Understanding Changes in Demographics, Preferences, and Markets for Public Transportation

DETAILS

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CONTRIBUTORS

Matthew Coogan, Greg Spitz, Tom Adler, Nancy McGuckin, Richard Kuzmyak, and Karla Karash; Transit Cooperative Research Program; Transportation Research Board; National Academies of Sciences, Engineering, and Medicine

TRANSIT COOPERATIVE RESEARCH PROGRAM

TCRP RESEARCH REPORT 201

Understanding Changes in Demographics, Preferences, and Markets for Public Transportation

Matthew Coogan
White River Junction, VT

Greg Spitz

AND

Tom Adler
RSG
White River Junction, VT

Nancy McGuckin
South Pasadena, CA

Richard Kuzmyak
Renaissance Planning
Orlando, FL

Karla Karash
Grantham, NH

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TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, adapt appropriate new technologies from other industries, and introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213—Research for Public Transit: New Directions,* published in 1987 and based on a study sponsored by the Urban Mass Transportation Administration—now the Federal Transit Administration (FTA). A report by the American Public Transportation Association (APTA), *Transportation 2000,* also recognized the need for local, problem-solving research. TCRP, modeled after the successful National Cooperative Highway Research Program (NCHRP), undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes various transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA; the National Academies of Sciences, Engineering, and Medicine, acting through the Transportation Research Board (TRB); and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at any time. It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products.

Once selected, each project is assigned to an expert panel appointed by TRB. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired effect if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

TCRP provides a forum where transit agencies can cooperatively address common operational problems. TCRP results support and complement other ongoing transit research and training programs.

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FOREWORD

By Dianne S. Schwager
Staff Officer
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TCRP Research Report 201 was developed to help transit managers, planners, and communities understand how changes in demographics, traveler preferences, and markets for public transportation affect transit ridership now and in the future. The research report, which is intended for practitioners and decision makers, is supported by seven appendices that will benefit researchers.

The research conducted for *TCRP Research Report 201*: *Understanding Changes in Demographics, Preferences, and Markets for Public Transportation* concludes that a mix of factors interacts and ultimately drives transit ridership. An individual's demographics affect that person's long-term values, current attitudes, and choice of neighborhood type. Each of these factors also affects the likelihood to ride transit. This research report presents findings in eight major areas:

1. Demographic factors are critical for predicting future markets for transit.
2. Location is critical for predicting the future markets for transit.
3. Market-based preferences are critical for predicting the future markets for transit.
4. Age, preferences, and location together affected changes over the past decade.
5. Age, preferences, and location together can explain expected changes for the future.
6. Transit level of service is more important than having a population that is pro-transit.
7. Transportation network companies (TNCs) will offer more competition to transit.
8. Study results have important implications for transit leaders.

The report is supplemented by seven technical appendices, which are available on the TRB website (www.trb.org) by searching for "TCRP Research Report 201". These appendices include a literature review and bibliography and provide additional information on the subjects covered in Chapters 2 through 7 in this final report:

- Technical Appendix 1. Literature Review and Project Bibliography,
- Technical Appendix 2. Demographics in Support of Chapter 2,
- Technical Appendix 3. Geography and Neighborhood Type in Support of Chapter 3,
- Technical Appendix 4. Survey and Market Segmentation in Support of Chapter 4,
- Technical Appendix 5. Analysis of Preference in Support of Chapter 5,
- Technical Appendix 6. Integrated Behavioral Modeling in Support of Chapter 6, and
- Technical Appendix 7. Information and Communications Technology in Support of Chapter 7.

This research was led by Resource Systems Group (RSG), where Thomas Adler served as principal in charge. Matthew Coogan, an independent contractor, served as the principal investigator and primary author of the final report. Greg Spitz of RSG served as the project manager. Major research concerning demographics was provided by Nancy McGuckin, and research in land use implications was provided by Richard Kuzmyak of Renaissance Planning. Karla Karash served as a senior advisor focusing on the implications for the transit industry.

CONTENTS

SUMMARY

Understanding Changes in Demographics, Preferences, and Markets for Public Transportation

The future of public transportation in the United States will be influenced by a set of factors reflecting underlying demand and a set of factors reflecting supply. While much has been written about alternative possible services and prices (supply), less is known about how characteristics of future markets might influence the future role of transit over the next decades.

Transit managers and those who advocate transit more generally often must focus on near-term issues (e.g., providing cost-effective services on significantly constrained annual budgets). At the same time, the same managers must prepare longer-term capital plans and provide close cooperation with metropolitan planning organizations, whose focus is usually on longer-term issues. Thus, whether the region is contemplating a major long-term investment in fixed facilities or the local transit agency needs to float a bond to fund a new maintenance facility, leaders of the transit community need to have an understanding about how markets for their services are likely to change over a two- or three-decade period.

Thus, transit managers, planners, and stakeholders need to understand how multiple future factors might influence the nature of demand for transit services in the United States. For this study, *TCRP Research Report 201: Understanding Changes in Demographics, Preferences, and Markets for Public Transportation,* the research team created a set of future scenarios for transit markets to understand how shifts in demographics, attitudes, and levels of service might affect demand for transit. The study focuses primarily on factors beyond travel times and costs (i.e., beyond supply characteristics) and seeks to improve the understanding of the background conditions that affect market behavior.

This research incorporated differing assumptions about demographics, the transit orientation of the neighborhood, and market-based preferences, including values and attitudes. All three elements would be needed to support the development and analysis of alternative scenarios for the future of the transit industry. All three elements are also needed to better understand the possible impacts of technology-based services such as transportation network companies (TNCs) in both the complementary and competitive role with transit ridership.

This report concludes with eight major findings:

1. Demographic factors are critical for predicting future markets for transit.
2. Location is critical for predicting the future markets for transit.
3. Market-based preferences are critical for predicting the future markets for transit.
4. Age, preferences, and location together affected changes over the past decade.
5. Age, preferences, and location together can explain expected changes for the future.
6. Transit level of service is more important than having a population that is pro-transit.

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7. TNCs will offer more competition to transit.
8. The results of the study have important implications for the leaders of the transit community.

The research team created seven technical appendices to accompany this report. These appendices include a bibliography and literature review and additional information on the subjects covered in Chapters 2 through 7 of the report:

- Technical Appendix 1. Literature Review and Project Bibliography,
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These appendices are not printed herein but can be downloaded from the TRB website (trb.org) by searching for "TCRP Research Report 201".

Implications of Demographic Shift in Age

The study found that there will be a major demographic shift that could affect the makeup of the transit market over the next three decades. The millennial generation is now the largest single age-based component of the United States population and will get proportionately larger. As of 2010 [the best census year for comparison with the results of the 2009 National Household Travel Survey (NHTS)] there were 1 million more millennials in the United States than baby boomers; by 2030, it is forecast that there will be 22 million more millennials than baby boomers. A cohort now in the age bracket roughly between 15 and 35 will be in the age bracket between 35 and 55 in 20 years. The project explored in some detail the market behavior of population age groups under 35, with particular attention to those between the ages of 25 and 35.

This pattern of demographic shift over time is important for transit policy makers for two reasons: first, because this cohort (the millennial generation) is the largest such group, and its dominance will simply increase over the next two decades, and second, because, in general, this generation has patterns of transit use that are quite positive. The millennial generation has a set of attitudes and preferences that sets it apart from the older demographic categories, including its views toward urbanism and auto dependence:

- Those under 35 years old are more likely than older groups to report that it is important to them to live in a neighborhood with ethnic diversity and shops and restaurants within walking distance.
- Millennials are more likely than any other group to prefer to live in the city.
- Over the past 12 years, the percentage of those under 35 who would prefer to live in a big city increased significantly, with nearly 40% stating that preference in the 2016 TCRP survey conducted for the current study, TCRP Project H-51.
- In the 2014 TransitCenter survey, which used a somewhat different set of location options, about 60% of millennials stated they would prefer to live in the suburbs (TransitCenter 2014).
- Younger age groups believe they are less dependent on cars than their parents.
- Younger age groups are far more open to sharing a vehicle than the older groups.
- The youngest age group (those less than 25 years of age) reported using a friend's car at four times the rate of older groups.

Millennials are now predicted to decrease their transit use patterns as the cohort ages over the next two decades. Although millennials have delayed household formation as compared with past generations, most fully expect that as they age and start families, they will choose to move to the suburbs and will use transit less. Thus, a critical market group presently consuming transit at high rates will most likely soon see a sharp decline in its transit use. Proactive policies should be developed to deal with this potential outcome.

All of this serves to set the demographic context for the next few decades. A loyal group of users with at least some very pro-transit values and preferences will be proceeding through middle age, where it will experience powerful forces that serve to decrease transit ridership. Figure ES-1 shows the impact of age-based factors on the propensity of different age groups to use transit. The implications are clear; as this cohort proceeds through the age groups and through phases of the life cycle (e.g., increasing presence of children in the household), its transit use rates will decline with age. The remaining question is the extent to which this pro-transit cohort can retain some portion of its positive travel behavior patterns, not whether it can totally avoid the age-based downward pattern illustrated in Figure ES-1.

Race and Ethnicity and Transit Ridership

Additional demographic factors have powerful and consistent implications for attitudes toward and use of public transportation. Transit riders are more diverse than they were previously, now nearly evenly split nationwide between white, African-American, and Hispanic riders. Chapter 2 describes how nonwhite populations have higher rates of transit use than white populations for every transit mode and for walking/biking. Hispanic populations also have higher transit use than non-Hispanics for every transit mode and for walking/biking, a pattern that remains dominant even when income level or home location are controlled for.

Location Is Critical

Understanding where people live is essential to understanding how much they choose transit today and how much they might choose it in the future under various scenarios tested in this study. The way in which geographic factors interact with propensity to use transit is explored in some detail in Chapter 3.

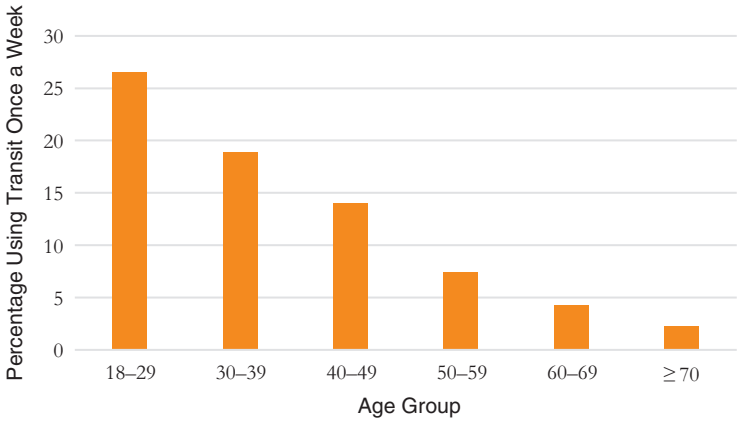

Figure ES-1. Effect of age on transit use.

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Transit Use by Residential Neighborhood Type

The nature of neighborhoods has a strong impact on transit ridership; neighborhoods with higher density and more pedestrian-oriented design tend to support higher levels of transit services. The combination of such land use patterns and a higher level of transit service is referred to in this report as being "transit-oriented." The transit orientation of a residential neighborhood can be categorized by the extent to which it supports transit ridership, as demonstrated in the Environmental Protection Agency's (EPA's) Smart Location Database project (EPA n.d.). Researchers in that program developed a new evaluative metric that takes the form of the ratio of transit accessibility divided by highway accessibility, with number of jobs per travel time as the metric for each. The overall transit orientation of any area can be characterized with this transit–highway ratio, a method that its developers report can stand as a surrogate for traditional indexes such as density, design, and diversity.

Consistent with expectations, the 2014 TransitCenter survey (TransitCenter 2014), which covered 42 metropolitan areas, found that 23% of trips were made by transit in the neighborhoods with the highest comparative transit accessibility; just 3% of trips were made by transit in neighborhoods with the lowest level of accessibility. Clearly, the nature of the neighborhood in which one lives is a key factor in understanding transit use.

What Will They Do in the Future?

More than 50% of the millennials in the sample live in cities now as compared with less than 40% of the older age groups. When respondents look 10 years in the future, fewer in all age groups except the oldest (65 years and older) expect to live in a city. Furthermore, millennials predict a substantial reduction in their personal public transit use, whereas the older two age groups see an increase.

The project's attitudinal research suggests the millennials will not continue to prefer the densely settled urban setting. A careful review of the factors documented above shows that millennials (particularly those in the group aged 25 to 34) are acutely aware that their lives will soon change, and many will be looking for better schools and more living space. They are ready to move on and more willing than other groups to increase their commute by 40 minutes to get a bigger home. As urban as their present situation might be, and as much as they want to live in an urban setting, they expect to appreciate the suburbs more as they age and even admit their future home may look like their parents' home. The youngest group (those under age 25) most expects it will have to drive more with increasing age.

Transit Level of Service Is More Important Than Having a Population That Is Pro-Transit

This project created a new method that examines all three forces (demographics, geographics, and psychographics) in influencing transit markets simultaneously in an integrated modeling process. The unified model integrates several service assumptions with multiple demographic and market preference assumptions. The results from the new model help us understand how market preference variation relates to transit choices.

As explored in both Chapter 1 and Chapter 6, future scenarios were modeled in which all the population in the future year adopts a set of preferences positive for transit. At present, those under 30 have many market-based preferences associated with higher rates of public transportation, as do those with a graduate education. The model predicted that in a scenario in which the entire population had the set of preferences of the under-30

group and the best-educated group combined, transit ridership would increase by 13%. In a future scenario based on the attitude sets of those older than 65 and those with no higher education, the model predicted that transit ridership would decrease by 8%.

The research team then applied the same model to explore possible future scenarios based on assumptions about the quality of transit services offered, as described in Chapter 6. When the quality of TNC services was held constant, the model predicted that with improved transit services, ridership would increase by 30%, as discussed in Chapter 1. (Note: The 30% increase is not an actual forecast, but rather a portion of a larger what-if scenario exercise.)

The new integrated travel demand model can separate the impacts of hard explanatory factors (e.g., times, costs) on the propensity to choose transit from those of soft explanatory factors (e.g., attitudes, preferences). The study concluded that

- Improving transit service has a much larger impact on transit use than does having a population with the attitudes, preference, and demographics of the most pro-transit members of the population and
- The fate of transit probably lies primarily with those designing the routes and services.

That is, transit's fate is not primarily determined by difficult-to-analyze issues such as future values, preferences, and attitudes or future demographic mixes.

Transportation Network Companies Will Offer More Competition

The integrated model described above offers some sense of scale for the vulnerability of various transit markets to new competing services from the TNCs. As reported in Chapter 6, an optimistic scenario for the future of transit is one in which both bus and train service are improved, resulting in a 30% increase for transit; this scenario holds future TNC services (both private and shared) constant. However, when improvements to TNC services are also assumed, the increase in transit use is only 22%. In other words, TNCs may have an impact on transit agencies even if the agencies improve their services as they explore and develop new forms of services.

Implications for the Leaders of the Transit Community

Chapter 1 presents a wide variety of implications and recommendations for leaders in the transit community. Some influencing factors are simply out of the control of those who would advocate more transit ridership: the progression of the separate cohorts through the age groups will happen independently of what transit proponents do or do not do, as will the ethnic composition of the local area population. Other factors, however, can be influenced by public policy, even if that policy is generated outside the transit agency.

The research concludes that new types of transit services will be urgently needed in areas of lesser density, where walking and neighborhoods that are transit attractive and accessible will be essential, even within the context of so-called suburban settings. To improve transit use, urban planners will need to stress the importance of urban design, livability, and walkability and emphasize the need for better coordination of planning, zoning, and housing policy with transportation planning and policy.

Finally, while it may be difficult to influence traveler preferences (including longer-term values and shorter-term attitudes), those in the transit community can try to affect the

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formation of attitudes. This is particularly important for those under 35, who, this research found, are highly influenced by peer pressure and the opinions of those within their immediate social networks. Although attitudes are less important than the design of routes and services, transit agencies can pursue efforts to influence attitudes toward their services through marketing (e.g., branding, image building, and promotion). Additionally, the design of services is highly correlated with the land use that is being served, and land use is influenced by many partners of transit agencies, such as regional and local leaders and planners through their policies, initiatives, and decisions. Attitudes and related demand for transit are influenced by density, diversity, and design, which are not within the control of transit managers. The three "D's" also greatly influence the design of affordable services. For these reasons, the phrase "leadership of the transit community" should be interpreted broadly to incorporate all whose actions contribute to the creation of a supportive transit market setting.

CHAPTER 1

Eight Major Findings and Policy Implications

Transit managers, planners, and stakeholders need to understand how multiple future factors might influence the nature of demand for transit services in North America. For this study, *TCRP Research Report 201: Understanding Changes in Demographics, Preferences, and Markets for Public Transportation,* the research team created a set of future scenarios for transit markets to understand how shifts in demographics, attitudes, and levels of service might affect demand for transit.

The study focuses primarily on factors beyond travel times and costs (supply characteristics) and seeks to improve the understanding of the background conditions that affect market behavior. The relationship between market demand, supply, and ridership is diagrammed in Figure 1. The research incorporated differing assumptions about demographics, transit orientation of the neighborhood, and market-based preferences, including values and attitudes. All three elements would be needed to support the development and analysis of alternative scenarios for the future of the transit industry in North America. All three elements are also needed to better understand the possible impacts of technology-based services such as transportation network companies (TNCs) in both the complementary and the competitive role with transit ridership.

Research Approach

Research has established that transit use is influenced by the urban form of the neighborhood, the demographics of the user, and the values and preferences of the user. These factors influence user mode choice through their relative times and costs. All three forces are interrelated when it comes to transit use—one's values influence the choice of residential neighborhood, and the characteristics of that neighborhood and the service options available there influence short-term attitudes about taking transit. These factors cannot be fully untangled, but this study attempted to look at the effects of each factor separately to the extent possible. Additionally, patterns of travel are influenced by age and membership in a cohort of travelers. Cohorts retain some level of consistency as they age.

The project has several implications for transit policy makers. For one, a critical market group presently consuming transit at high rates will soon see a sharp decline in its transit use: proactive policies must be developed to deal with this potential outcome.

The project used data from a 2014 survey of 11,000 residents in 46 metropolitan areas undertaken by RSG for TransitCenter (hereafter referred to as the "2014 TransitCenter survey") (TransitCenter 2014) and a new survey of 3,500 residents in 24 metropolitan areas undertaken by RSG in 2016 for TCRP Project H-51 (hereafter referred to as the "2016 TCRP survey"),

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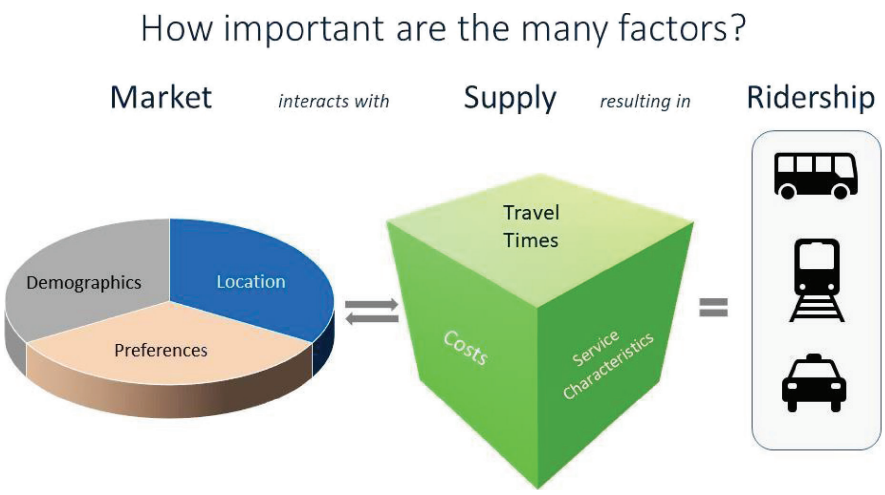

Figure 1. Factors affecting transit use: this study focused primarily on the underlying market factors shown in the pie chart on the left.

which is the subject of this report. In addition, members of the research team have leveraged extensive personal experience in interpreting the NHTS results of the past several decades.

This chapter covers eight major findings from the project:

1. Demographic factors are critical for predicting future markets for transit.
2. Location is critical for predicting the future markets for transit.
3. Market-based preferences are critical for predicting the future markets for transit.
4. Age, preferences, and location together affected changes over the past decade.
5. Age, preferences, and location together explain expected changes for the future.
6. Transit level of service is more important than having a population that is pro-transit.
7. TNCs will offer more competition.
8. The results of the study have strong implications for the leaders of the transit community.

The research team created seven technical appendices to accompany this report. These appendices include a bibliography and literature review and additional information on the subjects covered in Chapters 2 through 7 of the report:

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Major Finding 1. Demographic Factors Are Critical for Predicting Future Markets for Transit

The relationship of some demographic and geographic factors within transit markets is more direct than that of other factors. Nevertheless, these factors are critical for predicting transit markets.

Age and Transit Ridership

Age provides the most consistent reference point for the analysis of how the demographics of the traveler affect travel preferences, characteristics of the traveler's residential location, and the modes available for a specific trip. Chapter 2 explores this topic in greater detail and examines age as an organizing factor among many interrelated factors that affect transit use in North America. The chapter reveals the strong role age plays in explaining transit mode share and the much weaker role of gender. Younger people consume more public transportation services and older people consume fewer. The role of gender is less clear. Gender per se is not an effective predictor of propensity to use transit, but men tend to take more rail transit trips than women. On the other hand, differences exist between men and women in their attitudes and preferences concerning home location, tolerance for sharing space, and feelings of independence from the private automobile. These differences are explored throughout this report.

Age and Demographic Shift

This study concludes that there will be a major demographic shift that could affect the makeup of the transit market over the next three decades. Demographic analysis reveals that the millennial generation is now the largest single age-based component of the United States population. As of 2010 (the best census year for comparison with the results of the 2009 NHTS), there were 1 million more millennials in the United States than baby boomers; it is forecast that by 2030, there will be 22 million more millennials than baby boomers (McGuckin and Lynott 2012). In 20 years, a cohort now in an age bracket roughly between 15 and 35 will be in an age bracket between 35 and 55.

Role of Age Over a Two-Decade Period

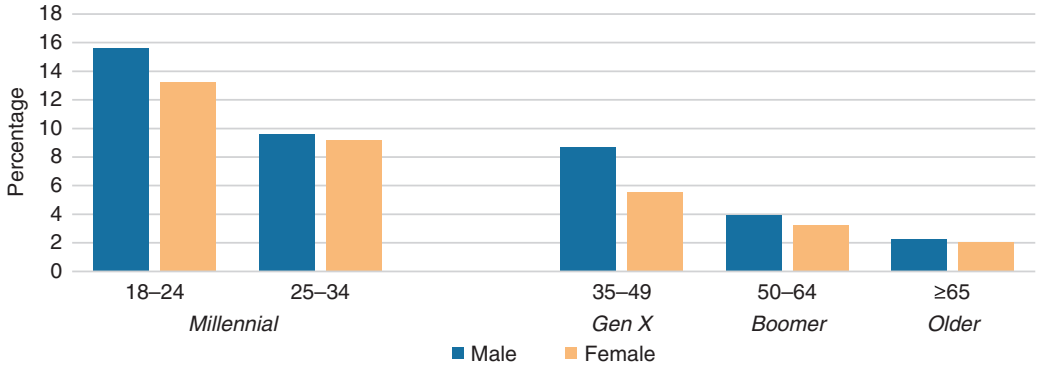
While transit trip rates grew solidly in the nearly two decades between the 1990 NHTS and the 2009 NHTS, the age groups showed different growth rates. In the 2009 data, those under 25 used transit at about the same rate as those in that age group two decades earlier: all the other age groups registered significant increases in their rates of transit trip making. Importantly, rates of transit use of individuals between the ages of 25 and 34 in 2009 were almost as high as those of the youngest age group (those under 25).

This study revealed new insights on issues potentially affecting the future of public transportation in the United States. Many factors have historically driven transit use; the most informative factor is age. The youngest age group (those under 25) has the highest rate of transit use and often has the highest propensity to hold pro-urban attitudes and preferences. Both Figure 2 and Figure 3 demonstrate that transit use decreases with increasing age. Whether millennials can maintain their historically high transit use is a key future question.

This research has documented something more complicated: the transit-riding behavior of the 16- to 24-year-old age group is no different from the behavior of past cohorts when in that age group. Transit use at this age is high, but that is no different from the pattern of the past 25 years. However, those aged 25 to 34 in 2009 were using transit at a far greater rate than those in that age group in the base year of 1990. In other words, this cohort continued the high transit use patterns of their youth as they proceeded into their late twenties and early thirties.

In addition, those aged 35 to 55 were using transit at a far greater rate than their historical predecessors. The extent to which the high rates of transit for the younger age groups can be partially maintained as the cohorts age is unknown. However, those who were between the ages of 35 and 55 at the time of the 2009 NHTS used transit considerably more often than those who were between 35 and 55 at the time of the 1990 NHTS. Notwithstanding the effects of migration, this finding implies that at least one cohort retained a certain level of transit orientation as

10 Understanding Changes in Demographics, Preferences, and Markets for Public Transportation



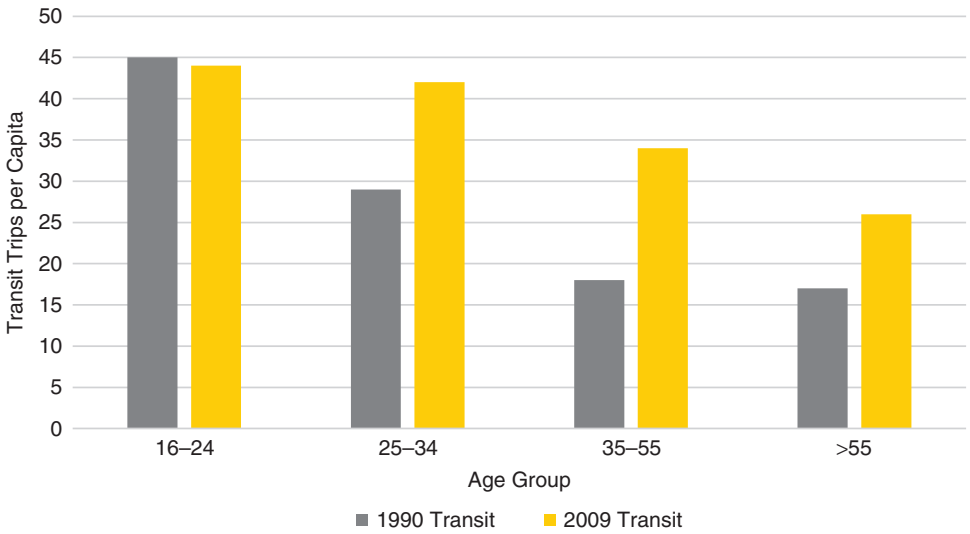
Source: TransitCenter 2014.

Figure 2. Transit share of all trips in metropolitan areas by age and gender.

it aged. This cohort's experience touches on the central research question: to what extent will those in the 25- to 34-year-old age group continue their current level of transit orientation? The research found that while fundamental attitudes supportive of urbanism will continue, pressures to find appropriate housing will result in some of these pro-transit individuals living in locations much less supportive of transit use.

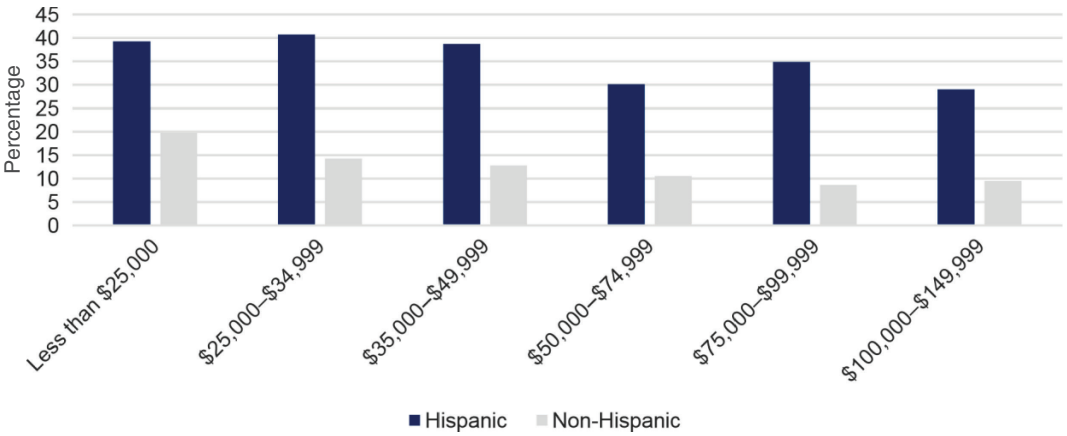
Race and Ethnicity and Transit Ridership

Demographic factors have powerful and consistent implications for attitudes toward and use of public transportation. Transit riders are more diverse than they were previously—now nearly evenly split nationwide among white, African-American, and Hispanic riders. Chapter 2 describes how nonwhite populations have higher rates of transit use than white populations for every transit mode and for walking/biking. Hispanic populations also have higher transit use than non-Hispanics for every transit mode and for walking/biking. The project also reviewed the extent to which transit use by Hispanics might be attributable to confounding factors such as income and exposure to better transit services rather than to race and ethnicity.



Source: 1990 and 2009 NHTS.

Figure 3. Annual transit trips per capita, 1990 compared with 2009.



Source: TransitCenter 2014.

Figure 4. Higher transit mode share by Hispanics not a function of income level.

Figure 4 shows that there is a wide difference between the propensity of Hispanics and non-Hispanics to take transit at all income levels. However, the research team found that this difference is not attributable to differing levels of transit service quality within residential neighborhoods. Hispanics use transit more than others at all levels of transit quality, which rebuts the argument that the higher rates might be attributable to their residential location relative to high-quality transit services, as discussed further in Chapter 2.

Effect on Transit Use of Being Born Outside the United States

The travel behavior of those who migrated from other countries reflects acculturation in which initial patterns are (eventually) replaced by patterns more influenced by the new community. Recent immigrants are less likely to have an automobile when they arrive, but the difference in auto availability decreases over time via acculturation.

Impact of Other Demographic Variables on Transit Use

The impact of socioeconomic variables such as income level is twofold. First, greater disposable income facilitates more travel. Second, greater income also allows for more selectivity in turning away from transit and toward driving. Other variables, such as education level, are highly intertwined with other factors and often difficult to sort out.

Major Finding 2. Location Is Critical for Predicting Future Markets for Transit

Knowing where people live is essential to understanding how much they choose transit today and how much they might choose it in the future.

Knowing where people live is essential to understanding how much they choose transit today and how much they might choose it in the future under various scenarios tested in this study. The way in which geographic factors interact with propensity to use transit is explored in some detail in Chapter 3.

Transit Use by Region

The quality of transit services offered varies by region, and the quality of transit accessibility affects transit demand. Analysis undertaken in the 2014 TransitCenter survey showed that six American cities—New York, Philadelphia, Boston, Chicago, San Francisco, and

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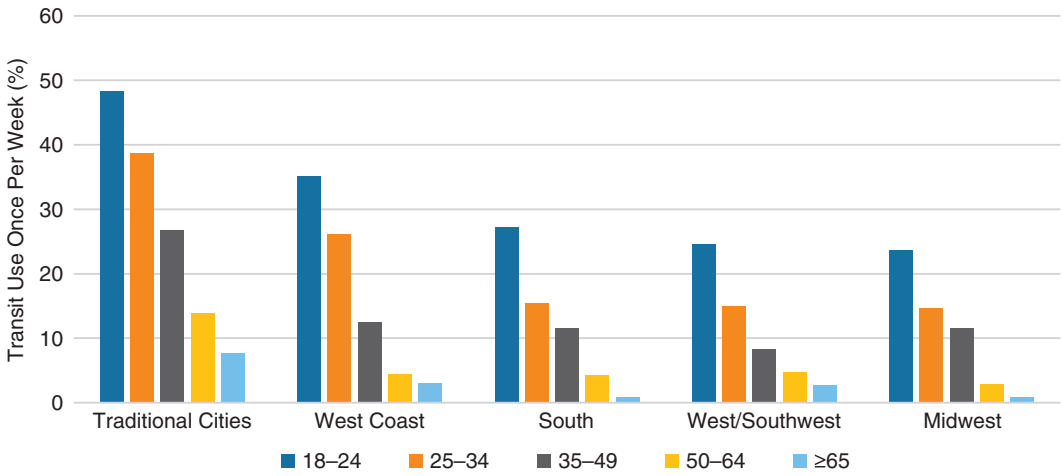


Source: TransitCenter 2014.

Figure 5. Transit use by age group and region.

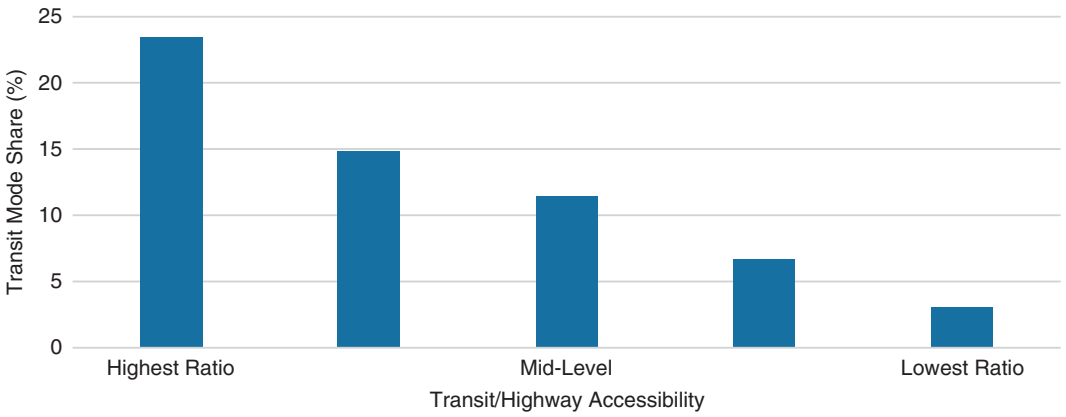
Washington, D.C.—had high and well-established transit ridership. These cities are categorized as "traditional cities." Beyond these cities, substantial variation by region was found.

Figure 5 shows that region explains some variation in propensity to use transit. For example, among those between 25 and 34 years old, 40% of those living in traditional cities used transit at least once a week, compared with only 15% in the Midwest. However, the study found that this variation in transit use was attributable to other factors, most of which reflect that the level of transit accessibility offered in the traditional cities is significantly higher than that in the Midwest, for example (see Chapter 7). Thus, there is no southern factor or northwestern factor for transit. This, in turn, suggests that the question of migration between regions can best be interpreted on its face value; individuals moving from an area with better transit to an area with worse transit decrease their transit ridership.

Region size is important, but its role is changing. This research found that the greatest rate of increase in transit ridership between 1995 and 2009 was not in the largest urban areas (e.g., New York City) but rather the midsized metropolitan areas. The highest rates of increase were seen in those metropolitan areas with populations between 500,000 and 3 million people. In some cases, but not all, these were areas in which new investments in capital facilities had occurred. Areas with populations between 1 and 3 million grew an impressive 45%, while those with populations greater than 3 million grew only about 10%; in the 2010 census, there were more than 30 metropolitan regions in the smaller population category. Quite simply, the increase in transit use does not all stem from New York City, Chicago, and San Francisco.

Transit Use by Residential Neighborhood Type

The nature of neighborhoods has a strong impact on transit ridership; neighborhoods with higher-density and more pedestrian-oriented design tend to support higher levels of transit services. The combination of such land use patterns and a higher level of transit service is referred to in this report as being "transit-oriented." The transit orientation of a residential neighborhood can be categorized by the extent to which it supports transit ridership, as demonstrated in a Smart Location Database research effort by EPA (EPA 2014). Researchers in that program developed a new evaluative metric that takes the form of the ratio of transit accessibility divided by highway accessibility, with the number of jobs within a given travel time as the metric for each. The overall transit orientation of any area can be characterized with this transit–highway



Source: TransitCenter 2014.

Figure 6. Effect of neighborhood type on transit mode share.

ratio (as shown in Figure 6)—a method its developers report can stand as a surrogate for traditional indexes such as density, diversity, and design.

Consistent with expectations, the 2014 TransitCenter survey of 42 metropolitan areas found that 23% of trips were made by transit in the neighborhoods with the highest transit–highway accessibility ratio; just 3% of trips were made by transit in neighborhoods with the lowest level of accessibility. Clearly, the nature of the neighborhood in which one lives is a key factor in understanding transit use.

Transit Use by Employment Location

The transit orientation of employment location is more difficult to draw conclusions from. Chapter 3 demonstrates that the pattern of job-location moving to the suburbs over the past few decades has been detrimental to transit. On the other hand, geographic experts have been documenting an evident return to highly urbanized downtown areas in the past few years by certain employer categories. The extent to which this pattern reverses a long-dominant trend of decentralization of jobs overall remains to be seen.

Major Finding 3. Market-Based Preferences Are Critical for Understanding Present and Future Orientation Toward Transit

This study defined four separate market segments of respondents in the 2016 TCRP survey conducted for the study. The segments were defined by their attitudes and preferences, ranging from those with attitudes supportive of transit to those with attitudes opposed to transit. These four groupings of survey respondents and the process used to derive them, are described in more detail in Chapter 4. The research revealed the attitudes of various demographic market groups toward several key issues. Highlights of those findings are as follows:

Attitudes about urbanism:

- Those under 35 years of age were more likely than those in the older age groups to report that it was important to them to live in a neighborhood with ethnic diversity and shops and restaurants within walking distance.
- Millennials were more likely than any other group to prefer to live in the city.

- Over the past 12 years, the percentage of those under 35 who would prefer to live in a big city increased significantly, with nearly 40% stating that preference in the 2016 TCRP survey; the remaining 60% were divided across a set of less urban options.
- About 60% of millennials stated they would prefer to live in the suburbs in the 2014 TransitCenter survey, which used a somewhat different set of location options.
- Most millennials indicated wanting to live in a bigger house and were more willing than those in other age groups to drive longer distances to get to their destination; the same was true for Hispanics, nonwhites, and those who had not attended college.

Attitudes toward auto dependence:

- The under-35 age group stated the belief that they were less dependent on cars than their parents.
- The younger age groups were far more open to sharing a vehicle than were the older groups.
- Those under 25 reported using a friend's car at four times the rate of older groups.

Attitudes toward the environment:

- Millennials were more likely to express environmental optimism and reported that this would influence their choice of mode.
- Conversely, millennials were less likely to want to raise taxes to fix environmental problems.

Attitudes about safety and privacy:

- Millennials were more likely to be concerned about the lack of privacy on transit and about having to travel with people they did not know when using transit.
- Millennials were more likely to express fear about crime on transit, a concern shared with women, Hispanics, nonwhites, and those with lower incomes.

Perception of normative influences: The results of several analyses in this report suggest that normative support (friends and family) for transit is a key factor in encouraging transit use. Both of the younger age groups indicated that, while their friends and family did not typically use transit, they would approve of the respondent taking transit.

Attitudes about improvement to transit: If improvements to transit were implemented, those most likely to state they would increase transit use were those with full-time employment and college degrees, Hispanics, nonwhites, and the foreign born.

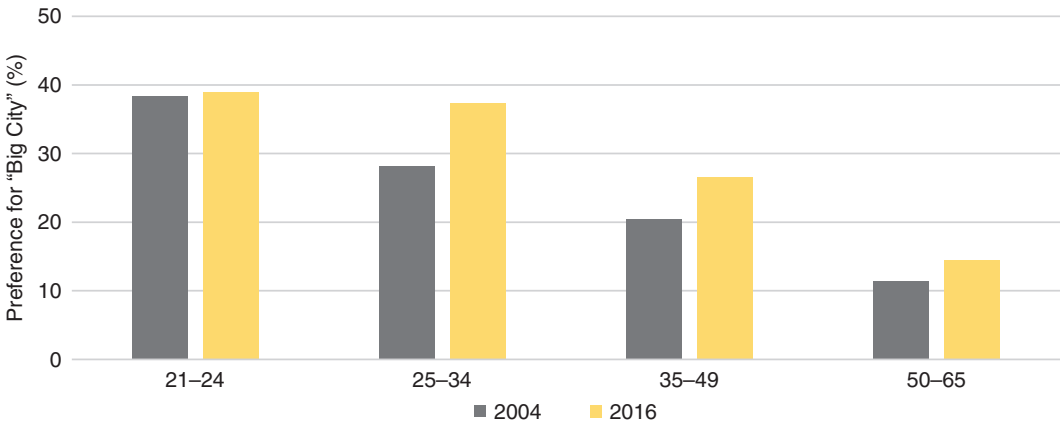
Attitudes about the need for information:

- Millennials were vastly more likely to report that their cell phone would be the most difficult possession to live without (as opposed to a vehicle or computer, for example); 50% of the youngest age group gave this response, compared with 10% of those over 65.
- Millennials—female millennials in particular—were more likely to report they were "not sure I know how to do all the things to make a bus or train trip work" than were those 35 years or older, with about 50% of millennial females agreeing compared with 32% of males 35 years or older.

Major Finding 4. How Age and Preferences Affect Location

Trends in Preferences for City Type

In a survey undertaken by the research team in 2004 as part of TCRP Project H-31 [see *TCRP Report 123: Understanding How Individuals Make Travel and Location Decisions: Implications for Public Transportation* (Karash et al. 2008)] and in the 2016 TCRP survey conducted for TCRP



Source: 2004 and 2016 TCRP surveys.

Figure 7. Percentage reporting a preference for "big city" in 2004 compared with 2016, by age group.

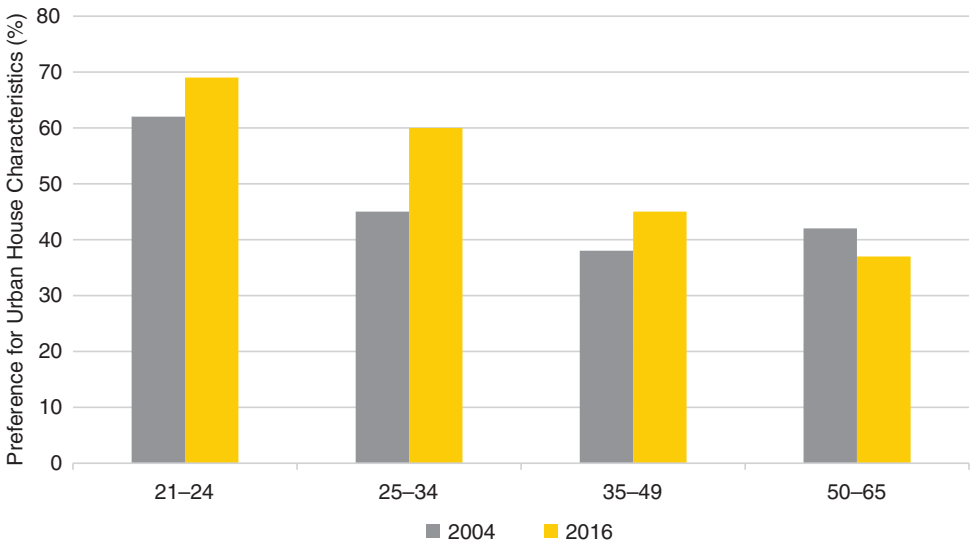
Project H-51, whose findings are the subject of the current report, respondents were asked to choose between a preference for a big city, small city, suburb, small town, or rural area. The research quantitatively documented that the preference for living in a big city increased over the 12-year period between 2004 and 2016 with little variation by age group. Figure 7 shows that over the 12-year period, each of the age groups increased its level of preference for the big city, with the highest rate of increase experienced in the 25–34 age group. Further results for this 12-year period presented in Chapter 5 show increasing preference for the small city and decreasing preference for the suburbs. With regard to the preference for the big city, the increase over the decade for those under age 35 was almost entirely attributable to the 25–34 age group, whose level of preference rose by a ratio of about 1.3 to 1 (i.e., the percentage preferring rose by a factor of 30%). The modest increase in preference for the big city, even among the older groups, is clearly consistent with the conclusion that these results reveal a general increase in the preference for urbanism between 2004 and 2016.

Trends in Preferences for Home Characteristics by Age

In a parallel attempt to elicit preferences about the type of home, the 2016 TCRP survey repeated the same question used in the 2004 TCRP survey:

> Suppose you have a choice between two similarly priced homes:
>
> 1. An urban townhouse within walking distance of stores and public transportation or
> 2. A house in the suburbs where you need to drive to get to most places.

Figure 8 shows an increase over time in the percentage of the sample preferring the urban townhouse over the house in the suburbs for age groups under 65. Again, the change between 2004 and 2016 was strongest for the 25–34 age group, whose preference for the townhouse increased from 45% to 61% (a ratio of 1.4 to 1)—a greater rate of increase than seen in the youngest age group, whose preference for the townhouse grew from 63% to 69% (a ratio of 1.1 to 1). This finding supports the observation that the preference for a more urban home setting seemed to be increasing between 2004 and 2016, particularly for those under 35; within that age group, the greatest rate of increase was seen among those between 25 and 34 years of age. It is also interesting that support for the urban context as expressed by the type of house (Figure 8) is so much higher than when expressed as the big city (Figure 7).



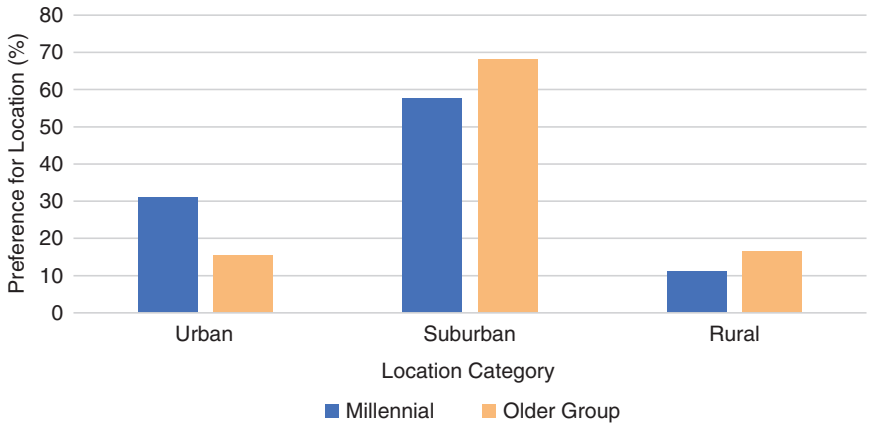
Source: 2004 and 2016 TCRP surveys.

Figure 8. Preference for urban house characteristics, 2004 versus 2016, by age group.

Present Preferences for Urban Locations

As noted, over the decade, support for the most urban condition has grown. In the 2016 TCRP survey, around 40% of those under 35 reported that they preferred the "big city" option, while the other 60% of this group reported preference for small cities, the suburbs, small towns, or rural locations (five options offered).

The 2014 TransitCenter survey asked respondents to choose their ideal location from only three options: urban, suburban, or rural; both those under and those over the age of 35 years expressed a clear preference for the suburban category over the other two options. Figure 9 shows the preferences of two age groups for the three types of location. While the trend over the



Source: TransitCenter 2014.

Figure 9. Preference for location, millennials versus older group. Suburban locations were preferred over both urban and rural locations for both age groups (2014).

decade is clearly improving for the most urban condition, most people in both surveys preferred less-urban options when given the choice.

Are the Reasons for Choosing a Home Location Changing?

Chapter 5 reports that the major considerations involved in the choice of the home location have not changed much at all, with little variation seen over the 12-year period between the surveys undertaken for TCRP Projects H-31 (TCRP Report 123) and H-51 (TCRP Research Report 201, the current report). In both years, the rank order of the three most important reasons were (1) price of the home, (2) minimization of commute distance, and (3) types of homes available. All three of these reflect the well-documented trade-off between wanting to minimize commute distance while desiring the variety of home and price combinations that increased distance provides. While some respondents did choose "within walking distance to stores" and "close to public transportation" as their primary reason for their choice of home location, both reasons ranked far lower than the top three in both survey years.

Major Finding 5. How Age, Preferences, and Location Explain Expected Changes for the Future

Age and Personal Expectations for Future Behavior

This study explored the concept that transit use is affected by several factors. Such factors are the backdrop against which the user chooses between immediately available modes on the basis of their relative times and costs. Importantly, these factors will again come into play when the individual enters a new life phase and chooses a new home location.

What Do They Expect to Happen in Their Lives?

Given the conclusion that there has been something of a shift in preferences and attitudes toward urbanism (most consistently among the 25- to 34-year-old cohort of millennials), how do the members of the 2016 TCRP survey sample expect that they will change their behavior over the next decade? As explored further in Chapter 5 of this report, the present research shows that the clear majority of those under 35 expect major events such as marriage and child-rearing to occur, while the majority of those over 35 have moved on to deal with other expectations, such as becoming an empty-nester and retiring.

Desires for Future Home Location

In the next phase of an individual's life, preferences for future home locations are influenced by age and by psychographic grouping (i.e., market segment). In the 2004 and 2016 TCRP surveys, the research found that most of the primary reasons for choice of residential location involved the trade-off between wanting to minimize commute distance and the home–price combinations that increased distance would provide. That is, the individual chooses the next home location in a high-stakes trade-off between desired attributes (short commuting distances) and constraining realities (price for a given set of home features).

What Will They Do in the Future? At the time of the survey more than 50% of the millennials in the sample lived in cities versus less than 40% of the respondents in the older age groups. When respondents looked 10 years into the future, fewer respondents in all age groups except the oldest (65 years and older) expected to live in a city. Millennials also predicted a substantial reduction in their use of personal public transit, whereas respondents in the older two age groups foresaw an increase.

When respondents in the 25–34 cohort age into the next age group, they will face new challenges. Two questions based on this project's framework then arise:

1. Will respondents continue to value densely settled urban settings and stay in these locations?
2. Will respondents continue to hold preferences and attitudes that question the importance of auto ownership and facilitate shared vehicle use?

Stay with Urban Location? Research results suggest that, for many millennials, the answer to the first question is no, they will not continue to prefer the densely settled urban setting. A careful review of the factors documented above shows that millennials (particularly those in the 25–34 age group) are acutely aware that their lives will soon change, and many will be looking for better schools and more living space. They are ready to move on and more willing than other groups to increase their commute by 40 minutes to get a bigger home. As urban as their present situation might be, and as much as they want to live in an urban setting, they expect to appreciate the suburbs more as they age, even admitting their future home may look like their parents' home. The youngest group most expects it will have to drive more with increasing age.

Millennials and Emerging Adulthood. Many millennials had difficulty finding initial jobs around the time of the 2009 NHTS.[1] As a result, many are getting married later and settling into the first-owned home later. However, the survey work undertaken for this project (and described in Chapter 5) suggests that their intention is to get back into a pattern similar to that of previous generations, however late.

On the basis of the research conducted for this report, the millennial generation is a cohort that has delayed—or postponed—the timing of major permanent household formation activities such as leaving the home of the parent, getting married, and purchasing a home associated with child rearing.

The millennial generation is a cohort that has delayed—or postponed—the timing of major permanent household formation activities. . . . These young households will at some point continue a pattern in which the preference to stay close to desired activities (schools, jobs, present neighborhoods) is traded off against the inescapable fact that a longer commute distance brings a wider selection of adequate homes, neighborhoods, and prices.

The millennial generation is not a cohort that is denying or rejecting the next steps in the life cycle. These young households will at some point continue a pattern in which the preference to stay close to desired activities (schools, jobs, present neighborhoods) is traded off against the inescapable fact that a longer commute distance brings a wider selection of adequate homes, neighborhoods, and prices. In metropolitan areas where housing costs in closer-in settings have not exploded, it may well be possible for the next home selection move to be to a (close-in) suburban neighborhood supportive of traditional transit services.

However, in the cities where transit has been most successful, it is possible that the explosion in home prices will make that desired relocation virtually impossible. This would result in many who hold pro-urban values ending up in distant, lower-density locations despite those long-held values. The result is a condition of dissonance between valued location and actual location. A recent study in Boston concluded

> [A]s Millennials age and consider planting more permanent roots, Greater Boston's housing market may push them to other locations. [Our] respondents reported that housing costs have already had an impact on their decisions: In the last five years, 33% were forced to move because either their rent or mortgage payments were too high. (Vance and Ciurczak 2017)

Implications

This study found that many in the cohort between 25 and 34 years of age will face location decisions that may or may not reflect their longer-term values to be loyal to a highly urban lifestyle. The study has shown that, as this cohort aged out of the youngest group, it kept up a strong pattern of transit use. Now, the members of this group report that they expect to move

[1] The unfavorable economic circumstances for the millennials in 2009 is explored in NCHRP 08-36, Task 132 (AASHTO 2017).

to less-dense settings and to use transit less. A major question for the transit industry is how to benefit from some of the basic pro-urban preferences of this group as they relocate to less transit-supportive locations.

Major Finding 6. Transit Level of Service Is More Important Than Having a Population That Is Pro-Transit

This study created a new method that examines all three forces (demographics, geographics, and psychographics) that influence transit markets simultaneously in an integrated modeling process. The unified model integrates several service assumptions with multiple demographic and market preference assumptions. The results from the new model are helpful in understanding how market preference variation relates to transit choices, with illustrative highlights shown in Table 1.

Scenarios Positive for Transit

Future scenarios were modeled in which the entire population in the future year adopts a set of preferences positive for transit:

- At present, those under 30 have many market-based preferences associated with higher rates of public transportation. In a future scenario, if the entire population had the attitudes and preferences of the under-30 market segment, the model predicts that overall transit ridership would increase by 5%.
- At present, those with a graduate education have market-based preferences associated with their higher rates of taking public transportation. In a future scenario, if the entire population had the attitudes and preferences of the best-educated market segment, the model predicts that overall transit ridership would increase by 8%.
- Finally, in a future scenario in which the entire population had the set of preferences of both the under-30 group and the best-educated group together, the model predicts that transit ridership would increase by 13%.

In all three future scenarios, the level of transit service offered was constant. In a less-dramatic scenario, if the entire population were to adopt the preferences of the group just one level lower in age and one level higher in education, transit ridership would increase by 4%.

Table 1. Projected mode use change from alternative attitudinal scenarios.

	Projected Change (%)					
Scenario	Bus	Train	Total Transit	TNC, Private	TNC, Shared	Car
Transit-Positive						
All adopt under age 30 and graduate degree attitudes	11	15	**13**	13	19	–26
All adopt graduate degree attitudes	6	10	**8**	–3	7	–11
All adopt under age 30 attitudes	6	5	**5**	18	12	–15
Transit-Negative						
All adopt over age 65 attitudes	–5	–1	**–3**	–23	–11	13
All adopt no college attitudes	–4	–6	**–5**	0	–5	8
All adopt over age 65 and no college attitudes	–9	–7	**–8**	–23	–16	21

Scenarios Negative for Transit

The research team also modeled future scenarios in which the entire population in the future year adopts a set of preferences negative for transit:

- At present, those over 65 have many market-oriented preferences associated with lower rates of taking public transportation. In a future scenario, if the entire population had the attitudes and preferences of the oldest market segment, the model predicts that overall transit ridership would decrease by 3%.
- At present, those with no college education have market-oriented preferences that are associated with lower rates of taking public transportation. In a future scenario, if the entire population had the attitudes and preferences of the least-educated market segment, the model predicts that overall transit ridership would decrease by 5%.
- Finally, in a future scenario in which the entire population had a set of attitudes and preferences reflecting those of both the oldest and the least-educated market segments, the model predicts that overall transit ridership would decrease by 8%.

Again, the level of transit services was held as a constant. In a less-dramatic scenario, if the entire population were to adopt the preferences of those just one level higher in age and one level lower in education, transit ridership would decrease by 5%.

The research team then applied the same model to explore possible future assumptions about the quality of transit services offered (Table 2).

Improving transit service has a much larger impact on transit use than does having a population with the attitudes, preference, and demographics of the most pro-transit among us.

The new integrated travel demand model can separate the impacts of hard explanatory factors for the propensity to choose transit (times, costs) from soft factors (attitudes, preferences). This comprehensive study concluded that the direct elasticities associated with improving transit services explained more than all the cross elasticities examined in the study. In other words, improving transit service has a much larger impact on transit use than does having a population with the attitudes, preference, and demographics of the most pro-transit among us. This study concluded that the fate of transit probably lies primarily with those designing the routes and services. Transit's fate will not primarily be determined by difficult-to-analyze issues such as future values, preferences, and attitudes or future demographic mixes.

Major Finding 7. TNCs Will Offer More Competition

Travel options have expanded over the past decade. People in urban areas depend on TNCs such as Uber and Lyft, carshare and bikeshare services, and other means for both work trips and nonwork trips. This shift seems to enable selecting a travel mode on the basis of daily

Table 2. Projected change in transit use on the basis of alternative service quality scenarios.

	Change (%)		
Change to Service	Bus	Train	Total Transit
All bus and train service better; TNC service worse	36	34	**35**
All bus and train service better	31	30	**30**
All bus and train service better; TNC service better	22	22	**22**
All train service better	–37	78	**19**
All bus service better	78	–40	**21**
All car usage worse	9	8	**8**

circumstances rather than habit. The integrated travel demand models developed in this project can be helpful to better understanding what might happen in the future with alternative roles for the new services.

New services from the TNCs could impact transit ridership, even if the agencies improve their services.

Variation in Use of and Attitude Toward TNC Services

The 2016 TCRP survey showed that younger people are more likely to use newer transportation options (e.g., TNCs, carshares, bikeshares) and to use them more often. Although trips using TNCs for nonwork purposes were reported across all age groups, millennials also reported using TNCs for commuting. The car ownership rate for people with access to carshare programs was about half that of those without such access.

As discussed in the recent literature, the role of new service types enabled by information and communications technology (ICT) remains one of the major unanswered questions concerning the future market setting for transit (Clewlow and Mishra 2017). The integrated model described above offers some sense of scale for the vulnerability of various markets to new competing services.

As shown in Table 2, an optimistic scenario for the future of transit is one in which both bus and train service are improved, resulting in a 30% increase in transit ridership; this scenario holds the two TNC service categories constant.

However, when improvements to TNC services are also assumed, the increase in transit is only 22%. In other words, TNCs could pose an increasing challenge to transit agencies, even if the agencies improve their services.

The propensity to take TNC services varies significantly by age group. The scenario testing model described a future in which all age groups adopted the preferences of the under-30 age group; in this alternative scenario, ridership in shared TNC increased by 12%. On the other end of the spectrum, if all age groups adopted the market preferences of the over-65 age group, overall ridership on the shared TNC service would decrease.

These calculations from the integrated modeling program support a basic paradigm that, in some cases, some new TNC services will operate as a competitive mode with transit. Further caution about the impact of demographic categories (in this case, age) comes from the response to the statement: "In general, if the shared car allowed me to wait less time than for the bus, I would take the shared car." More than 50% of those under 35 years old agreed with this statement, while less than 50% of those over 35 agreed. This is generally consistent with the response to the statement, "If driverless cars were to become a reality, I would be less likely to travel by public transportation." Here, about 48% of those under 35 agreed, with less than 30% of those over 35 agreeing. In both cases, the millennials displayed far more interest in moving away from traditional transit than the older age groups.

Looking forward, millennials are embracing technology and the changes in travel behavior. TNCs and share programs/services that offer options for multimodal travel are growing at aggressive rates, fueled mostly by younger travelers. Looking farther out, younger people tend to imagine a world where autonomous cars would replace transit, while older respondents do not.

Major Challenges Revealed

Millennials are more concerned about security and disturbing behavior on public transportation than other groups: this could be a serious problem as new forms of competition (e.g., shared TNCs) emerge. Millennials are also more likely to say that conditions on public

transportation expose them to undesirable, disturbing behavior. These concerns could affect their future choice of mode, as illustrated in the following hypothetical scenario:

> Millennials perceive a shared-ride car or van as being local and filled with local people, while they perceive the transit bus as being regional and filled with people "not like me" who exhibit disturbing behavior. Moreover, given that millennials are more open to trying new things, they have more propensity than other age groups to say they would take the shared car.

In their survey responses, millennials strongly supported the statement that they "would be less likely to travel by public transportation" in a world with autonomous cars.

All of this suggests that a valued transit market group is soon to move to less-dense and less–transit-supportive areas, and millennials hold some major concerns about their safety on transit. Over time, their mobility options will change, and traditional patterns will be reexamined. At that point, it would be highly desirable for transit operators and TNCs to work together to maximize the complementary nature of their service offerings. The perception by some that transit is associated with upsetting, disruptive behavior remains a serious challenge for the industry. If transit services can provide an increased feeling of safety on board transit, and other providers can offer supportive services to help meet noncommuting mobility needs, a pattern of a mobile life with less dependency on automobiles is more likely to be nurtured and survive.

Major Finding 8. Implications for the Leaders of the Transit Community

The research summarized in this report reinforces some basic observations about the forces that come together to influence the market setting for transit. Some factors are simply out of the control of those who would advocate more transit ridership: the progression of the separate cohorts through the age groups will occur independently of what transit proponents do or do not do, as will the ethnic composition of the local area population. However, other factors can be influenced by public policy, even if that policy is generated outside of the transit agency. The research makes abundantly clear how important it is to design higher-density neighborhoods that promote walking and are transit attractive and accessible. Urban planners will need to stress the importance of urban design, livability, and walkability and emphasize the need for better coordination of planning, zoning, and housing policy with transportation planning and policy.

Attitudes and related demand for transit are influenced by density, diversity, and design, which are not within the control of transit managers. . . . The phrase "leadership of the transit community" should be interpreted broadly to incorporate all whose actions contribute to the creation of a supportive transit market setting.

Finally, while it may be difficult to influence traveler preferences (including longer-term values and shorter-term attitudes), those in the transit community can try to affect the formation of attitudes. Although attitudes are less important than the design of routes and services, transit agencies can pursue efforts to influence attitudes toward their services through marketing (e.g., branding, image building, and promotion). Additionally, the design of services is highly correlated with the land use that is being served, which, in turn, is influenced by many partners of transit agencies, such as regional and local leaders and planners, through their policies, initiatives, and decisions.

Attitudes and related demand for transit are influenced by density, diversity, and design, which are not within the control of transit managers. The "three D's" also greatly influence the design of affordable services. For these reasons, the phrase "leadership of the transit community" should be interpreted broadly to incorporate all whose actions contribute to the creation of a supportive transit market setting.

Policy Implications of the Scenario Testing Exercise

The project's advanced travel demand model provides the ability to separate out the impacts of hard explanatory factors for the propensity to choose transit (times, costs) from the soft

factors (attitudes, preferences). Chapter 1 concludes with a short set of observations about how the results of this study might be applied in support of the activities of the leaders of the public transportation community. Leaders of the transit community will be confronted with the need to influence both the hard factors and the soft factors. On the one hand, those in the service-planning field must be responsive to the needs of their clients today; on the other hand, those in transit marketing and capital planning must understand how those preferences will change tomorrow. It is not an either–or issue: transit leaders will need to deal with both hard and soft factors when planning for the future.

Meeting the Market Needs of Those Between 25 and 34 Years Old

Millennials, particularly those in the 25–34 age group, provide much reason for optimism about the future of public transportation in the United States: their attitudes about independence from car ownership and enthusiasm for the basic tenets of an urbanistic life are all strong. However, it is more complicated than that. This study leaves an important question unanswered: To what extent will this cohort retain these values as it seeks additional housing space and a residential setting supportive of the needs of bringing up and educating children?

Meeting Millennial Market Needs via Service Changes

The following facts and questions remain. Millennials hold urban neighborhoods in high regard but plan to move to less-dense settings anyway. Can transit build on this pro-urban attitude in less-dense areas? A major market segment will leave the best geographic setting for transit. Can the transit industry take advantage of the positive attitude toward transit in newer, less-dense residential settings?

- For transit managers, retaining an existing market in a new geographic setting will not be easy. For commuting services in lower-density settings, bus and bus rapid transit can benefit from large parking areas.
- For nonpeak services, contracts with both private and shared TNC services may help to support lifestyles associated with decreased auto ownership.

Meeting Millennial Market Needs via Technology and Communication

Younger age groups and most other market segments were found to appreciate being connected and productive while traveling. In particular, younger women were more likely than other groups to say that they needed more information to "make the bus or train trip work."

- Onboard and in-station Wi-Fi should be enhanced and promoted. Advanced way-finding technologies must be applied to the total transit trip, from door to door. Information must be improved for those making a transfer or moving onto services from a separate provider.
- The good news about transit—where it is, when it is coming, and what it can do—must be communicated through the same electronic devices that now provide just about all other information to the young. If information is not presented on a smartphone, it will not be used by these riders.

Implications of Demographic Change and the Need for Outreach

Meeting the Market Needs of Racially and Ethnically Diverse Riders

Demographic trends show that transit riders are becoming more diverse. Some demographic factors, such as being nonwhite, being Hispanic, and having spent one's childhood outside the

United States, are associated with higher use of public transportation. Transit riders today are split nearly equally nationwide between white, African-American, and Hispanic riders.

- Practical implications for transit leaders include a need for outreach to these communities to understand their needs. Outreach can also boost knowledge of the availability of and use of transit services.
- Marketing messages need to show the diversity of users that constitute transit ridership today. Implicit in this is that transit marketing should be emphasizing that the system welcomes everybody (e.g., "This is my transit, and I am proud of it" and "The transit community is made up of lots of people like me, and I feel welcome here"). Information conveying this message and others should be presented in several languages.

Meeting the Market Needs of Riders of All Ages

Age has a dramatic effect on transit ridership, with transit use per capita decreasing as age increases. However, while the youngest age cohort in 2009 (ages 16–24) used transit more per capita than the older cohorts, this group used transit slightly less than the same age group in 1990. Surprisingly, each of the older cohorts used transit more per capita in 2009 than in 1990. Those in the 25–34 group have maintained their high ridership as they have begun to age, and the greatest increase in transit riders has come from those between the ages of 35 and 55.

- The practical implication is to understand that the increase in transit ridership is not just from youth. Improvements, marketing, and outreach should be broadly aimed to retain higher rates of ridership in each age group.
- Increase in transit ridership could also come from older customers. Policies could deal with losing one's driver's license, which will become more common as older boomers age despite better health and safer cars.

Meeting the Market Needs of Riders of All Lifestyles

The life cycle also has a dramatic effect on transit ridership. The two groups with the most per capita transit use include singles and single parents as compared with couples and families with two parents.

- The largest increase in transit use has been among single parents. Features to make transit use more convenient for single parents, such as day care near transit centers, child-friendly fare systems, and easy boarding and alighting with low-floor vehicles should be implemented and emphasized.
- Municipal planners and federal funding agencies should rethink transit-oriented development, and joint development more broadly, to specifically include daycare and services to reduce the need for trip-chaining. There is also a need to rethink zoning and development changes and to better coordinate housing and transit service policies.

Making Transit Normative in the Minds of Riders

The results of several analyses in this report suggest that normative support of transit is a key factor in encouraging transit use. Those under 35, in particular, are highly influenced by peer pressure and by the opinions and support of those in their immediate social networks. The younger age groups indicated that while their friends and family did not typically use transit, they would approve of the respondent using transit.

- Promotional efforts could be directed toward families rather than just toward individual drivers to help build a foundation of support for the value of using public transportation.

Programs emphasizing that transit is a welcoming experience can be communicated through the reference to the full family, with pricing and service design policies to match.
- The basic message that "people like me" use transit, value it, and approve of it should be carefully integrated into marketing strategies.

Looking Beyond the Largest Metropolitan Areas for New Riders

As discussed, the greatest rate of increase in transit ridership between 1995 and 2009 was not in the largest urban areas (e.g., New York City) but rather the smaller metropolitan areas. The highest rates of increase were in metropolitan areas with populations between 1 million and 3 million. Areas with populations between 1 million and 3 million grew 45%; areas with more than 3 million grew by 10%. (The 2010 Census had more than 30 metropolitan regions with populations between 1 and 3 million.) Outreach programs for new residents can be conducted to introduce transit service and explain how transit works. Use of transit will depend more on the local characteristics of land use and transit performance (as reflected in the transit accessibility index) than on the transit characteristics of the new residents' former communities.

Expanding the Reach of Existing Systems

Transit must be prepared to welcome those migrating away from larger cities, whose serious lack of affordable housing might be attributed to the continued migration into those cities, which is in part because of the contribution transit has made to the urban lifestyle there. Partnering with local transport services through shared stop locations and integrating schedules and fare systems will extend service reach.

Implications for Improvement to Transit Service

Improving Travel Times and Reliability

Millennials have a somewhat higher propensity to say they would use transit more if its overall performance, as measured by travel time, reliability, frequency, and proximity, were improved. Across all age groups, concerns about travel time and reliability are rated as more important than frequency or proximity. The implication is that changes in future attitudes toward specific aspects of transit can influence demand but not by nearly as much as changes in the quality and quantity of service that is offered.

- Transit should continue to offer options that reduce travel time, improve reliability, and provide accurate information about arrivals and travel time.
- An example of proactive service options would be bus rapid transit, which has been designed to rebrand transit service to change image and related attitudes while also improving service.

Considering Integrating New Mobility Services into Transit Operations

While the ultimate effect of TNCs, carsharing, and ridesharing programs on transit use is uncertain, the present research indicates that ridesharing programs may contribute to reducing car ownership in some market segments and thus increase transit use. However, the integrated demand model indicated a competitive relationship between transit and the TNC shared services.

- Services such as Uber and Lyft are not going away. Formal or informal relationships with these services should be developed to provide an overall level of service that reduces the need for private automobiles.
- New institutional and business models should be developed that explicitly facilitate better integration of transit and shared-use mobility such as "Mobility as a Service."

Implications for Planning and Urban Form

Improving Riders' Perceptions of Safety

Those who worry more about crime and other disturbing behavior are the same groups that use transit most: women, nonwhites, Hispanics, younger people, those with less formal education, and those with less income. Logically, perhaps, these are the groups who do indeed face more danger with more ridership, or at least worry about it.

- Efforts should be made to improve the perceived safety of transit service, including transit stations and bus stops. Making the transit system safer and more attractive will likely help riders and their families and friends feel more positive about transit.
- Transit managers need to review design standards for stops and stations and work with municipal planners and leaders to coordinate planning for safe pedestrian access to transit.

Considering the Needs of Families and Women

This study clearly shows that the burden of poor essential mobility services in low-density neighborhood settings may fall disproportionately on women, whose trip-chaining patterns are more challenging than those of men (McGuckin and Murakami, 1999). A package of mobility services based on the real needs of families should be provided by transit advocates and should include children's amenities and support services that would reduce the need for trip chaining.

CHAPTER 2

Demographic Characteristics Affecting the Market for Transit

This chapter summarizes several sociodemographic changes that have, directly or indirectly, influenced the nature of the transit market over the past two decades. This chapter is structured in four parts:

1. Chapter highlights,
2. Key characteristics of transit users,
3. Key characteristics of transit trips, and
4. Trends in overall American travel patterns influencing the market for public transportation services, including vehicle miles traveled (VMT).

Highlights of Demographic Trends of Transit Riders

Characteristics of Transit Users

- The average transit rider has changed in the past few decades. Following trends in the U.S. population, transit riders are now more diverse—split nearly equally nationwide between white, African-American, and Hispanic, with recent growth in Asian and "other" identifiers.
- In terms of age, the data show that younger people have always taken more per capita transit trips than older people, but overall transit use has grown faster than the population of both 18- to 34-year-olds and 35- to 44-year-olds; that is, transit is growing faster than population would indicate.
- Legacy transit markets include single people, especially single parents, people with no access to a vehicle, and those who do not have a license to drive.

Characteristics of Transit Trips

- Approximately one-half of transit trips are work commutes or work related—a proportion that has remained stable for many decades. Only recently has the proportion shifted slightly toward more nonwork travel, led by travel for shopping and for social or recreational purposes.
- Evidence exists that more people are occasional users of transit, and transit agencies will possibly see continued growth in occasional riders.

Characteristics of Overall American Travel Patterns and VMT

- After a multidecade increase in the rate of VMT per capita, this pattern of continuous travel increase peaked in the first decade of this century. This important indicator declined from 2006 to 2013 and has shown a rebound since then.

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- This pattern of decreased auto use occurred most strongly in urban areas, among those under 35, and among men.
- From 16 to 30 years of age, there is a steady increase in VMT per capita; from the ages of 30 to 50, it remains flat; after age 50, VMT per capita decreases dramatically.

Trends in Characteristics of Transit Users

Younger and Older Transit Users

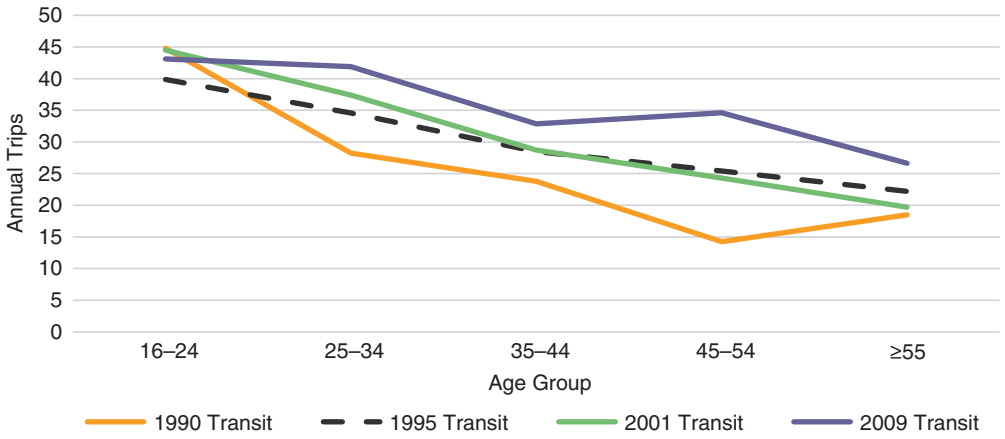
The discussion of the growing diversity of the U.S. population and transit riders must include the interrelationship between age and key demographic variables. As shown in Figure 10 the most recent NHTS data show higher per capita rates for transit use by all age groups except for the group aged 16 to 24; Figure 10 includes data from four NHTS surveys: 1990, 1995, 2001, and 2009. (These trends were explored earlier in Figure 3, which presented data only from 1990 and 2009.)

What Is Different About the Young Today?

The list of the ways young people today differ from those of earlier generations is extensive: the number of younger men who hold driver's licenses is at the lowest levels since 1970, and—for the first time—men between the ages of 25 and 29 are less likely than women of the same age to hold a driver's license (Office of Highway Policy Information 2017). More young people attend college (as a percentage of all high school graduates), and many return home after getting a degree. The highest percentage of people between the ages of 18 and 24 are living at home since 1960 (U.S. Census Bureau 2017). Since the recession, the unemployment rate for younger people remains stubbornly high (Bureau of Labor Statistics 2016, 2017). Other significant changes that affect travel choices have also been observed. For instance, the age of women when they have their first child is the oldest it has ever been (National Center for Health Statistics n.d.), as is the age of their first marriage (Arroyo et al. 2012). For the first time in history, for at least half of the younger generation, those life-changing events are in reverse order—first comes children, then comes marriage.

And the Older Groups?

While much of the public focus has been on younger people, at the other end of the spectrum are people in older age groups. The baby boomers (those born between 1946 and 1964) started



Source: NHTS.

Figure 10. Trends in annual per capita transit trips, by age group, 1990–2009.

turning 65 in 2011, and 1 million baby boomers will pass that milestone every year for the next 20 years. The population of older people in 2030 is projected to be twice as large as its counterpart in 2000, growing from 35 million to 72 million and representing nearly 20% of the total U.S. population (Federal Interagency Forum on Aging-Related Statistics n.d.).

Employment among people age 65 and older is at a record high. Nearly 27% of people between the ages of 65 and 74 are in the workforce, and baby boomers are swelling those numbers (Toosi 2005). The number of people living well past retirement age has been dubbed the "longevity revolution," and the mobility of older people has never been greater (Butler 2008). In fact, in 2009, the baby boomers had a high per capita vehicle use—much higher than that of previous generations of older Americans.

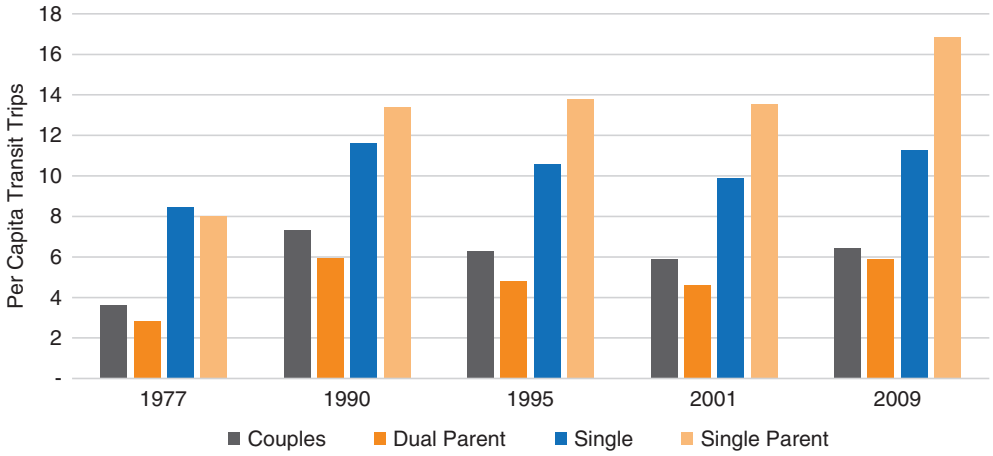
Although research shows that while most people age in place, baby boomers are also interested in mobility options as they age. Baby boomers who have moved in the past 5 years are more likely than any other age group to cite being close to public transportation as one of the reasons they chose their current home location (McGuckin and Lynott 2012).

Trends by Life Cycle

Over the past few decades, single people—and especially single parents—have used transit at higher rates than couples without children (including retirees) and couples with children at home. Figure 11 shows that single parents have the highest transit use per capita. This may illuminate some of the current transit use by younger people, who remain single longer than previous generations and delay marriage and child bearing. Traveling alone is the optimal situation for transit; traveling with children on transit can be a challenge, and trends show that people in nuclear family households—two parents and children—take the fewest transit trips per capita (Figure 11).

Race and Ethnicity

The population of the United States and its metropolitan areas diversified over the past few decades in tandem with the population of transit riders. The baby boomers, born after World War II when immigration was strictly limited, are one of the least diverse generations of the twentieth century. Since then, diversity has increased steadily—especially in the urban areas. Figure 12 shows the shifts in the proportion of transit riders by race and ethnicity between 1977



Source: NHTS.

Figure 11. Trends in per capita transit use by stage in the life cycle.

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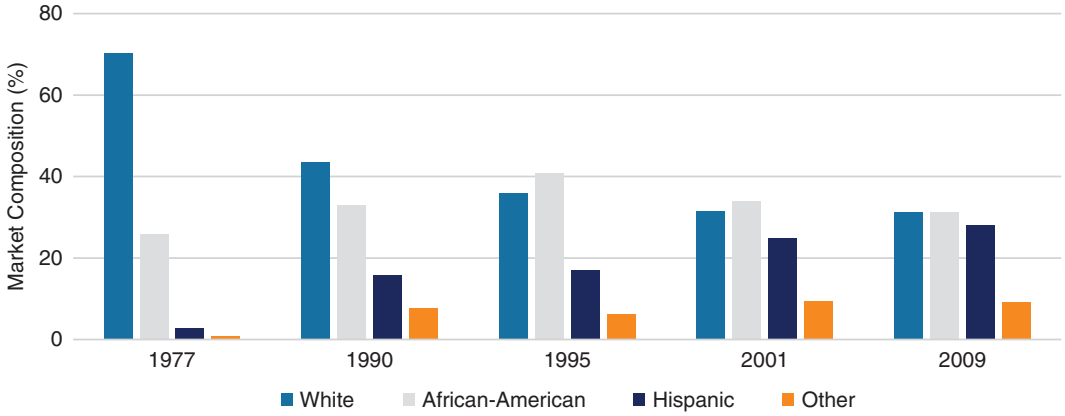


Source: NHTS.

Figure 12. Trends in market composition by race and ethnicity of transit riders (1977–2009).

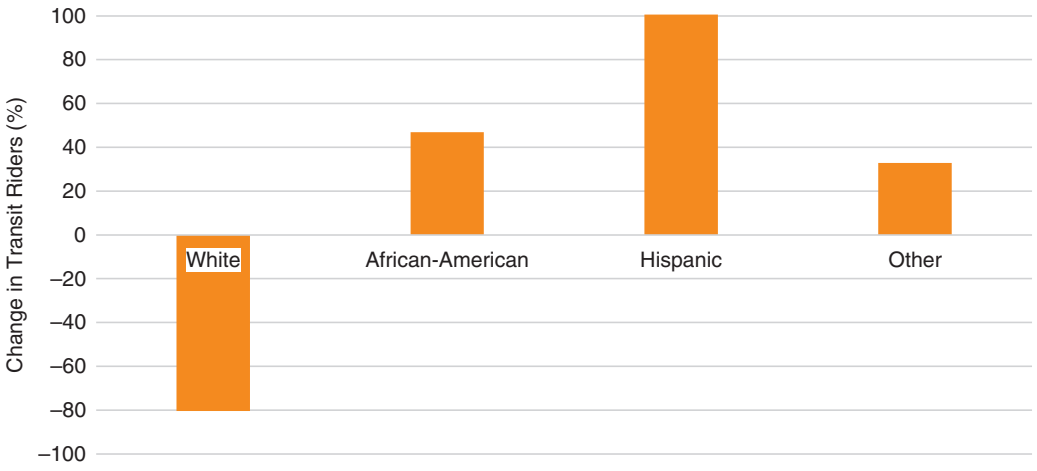
and 2009. The decline in the percentage of white transit riders is most pronounced in the 1980s and the growth in Hispanic riders is most pronounced in recent years.

Another way to look at the shifts in transit ridership by race and ethnicity is to track the added number of riders in each category. Figure 13 shows the percentage change in the number of riders by race and ethnicity between 1990 and 2009. The percentage of transit users who are Hispanic doubled while the percentage of transit users who are white declined by 80%.

Migrant and Immigrant Patterns

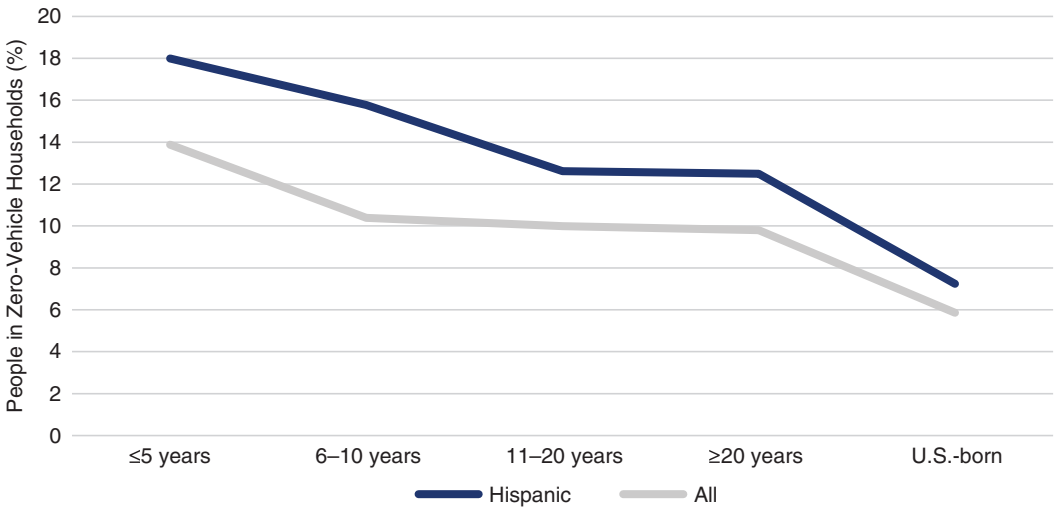
The increase in the diversity of the U.S. population has been fueled by increasing proportions of Hispanics and Asians, both native born and immigrants. Immigrants, especially new immigrants, travel in significantly different ways than U.S.-born residents. As shown in Figure 14, newer immigrants, for example, are more likely to live in a household without a vehicle than are native-born individuals. However, after 10 years or so of living in the United States, the rates of auto ownership become more comparable.

The 20-year time frame used in Figure 14 illustrates a major concept in the study of either racial/ethnic variation, or variation stemming from the years of acculturation of those who were



Source: 2009 NHTS.

Figure 13. Percentage change in transit riders by race and ethnicity, 1990–2009.



Source: 2009 NHTS.

Figure 14. Change in role of zero-vehicle household over time with migration.

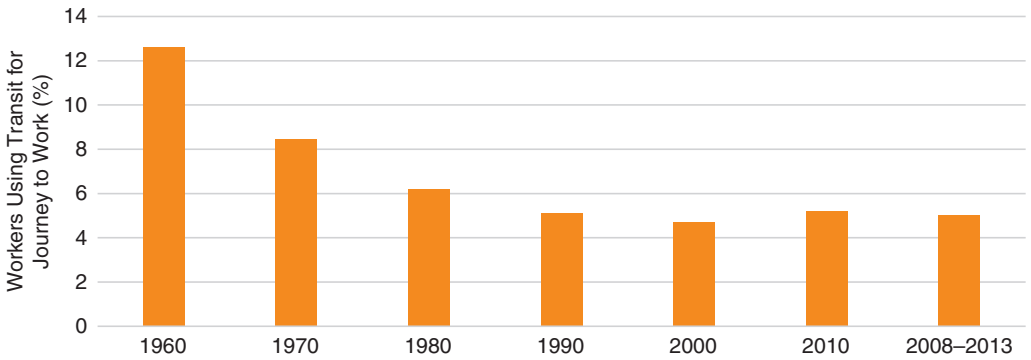
not born here. The two lines are similar in showing how the pattern of acculturation (in this case, the adoption of a car into the household) has various phases until it approximates the U.S.-born group. This use of auto ownership as a surrogate for transit dependence suggests that those on the lower end of the socioeconomic spectrum are transit dependent until a time when they are financially able to make a mode choice—a real choice involving inherent personal values, household size, age, employment, and so forth. Categories such as race and ethnicity represent a moveable target that shifts as economic conditions of ethnicities change in the United States and as new geopolitical crises sprout across the globe. Just as the present focus on important subgroups (Hispanics, for example) is fitting, so is the notion that long-term decisions may need repatterning based on new ethnicities that meet these common socioeconomic or immigration status circumstances.

Transit for the Work Trip

Overall, commute travel is an important market for transit. Commute travel is confined in time and space, and the morning and evening demand peaks determine peak transit service. Work travel has been a declining part of all person travel, by all modes, in the past few decades as travel for other purposes—shopping, errands, and recreational trips—has grown faster than travel for work. However, the percentage of transit use for journey-to-work travel nationwide has remained a rather steady "half" over the past few decades (Figure 15). Because transit serves the commuter market, there are strong ridership peaks during the 6:00 to 9:00 a.m. and 3:00 to 6:00 p.m. periods, when nearly one-half of transit riders travel. NHTS data for 2009 show just a small shift to a greater percentage of transit use for other purposes that are explored in the next section.

Trends in Characteristics of Transit Trips

One of the factors complicating the commute trip is the role of trip-chaining (i.e., incorporating nonwork stops into a work-trip tour). In 2009, about 15% of men and 20% of women stopped during their commutes—either on the way to or from work or (less often) in both directions. Women are more likely than men to trip chain since the stops are often related to household duties and dropping off or picking up children. The percentage of workers stopping



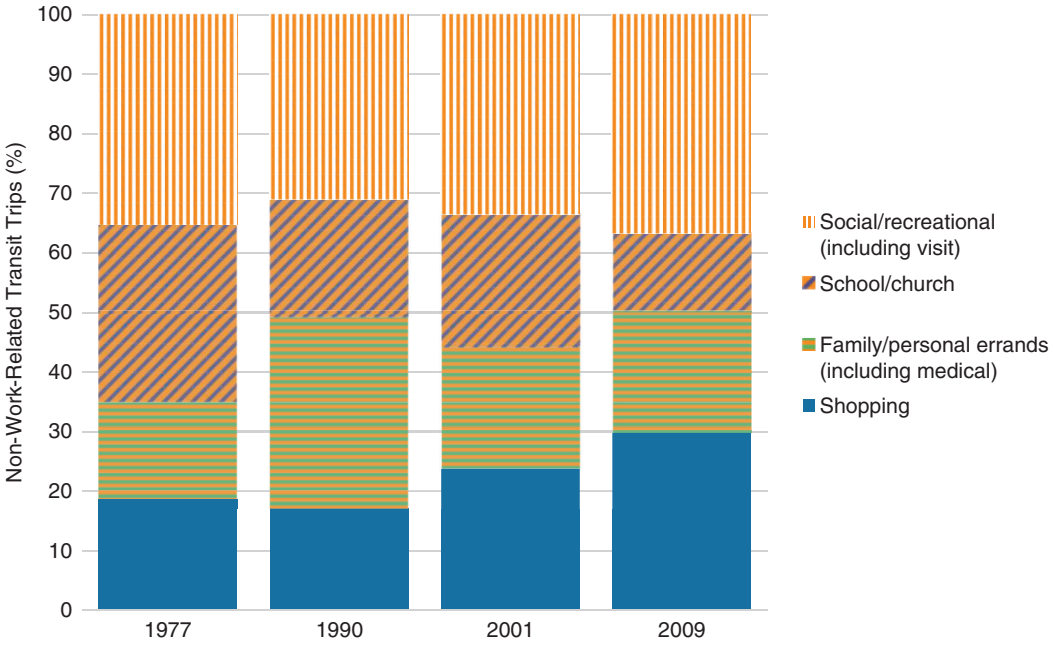
Source: U.S. Census, American Community Survey.

Figure 15. Trends in using transit for journey to work, 1960–2013.

during their commutes has remained stable since the 1995 Nationwide Personal Transportation Survey; while the proportion of workers who stop is significant, it does not appear to be growing.

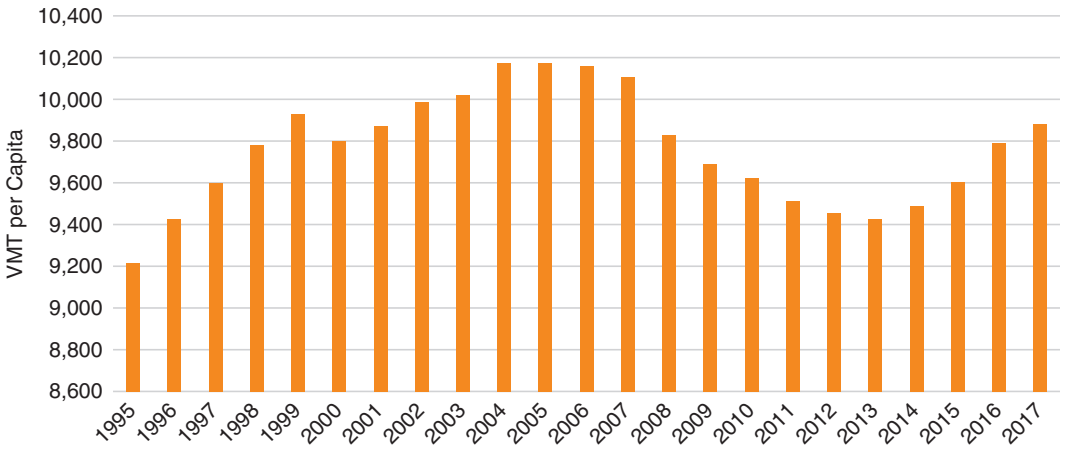
Transit Use for Nonwork Purposes

Overall, the trends in the percentage of transit use for nonwork purposes indicate that school and church trips constituted a larger share of non-work-related transit use in the 1977 NHTS data as compared with later years (note that "school bus" is separate from "local bus" in all survey years and is not included in this transit analysis). On the other hand, and like overall travel, shopping and social/recreational travel have increased in share (Figure 16). The change in using transit for non-work-related travel mirrors the overall growth in non-work-related trips over the past few decades—leading with shopping. The most recent NHTS data show per capita declines in travel (by all modes) for shopping and family/personal errands, although medical travel has grown.



Source: NHTS.

Figure 16. Trends in the shift of percentage of non-work-related transit trips, 1977 to 2009.



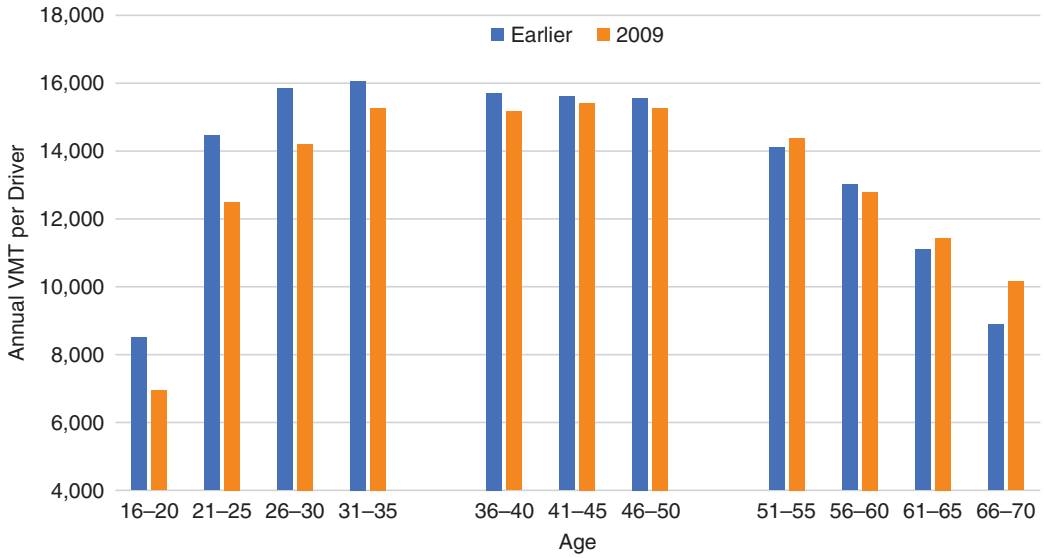
Source: VMT: Federal Highway Administration n.d.; population: U.S. Census Bureau n.d.

Figure 17. Variation in total VMT per capita over a 22-year time frame (1995–2017).

Trends in Overall American Travel Patterns and VMT Across Two Decades

This section summarizes the changes in vehicle travel over the past 20 years. Particular attention is paid to travel patterns in urbanized areas (i.e., places where fixed-route and scheduled public transportation services have been primarily located). This section attempts to put these patterns into a 20-year perspective. Figure 17 shows that total VMT divided by total U.S. population (VMT per capita) grew between 1995 and 2004. VMT per capita peaked between 2004 and 2007 and began to decline with the recession of 2008 and 2009. Interestingly, this VMT measure continued to fall until about 2013, and a clear rebound is now occurring. To analyze what is happening with VMT, the research team looked at more detailed survey data for 1995, 2001, and 2009 to better understand the roles of variables such as place, age, and gender; updated survey data is being collected in 2016 as part of the NHTS.

Travel mode preferences change as people age. Figure 18 shows the relationship between age (in detailed 5-year segments) and annual VMT (in this case for 2009). The years generally



Source: NHTS.

Figure 18. Change in VMT per driver by age group, 2009 versus previous decade.

between 30 and 50 are marked by a steady, uniform pattern of auto use and auto dependency. By contrast, the years between 16 and 30 are marked by nonauto use (including transit, walking, and biking) that decreases with age. Then, after age 50, auto dependence decreases, potentially allowing for a greater role for walking, transit, and biking. Figure 18 shows individual VMT in 2009 with 11 age groups of 5 years each; these groups are compared with the average VMT for 2001 and 1995.

CHAPTER 3

Variation in Transit Use by Neighborhood Type and Urban Form

The characteristics of the residential setting, in terms both of physical characteristics and of transportation options offered, have a profound effect on the frequency of transit use. Chapter 3 includes five sections:

1. Trends in location of residence,
2. Patterns needed to support transit,
3. Trends in the location of employment,
4. Telecommuting and working at home, and
5. Defining new ways to understand neighborhood characteristics.

Trends in Location of Residence

This section reviews how changes in settlement patterns at the end of the previous century are associated with the decrease in transit use during those decades. In the last half of the twentieth century, populations in the central cities stagnated while all growth occurred in suburban areas. Over a 60-year period, the nonmetropolitan areas lost population.

Changes in Density Patterns Over Several Decades

Trends in development since the mid-20th century may be broadly characterized as a movement from rural to metropolitan areas. These patterns also suggest a dispersion of both population and employment outward from historical central cities to the suburban areas surrounding those cities. This pattern of growth, substantially enabled by the popularity of the automobile and programs of major roadbuilding, produced patterns of development most suited to travel by automobile and unfavorable to transit. These trends challenge the design, performance, and utilization of transit service moving forward.

Interestingly, early 21st century developments are upending the narrative of the past 50 years or more. Urbanized living has found a new attractiveness among various population segments: those of the millennial and generation X (gen X) cohorts who appear to be attracted to the vitality of cities and the opportunity to live without or with less dependence on a car, single professionals or those who are married without children, and, increasingly, empty-nesters and retirees who no longer want the maintenance burden of a large single-family house in the suburbs. To serve these evolving markets, cities have been undergoing major revitalization and infill, drawing a new class of developers to the marketplace; and since the working version of this often highly educated population is regarded as the more highly skilled creative class, employers are also trending back into the center city and surrounding city-like urban centers. These trends, whose effects remain to be quantified, offer a promising lift to transit in overcoming the challenges of the past half century.

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Residential Settlement Patterns Were Not Supportive of Transit

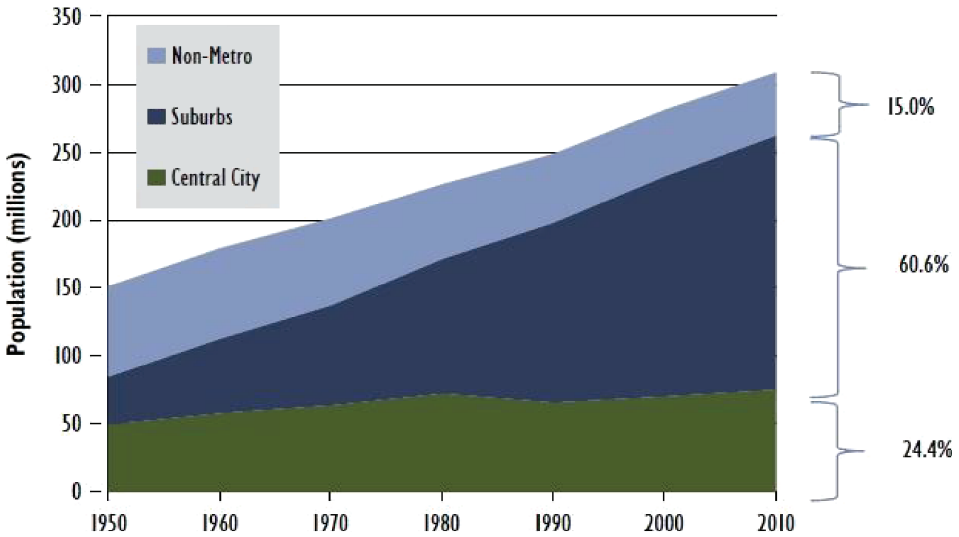
Transit is at its most effective and attractive as a transportation mode when it can provide frequent on-time service, have few restrictions on its travel speed, serve a finite number of stops (to not overly diminish average speed), and be readily accessed on foot at both the origin and destination of a trip. When these criteria are met, transit can provide service that is competitive with—or even superior to—that of the private automobile, and thus become a preferred choice for travelers. The setting in which these performance criteria are maximized is an urbanized region with moderate to high densities along the route and service to one or more nodes with significant attractions. These attributes allow transit to realize a sufficient mass of potential trip flows to justify a high quality of transit service with frequent headways and adequate speeds.

Clearly, this description does not fit the growth patterns seen in the United States over the past half century. As a result, it is unsurprising to observe the corresponding decline in the share of person trips made by transit over that period (even though total transit trips have increased with overall growth in travel). Although the land area of the United States is still substantially rural (only about 5% has been developed), the proportion of the population living in metropolitan areas grew from 46% in 1910 to more than 80% in 2010. Significant differences exist in where that metropolitan growth occurred and in the form it has taken. Most metropolitan growth over the past 60 years has gone into the areas outside of central cities. The area at suburban or exurban densities (one dwelling unit per 1 to 40 acres) covers 15 times the land area developed at urban densities (National Land Cover Database 2016).

Figure 19, taken from *Commuting in America 2013,* vividly shows not only the growth nationally in metropolitan areas that occurred between 1950 and 2010, but the ever-expanding proportion of that growth that occurred in the suburbs outside of the central cities (Pisarski and Polzin 2013). From a share of only about 20% of all population in 1950, the suburbs grew to be the location of more than 60% of all the U.S. population by 2010.

Where the Growth Occurred Over Several Decades

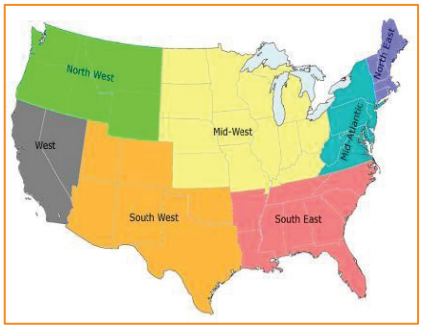
Commuting in America 2013 also points out that where this growth occurred is also related to the size of the metropolitan area and the region of the country (Pisarski and Polzin 2013).



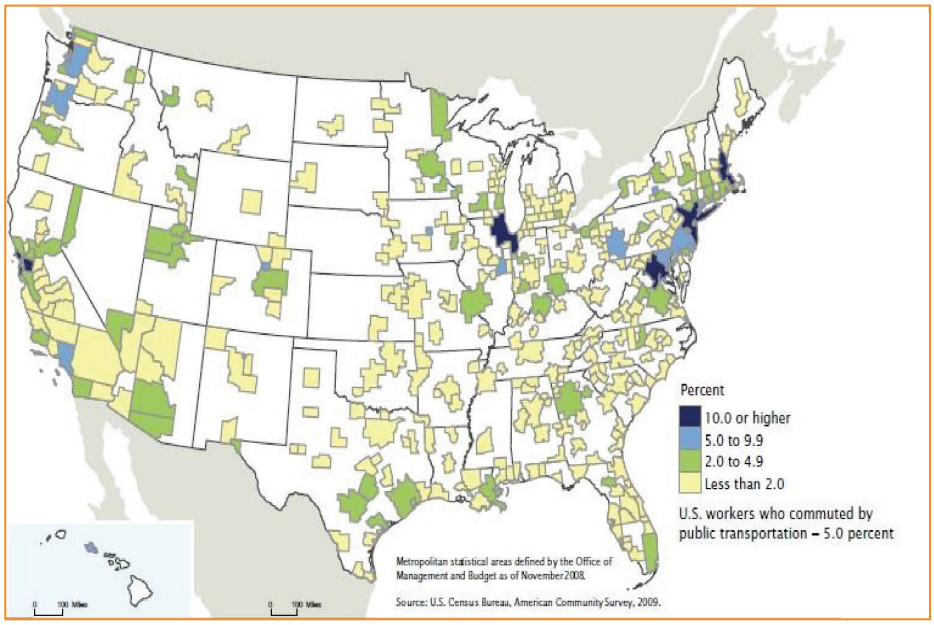
Source: U.S. Census Bureau (as cited in Pisarski and Polzin 2013, Brief 4, Fig. 4-10).

Figure 19. Population growth within metropolitan areas, 1950–2010.

Region	# Metro Areas	Population (mil) 1990	Population (mil) 2010	Change Increase	Change %	Transit Work Share
Northeast + Mid-Atlantic	6	41.5	50.7	9.2	22%	12%
Southeast	9	14.7	26.1	11.4	78%	2%
Midwest	11	30.2	36	5.8	19%	3%
Southwest	8	17.4	28	10.6	61%	3%
Northwest + West	6	28.4	38.5	10.1	36%	7%
All	40	132.2	179.3	47.1	36%	



- Highest growth rates in Southeast and Southwest.
- Newer areas developed after the automobile.
- Much lower rates of transit use.



Source: U.S. Census Bureau, American Community Survey; Pisarski and Polzin 2013, Brief 4, Table 4-10.

Figure 20. Population growth trends and transit use rates by region for 40 largest metropolitan areas, 1990–2010.

Most of the growth between 1990 and 2010 appears to have occurred in large metropolitan areas with populations of 5 million or more. Figure 20 illustrates how the greatest population growth since 1990 occurred in the Southeast and Southwest regions of the United States. These areas have historically had the lowest rates of transit use attributable to having grown under the shaping force of the automobile. With some important exceptions (e.g., Chicago, Minneapolis, and Milwaukee), the Midwest shares these land use characteristics and the low rates of transit use; however, population growth in the Midwest has occurred at even lower rates than in the Northeast.

Transit-Supportive Conditions

Analysts have studied key factors to try to categorize activity level thresholds necessary to support types of transit service. Pushkarev and Zupan developed a set of screening criteria back in the early 1980s, suggesting the appropriate levels of residential density and destination activity levels to support several types of transit, from simple bus to heavy-rail and subway service (Pushkarev and Zupan 1982). Table 3, taken from TCRP Report 95, Chapter 15 (Kuzmyak et al. 2003), presents a more recent effort sponsored by the Institute of Transportation

Table 3. ITE-recommended minimum densities to support transit service.

Mode and Service Level	Residential Density (dwelling units/residential acre)	Employment Center Size (million ft^2 commercial or office space)
1 bus/hour	4–6	5–8
1 bus/30 minutes	7–8	8–20
Light rail or feeder buses	9	35–50

Source: Holzclaw 1994, as cited in Kuzmyak et al. 2003.

Engineers (ITE) that provides a similar and slightly simpler classification. It suggests that for even a basic transit service consisting of a local bus with 1-hour headways, a density of four to six dwelling units per acre is needed, and the bus route should be serving an activity center of at least 5 to 8 million square feet of attractions (office and commercial space). To justify a bus with 30-minute headways requires a minimum of 7 to 8 dwelling units per acre and a destination activity level of 8 to 20 million square feet. Of course, this is minimalist transit service; to support rail transit service with 5-minute headways requires a minimum of 9 dwelling units per acre and more than 35 million square feet of commercial/office space at the destination. Most of suburban America does not achieve such densities, but neither do most activity centers outside of the regional central business district (CBD).

Trends in Employment Location

The Move to the Suburbs

Patterns in residential development and densities are only part of the challenge for transit. Employment also pushed out to the suburbs: first, retail and service activity to serve early residents in the 1950s and 1960s, and later—in the 1970s and 1980s—office and other professional employers in pursuit of lower rents and (seemingly) greater access to employees. The retail and service activities found it most effective to locate in shopping centers or commercial strips adjacent to major highways to serve visitors arriving by auto. Meanwhile, office and other professional activities gravitated to office parks and isolated campus locations, presuming that employees would drive to their jobs and be provided with free parking.

Sometime in the late 1980s, the trends in outward movement of employment resulted in most metropolitan area employment nationwide being located outside central cities. Table 4 indicates that as of 2010, about 30% of all jobs (35% of metropolitan area jobs) were in central cities, while about 42% (50% of metropolitan area jobs) were in the suburbs (Pisarski and Polzin 2013). The 10% of jobs (11.5% of those in metropolitan areas) located in principal cities were a toss-up for transit: while these areas may possess urban characteristics, they are still generally located in the suburbs with surrounding lower densities and suburban road networks and are not necessarily conducive to transit use.

Transit routes connecting inner suburbs to major employment concentrations in regional CBDs could offer reasonable levels of service and be competitive with auto travel. However, the dispersion of both population and employment has made it increasingly difficult to connect the dots and compete efficiently with transit in this many-to-many marketplace.

A New Pattern for Relocation of Jobs Since 2005?

Data with which to examine employment location trends in detail after 2005 are not readily available. Table 5 shows that as of 1996, the share of metropolitan area employment located

Table 4. Geographic distribution of population, workers, and jobs, 2010.

Geography	Population	Workers	Workers per Capita	Jobs	Jobs per Worker
Metro—central cities	75,283,196	27,899,370	0.37	40,536,506	1.45
Metro—other principal cities	24,065,670	9,340,785	0.39	13,267,941	1.42
Metro—suburbs	163,103,266	71,420,007	0.43	57,306,197	0.80
Metro—all	262,452,132	108,660,162	0.41	111,110,644	1.02
Non-Metro (by subtraction)	46,293,406	28,280,848	0.61	25,830,366	0.91
Total United States	308,745,538	136,941,010	0.44	136,941,010*	1.00
Central city share	24.3%	20.3%		29.6%	
Other principal city share	8.8%	6.8%		9.7%	
Suburban share	52.8%	52.2%		41.8%	
Non-Metro share	15.0%	20.7%		18.9%	

Source: Summary of American Community Survey as cited in Pisarski and Polzin 2013, Brief 5, Table 5-1.
*For purposes of analysis, total U.S. jobs set to equal workers.

in the regional core (defined as within 3 miles of the city center) had dropped to 23.3% from about two-thirds in 1950 and one-half in 1963 (Cortright 2015). A study by Kneebone (2009) suggested that employment decentralization continued through at least 2006. This work found that the percentage of metropolitan employment located in the core reached a low of 21.3% in 2006. Suburban job growth averaged 1.8% annually over the period from 1996 to 2006 as compared with only 0.1% in the city centers (of the largest 98 metropolitan areas).

The general sense among researchers and representatives of the development community is that a turning point in metropolitan employment trends from suburban to urban occurred somewhere in conjunction with the Great Recession. Between 2007 and 2011, job growth in city centers grew at an average annual rate of 0.5%, while the suburbs lost jobs, shrinking by 0.1% annually (Smart Growth America 2015). Following the recession, jobs based outside cities, such as construction and manufacturing, were hit much harder than urban jobs such as business services. Jobs disappeared everywhere, but the reversal occurred more rapidly outside cities (Miller 2015).

Assorted reasons are given for the presumed reversal. A study in 2011 by the Urban Land Institute provides its members in the international real estate industry with a prospective view of key trends likely to shape the industry in the coming decades, particularly in the wake of the recent recession (Urban Land Institute 2012). The study cites several economic and demographic

Table 5. Zip code–based estimates of city center and periphery employment.

			Employment	
Year	98-MSA Total	3-Mile Share (%)	City Center	Periphery
1996	70,159,860	23.3	16,347,247	53,812,613
2006	77,411,492	21.3	16,488,648	60,922,844

Source: Kneebone 2009, Appendix A, page 17, as presented in Cortright 2015.
Note: Annual growth rate, 1996–2006: city center = 0.1%; periphery = 1.8%; MSA = metropolitan statistical area.

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drivers that it suggests will dramatically influence future real estate investment and urban development decisions. The Urban Land Institute report argues that these trends in the wake of the recession illustrate systematic changes in the perception of and planning requirements for future cities. The report advises its members that the past decade provides an opportunity to rethink and evolve, reinvent, and renew. It asserts that nearly 100% of robust growth is in urban areas and that growth is embracing a new mixture of land uses, new suburban centers, and in-town reconfigurations.

The 2015 City Observatory study provides additional detail and insight into the changing shape of urban areas (Cortright 2015). The study explores what appears to be a growing preference for urban living, in which it observes the following:

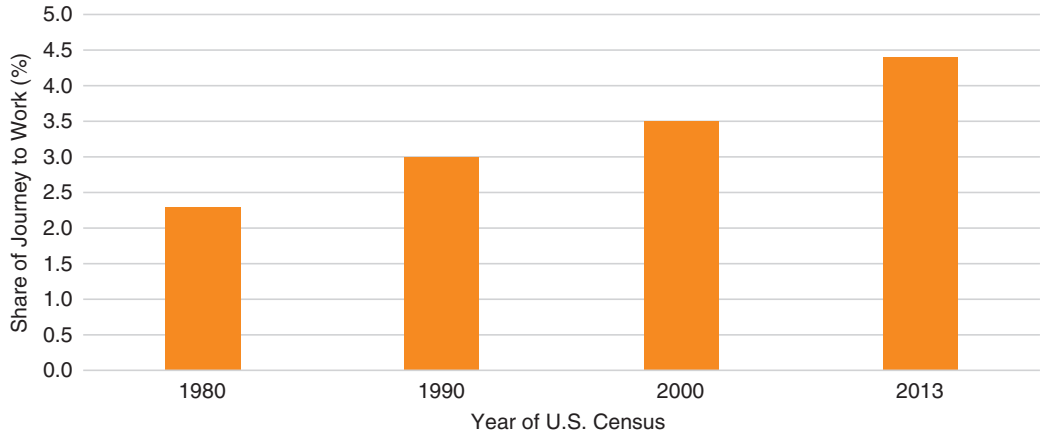
- Some young adults are showing a clear preference for close-in urban locations. Cortright reports that between 2000 and 2012 the number of 25- to 34-year-old adults with at least a bachelor's degree who chose to live in city centers outnumbered those who chose the metropolitan area by a rate of 2 to 1. This suggests that highly educated individuals are choosing city centers. The 2016 TCRP survey showed about 37% of individuals between the ages of 25 and 34 preferred the big city, leaving more than 60% reporting a preference for less-dense residential locations. The results of the analysis support the conclusion in Chapter 1 of the present report that preference for city living by millennials increased between 2004 and 2016, but not necessarily for most of them.
- In 2010, college-educated young adults were 126% more likely to live within 3 miles of the center of the CBD of a large metropolitan area than other metropolitan residents, up from about 77% more likely in 2000 (Cortright 2015).
- This finding is important because this group of people constitutes an important source of labor for fast-growing knowledge-based firms, which seem willing to alter their growth or expansion plans to tap this labor pool.

Perhaps the most definitive study of the changes underway in the shaping of metropolitan areas was performed by Smart Growth America in partnership with Cushman–Wakefield and the George Washington University Center for Real Estate and Urban Analysis. The study report, *Core Values: Why American Companies Are Moving Downtown*, summarizes a research project that identified almost 500 companies that relocated, opened new offices, or expanded in walkable downtowns and investigated their underlying characteristics, motives, and preferences (Smart Growth America 2015). That project identified key aspects of industries that require highly educated, technically competent young people for whom the urban environment is desirable. The project also documented recent patterns of job relocation by these firms to certain downtown areas (see Technical Appendix 3).

Telecommuting and Working at Home

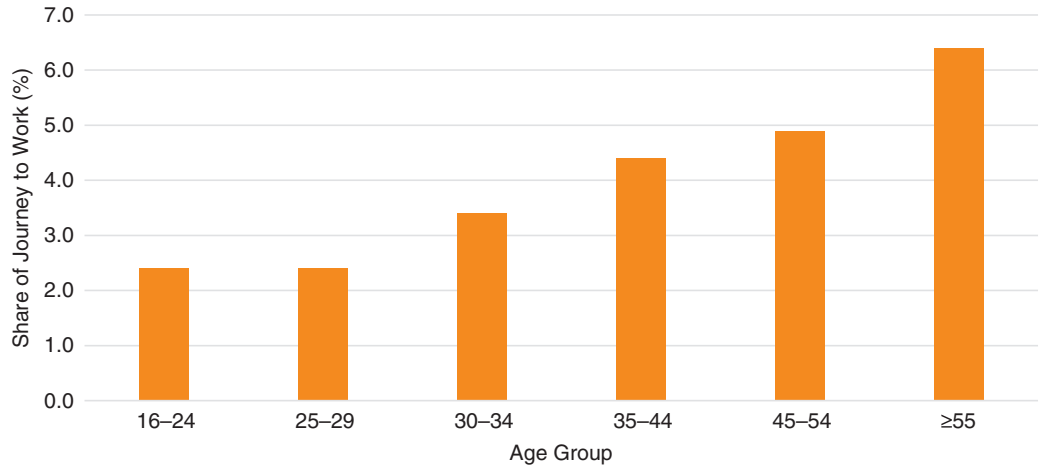
One major trend affecting the number of commuting trips taken is the propensity to work at home, and thus have no trip to work. The share of workers who report working at home doubled between 1980 and 2013, according to the Census journey-to-work data shown in Figure 21. Figure 22 shows that the propensity to work at home increases directly with age—a pattern quite different from the propensity to have a job and accept the option of telecommuting for some days, a pattern which decreases with age, as discussed in Chapter 7.

Employers incentivize nonauto commuting in different ways. The types and amounts of incentives offered to employees vary widely. Young millennials seem to be more likely to have a job with an employer that offers a bike subsidy, a shuttle to the transit station, or a subsidy on either the transit fare or vanpooling charges. As expected, millennials have a much higher propensity to use the bike incentives offered at the workplace than their older colleagues. Figure 23



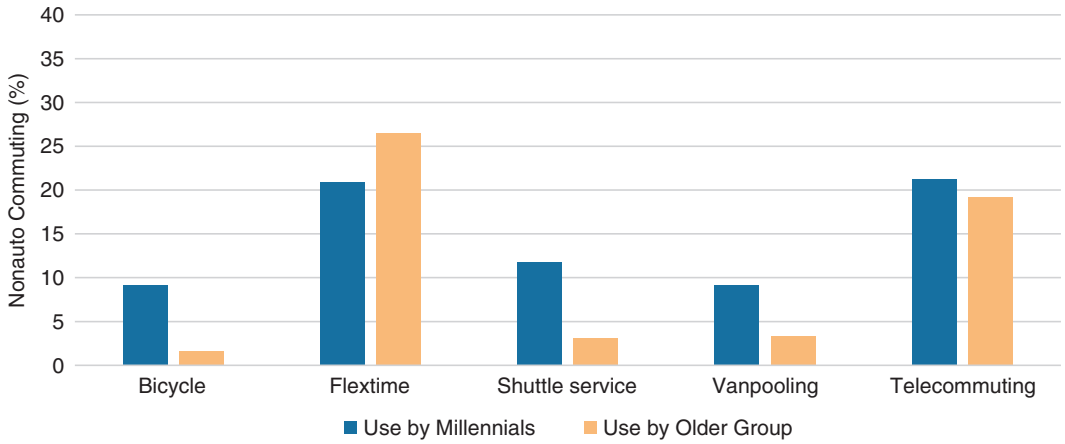
Source: McKenzie 2015.

Figure 21. Growth of work-at-home share over 33 years.



Source: McKenzie 2015.

Figure 22. Effect of age on work-at-home commute share.



Source: TransitCenter 2014.

Figure 23. Incentives used to encourage nonauto commuting, by age group.

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shows that millennials are far more likely than their older colleagues to use the subsidized shuttle service and the subsidies for transit and vanpooling. Flextime use occurs more often with those over age 35 than with those under 35. The 2014 TransitCenter survey found that age was not a major factor in using telecommuting.

Defining New Ways to Understand Neighborhood Characteristics

Going Beyond Density

Density is a widely used measure to describe the "urbanicity" of a setting and its suitability for transit service and use. However, research on the interplay between land use and travel behavior has shown that the influence of land use is considerably more nuanced than just density.

Pioneering work by noted researchers including Robert Cervero, Reid Ewing, and Kara Kockelman in the 1990s revealed that while density clearly played a role in terms of reflecting compactness and proximity, other contextual factors, such as the mix and balance of activities, the connectivity between those activities facilitated by design, and the level of accessibility to regional opportunities added critical insights in explaining travel behavior such as vehicle ownership rates, mode choice, and VMT generation (Cervero and Kockelman 1997; Ewing and Cervero 2010).

These measures of land use have been widely referred to as the "four D's": density, diversity, design, and destinations. These advanced measures have been enabled by technological breakthroughs in tools such as the geographic information system (GIS). GIS tools can sharpen the spatial resolution of the built environment to create relationships that were previously lost in large-area aggregation of the characteristics. Traditional transportation planning models used by metropolitan planning organizations were not designed to function at a level of detail fine enough to capture the critical interplay between the design of the microenvironment and its effect on walking, biking, and even transit use (given the importance of walk access/egress). GIS methods helped focus the analysis at the level of individual households, employment sites, or any number of trip generators or attractors.

Subsequent research has placed greater emphasis on the relationship between accessibility and travel behavior. *NCHRP Report 770* uses accessibility as a major strategy for understanding bicycle and pedestrian travel behavior (Kuzmyak et al. 2014). One of the new procedures developed by the study focused on the calculation of accessibility scores for each mode and trip purpose by leveraging geospatial data on employment, households, travel networks, and other contextual data. The procedure for calculating the scores is similar to that of the popular Walk Score on the Internet, although the calculation is considerably more sophisticated. Geospatial layers of employment establishments are overlaid onto layers with the various transportation networks, and then sophisticated path-building methods are used to locate the number of opportunities (e.g., jobs, grocery stores) that can be reached within a travel time budget. The numbers of such opportunities are added to calculate a total for any given location (e.g., a residence address); the value of each opportunity is reduced (decayed) by the amount of time required to reach it. This is done for each mode and for work- and non-work-trip purposes.

The U.S. Environmental Protection Agency's Office of Sustainable Communities' Smart Location Database, a web-based resource, contains sociodemographic, employment, land use, and transportation information for each census block group in the contiguous states (Ramsey and Bell 2014). Among the more innovative variables brought into this version of the database are various measures of accessibility, including scores for regional access (from each census block group) to jobs by auto and by transit, and, conversely, employer access to workers, also by auto

Table 6. Demographic characteristics of the five neighborhood types, 2016.

Neighborhood Type	Age (years)	White (%)	Single (%)	Income ($)	Student (%)	Employment (%)		Share Without Driver's License (%)
						Full Time	Unemployed	
Most transit-oriented	40.9	71.1	43.9	61,783	9.4	52.5	23.8	9.6
Transit-oriented	45.7	77.5	34.4	60,537	6.4	44.9	32.6	8.2
Mid	48.9	78.7	31.9	61,145	5.5	42.3	38.0	3.9
Highway-oriented	51.6	80.8	21.9	69,359	4.1	38.6	40.1	2.9
Most highway-oriented	52.7	85.8	21.7	70,763	3.3	38.4	44.1	2.4

and by transit. In working with these data, Ramsey and Bell found a strong relationship between the ratio of the transit- and auto-accessibility scores and the transit/auto mode split for work trips (as captured in the American Community Survey).

Creating Five Categories of Neighborhood Accessibility

The research team accessed and attached these measures to the databases for the 2014 TransitCenter survey and the 2016 TCRP survey to create an objective measure of the quality of transit service at any of the respondent household locations. This study used five neighborhood types, ranging from the most transit oriented to the least. Table 6 summarizes eight demographic categories for each neighborhood type.

Moving from the highest transit orientation toward the highest highway orientation, the populations become (1) increasingly old, (2) increasingly white, (3) increasingly married, and (4) increasingly unemployed. Along the same scale, populations become decreasingly employed full time, decreasingly students, and decreasingly without driver's licenses.

The research team used this accessibility ratio as another potential explanatory factor when analyzing the range of attitudes and choices captured in the 2016 TCRP survey. In Chapter 6 of this report, the five levels of neighborhood accessibility are applied in tandem with five age groups and four attitude-based market segments to obtain a better understanding of how key preferences vary in relation to demographic variation, geographic variation, and market segment variation.

CHAPTER 4

Market Segments for Transit Use

The potential markets for transit can be analyzed in terms of their demographic similarity (Chapter 2), their geographic similarity (Chapter 3), and their similarity in market preferences. Market segmentation is a key strategy in market research; it allows marketers to understand different motivations for market behavior by different segments. Chapter 4 summarizes the market segmentation process, presents the four groups revealed in the process, and summarizes groups' characteristics.

Market Segmentation for Transit

To better understand the preferences and needs of different subgroups of the traveling population, the research team applied latent class cluster (LCC) analysis to the collected sample. This approach attempts to segment the population into a finite number of classes on the basis of a combination of characteristics observed in the data—in this case, attitudinal statements. LCC allows subgroups of the transit market to be segmented on dimensions beyond basic demographics. Respondents within each class share similar preferences, values, and characteristics that distinguish them from the respondents in other classes.

Methodology

The segmentation process began with more than 60 attitudinal statements ranging from environmental concerns to future transit use. Attitudinal statements with relatively minor variation between the classes were dropped, and iterations of the segmentation process continued. Ultimately, 13 attitudinal statements segmented the collected sample into five distinct classes. These 13 statements, shown below, primarily revolve around preferences regarding transit, the environment, personal safety, the influence of friends and family, and driving and commuting:

1. I like the idea of doing something good for the environment by riding public transportation.
2. I think that environmental concerns are overblown.
3. Traveling by transit would be a more pleasant experience than driving.
4. I would definitely consider using public transportation more often.
5. In a world with driverless cars, I really would not see much role for buses and subways anymore.
6. My spouse/partner/family would approve of me taking public transportation.
7. In the future, people who are important to me will approve of me taking public transportation.
8. If they had to make a trip, most people who are important in my life would take public transportation.
9. My family and friends typically use public transportation.

10. I enjoy meeting people on the bus or train.
11. Because of new services helping me make trips, I feel less need to own a car.
12. As I get older, I expect I'll have to drive more than I do now.
13. I would be willing to commute an additional 45 minutes to live in a larger home.

The Four Market Segments from the 2016 TCRP Survey

Overview of Classes

Five clusters emerged from the LCC segmentation; however, the research team determined that about 8% of the sample was responding in an inconsistent manner to the attitudinal questions, possibly because of fatigue or simple misunderstanding the questions; this cluster did not add to the team's understanding of the issues at hand. Therefore, these respondents have been omitted from the charts and tables in this report. Their responses to other portions of the survey made sense, and so they were retained for those analyses. The remaining sample produced four interesting clusters helpful for understanding the attitudes, preferences, and mode and residential location choices of the respondents. An analytic technique used in market research was used to identify four key groups on the basis of the similarity of their psychographic characteristics: urban commuters, single millennials, occasional users, and car lovers.

Urban Commuters

The urban commuter cluster (11% of the sample) comprises professionals who live and work in a big city. Nearly all urban commuters would consider using transit more often, and the majority believe that traveling by transit is a more pleasant experience than driving. Proximity to public transportation is important to these commuters and was often the primary selection criterion in the choice of their current home. They are the least likely cluster to cite that environmental concerns are overblown; the urban commuter believes that riding transit is a way to do something good for the environment.

Friends and family approve of the urban commuter's choice to ride transit but do not typically use transit themselves. The urban commuter is quick to adapt to rideshare services and thus feels less need to own a car. This class is the least likely to have typical access to a vehicle.

Single Millennials

Single millennials (8% of the sample) expressed an openness to all transportation options. Single millennials are willing to consider using public transportation more often but acknowledge that traveling by transit is not as pleasant as driving. Friends and family of these millennials approve of their transit use but are not likely to use transit themselves. Much of this group expects to drive more in the future and, despite the increasing availability of rideshare services, still feels owning a car is a necessity. In a world with autonomous cars, these millennials do not see much of a role for transit. This group's interest in owning and using cars aligns with their neutral stance toward the environment. Interestingly, this cluster would be willing to extend their commute by 45 minutes in exchange for a larger home. This may speak to the expectation of an increasing family size in the future.

Occasional Transit Users

Occasional transit users constituted 28% of the sample. These semiretired suburban environmentalists like the idea of doing something good for the environment by riding transit. This cluster is open to using transit more often but currently choose to ride transit only on occasion. The reluctance to use transit can be explained by the cluster's disinterest in riding on transit with strangers and the belief that driving is more pleasant than traveling by transit. Nearly half

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of the cluster cited no transit use in the past month and, for those who do ride transit, it is often on an infrequent basis. Important people in their lives approve of their transit use but rarely use transit themselves. Interestingly, despite their occasional transit use, these drivers were the strongest advocates of the role of transit in an imagined autonomous car world. This cluster does not expect their driving habits to change in the future and are unaffected by the development of new services that help make trips.

Car Lovers

The least transit-friendly cluster, car lovers (45% of the sample), includes retired boomers and is the least likely of the four groups to express a willingness to change its traveling habits. Car lovers live in suburban and rural neighborhoods and prefer it that way. The cluster is most united by the belief that environmental concerns are overblown. This group does not currently use transit and is the least likely to consider using transit more often. This group is also the least likely to enjoy being with strangers on transit. Similarly, friends and family of this cluster do not use transit and do not approve of transit use. If these boomers were to use transit, it would not be motivated by environmental concerns. They do not like the idea of doing something good for the environment by riding transit. In the future, this cluster does not expect to drive more and will likely never adopt new rideshare services.

Who Is in Each Segment?

Table 7 presents a cross section of data on demographic and transportation use to help illuminate the differences between the four market segments, as organized by the similarity of their attitudes.

The immediate implications are as follows: First, slightly less than 20% of the surveyed population could be described as a "good" market for public transportation; this group can readily be broken down into two separate positive market segments that have similar current transit-riding behavior but different views of the future. At present, the commuters make the work trip by transit at a higher rate than do the single millennials. The single millennials make the nonwork trip by transit at a higher rate than the commuters. Chapter 5 examines the extent to which each market segment perceives that it will change its lifestyle and lower its use of transit. One group has every intention to continue commuting, and the second group sees little future in continued dependence on transit for several supporting activities. Finally, the preferences of the occasional transit users may have implications for marketing strategies to those becoming empty-nesters.

Table 7. Demographic characteristics of four market segments, 2016.

	Characteristic (%)							
Market Segment	Used Transit Within Month	Under Age 35	Single	Has Had Children	Student	Employed Full Time	Nonwhite	Hispanic
Urban commuter	79	44	41	35	9	61	23	6
Single millennial	73	68	46	40	11	73	33	10
Occasional transit user	52	28	28	49	5	54	13	4
Car lover	26	19	22	53	3	51	13	3

CHAPTER 5

Preferences About Where We Live and How We Travel

The future of transit markets will be strongly influenced by the preferences held by the metropolitan population of that time. Several preferences come into play in selecting where one lives and how one travels. Some preferences concern basic, long-term values about urbanism and about the need for the automobile; others concern more short-term attitudes about things people do and do not like about metropolitan travel. To a greater and lesser extent, all these preferences can be examined for their impact on the choice of mode of metropolitan transportation.

Chapter 5 presents a detailed analysis of how a wide variety of preferences is associated with separate age groups, separate geographic settings, and separate market-based segments. The analysis is presented in five sections:

1. Transportation mode share by age, geography, and segment;
2. Attitudes about where one prefers to live;
3. Attitudes about car use and reliance;
4. Concerns about the transit experience (safety, crime, and disturbing behavior); and
5. Expectations for personal change.

Mode Share by Age, Neighborhood Type, and Market Segment

The basic analytical framework applied in Chapter 5 is shown in Table 8. In the table, mode share information is shown as a series of four columns; the 14 rows represent the five age groups; five neighborhood types; and four preference-based market segments. In the remaining tables in the chapter, the columns each represent a statement or question concerning the preference of the respondents, while the rows provide the same categories used in Table 8.

The format of the tables in this chapter is designed to reveal variation in preferences by age, neighborhood type, and market segments. In general, the mode shares reported from the 2016 TCRP survey are consistent with the ranking of the categories for their pro-transit characteristics. As reported in Chapter 1 (from the larger 2014 TransitCenter survey) transit share fell as age increased, in parallel with the rise of auto share as age increased. Shares of both walking/biking and transportation network companies (TNCs) fell with increasing age, but not as linearly as in the case of transit or auto use. As expected, the categories reflecting neighborhood transit orientation and market segment both had mode shares that decreased as highway-oriented conditions or values increased.

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Table 8. Mode share, by age, neighborhood type, and market segment, 2016.

Characteristic	Mode Share (%)			
	Transit	Walking/Biking	TNC	Car
Age group				
18–24	**17**	13	6	64
25–34	**14**	9	7	70
35–49	**8**	5	2	84
50–64	**7**	7	1	86
≥65	**4**	5	1	90
Neighborhood type				
Most transit-oriented	**27**	21	6	46
Transit-oriented	**14**	9	4	73
Mid	**8**	6	2	84
Highway-oriented	**5**	5	2	88
Most highway-oriented	**3**	3	2	93
Market segment				
Urban commuters	**26**	19	3	53
Single millennials	**13**	11	5	71
Occasional transit users	**9**	7	2	82
Car lovers	**3**	4	1	92

Note: Detail may not add to total because of rounding.

Preferences About Where to Live

Preferences for Residential Location

Among the 14 subgroups examined, the most extreme contrasts were between those living in the neighborhood type "most transit-oriented" (in their preference for the big city), and those in the market segment "car lover" (in their preference for the suburbs). Table 9 shows variation in preference by age, neighborhood type, and market segment.

- **Age.** Increase in age generally predicted an increase in preference for the suburbs. Overall, preference for the big city fell with age; however, those aged 65 or older preferred the big city more than those aged 50 to 64.
- **Neighborhood type.** When asked where they would live if their choice were unconstrained by cost or other factors, respondents tended to reflect the same priorities evident in their current home location. Those in locations with the highest transit accessibility indicated they would prefer to continue to live in downtown areas and eschew suburban or rural locations, while those in locations with the lowest transit accessibility continued to prefer suburban or rural locations and dislike urban locations.
- **Market segment.** The rank ordering of the four segments by transit use (defined above) is repeated in the ordering of the segments regarding preference for the big city; however, the single millennials had a somewhat higher preference for the suburbs than did the urban commuters.

Choice Between the Townhouse and the Suburban House

Respondents were asked to put aside issues about what they could afford and indicate which of two housing types they would prefer: the townhouse or the suburban house. As hypothesized, all three of the methods predicted the ranking of the preference for house type. Of the 14 subgroups shown in Table 9, the group with the highest preference for the town

Table 9. Preference for residential location, by age, neighborhood type, and market segment, 2016.

Characteristic	Preference (%)			Urban House Type Ideal
	Big City	Small City	Suburbs	
Age group				
18–24	38	25	29	71
25–34	37	24	29	61
35–49	27	16	43	46
50–64	14	20	45	37
≥65	18	15	52	40
Neighborhood type				
Most transit-oriented	52	24	16	79
Transit-oriented	36	23	30	63
Mid	23	19	44	48
Highway-oriented	17	18	51	38
Most highway-oriented	13	16	52	34
Market segment				
Urban commuters	43	25	22	78
Single millennials	34	19	38	30
Occasional transit users	27	21	37	56
Car lovers	13	17	52	30

Note: The respondent was offered five options for location. Preferences for small towns and rural locations are not included in this table. See Chapter 1 for discussion.

house ("urban house type ideal") was the neighborhood type "most transit-oriented" (79%); the lowest preference (30%) for the town house came from the market segments "car lover" and "single millennials." Some variation by gender occurred. (Men had a higher propensity than women to choose the suburban house.)

- **Age.** Increase in age was associated with increased preference for the suburban house. Those younger than 35 preferred the urban house, while those 35 and older preferred the suburban.
- **Neighborhood type.** Consistent with their residential setting, most respondents in the two most transit-oriented neighborhood types preferred the urban house, while the rest preferred the suburban.
- **Market segment.** All three of the market segments that reported some transit use preferred the urban house, while an overwhelming majority of the car lovers chose the suburban house.

Neighborhood Preferences: What Kind of Neighborhood Do You Live in Now, and Why Did You Choose It?

Table 10 shows the urban form of the respondent's present neighborhood, presented as five columns; 14 rows are shown, organized by age, neighborhood type, and market segment. The reasons for the respondents' choices are presented in Table 11.

- **Age.** The youngest respondents were most likely to reside in the urban downtown, while the older segments were in the suburbs and small towns. Younger persons were more motivated by the desire for a short commute than older persons.
- **Neighborhood type.** Among the neighborhood-based segments, a clear association is seen between the level of transit accessibility and residence within the urban downtown, and this

Table 10. Urban form of respondent's present location, by age, neighborhood type, and market segment, 2016.

Characteristic	Urban Downtown (%)		Suburban (%)		
	Mixed Use	Residential Only	Mixed Use	Residential Only	Other[a]
Age group					
18–24	25	29	28	14	3
25–34	27	29	26	15	3
35–49	16	23	31	28	2
50–64	6	21	29	38	5
≥65	6	20	33	39	3
Neighborhood type					
Most transit-oriented	42	41	11	4	1
Transit-oriented	19	38	28	14	1
Mid	12	24	37	24	3
Highway-oriented	7	19	37	34	3
Most highway-oriented	4	13	33	44	6
Market segment					
Urban commuters	21	35	25	16	2
Single millennials	25	31	29	14	1
Occasional transit users	12	24	30	30	4
Car lovers	7	19	32	38	4

[a]Small towns and rural settings.

association transitions steadily to suburban and single-use locations as the accessibility value declines. Valuing short distances, walking to stores, and using transit are all logically associated with the transit orientation categorization.

- **Market segment.** The segment with the highest transit use is not located disproportionally in the downtown mixed use area but is well represented in the downtown residential only category.

Scale and Setting of the Residence: Suburban-ness of the Desired House

Table 12 shows the level of importance assigned to three attributes of house scale in the selection of the present residence as well as willingness to commute an extra 45 minutes to attain a larger house, organized by age, neighborhood type, and market segment.

Most people in the survey would not trade an additional 45 minutes of driving time to attain a better house setting; only about 14% of the survey respondents said they would make the longer drive. While most people reported valuing a larger house, variation was strongest on the question of willingness to drive an extra 45 minutes to get there, which was largely explained by age and by market segment. Some variation by gender was seen. Men were more likely to say they

Table 11. Primary and additional reasons for choice of present location, by age, neighborhood type, and market segment, 2016.

Characteristic	Primary Reason for Choice (%)			Additional Reasons for Choice (%)		
	Commute Distance	Walk to Stores	Near Transit	Commute Distance	Walk to Stores	Near Transit
Age group						
18–24	27	7	4	28	20	26
25–34	27	5	4	40	24	26
35–49	18	5	3	30	18	16
50–64	16	5	2	27	15	15
≥65	12	5	2	20	12	12
Neighborhood type						
Most transit-oriented	25	11	7	32	36	41
Transit-oriented	17	9	6	37	27	31
Mid	22	6	3	27	18	20
Highway-oriented	22	2	1	27	12	11
Most highway-oriented	15	2	1	25	10	7
Market segment						
Urban commuters	21	11	9	37	36	44
Single millennials	19	9	6	26	19	22
Occasional transit users	21	5	2	31	19	22
Car lovers	16	3	1	25	11	8

Note: Only three of five reasons are shown; therefore, the data do not add to 100%.

Table 12. Importance of house scale and setting, by age, neighborhood type, and market segment, 2016.

Characteristic	House Scale and Setting [scale from –3 (strongly disagree) to 3 (strongly agree)]			
	Home with Adequate Separation	Importance of Larger Home	Importance of Large Lot	Willingness to Commute an Extra 45 Minutes to Live in a Larger House
Age group				
18–24	0.48	0.53	–0.21	–0.27
25–34	0.84	0.74	0.11	–0.32
35–49	0.75	0.50	–0.04	–0.87
50–64	0.79	0.07	–0.27	–1.71
≥65	0.57	–0.32	–0.76	–2.07
Neighborhood type				
Most transit-oriented	0.06	0.10	–0.89	–1.40
Transit-oriented	0.41	0.13	–0.48	–1.34
Mid	0.64	0.20	–0.28	–1.08
Highway-oriented	0.85	0.34	–0.16	–1.04
Most highway-oriented	1.00	0.25	–0.05	–1.12
Market segment				
Urban commuters	0.10	–0.06	–0.97	–1.89
Single millennials	0.82	0.82	0.39	0.42
Occasional transit users	0.49	–0.10	–0.69	–1.26
Car lovers	0.77	0.12	–0.30	1.91

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would drive an extra 45 minutes for a bigger house, while women were more likely to say that they expected to drive more in general.

- **Age.** The importance of obtaining a larger and stand-alone house in the most recent residential choice was highest for those in the 25–34 age group. The desire to obtain a bigger home was not seen in those over 50, who might well have obtained an adequately sized house earlier. Age groups appear to explain little about the importance of a large lot until the age of 50, although the older groups disagreed about its importance. Each age group seemed to place value on having a home with adequate separation from the neighbors, with little variation by age.
- **Neighborhood type.** Logically enough, those who lived in an auto-oriented neighborhood placed relatively higher importance on having a large lot and a home with better separation from others. Variation in the importance of the size of the house is less pronounced among these groups, as is variation in the willingness to drive farther to get to a big house. Although it may appear counterintuitive, those living in transit-rich areas tended to be younger persons who were expecting to want a larger house. Persons living in high-transit areas identified their highest priority as being able to walk to activities.
- **Market segment.** Consistent with the observations here, the two pro-transit segments may have unique needs. The traditional transit commuters did not report placing high importance on a bigger house or lot in their last moving decision, whereas the single millennials did. The traditional transit commuting group had no interest in driving more to have a larger house, while the other pro-transit group reported some interest. The car lovers had no problem with the idea of driving more.

Car Preferences

Auto Use and Auto Dependence

Table 13 shows the level of agreement with four statements about auto orientation, organized by age, neighborhood type, and market segment. No disagreement on the "need to drive my car to get where I need to go" was indicated in the average attitude ratings of any of the 14 groupings of respondents in the survey sample.[2] Strong levels of agreement were reported by the car lovers (those in the most auto-oriented neighborhoods) and by those 65 years of age or older. Some variation by gender was observed (these data are not included in the table). Women agreed more than men with the statement "Leaving the driving to someone else is desirable for me." Men were more likely to agree that they loved "the freedom and independence" that comes with owning cars. Men were also more likely than women to report that reducing auto use would be difficult.

- **Age.** Being older makes one more likely to report car dependence and more likely to feel the need for a car "to get where I need to go." There was surprisingly little variation in car affinity by age. Although there was a statistically significant bump for those between the ages of 25 and 34, there was no other age-based pattern. The younger age groups were less likely to feel that they needed a car to travel, feel peer pressure to drive, or worry about leaving the driving to someone else. Interestingly, those aged 25 to 49 were among the most likely to say that it would be hard to reduce their car use or the number of cars they owned.
- **Neighborhood type.** Table 13 reinforces that persons living in the most transit-based and urban settings feel much less need to drive a car to where they need to go and do not believe that it would be difficult either to own fewer cars or reduce their auto mileage or fuel use. These groups are somewhat willing to concede the driving environment to others.

[2]This question was included twice in the 2016 TCRP questionnaire. These values represent averages between the two responses, which were similar in content.

Table 13. Attitudes toward car use and reliance, by age, neighborhood type, and market segment, 2016.

	Auto Orientation [scale from –3 (strongly disagree) to 3 (strongly agree)]			
Characteristic	I need to drive my car to get where I need to go.	It would be hard for me to reduce my auto mileage and usage of gasoline.	It would be very difficult for my household to own fewer cars.	I love the freedom and independence that owning several cars provides for my household.
Age group				
18–24	0.85	0.25	0.46	0.67
25–34	1.09	0.53	0.75	0.80
35–49	1.37	0.60	0.74	0.83
50–64	1.43	0.28	0.52	0.65
≥65	1.56	0.49	0.42	0.45
Neighborhood type				
Most transit-oriented	0.27	–0.13	–0.10	0.00
Transit-oriented	1.03	0.16	0.50	0.36
Mid	1.41	0.48	0.50	0.61
Highway-oriented	1.58	0.63	0.84	0.92
Most highway-oriented	1.72	0.68	0.78	0.93
Market segment				
Urban commuters	–0.01	–0.74	–0.45	–0.47
Single millennials	0.87	0.29	0.25	0.81
Occasional transit users	1.15	0.26	0.47	0.36
Car lovers	1.75	0.62	0.76	0.88

- **Market segment.** Only the most transit-oriented market segment, urban commuters, reported no agreement with the need to drive a car to get where one needs to go. Only this attitudinally defined segment was consistent in reporting disagreement with the idea that it would be hard to drive less and own fewer cars. Their responses indicated disagreement with the idea that owning several cars provides freedom and independence and agreement with the idea that leaving the driving to someone else would be desirable. The other market segments tended to show expected levels of agreement with concepts of auto orientation.

Auto Ownership Versus Auto Sharing

Table 14 shows the level of agreement with four statements about auto ownership or the option of sharing, organized by age, neighborhood type, and market segment. The small scale of actual carsharing and bikesharing is reflected in the high level of disagreement with the first two statements reported in Table 14. All segments in all three categories expressed, to varying degrees, their disagreement with sharing a vehicle rather than owning it. The variance in the strength of these statements of disagreement, however, is worthy of further examination.

- **Age.** The near-universal reaction to the idea that one would "prefer to borrow, share, or rent a car just for when I need it" was almost linearly influenced by age, with the highest agreement from those under 25 and the least agreement from those 65 and over. (Men were more likely to prefer to share than were women.) No age group agreed that they had less need for a car because of the new services, and disagreement increased with increasing age.

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Table 14. Attitudes toward car ownership and sharing, by age, neighborhood type, and market segment, 2016.

	Attitude Toward Car Ownership and Sharing [scale from –3 (strongly disagree) to 3 (strongly agree)]			
Characteristic	I am a person who likes to participate in programs such as carshare and bikeshare.	Rather than owning a car, I would prefer to borrow, share, or rent a car just for when I need it.	Because of new services helping me make trips, I feel less need to own a car.	I feel I am less dependent on cars than my parents are/were.
Age group				
18–24	−0.31	−0.50	0.05	0.24
25–34	−0.34	−0.64	−0.01	0.24
35–49	−1.11	−1.10	−0.55	−0.45
50–64	−1.73	−1.68	−1.12	−0.89
≥65	−2.05	−1.93	−1.37	−1.16
Neighborhood type				
Most transit-oriented	−0.67	−0.49	0.32	0.66
Transit-oriented	−1.11	−1.07	−0.52	−0.16
Mid	−1.22	−1.19	−0.63	−0.46
Highway-oriented	−1.47	−1.60	−1.09	−0.97
Most highway-oriented	−1.56	−1.70	−1.17	−1.03
Market segment				
Urban commuters	−0.47	−0.15	0.63	0.65
Single millennials	−0.11	−0.34	0.51	0.30
Occasional transit users	−1.33	−1.46	−0.95	−0.57
Car lovers	−2.13	−2.18	−1.63	−1.31

- **Neighborhood type.** The level of support for carsharing and bikesharing programs decreases directly with the auto orientation of the neighborhood. Moderate agreement for a decreased level of auto dependence was expressed by the most urban neighborhood group.
- **Market segment.** As before, variation between the market segments was more nuanced, as the single millennials showed somewhat less dislike for carsharing and bikesharing programs, which often save money in trip making. The two highest transit-using market segments showed moderate agreement with the idea that new services are making them less auto dependent.

Concerns About Transit: Safety, Crime, and Disturbing Behavior

Many aspects of the public transportation trip caused concern, to varying degrees, to the participants in the sample, as shown in Table 15. The statement in the first column establishes that the transit trip might cause one to be with people with unpleasant behavior. There was little variation in the response to this statement; subsequent statements revealed a higher level of variation in the response. The single millennial market segment had a high level of concern about unpleasant people, at about the same level as that of the car lovers. Relevant variation was found here for gender. (Men were more likely to agree that they felt safe during the transit trip. Women were more likely to worry about crime or other disturbing behavior.)

- **Age.** Age proved a good explanatory variable for feeling uncomfortable traveling with people one does not know. Those under 35 did not disagree with the statement, while those above 35

Table 15. Concerns about public transportation trips, by age, neighborhood type, and market segment, 2016.

Characteristic	Concern About Public Transportation Trips [scale from –3 (strongly disagree) to 3 (strongly agree)]				
	If I take a trip by transit, I might have to be with people whose behavior I find unpleasant.	The idea of being on a train or a bus with people I do not know is uncomfortable.	It might be unsafe to make a trip by public transportation.	I worry about personal safety/disturbing behavior on a bus or train.	I worry about crime or other disturbing behavior on public forms of transportation.
Age group					
18–24	0.97	0.12	0.33	0.42	0.55
25–34	0.97	0.09	0.31	0.46	0.65
35–49	0.98	–0.06	0.17	0.39	0.65
50–64	0.74	–0.45	0.05	0.35	0.52
≥65	0.42	–0.80	–0.23	–0.03	0.14
Neighborhood type					
Most transit-oriented	0.75	–0.70	–0.20	0.01	0.20
Transit-oriented	0.84	–0.36	–0.07	0.20	0.45
Mid	0.87	–0.26	0.16	0.39	0.56
Highway-oriented	0.75	–0.18	0.23	0.39	0.57
Most highway-oriented	0.70	–0.24	0.11	0.33	0.50
Market segment					
Urban commuters	0.49	–1.46	–0.93	–0.47	–0.25
Single millennials	0.84	0.17	0.40	0.42	0.63
Occasional transit users	0.44	–1.11	–0.55	–0.36	–0.07
Car lovers	0.82	0.01	0.37	0.60	0.72

did disagree. Persons aged 65 or more did not report being uncomfortable when being on transit with others.

Strong agreement with the "might be unpleasant" statement did not vary in the youngest three age groups, but it decreased with increasing age after 50. Persons aged 65 or more did not seem to have much concern about simply being with unpleasant people. The younger groups were more likely to agree that the transit trip might be unsafe, while those aged 50 or more tended to feel that the trip was not unsafe.

When crime was specifically included in the survey question, the pattern of responses showed a higher level of worry, with variation largely consistent with that of the responses to the previous two statements: little variation in the level of agreement by those under age 50, with those age 50 or more having less concern about crime and disturbing behavior.[3]

- **Neighborhood type.** The persons in the two transit-oriented neighborhoods were less likely to feel that being on the bus with people they did not know was "uncomfortable" and less likely to report that they worried about crime and disturbing behavior than those in the highway-oriented neighborhoods. The tendency to "feel safe when riding public transportation"

[3]The pattern of agreement and disagreement with the statement "I feel safe when riding public transportation" was different, with those aged 25 to 34 having the highest propensity to say transit is safe. This is somewhat surprising, given that this group had a distinctively higher propensity to worry about crime or disturbing behavior while on board public transportation. This implies that concerns for unpleasant and disruptive behavior did not rise to the level of concluding transit to be unsafe.

was strongest for the two most transit-oriented neighborhood types and weakest for the two most highway-oriented neighborhood types. Implicitly, the more experience one has with transit, the more one reports feeling safe.

- **Market segment.** The urban commuters and the occasional transit users tended to think alike, with opinions that were less concerned about unpleasant activities and more positive about transit. Both the urban commuters and the occasional transit users had a higher-than-average propensity to report feeling safe while on transit. On the other hand, the single millennials tended to view the situation in a manner such as the car lovers; that is, although the single millennials do indeed use transit, they worry about it.

Expectations for Personal Change

Attributes for the Next Home Location

In the next phase of life, preferences for the future home location are influenced by age and market segment. When the results reported in 2016 are compared with those reported in 2004, the reasons for choosing a house look quite similar: commute distance, price, and more living space. All three reasons involve the trade-off between wanting to minimize the commute distance while valuing the variety of home and price combinations that increased distance would provide. The user chooses the next home location in a high-stakes trade-off between desired attributes (short distance) and constraining realities (price for a given set of home features).

With regard to the question of the attributes desired in the next home, the most extreme pattern of variation was seen in the importance of minimizing the commute (see Table 16, bottom half, "Other Reasons"): 47% of the youngest group supported the premise versus 2% of the oldest group.

- **Age.** As the primary reason for choosing the next house location, having a short commute distance decreased directly as age increased; 23% of those under 25 reported this as their primary reason, compared with less than 2% of those 50 years of age or older. Logically enough, the same was true for schools: while relocating for better schools was the primary reason for 16% of those between the ages of 25 and 34, this reason dropped suddenly to 7% for those between 35 and 49 and dramatically to 0% for those older than that. A similar pattern was seen concerning the motivation to move to get more living space, with young persons giving this explanation more than older persons. The same pattern was seen even more dramatically as a secondary motivation for choosing the location of the next house: 40% of the youngest group identified more living space as a reason to move, compared with 6% of the oldest group. In contrast, reference to having the ability to walk to shops and services as a primary reason for choosing the location of the next house increased with increasing age.
- **Neighborhood type.** Neither the desire to minimize the commute distance nor the importance of price varied much by neighborhood type. Increasing levels of the highway orientation of the neighborhood were associated with a decrease in the value placed on either walking to stores or proximity to transit.
- **Market segment.** Of all the analysis segments, the urban commuters showed the greatest loyalty to transit, particularly with their mention of closeness to transit (47%) as a secondary reason for the next home location, while only 20% of the single millennials even mentioned proximity to transit as a consideration for the next move. Consistent with their patterns, only 9% of the car lovers mentioned this reason. Some 50% of the urban commuters mentioned nearness of stores and services—again, considerably more than the single millennials (27%).

Table 16. Reasons for selecting the next home location, by age, neighborhood type, and market segment, 2016.

	Reason to Select Next Home Location (%)						
Characteristic	Commute Distance	Price	Schools	Walk to Stores	Close to Transit	Close to Family and Friends	More Living Space
Primary Reason							
Age group							
18–24	23	21	11	6	2	5	9
25–34	17	21	16	7	2	5	9
35–49	14	26	7	7	2	7	6
50–64	2	25	0	13	4	17	4
≥65	0	19	0	12	4	27	2
Neighborhood type							
Most transit-oriented	16	25	9	9	4	4	9
Transit-oriented	9	26	9	9	3	11	6
Mid	13	21	8	10	4	15	5
Highway-oriented	10	23	6	9	1	12	7
Most highway-oriented	8	21	5	10	2	16	5
Market segment							
Urban commuters	15	24	9	15	5	6	6
Single millennials	12	12	15	7	6	7	9
Occasional transit users	11	23	6	10	4	15	4
Car lovers	7	24	4	8	1	16	7
Other Reasons							
Age group							
18–24	47	50	39	36	25	33	40
25–34	50	57	39	31	24	40	38
35–49	33	51	12	25	19	23	22
50–64	8	47	2	31	19	26	10
≥65	2	49	1	29	22	34	6
Neighborhood type							
Most transit-oriented	40	53	27	43	36	31	33
Transit-oriented	32	55	19	37	29	38	26
Mid	23	51	18	32	19	36	19
Highway-oriented	19	52	15	26	17	32	17
Most highway-oriented	19	51	13	24	17	30	19
Market segment							
Urban commuters	45	53	25	50	47	36	33
Single millennials	25	39	25	27	20	31	26
Occasional transit users	27	57	17	39	32	38	23
Car lovers	19	52	11	22	9	29	19

Expectations About How One's Life Will Change

Major Events Expected?

Those under 35 fully expected major changes in their lives over the next 10 years, with about 75% expecting to get married and about 66% expecting to have children. Logically, the percentage of respondents reporting this expectation decreases linearly with increasing age.

Expectations by Age

More than 50% of millennials live in cities now versus less than 40% of the older age groups (Table 17). When respondents looked 10 years into the future, a slightly smaller percentage in all age groups except the oldest (65 years and older) expected to live in a city.

Table 17. Expectations for change in location and transportation 10 years in the future, by age, 2016.

	Expectation (%)			Live in City (%)	
Age	As I get older, I expect I'll have to drive more than I do now.	As I get older, I expect to value the suburban setting more than I do now.	As I get older, I think that I will eventually want to settle in the kind of house and neighborhood that my parents had.	At Time of Survey	Expect to Do So in Future
18–24	65	59	50	54	49
25–34	54	64	56	56	44
35–49	28	50	36	39	35
50–64	11	43	21	28	25
≥65	7	41	15	25	27
Total	27	50	32	38	33

Table 17 shows that millennials expected a large reduction in their use of public transit, whereas the older two age groups expected an increase. For the sample overall, there was an expectation of a small reduction in using transit, from approximately 1.1 days per week currently to 1 day per week in the future. The expectations of the youngest millennials, however, went from current use of transit 2.1 days per week to future use of 1.3 days per week; the expectations of the older millennials went from 2 days per week currently to 1.6 days per week in the future. The expectations of using transit of the group aged 65 or more, however, increased from current use of 0.4 days per week to future use of 0.6 days per week.

The members of the millennial generation seem to understand that changes lie ahead in their path through the life cycle. The youngest age group knows that more auto orientation is coming; 65% agreed that they expect to drive more as they get older. While a majority of the group aged 25 to 34 indicated that they expect that more driving is coming, this percentage fell sharply at middle age and beyond.

A total of 64% of the 25- to 34-year-olds indicated that they believed they would end up valuing the suburban setting more than they do now, with a full 56% responding that they would end up in a house like their parents'. While some 56% of this age group reported living in the city at the time of the survey, only 44% expected to live there in a decade.

CHAPTER 6

Understanding How the Factors Fit Together: Integrated Modeling

Previous chapters explored the role of demographics, location, and preferences separately as influences on the transit markets. This chapter analyzes all of these factors together by using two market research–based travel demand models developed specifically in this study. The chapter is presented in two sections:

1. **New scenario-building model.** The first section of the chapter presents the results of the application of a new travel demand model that includes both hard factors (e.g., travel times and costs) and soft factors (preferences and attitudes) in one unified analytical format.
2. **New attitude-based model.** The second section of the chapter presents the results of a new analytical model that focuses primarily on preferences to examine the relationships between key long-term values and shorter-term attitudes and the propensity to use transit.

A New Integrated Scenario Forecasting Model for Transit

What Can Be Learned from the Creation and Testing of Alternative Scenarios

This section presents the results of the new scenario development and testing exercise, which applies a set of advanced hybrid choice models—also often referred to as "integrated choice latent variable" (ICLV) models—to analyze the data from the 2016 TCRP survey, which was a stated choice survey. As described in Technical Appendix 6, these models account for the differences across an individual respondent's preferences with regard to how the respondent reacts to the level of service variables, such as time and cost, and to the respondent's baseline preferences for given modes of transport. The explanation of variation in the work used three separate components:

1. The research team sought to explain a substantial share of the variation by linking it to observed respondent characteristics, such as age and education, and trip characteristics, such as purpose.
2. The research team allowed for additional random variation (i.e., differences across an individual respondent's preferences that cannot easily be linked to observed characteristics of the respondents). This and the first type of variation were allowed for in both the marginal sensitivities to level of service variables (e.g., time and cost) and the baseline mode preferences.
3. The research team allowed for further variation in these modal constants that is linked to attitudinal constructs. These latent attitudes varied both deterministically (e.g., as a function of age) and randomly (i.e., on the basis of unobserved factors) across individuals. At the same time as these attitudes explained a share of the variation in modal preferences across

respondents, they also explained answers that these same respondents gave to a set of attitudinal questions. A complete description of the development of these ICLV models is presented in Technical Appendix 6.

This section presents results of applying the ICLV models described above in various scenarios concerning the future of public transportation in the United States. The scenarios that were tested varied both the level-of-service variables (travel times and costs) of the various modes and potential shifts in attitudes. Some of the results are also broken out by different market segmentations: age group, trip purpose, region of the country, and residence neighborhood type.

First, brief summaries of the policy-oriented results of the exercise are presented. Then, a more detailed description of how the scenarios were created from a base model and several refinements of that model is presented.

Summary of the Results of the Scenario Testing

The research team ran several scenarios by changing all the time and cost attributes for specific modes simultaneously. These scenarios provide an idea of the range of response to more pronounced overall changes in service levels. The results are presented in Table 18 in the order of their overall effect on transit mode share. (The "total transit" column is for bus and rail combined.)

Table 18. Scenario results for overall shifts in mode time and cost attributes, 2016.

	Changes to Service Variables (%)					
Scenario	Bus	Train	Private TNC	Shared TNC	Car	Total Transit[a]
Increase in Transit Share						
All bus and train better, both TNC worse	36	34	–44	–53	–19	35
All bus and train better	31	30	–27	–32	–24	30
All bus and train better, both TNC better	22	22	2	6	–31	22
All train better	–37	78	–17	–21	–15	19
All bus better	78	–40	–19	–23	–16	21
All car worse	9	8	14	15	–18	8
All private and shared TNC worse	6	5	–24	–31	7	6
All shared TNC worse	3	3	10	–38	4	3
All private TNC worse	3	2	–33	9	3	2
Decline in Transit Share						
All private TNC better	–5	–4	55	–12	–6	–5
All shared TNC better	–7	–6	–15	73	–7	–6
All bus worse	–50	34	8	10	7	–9
All train worse	33	–50	6	8	6	–8
All private and shared TNC better	–11	–9	36	54	–11	–10
All car better	–12	–11	–14	–16	23	–11
All bus and train worse, both TNC worse	–16	–16	–8	–13	26	–16
All bus and train worse	–22	–21	20	26	17	–22
All bus and train worse, both TNC better	–33	–31	60	91	2	–32

[a]Bus and rail combined.

Best for All Transit

The effects of changing transit level of service on projected demand also depend on what changes occur in the ride-hailing market. The best scenario for transit decreases all the bus and train time and cost attributes by 25% ("bus and train better"), while increasing all the private TNC and shared TNC time and cost attributes by 25% ("both TNC worse"). Projected demand for both bus and train increases by about 35% (as a percentage of their base scenario mode shares). If bus and train are improved, but with no change to private TNC or shared TNC service ("All bus and train better"), projected demand for both bus and train increases by about 30%. If bus and train are improved, but private and shared TNC also improve ("All bus and train better, both TNC better"), demand for both bus and train increases by about 22%.

Best for a Given Mode

When just one of the transit modes is improved, but not the other, the model shows a large increase in projected demand for that mode (78%), but a reduction in demand for the other transit mode by about 40%, so that the overall predicted increase in transit demand is about 20% in each case. If all car costs and times increase by 25% ("all car worse"), then the result is an 8% increase in transit demand (but a 15% increase in private and shared TNC demand). If all the times and costs for private and shared TNC increase, transit demand only increases in the range of 2% to 6%. This is because private and shared TNC have relatively small mode shares in the base scenario, so the cross-elasticities for transit are not that large.

The second half of Table 18 shows scenarios that are increasingly bad for transit demand, with either the transit times and costs increased, or the competing mode times and costs decreased. The results show a near mirror image of the first half of the table, with the predicted drops in total demand ranging from 5% for "all private TNC better" to 32% for "all bus and train worse, both TNC better." One difference is that the model predicts that improving both private and shared TNC has a larger influence on transit demand than making both worse because there are more current transit riders to lose when ride-hailing improves relative to the current number of ride-hailing users to gain if ride-hailing service worsens.

Variation, by Attitude

Another set of scenarios was run leaving the mode travel time and cost attributes constant and assuming future shifts in the attitudes of the travelers in specific ways, as compared with the attitudes simulated in the base scenario. The attitudinal effects in the model are related to the age and education level of the traveler and the traveler's attitudes toward five attitudinal constructs: (1) willingness to share services, (2) safety in traveling, (3) use of technology while traveling, (4) pro-transit attitudes, and (5) concern for the environment.

Although the research team tested more than 100 different scenarios of attitudinal shifts, most showed minor changes in demand. Table 19 shows the results only for those that showed at least a 3% shift in total transit demand. The range of changes in total transit demand in the table is from a 13% increase to an 8% decrease, which is only about one-third of the range of changes shown in Table 18 (35% increase to 32% decrease). The implication is that changes in future attitudes toward specific aspects of transit can influence demand but not nearly as much as changes in the quality and quantity of service that is offered.

The largest predicted increase in transit demand (13%) is if all future travelers were to adopt the same attitudes toward all the attitudinal constructs as those in the survey who are under age 30 and highly educated. Conversely, the largest predicted decrease in transit demand (8%) is if all future travelers were to adopt the same attitudes as those who are over age 65 and those with no college education. Other results indicate that of the 13% increase in the best scenario, about 8% appears to be related to current differences in attitude that are correlated with

Table 19. Scenario results for shifts in attitudes.

	Results (%)					
Scenario	Bus	Train	Private TNC	Shared TNC	Car	Total Transit
All adopt under age 30 and graduate degree attitudes	11	15	13	19	−26	13
All adopt grad degree attitudes	6	10	−3	7	−11	8
All adopt under age 30 attitudes	6	5	18	12	−15	5
All shift one category younger and one education level higher	4	5	9	8	−10	4
All adopt under age 30 attitude toward service sharing only	5	3	14	6	−10	4
All adopt over age 65 attitudes	−5	−1	−23	−11	13	−3
All adopt over age 65 attitudes toward service sharing only	−5	−3	−15	−6	11	−4
All shift one category older and lower education	−5	−5	−11	−8	11	−5
All adopt no college attitudes	−4	−6	0	−5	8	−5
All adopt over age 65 and no college attitudes	−9	−7	−23	−16	21	−8

education level, while 5% appears to be related to current differences in attitude that are correlated with age. Similarly, of the 8% decrease in the worst scenario, about 5% appears to be related to education level, and 3% appears to be related to age.

Other scenarios tested less-complete shifts in attitudes. Instead of everyone shifting to the extreme category of age or education, everyone's attitudes shifted to those of one age group younger or older and one education level higher or lower. If everyone's attitudes shift one age group lower and one education level higher, the increase in transit demand is about 4%. If everyone's attitudes shift in the opposite direction—one age group higher and one education level lower—the decrease in transit demand is about 5%. (The former change seems more likely, as age cohorts grow older and generally have higher education levels than previous age cohorts.)

The one single attitudinal effect that appears to have the highest effect on transit demand is the relationship between age and the attitude toward shared services. If all age groups adopted the attitudes of those under age 30 for this construct, the predicted increase in transit demand would be about 4%, whereas if all adopted the attitudes of those over age 65, transit demand would decrease by 4%.

Another outcome of note in Table 19 is that the changes for the private TNC and shared TNC modes are typically in the same direction as the changes for bus and train; they are usually even larger than the changes in transit demand—particularly the age-related effects. This result indicates that the attitudinal shifts that most strongly favor transit will also strongly favor ride-hailing services; thus, much of the potential increase in transit demand may be attracted away by Uber, Lyft, and similar services, particularly if those services become more convenient or less expensive through automation technology.

Table 20 shows the variation in the base mode shares of reference point scenarios by national region.

The mode shares for the reference point scenarios are also similar across regions. However, transit use is much higher in the northeast and northwest regions than in the other regions. The model results indicate that the variations in mode shares are more an outcome of different

Table 20. Base mode shares of reference points used in the modeling process.

	Base Mode Share (%)				
Scenario	Bus	Train	Private TNC	Shared TNC	Car
Northeast	24	24	10	10	33
North Central	26	19	9	9	37
Northwest	23	27	9	9	32
Southeast	21	23	9	9	38
Southwest	24	19	11	9	37

levels of transit service offered in the regions than they are of any major differences in people's underlying mode preferences or attitudes across the regions.

Variation, by Neighborhood Type

The scenario results were also segmented by four neighborhood types, as self-reported by the respondents: (1) urban or (2) suburban/small town areas and (3) mixed-use or (4) residential neighborhoods. As shown in Table 21, transit mode shares are rank-ordered in the direction that one would expect, rising from 42% in suburban/residential areas to 52% in urban/mixed use areas. Mode share for private TNC plus shared TNC also increases from 16% to 22%.

This segmentation by neighborhood type was not included in the model explanatory variables, so any differences in predicted mode share arose from differences in the demographics of the people who live in the different types of neighborhoods. In the actual current situation, transit and ride-hailing levels of service also tend to vary a great deal across these neighborhood types, so the actual variations in mode shares are much more pronounced than in the base scenario.

This data analysis suggests that it is not some inherent characteristics of residents of different regions of the United States that leads to transit ridership, but rather the actual times and costs of the services they are exposed to. In and of itself, this suggests that the study of migration of populations is less a study in the differences of region (e.g., moving from Providence to Phoenix) but more a study of the difference in the quality of service experiences at the residential location in the two regions.

Definition of Elasticities and Cross Elasticities

The research team ran several scenarios to gauge the elasticities of the model outcomes to the changes in the mode travel time and cost attributes that were varied in the stated choice experiment. Each scenario changed only one of the attributes, increasing or decreasing the

Table 21. Base mode shares of reference points, by residential demographic composition.

	Mode Share (%)				
Scenario	Bus	Train	Private TNC	Shared TNC	Car
Suburban/town residential	21	21	8	8	41
Suburban/town mixed use	24	21	9	9	37
Urban residential	25	23	10	11	31
Urban mixed use	26	26	11	11	26

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specific time or cost level by 25% of the reference level for each trip in the survey sample (Table 22). The values shown in the first column are direct elasticities—the percentage change in demand for each percentage change in a service attribute for the same mode. The other cells are the cross elasticities: the percentage change in demand for each percentage change in a service attribute for a competing mode. The shaded cells are the largest cross elasticities for each variable: blank cells represent cross elasticities so low as to be deemed not meaningful for this discussion.

By looking at the patterns of unshaded and shaded cells, one can see that bus and train compete more closely with each other than they do with the nontransit modes. The same is true for the private TNC and shared modes, which also compete most closely with each other. It also appears that private TNC and shared are the closest substitutes for the car mode, although the cross elasticities for private TNC and shared for changes in car attributes are not that much higher than the cross elasticities for bus and train. Finally, for changes in bus and train attributes, the cross elasticities for private TNC and shared are typically somewhat higher than for the car, meaning that ride hailing appears to be a somewhat closer substitute for transit.

Table 22. Elasticities to mode travel cost and time attributes.

Variable	Elasticity[a]	Bus	Train	Private TNC	Shared TNC
Bus fare	–0.75		0.63		
Bus in-vehicle time	–0.59		0.36		
Bus access time	–0.57		0.32		
Bus headway	–0.10		0.06		
Bus transfers (base of 1)	–0.18		0.08		
Train fare	–0.75	0.60			
Train in-vehicle time	–0.58	0.34			
Train access time	–0.58	0.30			
Train headway	–0.10	0.05			
Train transfers (base of 1)	–0.18	0.08			
Private TNC cost	–0.79				0.24
Private TNC in-vehicle time	–0.59				0.12
Private TNC wait time	–0.34				0.07
Shared TNC cost	–0.91			0.20	
Shared TNC in-vehicle time	–0.62			0.14	
Shared TNC wait time	–0.40			0.11	
Shared TNC extra person (base = 1)	–0.05			0.01	
Car in-vehicle time	–0.34			0.26	0.21
Car parking cost	–0.34			0.22	0.31
Car toll cost	–0.09			0.05	0.08
Car fuel cost	–0.04			0.02	0.03

Note: A column for "car" would show no cross elasticities large enough for inclusion.
[a]Direct elasticity = (percentage change in demand + percentage change in own mode attribute).

A New Model for the Impact of Values and Attitudes on Transit Ridership

A separate model was built to focus on attitudes and values, with little emphasis on supply characteristics. The study of preferences in the explanation of variation in public transportation ridership involves multiple attitudinal factors, some of which involve longer-term decisions (e.g., where to live and how many cars to own), and some of which involve shorter-term judgments ("I think transit is stressful or nonstressful").

This research project applied the method called structural equation modeling to examine not only the direct relationship between a given preference and the propensity to use transit, but also the indirect impact, where an independent variable may influence a second variable, which in turn influences the outcome variable. An example of this might be long-term values about urbanism, which influence the density of one's location, which in turn influences the amount of transit consumed.

A powerful tool within structural equation modeling is the calculation of total effect, the sum of the direct impact of the factor plus the sum of the indirect factors. The total effect allows the quick observation of the total impact of a given independent factor on the outcome factor. The method employs the concept of latent factors, which help examine multiple observed variables together, as documented in Technical Appendix 6.

Elements of the Attitudinal Model

The attitudinal model of the 2016 TCRP survey (Figure 24) has four major component parts, as follows:

- **Longer-term values.** On the left-hand side of the diagram, four longer-term values are defined that are hypothesized to cast influence on the next three component parts, both directly and through intervening factors.

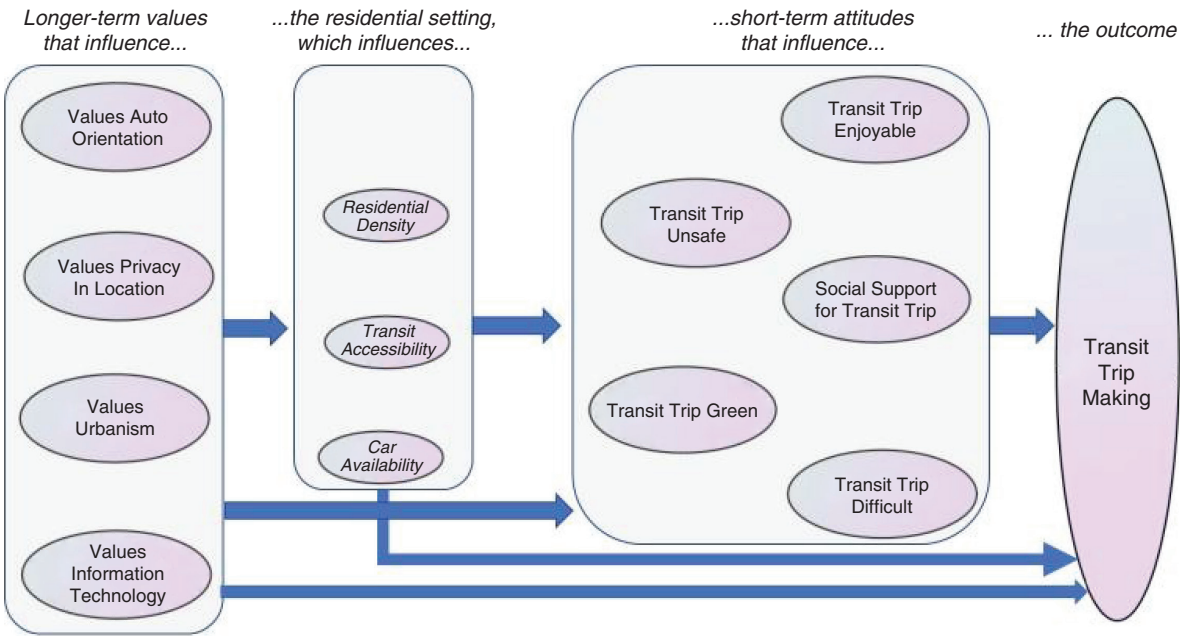

Figure 24. Conceptual diagram of attitude-based model.

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- **Residential setting.** Next, the residential setting of the participant is reported in terms of density, design, accessibility, and car ownership. These indexes of residential setting are hypothesized to influence transit use directly and also indirectly through shorter-term attitudes, which in turn influence propensity to use transit.
- **Shorter-term attitudes.** Five latent variables represent shorter-term attitudes with direct impact, including four concerning the evaluation of the transit trip and one representing perceived normative influence and peer influence.
- **Outcome/ridership.** On the right-hand side, a latent variable represents the outcome factor (transit ridership).

Eleven Factors Help to Explain Variation in Transit Use

The model is not designed to predict behavior but rather to contribute to understanding of the relationship between and among factors, given the relationships hypothesized in Figure 24. Structural equation models can reveal the combination of direct and indirect effects of one factor on another, called the standardized total effect (STE). For example, to explain the meaning of the total effect, the AMOS software program states:

> The standardized total (direct and indirect) effect of 'Values Auto Orientation' on Transit Use is –.264. That is, due to both direct (unmediated) and indirect (mediated) effects of Values Auto Orientation on Transit Trip making, when Values Auto Orientation goes up by 1 standard deviation, Transit Trip making goes down by 0.264 standard deviations.

Table 23 shows the ranking by level of importance of 12 explanatory factors, of which one was found to be statistically insignificant. The table shows that the strongest factor in the explanation of transit use is the normative factor, or the idea that those in one's social network would

Table 23. Rank order of importance of factors in the explanation of transit use.

Rank Order by Absolute Value of STE	STE	Factor[a]
1	0.46	Normative (social support)
2	–0.35	*Car available*
3	0.35	***Values urban setting***
4	–0.26	***Values auto orientation***
5	0.22	Transit trip green
6	0.21	Transit trip enjoyable
7	0.21	*Design and accessibility*
8	0.16	*Density*
9	0.13	***Values productivity, ICT***
10	–0.13	Transit trip difficult
11	0.12	***Values suburban house***
12	ns	Transit trip unsafe

[a]Bold italic type indicates latent factors for the four basic values, italic type indicates the three items concerning residential setting, and roman type indicates the five short-term attitudes (see Figure 24); ICT = information and communications technology; ns = not significant.

approve of one using transit and that they would use transit themselves. In Figure 24, this factor representing normative pressure is labeled "Social Support for Transit Trip."

The data in Table 23 can be interpreted in several ways. While the STE is usually expressed in the scale of a 100% increase in the independent factor, a more realistic interpretation can be stated in terms of a 10% increase in the independent factor. By way of example, Table 23 shows the following:

- A 10% increase in the value of the factor "values urban setting" would be associated with a 3.5% increase in the outcome factor, "transit trip making."
- A 10% increase in the value of the factor "values auto orientation" would be associated with a 2.6% decrease in the outcome factor, "transit trip making."
- A 10% increase in the value of the factor "transit trip enjoyable" would be associated with 2.1% increase in the outcome factor, "transit trip making."

Exploration of the Interactions Between Factors

As shown in Table 23, the most important explanatory factor in interpreting transit use is normative (social support), with an STE of +0.46. Phrased differently, the propensity to believe that people in one's social network either use public transportation or would approve of one's use of public transportation is a powerful factor in the prediction of transit use. The role of peer influence is a major theme in the social psychology of transportation behavior and in the social psychology of multiple other behaviors.[4] Other important factors in the explanation of transit use are as follows:

- The factor of car availability has strong (negative) impacts on transit ridership, with an STE of −0.35.
- Another powerful explanatory factor reported in the table is that of basic values toward urbanism (STE of +0.35), which plays a key role in the choice of residential setting, which in turn plays a key role in the propensity to choose transit.
- The fourth most important explanatory factor in Table 23 concerns one's values and preferences with regard to the automobile, with an STE of −0.26. Logically enough, the stronger one feels about the importance of owning a car, and the greater the pleasure one derives from the car, the lower will be one's propensity to use transit.
- The factor representing neighborhood design and accessibility has an STE of +0.21. This factor is clearly interrelated with residential density and is a good predictor of transit use.

[4] The potential role of social normative pressure was noted in a paper by Popuri et al. (2011) that was based on an early attitudinal survey fielded by RSG in 2010.

CHAPTER 7

Information and Communications Technology Might Change the Setting for Transit

Leaders in the transit community are grappling with the future role of products and services influenced by the rapidly advancing ICT sector. Strong differences by age and gender exist in the way in which communications devices are adopted today. These differences have implications for the way in which different groups will react in the future to services and products being developed. In many cases, the predictions for transit can be optimistic: services such as advanced passenger information systems will soon provide personalized guidance within and between public modes that is not available today. In other areas, leaders in the transit community are now debating whether new services to be provided by transportation network companies (TNCs) will either help or hinder the future of public transportation.

The chapter is presented in five sections:

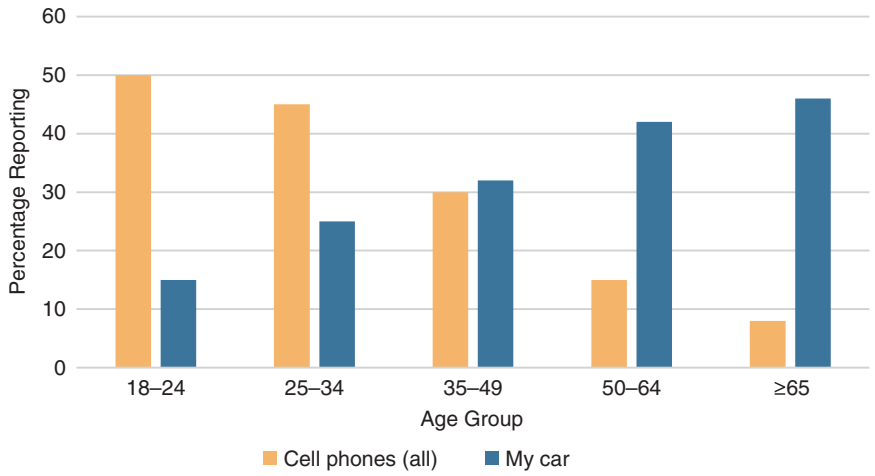
1. Ownership of communication devices,
2. Use of and attitudes toward existing advanced communications,
3. Services from TNCs,
4. Autonomous vehicles and transit, and
5. Replacement of travel because of communications technology.

Who Owns Communications Devices?

According to recent Pew research (Rainie 2017), 77% of all Americans have a smartphone—64% of those with incomes less than $30,000 per year and 90% or more of those with incomes greater than $75,000 per year. Rates of smartphone ownership are similar for whites, African-Americans, and Hispanics, although minorities are more likely to use a smartphone to access the Internet, which suggests they are less likely to have broadband service at home. More than 90% of urban millennials reported owning a smartphone in the Pew research. The 2016 TCRP survey found similar distributions across age groups: more than 90% of the respondents 18 to 34 years old reported owning a smartphone. The same research indicates the people who were least likely to own a smartphone were older, rural, and poor.

Who Finds Communications Devices Important and How Do They Use Them?

The TransitCenter survey (2014) asked respondents what device would be most difficult to live without, with a broad definition of "device" that included everything from televisions to cars. The results powerfully show the effect of increasing age on personal priorities about staying connected, as shown in Figure 25. While fully half (50%) of those between the ages of 18 and 24 say the hardest device to live without would be 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



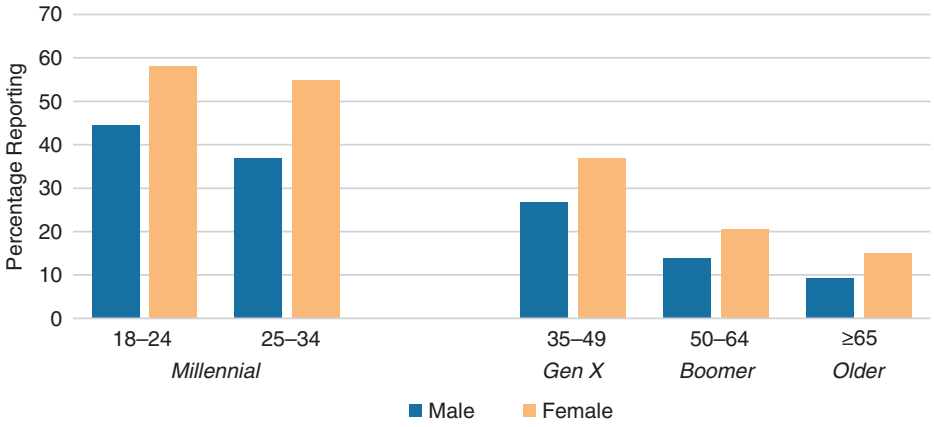
Source: TransitCenter 2014.

Figure 25. Percentage reporting most difficult device to live without—cell phone or car—by age.

age, with more than 45% of those over 65 stating the car would be the hardest device to live without (Figure 25).

Gender is also an important factor in attitudes about mobile technology. Figure 26 reveals that women place a higher value on connected devices than men in every age group.

Half of the project sample for the 2016 TCRP survey used a connected device to help with driving directions and one-quarter used a connected device to obtain real-time traffic information within the past week. 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. Overall, in the 2016 survey, 15% of the respondents had used a device to navigate transit or obtain real-time transit information in the past week. Younger people and individuals with lower incomes were more likely to use a connected device for assistance in navigating transit travel. While everyone values staying connected throughout the day, higher-income people indicated it was slightly more important for them as compared with respondents with lower incomes. People with lower incomes were slightly less (4% less)



Source: TransitCenter 2014.

Figure 26. Percentage reporting connected portable device most important, by age and gender.

likely to agree with the statement "It is important for me to have access to communication technology throughout the day" as compared with the average response to the statement.

Services from Transportation Network Companies

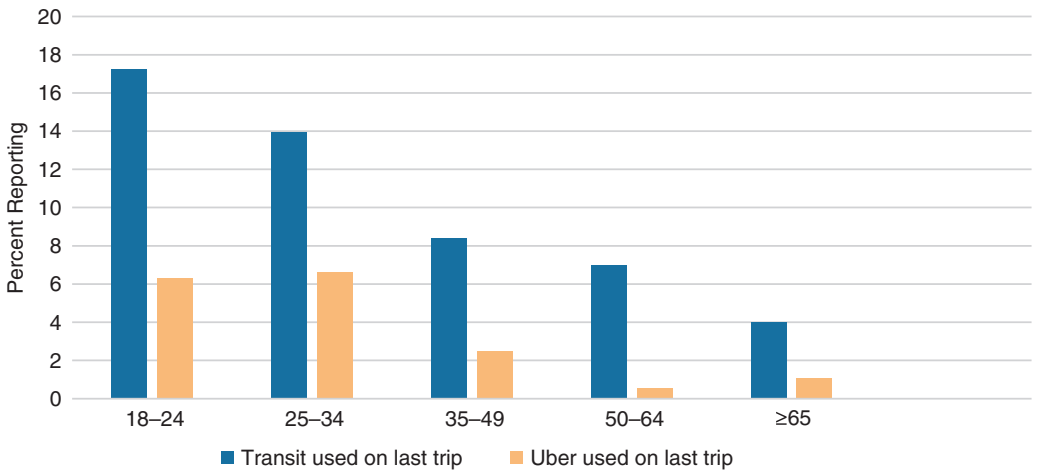
TNCs and Transit Use

An established player in the set of new travel options are TNCs (e.g., Uber and Lyft) 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. In the 2016 TCRP survey, 22% of respondents indicated that they had used a TNC to make trips in the past week.

Public Transportation and Ride-Hailing

Younger people embrace both new means of travel—such as the original ride-hailing services of the TNCs. Arrangement of a ride for a single person is referred to as "private" TNC service; arrangement of a ride to be shared with strangers in the same vehicle is referred to as "shared" TNC service. Figure 27 shows the percentage of people, by age group, who reported a transit trip or private TNC trip as the mode of travel for their most recent trip: both means of travel seem to be influenced by the age of the traveler. Seventeen percent of 18- to 24-year-old respondents reported their last trip was on transit, compared with half that (8%) for middle-aged people aged 35 to 49, and half again (4%) for those aged 65 and over. Around 6% of 18- to 34-year-old respondents reported that private TNC was used for their last trip, compared with negligible use (less than 2%) in the older age groups.

According to the Pew study (Smith 2016), 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 available research on the types of trips made using TNCs, many trips are late-night nonwork trips. The current survey obtained the reported number of work and nonwork trips using TNCs . On average, people who reported using TNCs had used them twice in the past week. Most of these trips were for nonwork purposes. The single millennials market segment reported using a private TNC for commute purposes more than other people but used it slightly less for other types of trips. The urban commuters market segment reported using private TNC for nonwork trips more often than other groups, but less often for commuting.



Source: 2016 TCRP survey.

Figure 27. Percentage mode share for last trip, by age group, 2016.

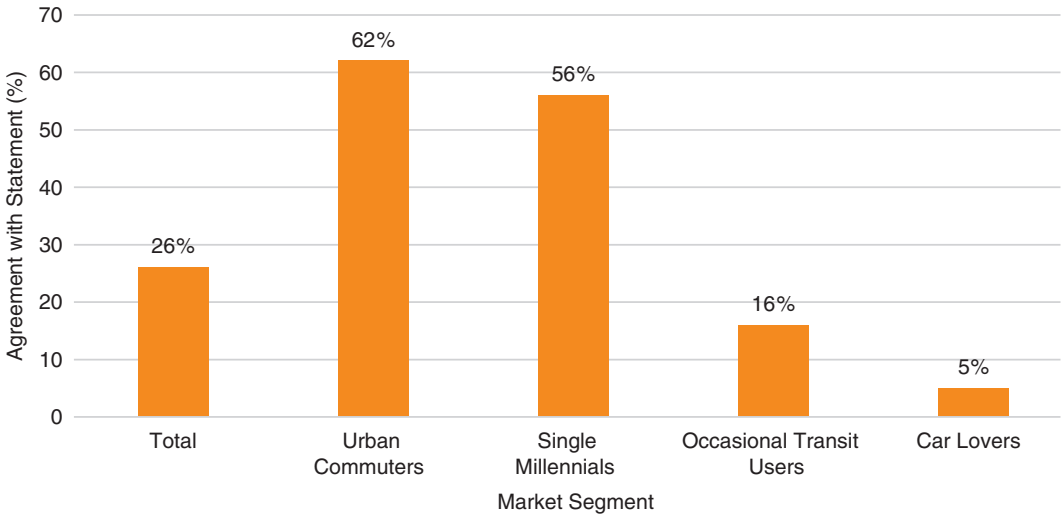
Both the Pew study and *TCRP Research Report 188: Shared Mobility and the Transformation of Public Transit* (Feigon and Murphy 2016) found that people who used ride-hailing services such as Uber and Lyft were less likely to own a personal vehicle and more likely to use public transit. The present study supports those findings. People in the 2016 TCRP survey who used TNCs were less likely to own a personal vehicle than those who did not: 79% of people who used private TNC had access to a vehicle, compared with 86% of people who did not use a TNC. However, the impact of new services on the decision to own a car (or an additional car) varied sharply by the attitudes held by the traveler: Figure 28 shows that the majority of those in the two transit-positive market segments agreed with the proposition that "Because of new services helping me make trips, I feel less need to own a car." By contrast, about 5% of the most car-oriented group agreed with the statement.

According to the Pew study, people who use 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-share services. In each instance, frequent ride-hailing users are significantly more likely than other Americans to engage in these behaviors.

The 2016 survey also found that people who use ride-hailing TNCs were more likely to be transit users. About half of the sample in the survey indicated they used transit, and, of those, 40% also had used a ride-hailing TNC in the past week and 60% had not. Of all the people who reported any TNC use, 85% also reported transit use compared with 37% who did not use any TNC.

The interrelationship of auto ownership, new services, and transit use is revealed repeatedly in the survey data. As noted, TNC users were also more likely to use public transit and own fewer cars. In addition, the survey supports research that found that people who have access to carshare services (car2go or Zipcar, for instance) were less likely to own a vehicle. Just 2% of the overall sample said they had regular access to a carshare program—too small to break out the vehicle ownership by cluster. However, about half of the percentage of people with access to a carshare program owned a vehicle (40%) compared with those without such access (85%). A sharp variation exists in attitudes about the extent to which new services will lower the need for the car; significant differences are shown by market segment in Figure 28.



Source: 2016 TCRP survey.

Figure 28. Agreement in 2016 with the statement: "Because of new services helping me make trips, I feel less need to own a car."

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More Direct Competition with Fixed Route and Schedule Transit? The Slow Emergence of Shared Services

While most of the professional literature does not currently focus on new shared service that could compete directly with transit, the emergence of new kinds of shared services is discussed in *Special Report 319: Between Public and Private Mobility: Examining the Rise of Technology-Enabled Transportation Services* (Transportation Research Board 2016, p. 2):

> 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.

Considerably less is known about these spin-offs from ride-hailing services, described in this report as "shared TNC" services. Ford Motor Company's Chariot, Via, Lyft Shuttle and uberPOOL are offering services similar to those pioneered by Bridj. These services share a similar concept that certain routes can be operated in smaller vehicles, carrying multiple parties with some common origins and destinations, based on last-minute pairing though mobile devices. The extent to which these specialized bus services can or cannot be integrated into (or coordinated with) existing networks is the subject of much debate in the international transit community at this point.

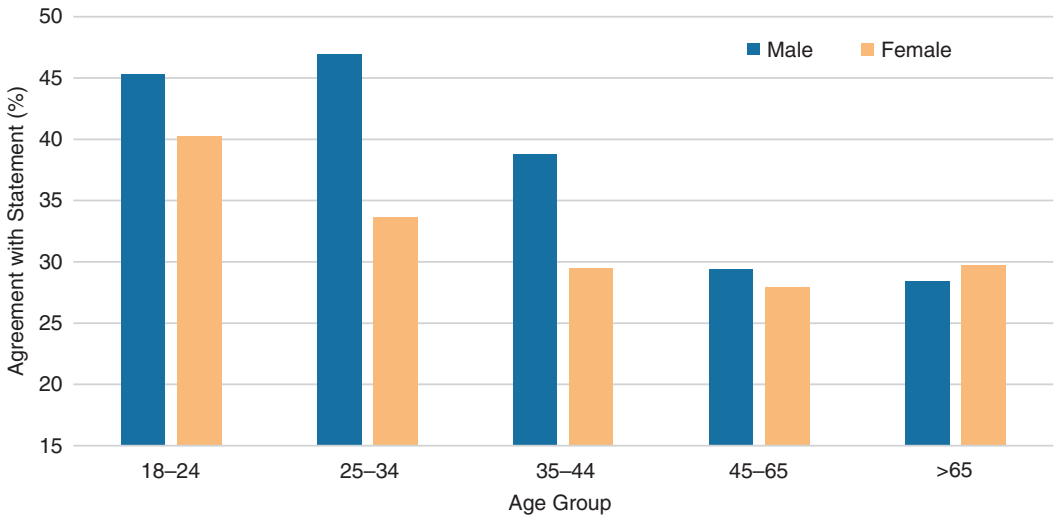
Autonomous Vehicles and Transit

Some future technologies could completely disrupt current patterns of travel behavior. While private TNC services provide a platform to connect drivers and people wanting rides, in practice it is like a taxi service, and thus not the same market as most transit. On the other hand, a more disruptive technology, autonomous vehicles, will likely be used for mobility in the future, with direct impact on transit ridership patterns—but how will autonomous vehicles be used? Recent research points to three possibilities (Correia 2016):

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

The reality will probably be a combination of all three. In the 2016 survey, the respondents' thoughts about how autonomous cars would affect their transit use varied starkly by market segment. A sharp difference was seen between the urban commuters, who had less than mean propensity to agree that "In a world with driverless cars, I would not see much of a role for buses and subways anymore," and the single millennials, who strongly agreed with the statement. Importantly, younger people (millennials) tended to imagine a world where autonomous cars would replace transit, while older respondents (and "occasional transit users") did not.

The mix of future services and their relationship to fixed route and schedule transit is a matter of some concern for the transit industry. Currently, TNCs are most frequently used for social trips between 10:00 p.m. and 4:00 a.m., times when public transit runs infrequently or is not available; however, the data showed that single millennials were starting to use TNCs as part of their commute options. TNCs may currently substitute more for automobile trips than public transit trips, but as TNCs encourage people to own fewer vehicles and depend more on shared services—and, more importantly, as those services develop and change in response to market forces—they may compete directly with transit. Young people believe that autonomous cars would change their trip-making behavior, and males believe this somewhat more than the females (Figure 29).



Source: Coogan et al. 2016.

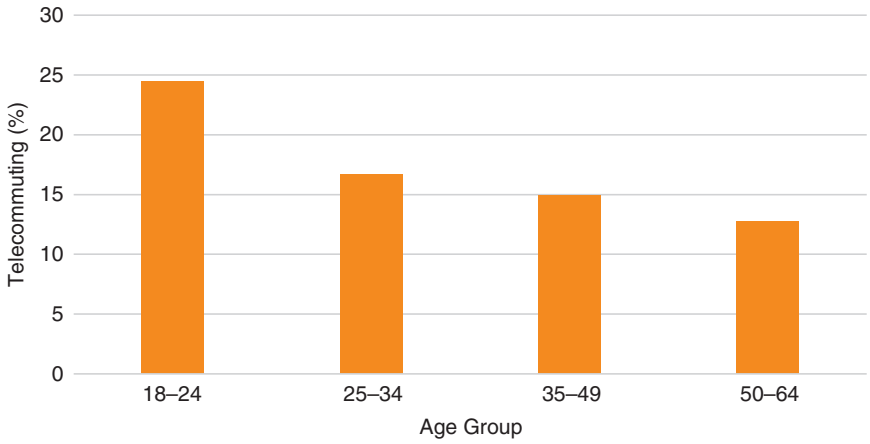
Figure 29. Effect of age and gender on agreement that autonomous cars would alter present travel behavior.

Are Trips Being Replaced by Information Technology?

Variation in Telecommuting, by Age

Predicting how evolving information technology will affect the total number of trips taken in the future is highly challenging. Perhaps the simplest form of substitution occurs when the employer encourages the worker to work a part of the week outside of the established office.

This pattern is not the same as the decision to base one's work at home, which was reported in Chapter 3 in the discussion of journey-to-work data. The propensity to base work at home rises directly with increasing age. The propensity to report telecommuting decreases directly with increasing age, as shown in Figure 30. Thus, given the observed fact that the younger cohort is used to working remotely more often, a reasonable forecast is that this trend will not be good for daily transit ridership to work: if this trend is a cohort-based pattern, higher overall telecommuting rates will result; if it is an age-based pattern, some decrease over time would be expected.



Source: 2016 TCRP Survey.

Figure 30. Effect of age on telecommuting at least once per week, 2016.

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When Are Trips Substituted?

The effect of information technology on travel is most apparent in two areas:

1. When the technology supports travel choices that include applications and tools such as real-time travel information, mapping, and car- or ride-share services, the new technology complements travel.
2. When information provides a more attractive method for completing a task, then it substitutes for travel. This is evident in activities such as shopping or banking, for which smart devices have enabled activities without travel to the location.

The classic model developed by Circella and Mokhtarian (2010) 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. In a major study undertaken in Germany and the United Kingdom, *ICT and Physical Mobility*, Pawlak et al. (2015) concluded

> that the naïve expectation that ICT is serving to replace physical mobility is unsupported by either theory or the empirical evidence in the public domain. Leading scholars demonstrate that, depending on one's interpretation, the results are either indeterminate in their conclusions or tend to, on balance, refute this "replacement hypothesis."

Changes in Retail Travel Patterns?

If fewer total trips are going to be made to brick-and-mortar stores, then transit ridership will decline for those trips. Online retail options are growing, and the effect on land use is apparent: large trip generators such as record stores, book stores, and electronic stores have disappeared from malls and retail centers. However, 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, demonstrate that the effect of ICT 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.

Additionally, there is another way to look at the issue. The 2009 NHTS showed that adults (ages 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 than they did in 1995, and women spent 30 minutes more time at home per week. 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. The implications here are complicated, but, to some extent, improved information technology may have a role in lowering the total number of trips rather than in replacing them.

CHAPTER 8

Conclusions and Further Research

This study of factors influencing markets for public transportation has examined the relevant factors and anticipated trends that may affect future travel behavior. The future for markets for public transportation can be characterized in part as too uncertain to predict and in part as predictable within reasonable levels of uncertainty. This concluding chapter reviews that which one can know (or reasonably guess) and that which one cannot know.

Things That Can Be Predicted About Future Transit Markets

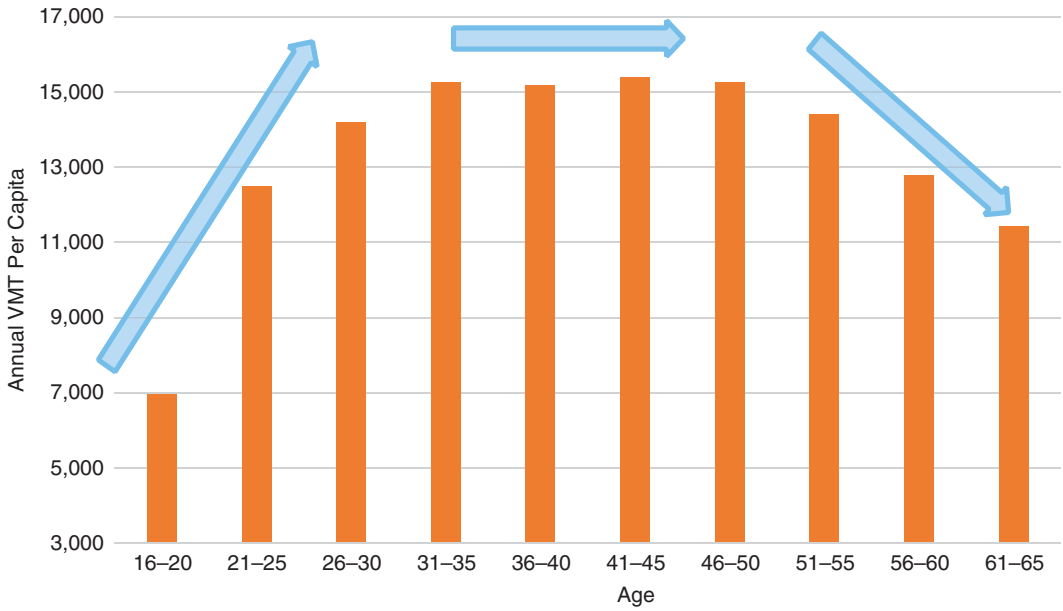
What is known is that in 20 years, the population will be 20 years older than it is today. Each cohort will move into an entirely different age group and, quite possibly, carry with it some of the unique characteristics that make this cohort different from others. That they will be in a new age group is certain; the extent to which they will retain their values and market preferences as they age is far from certain.

Also known is that a new cohort, generation Z, will move into the age groups generally from ages 15 to 34 and that transit-supportive life patterns have consistently resulted in high transit orientation for the younger members of these age groups.

The proportion of the population that is white and living in a two-partner household with children will decrease over time. Markets for transit will continue to become more diverse from a sociodemographic perspective. Much of this is good news for transit ridership, especially as the Hispanic portion of the American metropolitan population becomes larger, on the basis of the patterns discussed in Chapter 2.

Also known is that within a given 20-year period, the percentage of the housing stock that is newly built is quite small: the physical urban form of a metropolitan area takes a long time to change, even as trendy condominium towers appear in more dense areas and settlement patterns in the suburbs become somewhat more dense. By comparison, the migration of the population within a comparatively fixed urban form occurs more quickly; a housing stock well suited for lower-middle-class families can be overtaken by younger, more single populations ready to live with roommates who together can pay more rent than the traditional families they have displaced.

Further, the motivational forces in the stages of the life cycle are largely stable. The influence of age-based factors on residential location is easier to forecast than the cohort-based consistencies in behavior over time. Figure 31 suggests that the high need for and reliance on the private car for those between 30 and 50 years of age is largely stable and predictable. Figure 31 also shows two more things: (1) the transportation needs of those up to 30 years of age are highly



Source: 2009 NHTS.

Figure 31. Effect of age on vehicle miles traveled (VMT), 2009. Three conceptual trend lines show that those younger than 30 and older than 50 may see a change in their need for a vehicle.

unstable and changing constantly, and (2) the transportation needs of those between 50 and 65 years of age also are susceptible to change, with the advent of empty nesting and retirement.

With regard to the vulnerability of separate market groups, those moving from their 20s to their 30s and those moving from their 50s to their 60s are about to make highly important decisions about which patterns they retain and which patterns they reject in the next phase of life. This study concludes that those currently in the age groups near 30 will make major decisions that are (overall) not positive for traditional transit use. Those in the age groups near 50 might make decisions that are positive for transit, walking, and biking—quite possibly with a diminished role for large home formats and for the number of automobiles owned, in spite of the overall pattern of low transit use by older groups.

Things That Cannot Be Predicted About Future Transit Markets

Massive swings in cultural preference for locations and for automobiles are theoretically possible—but unlikely. This study has revealed that basic, deeply established beliefs associated with the phases of life will drive changes in residential location, and some of those changes in residential location will make intensive transit use far more difficult. There will continue to be meaningful preference for dense urban life by many of those under 30, followed by stable preference for more living space with continued aging until 50.

Need for Owning Autos?

The question of cultural attitudes toward the automobile is also hard to predict. While a massive rejection of the role of the automobile in American society is unlikely, variations in the way customers access them is another question. Assumedly, a decrease in the pattern of

affinity for the automobile would be positive for transit: further research should monitor for any change in the willingness to see the auto in a utilitarian manner rather than a hedonic manner. In some market segments, a lifestyle of owning no autos might be a preferred option for those who have not yet entered the child-rearing years. For those in the child-rearing years, a life with one less auto owned might be possible for some.

Future TNC Services?

The future roles of shared TNC services are as yet relatively difficult to forecast, as not enough is known about them. While the advent of TNC-dispatched private ride-hailing services has displaced other forms of taxi-like services, such an impact on traditional transit would be much less likely.

In the future, using cell phone–based dispatching for vans and large autos could either end up as one element in a family of combined mobility services, or (more pessimistically), result in the cherry-picking of low-hanging fruit from transit agencies who have worked for decades to build up ridership on fixed route and schedule services in those corridors.

It is too early to tell which will happen, but studies show that the youngest market segments would be the first to defect. Within the larger market supporting transit today, one market segment truly appreciates what transit does for the work commute, and a second (younger) segment is ready to move on to something else.

Predicting the role of autonomous vehicles is even more uncertain. On the one hand, the rapid dispatching of small vehicles to serve as the either the last urban mile or the first urban mile could solve collection and distribution problems long faced in transit line-haul corridors. But the ultimate use of a massive number of small vehicles in place of efficient high-capacity line-haul services could have decidedly negative implications for the functioning of urban transportation systems as a whole. Again, it can be predicted that when the transition comes, the younger groups will be the first to test the new services, and the older groups will be the last.

Implications for Further Research

This project sought to better understand underlying forces that might affect the nature of markets for public transportation. To accomplish this goal, the research team utilized several factors based on a specific paradigm for how they interact, as diagrammed in Figure 32. Further research in this area should be guided by, and should build on, the following project findings:

1. **Longer-term values, attitudes, and preferences influence the choice of residential setting and neighborhood characteristics.** The results support the hypothesis that longer-term attitudes toward urbanism (such as being active in public places and living in a community with a mix of people of diverse backgrounds) have an impact on the density, car availability, and transit orientation of the residential neighborhood chosen. Further research should monitor the extent to which certain market segments value the urban setting so much that they would be less likely to move away.
2. **The demographics of the user have a profound effect on the way longer-term values, attitudes, and preferences interrelate to ultimately influence the choice of mode.** Of these factors, age is the most important in the examination of past and future behavior. Further research should monitor the extent to which transit-positive groups such as Hispanics are retaining their ridership patterns over time.
3. **The physical settings and services of the neighborhood influence the formation of shorter-term attitudes about taking public transportation.** A wealth of data in Chapter 5

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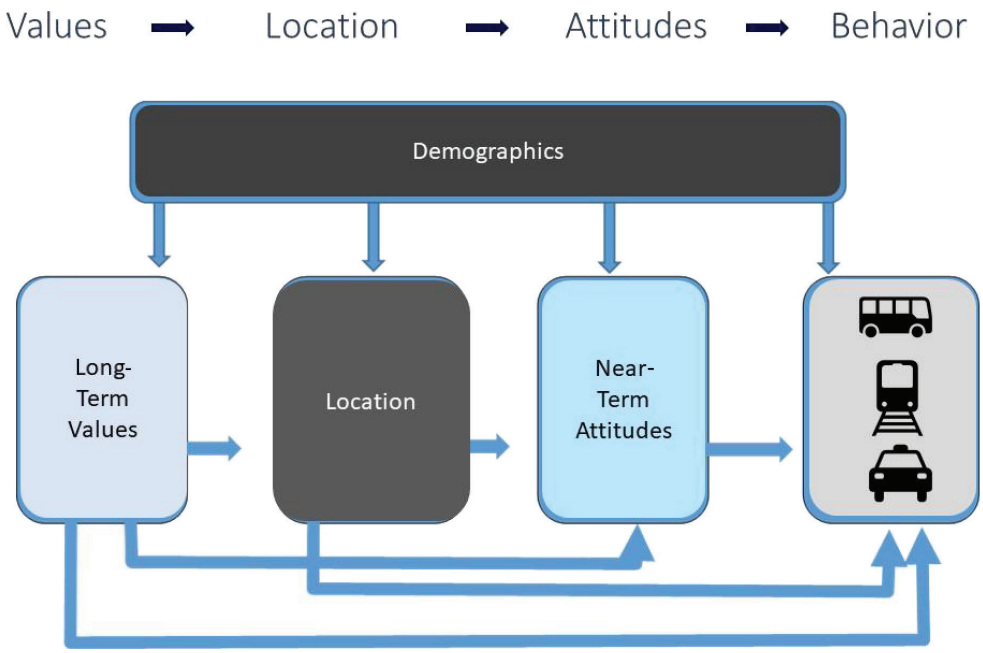

Figure 32. Further studies of demographics, location, and psychographics can benefit from this project's analytical framework.

shows how preferences and attitudes about available modal options vary by the nature of the neighborhood type. Further research should monitor the extent to which the current trend of high-income, high-density housing in downtowns is proving to be supportive of transit ridership.

4. **Near-term attitudes and assessments of the modes are influential in the choice of modes.** Near-term concerns about safety in transit, sharing space with others in transit, and feeling that transit is more enjoyable or less stressful are reflected in statistically valid model parameters.
   - Further research should monitor any change in the reported concerns of the younger generation about fear of crime and disturbing behavior on transit and note any change in empirically observed conditions.
   - Further research should explore and build upon findings of this research that peer influence and the impact of one's extended social network are key to developing positive attitudes toward transit, especially among those under 35.

Specific Project Ideas for Further Research

The publication of this report occurs within the same time frame as the release of the 2017 NHTS, which updates the 2009 results used in this project.

1. It would be highly desirable to do a follow-up study that benefits from the richness of sample size of the 2017 NHTS to further document the implications for public transportation markets of changes between 2009 and 2017. VMT per capita has rebounded since 2013, but there is currently no way to know the differences by demographic category (particularly age and race and ethnicity) for trip making above and beyond the journey to work. Such a study should utilize the new data from the 2017 NHTS to further examine how the growth pattern for rail services in this country differs from the market behavior pattern for bus services.
2. It would be highly desirable to continue to explore the market reaction to new and developing services such as the shared TNC services being tested around the country. Such a study

would explore the question of the new services being in a competitive as opposed to a complementary role; the study would attempt to resolve differences in conclusions currently being reached in the present literature.

3. A study of the implications of recent demographic, geographic, and psychographic data for the creation of local transit marketing studies should be undertaken. Given that previous TCRP reports aimed at local transit marketing managers have made positive contributions to the ability of the practitioner, a follow-on study that benefits from recent survey work, with the 2017 NHTS augmented by new and recent attitudinal surveys could be undertaken. Such a study would ensure that the information prepared for transit marketers would be as accurate as possible. While the present study should provide background information to support the creation of locally specific transit marketing programs, it was designed to examine underlying patterns rather than to provide near-term guidance in the development of marketing programs. With the arrival of the 2017 NHTS data to support new strategies, a new research effort aimed entirely at transit marketers should be undertaken. This study should explore and build upon the results of the present research that peer pressure and the influence of one's social network are strongly related to transit use.
4. A study on the role of public transportation in serving the mobility needs of empty nesters could be undertaken. While a major conclusion of the present study has been that those approaching their 30s will be changing their lifestyle, a parallel conclusion is that some market segments in their 50s are considering a smaller home with greater potential for transit, walking, and biking to provide mobility in somewhat denser locations than those of the previous 20-year period. Such a study of occasional transit users would acknowledge the lessened role of the work trip and document changes in walking and biking.

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Acronyms

CBD	central business district
GIS	geographic information system
ICLV	integrated choice latent variable
ICT	information and communications technology
ITE	Institute of Transportation Engineers
LCC	latent class cluster
NHTS	National Household Travel Survey
STE	standardized total effect
TNC	transportation network company
VMT	vehicle miles traveled

Appendices

The following seven technical appendices to this report are available individually on the TRB website (trb.org) by searching for "TCRP Research Report 201".

Technical Appendix 1	Literature Review and Project Bibliography
Technical Appendix 2	Demographics in Support of Chapter 2
Technical Appendix 3	Geography and Neighborhood Type in Support of Chapter 3
Technical Appendix 4	Survey and Market Segmentation in Support of Chapter 4
Technical Appendix 5	Analysis of Preference in Support of Chapter 5
Technical Appendix 6	Integrated Behavioral Modeling in Support of Chapter 6
Technical Appendix 7	Information and Communications Technology in Support of Chapter 7

Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FAST	Fixing America's Surface Transportation Act (2015)
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TDC	Transit Development Corporation
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation

TRANSPORTATION RESEARCH BOARD
500 Fifth Street, NW
Washington, DC 20001

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