connectedness in the Project Survey. In reaction to the statement, “It is important for me to have access to communication technology throughout the day,” women are more likely than men to agree, with those under 35 agreeing more strongly than those over 35, with a marked decrease for those over 50.

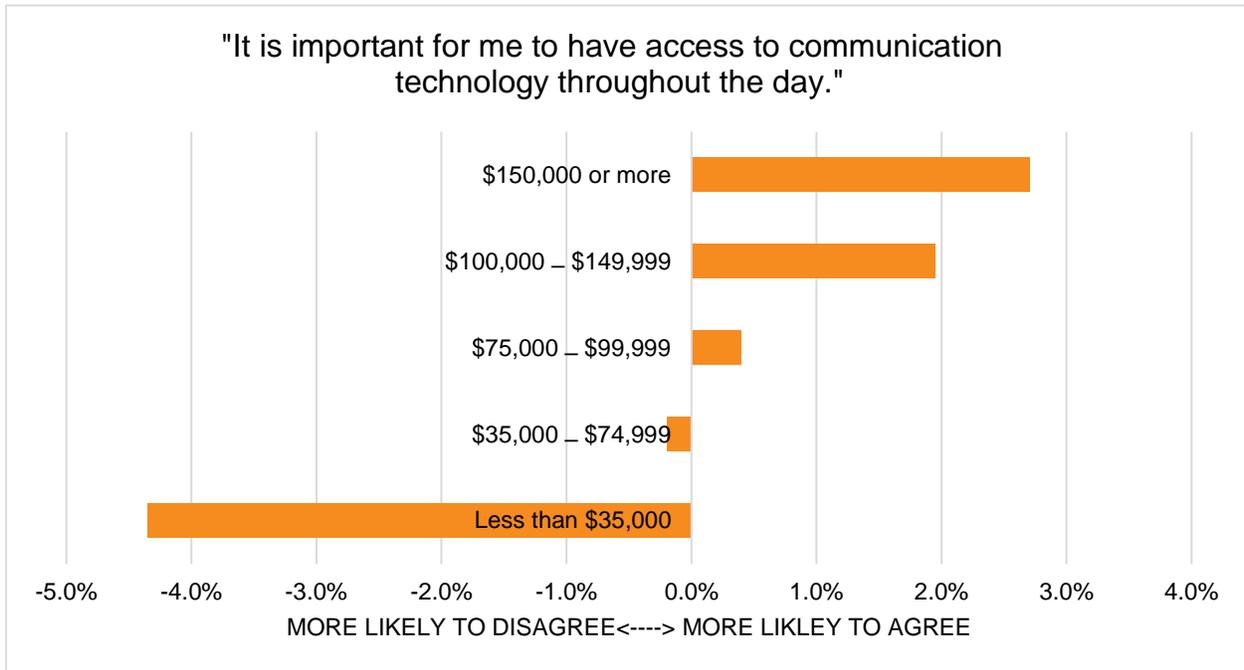


**FIGURE 11. IMPORTANCE OF CONNECTED PORTABLE DEVICE, BY AGE AND GENDER**

Source: Project Survey, 2016

While everyone values staying connected throughout the day, high-income people indicated it was slightly more important for them compared to respondents with lower incomes, as shown in Figure 12. The following data are presented here as an index of the Likert scale response (the Likert scale in the survey measured these attitudes from 0=strongly disagree to 7=strongly agree). The indexed data shows the percent difference between the mean score for the whole sample and the mean for each group or market segment, that is, these values represent an index comparing each group to the overall mean.

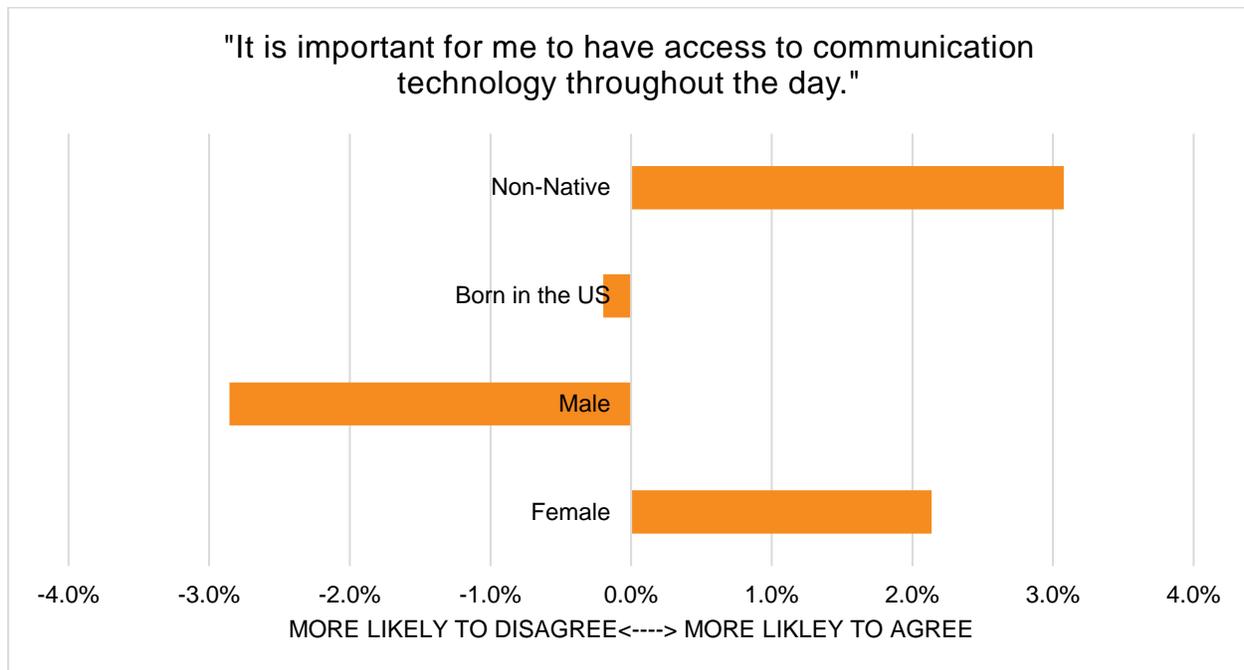
People with lower incomes are slightly less (4.3% less) likely to agree with the statement “It is important for me to have access to communication technology throughout the day” compared to the overall sample mean—which was a positive five for the whole sample on the seven-point scale.



**FIGURE 12. INDEX OF ATTITUDES ABOUT STAYING CONNECTED THROUGHOUT THE DAY, BY INCOME**

Source: 2016 Project Survey

Interestingly, the concept of being connected throughout the day was slightly more appealing to non-natives (3 percent more likely to agree) and to women (just over 2 percent more likely to agree) compared to native-born people and men, as shown in Figure 13. These are not critical differences, as most of the sample highly valued staying connected.



**FIGURE 13. INDEX OF ATTITUDES ABOUT BEING CONNECTED, BY GENDER AND NATIVITY**

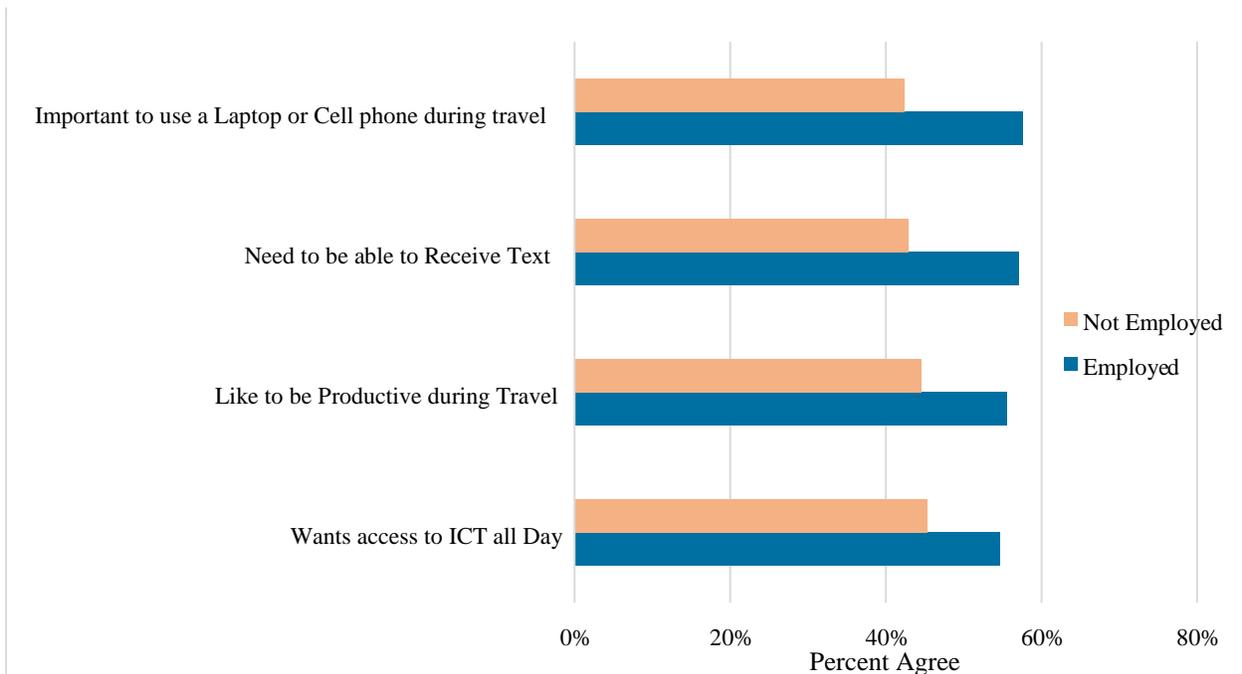
Source: 2016 Project Survey

### *The Shift in Value of Travel Time*

Another aspect of being connected is the idea that even when traveling one can use the device in ways that are not safe or legal to do while driving. In-vehicle time can now be ‘down time’ or social time or even work time. Studies have shown that Millennials are likely to use mobile devices while in transit which can decrease the disutility of travel time. When travel time is considered valuable time to continue working, connect with friends, be entertained, or organize social activities, modes of travel that allow such multitasking have an advantage that may offset longer travel times.

Recent research has tracked the rise in use of mobile devices for reading, texting, and viewing video while on transit (all these activities are illegal to do while driving). A hypothesis gaining evidence is that the ability to use electronic devices during travel may favor transit—especially trains where there is less crowding and longer rides. The theory is that the growing use of personal electronic devices appears to have altered the perceived “disutility” of spending time on transit.

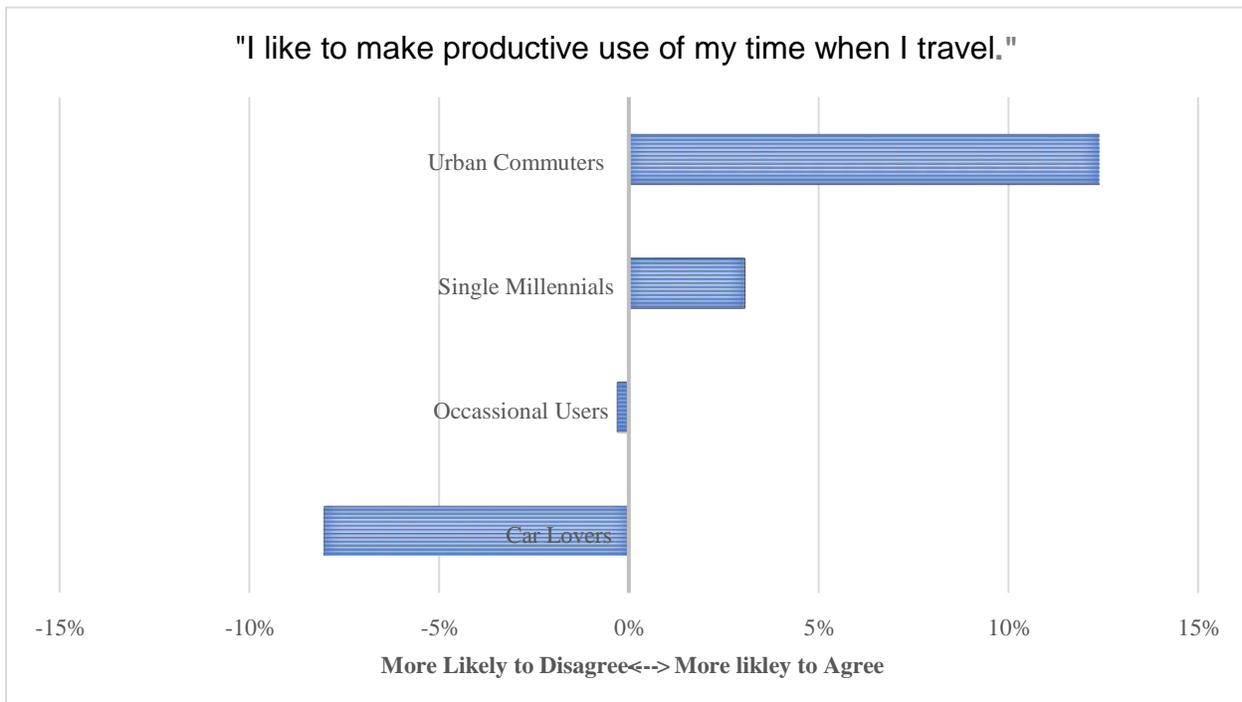
Figure 14 shows that attitudes about being connected and productive during travel vary consistently with employment status. Workers want to work while in transit, they want to use a cell phone or laptop, send and receive text, and stay productive and connected.



**FIGURE 14. INTEREST IN STAYING CONNECTED AND PRODUCTIVE DURING TRAVEL, BY EMPLOYMENT STATUS**

Source: 2016 Project Survey

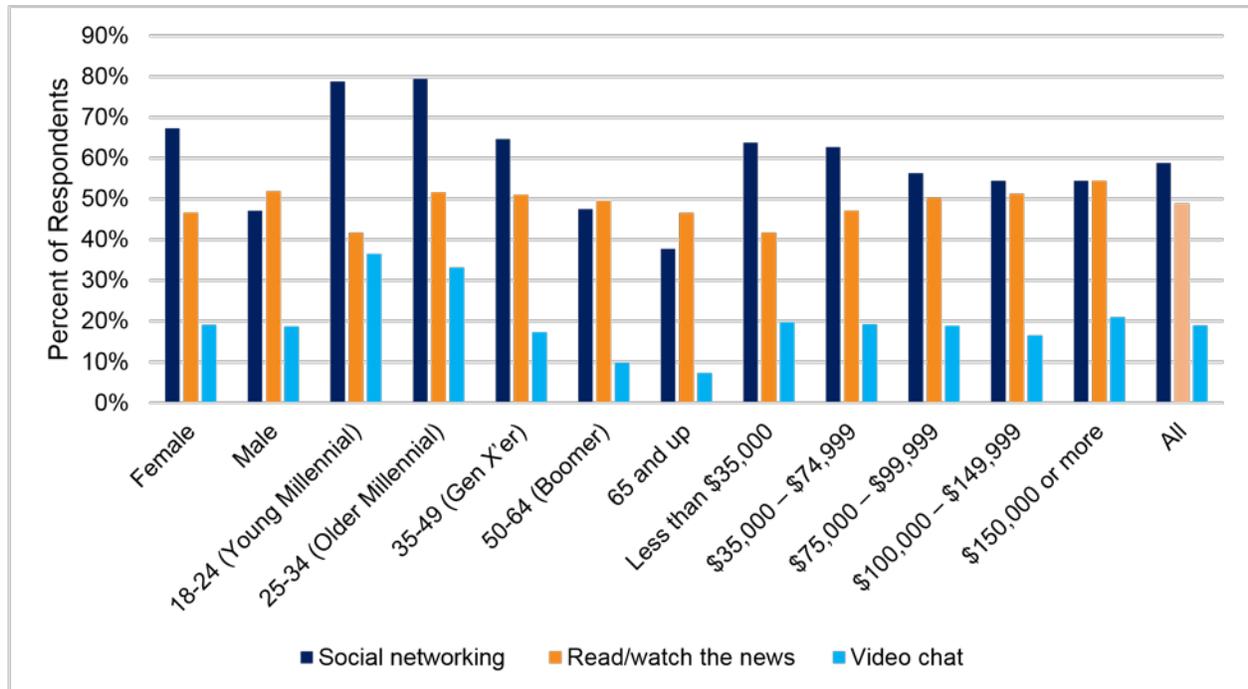
The project market segments ‘Urban commuters,’ and ‘Single millennials’ show a greater than average interest in using a mobile device and staying productive during travel. Figure 15 shows the indexed results of the importance of being able to use one’s time productively while traveling. As shown, ‘Urban commuters’ showed the greatest interest in being productive while traveling. On the other hand, ‘Car lovers’ were 8 percent less likely than the overall average to agree that staying productive during travel was important to them.



**FIGURE 15. IMPORTANCE OF BEING PRODUCTIVE WHILE TRAVELING, BY MARKET SEGMENT**

Source: 2016 Project Survey

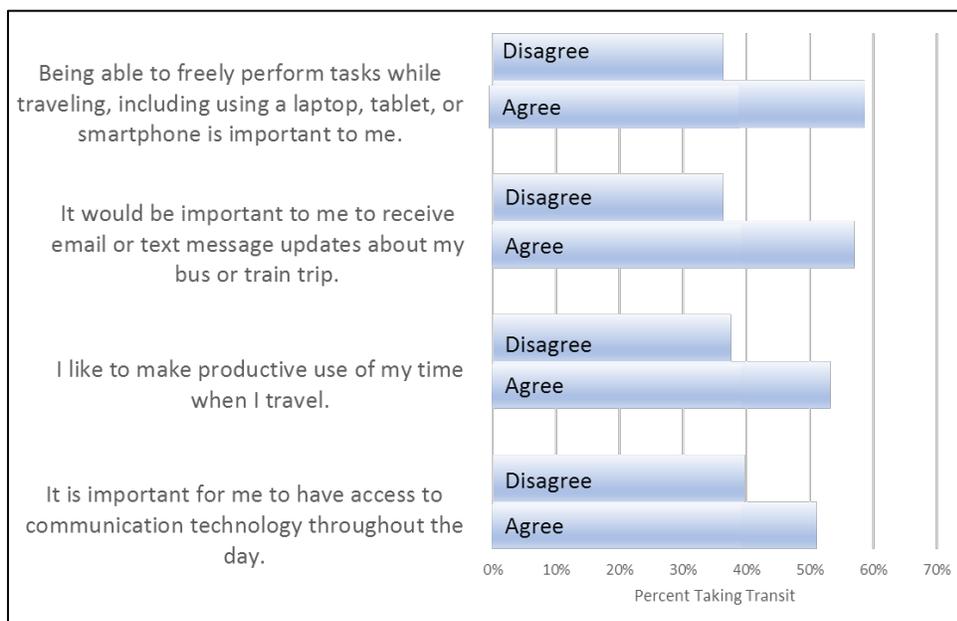
Younger people were the most likely to use their devices for social networking, getting news, or video chat compared to older people, as shown in Figure 16. People with lower incomes and women were also more likely to report using their devices for social networking.



**FIGURE 16. USE OF DEVICES FOR SOCIAL NETWORKING, NEWS, AND VIDEO CHAT**

Source: 2016 Project Survey

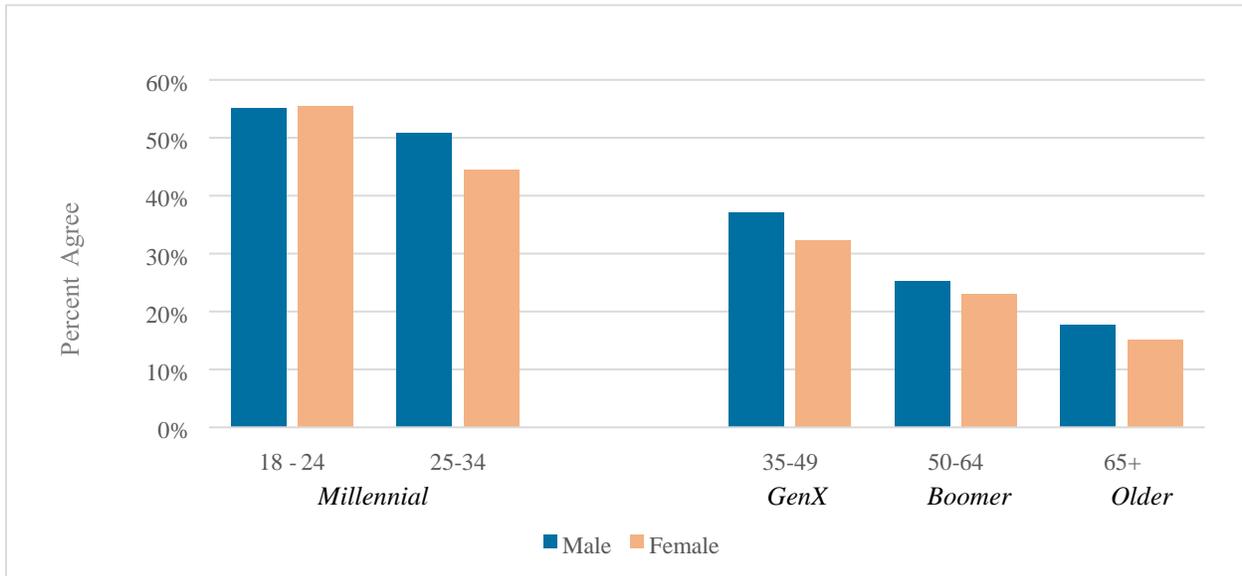
The impact of attitudes on behavior, particularly attitudes about being productive and connected during travel, has further evidence from the 2016 project survey. Each subgroup who agreed with the series of statements shown in Figure 17 is more likely to take transit than the subgroup who disagreed.



**FIGURE 17. TRANSIT USE, BY ATTITUDES ON PRODUCTIVITY AND CONNECTEDNESS**

Source: 2016 Project Survey

Figure 18 shows that over half of younger people say that they would use transit more if connectivity were improved. After age 25, men are slightly more likely to say better Wi-Fi on transit would encourage them to use transit more often.



**FIGURE 18. WOULD USE TRANSIT MORE IF WIFI WAS RELIABLE, BY AGE AND GENDER**

Source: TransitCenter, 2014

### Summary

Staying connected is highly valued by everyone in the TCRP survey, but slightly more important to younger people, women, and high-income travelers. Younger people used their connected devices more intensely and for a wider range of purposes when compared to older people. Eight out of 10 younger people used their devices for social networking, along with over 60% of women and lower- and middle-income people. About half of the respondents across all ages and incomes read or watched the news online with their devices.

This ability to multitask may be changing the value of time in a way that favors transit. Being able to use a laptop or smartphone to stay productive is valued by employed people, and being able to multitask and receive texts updating them about their trip is important to ‘Urban Commuters.’ Younger people, and slightly more men, say they would use transit more if there was reliable WIFI available.

Research on “the digitally connected commuter” importantly noted these changing expectations. Schwieterman *et al.* (2015) write:

“When interpreted broadly, the results from last year’s The Digitally Connected Commuter report suggests that the growth in rail transit ridership in Chicago and the rest of United States is being fueled in part by the advantages of train travel to those who put

a premium on using electronic devices. Passengers who would otherwise drive alone, and thus would need to limit their technological activity, have particularly strong incentives to take the train. Public agencies have much to gain by providing tech-friendly amenities—and airport-style waiting room environments—that leverage the desire of passengers to use electronic devices in the most enjoyable and productive manner possible over the course of their trip.”

### **PART THREE: ATTITUDES AND USE OF NEW SERVICES**

There has been major growth in the last decade of platforms to enable multimodal travel (e.g., “Where’s My Bus?”, bike share, Uber/Lyft). With information available in real-time, many travelers living in areas with multiple travel options make mode choices on the spot, sometimes piecing together multiple modes on a single journey. Mobile connected devices facilitate realtime evaluation of destination, mode, and route choices: information on alternatives are readily gathered (e.g. Google maps offers choices of drive, walk, transit, and now Uber) and consolidators are coming into the market to facilitate reservations/ticketing across multiple mode journeys.

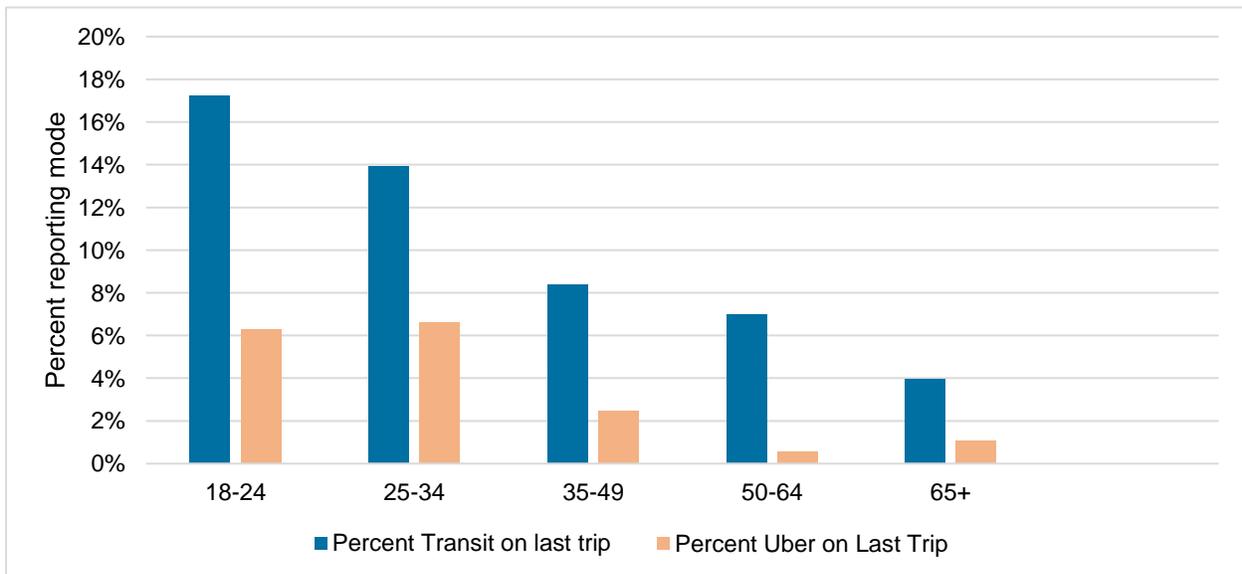
Also, new services allow the traveler to find the best set of choices for convenience, cost, travel time, and activity (walking/biking on either end of the trip), which can even increase the travel time utility to fit physical activity into a sedentary day. As consumers, young people are accustomed to having lots of options to select from—marketers have dubbed this generation ‘a million markets of one’—so individuals are looking for options that best serve their needs at a particular time.

#### *Transportation Network Companies and Transit Use*

A big player in the set of new travel options are Transportation Networks Companies (TNC) that offer ‘ride-hailing’ services initiated, tracked, paid for, and reviewed via smartphone. A recent survey by the Pew Research Center (Smith 2016) found that 21% of urban residents nationwide have used a TNC service such as Uber or Lyft. In the 2016 survey, 22% of respondents indicated that they made trips using a TNC in the past week.

As we have seen, younger people embrace both new means of travel—such as Uber/Lyft—as well as traditional transit. To link those attitudes to behavior, Figure 19 shows the percent of people who reported a transit trip or Uber/Lyft trip as the mode of travel for their most recent trip.

As shown, both means of travel seem to be associated with the age of the traveler. Seventeen percent of 18- to 24-year-old respondents reported their last trip was on transit compared to half that (8 percent) for middle-aged people 35-49, and half again (4 percent) for those aged 65 and over. Around 6 percent of 18- to 34-year-old respondents reported that Uber/Lyft was used for their last trip, compared to negligible use (1-2%) in the older age categories.



**FIGURE 19. PERCENTAGE MODE SHARE FOR LAST TRIP, BY AGE GROUP: TRANSIT AND TNC**

Source: 2016 Project Survey

According to the Pew study cited earlier, 10% of 18- to 29-year-old individuals living in urban areas use ride-hailing TNCs on a daily or weekly basis. However, according to the scant research on the types of trips made using TNCs, many trips are late-night non-work trips. The current Project Survey obtained the number of work and non-work trips reported using TNCs (only including the 20% of the sample that reported TNC trips in the last week). For people who reported using TNCs, on average they used them twice in the last week. Most of these trips were for non-work purposes.

Both the Pew study and the recent *Report on Shared Mobility* (TCRP Report 188) found that people who used TNC ride-hailing services like Uber/Lyft were less likely to own a personal vehicle and more likely to use public transit. The current research replicates those findings. People in the current Project Survey who use TNCs are less likely to own a personal vehicle: 79% of people who used Uber/Lyft had access to a vehicle compared to 86% of people who did not use a TNC.

According to the Pew study, people using ride-hailing services are “significantly more likely to use a wide range of other personal transportation options in addition to ride-hailing. Among daily or weekly ride-hailing users, 70% report that they regularly walk or ride a bike somewhere; 56% regularly take public transportation; 55% regularly use traditional taxi services; and 14% ever use bike-sharing services. In each instance, frequent ride-hailing users are significantly more likely than other Americans to engage in these behaviors.”

The current survey also finds that people who use ride-hailing TNCs are more likely to be transit users. About half of the sample in the Project Survey indicated they used transit, and of those 40% also used a ride-hailing TNC and 60% did not in the last week. Of all the people who

reported any TNC use, 85% also reported transit use compared to 37% who did not use any TNC.

The flexible nature of the decision on choice of mode of travel can be seen in the rise of ‘occasional users’ of transit, as noted in our previous work. According to the NHTS there is evidence that more people were occasional users of transit in 2009 compared to 2001 (the only two years in which the questions was asked in the same way). Table 1 shows the percentage of people aged 16 and older by the frequency of their use of transit where transit was available (self-reported by the respondent in both surveys). Given the rise in total population, along with the higher percent of people responding in each category, occasional users could add as many as 4 million transit riders per year.

**TABLE 1. FREQUENCY OF TRANSIT USE FOR OCCASIONAL USERS**

Source: 2016 Project Survey

CATEGORY	2001	2009
Two or more days a week	7.26%	8.59%
About once a week	2.78%	4.20%
Once or twice a month	4.83%	7.18%
Less than once a month	3.77%	4.18%
Never	81.35%	75.85%
<b>Total</b>	<b>99.99%</b>	<b>100.00%</b>

The current Project Survey also finds more occasional use of transit—especially for non-work purposes. The percent of respondents using transit 1-2 days is 14.3% compared to the percent using transit 3-5 days, which is just 3.7 percent.

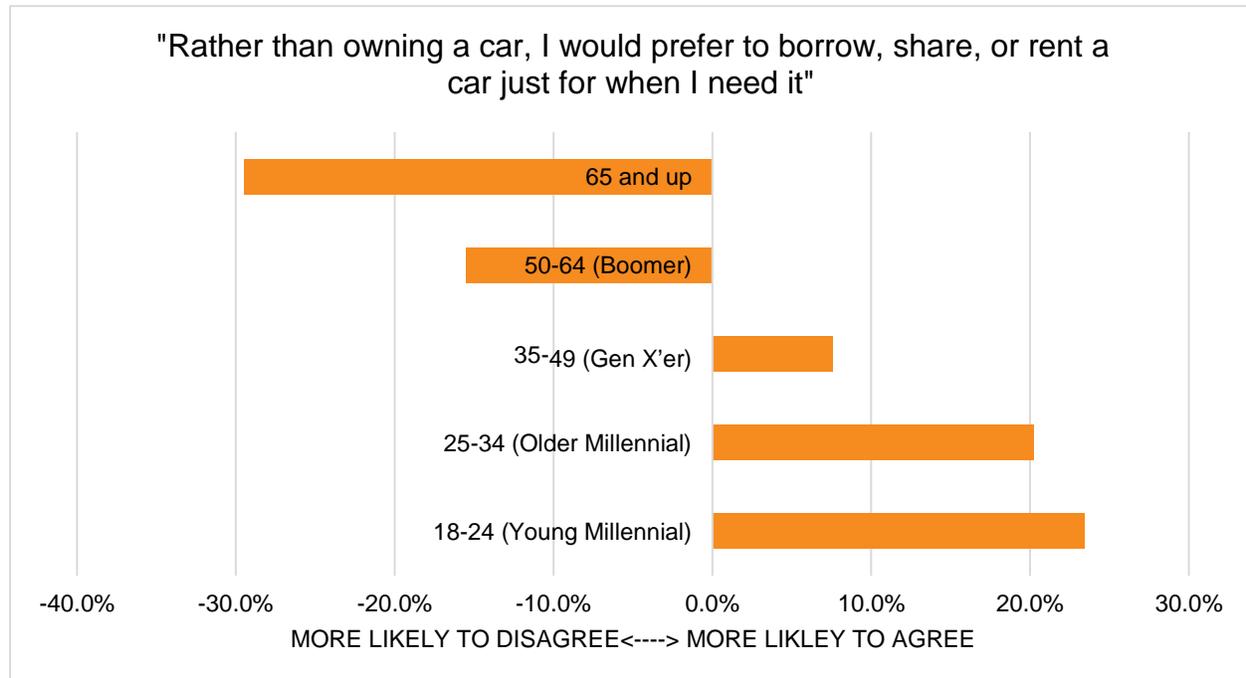
The occasional use of transit is especially interesting when connected to increased multimodalism sought by Millennials in growing urban areas. TCRP Report Web-Only Document 6 found that younger aged people did not describe their commutes as a habitual single mode choice, but the product of several competing factors based on circumstance.

### *Attitudes about Vehicle Ownership*

One of the key features of digital technologies is that they enable people to perform activities remotely, rather than in person. This type of freedom could displace the perceived freedom granted by ownership of a car—which has long been a key selling point for auto manufacturers (Goodwin 2012). Research has indicated that young people want the ability to be self-sufficient when it comes to transportation, and that means *not* relying on a car. A portion of Millennials agreed that the cost of owning a car outweighs the benefits. Note that it is not the cost of buying a vehicle that people mention, but gas, parking, insurance, maintenance, and other operational

costs. An additional consideration is the ‘hassle’ factor. When someone owns a car, that person must deal with the hassle of parking, insurance, maintenance, etc. For many young people interviewed in the research, a car does not conjure a sense of freedom, but rather conjures the stress of the hassle.

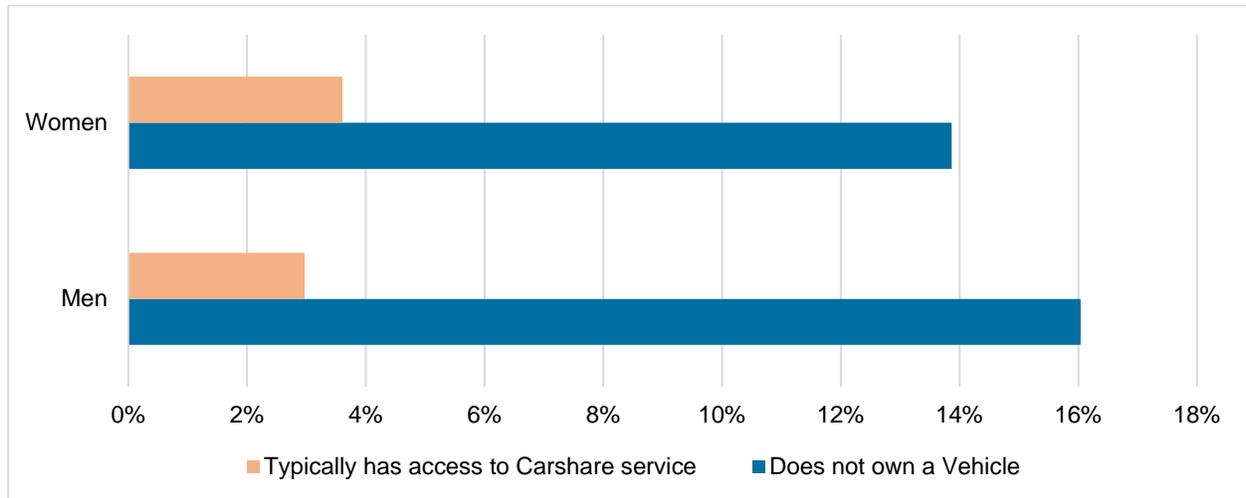
Figure 20 shows the index of attitudes about owning versus borrowing or sharing a car by age group. Consistent with the findings in 2014, younger people are much more likely to agree that having a car just when they need it is better than owning a car.



**FIGURE 20. VARIATION IN PREFERENCE FOR SHARING CARS**

Source: NCRRP REPORT #4, 2016

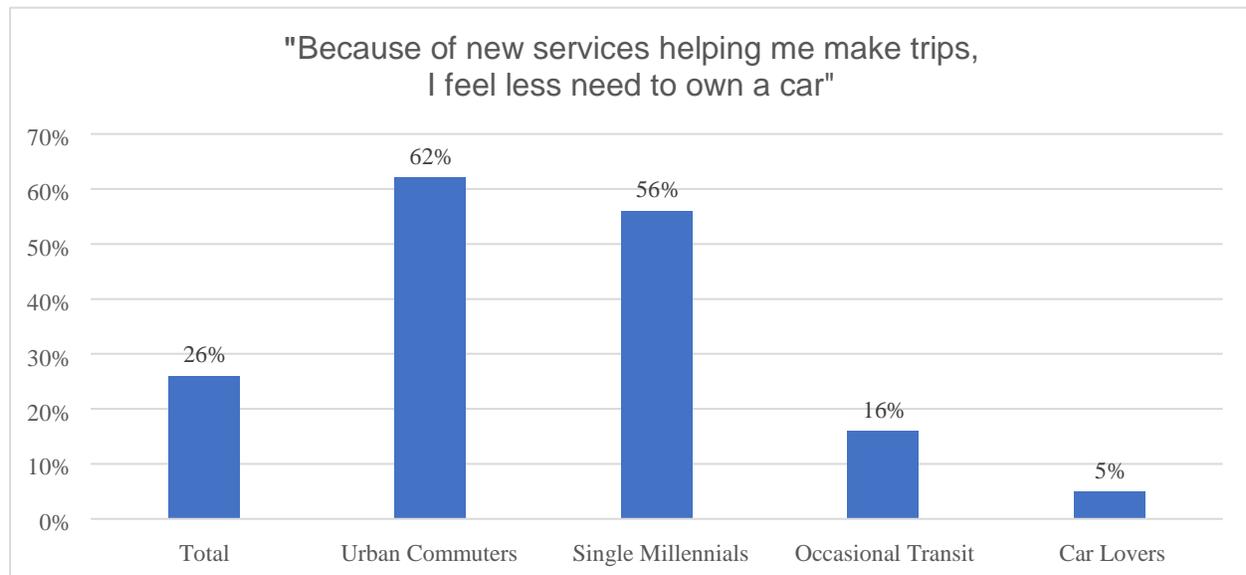
Working women are more likely to own a vehicle but also slightly more likely to have access to car-share services than working men (Figure 21). Chapter 6 of the Final Report details how attitudes differ between men and women, especially workers and even more so working parents. For example, men were more likely to agree than women—by a difference of 10 points--that “I am a person who likes to participate in programs like car-share and bikeshare.” For working parents, the difference between men and women grew to 22 points.



**FIGURE 21. DIFFERENCES IN VEHICLE AVAILABILITY AND ACCESS TO CAR-SHARE**

Source: 2016 Project Survey

Figure 22 shows the percent by market segment who agree that these new services make it easier to live without a personal vehicle. The majority of ‘Urban commuters’ and ‘Single millennials’ agree that access to these new services impacts their need to own a car.



**FIGURE 22. PERCENTAGE AGREEING WITH THE STATEMENT: “BECAUSE OF NEW SERVICES HELPING ME MAKE TRIPS, I FEEL LESS NEED TO OWN A CAR.”**

Source: 2016 Project Survey

### *Summary*

The availability of new services, like other paradigm-shifting technologies, is going to change travel behavior as mounting evidence indicates the use of new services impacts the auto ownership of households in urban areas. Car-sharing not only reduces the number of personal vehicles owned across the sample; it also seems to deter carless households from acquiring a vehicle (Martin and Shaheen 2011). The relationship between new services, such as car-share, vehicle ownership, and transit use is complex.

It is doubtful that these choices will stay a niche market, but what is unknown is whether the availability of car/ride-share will compete with transit and possibly take riders away. In the long term, there is a question of whether the availability of car/ride-share will influence vehicle ownership by providing a reliable alternative. But the current research indicates that, like the driver's licensing phenomenon, auto ownership seems to be delayed, not foregone. Probabilities of auto ownership increase with age within the large Millennial cohort. However, uncertainty remains as the car/ride-share technologies are just beginning.

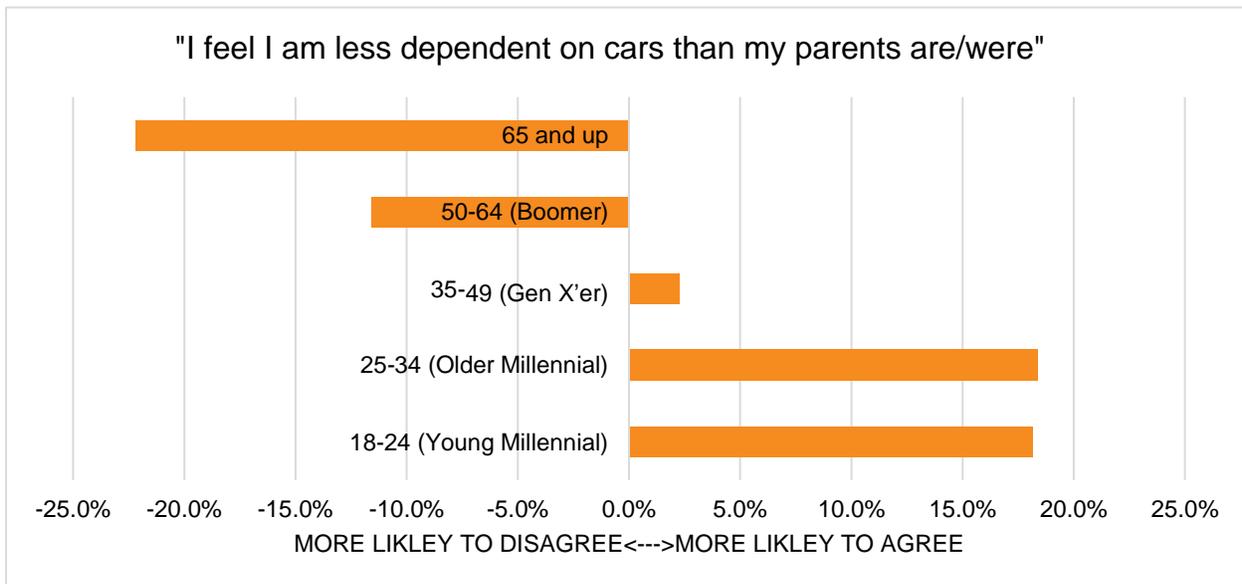
But as new and more disruptive technologies enter the field, the emerging picture is not at all clear.

## **PART FOUR: PERCEPTIONS OF THE FUTURE FROM THE PROJECT SURVEY**

While creating hypotheses about the impact of Information and Communications Technology on travel in general is challenging, speculating on how future technologies might affect the market for public transportation is even more difficult. In the short term, technology has already improved the ability to match the needs of a “rider” for a trip with the availability of a vehicle to provide that trip. While the original vision of “Uber” focused on the single-party trip (i.e. the taxi market), newer services are allowing multiparty trip-making, which looks more a market traditionally served by fixed route and scheduled transit.

As these services evolve, a growing debate will take place between considering these services as “competitive” to transit, or “complementary” to transit. Encouraging results come from the work reported in TCRP Report 188 which concluded, “The more people use shared modes, the more likely they are to use public transit, own fewer cars, and spend less on transportation overall.” The research presented here supports the interactive role of transit and new services in enabling more urban households to go car-free.

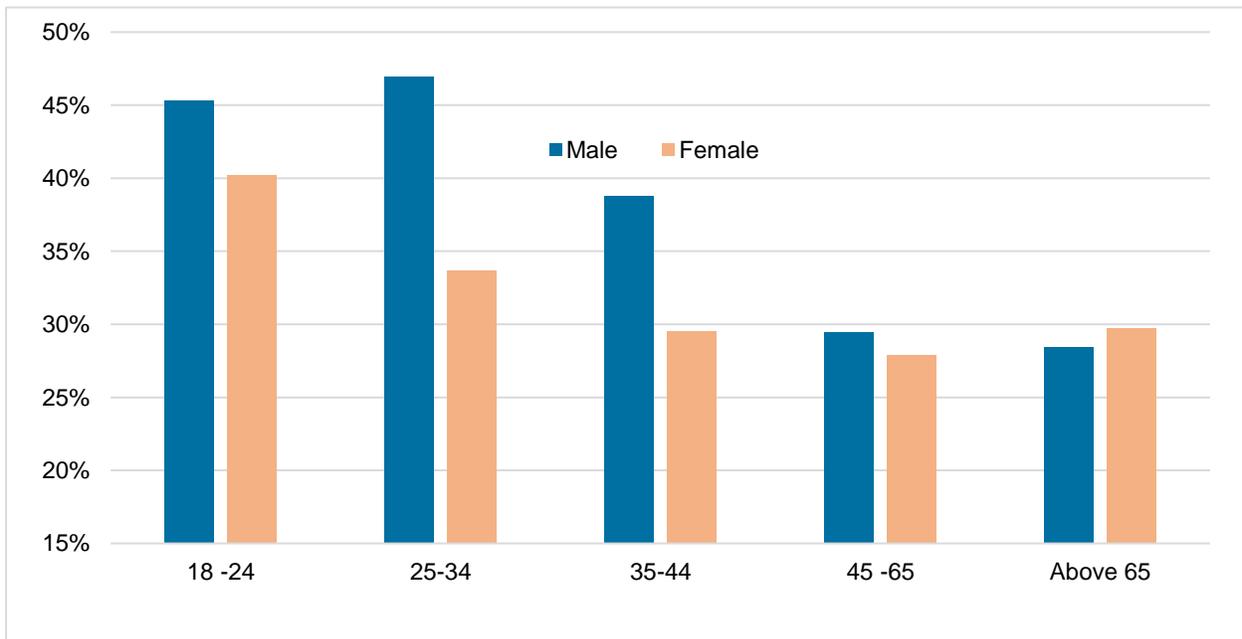
Looking forward, it is important to underline the differences between the younger age groups and older driver-dependent people in the TCRP survey. For example, younger people feel less dependent on cars than their parents were, the differences are large compared to older age groups (Figure 23).



**FIGURE 23. VARIATION IN FEELING LESS DEPENDENT ON CARS, BY AGE**

Source: 2016 Project Survey

Men—especially young men--were more enthusiastic than women that driverless vehicles might replace transit. In Figure 24, men under the age of 35 show a strong propensity to say they would change their mode to the autonomous car, a belief that decreased steadily after the age of 35. Women were more skeptical and did not agree at the same level as men until the oldest age group.



**FIGURE 24. ROLE OF AGE AND GENDER ON BELIEF THAT DRIVERLESS CARS WOULD ALTER PRESENT TRAVEL BEHAVIOR**

Source NCRRP REPORT 4

While it is not possible to predict how different market segments might respond to new sets of services and concepts, the older groups will be slower to adopt new patterns and lifestyles than the younger groups. In the Project Survey the younger respondents seemed to embrace new service options while older respondents demurred.

Still emerging is the concept that the future of mobility is moving away from individually owned and operated personal vehicles to more complex arrangements and combinations: shared car services, on-demand taxi (autonomous or not), bike share, and transit in many traditional and new formations (e.g., bus rapid transit [BRT], on-demand shuttles, intercity bus, light rail).

## IMPLICATIONS FOR THE FUTURE

The mobile ICT industry is constantly evolving and growing at an astronomical pace: the intrinsic value of owning a mobile device has significantly changed in recent years. What was once simply a constant voice connection to anyone with a telephone is now enabling communications in a variety of different ways, such as text messages, e-mails, social media updates, instant messages, blog posts, web searches, shopping, entertainment streaming, and—of course—information and navigation (as well as ticketing) of complex multimodal travel. Research suggests that cohort effects alone will change the travel behavior of the next generation in unique ways from their predecessors (Blumenberg *et al.* 2012).

The effect of ICT on travel is most apparent in two areas: (1) When the internet supports travel choices including applications and tools such as real-time travel information, mapping, and

car/ride-share services, ICT complements travel. (2) When it provides a more attractive method for completing a task, then it substitutes for travel. This is evident in activities such as shopping or banking where smart devices have enabled activities without travel to the location. The classic model developed by Mokhtarian also includes ICT as an inspiration to travel, and the impact of ICT in freeing resources (time or money) that can be shifted to more travel. Demonstrably, a complex interrelationship exists that will potentially affect the way people go about their daily lives, including how, when, and why they travel.

### *Changes in Retail Travel Tripmaking?*

Many young people have become dependent on online retail as part of their everyday shopping. Online retail options are growing, and the effect on land use is apparent: large trip generators like record stores, book stores, and electronic stores have disappeared from malls and retail centers.

But new behaviors, such as ‘showrooming’ (i.e. going to a retail shop to examine something before purchasing online) and looking at choices online before buying from a brick-and-mortar shop, remind us that the effect of communications technology on travel is complicated and largely unknown. In addition, the theory of the travel time budget suggests time not spent shopping and doing errands will be replaced by other travel.

However, there is another way to look at the issue. The 2009 NHTS shows that adults (16-65) spent more time at home –an average addition of 1 hour and 15 minutes a week – than they did in 1995, and men’s time at home changed more than women’s. Men spent about 2 hours more time at home per week compared to 1995, and women spent 30 minutes more time at home per week. And, in keeping with the analysis presented so far, the youngest cohort showed the greatest change. What can be keeping young men at home? The American Time Use Survey indicates a growth in time spent in leisure activities at home (comparing 2003 and 2014 data), including gaming. In addition, new streaming options for entertainment, more online social and communication options, and the overall greater diversity of activities accomplished online may also contribute to this pattern of staying at home.

### Diversity

The younger generation is more diverse than older age sets, and the greater use of transit by nonwhites was detailed in Chapters 1 and 2 of the Final Report. As the racial and ethnic diversity among the younger generations in the US grows, one result is a change to what is considered ‘normal’ travel behavior to include a wider range of travel patterns. Currently, Hispanics—the greatest share of young people after whites and growing faster--are more likely to use transit and carpool. They may already be influencing what is considered normal travel behavior, and that influence will likely continue. As shown in this research, Hispanics are more likely to want to use their connected device while traveling, and to say they would rather do without a car than a cell phone. On the other hand, we expect the ‘car lovers’ (older whites) to keep driving into older ages, especially as technology facilitates driving independently for more years. Older adults will still make commute trips, as ‘working retirement’ becomes the norm, which in turn will increase

the travel of the "young elderly" (65-75). In conjunction, there will be increased demand for paratransit type services (accessible TNC?). In addition, as healthier and wealthier baby boomers age we expect more leisure travel—currently the over 55 set is the second biggest market segment for intercity bus (the ‘sliver surfers’), after the Millennials.

#### Work and Non-Work Share of Travel

While commuting is still half of transit use, as discussed in Chapter 2 of the Final Report, over the last few decades the growth in per capita travel rates came not only from more people (women) entering the workforce, but more shopping and errands as ‘in-home’ activities were outsourced (day care, meals). Since the earliest NHTS (1969) the number of shopping trips per household doubled and “other family/personal errands” trips increased 2.5 times.

This trend of growth in non-work travel has leveled off in recent years. The 2009 NHTS identified declines in travel for non-work purposes across all age groups and for both genders (Santos *et al.* 2011). For example, women’s travel for personal errands declined 10% between 2001 and 2009, while men’s travel for social and recreational purposes declined over 5 percent. As noted earlier, people seem to be spending more time at home.

New NHTS data will inform the continuation of these trends, but related impacts are occurring in the retail and service markets: the demand for at-home services and deliveries of goods (like pet medicines or groceries) continues to grow at remarkable rates. The brick-and-mortar retail sector is declining, malls are empty, and nearly half of US households have an Amazon Prime account.

#### Disruptive Technology

While the professional literature does not currently focus on new service that could compete directly with transit (that we could locate), the emergence of new kinds of shared services was discussed in "*Between Public and Private Mobility Examining the Rise of Technology-Enabled Transportation Services.*" The TRB Committee for Review of Innovative Urban Mobility Services (2016) notes,

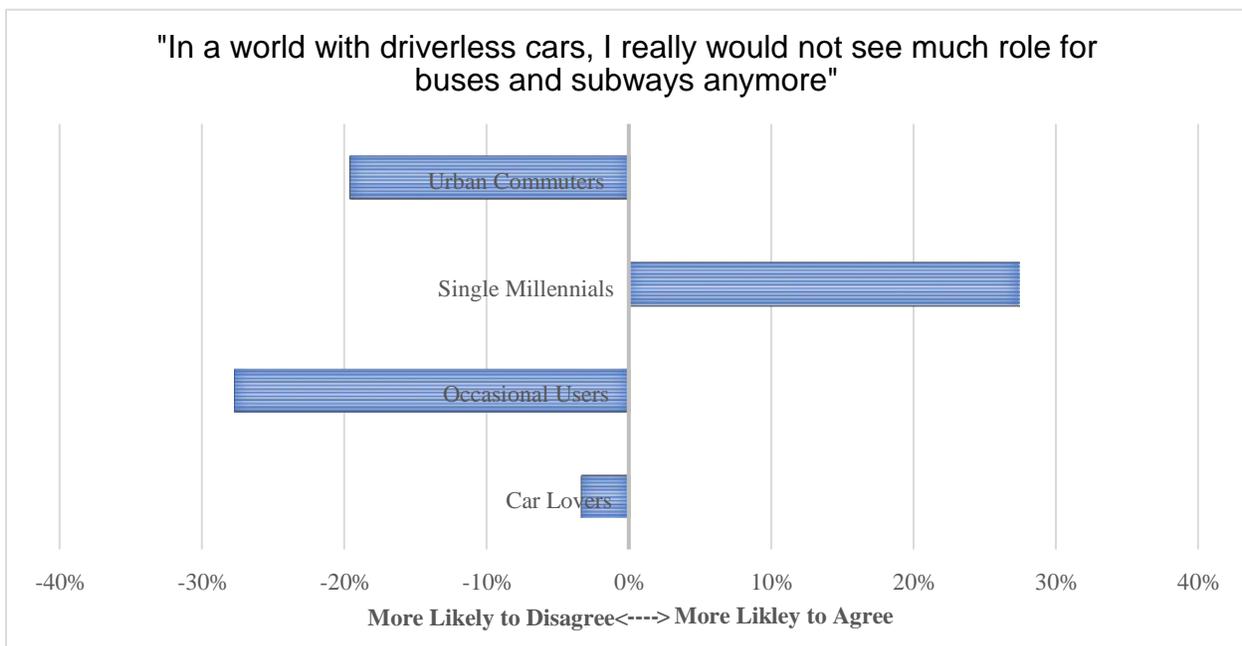
To date, the most rapidly growing forms of shared mobility entail sequential sharing of vehicles, with each user in turn having exclusive use of a motor vehicle or bicycle. Potentially more consequential, but still in its infancy, is concurrent sharing of vehicles among strangers. By increasing vehicle occupancy, this form of shared services may collectively have greater effects—in terms of affordable personal mobility, vehicle use, energy consumption, traffic congestion, and environmental benefits—relative to today’s most popular new sequential mobility options.

Therefore, we note that some technologies could completely disrupt travel behavior as we know it. While the present TNCs provided a platform to connect drivers and people wanting rides, in practice it is like a taxi service. On the other hand, a more disruptive technology--autonomous

vehicles--will likely be used for mobility in the future. But how will they be used? Recent research points to three possibilities (Correia 2016):

- A taxi fleet available throughout urban areas
- Autonomous cars replacing families' privately-owned cars
- Public transport vehicles substituting buses and trams

The reality will probably be a combination of the three. In the TCRP survey, we find a stark difference between the different market clusters on how the respondents think autonomous cars will affect their transit use. Figure 25 shows the indexed responses. Importantly, younger people (Millennials) tend to imagine a world where autonomous cars would replace transit, while older respondents ('Occasional users' have an average age of 52) do not.



**FIGURE 25. DRIVERLESS CARS MAY REPLACE TRANSIT**

Source: 2016 Project Survey

But overall, the future paradigm of transit use is in conjunction and with a complement of alternatives that each fill a gap in the overall travel ecosystem. Currently, TNCs are most frequently used for social trips between 10 pm and 4 am, times when public transit runs infrequently or is not available. But the data showed that 'Single Millennials' were starting to use TNCs as part of their commute options. TNCs may currently substitute more for private automobile trips than public transit trips, but as they encourage people to own fewer vehicles and depend on shared services more—and more importantly as the services develop and change in response to market forces—they may compete directly with transit, as discussed in the Final Report.

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