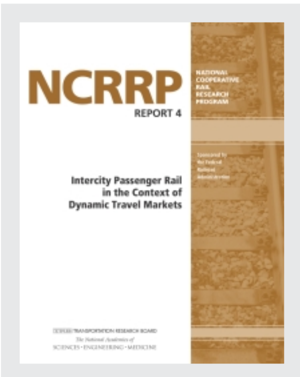

Intercity Passenger Rail in the Context of Dynamic Travel Markets

DETAILS

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NATIONAL COOPERATIVE RAIL RESEARCH PROGRAM

NCRRP REPORT 4

Intercity Passenger Rail in the Context of Dynamic Travel Markets

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NATIONAL COOPERATIVE RAIL RESEARCH PROGRAM

The National Cooperative Rail Research Program (NCRRP) conducts applied research on problems important to freight, intercity, and commuter rail operators. Research is necessary to solve common operating problems, adapt appropriate new technologies from other industries, and introduce innovations into the rail industry. NCRRP carries out applied research on problems that are shared by freight, intercity, and commuter rail operating agencies and are not being adequately addressed by existing federal research programs. NCRRP undertakes research and other technical activities in various rail subject areas, including design, construction, maintenance, operations, safety, security, finance and economics, policy, planning, human resources, and administration.

NCRRP was authorized in October 2008 as part of the Passenger Rail Investment and Improvement Act of 2008 (PL 100-432, Division B). The Program is sponsored by the Federal Railroad Administration (FRA) and managed by the National Academies of Sciences, Engineering, and Medicine, acting through its Transportation Research Board (TRB), with program oversight provided by an independent governing board (the NCRRP Oversight Committee [ROC]) including representatives of rail operating agencies.

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FOREWORD

By Lawrence D. Goldstein
Staff Officer
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NCRRP Report 4: Intercity Passenger Rail in the Context of Dynamic Travel Markets develops an analytical framework or structural plan to improve understanding of how current or potential intercity travelers make the choice to travel by rail—a choice that is often made in a competitive context that includes options to travel by air, rail, bus, or private automobile for the majority of their trip. This framework provides guidance for use by a diverse audience of practitioners and decision makers considering alternative planning, operating, financing, service, and capital investment strategies for intercity passenger rail service in existing and potential travel markets; and it allows users to evaluate how mode choice is affected by a variety of changing and evolving parameters. The framework developed through this research is based on an examination of fundamental values, preferences, and attitudes affecting travel mode choice. Identification of relevant parameters extracted from this analysis served as input to a comprehensive survey used to gather necessary data for developing an Integrated Choice/Latent Variable (ICLV) forecasting model. Building directly on the results calculated in this forecasting model is the scenario testing tool, a series of interconnected spreadsheets which make available to the analyst a wide variety of data and procedures needed in the application of quick-turn-around scenario testing. Together, the ICLV forecasting model and scenario testing tool provide a sophisticated framework for analyzing intercity travel behavior.

Intercity passenger rail in the United States is often studied from the supply-side perspective. As a result, the importance of travel times, frequency, and service quality is generally well documented in the literature and in actual market experience; however, intercity passenger decisions regarding mode choice in a changing marketplace are less well studied. Because of this imbalance, decision makers responsible for planning, financing, building, and operating intercity passenger rail lack an effective analytical framework that takes into account changing demand-side attributes (consumer demand) in the context of changing supply-side capacity (available level of service) by competing travel mode. This is a problem when considering levels of service, modal attributes, costs, and other relevant factors that are necessary when evaluating alternative transportation system improvement strategies.

Also contributing to this uncertainty is a lack of understanding of the decision-making process from the perspective of the passenger:

- What are the factors behind an individual's decision to choose rail or some other mode of travel for an intercity trip?
- How do these factors vary among individuals, markets, types of service, and trip purposes?

Many travel markets have recently experienced major shifts in travel patterns, illustrated by three characteristics: (1) a rapid rise of intercity bus travel in selected city-to-city travel markets, (2) significant air-to-rail mode shift in markets such as the Northeast Corridor, and (3) significant changes in mode preference among younger and older generational cohorts. Some of these changes are directly related to changes in the supply or quality of service, but many are based on additional factors that have not been as thoroughly researched or documented. Given this complex decision-making environment, the research team, under NCRRP Project 03-02, developed an analytical method testing the range of variables affecting mode choice, including demographic factors that potentially have a significant impact. These factors are separate from the usual supply-side factors considered in traditional demand analysis. The team, which included a wide range of professional disciplines, was led by RSG with Matthew Coogan, an independent consultant, serving as the Principal Investigator for the project.

The research presented in *NCRRP Report 4* demonstrates how these additional factors can be used to compare demand for rail and other travel modes so that future decision makers can more accurately measure the benefits and costs of alternative investment strategies on the multimodal transportation network. *NCRRP Web-Only Document 2*, available on the TRB website (www.trb.org), contains a bibliography and technical appendices to this report. The extensive bibliography in *NCRRP Web-Only Document 2* concerns related research and background data and analysis in support of development of the ICLV hybrid model. The technical appendix for ICLV and Hybrid Choice Model Development, in particular, demonstrates that the results obtained in this study have the ability to help formulate real policy implications using advanced modeling techniques in a real-world setting.

The scenario testing tool will be available to download from the TRB website in June 2016 (by searching for “NCRRP Report 4”).

CONTENTS

CHAPTER 1

Introduction and Major Conclusions

1.1 The Purpose of This Research

1.1.1 Project Objectives

"The overall objective of this research is to develop an analytical framework to improve understanding of how current or potential intercity travelers make the choice to travel by air, rail, bus, or private automobile for the majority of their trip. This framework should provide guidance for use by a diverse audience of practitioners and decision makers considering alternative planning, operating, financing, service, and capital investment strategies for intercity passenger rail service in existing and potential travel markets, and it should allow users to evaluate how mode choice is affected by a variety of changing and evolving parameters.

A second objective is to produce this analytical framework on two levels: one that is designed to help the practitioner understand the interaction of key factors in the process of attitude formation toward intercity travel by mode and a second level in which these relationships are operationalized with methods designed to be ultimately incorporated into the transportation demand forecasting process." [Unpublished request for proposals for National Cooperative Rail Research Program (NCRRP) Project 03-02]

1.1.2 Context and Work Plan

Americans may be changing some fundamental patterns of their travel. For decades, transportation analysts have seen demand for automobile travel as almost inevitably rising with the continued growth of national economic activity. Today, analysts agree that overall rates of automobile use are down since the new millennium, although there is debate about why rates are down. Ridership on rail and intercity bus, however, is consistently up.

As travel demand analysts began examining why rates of automobile use are down, this NCRRP project sought to understand how a wide range of causal factors seemed to be coming into play at once, affecting both our present patterns of travel, and logically affecting the future patterns. Analysts of travel demand have focused on approaches based on economic theory—assuming that choices among modes are driven by modal service variables such as travel times and travel costs. Advocates of social psychology and market research look at values, attitudes, and preferences that influence our travel behavior. With original market-based data collection, this NCRRP project undertook the largest effort ever attempted to integrate traditional economic approaches with those used by market researchers and psychologists in order to answer these key questions about travel behavior. The work plan included a major, original survey of residents of the Northeast Corridor (NEC) and the Cascade Corridor.

Early in the project, the research team proposed an analytical framework for the examination of values, preferences, and attitudes; this framework was key to the creation of a survey instrument, which broke out longer-term basic values from shorter-term attitudes toward the modes and trips. The results of the survey first provided the basis for the creation of attitudinal models

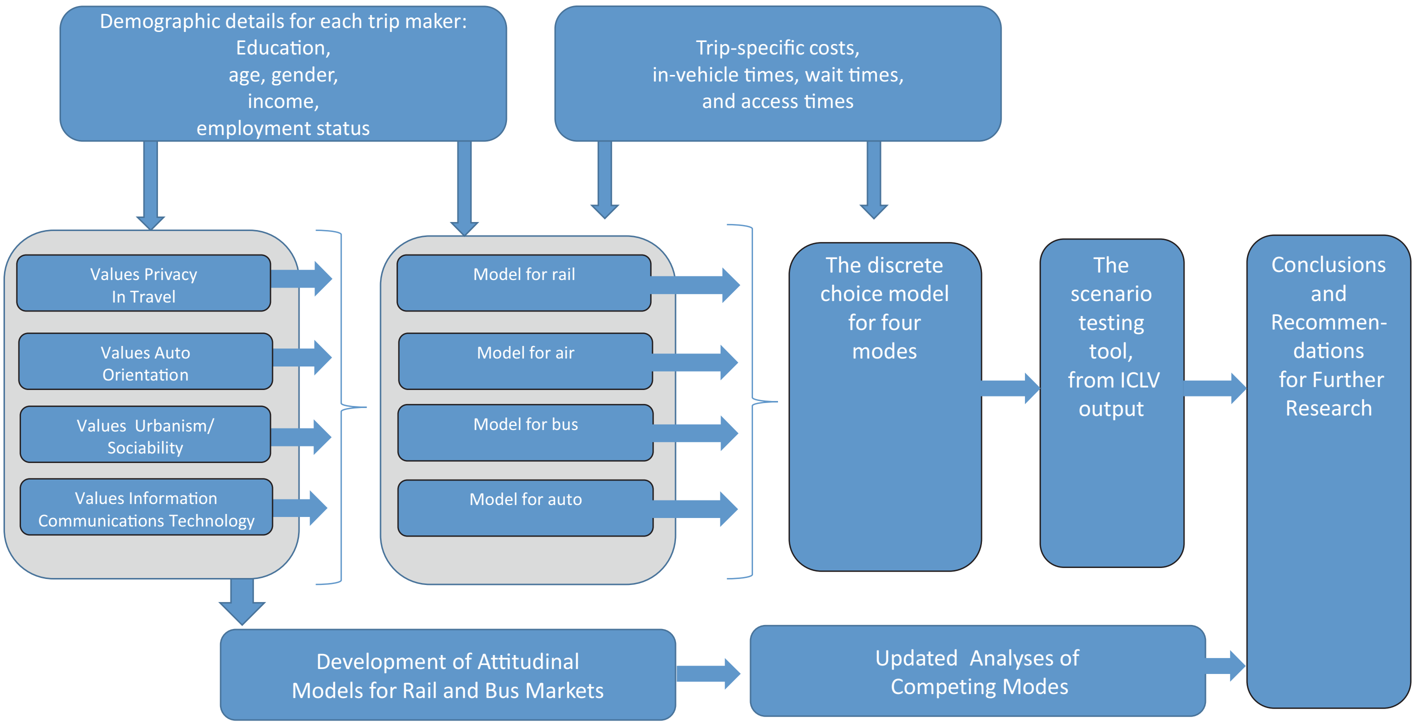


Figure 1. Conceptual diagram of the work plan for NCRRP 03-02.

for rail and bus markets, using structural equation modeling, which did not attempt to reflect detailed variation in trip characteristics (e.g., service levels and costs). The same survey results were then used in the creation of a single unified integrated choice/latent variable model that integrated both basic values and highly detailed information about specific trip choices. A scenario testing tool was then created to help the practitioner to interpret the very large amount of information from the unified model. Figure 1 diagrams the elements of the project work plan.

1.2 Need to Understand the Nature of Intercity Demand

Travel behavior is a consumer behavior like other behaviors: it is affected by cold hard facts, such as those describing the travel times and costs of rail service versus competitive modes. But it may also be affected by human beliefs and attitudes that affect individuals on both rational and emotional levels. For example, people might be influenced by normative pressures, such as the belief that "others like me" choose to take rail, or by a personal desire for a pleasurable, stress-free experience.

Several factors influence long-distance travelers to select rail, given the competition that exists from air, bus, and the private car. For decades, research into rail demand has focused on comparative travel times and costs for rail against each of its competitors in a dynamic market. The purpose of this NCRRP project is to better understand a wider set of factors that seem to be also influencing the propensity to select rail. The additional factors include demographic factors and cultural factors involving values held over the long term and shorter-term attitudes that may vary by the day-to-day context in which they are formed. In sum, an individual's propensity to choose rail may be influenced by demographic, geographic, and psychographic factors.

- **Demographic differences are easiest to spot.** In this project, older males make long-distance modal decisions in a manner radically different from younger females, as shown in Figure 2.

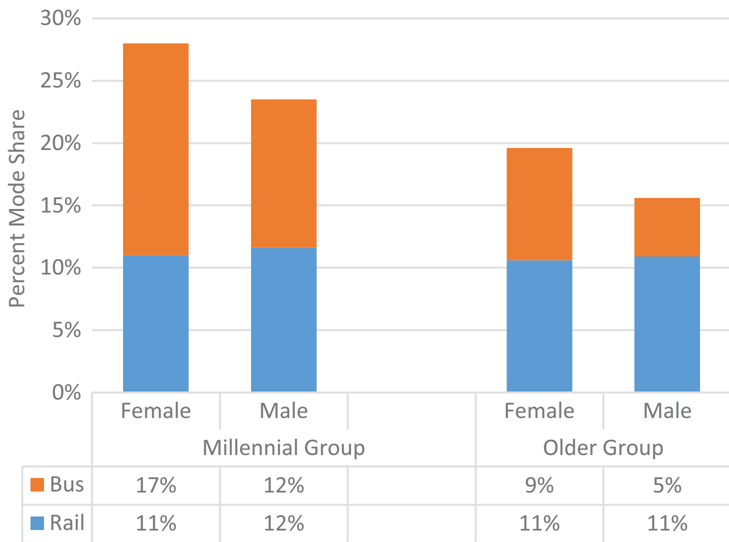


Figure 2. The influence of age and gender on choice of rail and bus.

The two groups face the same set of times and costs, but younger females choose the bus at a rate 3.5 times that of older males. This prompts the question: Do these groups have a different set of values, attitudes, or preferences?

- **Geographic differences merit examination.** Intercity trips with higher activity density at the point of destination attract far more riders to rail than do destinations with lower density. In many cases in other domains of travel demand, people from higher-density residential areas make more trips by public mode than people in lower-density residential areas.
- **Psychographic differences may be the hardest to examine,** as there is little agreement in the literature about which of these are relevant in affecting the choice of rail. There is a body of research literature that relates travel to deeply held psychological beliefs, but the application of such concepts to public policy has been problematic, at best.

1.2.1 The Influence of Theory from Social Psychology

This NCRRP project attempts to integrate all three of these categories in examination of factors beyond times and costs that are influencing demand for intercity rail today, and presumably will be influencing demand in the future. By far, the most difficult category to incorporate into the research is the third, the psychographic factors. In this work, they will be examined in terms of long-term preferences, referred to as "values," and shorter-term preferences, referred to as "attitudes." Longer-term values tend to influence long- and medium-term decisions, such as the location of one's residence or the number of cars owned. Shorter-term attitudes might concern one's feelings (1) that a mode (e.g., rail) is safe, convenient, or stressful or (2) that going from 0 to 60 miles per hour in 3 seconds in a new car makes one feel happy. Considerable research in this area has been based on the value–attitude–behavior hierarchical model, as illustrated in Figure 3 (Note that the values explored in this NCRRP project were not designed to reflect such psychological concepts as hedonism, security, and power, but rather more direct alternative influences on transportation behavior 25 years in the future).

There are several methods for applying and implementing the basic theory that suggests behavior is influenced by salient short-term attitudes, which in turn have been influenced by longer-term values and preferences. The dominant theory applied in the analysis of transportation

Figure redacted for on-line use; available in printed version.

Source: Paulssen et al. (2014, p. 875, Figure 1: An illustrative representation of the value–attitude–behavior hierarchical model). © Springer Science+Business Media New York 2013, used with permission of Springer.

Figure 3. The NCRRP analytical framework builds directly upon the value–attitude–behavior model now prominent in the literature.

issues is the Theory of Planned Behavior (TPB), developed by Dr. Icek Ajzen based on earlier work he undertook with Dr. Martin Fishbein, the Theory of Reasoned Action. The survey instrument developed by the research team was undertaken with the advice of Dr. Ajzen and was utilized in many phases of the work plan, including the creation of a new discrete choice model, called the "Integrated Choice/Latent Variable (ICLV) Model," presented in Chapter 5. According to Dr. Ajzen, this project represents the largest application yet of the TPB to transportation, but not the largest in other domains.

1.2.2 A Framework for Long- and Short-Term Preferences in the Choice of Rail

Prior to beginning the analysis of highly diverse and multifaceted attitudinal data, it is important to first establish a unifying theory of how the pieces fit together. In this NCRRP project, the research team applied the basic logic of the value→attitude→behavior concept to years of applied research undertaken in the analysis of transportation. Figure 4 shows a simple approach to assigning preferences to a logical sequence of experience. Although conceptually part of an approach, this analytical framework for preferences was specifically created to serve the needs of this research project, in which several alternative scenarios for the future will be created. By way of example, in one scenario one could hypothesize that in 25 years a given cohort group will (1) hold positive values about urbanism, (2) be located in a dense urban area, (3) have near-term attitudes based on their experience at that location, and (4) have their mode choice affected by some combination of the three aforementioned explanatory factors. By the midpoint of this

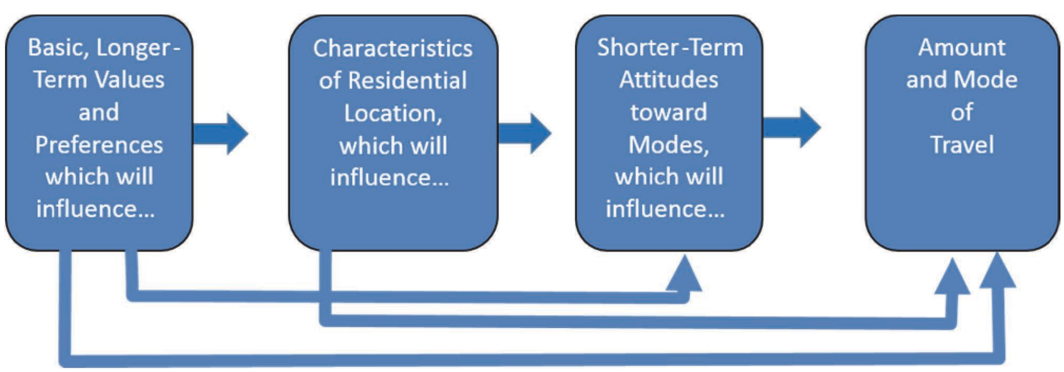


Figure 4. The NCRRP analytical framework for attitudes and preferences.

project, the research team had designed the survey instrument to gather information in all four subject areas—values, location, attitudes, and travel—shown in Figure 4.

1.2.3 What Are the Long-Term Values in the Analytical Framework?

The NCRRP analytical framework incorporates four basic, longer-term values (i.e., underlying factors) that might influence the choice of transportation mode:

1. **Values Privacy in Travel.** This factor represents a propensity to not want to travel with other people and to be uneasy and uncomfortable with the idea of being with people that one does not know.
2. **Values Auto Orientation.** This factor represents a propensity to value the freedom and independence gained from owning cars and to disagree with the concept that borrowing or sharing a car is just as good as owning one. It also reflects a feeling that one is (or is not) less dependent on the car as their parents were at that age.
3. **Values Urbanism and Sociability.** This factor represents the idea that one likes being in an urban setting, likes being able to meet and greet people, and feels that, when people work together, improvements to the world around them can result.
4. **Values Information Communications Technology (ICT).** This factor represents the propensity to value being productive with one's time and desire to stay connected and to own/use mode-connected information technology.

1.2.4 Why Create a Unified Model?

The analytical framework for understanding attitudes does not include much about specific times and costs (a diagram of the NCRRP 03-02 work plan that does integrate all elements was presented as Figure 1). Meanwhile the discrete choice modeling does not include much about attitudes. Therefore, the challenge turned to the *integration* of the two methods. A highly valuable (and critical) summation of the logic behind the concept of integrating the strong points of discrete choice mode modeling with that of attitudinal-based research is provided by Vij and Walker (2015):

> "Traditional models of disaggregate decision making have long ignored the question of why we want what we want. Human needs have been treated as given, and attention has largely centered on the expression of these needs in terms of behavior in the marketplace. As a consequence, traditional models of disaggregate decision making have focused on observable variables, such as product attributes, socio-economic characteristics, market information and past experience, as determinants of choice, at the expense of the biological, psychological, and sociological reasons underlying the formation of individual preferences (McFadden 1986). This idealized representation of consumers as optimizing black boxes with predetermined wants and needs is at odds with findings from studies in the social sciences that have attempted explicitly to map the cognitive path that leads consumers from observable inputs to their observed choices in the marketplace. These studies have consistently shown that latent constructs such as attitudes, norms, perceptions, affects, and beliefs can often override the influence of observable variables on disaggregate behavior. . . ."

The NCRRP 03-02 work plan called for the collection of original data that would support (1) the analysis of the value of times and costs for intercity modes as expressed in stated preference models, (2) the creation of attitudinal models that seek to reveal roles of both longer-term values and shorter-term preferences by the consumer toward intercity modes, and (3) the creation of an ICLV hybrid model, generally as advocated by Vij and Walker.

1.2.5 Can the Future Market Context for Rail Be Predicted?

The future market context for rail cannot be predicted. However, a small number of scenarios can be created to represent several possible futures for American society. These scenarios can explore how several alternative futures might affect the propensity to choose rail. The concept of uncertainty must be addressed in long-term planning; these new tools help decision makers understand numerous potential scenarios, thereby mitigating the inevitable uncertainty of the future. Without doubt, even after the careful examination of possible alternative scenario futures, uncertainty remains a key concept.

The NCRRP work plan called for the creation of four separate scenarios for the future market context for future rail travel. These four scenarios assumed the same level of rail service, in terms of both times and costs relative to competing modes.

1.3 Major Conclusions

1.3.1 What the Scenarios Revealed

The scenarios revealed how certain demographic, geographic, and psychographic factors in the future might impact rail ridership more powerfully than other factors and why some patterns might be important to start tracking more carefully than before. Specifically, work undertaken in several parallel research efforts of this project suggests that the millennial generation seems to have a serious concern with what it perceives as a lack of personal safety making trips by both bus and rail (a theme which will be developed later in this report). The research team's analysis suggests that—over time—this could seriously imperil the growth of rail and bus markets.

On the other side of the spectrum, the research team's findings suggest that the millennial generation holds certain values and attitudes concerning the *lack of need* for traditional forms of auto ownership that differ distinctively from older cohort groups. The research team's scenario testing exercise suggests that if, over time, this cohort abandons this orientation as it proceeds through the life cycle (e.g., as this cohort enters the child-rearing and child-educating age category), then any evident positive orientation of this group to rail and bus would be in jeopardy.

These concepts are developed in some quantitative detail in Chapter 6, with the implications explored in Chapter 10.

1.3.2 Differences Between Millennials and Older Groups in the Four Values

There were statistically significant differences between the mean scores of millennials and the older groups for privacy in travel, auto orientation, and ICT. The differences between groups for urbanism values were insignificant. While the comparative mean values for auto orientation and desire for ICT were consistent with conventional wisdom, the fact that millennials had more interest in privacy in travel than their elders was perhaps surprising. Basic relationships between demographic category and survey responses are presented in Chapter 3.

1.3.3 How Important Were Each of the Factors in the Explanation of Present Rail Choice?

The Attitudinal Model for Rail was applied to the question of relative importance of factors contributing to rail choice. As shown in Table 1, the strongest explanatory factor in rail choice is the idea that the rail service is inconvenient, which is influenced by finding the schedule frequency unacceptable. This factor is similar to the role of travel times in more traditional demand modeling; thus, its high ranking is not unexpected. The concept that a car trip is more stressful than a rail trip is also a key explanatory factor. The methods and assumptions underlying these conclusions are presented in Chapter 4, with further documentation in Technical Appendix: Documentation for the Structural Equation Models in *NCRRP Web-Only Document 2.*

Table 1. Ranking of importance of factors in the explanation of rail mode choice.

Rank Order	Standardized Total Effect*	Factor**
1	−0.73	Train Trip Inconvenient
2	−0.34	***Values Auto Orientation***
3	0.33	Train Trip Less Stressful
4	−0.29	***Values Privacy in Travel***
5	−0.22	Train Trip Unsafe
6	0.19	***Values ICT***
7	−0.15	Train Trip Expensive
8	0.09	*Education*
9	0.03	*Employed*
10	0.03	***Values Urbanism/Sociability***
11	Not Significant	*Density*

* Standardized total effect is defined and discussed in Chapter 4.

The four basic values are shown in ***italic bold*; four short-term attitudes are shown in roman; and demographics are shown in *italic*.

At the other end of the rank ordering, residential density turned out not to be a significant factor and values toward urbanism is on the border of being statistically insignificant, and certainly inconsequential, in the explanation of long-distance mode choice.

1.3.4 How Did the Four Future Scenarios Address These Issues?

As described in more detail in Chapter 6, four long-term scenarios for the future market context were developed by the research team. Each scenario assumed the same level of service from the transportation system, and the same set of demographics for education and employment. Highlights of the four long-term scenarios included the following:

- **Pessimistic interpretation of trends extended.** Each of the relevant policy input assumptions was set at a level not supportive of rail ridership. Millennials were assumed to drop their "anti-auto" attitudes as they transitioned into the prime child-rearing years (35 to 55 years old). Millennials were assumed to keep their "pro-privacy" values as they moved into middle age. No increase in education level or employment level was assumed. As groups get older, they were assumed to lose interest in their ICT devices.
- **Mixed Scenario A with continued preference for privacy in travel.** This scenario assumed that millennials would adopt the same attitudes toward the auto as those currently in their child-rearing years. However, this scenario assumed they would outgrow their fear of and discomfort with travel with others, even as they gain more experience in life. As they grow older, the need for ICT was assumed to continue.
- **Mixed Scenario B with continued anti-auto pattern.** As the mirror image of Mixed Scenario A, this scenario assumed that millennials would keep their anti-auto patterns throughout the child-rearing years. At the same time, it was assumed that, even with more experience, this cohort retains its fears about traveling with people they do not know. With increasing age, they were assumed to lose interest in their ICT devices.
- **Optimistic interpretation of future trends.** To test the upper levels of societal support for rail, this scenario assumed millennials would keep their anti-auto patterns. They would lose their pro-privacy concerns about traveling with others, to mimic the attitude of present senior citizens who have little fear of traveling with others. ICT devices would be important to everyone.

Table 2. Summary of change in rail ridership by scenario.

Decreasing Role of Auto Orientation in Future →		*Decreasing Concern for Privacy in Travel in Future →*
Pessimistic for Rail • Bad future for auto rejection • Bad future for privacy tolerance • ICT need will decrease with age ***Rail decreases by 4%***	*Mixed Scenario B* • Good future for auto rejection • Bad future for privacy tolerance • ICT need will decrease with age ***Rail increases by 4%***	
Mixed Scenario A • Bad future for auto rejection • Good future for privacy tolerance • ICT need will continue with age ***Rail increases by 10%***	*Optimistic for Rail* • Good future for auto rejection • Good future for tolerance • ICT need will continue with age ***Rail increases by 18%***	

1.3.5 Do the Scenarios Suggest a Wide Range of Possible Future Market Contexts?

Accepting the logic that the scenarios were indeed designed to emphasize variation, the scale of the variation based on alternative future cultural settings is significant. Holding constant the quality of rail services (and that of its competitors), the optimistic scenario predicts rail ridership to be 22% higher than ridership in the pessimistic scenario. These analyses are made possible by a combination of the hybrid travel demand model described in Chapter 5 and the scenario testing tool described in Chapter 6. Table 2 shows a summary of the scenario testing.

The predictions for each of the four future scenarios were undertaken for four trip purposes—business, vacation, visiting friends/relatives, and other. The "other" trip purpose, which is the smallest segment, is the most volatile, while the other three trip purposes all show fairly similar trends across the scenarios (see Table 3).

The NCRRP analysis process illustrates how differences between demographic groups can explain the differences in propensity to choose intercity rail, as shown in Table 4. To provide some interpretation: If all the members of the population sample were to adopt the values and attitudes of millennials concerning their need for privacy in travel, rail ridership would go ***down*** by 3.4%. If all the members of the population were to adopt the values and attitudes of those over 65 years of age concerning their need for privacy in travel, rail ridership would *go* ***up*** by 10.4%.

Looking at the basic value of auto orientation, if all the members of our population were to adopt the millennials' view of a decreased need for a private car, rail ridership would increase by 17.9%. If the values of the total population mirrored those of the population over 65 years of age concerning

Table 3. Change in rail trips under the four scenarios by trip purpose.

Trip Purpose	Pessimistic	Mixed Scenario A	Mixed Scenario B	Optimistic
Business	−5%	13%	3%	22%
Vacation	−4%	8%	2%	14%
Visit friends/relatives	−2%	9%	4%	15%
Other	−11%	14%	9%	35%
Total	**−4%**	**10%**	**4%**	**18%**

Table 4. Variation in rail use by basic value, expressed as shift in demographics.

Demographic Shifts in Attitude	Latent Factors for Four Basic Values				All Values at Once
	Privacy	Auto Need	Urbanism	Technology	
Female to male	−0.4%	2.3%	−0.3%	−0.4%	1.2%
Male to female	0.4%	−1.8%	0.2%	0.3%	−1.0%
All age groups to under 35	−3.4%	17.9%	0.0%	2.5%	16.4%
Under 35 to 35–44	0.0%	−1.7%	0.0%	0.0%	−1.7%
All age groups to over 65	10.4%	−11.9%	0.0%	−3.4%	−5.7%
No college to college	2.7%	1.2%	0.1%	0.1%	4.2%
College to no college	−7.5%	−3.6%	−0.2%	−0.3%	−11.4%
Unemployed to employed	1.3%	−0.6%	0.0%	0.2%	0.9%
Employed to unemployed	−2.5%	1.2%	0.0%	−0.4%	−1.7%

the need for a private car, rail ridership would go down by 11.9%. Table 4 also illustrates the interrelationship between the demographic category and the four latent factors by allowing the (unlikely) assumption that a given demographic shift would apply to all four latent factors at once, which may or may not be a realistic scenario future (see column "All Values at Once").

1.3.6 Key Factors Identified in this Report

A major theme of this report is the need to undertake further research around both the latent factor concerning decreased car orientation (here labeled Auto Need) and the latent factor concerning need for privacy in travel. These two factors have the greatest impact on the change in rail ridership across the research methods employed in this NCRRP project.

The results of the project's scenario testing task suggest there are elements of the choice of longer-distance mode that are based on market reaction to improved services at competitive costs. However, beyond this important component of choice, the decision to choose a mode is associated with highly personal preferences about privacy and personal safety, and devotion to or freedom from the personal automobile. To a lesser extent, these decisions may be associated with the desire for travel time to be productive time, connected to the electronic world. In the scenario analyses, attitude toward the urbanity of dense cities seems to predict less than originally hypothesized (this observation, drawn from the Chapter 6 scenario analysis, is consistent with the Chapter 4 conclusion that density is not a significant factor in the explanation of rail mode share).

1.3.7 Why Are These Alternative Future Scenarios Important?

This NCRRP project is demonstrating the logic of creating a set of alternative background futures, in a disciplined manner. The futures must reflect what is known about the key variables affecting background market conditions. Then, these alternative futures can be used to examine various policies and facilities characterized by the relative times and relative costs. A particular vision of new rail facilities, better headways, more coverage, and improved travel times might be tested under four possible futures, rather than one. Recently, a federal court in North Carolina struck down an environmental impact statement simply because it was based on one assumed future, rather than several possible futures (McDonald 2015). Most importantly, incorporation of values, attitudes, and preferences in the travel demand analysis process may help policy planners understand which strategies and practices might be most effective in changing travel patterns.

1.3.8 Additional Factors to Explore

The Influence of One's Peers on the Selection of Intercity Mode

The modeling of the attitudes through the format of the TPB suggests two more possible areas for future research. First, the choice of rail may be—perhaps more than anticipated—influenced by **normative pressures**. Even the novice student of human behavior would expect that issues like "what clothes I wear" or "what dancing I like" to be influenced by the views of peers and friends; however, the research team's findings suggest that the choice of intercity mode may be influenced by a person's sense that "others like me" are also taking this mode. Figure 5 shows that millennials are more likely than older groups to report that "people who are important to my life" or "my friends and coworkers" take the train. And yet, millennials have the same overall propensity to take the train as the older groups, as shown in Figure 2. In the present literature in social psychology, this concept of descriptive norm is being explored as a strong explanation for propensity to change behavior. Interestingly, in the development of the TPB model (see Chapter 4), in the millennial-only sample, little relationship was observed between choice of rail and belief that others would *approve* of one's behavior; however, a strong relationship was observed with the belief that rail was being taken by "people who are important in my life." This suggests that one's personal attitudes may be intertwined with the perceptions of those of his/her peers and equals.

Further research should examine the possibility that younger groups might be more receptive to information seen in the context of their relationship to their personal social networks.

Hedonic Considerations in the Choice of Mode

This research suggests that choice of intercity mode is strongly influenced by what psychologists call hedonic considerations [see, for example, Steg et al. (2014)]. Consistently, and over several studies, the analyses show that a clear explanation for the propensity to choose rail or bus is the desire to avoid the sheer stress of the automobile trip. Work on the TPB showed this concern with the stress of the car trip was highly correlated with reporting that the overall rail trip was more "pleasant." Both of these concepts are reflected in the literature of social psychology as being part of a larger category referred to as "hedonic" or "hedonistic," which refers to desire to maximize personal pleasure (rail managers might consider this when pressured by political forces seeking to end food and beverage services on intercity trains).

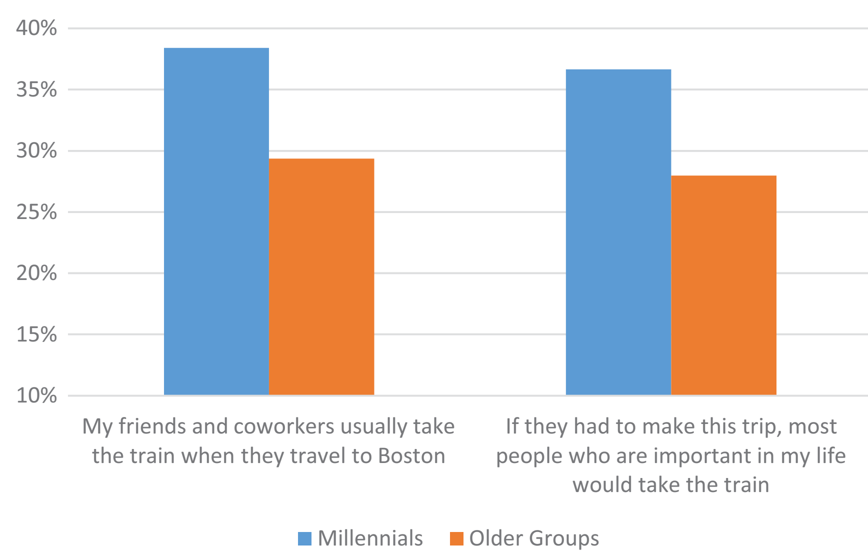


Figure 5. Reported descriptive norms for taking rail by age cohort.

1.3.9 Rail in a Competitive Dynamic Market—What about the Competing Modes?

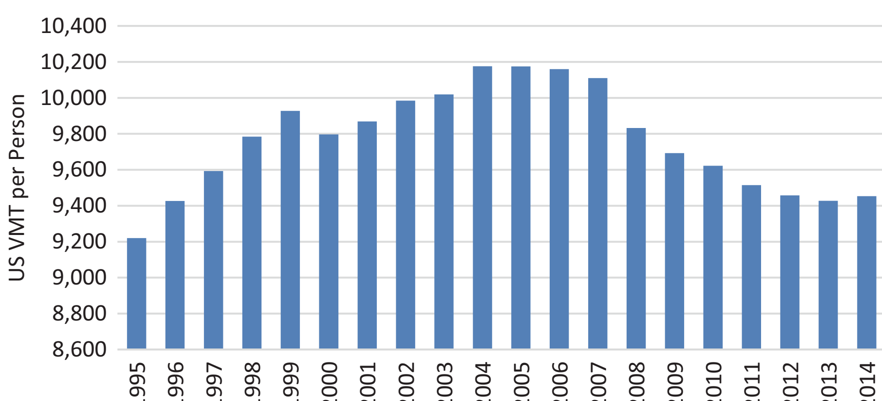
This project provides a major update on the status of competing modes in the United States. The research also examined bus and rail together in smaller markets between rural areas and major urban destinations. In addition, the research team has concluded that the competition between rail and air may be fundamentally different in nature, as the comparative variation in both travel times and costs is so dramatic. Given the evident importance of both rail travel times and variation in air fares, a somewhat different analysis has been undertaken to explore the interaction between these two factors, including the following investigations:

- The research team applied the basic structure of the NCRRP Attitudinal Model for Rail to the analysis of bus travel in the study area. The research team found that the bus industry has, compared to rail, an even more serious challenge in terms of concerns for personal safety, even among the millennials that use it. The team also found that, compared to rail choice, the selection of bus may be more related to the perceived level of stress from the auto alternative.
- The research team applied the basic structure of the NCRRP Attitudinal Model for Rail to a rural market that offered both rail and bus services and found that the majority of this market has fears for their personal safety in the bus or rail trip to the urban area.
- The research team further developed a separate model for the competition between rail and air. This revealed that higher-speed, faster trains may be specifically vulnerable to changes in the price of the competing air service.

1.3.10 What Is Happening to Travel Behavior as a Whole?

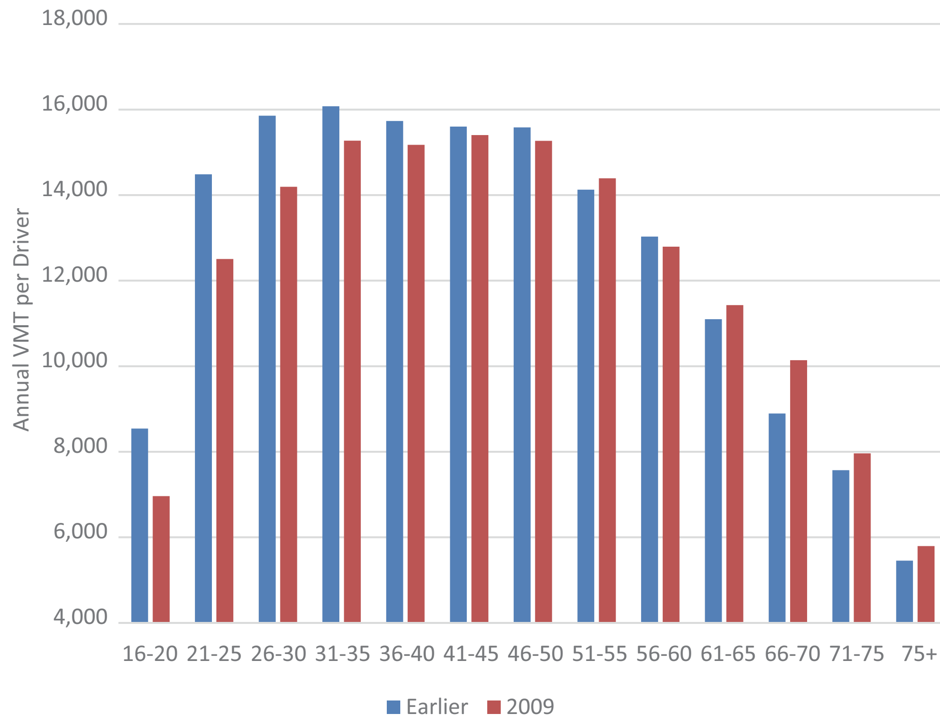
In areas where good services are provided, Amtrak ridership is consistently up. Is this consistent with broader trends affecting travel? For decades, the expectation has been that automobile vehicle miles traveled (VMT) per person would continue to grow in parallel with economic growth. However, even this assumption regarding the pattern of auto dependence is now being challenged around the developed Western world.

As will be discussed further in the following chapter, any assumption that the historical rise in personal VMT would continue the unbroken pattern witnessed in the previous century is unjustified. Several calculations have shown that personal auto use seems to have peaked around 2004–2005, as shown in Figure 6; however, this pattern is highly influenced by age. Figure 7



Source: FHWA for VMT, US Census for Total Population.

Figure 6. Change in vehicle miles traveled per person in the US population over the last two decades.



Source: NHTS data provided through the Oak Ridge National Laboratories website.

Figure 7. Effect of age on annual VMT per driver, 2009 versus 1995–2001 average.

shows that—between 1995 and 2009 [the analysis years available from the National Household Travel Survey (NHTS)]—for those under 36 years of age, VMT per person was down and, for individuals 51 years old or older, the VMT per person was up. Thus, the decline by the millennial generation in those years was strong enough to overpower the increase for those in the post child-rearing decades. The answer to the question of how the millennials will either retain their unique patterns, or adopt the patterns of older Americans, will be addressed in some detail in the scenario analysis of Chapter 6.

1.4 Report Organization

NCRRP Project 03-02, “Intercity Passenger Rail in the Context of Dynamic Travel Markets,” was designed to help practitioners understand the forces influencing the choice of the rail travel mode and, once these forces are understood, to predict alternative contexts for travel behavior in the future.

The remaining nine chapters document the research team’s actions and findings in conducting NCRRP Project 03-02:

- **Chapter 2: Previous Research and the Collection of New Data.** This chapter reviews the existing literature. It describes the process of collecting the data used in the project and presents the basic descriptions for much of these data.
- **Chapter 3: Survey Results by Demographics, Region, and Market Segment.** This chapter presents several relationships between basic demographic categories and key results of the NCRRP 03-02 survey. Market segmentation identifies groups that are bonded to rail; groups that will never come to rail; and a dynamic, malleable portion of the market between these two extremes.

- **Chapter 4: Understanding Values, Preferences, and Attitudes in the Choice of Rail.** This chapter presents the concept of an "analytical framework," which develops the concept that long-term values might influence residence, that the geographic characteristics of residence might influence short-term attitudes, and that all these factors might converge to facilitate understanding variation in rail ridership.
- **Chapter 5: Merging Economic Modeling Theory with Analysis of Attitudes and Preferences.** This chapter provides the reader with a unified behavioral model that explicitly adds "softer" factors into the same modeling process used by the economists.
- **Chapter 6: Model Application for Scenario Analysis.** This chapter illustrates how the results of the modeling process were combined to create four future scenarios, easily understandable by planners, policy makers, and all those interested in the future of rail.
- **Chapter 7: The Role of Rail in a Rural Market.** This chapter reviews what can be learned about rail ridership patterns in markets where the more sustainable modes (rail and bus) must attract riders from more rural settings, such as those surveyed in northern New England by the research team.
- **Chapter 8: Competition to Rail from Intercity Bus.** Given the intense competition now coming from the intercity bus industry for some demographic groups, bus and rail may have much in common in their need to compete with the private car.
- **Chapter 9: Competition Between Rail and Air.** This chapter provides a brief summary of new research commissioned by NCRRP to better understand how the competition from air may differ from the competition from other modes; it examines a newly documented interaction between an improvement in rail travel time with variation in air price.
- **Chapter 10: Bringing It All Together: Where Do We Go from Here?** This report concludes with a discussion of the way in which these findings suggest the need for further research in a manner most conducive to helping policy makers decide wisely about investing in intercity transportation. As FRA proceeds with follow-up work to its NEC Futures study, how might the direction of this NCRRP project affect future efforts to better understand rail demand?

CHAPTER 2

Previous Research and the Collection of New Data

Chapter 2 concerns a review of the key lessons learned from the literature review, which is presented in full in *NCRRP Web-Only Document 2*, and documents the data collection process, including the surveys undertaken in conjunction with the project, and presents an overview of the results.

2.1 Highlights from the Project Bibliography

This research project included an extensive literature review, which is presented in its entirety in the project bibliography in *NCRRP Web-Only Document 2.* The bibliography includes the formal citations and the authors' abstracts for the most relevant articles, most of which were published in peer-reviewed journals. Other articles, such as agency documents, may not include formal abstracts. The following sections present highlights from the full literature review by theme.

2.1.1 Theme 1: Trends and Differences by Generation

NCRRP 03-02 was largely concerned with change that might happen in the future, particularly in terms of possible changes in cultures, attitudes, and preferences related to more sustainable modes of travel, such as rail and intercity bus. The first theme includes literature reviews of two somewhat independent concepts. The first concept is general trends, including a possible decrease in VMT by various submarkets in the United States and in other places in the Western world. The second concept is somewhat more complicated, as it covers attitudinal and behavioral differences by age segment and possible shifts in behavior over time. That a younger age group has a different set of attitudes and behaviors toward transportation does not mean there is a shift occurring between generations—nor does it exclude the possibility. As they age, those in the younger age group could adjust their attitudes and behaviors to look more like the older generations, particularly once they enter their child-rearing years.

The information assembled in the bibliography reveals that something has changed, but there is little agreement on what this change means. To some, the change in national VMT per capita—shown in Figure 6 of this document and discussed in the article by McCahill (2014) of the State Smart Transportation Initiative—suggests that personal decision making is shifting away from auto orientation. For others, the lowered personal VMT reflects lower levels of employment, and a lack of disposable income.

The results of the literature search identify the need for a rigorous examination of the relationship between transportation behavior and the motivations that influence behavior. For many researchers, there is no discordance at work when viewing the decreased levels of auto trip making. In the vision of Dutzik and Baxandall (2013), this represents a major shift in the culture of a generation. In the view of others, it represents the result of bad economic conditions for many members of the millennial generation [see, for example, Ralph (2015), quoted below].

Figure 6 shows FHWA traffic monitoring data for per-person VMT over time. The fact that automobile travel in the United States has decreased for millennials seems unmistakable from Figure 7 in Chapter 1, shown there as VMT per driver. However, the reasons behind this decrease are worthy of more policy research attention. Work under way at the University of California at Los Angeles, including that reported in Blumenberg et al. (2013), explores the depth of the unemployment (or underemployment) problem for millennials.

A series of studies by Le Vine and Jones (2012) on British travel, whose original abstracts are included in the bibliography, shows a strong pattern of decrease in the auto mileage of males under 50, with a weaker pattern of increase in males over 50. This is a startling contrast to the lack of such a decrease in females under 50, with increases reported for every age group above 30. Important work by Kuhnimhof et al. (2012) allows more detailed observation of the role of gender in these patterns. In Germany, they found a sharp decline in auto travel for men after 2000 and a much more moderate decline for women. In the UK, they found a sharp decline for men and a much smaller decline for women, in a generally similar time frame. Later work of Le Vine, Jones et al. (2014) and Le Vine, Latinopoulos et al. (2014a,b) explore the UK patterns in more detail, finding one group to be driven by financial constraints, while a second group had more nuanced reasons for the delay in obtaining a driver's license. Le Vine et al. establishes that the delayed driver's licenses were *not* associated with greater Internet browsing or greater environmental sensitivity.

Two additional works on this theme were published in 2015. The PhD thesis of Kelcie Ralph presents a highly original work which examines the type of information that can be mined from the NHTS, in this case using a form of market segmentation to better interpret the data. The NHTS has very limited content about values and preferences (except about the journey to school), but Ralph was able to creatively draw conclusions in spite of these data limitations. Concerning the supposed rise of a new, urbane age cohort, Ralph (2015) concluded that

> . . . economic constraints, role deferment, and racial/ethnic compositional changes in the population primarily explain the travel trends during this period. The evidence in support of preferences and residential location explanations was substantially more limited. The concluding chapter contextualizes these findings, arguing that a large and growing share of young adults suffer from transportation disadvantage.

At about the same time, Noreen McDonald of the University of North Carolina at Chapel Hill, in a well-received article in the *Journal of the American Planning Association*, used the same basic data sources to examine the sources of the drop in VMT. Again, the author did not utilize any studies of values, attitudes, and preferences in the article. McDonald (2015) was able to estimate the portion of the total phenomenon of lowered VMT attributable to several causal forces:

> Among young adults, lifestyle-related demographic shifts, including decreased employment, explain 10% to 25% of the decrease in driving; millennial-specific factors such as changing attitudes and use of virtual mobility (online shopping, social media) explain 35% to 50% of the drop in driving; and the general dampening of travel demand that occurred across all age groups accounts for the remaining 40%.

2.1.2 Theme 2: Long-Distance Travel

This rail research project focused on intercity travel, and because it looked at rail in a competitive environment, the focus was primarily on those trips between 100 and 500 miles, which narrowed the focus somewhat. Theme 2 explores these long-distance issues.

In terms of building the methodological tools to better understand longer-distance markets, the US DOT has undertaken a series of projects that were beneficial to the research team. Steer

Davies Gleave produced a series of methodological reports for US DOT, one of which is titled, *HSIPR Best Practices: Ridership and Revenue Forecasting.* Some of the key concepts recommended in that report re-appear in the FRA's Project CONNECT, which includes a travel forecasting model that breaks out diversion to rail from auto, direct air, and connecting air services. A similar model, just for diversion to rail from air, was developed through Airport Cooperative Research Program (ACRP) Project 03-23, and has been refined in this project and its application documented in Chapter 9. This ACRP model allows an exceptional level of policy sensitivity, as it is designed to let the analyst vary all of the input assumptions for various forms of sensitivity analysis and policy exploration.

A most relevant article in the literature is "Travel Behavior of the Lone Rangers: An Application of Attitudinal Structural Equation Modeling to Intercity Transportation Market Segmentation" by Ripplinger et al. (2011, Appendix Figure 10) in North Dakota. This paper is (by its own description) highly influenced by an earlier paper by Outwater et al. (2003) titled, "Use of Structural Equation Modeling for an Attitudinal Market Segmentation Approach to Mode Choice and Ridership Forecasting," which focused on within-metropolitan-area travel in the San Francisco Bay Area. This paper was an early example of the direct use of market segmentation to predict changes is travel behavior.

2.1.3 Theme 3: Attitudinal Theories Applied to Transportation

NCRRP 03-02 explored the relationship between values, attitudes, and preferences concerning longer-distance travel choices and the actual travel behaviors undertaken. As such, it benefited from a long tradition of research in the application of attitudes to the understanding of transportation behavior. A major contribution to the field was made in the 1970s by Dobson et al. (1978). More recently, a wide variety of theories of the role of attitudes, lifestyles, and behavior have been applied and quickly summarized in Holz-Rau and Scheiner (2010). As noted previously, original abstracts for these articles are reproduced in the bibliography in *NCRRP Web-Only Document 2.*

Most of the research concerning the effect of attitudes in the explanation of transportation behavior starts with references to Ajzen's TPB or its predecessor, the Theory of Reasoned Action (Fishbein and Ajzen 2010). Ajzen's diagram explaining the theory is shown as Figure 38 in Chapter 4. The review of the literature shows that very few TPB studies have had the luxury of benefiting from a longitudinal design: a major exception is the article titled, "Choice of Travel Mode in the Theory of Planned Behavior: The Roles of Past Behavior, Habit, and Reasoned Action" by Bamberg et al. (2003), which both examines recorded intent to change mode to the bus after a free pass is implemented and captures actual change of transportation mode after the implementation of the bus pass. This article is recommended to readers interested in the role of attitudes in impacting mode choice and those who want to understand the TPB better.

Importantly, almost all articles that apply the TPB to transportation behavior tend to embellish it by adding one, or several, additional factors as direct predictors of intent. The paper, titled "Reduced Use of Environmentally Friendly Modes of Transportation Caused by Perceived Mobility Necessities: An Extension of the Theory of Planned Behavior," by Haustein and Hunecke (2007) first ran a reference model of the TPB without the additional factor, and then again with it. In this work, the authors suggest that, for their purposes, a concept of "perceived mobility necessities" would improve the overall model performance. This would perhaps be an example of a modification for one kind of application of the theory, and not a need to modify the theory itself.

Of interest to the work plan is the conceptual model of attitudes toward transportation developed by Noblet et al. (2014). These authors hypothesized that two underlying factors—environmental concern and support environmental group—influenced the three basic predictors in the TPB:

attitude, subjective norm, and perceived behavioral control. An ambitious attempt to integrate a very wide variety of physical and cognitive processes was proposed by Spears et al. (2013) in a study of travel behavior in Los Angeles, which places the TPB in the center of a much more elaborate over-arching structure.

Perhaps the most ambitious proposal to integrate physical and cognitive factors was in the Van Acker et al. (2010) article, "When Transport Geography Meets Social Psychology: Toward a Conceptual Model of Travel Behaviour." There a core set of factors from transport geography (i.e., locational behavior, activity behavior, and travel behavior) is allowed to interact with a set of "perceptions, attitudes, and preferences" for each factor from transport geography. From the vantage point of social psychology, there is a large body of literature building on the concept of "reasoned action," which emphasizes the process of deliberately thinking through the implications of decisions like the choice of mode of long-distance transportation (Fishbein and Ajzen 2010). There is also a significant body of literature that reflects the concern that much of the process of travel choice simply reflects habit based on a history of repetitive actions (Aarts et al. 1997). And, of course, there are theories that bypass this dichotomy in general and propose different frameworks altogether, such as that of Triandis (1989).

2.1.4 Theme 4: Hybrid Models to Integrate Attitudes

The fourth theme concerns those theories and methods specifically under discussion for the improvement of mode choice *modeling* by the inclusion of attitudes and preferences into the model estimation process. In addition to reflecting the approaches based in social psychology, this theme includes a part of a growing body of literature concerning new and developing approaches to mode choice modeling in fields such as marketing, specifically including attitudes and preferences along with times and costs in the prediction process.

Theme 4 includes the important article "Extended Framework for Modeling Choice Behavior" (Ben-Akiva, McFadden et al. 1999). As the original article can be located on the Internet, those who are interested in the progress reported in Chapter 5 are encouraged to read the full article. It states the basic logic in support of an integrated model as well as anything written since.

Theme 4 also presents the first references in the literature review to the ICLV models. An early ICLV model is presented in the paper by Vredin-Johansson et al. (2006), titled "The Effects of Attitude and Personality Traits on Mode Choice." Temme et al. (2008) showed how such a complex model could be built with publicly available structural equation modeling software. In an early example of the kind of integration we implemented in Chapter 5. Temme et al. concluded that this model format developed in the transportation domain could be more widely applied in marketing studies.

Building on this work, Paulssen et al. (2014) created an ambitious model (see Figure 8) that spells out how key personality traits—power, hedonism, and security—are associated with more short-term attitudes predicting mode choice—comfort/convenience, ownership, and flexibility. This model deals with several of the key factors identified in NCRRP 03-02 in that it connects longer-term values—or, in the case of Paulssen et al. (2014), *personality traits*—to more immediate and short-term attitudes, which are assumed to directly influence mode choice.

Readers with a particular interest in Chapter 6, concerning new approaches to scenario analysis, should note the article by Chakraborty and McMillan (2015), "Scenario Planning for Urban Planners: Toward a Practitioner's Guide," from the *Journal of the American Planning Association.* A thoughtful critique of the application of the new methods is provided by Chorus and Kroesen (2014) in their article "On the (Im-)Possibility of Deriving Transport Policy Implications from Hybrid Choice Models." In fact, some of the format established in Chapter 6 was

Figure redacted for on-line use; available in printed version.

Source: Paulssen et al. (2014, p. 877, Figure 2: ICLV model of travel mode choice as posited by the value–attitude–behavior hierarchy of cognition). © Springer Science+Business Media New York 2013, used with permission of Springer.

Figure 8. Advanced ICLV model using three long-term values from the social psychological literature.

developed with this critique in mind. And, finally the thoughtful article "Statistical Properties of Integrated Choice and Latent Variable Models" by Vij and Walker (2015) helps provide a setting for determining the best application of the new tools.

2.1.5 Theme 5: Environmental Motivations and Strategies

A major theme of much work in Europe concerning attitudes toward transportation, and mode choice in particular, is that of the role of pro-environmental concerns on actual travel decisions. The documentation of the literature review presents a cross section of published research concerning the role of pro-environmental attitude on transportation behavior. Most of the work is based on the experience of European populations, not North American populations.

Clearly, the role of environmental motivations as contributors to the choice of bus or rail over auto or air needs some further research. But, a major review of the literature has not found much to support the concept that Americans are currently considering the global environmental implications of their modal choices in the markets of interest to NCRRP 03-02. The international data seem to be somewhat more nuanced, but not completely clear. For instance, looking at the idea that environmental sensitivity might be a factor in the recent pattern of delayed and lowered rates of drivers' licenses in Britain, Le Vine et al. (2014) found that only 1% of those sampled even mentioned the issue. After creating a structural equations model based on the TPB, Grob (1995) concluded that "No effects on environmental behavior from factual knowledge was found." Likewise, Line et al. (2010) found their sample of young people claimed "that their current environmentally friendly travel behaviors (such as walking or cycling to school) are not influenced by the issue of climate change. . . ." Delbosc and Currie (2013) reported that, in their panels of young people in Australia, "not one person in the sample spontaneously mentioned that environmental concerns shaped their travel choices; even when prompted, these concerns were far removed from travel decisions." Vredin-Johansson et al. noted, "Previous research has . . . shown little support for environmental criteria being of importance in travel mode choices . . ." (2006, p. 509). On the other hand, the growing body of literature on the propensity to buy an electric vehicle reveals an interesting variety of motivations, including some which are pro-environmental in nature. The article by Rasouli and Timmermans (2013), "The Effect of Social Adoption on the Intention to Purchase Electric Cars: A Stated Choice Approach," explores the role of normative pressure in the choice of vehicle purchase:

> "Results indicate that although social influence plays a less significant role than attributes of electric cars in the buying process, different elements of social networks do exert an influence on people's buying decisions. These effects vary between friends, relatives, colleagues, and the larger peer group."

2.1.6 Theme 6: Information Technologies and the Productivity of Time

While no one can predict the future, one *can* reasonably predict that the enormous rise in the acceptance and use of ICT will have *some* impact on travel over the next 50 years. Whatever future intercity travel will look like, it is safe to assume that it will be influenced by ICT. The work plan allows the exploration of this in two somewhat different formats. First, the wide acceptance of ICT could allow a fundamental shift in the way in which in-vehicle time on public modes is evaluated. If one mode (e.g., car) does not allow for productive use of time, while a second mode (e.g., train) does allow for such productivity, the absolute importance of time minimization in mode choice might decrease over time. Second, the predicted emergence of real-time information to support the multisegment, multimodal trip may decrease the sense of anxiety that is associated with a complicated trip compared to the door-to-door convenience of the private automobile.

A good introduction to this field comes from several published articles by Schwieterman and Fischer, including "Privacy Invades Public Space: The Growing Use of Portable Electronic Technology on Intercity Buses, Trains and Planes between 2009 and 2010" (2011b) and related articles about the new market for curbside bus services. The value placed on such use in the vehicle is explored by Dong et al. (2013) and Ettema et al. (2012). The question of the role of ICT in preparing the traveler for the trip is explored by Dzietkan (2008), Farag and Lyons (2012), and Kenyon and Lyons (2003).

The possibility that more time online equates to lower levels of VMT is challenged by Le Vine et al. (2014a) in "Establishing the Links Between Online Activity and Car Use: Evidence from a Combined Travel Diary and Online-Activity Pseudo-Diary Data Set." In one of a series of articles (some of which are in Bibliography Theme 1), they conclude, "It was found that, net of other effects, Internet usage is positively associated with car use."

2.1.7 Theme 7: Application of Market Segmentation Techniques

A key technical strategy in the integration of attitudes with more traditional predictive factors is the use of market segmentation. Essentially, by dividing the full sample into market segments, the model builder, or the analyst in general, can explicitly deal with attitudes, values, and preferences while retaining the traditional prediction power of times, costs, and basic demographics. Anable (2005) was a pioneer in making segmentation a key strategy for policy analysis, based on her application of the TPB.

An excellent introduction to segmentation for anyone involved in transportation analysis is provided by *TCRP Report 36: A Handbook: Using Market Segmentation to Increase Transit Ridership* (Elmore-Yalch 1998). While *TCRP Report 36* represents a good introduction to the subject, the methods recommended may be somewhat dated. A more recent approach to market segmentation methodology is provided by Vermunt and Magidson (2005a), who are the developers of the Latent Gold software package available to the public. This statistical method was applied to the question of a safe driving culture by Coogan et al. (2014). Another state-of-the-art application of segmentation technology was provided by Ayvalik et al. (2008) in a study of potential markets for transit-oriented development in the San Francisco Bay Area. This followed upon similar work by Cambridge Systematics for transit riders in San Mateo County (Zhou et al. 2004).

Karash et al. applied this kind of market research for transit in *TCRP Report 123: Understanding How Individuals Make Travel and Location Decisions: Implications for Public Transportation* (2008). There, the sample was divided into five segments, assembled by their similarity of attitudes relevant to increasing transit ridership. In an early effort, this 2004 survey exposed the different market segments to new ideas, such as the idea that people could get transit and traffic data sent right to their phones. The utilization of specific market segments was helpful in interpreting the results of the survey.

A pioneering research effort in the analysis of improving the sustainability of travel was the article (and doctoral dissertation) by Anable (2005), "'Complacent Car Addicts' or 'Aspiring Environmentalists'? Identifying Travel Behaviour Segments Using Attitude Theory." Anable undertook a market segmentation procedure for change in modal behavior based on the construct of the TPB, as expanded. The Anable work is important in that it utilized a specific theory within social psychology (the TPB) to help order, analyze, and interpret the meaning of the attitudes and beliefs revealed in the survey process.

2.2 Data Collection Methodologies

2.2.1 Data Collected to Support the Project's Goals

The research team surveyed more than 6,000 individuals to understand their long-term values and short-term attitudes and subjected more than 5,000 of them to a stated choice exercise through which they indicated their preference for the choice of a long-distance mode, based on highly detailed market conditions.

2.2.2 Survey Sampling Frame and Eligibility Requirements

The overall survey sample was divided into two markets: the NEC and the Cascade Corridor. Since this project was research driven, the research team set out to obtain a sample that provided good coverage and enough samples of various income, age, and home location distributions rather than strictly being population-proportional.

Sampling Sources and Procedure

Data were collected through several different sampling strategies. For the NEC survey sampling, the research team utilized the e-mail addresses of respondents from the Northeast Corridor Commission's Automobile Origin–Destination (OD) Study who indicated that they would be willing to participate in future research. Afterwards, the research team coordinated with commercial sample providers and recruited additional respondents. A supplemental, purchased online sample was targeted to counterbalance some of the demographic skew in the NEC Auto OD sample (e.g., the sample was older, more likely to own car). For the Cascade Corridor, no preexisting sample existed and the entire sample was purchased from a commercial sample provider.

Data Cleaning and Sample Size

A total of 6,184 completed surveys were collected. To ensure that only valid responses were accepted, the data were cleaned based on the following criteria:

- Respondents were excluded if they completed the entire survey in less than 6 minutes, since that survey completion time did not allow respondents to read, process, and respond to the questions that were presented to them.
- Respondents were excluded if they consistently “straight-lined.” Straight-lining refers to the response set whereby respondents select the same answer choice on an attitudinal battery (e.g., always selecting “strongly agree” for all attitudinal questions that are presented on a screen). To be excluded based on straight-lining, a respondent had to straight-line on *all* attitudinal batteries of the survey.
- Respondents were excluded if they selected an option in a stated choice exercise for which the chosen versus the cheapest option available in the exercise was in the 95.5 percentile of cost.

In total, less than 10% of the sample were excluded based on the foregoing criteria, leaving a final sample size of 5,625, of which 513 respondents came from the Cascade Corridor and 5,112 from the NEC.

2.2.3 Additional Data Collection

In addition to the previously mentioned sample, supplemental data were collected from 517 NEC respondents. These respondents were recruited from the NEC e-mail list and, strictly speaking, did not live in one of the eligible metropolitan areas (i.e., metropolitan areas of Boston, New York City, Philadelphia, and Washington, DC). For instance, these respondents might live in between two larger metropolitan areas (Plainsboro Township, New Jersey, located in between New York City and Philadelphia) or too far away from any of the metropolitan areas (e.g., Killingworth, Connecticut, or Perryville, Maryland). Of importance, these individuals did not complete the stated choice exercise but did complete the attitudinal statements and any questions not related to the stated choice exercise. Unless explicitly mentioned otherwise, analyses are based on the smaller sample of those 5,625 respondents who completed the entire survey, including the stated choice exercise. All 6,142 survey responses were used in the TPB model, whose data requirements did not include any data from the exercise.

2.2.4 Additional Surveys Used in the Project

RSG conducted a 2014 survey on intercity travel behavior on behalf of the New England Transportation Institute (NETI) and the University of Vermont’s Transportation Research Center (UVM TRC). Respondents were recruited by a commercial provider and directed to RSG’s survey platform. After eliminating hasty responses (i.e., under 6 minutes) and respondents who straight-lined, a total of 2,560 valid responses were collected. Massachusetts had the highest number of respondents, followed by New Hampshire, Maine, and Vermont.

In addition, the data analysis process in Chapter 3 utilized additional survey resources, including an 11,000-person survey undertaken by RSG, also in 2014, for TransitCenter, an advocacy group for better public transportation. A shortened description of the methods used in that survey can be found in TransitCenter and RSG Inc. (2014). The survey instruments used in both the UVM TRC and TransitCenter projects were designed by RSG to provide data largely compatible from one study to another.

2.2.5 Design of the Survey Instrument

The survey instrument was created during a several-month process to ensure that it contained all of the data-gathering activity required for the development of the new ICLV models, and for the development of the new NCRRP long-distance attitudinal models. Examples of the kinds of data collected are shown in Figure 9.

Data Needs for Activities in the Development of the Stated Choice Exercise

The research team developed a data collection approach to gather cost and time sensitivities. These data were used in the development of the full ICLV model, and the reference or "base case" model without the attitude component. An image of what the survey respondent saw is shown here as Figure 10. Each survey respondent was asked to provide detailed information about one specific, eligible intercity trip. If the respondent reported taking several eligible trips, he or she was asked about the most recent.

The programmed web survey defined a trip for the user, based on the home location of the traveler. For NEC respondents, distances from their home zip code to Boston, New York City, Philadelphia, and DC were computed, and the city that was located the shortest distance from the home zip code was assigned as the respondent's "metro home area." Similarly, Cascade participants were assigned to Portland, Oregon, as their "metro home area," if their home zip code was one of the qualifying counties in Oregon (Benton, Clackamas, Columbia, Lane, Linn, Marion, Multnomah, Polk, Washington, Yamhill) or Clark County, Washington. Participants with zip codes in all other qualifying counties in Washington (King, Kitsap, Mason, Pierce, Skagit, Snohomish, Thurston, and Whatcom) and all qualifying counties in Canada (Greater/Metro Vancouver, Fraser Valley) were assigned to Seattle, Washington, as their metro home area.

The results of this stated choice exercise are reported in Section 5.1 in a model with no reference to attitudes and values. Section 5.2 shows the use of the results of the model in the creation of the ICLV model.

The Survey Instrument

The research team developed a refined approach to the design of a flexible, innovative, and statistically adequate/efficient survey. This is a key prerequisite to enable advanced modeling

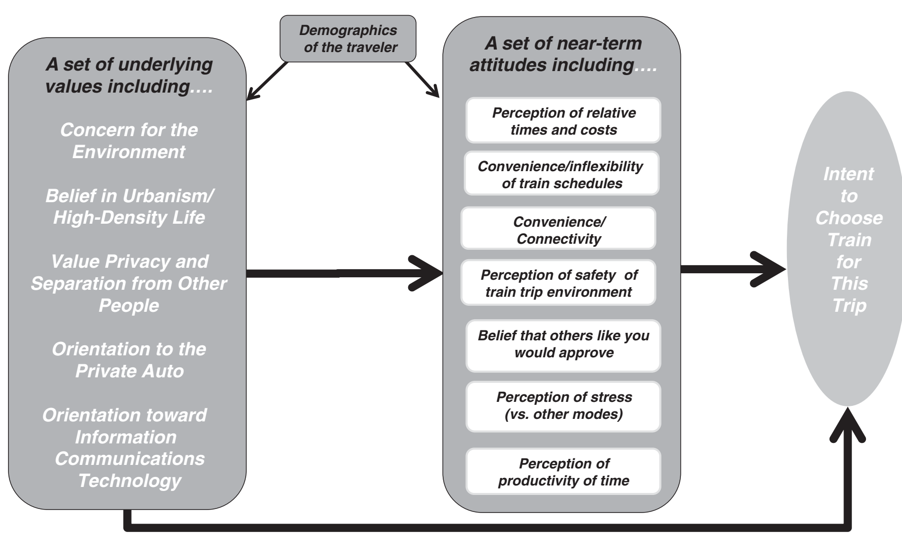
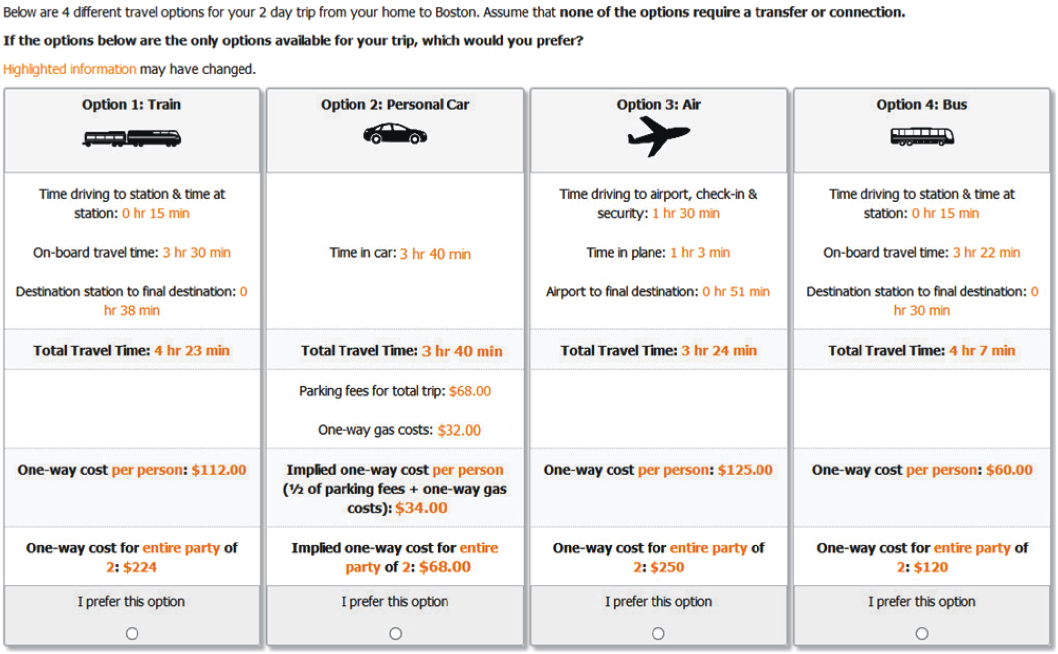


Figure 9. The survey instrument gathered respondents' values and attitudes.



Below are 4 different travel options for your 2 day trip from your home to Boston. Assume that **none of the options require a transfer or connection.**

If the options below are the only options available for your trip, which would you prefer?

Highlighted information may have changed.

Option 1: Train	Option 2: Personal Car	Option 3: Air	Option 4: Bus
Time driving to station & time at station: 0 hr 15 min On-board travel time: 3 hr 30 min Destination station to final destination: 0 hr 38 min	Time in car: 3 hr 40 min	Time driving to airport, check-in & security: 1 hr 30 min Time in plane: 1 hr 3 min Airport to final destination: 0 hr 51 min	Time driving to station & time at station: 0 hr 15 min On-board travel time: 3 hr 22 min Destination station to final destination: 0 hr 30 min
Total Travel Time: 4 hr 23 min	**Total Travel Time: 3 hr 40 min**	**Total Travel Time: 3 hr 24 min**	**Total Travel Time: 4 hr 7 min**
	Parking fees for total trip: $68.00 One-way gas costs: $32.00		
One-way cost per person: $112.00	**Implied one-way cost per person (½ of parking fees + one-way gas costs): $34.00**	**One-way cost per person: $125.00**	**One-way cost per person: $60.00**
One-way cost for entire party of 2: $224	**Implied one-way cost for entire party of 2: $68.00**	**One-way cost for entire party of 2: $250**	**One-way cost for entire party of 2: $120**
I prefer this option ○	I prefer this option ○	I prefer this option ○	I prefer this option ○

Figure 10. Example screenshot how data was collected in support of the stated choice modeling used in NCRRP.

approaches that can accommodate attitudinal factors to better understand how those attitudes influence choice behavior beyond level-of-service variables. This is done using advanced models that can estimate latent factors and segments that are driving different choice behaviors. As can be seen in the set of questions presented in Section 2.3.3, the research team designed the survey to gather data on both level-of-service variables (e.g., times and costs) and attitudinal variables in order to gain a deeper understanding of intercity mode choice using advanced models.

2.3 Survey Respondent Sample Overview

2.3.1 Demographics

The results confirm that the primary goal of obtaining a cross section of the population with good coverage in various demographic categories was achieved. For instance, Figure 11 shows the income distribution was close to normal, and respondents from different age groups were

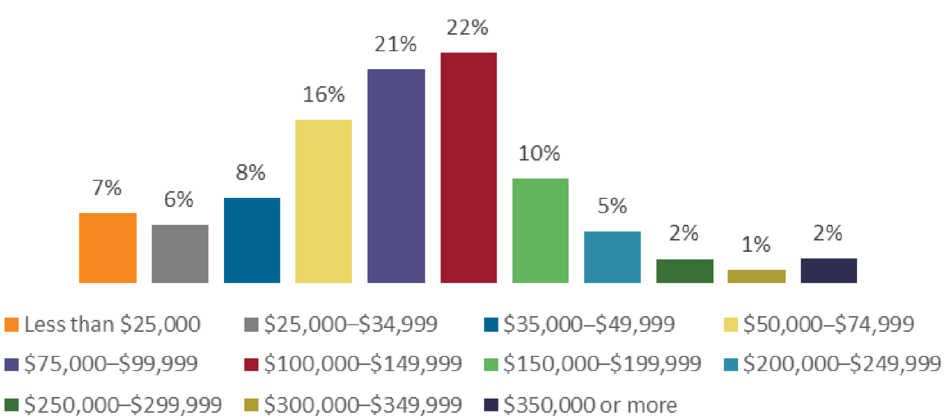


Figure 11. Household income distribution.

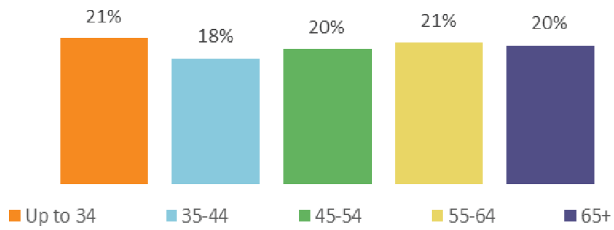
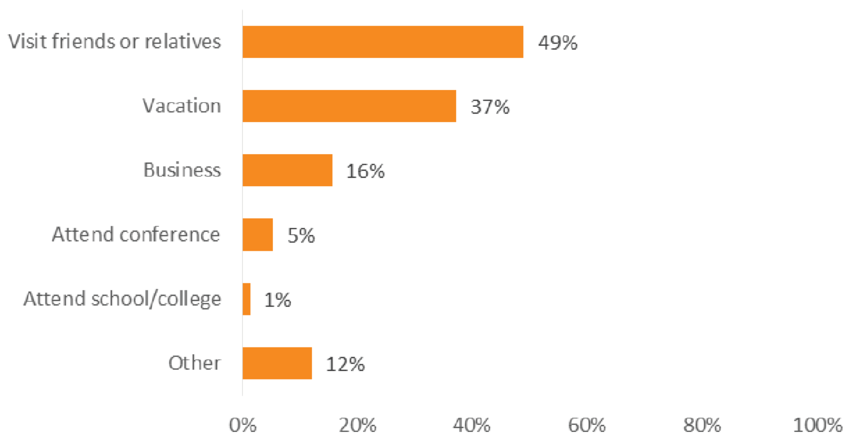


Figure 12. Age distribution.

represented in almost equal proportions. Further, as would be expected, most respondents were employed full time; most identified as White though the sampling effort was also successful in recruiting a sizable number of respondents who identified as other than White (20%). The age distributions provide adequate samples for key age categories to be used in the project (Figure 12).

2.3.2 Characteristics of Recent Trip

The most common recent trip that respondents reported was traveling with one additional travel companion to visit friends or relatives (see Figures 13 and 14).



Note: Bars total more than 100% due to multiple responses per record.

Figure 13. Trip purpose of most recent trip.

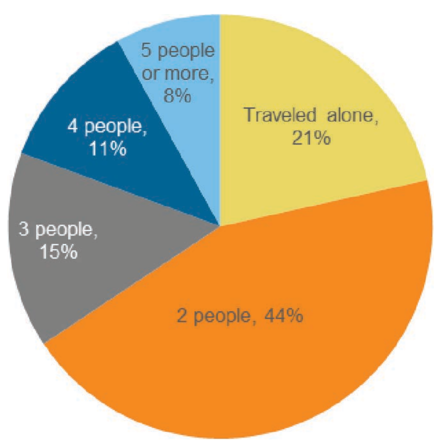


Figure 14. Party size of most recent trip.

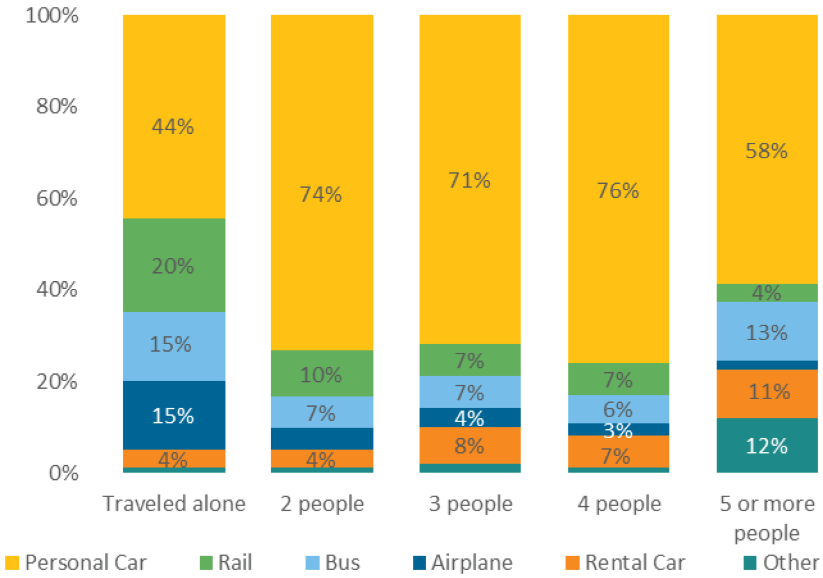


Figure 15. Mode of recent trip by group size.

As might be expected, respondents decided to take different modes depending on how many other people were in the party, such that traveling with just one additional person increased the chance of traveling by car quite strongly. Specifically, Figure 15 shows that only 44% of those traveling alone took a personal car and 20% traveling alone went by train, making it the second most common travel mode among this group. However, having an additional travel companion increased the likelihood of taking a personal car to 74%. This percentage stayed relatively stable for party sizes of three and four people, but decreased again for groups with five or more people (58%).

2.3.3 Attitudinal Variables

Table 5 presents the major attitudinal questions (sometimes shortened) included in the survey, followed by the mean value and the standard deviation. The first results from the attitudinal portion of the survey can be seen in Table 6.

Table 6 presents a matrix of the correlations between and among the attitudinal variables, to which has been added one demographic variable: age. Being a millennial is given the value 0 and being older is given the value 1. The first column in the matrix shows the relationship between the row variable and age category: a positive correlation shows that, as age increases, the values of the column variable increases. For all correlations shown in Table 6, two asterisks (**) mean that the correlation is significant at the $p < 0.01$ level and one asterisk (*) means that the correlation is significant at the $p < 0.05$ level, showing a weaker statistical connection. No asterisk implies that there is no statistically significant relationship between the column variable and the row variable.

Table 5. Means and standard deviations of the 49 attitudinal variables from the survey (sample size = 6,142).

Attitudinal Variable	Mean	Std. Deviation
I enjoy being out and about and observing people	5.53	1.27
I like a neighborhood where I can walk to a village center	5.32	1.57
If everyone works together, we could improve the environment	5.95	1.27
Value having a private home with separation from others	5.00	1.62
Value living in a community with mix of people and backgrounds	5.05	1.49
I feel I am less dependent on cars than my parents	3.42	1.88
I need to drive a car to get where I need to go	5.18	1.73
I love the freedom and independence I get from car	5.73	1.44
It is important to me to control the radio and the air conditioning	4.90	1.47
I would prefer to borrow, share, or rent a car just when I need it	2.56	1.70
I feel really stressed when driving congestion in big cities	4.64	1.80
With driverless cars I would be less likely to travel by rail or bus	3.95	1.65
On a train or a bus with people I do not know is uncomfortable	3.11	1.62
I don't mind traveling with people I do not know	4.64	1.59
The process of going through airport security is stressful	4.42	1.70
Important to me to receive email or text updates about trip	5.15	1.47
Using a laptop, tablet, or smartphone is important to me	5.28	1.43
I could deal with the schedules offered by the train	4.89	1.51
I would need the flexibility of a car at my destination	4.28	2.07
Getting to the train station is inconvenient	4.07	1.87
Sharing a car with others for such a trip seems unpleasant	3.93	1.73
Estimate cost of train more than the cost by car	4.94	1.63
Estimate cost of bus more than the cost by car	3.67	1.77
Estimate cost of train more than the cost by bus	5.42	1.40
Worry about personal safety/disturbing behavior - Bus	4.15	1.68
Worry about personal safety/disturbing behavior - Train	3.50	1.61
Worry about personal safety/disturbing behavior - Air	3.45	1.67
Worry about personal safety/disturbing behavior - Car	2.75	1.60
Concerned about flexibility of schedules - Air	4.85	1.60
Concerned about flexibility of schedules - Bus	4.81	1.52
Concerned about flexibility of schedules - Train	4.69	1.54
Compared to car, I would be less tired and stressed by air	4.13	1.78
Compared to car, I would be less tired and stressed by bus	3.93	1.68
Compared to car, I would be less tired and stressed by train	4.94	1.61
Difficult for me to get from train station to where I need to go	3.83	1.82
Worry about crime or unruly behavior at the train station and train	3.17	1.59
I would feel uncomfortable being on the train with strangers	2.80	1.51
Having to be with people whose behavior I find unpleasant	3.86	1.57
It might be unsafe to make this trip by train	2.75	1.46
People whose opinion I value would approve of the train	5.06	1.42
My friends and coworkers usually take the train	3.80	1.62
My family would approve of my taking the train	5.10	1.51
Most people who are important in my life would take the train	3.44	1.93
I could easily take the train for this trip	5.40	1.87
How possible is it to take the train for this trip	5.75	1.66
How efficient to take the train for this trip	4.54	1.93
How pleasant to take the train for this trip	5.00	1.60
I would definitely consider taking the train for this trip	5.04	1.90
How likely for you to take the train for this trip	3.84	2.06

Table 6. Correlations between/among survey attitudinal variables (sample size = 6,142).

	Millennial is zero, older is one	I enjoy being out and about and observing people	I like a neighborhood where I can walk to a village center	If everyone works together, we could improve the environment	Value having a private home with separation from others	Value living in community with mix of people	I feel I am less dependent on cars than my parents	I need to drive a car to get where I need to go	I love the freedom and independence I get from car	Important to me to control the radio and the air conditioning	I would prefer to borrow, share, or rent a car just when I need it	I feel really stressed when driving congestion in big cities	With driver less cars I would be less likely to travel by rail or bus	On a train or a bus with people I do not know is uncomfortable	I don't mind traveling with people I do not know	The process of going through airport security is stressful	Important to me to receive mail or text updates about trip
Millennial is zero, older is one	1	0.01	−0.046**	−0.004	0.022	−0.019	−0.155**	0.102**	0.085**	−0.058**	−0.122**	−0.028*	−0.077**	−0.113**	0.014	0.014	−0.054**
I enjoy being out and about and observing people	0.01	1	0.232**	0.245**	0.008	0.252**	0.048**	0.038**	0.081**	0.054**	0.011	0.024	0.019	−0.075**	0.148**	0.001	0.077**
I like a neighborhood where I can walk to a village center	−0.046**	0.232**	1	0.207**	−0.049**	0.289**	0.167**	−0.099**	−0.021	0.069**	0.121**	0.072**	0.057**	−0.037**	0.139**	0.052**	0.111**
If everyone works together, we could improve the environment	−0.004	0.245**	0.207**	1	0.066**	0.294**	0.053**	0.037**	0.070**	0.052**	0.016	0.090**	0.032*	−0.036**	0.108**	0.048**	0.114**
Value having a private home with separation from others	0.022	0.008	−0.049**	0.066**	1	−0.058*	−0.078**	0.146**	0.165**	0.090**	−0.079**	0.042**	0.073**	0.108**	−0.049**	0.051**	0.031*
Value living in a community with mix of people and backgrounds	−0.019	0.252**	0.289**	0.294**	−0.058*	1	0.148**	−0.060*	0.004	0.061*	0.114**	0.057*	0.011	−0.022	0.205**	0.001	0.122**
I feel I am less dependent on cars than my parents	−0.155**	0.048**	0.167**	0.053**	−0.078**	0.148**	1	−0.301**	−0.193**	0.002	0.305**	0.074**	0.074**	−0.002	0.115**	0.053**	0.079**
I need to drive a car to get where I need to go	0.102**	0.038**	−0.099**	0.037**	0.146**	−0.060*	−0.301**	1	0.372**	0.183**	−0.227**	0.045**	0.033*	0.117**	−0.039**	0.046**	0.023
I love the freedom and independence I get from a car	0.085**	0.081**	−0.021	0.070**	0.165**	0.004	−0.193**	0.372**	1	0.173**	−0.276**	0.021	0.023	0.079**	−0.021	0.044**	0.063**
It is important to me to control the radio and the air conditioning	−0.058**	0.054**	0.069**	0.052**	0.090**	0.061*	0.002	0.183**	0.173**	1	−0.030*	0.116**	0.087**	0.125**	−0.009	0.097**	0.138**
I would prefer to borrow, share, or rent a car just when I need it	−0.122**	0.011	0.121**	0.016	−0.079**	0.114**	0.305**	−0.227**	−0.276**	−0.030*	1	0.076**	0.124**	0.043**	0.118**	0.054**	0.059**
I feel really stressed when driving congestion in big cities	−0.028*	0.024	0.072**	0.090**	0.042**	0.057*	0.074**	0.045**	0.021	0.116**	0.076**	1	0.100**	0.090**	0.039**	0.217**	0.102**
With driverless cars I would be less likely to travel by rail or bus	−0.077**	0.019	0.057**	0.032*	0.073**	0.011	0.074**	0.033*	0.023	0.087**	0.124**	0.100**	1	0.134**	0.005	0.093**	0.102**
On a train or a bus with people I do not know is uncomfortable	−0.113**	−0.075**	−0.037**	−0.036**	0.108**	−0.022	−0.002	0.117**	0.079**	0.125**	0.043**	0.090**	0.134**	1	−0.262**	0.164**	0.042**
I don't mind traveling with people I do not know	0.014	0.148**	0.139**	0.108**	−0.049**	0.205**	0.115**	−0.039**	−0.021	−0.009	0.118**	0.039**	0.005	−0.262**	1	0	0.116**
The process of going through airport security is stressful	0.014	0.001	0.052**	0.048**	0.051**	0.001	0.053**	0.046**	0.044**	0.097**	0.054**	0.217**	0.093**	0.164**	0	1	0.093**
Important to me to receive email or text updates about trip	−0.054**	0.077**	0.111**	0.114**	0.031*	0.122**	0.079**	0.023	0.063**	0.138**	0.059**	0.102**	0.102**	0.042**	0.116**	0.093**	1
Using a laptop, tablet, or smartphone is important to me	−0.090**	0.108**	0.101**	0.110**	0.045**	0.088**	0.074**	0.032*	0.074**	0.139**	0.056**	0.113**	0.116**	0.059**	0.106**	0.086**	0.323**
I could deal with the schedules offered by the train	−0.027*	0.114**	0.156**	0.118**	−0.015	0.174**	0.152**	−0.081**	−0.008	0.023	0.099**	0.086**	0.034**	−0.109**	0.193**	0.054**	0.116**
I would need the flexibility of a car at my destination	0.039**	−0.033**	−0.039**	−0.014	0.092**	−0.021	−0.107**	0.188**	0.184**	.041**	−0.063**	−0.052**	0.077**	0.162**	−0.071**	0.069**	−0.021
Getting to the train station is inconvenient	0.054**	−0.024	−0.084**	−0.022	0.111**	−0.063*	−0.124**	0.208**	0.155**	0.052**	−0.060**	0.056**	0.058**	0.148**	−0.062**	0.118**	−0.002
Sharing a car with others for such a trip seems unpleasant	0.016	−0.051**	−0.015	−0.029*	.104**	−0.034	−0.002	0.095**	0.095**	0.138**	0.008	0.093**	0.044**	0.191**	−0.117**	0.099**	0.030*
Estimate cost of train more than the cost by car	0.027*	0.037**	0.045**	0.063**	0.047**	−0.004	0.001	0.102**	0.107**	0.050**	−0.035**	0.054**	0.036**	0.030*	0.039**	0.096**	0.067**
Estimate cost of bus more than the cost by car	0.012	−0.007	0	−0.002	0.060**	−0.028	−0.043**	0.129**	0.100**	0.048**	−0.001	0.043**	0.084**	0.141**	−0.026*	0.071**	0.024
Estimate cost of train more than the cost by bus	−0.004	0.053*	0.070**	0.116**	0.036	0.065**	0.069**	−0.013	0.041	0.076**	0.035	0.101**	0.021	−0.008	0.104**	0.067**	0.079**
Worry about personal safety/disturbing behavior – Bus	−0.080**	−0.021	0.021	0.009	0.093**	−0.097**	−0.018	0.075**	0.072**	0.103**	−0.001	0.103**	0.080**	0.257**	−0.101**	0.151**	0.085**
Worry about personal safety/disturbing behavior – Train	−0.103**	−0.046**	−0.013	−0.016	0.103**	−0.097**	−0.024	0.067**	0.069**	0.086**	0.018	0.067**	0.110**	0.326**	−0.135**	0.114**	0.039**
Worry about personal safety/disturbing behavior – Air	−0.069**	−0.048**	0	0.005	0.068**	−0.055*	0.008	0.044**	0.028*	0.072**	0.048**	0.086**	0.084**	0.230**	−0.077**	0.172**	0.050**
Worry about personal safety/disturbing behavior – Car	−0.136**	−0.005	0.038**	−0.002	0.013	0.03	0.131**	−0.040**	−0.040**	0.038**	0.174**	0.087**	0.109**	0.118**	0.026*	0.071**	0.047**
Concerned about flexibility of schedules – Air	−0.009	0.040**	0.037**	0.042**	0.069**	−0.004	−0.037**	0.099**	0.104**	0.078**	−0.030*	0.070**	0.062**	0.077**	0.018	0.135**	0.073**
Concerned about flexibility of schedules – Bus	−0.005	0.023	0.019	0.037**	0.111**	−0.012	−0.093**	0.160**	0.146**	0.086**	−0.077**	0.049**	0.085**	0.130**	−0.024	0.091**	0.072**
Concerned about flexibility of schedules – Train	−0.021	0.012	0.008	0.033*	0.103**	−0.023	−0.078**	0.144**	0.135**	0.085**	−0.057**	0.053**	0.066**	0.145**	−0.036**	0.089**	0.054**
Compared to car, I would be less tired and stressed by air	−0.059**	0.057**	0.044**	0.053**	0.037**	0.058*	0.068**	−0.017	0.009	0.015	0.070**	0.063**	0.081**	0.018	0.063**	−0.075**	0.071**
Compared to car, I would be less tired and stressed by bus	−0.002	0.067**	0.092**	0.052**	−0.003	0.085**	0.107**	−0.062**	−0.043**	0.01	0.145**	0.092**	0.087**	−0.077**	0.145**	0.009	0.063**
Compared to car, I would be less tired and stressed by train	0.015	0.094**	0.130**	0.113**	0.004	0.182**	0.119**	−0.052**	−0.007	0.023	0.100**	0.149**	0.052**	−0.123**	0.176**	0.053**	0.131**
Difficult for me to get from train station to where I need to go	0.027*	−0.052**	−0.050**	−0.011	0.090**	−0.091**	−0.092**	0.172**	0.134**	0.047**	−0.042**	0.014	0.074**	0.185**	−0.075**	0.102**	−0.02
Worry about crime or unruly behavior at the train station and train	−0.079**	−0.044**	−0.022	−0.032*	0.109**	−0.096**	−0.013	0.076**	0.064**	0.089**	0.052**	0.045**	0.120**	0.338**	−0.121**	0.105**	0.028*
I would feel uncomfortable being on the train with strangers	−0.090**	−0.084**	−0.040**	−0.055**	0.098**	−0.051*	0.030*	0.058**	0.037**	0.090**	0.064**	0.041**	0.111**	0.469**	−0.199**	0.117**	0.012
Having to be with people whose behavior I find unpleasant	−0.127**	−0.036**	0.003	−0.018	0.122**	−0.059*	−0.013	0.077**	0.057**	0.100**	0.037**	0.075**	0.106**	0.331**	−0.136**	0.120**	0.031*
It might be unsafe to make this trip by train	−0.107**	−0.069**	−0.029*	−0.038**	0.086**	−0.095**	0.034**	0.058**	0.043**	0.070**	0.063**	0.041**	0.108**	0.334**	−0.113**	0.089**	0.027*
People whose opinion I value would approve of the train	−0.034**	0.132**	0.121**	0.126**	0.007	0.156**	0.124**	−0.029*	0.009	0.055**	0.078**	0.094**	0.018	−0.105**	0.216**	0.063**	0.159**
My friends and coworkers usually take the train	−0.080**	0.059**	0.068**	0.048**	0.001	0.091**	0.158**	−0.053**	−0.021	0.038**	0.137**	0.075**	0.096**	0.01	0.088**	0.072**	0.104**
My family would approve of my taking the train	−0.014	0.127**	0.130**	0.124**	−0.003	0.159**	0.113**	−0.028*	0.008	0.055**	0.085**	0.090**	0.006	−0.125**	0.211**	0.054**	0.152**
Most people who are important in my life would take the train	−0.072**	0.068**	0.088**	0.044**	−0.015	0.098**	0.145**	−0.049**	−0.054**	0.039**	0.164**	0.064**	0.080**	−0.012	0.095**	0.044**	0.083**
I could easily take the train for this trip	−0.025	0.084**	0.115**	0.074**	−0.034**	0.133**	0.149**	−0.097**	−0.030*	0.011	0.069**	0.028*	00.018	−0.087**	0.113**	−0.014	0.086**
How possible is it to take the train for this trip	−0.021	0.092**	0.109**	0.083**	−0.028*	0.135**	0.093**	−0.044**	0.005	0.030*	0.038**	0.041**	0.009	−0.089**	0.128**	−0.007	0.091**
How efficient to take the train for this trip	−0.066**	0.078**	0.127**	0.073**	−0.041**	0.148**	0.183**	−0.122**	−0.076**	0.02	0.145**	0.060**	0.039**	−0.095**	0.137**	0.02	0.083**
How pleasant to take the train for this trip	0.018	0.102**	0.136**	0.091**	−0.062**	0.194**	0.165**	−0.106**	−0.077**	−0.009	0.109**	0.056**	0.014	−0.230**	0.228**	−0.027*	0.093**
I would definitely consider taking the train for this trip	−0.016	0.121**	0.162**	0.105**	−0.046**	0.174**	0.162**	−0.108**	−0.045**	0.015	0.102**	0.079**	0.021	−0.169**	0.199**	0.002	0.119**
How likely for you to take the train for this trip	−0.058**	0.067**	0.093**	0.036**	−0.036**	0.106**	0.180**	−0.121**	−0.087**	0.004	0.162**	0.061**	0.065**	−0.085**	0.134**	0.030*	0.082**

(continued on next page)

Table 6. (Continued).

	Using a laptop, tablet, or smartphone is important to me	I could deal with the schedules offered by the train	I would need the flexibility of a car at my destination	Getting to the train station is inconvenient	Sharing a car with others for such a trip seems unpleasant	Estimate cost of train more than the cost by car	Estimate cost of bus more than the cost by car	Estimate cost of train more than the cost by bus.	Worry about personal safety/disturbing behavior – Bus	Worry about personal safety/disturbing behavior – Train	Worry about personal safety/disturbing behavior – Air	Worry about personal safety/disturbing behavior – Car	Concerned about flexibility of schedules – Air	Concerned about flexibility of schedules – Bus	Concerned about flexibility of schedules – Train	Compared to car, I would be less tired and stressed by air
Millennial is zero, older is one	−0.090**	−0.027*	0.039**	0.054**	0.016	0.027*	0.012	−0.004	−0.080**	−0.103**	−0.069**	−0.136**	-0.009	-0.005	-0.021	−0.059**
I enjoy being out and about and observing people	0.108**	0.114**	−0.033**	-0.024	−0.051**	0.037**	-0.007	0.053*	-0.021	−0.046**	−0.048**	-0.005	0.040**	0.023	0.012	0.057**
I like a neighborhood where I can walk to a village center	0.101**	0.156**	−0.039**	−0.084**	-0.015	0.045**	0	0.070**	0.021	-0.013	0	0.038**	0.037**	0.019	0.008	0.044**
If everyone works together, we could improve the environment	0.110**	0.118**	-0.014	-0.022	−0.029*	0.063**	-0.002	0.116**	0.009	-0.016	0.005	-0.002	0.042**	0.037**	0.033*	0.053**
Value having a private home with separation from others	0.045**	-0.015	0.092**	0.111**	0.104**	0.047**	0.060**	0.036	0.093**	0.103**	0.068**	0.013	0.069**	0.111**	0.103**	0.037**
Value living in a community with mix of people and backgrounds	0.088**	0.174**	-0.021	−0.063*	-0.034	-0.004	-0.028	0.065**	−0.097**	−0.097**	−0.055*	0.03	-0.004	-0.012	-0.023	0.058*
I feel I am less dependent on cars than my parents	0.074**	0.152**	−0.107**	−0.124**	-0.002	0.001	−0.043**	0.069**	-0.018	-0.024	0.008	0.131**	−0.037**	−0.093**	−0.078**	0.068**
I need to drive a car to get where I need to go	0.032*	−0.081**	0.188**	0.208**	0.095**	0.102**	0.129**	−0.013	0.075**	0.067**	0.044**	−0.040**	0.099**	0.160**	0.144**	−0.017
I love the freedom and independence I get from a car	0.074**	−0.008	0.184**	0.155**	0.095**	0.107**	0.100**	0.041	0.072**	0.069**	0.028*	−0.040**	0.104**	0.146**	0.135**	0.009
It is important to me to control the radio and the air conditioning	0.139**	0.023	0.041**	0.052**	0.138**	0.050**	0.048**	0.076**	0.103**	0.086**	0.072**	0.038**	0.078**	0.086**	0.085**	0.015
I would prefer to borrow, share, or rent a car just when I need it	0.056**	0.099**	−0.063**	−0.060**	0.008	−0.035**	−0.001	0.035	−0.001	0.018	0.048**	0.174**	−0.030*	−0.077**	−0.057**	0.070**
I feel really stressed when driving congestion in big cities	0.113**	0.086**	−0.052**	0.056**	0.093**	0.054**	0.043**	0.101**	0.103**	0.067**	0.086**	0.087**	0.070**	0.049**	0.053**	0.063**
With driverless cars I would be less likely to travel by rail or bus	0.116**	0.034**	0.077**	0.058**	0.044**	0.036**	0.084**	0.021	0.080**	0.110**	0.084**	0.109**	0.062**	0.085**	0.066**	0.081**
On a train or a bus with people I do not know is uncomfortable	0.059**	−0.109**	0.162**	0.148**	0.191**	0.030*	0.141**	−0.008	0.257**	0.326**	0.230**	0.118**	0.077**	0.130**	0.145**	0.018
I don't mind traveling with people I do not know	0.106**	0.193**	−0.071**	−0.062**	−0.117**	0.039**	−0.026*	0.104**	−0.101**	−0.135**	−0.077**	0.026*	0.018	−0.024	−0.036**	0.063**
The process of going through airport security is stressful	0.086**	0.054**	0.069**	0.118**	0.099**	0.096**	0.071**	0.067**	0.151**	0.114**	0.172**	0.071**	0.135**	0.091**	0.089**	−0.075**
Important to me to receive email or text updates about trip	0.323**	0.116**	−0.021	−0.002	0.030*	0.067**	0.024	0.079**	0.085**	0.039**	0.050**	0.047**	0.073**	0.072**	0.054**	0.071**
Using a laptop, tablet, or smartphone is important to me	1	0.128**	−0.009	−0.024	0.042**	0.063**	0.013	0.051*	0.068**	0.065**	0.063**	0.051**	0.052**	0.060**	0.045**	0.092**
I could deal with the schedules offered by the train	0.128**	1	−0.168**	−0.128**	0.011	0.031*	−0.044**	0.153**	−0.006	−0.077**	−0.015	0.061**	−0.041**	−0.104**	−0.164**	0.102**
I would need the flexibility of a car at my destination	−0.009	−0.168**	1	0.199**	0.075**	0.070**	0.174**	0	0.111**	0.170**	0.104**	0.01	0.142**	0.200**	0.242**	−0.013
Getting to the train station is inconvenient	−0.024	−0.128**	0.199**	1	0.127**	0.132**	0.143**	0.070**	0.101**	0.106**	0.038**	0.001	0.173**	0.205**	0.220**	−0.037**
Sharing a car with others for such a trip seems unpleasant	0.042**	0.011	0.075**	0.127**	1	0.070**	0.095**	0.071**	0.154**	0.109**	0.068**	0.091**	0.059**	0.087**	0.071**	0.016
Estimate cost of train more than the cost by car	0.063**	0.031*	0.070**	0.132**	0.070**	1	0.345**	0.351**	0.076**	0.036**	0.033**	−0.01	0.132**	0.134**	0.148**	−0.007
Estimate cost of bus more than the cost by car	0.013	−0.044**	0.174**	0.143**	0.095**	0.345**	1	0.065**	0.080**	0.143**	0.107**	0.045**	0.127**	0.176**	0.178**	0.012
Estimate cost of train more than the cost by bus	0.051*	0.153**	0	0.070**	0.071**	0.351**	0.065**	1	0.024	−0.063*	−0.025	−0.013	0.041	0.02	0.022	0.045
Worry about personal safety/disturbing behavior – Bus	0.068**	−0.006	0.111**	0.101**	0.154**	0.076**	0.080**	0.024	1	0.587**	0.436**	0.194**	0.155**	0.208**	0.179**	0.030*
Worry about personal safety/disturbing behavior – Train	0.065**	−0.077**	0.170**	0.106**	0.109**	0.036**	0.143**	−0.063*	0.587**	1	0.573**	0.237**	0.169**	0.206**	0.225**	0.060**
Worry about personal safety/disturbing behavior – Air	0.063**	−0.015	0.104**	0.038**	0.068**	0.033**	0.107**	−0.025	0.436**	0.573**	1	0.285**	0.196**	0.149**	0.164**	0.003
Worry about personal safety/disturbing behavior – Car	0.051**	0.061**	0.01	0.001	0.091**	−0.01	0.045**	−0.013	0.194**	0.237**	0.285**	1	0.045**	0.024	0.030*	0.101**
Concerned about flexibility of schedules – Air	0.052**	−0.041**	0.142**	0.173**	0.059**	0.132**	0.127**	0.041	0.155**	0.169**	0.196**	0.045**	1	0.538**	0.570**	−0.102**
Concerned about flexibility of schedules – Bus	0.060**	−0.104**	0.200**	0.205**	0.087**	0.134**	0.176**	0.02	0.208**	0.206**	0.149**	0.024	0.538**	1	0.728**	0.005
Concerned about flexibility of schedules – Train	0.045**	−0.164**	0.242**	0.220**	0.071**	0.148**	0.178**	0.022	0.179**	0.225**	0.164**	0.030*	0.570**	0.728**	1	−0.002
Compared to car, I would be less tired and stressed by air	0.092**	0.102**	−0.013	−0.037**	0.016	−0.007	0.012	0.045	0.030*	0.060**	0.003	0.101**	−0.102**	0.005	−0.002	1
Compared to car, I would be less tired and stressed by bus	0.066**	0.170**	−0.103**	−0.058**	−0.037**	0.018	0.016	0.042	−0.119**	−0.007	0.050**	0.135**	0.038**	−0.038**	−0.016	0.288**
Compared to car, I would be less tired and stressed by train	0.131**	0.304**	−0.158**	−0.075**	0.003	0.052**	−0.042**	0.112**	0.023	−0.068**	0	0.091**	0.028*	−0.021	−0.056**	0.337**
Difficult for me to get from train station to where I need to go	−0.045**	−0.193**	0.445**	0.330**	0.115**	0.111**	0.173**	0.025	0.122**	0.159**	0.086**	−0.002	0.183**	0.251**	0.288**	−0.035**
Worry about crime or unruly behavior at the train station and train	0.030*	−0.093**	0.170**	0.124**	0.127**	0.017	0.150**	−0.078**	0.321**	0.430**	0.308**	0.133**	0.114**	0.168**	0.166**	0.058**
I would feel uncomfortable being on the train with strangers	0.031*	−0.088**	0.145**	0.105**	0.150**	0.01	0.134**	−0.023	0.238**	0.345**	0.246**	0.126**	0.077**	0.123**	0.130**	0.047**
Having to be with people whose behavior I find unpleasant	0.057**	−0.047**	0.119**	0.095**	0.137**	0.021	0.110**	0.018	0.319**	0.377**	0.275**	0.105**	0.128**	0.156**	0.171**	0.041**
It might be unsafe to make this trip by train	0.021	−0.084**	0.143**	0.115**	0.120**	0.015	0.150**	−0.048	0.229**	0.353**	0.240**	0.138**	0.075**	0.104**	0.111**	0.046**
People whose opinion I value would approve of the train	0.130**	0.320**	−0.175**	−0.084**	0.002	0.022	−0.050**	0.086**	−0.024	−0.119**	−0.039**	0.042**	0.004	−0.063**	−0.089**	0.080**
My friends and coworkers usually take the train	0.097**	0.191**	−0.150**	−0.075**	0.022	−0.030*	−0.005	−0.009	0.044**	0.024	0.072**	0.111**	0.018	−0.062**	−0.097**	0.049**
My family would approve of my taking the train	0.124**	0.331**	−0.189**	−0.091**	0.004	0.043**	−0.058**	0.118**	−0.042**	−0.140**	−0.046**	0.048**	0.004	−0.060**	−0.095**	0.075**
Most people who are important in my life would take the train	0.093**	0.222**	−0.172**	−0.106**	0.023	−0.048**	−0.005	−0.009	0.005	−0.021	0.032*	0.112**	−0.017	−0.092**	−0.140**	0.064**
I could easily take the train for this trip	0.088**	0.314**	−0.135**	−0.260**	−0.02	−0.017	−0.067**	0.091**	−0.018	−0.068**	−0.011	0.027*	−0.063**	−0.104**	−0.151**	0.105**
How possible is it to take the train for this trip	0.103**	0.258**	−0.111**	−0.152**	−0.01	0.01	−0.048**	0.092**	−0.011	−0.067**	−0.028*	0.025	−0.005	−0.028*	−0.065**	0.073**
How efficient to take the train for this trip	0.110**	0.329**	−0.225**	−0.243**	−0.028*	−0.052**	−0.086**	0.002	−0.008	−0.052**	0.027*	0.104**	−0.057**	−0.135**	−0.191**	0.113**
How pleasant to take the train for this trip	0.098**	0.338**	−0.199**	−0.153**	−0.060**	0.005	−0.068**	0.066**	−0.138**	−0.216**	−0.095**	0.038**	−0.038**	−0.120**	−0.145**	0.077**
I would definitely consider taking the train for this trip	0.123**	0.391**	−0.231**	−0.180**	−0.045**	−0.009	−0.084**	0.076**	−0.065**	−0.152**	−0.060**	0.033*	−0.022	−0.094**	−0.133**	0.106**
How likely for you to take the train for this trip	0.107**	0.332**	−0.244**	−0.191**	−0.016	−0.083**	−0.063**	−0.014	−0.01	−0.053**	0.015	0.117**	−0.041**	−0.123**	−0.177**	0.097**

Table 6. (Continued).

	Compared to car, I would be less tired and stressed by bus	Compared to car, I would be less tired and stressed by train	Difficult for me to get from train station to where I need to go	Worry about crime or unruly behavior at the train station	I would feel uncomfortable being on the train with strangers	Having to be with people whose behavior I find unpleasant	It might be unsafe to make this trip by train	People whose opinion I value would approve of the train	My friends and coworkers usually take the train	My family would approve of my taking the train	Most people who are important in my life would take the train	I could easily take the train for this trip	How possible is it to take the train for this trip	How efficient to take the train for this trip	How pleasant to take the train for this trip	I would definitely consider taking the train for this trip	How likely for you to take the train for this trip
Millennial is zero, older is one	−0.002	0.015	0.027*	−0.079**	−0.090**	−0.127**	−0.107**	−0.034**	−0.080**	−0.014	−0.072**	−0.025	−0.021	−0.066**	0.018	−0.016	−0.058**
I enjoy being out and about and observing people	0.067**	0.094**	−0.052**	−0.044**	−0.084**	−0.036**	−0.069**	0.132**	0.059**	0.127**	0.068**	0.084**	0.092**	0.078**	0.102**	0.121**	0.067**
I like a neighborhood where I can walk to a village center	0.092**	0.130**	−0.050**	−0.022	−0.040**	0.003	−0.029*	0.121**	0.068**	0.130**	0.088**	0.115**	0.109**	0.127**	0.136**	0.162**	0.093**
If everyone works together, we could improve the environment	0.052**	0.113**	−0.011	−0.032*	−0.055**	−0.018	−0.038**	0.126**	0.048**	0.124**	0.044**	0.074**	0.083**	0.073**	0.091**	0.105**	0.036**
Value having a private home with separation from others	−0.003	0.004	0.090**	0.109**	0.098**	0.122**	0.086**	0.007	0.001	−0.003	−0.015	−0.034**	−0.028*	−0.041**	−0.062**	−0.046**	−0.036**
Value living in a community with mix of people and backgrounds	0.085**	0.182**	−0.091**	−0.096**	−0.051*	−0.059*	−0.095**	0.156**	0.091**	0.159**	0.098**	0.133**	0.135**	0.148**	0.194**	0.174**	0.106**
I feel I am less dependent on cars than my parents	0.107**	0.119**	−0.092**	−0.013	0.030*	−0.013	0.034**	0.124**	0.158**	0.113**	0.145**	0.149**	0.093**	0.183**	0.165**	0.162**	0.180**
I need to drive a car to get where I need to go	−0.062**	−0.052**	0.172**	0.076**	0.058**	0.077**	0.058**	−0.029*	−0.053**	−0.028*	−0.049**	−0.097**	−0.044**	−0.122**	−0.106**	−0.108**	−0.121**
I love the freedom and independence I get from a car	−0.043**	−0.007	0.134**	0.064**	0.037**	0.057**	0.043**	0.009	−0.021	0.008	−0.054**	−0.030*	0.005	−0.076**	−0.077**	−0.045**	−0.087**
It is important to me to control the radio and the air conditioning	0.01	0.023	0.047**	0.089**	0.090**	0.100**	0.070**	0.055**	0.038**	0.055**	0.039**	0.011	0.030*	0.02	−0.009	0.015	0.004
I would prefer to borrow, share, or rent a car just when I need it	0.145**	0.100**	−0.042**	0.052**	0.064**	0.037**	0.063**	0.078**	0.137**	0.085**	0.164**	0.069**	0.038**	0.145**	0.109**	0.102**	0.162**
I feel really stressed when driving congestion in big cities	0.092**	0.149**	0.014	0.045**	0.041**	0.075**	0.041**	0.094**	0.075**	0.090**	0.064**	0.028*	0.041**	0.060**	0.056**	0.079**	0.061**
With driverless cars I would be less likely to travel by rail or bus	0.087**	0.052**	0.074**	0.120**	0.111**	0.106**	0.108**	0.018	0.096**	0.006	0.080**	0.018	0.009	0.039**	0.014	0.021	0.065**
On a train or a bus with people I do not know is uncomfortable	−0.077**	−0.123**	0.185**	0.338**	0.469**	0.331**	0.334**	−0.105**	0.01	−0.125**	−0.012	−0.087**	−0.089**	−0.095**	−0.230**	−0.169**	−0.085**
I don't mind traveling with people I do not know	0.145**	0.176**	−0.075**	−0.121**	−0.199**	−0.136**	−0.113**	0.216**	0.088**	0.211**	0.095**	0.113**	0.128**	0.137**	0.228**	0.199**	0.134**
The process of going through airport security is stressful	0.009	0.053**	0.102**	0.105**	0.117**	0.120**	0.089**	0.063**	0.072**	0.054**	0.044**	−0.014	−0.007	0.02	−0.027*	0.002	0.030*
Important to me to receive email or text updates about trip	0.063**	0.131**	−0.02	0.028*	0.012	0.031*	0.027*	0.159**	0.104**	0.152**	0.083**	0.086**	0.091**	0.083**	0.093**	0.119**	0.082**
Using a laptop, tablet, or smartphone is important to me	0.066**	0.131**	−0.045**	0.030*	0.031*	0.057**	0.021	0.130**	0.097**	0.124**	0.093**	0.088**	0.103**	0.110**	0.098**	0.123**	0.107**
I could deal with the schedules offered by the train	0.170**	0.304**	−0.193**	−0.093**	−0.088**	−0.047**	−0.084**	0.320**	0.191**	0.331**	0.222**	0.314**	0.258**	0.329**	0.338**	0.391**	0.332**
I would need the flexibility of a car at my destination	−0.103**	−0.158**	0.445**	0.170**	0.145**	0.119**	0.143**	−0.175**	−0.150**	−0.189**	−0.172**	−0.135**	−0.111**	−0.225**	−0.199**	−0.231**	−0.244**
Getting to the train station is inconvenient	−0.058**	−0.075**	0.330**	0.124**	0.105**	0.095**	0.115**	−0.084**	−0.075**	−0.091**	−0.106**	−0.260**	−0.152**	−0.243**	−0.153**	−0.180**	−0.191**
Sharing a car with others for such a trip seems unpleasant	−0.037**	0.003	0.115**	0.127**	0.150**	0.137**	0.120**	0.002	0.022	0.004	0.023	−0.02	−0.01	−0.028*	−0.060**	−0.045**	−0.016
Estimate cost of train more than the cost by car	0.018	0.052**	0.111**	0.017	0.01	0.021	0.015	0.022	−0.030*	0.043**	−0.048**	−0.017	0.01	−0.052**	0.005	−0.009	−0.083**
Estimate cost of bus more than the cost by car	0.016	−0.042**	0.173**	0.150**	0.134**	0.110**	0.150**	−0.050**	−0.005	−0.058**	−0.005	−0.067**	−0.048**	−0.086**	−0.068**	−0.084**	−0.063**
Estimate cost of train more than the cost by bus	0.042	0.112**	0.025	−0.078**	−0.023	0.018	−0.048	0.086**	−0.009	0.118**	−0.009	0.091**	0.092**	0.002	0.066**	0.076**	−0.014
Worry about personal safety/disturbing behavior – Bus	−0.119**	0.023	0.122**	0.321**	0.238**	0.319**	0.229**	−0.024	0.044**	−0.042**	0.005	−0.018	−0.011	−0.008	−0.138**	−0.065**	−0.01
Worry about personal safety/disturbing behavior – Train	−0.007	−0.068**	0.159**	0.430**	0.345**	0.377**	0.353**	−0.119**	0.024	−0.140**	−0.021	−0.068**	−0.067**	−0.052**	−0.216**	−0.152**	−0.053**
Worry about personal safety/disturbing behavior – Air	0.050**	0	0.086**	0.308**	0.246**	0.275**	0.240**	−0.039**	0.072**	−0.046**	0.032*	−0.011	−0.028*	0.027*	−0.095**	−0.060**	0.015
Worry about personal safety/disturbing behavior – Car	0.135**	0.091**	−0.002	0.133**	0.126**	0.105**	0.138**	0.042**	0.111**	0.048**	0.112**	0.027*	0.025	0.104**	0.038**	0.033*	0.117**
Concerned about flexibility of schedules – Air	0.038**	0.028*	0.183**	0.114**	0.077**	0.128**	0.075**	0.004	0.018	0.004	−0.017	−0.063**	−0.005	−0.057**	−0.038**	−0.022	−0.041**
Concerned about flexibility of schedules – Bus	−0.038**	−0.021	0.251**	0.168**	0.123**	0.156**	0.104**	−0.063**	−0.062**	−0.060**	−0.092**	−0.104**	−0.028*	−0.135**	−0.120**	−0.094**	−0.123**
Concerned about flexibility of schedules – Train	−0.016	−0.056**	0.288**	0.166**	0.130**	0.171**	0.111**	−0.089**	−0.097**	−0.095**	−0.140**	−0.151**	−0.065**	−0.191**	−0.145**	−0.133**	−0.177**
Compared to car, I would be less tired and stressed by air	0.288**	0.337**	−0.035**	0.058**	0.047**	0.041**	0.046**	0.080**	0.049**	0.075**	0.064**	0.105**	0.073**	0.113**	0.077**	0.106**	0.097**
Compared to car, I would be less tired and stressed by bus	1	0.480**	−0.079**	−0.004	−0.007	−0.018	0.009	0.159**	0.144**	0.142**	0.167**	0.130**	0.086**	0.186**	0.204**	0.177**	0.163**
Compared to car, I would be less tired and stressed by train	0.480**	1	−0.143**	−0.094**	−0.107**	−0.056**	−0.111**	0.301**	0.181**	0.304**	0.203**	0.234**	0.211**	0.289**	0.365**	0.359**	0.277**
Difficult for me to get from train station to where I need to go	−0.079**	−0.143**	1	0.235**	0.214**	0.184**	0.235**	−0.160**	−0.126**	−0.195**	−0.173**	−0.239**	−0.173**	−0.282**	−0.246**	−0.256**	−0.268**
Worry about crime or unruly behavior at the train station and train	−0.004	−0.094**	0.235**	1	0.463**	0.460**	0.531**	−0.111**	0.044**	−0.142**	−0.015	−0.090**	−0.088**	−0.056**	−0.221**	−0.157**	−0.066**
I would feel uncomfortable being on the train with strangers	−0.007	−0.107**	0.214**	0.463**	1	0.366**	0.500**	−0.104**	0.037**	−0.119**	0.01	−0.070**	−0.087**	−0.058**	−0.217**	−0.175**	−0.059**
Having to be with people whose behavior I find unpleasant	−0.018	−0.056**	0.184**	0.460**	0.366**	1	0.366**	−0.051**	0.028*	−0.076**	−0.028*	−0.031*	−0.021	−0.059**	−0.206**	−0.119**	−0.062**
It might be unsafe to make this trip by train	0.009	−0.111**	0.235**	0.531**	0.500**	0.366**	1	−0.113**	0.066**	−0.148**	0.01	−0.065**	−0.075**	−0.045**	−0.188**	−0.170**	−0.039**
People whose opinion I value would approve of the train	0.159**	0.301**	−0.160**	−0.111**	−0.104**	−0.051**	−0.113**	1	0.332**	0.695**	0.305**	0.284**	0.249**	0.310**	0.380**	0.406**	0.305**
My friends and coworkers usually take the train	0.144**	0.181**	−0.126**	0.044**	0.037**	0.028*	0.066**	0.332**	1	0.294**	0.457**	0.216**	0.153**	0.330**	0.221**	0.272**	0.384**
My family would approve of my taking the train	0.142**	0.304**	−0.195**	−0.142**	−0.119**	−0.076**	−0.148**	0.695**	0.294**	1	0.284**	0.282**	0.270**	0.314**	0.385**	0.436**	0.317**
Most people who are important in my life would take the train	0.167**	0.203**	−0.173**	−0.015	0.01	−0.028*	0.01	0.305**	0.457**	0.284**	1	0.227**	0.145**	0.352**	0.286**	0.313**	0.447**
I could easily take the train for this trip	0.130**	0.234**	−0.239**	−0.090**	−0.070**	−0.031*	−0.065**	0.284**	0.216**	0.282**	0.227**	1	0.487**	0.443**	0.371**	0.412**	0.344**
How possible is it to take the train for this trip	0.086**	0.211**	−0.173**	−0.088**	−0.087**	−0.021	−0.075**	0.249**	0.153**	0.270**	0.145**	0.487**	1	0.374**	0.352**	0.350**	0.248**
How efficient to take the train for this trip	0.186**	0.289**	−0.282**	−0.056**	−0.058**	−0.059**	−0.045**	0.310**	0.330**	0.314**	0.352**	0.443**	0.374**	1	0.436**	0.463**	0.525**
How pleasant to take the train for this trip	0.204**	0.365**	−0.246**	−0.221**	−0.217**	−0.206**	−0.188**	0.380**	0.221**	0.385**	0.286**	0.371**	0.352**	0.436**	1	0.589**	0.436**
I would definitely consider taking the train for this trip	0.177**	0.359**	−0.256**	−0.157**	−0.175**	−0.119**	−0.170**	0.406**	0.272**	0.436**	0.313**	0.412**	0.350**	0.463**	0.589**	1	0.520**
How likely for you to take the train for this trip	0.163**	0.277**	−0.268**	−0.066**	−0.059**	−0.062**	−0.039**	0.305**	0.384**	0.317**	0.447**	0.344**	0.248**	0.525**	0.436**	0.520**	1

* Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

CHAPTER 3

Survey Results by Demographics, Region, and Market Segment

In the first half of this chapter, key survey responses are reviewed in terms of gender and age. The second half presents the segmentation of the full sample not into predefined categories (e.g., gender and age) but rather into clusters of survey respondents who share similar patterns of attitudes and behaviors; the concept of latent class cluster segmentation is briefly presented in the second half of the chapter, and the market segments are described.

3.1 Relationship Between Key Demographic Categories and Survey Responses

This section will present a wide array of relationships between basic demographic categories and key results of the NCRRP survey. Data presented in this section are simply empirical in nature—major interpretations of the meaning of this information are not emphasized here, as most of them benefit from the results of the statistical efforts presented in Chapters 4 (attitudinal model), 5 (hybrid model), and 6 (scenario model).

Figure 16 shows that there are stark generational differences in mode choice for intercity trips. Whereas the likelihood of taking rail does not differ between millennials (11%) and those 35 years old and older (11%), pronounced differences occur about taking the bus and a personal car. Twice as many millennials compared to older respondents took the bus for their last intercity trip (15% and 7%, respectively), surpassing rail as the second most preferred mode after car among millennials. On the other hand, millennials are much less likely to have taken a personal car on their last trip (58%) compared to those 35 years old and older (69%).

Consistent with prior research, millennials are less likely to hold a driver's license than older generations. Whereas 91% of the millennial respondents hold a driver's license, that percentage jumps to 96% for respondents 35 years old and older (Figure 17).

As shown in Figure 18, there were statistically significant differences ($p < 0.001$) between the mean scores of the millennial group and the older group for auto orientation, privacy in travel, and ICT/productivity (Mean scores for the four basic longer-term values were estimated by taking an unweighted average of the mean scores for each of the observed variables used in the creation of the factors). The differences between the values of the groups for urbanism were not significant. While the comparative mean scores for auto orientation and desire for ICT were consistent with conventional wisdom, the fact that millennials had more interest in privacy in travel than older respondents was an important result and is further examined in Chapter 8, where factors influencing the use of intercity bus are investigated.

As previewed in Chapter 1, Figure 19 demonstrates the important interaction of gender and age on mode choice for intercity travel. Importantly for this project, millennials have the same

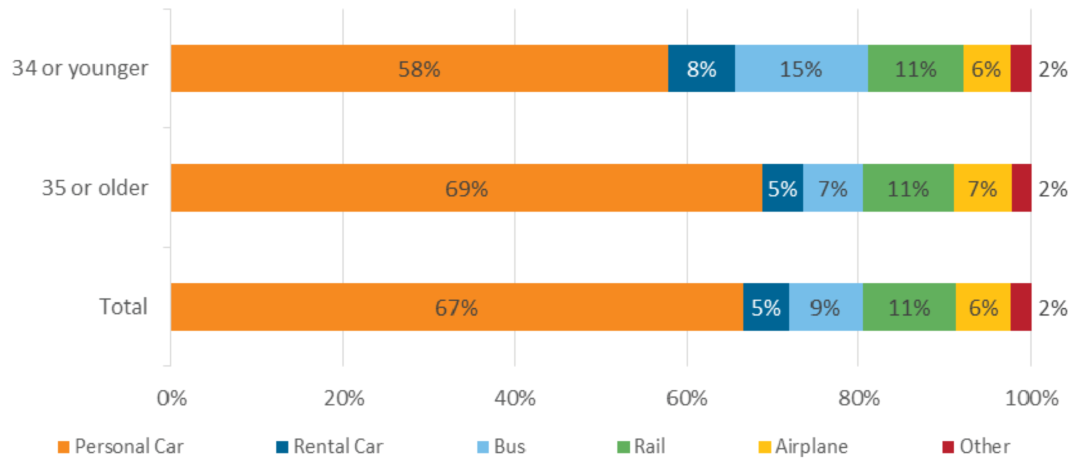


Figure 16. Mode choice by age.

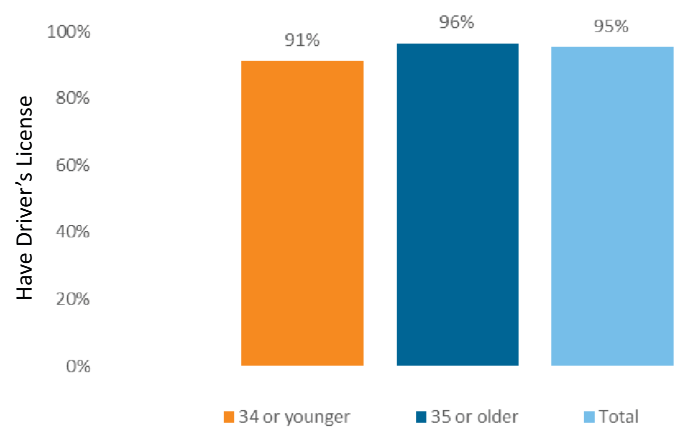


Figure 17. Percentage of respondents who have driver's licenses by age.

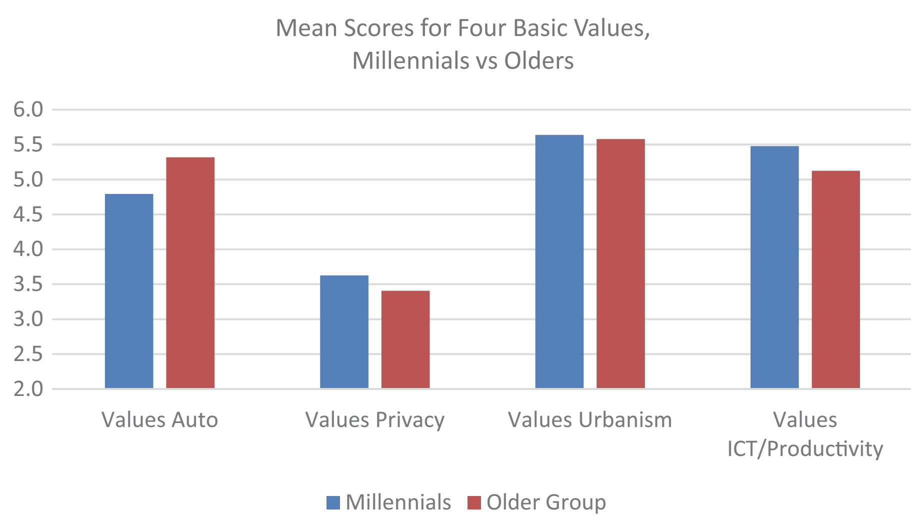


Figure 18. Millennials report greater concern about privacy and ICT compared to older groups.

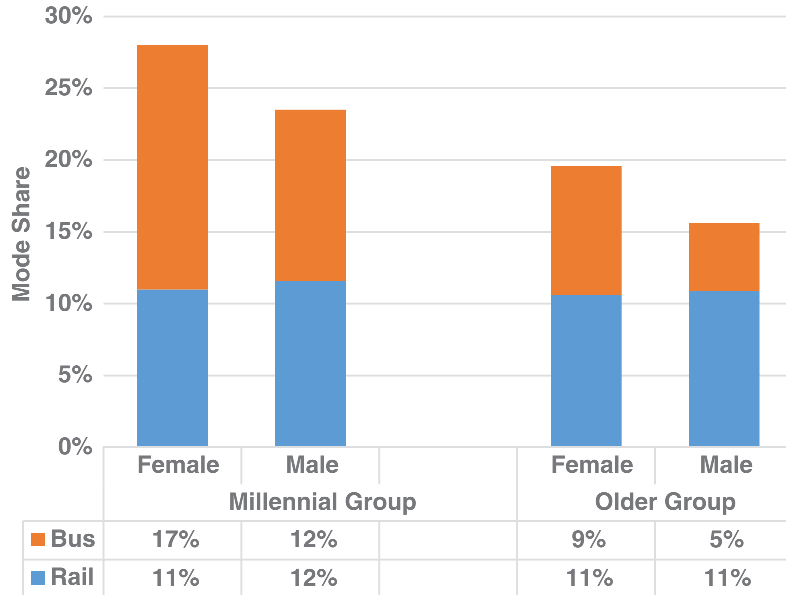


Figure 19. Effects of gender and age on choice of rail and bus.

propensity to ride trains as older respondents, at about 11% of this sample. However, important variations occur in the choice of intercity bus. For this mode, older male participants have a rate of bus use of 5%, while younger female respondents have a rate of bus use of 17%.

Looking at three attitudes toward auto orientation, it is clear that the millennial group has lower positive attitudes toward cars and car ownership than the older age category. As shown in Figure 20, they have a lower propensity to "love the freedom and independence" associated with owning cars than the older group, but still a high portion of them (about three-quarters) report this feeling toward ownership. In a similar manner, only about one-quarter of the millennials would prefer *not* to own a car—which is still markedly higher than rest of the population.

As a cross-check to the observation of lower levels of auto orientation by millennials in the NCRRP survey, the research team undertook a review of similar questions in a metropolitan

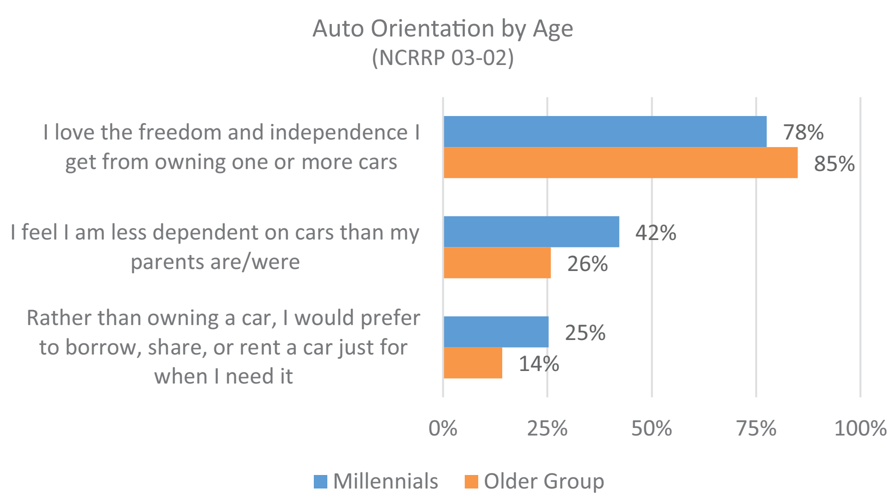
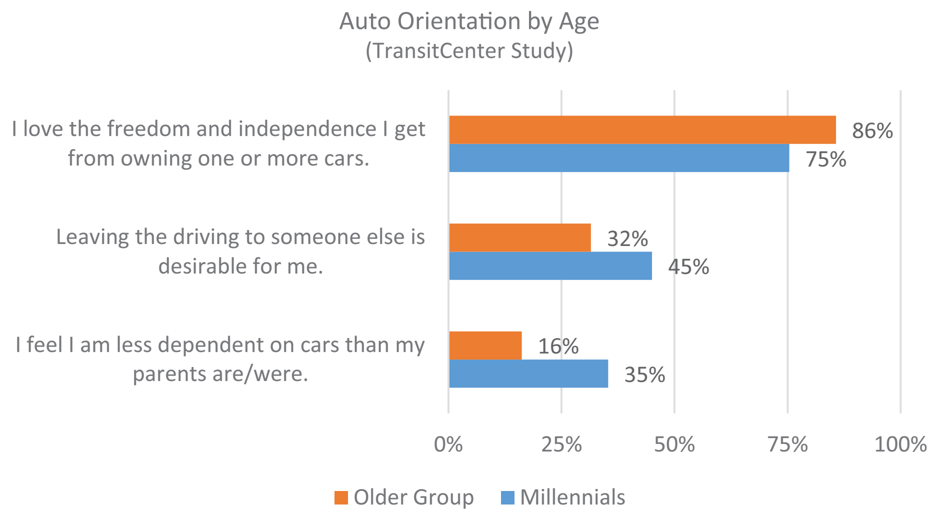


Figure 20. Millennials report less dependence on the auto, more willingness to share.



Source: Metropolitan sample (TransitCenter and RSG Inc. 2014).

Figure 21. Lower auto orientation among millennials also found in short-distance data sets.

sample gathered for a study for TransitCenter (Figure 21). In each case, millennials had lower auto orientation compared to older age groups, consistent with the longer-distance data set.

In the NCRRP survey, the millennial group had consistently higher levels of concern for their personal safety on the intercity trip than did the rest of the sample (Figure 22). That concern for safety seems to be associated with the public modes, specifically: In a question (not shown) about "sharing a car with others" for a long-distance trip, the millennials showed less concern than did the older group. This suggests less of an abstract concern for "privacy" than a specific concern about the persons believed to be riding the public modes.

To confirm the idea that younger individuals have greater concerns about personal safety on public transportation, the data was cross-checked with the metropolitan sample from the TransitCenter study. In general, in Figure 23 the pattern continues in which millennials reported a higher level of concerns about personal safety than did the older group. However, these concerns did not necessarily rise to the level of reporting feeling more "unsafe" than the older group. Clearly,

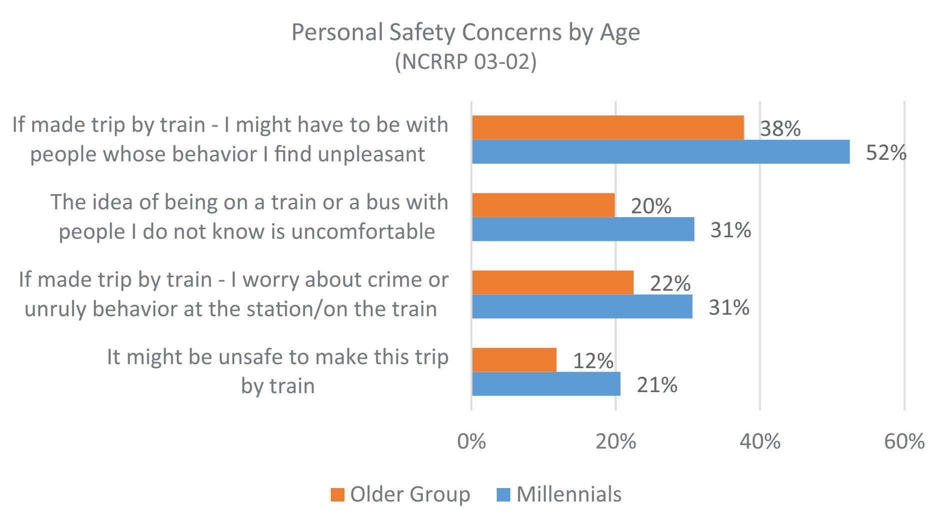
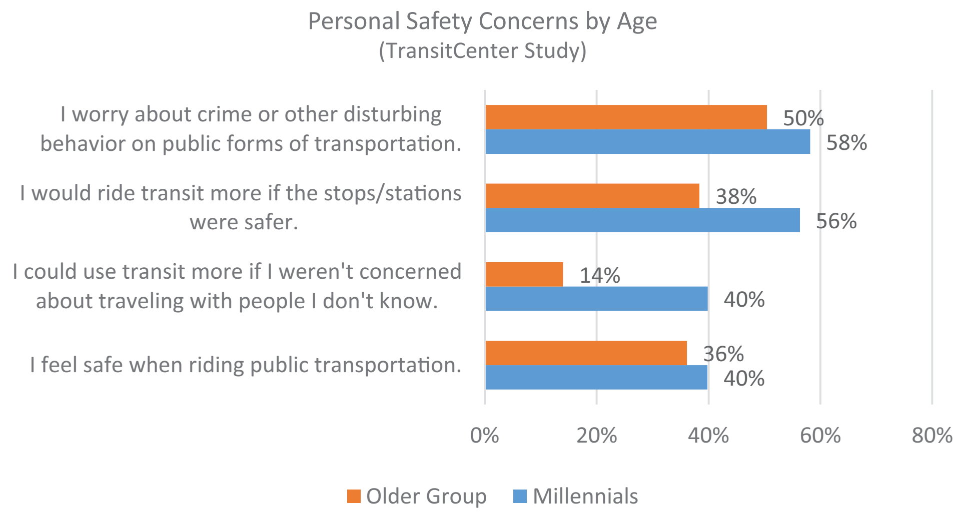


Figure 22. Millennials report higher concern for crime and lack of privacy.



Source: Metropolitan sample (TransitCenter and RSG Inc. 2014).

Figure 23. Higher concern by millennials was also found in short-distance data sets.

the younger generation has major concerns about traveling with people they do not know, and the disturbing behavior that might be associated with it.

In a similar pattern, females consistently report greater concern for their personal safety and being less comfortable traveling with others during a long-distance trip than do males (Figure 24).

Although the differences are not pronounced, the survey showed that for both millennials and non-millennials, those with higher levels of education report worrying less about crime or unruly behavior. For instance, those with higher levels of education were less likely to express a concern about being "with people whose behavior I find unpleasant."

While the fear of personal safety and level of "comfort" in traveling with others is a major concern in the study of factors influencing the choice of rail, it is worth noting that the millennial cohort has stronger feelings on this matter than the older groups for all of the long-distance modes, even for the automobile (Figure 25).

Thus, it is somewhat troubling that nearly half of the sampled population worries about personal safety in the intercity bus trip, while less than 20% of the same population is concerned about personal safety when taking a car (Figure 25). It is clear that for all four modes being young

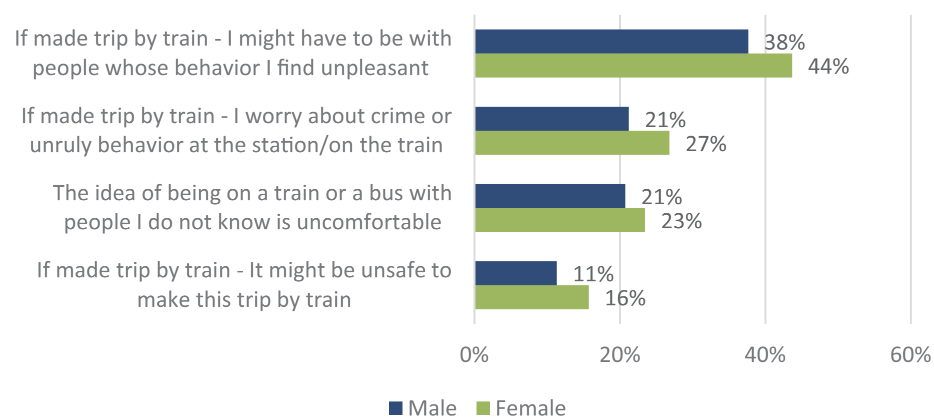


Figure 24. Females report greater concern about crime and lack of privacy.

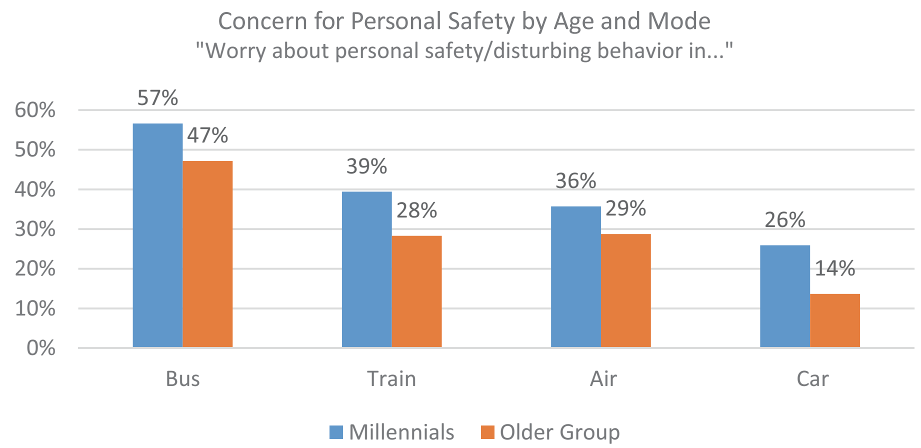


Figure 25. Millennials worry more about safety for all modes.

and less experienced in travel seems to be associated with higher levels of concern. To further explore the idea that experience with intercity travel is negatively related to worrying about travel, the research team correlated the total number of reported intercity trips (e.g., experience with intercity travel) and reported worrying. However, the relationship was not significant. The research team also cross-tabbed the city of destination of the reported trip and found a slightly higher rate of worry for trips to New York City and the lowest rate for trips to Vancouver, but the pattern was not strong. In a similar vein, being female is generally associated with moderately higher levels of safety concern for all modes—except for the private car, where there is no significant difference by gender (Figure 26). Thus, for all modes except auto, there is a clear pattern whereby females express the greatest level of concern for safety and or disturbing behavior.

3.2 Results by Coastal Region

3.2.1 Background

The research team surveyed 513 participants on the West Coast and 5,112 participants on the East Coast. West Coast participants from the larger metropolitan areas of Portland, Oregon; Seattle, Washington; and Vancouver, British Columbia were eligible to participate in the study

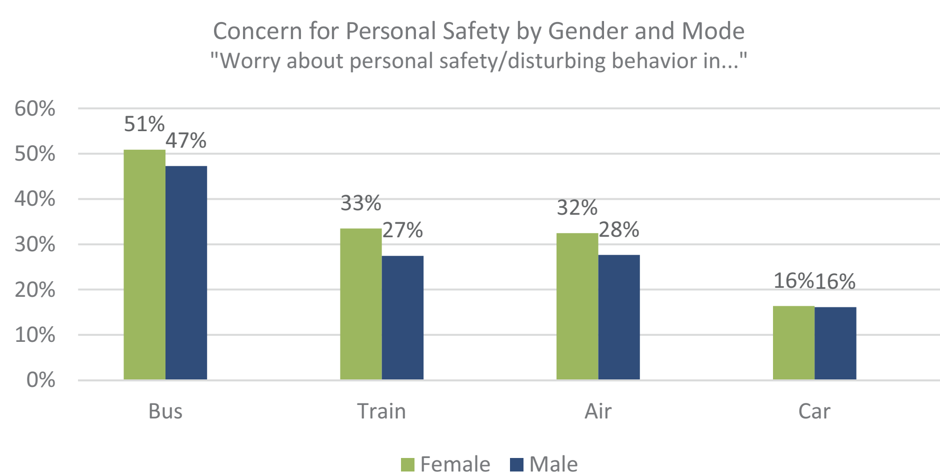


Figure 26. Females report greater safety concerns for all three public modes.

as part of the West Coast sample. NEC participants had to live in the larger metropolitan area of either Boston, New York City, Philadelphia, or Washington, DC. All cities on the East and West Coasts were chosen because rail, bus, plane, and car options are all viable for travel among the cities of either coast. Further, all cities are served by Amtrak and several airlines offer nonstop flights between each city.

To qualify as a participant, respondents had to have made an eligible intercity trip within the last 5 years. The home location of eligible respondents was broadly defined in that it included the larger metropolitan areas of the respective cities. However, the destination cities were more narrowly defined such that West Coast respondents had to have made a trip to either Seattle (which included Bellevue), Portland (which included Beaverton, Gresham, and Hillsboro), or Vancouver (which included West Vancouver, North Vancouver, Coquitlam, Burnaby, and Richmond). East Coast respondents had to have made a trip to at least one of the eligible East Coast cities, which included Boston (including Allston, Arlington, Auburndale, Cambridge, Charlestown, Belmont, Brookline, Newton, Somerville, and Watertown), New York City (including the boroughs of Brooklyn, the Bronx, Manhattan, and Queens, and Hoboken and Jersey City, New Jersey), the City of Philadelphia, or Washington, DC (including Alexandria, Arlington, and Reston, Virginia, and Bethesda, Frederick, Gaithersburg, Rockville, and Silver Spring, Maryland).

3.2.2 Sample Characteristics by Coast

The East and West Coast samples were very similar with regard to the gender breakdown. Females comprised 52% of West Coast respondents and 54% of East Coast respondents. West and East Coast respondents also differed little by age. There were slightly fewer millennials and slightly more 55 to 64 year olds represented among West Coast respondents compared to East Coast respondents, but these differences were small (3% and 4%, respectively).

3.2.3 Trip Characteristics and Attitudinal Differences by Coast

As can be seen in Figure 27, West and East Coast respondents had different reasons for making their last intercity trip. Compared to West Coast respondents, East Coast respondents

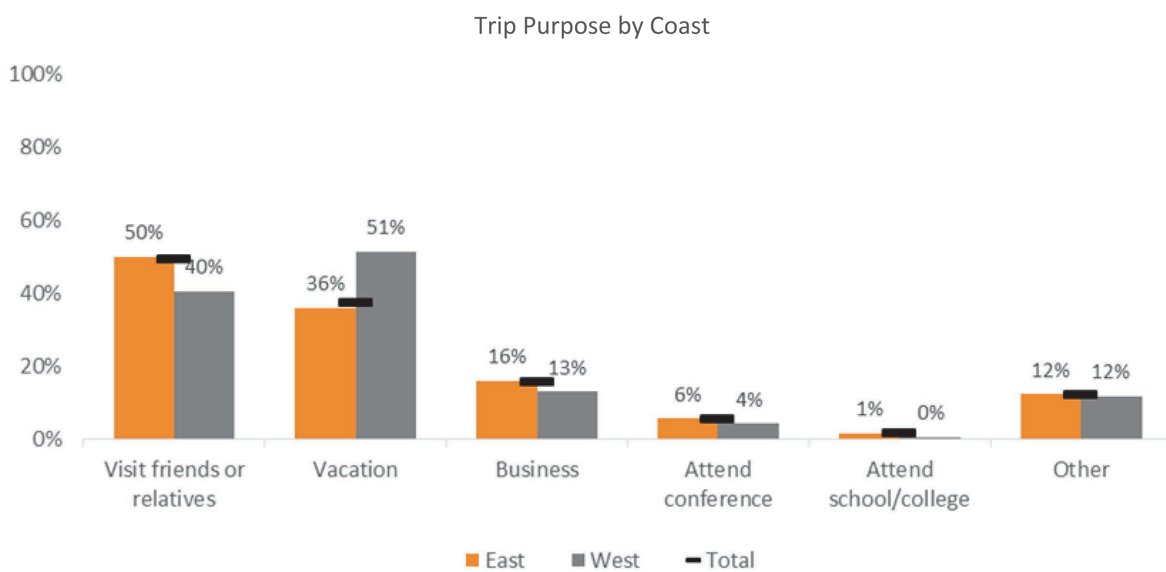


Figure 27. Vacation trips were more common and visiting friends or relatives less common among the West Coast sample.

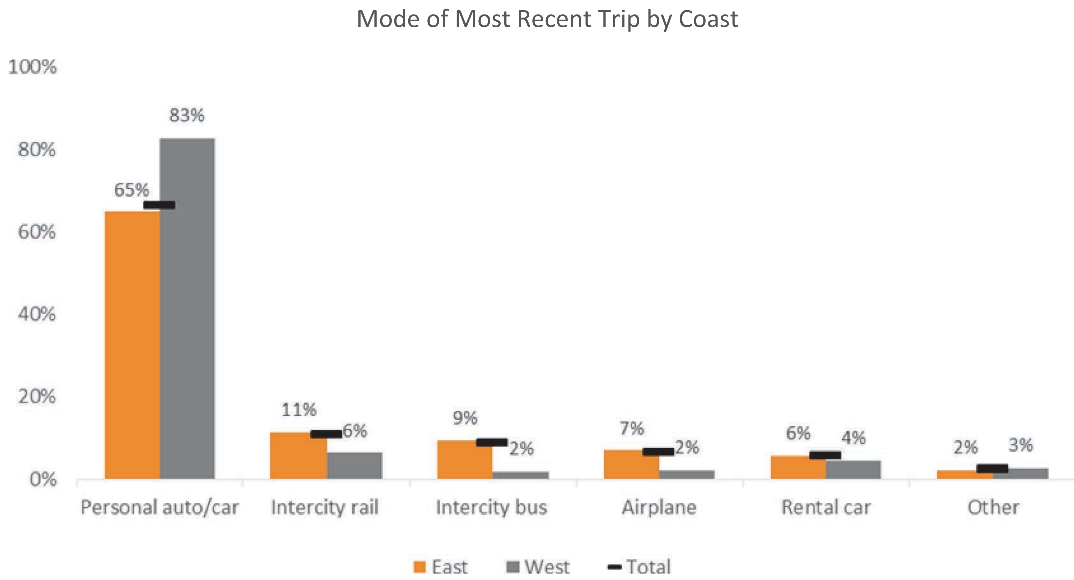


Figure 28. Greater dominance of auto on the West Coast.

were more likely to visit friends and relatives (40% versus 50%, respectively), whereas West Coast respondents were much more likely to be on vacation than East Coast respondents (51% versus 36%, respectively).

There were also substantial differences between West and East Coast respondents concerning the mode they took during their last intercity trip. As can be seen in Figure 28, many more West Coast than East Coast participants traveled by car (83% versus 65%, respectively) and, compared to East Coast participants, West Coast participants were less likely to take any of the remaining modes, such as rail, bus, plane, or a rental car.

Apart from the differences in demographic and trip characteristics mentioned in the previous paragraph, attitudinal differences emerged. Pronounced differences occurred between West and East Coast participants with regard to social norms about taking the train, with West Coast respondents being much less likely to say that their friends and coworkers usually take the train for similar trips. They were also much less likely to think that the most important people in their lives would take the train.

West Coast participants were generally more likely to state that they are uncomfortable about the idea of being on a train or bus with people they do not know (Figure 29). However, follow-up questions about each mode revealed that these privacy and safety concerns are mode specific. West Coast participants are more concerned than East Coast participants about safety and disturbing behavior when traveling by bus, but less concerned when traveling by train or plane. This suggests that the general concern that West Coast participants voice about traveling with others is primarily driven by particular modes (specifically bus) but does not extend to others such rail or the plane.

As can be seen in Figure 30, when explicitly asked which mode other than rail they would prefer to take, West Coast participants were more likely than East Coast participants to select the car as the preferred mode, but less likely to select the plane or the bus. The reluctance to consider the bus might be driven by the greater concern that West Coast participants proclaim about safety and disturbing behavior when traveling by bus (Figure 29).

In general, West Coast participants voice greater concerns about the lack of flexibility when traveling by train (Figure 31) and are more likely to be concerned about the lack of flexibility

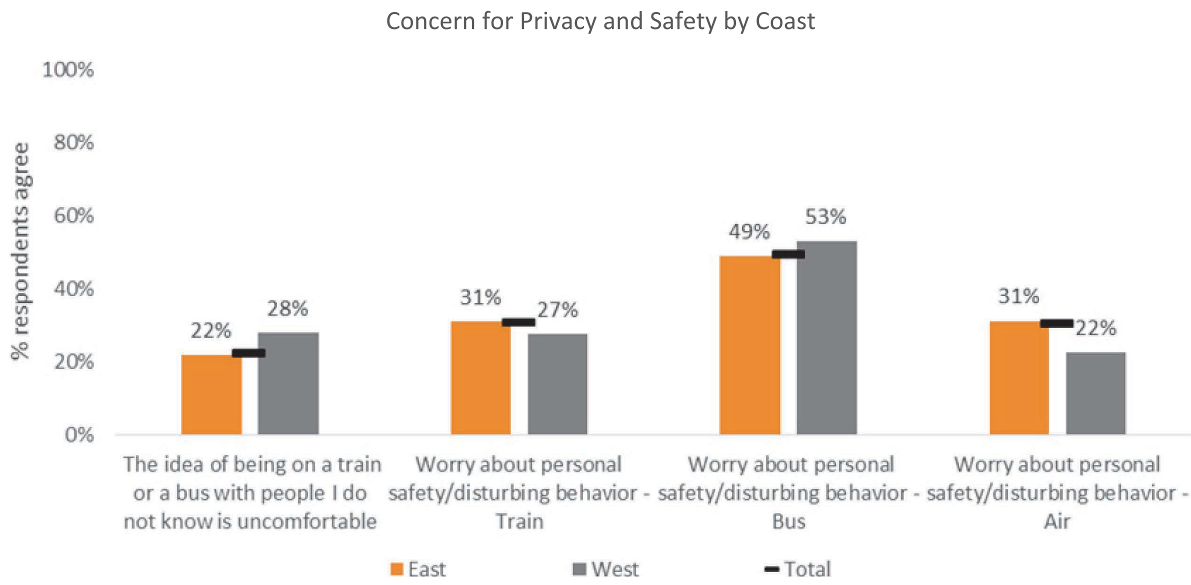


Figure 29. Slightly greater concern for privacy and safety on buses among West Coast sample.

and schedule constraints when traveling by train. They are also much more likely to state that they need the flexibility of a personal car at their destination. Taken together, it is possible that these attitudinal differences simply reflect objective differences in the availability and frequency of train service on the West versus East Coast.

3.3 Latent Class Cluster Segmentation

3.3.1 Methodological Overview and Benefits of Latent Class Analysis

The behaviors, needs, and wants of the American population are hugely variable. For the purposes of discussion and analysis, it is often useful to group a population into discrete categories that can be characterized and compared to one another. While many commonly used cluster

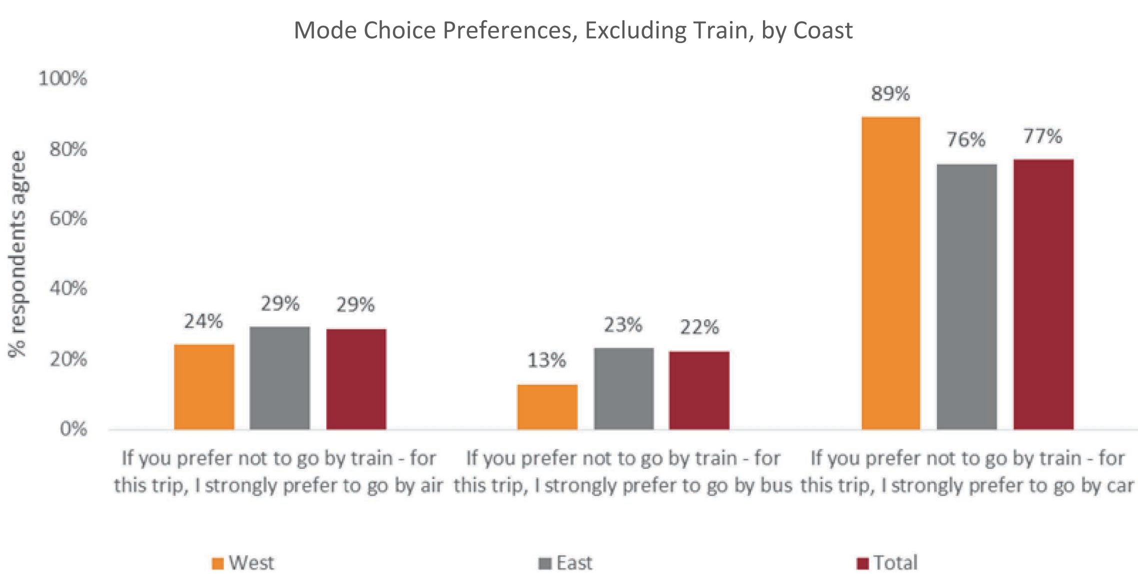


Figure 30. Modes preferred over train, by coast.

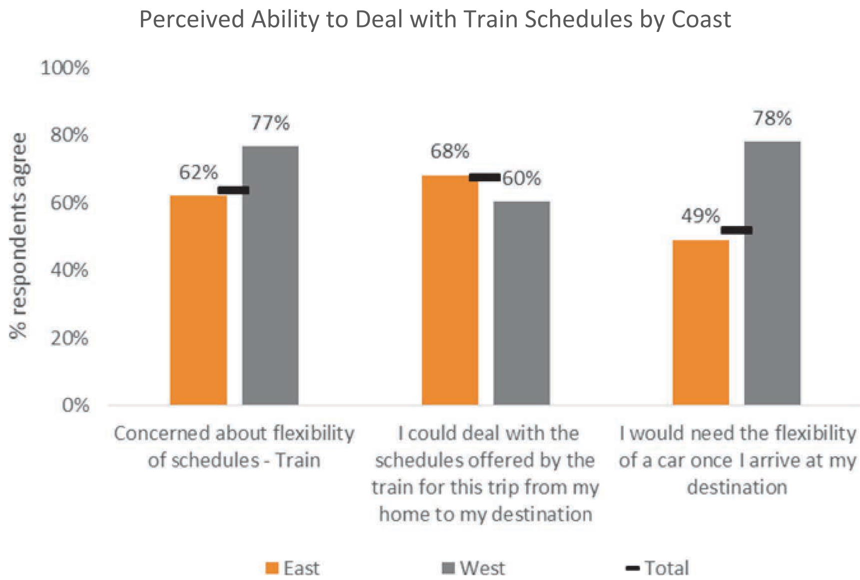


Figure 31. West Coast participants report greater need for flexibility.

analysis methods achieve this by using an a priori segmentation approach based on demographic variables such as income, gender, or age, the goal of latent class cluster (LCC) analysis is to identify groups based on *latent* variables such as attitudes, preferences, values, or personality differences (Magidson and Vermunt 2005). For example, differences among individuals in their preference for using transit might be due in part to the traveler's household income, or perhaps the differences are not driven by income at all but more strongly by a particular set of attitudes toward, for instance, privacy, the environment, or convenience when traveling. LCC has routinely been used in private sector market research where it is used to better understand customer segments and to target products/ads to various customer groups. However, only recently has LCC been applied in the transportation domain, and one of the first applications came from the research team to better understand attitudinal factors leading to risky driving behavior and how these attitudinal differences might be related to demographic and geographic variables (Coogan et al. 2011).

To identify unique groups, LCC uses a "finite mixture model," which assumes that a population can be segmented into a finite number of groups, or classes, by "unmixing" the data to identify the number and characteristics of the populations, or latent classes (Vermunt and Magidson 2005b). The result of this method is that, for each individual, probabilities for membership in each class are assigned and individuals are grouped who share similar characteristics but whose characteristics are dissimilar from those in other groups. To find the most appropriate number of clusters, which variables to include in the model, and model fit, standard statistical tests are applied. For instance, the coefficient of determination (R^2) is used as a guide to determine which variables should be retained in the latent class model; chi-square (χ^2) and bootstrapping are used to assess the model fit and are used as measures of parsimony (Vermunt and Magidson 2005b).

Once classes are defined, members of the classes can then be profiled by other variables. For example, once a class is defined, its income distribution can be examined. If that distribution is mostly high income, then high income is known to be one of the indicators of that segment. Each of these classes represent "building blocks" of attitudes, values, and preferences, which might influence the propensity to choose a more environmentally sustainable long-distance trip, such as rail or intercity bus. LCC is ideally suited to address some of NCRRP's goals—as a data-driven analysis method based on latent variables, it allows researchers to identify subgroups that are based on distinct psychological profiles that go beyond simple concerns for travel time and costs.

3.3.2 Results

Predictive Variables

The modeling effort started with a large number of variables ("indicators") used in the specification of the model. From there, the research team narrowed down the set of variables to only include those variables that have significant effects on cluster classification, or had strong theoretical relevance to the project goal. As described in Table 7, the indicator variables used in the final model developed for this analysis were all based on the predictive power of these variables for group membership (R^2 above 10%) or based on theoretical considerations (e.g., age). It should be emphasized that the variables listed in Table 7 were used to determine the model and the number of segments, but that once clusters are determined, they can be profiled by demographics and other variables that were not originally part of the model specification.

Overview of Results

A five-cluster solution provided the best model fit and made the most intuitive sense. The five segments that were identified and named—Open to Rail, Cars for Convenience, Curious but Cautious, Rail Rejecters, and Young Urbanities—are shown in Figure 32.

As described in more depth in Section 3.3.3, three of the five clusters (Open to Rail, Curious but Cautious, and Younger Urbanites) stand out in that their cluster members either already use rail or are open to the idea of using rail for their intercity travel needs. The following sections provide an overview of the different segments and how their attitudes differ. They are summarized in Section 3.4.

3.3.3 Description of Clusters, Ranked from Most Receptive to Least Receptive to Rail

Young Urbanites (11%)

Transit-loving Young Urbanities are the most enthusiastic about rail. This group is younger, least likely to have children in the household, more likely to be female, and more ethnically and racially diverse than all other segments. Young Urbanites overwhelmingly prefer living in an urban environment where they can be out and about, observe and interact with people from different backgrounds. They have a deeper affinity for their smartphone than for cars, are less likely to have a driver's license, and are less likely to equate having a car with freedom than other segments. As a group that describes itself as less dependent on the car than their parents' generation, they are open to the idea of using car-sharing programs as an alternative to owning a car. Their preferred mode of choice for intercity travel is bus, but rail also enjoys a relatively high popularity. Consistent with these travel mode choices, this group exhibits little concern about traveling with other people, potential crime on the train, or inflexibility of the schedule. There are two primary challenges with keeping this group on rail in the future. First, as mentioned, they are more likely to be found on intercity buses than trains and efforts should be undertaken to not lose further market share to intercity buses. Second, while they are enthusiastic about bus and rail service now, as the group least likely to currently have children in the household, the challenge may be to keep them riding transit as they go through different life stages (e.g., have children, secure higher paying jobs).

Table 7. Indicator variables and variance explained.

Indicator Variables	R^2
Worry about personal safety/disturbing behavior—train	52%
Vehicle available	45%
I would definitely consider taking the train for this trip	43%
How efficient would it be to take the train for this trip	41%
How likely would it be for you to take the train for this trip	40%
How pleasant would it be to take the train for this trip	38%
If made trip by train—I would worry about crime or unruly behavior at the train station and on the train	36%
Worry about personal safety/disturbing behavior—air	30%
I love the freedom and independence I get from owning one or more cars	28%
Worry about personal safety/disturbing behavior—bus	28%
If made trip by train, I might have to be with people whose behavior I find unpleasant	27%
If made trip by train, I would feel uncomfortable being on the train with strangers	26%
My spouse/partner/family would approve of my taking the train to go to Boston	26%
It might be unsafe to make this trip by train	25%
Most people whose opinion I value would approve of my taking the train to Boston	24%
I need to drive a car to get where I need to go	24%
If I wanted to, I could easily take the train for this trip	23%
The idea of being on a train or a bus with people I do not know is uncomfortable	22%
If made trip by train—It would be difficult to get from the destination station to where I need to go	21%
If they had to make this trip, most people who are important in my life would take the train	20%
I could deal with the schedules offered by the train for this trip from my home to my destination	19%
I would need the flexibility of a car once I arrive at my destination	18%
My friends and coworkers usually take the train when they travel to Boston	18%
Rather than owning a car, I would prefer to borrow, share, or rent a car just for when I need it	17%
Compared to car, I would be less tired and stressed if I took the trip by train	16%
Concerned about flexibility of schedules—train	16%
If prefer not to go by train for this trip, I strongly prefer to go by car	14%
Rate how possible it would be for you to make this trip via train	14%
Concerned about flexibility of schedules—bus	14%
I feel I am less dependent on cars than my parents are/were	14%
If prefer not to go by train for this trip, I strongly prefer to go by bus	13%
Getting from my home to the train station is inconvenient	12%
License	12%
Age	2%

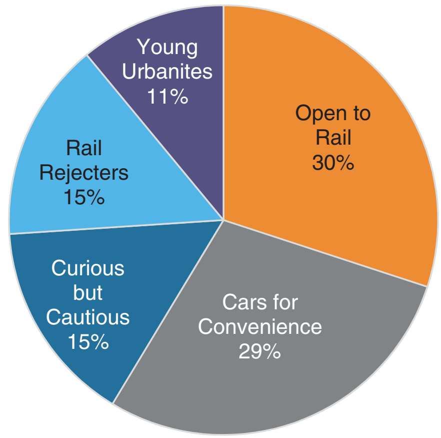


Figure 32. Latent class clusters for this project

Open to Rail (30%)

The largest potentially positive segment identified in the sample is the Open to Rail segment. People in this group may or may not have children but are highly educated and slightly older and have a high household income. Generally speaking, these individuals are interested in exploring new things and enjoy being around people from different backgrounds. Despite the fact that the overwhelming majority owns and has access to a private car, they are less likely to have used a personal car on their last intercity trip than several other segments. In fact, more than one-fifth of this group (22%) took the train on their most recent intercity trip, making it a viable and competitive option. This willingness to consider rail stems from a variety of positive attitudes they have toward trains: They do not associate train schedules with inflexibility, do not think that they necessarily need a car at their destination, and do not have strong privacy or security concerns regarding rail or bus travel. In fact, people in this group perceive the train to have several advantages over the car, such as that train travel makes for a less tiresome and stressful travel experience. Further adding to their propensity to consider rail are normative and social influences, as friends and family members of this segment use the train and approve of them doing the same.

Curious but Cautious (15%)

The Curious but Cautious group is slightly more likely to be female, younger, and dabbling in an urban lifestyle. As the group that is most likely to both have children and to be full-time employed, they are grappling with the competing demands of balancing family and work. Perhaps as a result, for these individuals being productive and able to work while traveling is especially important. Even though rail might arguably be the mode that is most conducive to working while traveling, this group's attitudes toward rail are at best ambivalent. In theory, they are open to taking the train, they think that they would have no problem doing so, and even feel some subtle pressure from friends and family to take the train. At the same time, several major hurdles keep them from actually switching to rail. For instance, this group worries more when it comes to train travel, as they are very concerned about the perceived lack of safety, privacy, and flexibility. Given that perceived lack of safety can serve as a strong deterrent to behavior, it is unlikely that this group will adopt rail until they perceive that their safety concerns were adequately addressed.

Cars for Convenience (29%)

The Cars for Convenience cluster is another cautious group. These stalwarts of automobile travel are nearing retirement age and are satisfied with their car-centric, suburban lifestyle. As a group, they are mostly White and male, are well-educated, have a high household income, and have, relatively, many vehicles in their household. They are not ideologically opposed to train travel and their unwillingness to use the train or bus is not driven by privacy or safety concerns as they do not worry about crime or being around other people when traveling. Rather, they might be described as "set in their ways," simply perceiving the car to be the more convenient and flexible choice that provides them greater independence—even when taking the car might entail driving in a congested city for a long time.

Rail Rejecters (15%)

The least promising group identified are Rail Rejecters. On average, they are less educated, less likely to be full-time employed, and slightly more likely to be female. As a group, they are highly protective of their personal space and show less interest in exploring new places or having contact with people from different backgrounds. According to their own responses, there is little that can be done to get this group out of the car and onto the train: They are convinced that they need to drive a car once at their destination, name their car as the technology they could least live without, and perceive themselves to be more dependent on their car than their parents' generation. Coupled with this positive attitude toward the car are strong negative attitudes toward alternative modes of traveling. For instance rail, to their mind, is inflexible, inconvenient, dangerous, and lacks privacy. In fact, this segment does not acknowledge any redeeming features of trains and, unlike all other groups, does not even perceive train travel to make for a less stressful or tiresome travel experience than taking the car.

Difference in Segment Composition, by Coast

Some latent class segments were more prevalent among West Coast respondents compared to East Coast participants. As can be seen in Figure 33, the starkest difference occurred for Cars for Convenience, which describes 40% of the West Coast, but only 28% of the East Coast sample. Open to Rail, on the other hand, was much more prevalent among East Coast respondents (31%)

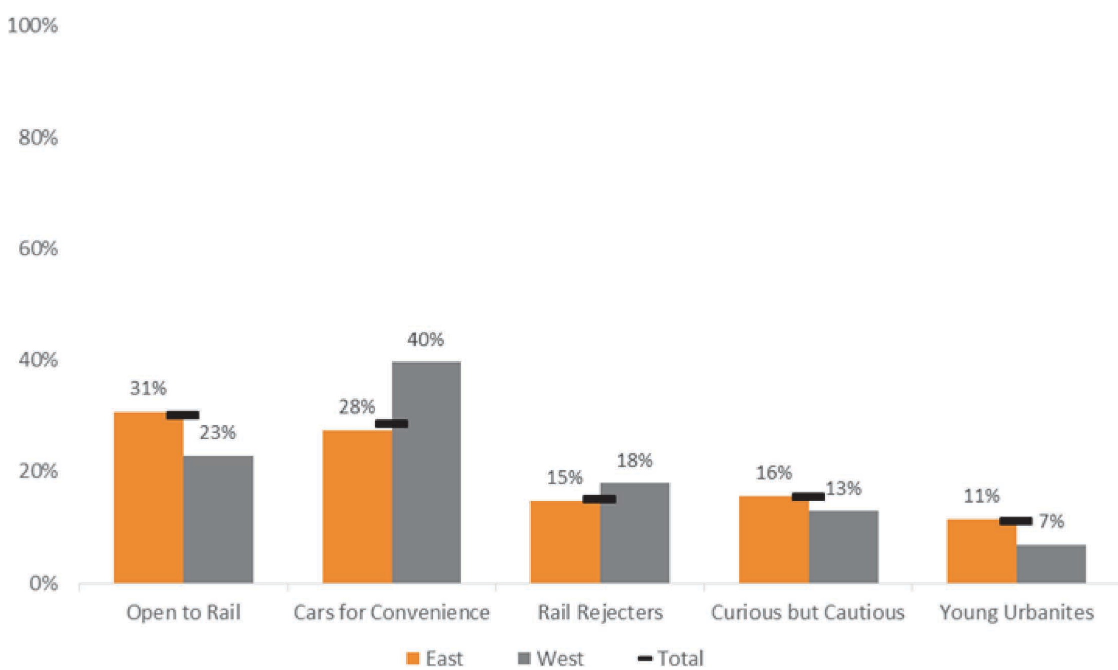


Figure 33. LCC sizes by coast.

compared to West Coast respondents (23%). Relative differences for other segments between West and East Coast respondents were smaller.

3.4 Summary of the Market Segmentation

Through this analysis, the research team identified three clusters, or segments, that are willing to use rail: an Open to Rail segment consisting of individuals who are slightly older and have the option of driving but see several advantages to taking rail, nevertheless; a Curious but Cautious segment with individuals who, in theory, acknowledge several benefits of taking rail but are also deeply concerned about lack of flexibility, privacy, and crime and are therefore much less likely to act on their generally positive attitudes toward rail; and the segment least likely to own a car, Young Urbanites, who currently depend on bus and rail service for their intercity travel needs. The research team also found two segments that are highly dependent on cars and unlikely to try rail or bus for their intercity travel needs. Individuals in the Cars for Convenience segment use the car because it provides the flexibility and convenience they demand from their mode choice. Rail Rejecters are similar in this regard to the Cars for Convenience segment. However, unlike the Cars for Convenience segment, Rail Rejecters are strongly worried about crime, safety, and lack of privacy and are therefore unlikely to try travel modes that place them in proximity to other people. In general, these results also indicated that those segments that take the bus (Open to Rail, Curious but Cautious, Young Urbanites) are also more likely to take rail. A summary of all characteristics of the segments is presented as Table 8.

Table 8. Summary of cluster characteristics.

		Cluster Characteristics	Open to Rail	Cars for Convenience	Curious but Cautious	Rail Rejecters	Young Urbanites
		Cluster Size	***30%***	***29%***	***15%***	***15%***	***11%***
Demo-graphics		% under 35	16%	12%	34%	23%	39%
		% Female	51%	47%	59%	60%	60%
		% Hispanic	4%	3%	9%	6%	10%
		% White	84%	86%	71%	80%	68%
		% Full-Time Employed	55%	50%	56%	47%	47%
		% $75k or more Household Income/Year	73%	71%	55%	60%	36%
		% College Graduates or higher	78%	73%	62%	59%	67%
		% With Kids at Home	26%	25%	39%	33%	20%
		Average Number of Vehicles in Household	2.0	2.1	1.8	2.0	0.7
		% Owns Car	98%	98%	86%	90%	24%
Recent Trip		Average Party Size	2.4	2.4	2.7	2.8	2.2
		Average Trip Length (days)	3.4	3.4	3.5	3.5	3.7
	Mode Choice	% Personal Car	57%	84%	67%	85%	23%
		% Rental Car	4%	3%	10%	5%	10%
		% Bus	8%	3%	8%	3%	33%
		% Rail	22%	1%	9%	0%	22%
		% Airplane	6%	8%	4%	5%	8%
	Purpose	% Business	17%	13%	20%	14%	14%
		% Vacation	38%	34%	42%	40%	34%
		% Visit Friends or Relatives	49%	49%	49%	45%	56%
Car Ownership		Average Number of Vehicles in Household	2.0	2.1	1.8	2.0	0.7
		% Owns Car	98%	98%	86%	90%	24%
Key Attitudes		I feel I am less dependent on cars than my parents are/were	30%	16%	37%	14%	70%
		Rather than owning a car, I would prefer to borrow, share, or rent a car just for when I need it	11%	7%	25%	8%	58%
		The idea of being on a train or a bus with people I do not know is uncomfortable	7%	13%	45%	57%	9%
		Worry about personal safety/disturbing behavior on train	6%	7%	84%	81%	17%
		Worry about personal safety/disturbing behavior on bus	33%	29%	91%	89%	33%
		I like to live in a neighborhood where I can walk to a commercial or village center	79%	69%	81%	66%	84%
		In choosing my next home I would value having a private home location with adequate separation from others	63%	66%	75%	76%	47%
		In choosing my next home I would value living in a community with a mix of people from different backgrounds	70%	54%	69%	48%	74%
		Prefer living in urban environment	32%	16%	29%	18%	61%
		I enjoy being out and about and observing people	88%	80%	84%	75%	78%
		Compared to car, I would be less tired and stressed if I took the trip by train	90%	54%	82%	39%	73%
		I could deal with the schedules offered by the train for this trip from my home to my destination	91%	49%	80%	36%	75%
		I would need the flexibility of a car once I arrive at my destination	30%	68%	63%	77%	17%
		Most people whose opinion I value would approve of my taking the train to my destination	91%	47%	83%	26%	69%
		If I wanted to, I could easily take the train for this trip	97%	56%	92%	43%	85%

Top ranked in row
2nd ranked in row
3rd ranked in row
4th ranked in row
5th ranked in row

CHAPTER 4

Understanding Values, Preferences, and Attitudes in the Choice of Rail

In Section 4.1, the development of the NCRRP Attitudinal Model for Rail (Figure 34) is documented, as it was developed to help understand the inter-relationship of factors influencing the propensity to take rail in the project sample. In Chapter 7, the Attitudinal Model will be applied to rural areas and individuals' propensity to take either rail or bus to a major destination city. In Chapter 8, the Attitudinal Model will be applied to the propensity to take the intercity bus. This model has been created by the research team to focus primarily on key explanatory factors which could (in theory) be influenced by the policies and interventions of rail managers and those involved in forming public policy toward investing in rail.

Section 4.2 introduces a new model developed by the research team based on the TPB. The new model was developed under the direction and advice of Dr. Icek Ajzen, professor at the University of Massachusetts, and the author of the TPB. Ajzen also had a major role in the creation of the

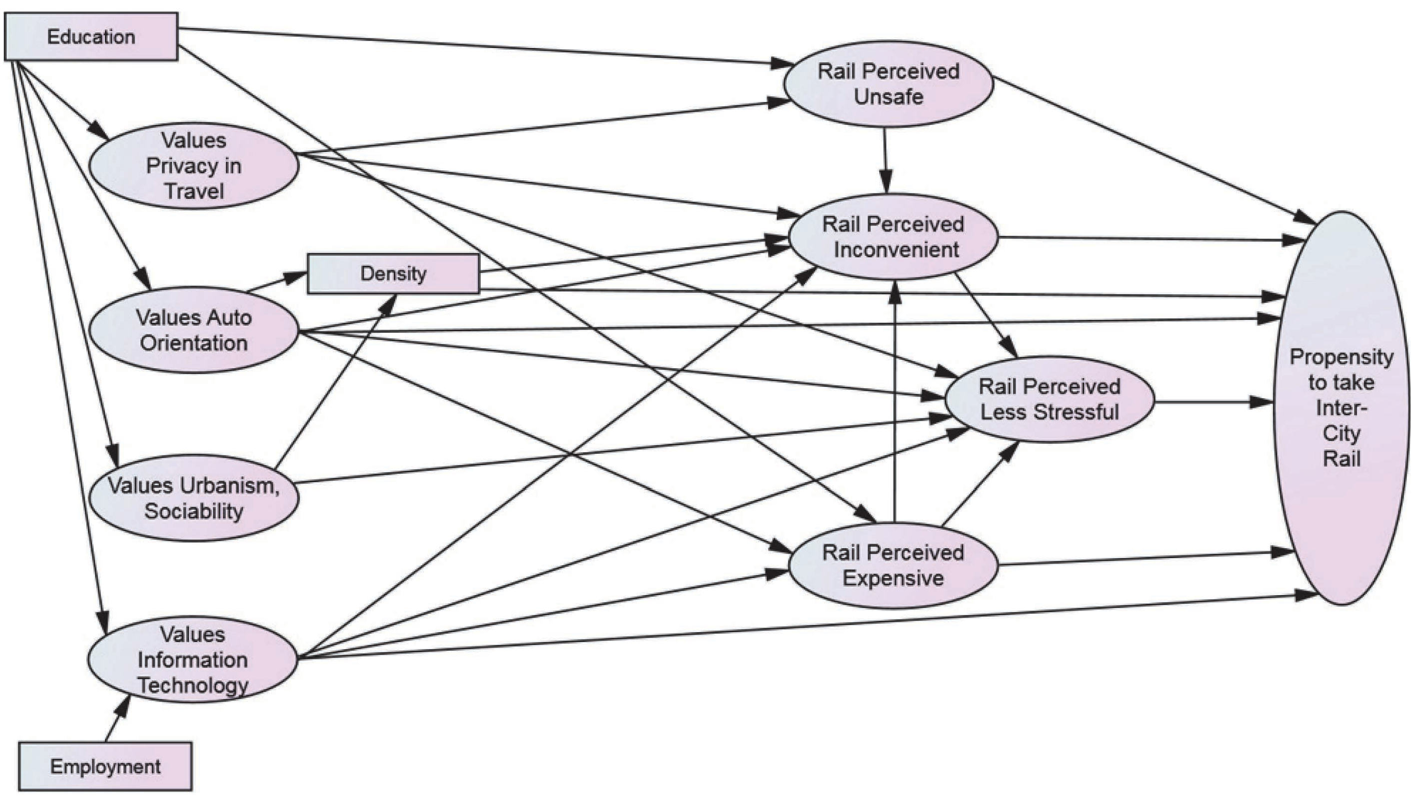


Figure 34. NCRRP Attitudinal Model for Rail was created using structural equation modeling.

survey instrument itself, and survey data used throughout this project reflect the survey questions highly influenced by the structure of the TPB. Use of the theory helps introduce the concept of normative pressures revealed in the decision to choose rail, as well that of hedonic influences, which are reflections of perceived pleasure concerning the trip.

Finally, the reader of Chapter 4 is strongly encouraged to refer to Technical Appendix: Documentation for the Structural Equation Models in *NCRRP Web-Only Document 2*. In that appendix, the full documentation of the three attitudinal models (for rail, for intercity bus, and for rural use of rail and bus) is presented. In addition, documentation for the TPB model is presented. Models are first presented in diagram form, with presentations of both unstandardized and standardized coefficients for all parameters in each model, with levels of statistical significance for each. Several measures of goodness of fit are presented for each model. The TPB model is documented for the full sample, millennials only, and older groups only.

4.1 The NCRRP Attitudinal Model for Rail

4.1.1 Development of the Attitudinal Model

In addition to the demographic variables, the Attitudinal Model can be seen as having four basic elements. Consistent with the analytical framework established earlier in the project, Figure 35 shows longer-term values as having an effect on all three later elements. Most directly, perhaps, these underlying values might influence one's choice of a residential location. The characteristics of location set the stage for experiences one has in transportation (e.g., a traveler living in a rural area will experience rail in a different way than one living in Manhattan). Those experiences will lead to shorter-term attitudes (e.g., "the bus from my town is full of people I do not like"). These attitudes will almost certainly influence the choice of long-distance mode, in conjunction with both direct and indirect influences from the other factors in the model.

Each of the factors in the Attitudinal Model was created from a process called "factor analysis." The research team used a two-phase process, where all of the relevant variables were first reviewed through exploratory factor analysis, largely based on principal component analysis, as provided in the SPSS software package. Exploratory factor analysis provided a quick suggestion of which variables should be clustered with similar variables in the formation of a list of candidates for inclusion in the creation of the final factors.

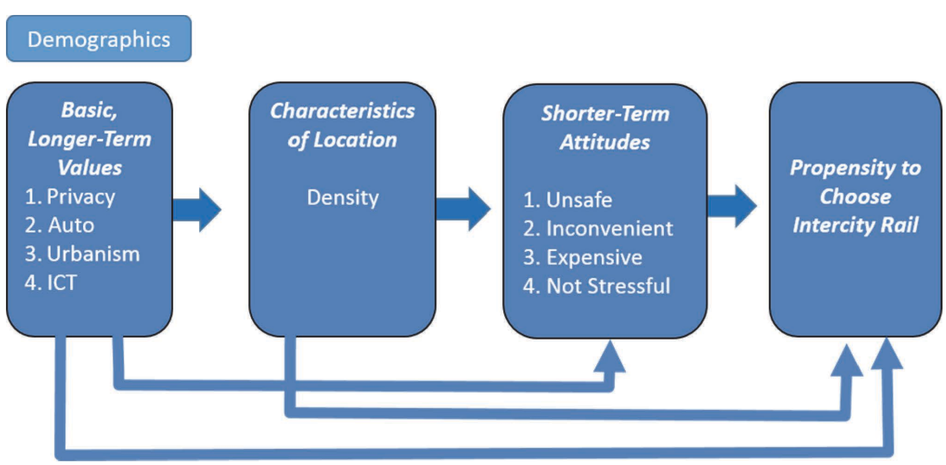


Figure 35. Diagram of major elements of the analytical framework for attitudes.

Four Factors Representing Long-Term Values

Observed variables that were identified through exploratory factor analysis were then considered for final acceptance by a process known as confirmatory factor analysis. For example, Figure 36 shows four latent factors (in ovals) linked to 11 observed variables (in rectangles). The strength of the bond between the latent factor and its component observed variables is reflected in its "factor loading" coefficient. In a mathematical equation describing the extent to which the variance in the observed variable *I love the freedom and independence I get from owning one or more cars* is explained by the latent factor, a standardized coefficient of 0.58 is calculated (located above the arrow). This factor loading is often called the "R" value. The R^2 value is shown to the left of the rectangle, in this case 0.34. From this it is deduced that 34% of the variance in the observed variable *I love the freedom. . . .* is explained by the values auto orientation latent factor.

An iterative process was undertaken to ensure that each observed variable was correctly assigned to its latent factor, by confirming that no higher loading factor would be created by connection with a different latent factor. Alternative candidate observed variables were tested to see which combination resulted in the highest quality level of fit in the overall model. The final set of observed variables were chosen based on their overall model fit, provided that the variables reflect the overall theories being tested (e.g., an observed variable representing the price of fish in China would not be accepted, even with a good model fit, if that variable did not reflect the concepts being examined).

Values and Location

The NCRRP Attitudinal Model for Rail has four latent factors representing four longer-term values held by the respondent. Similarly, a density factor was developed for the residential

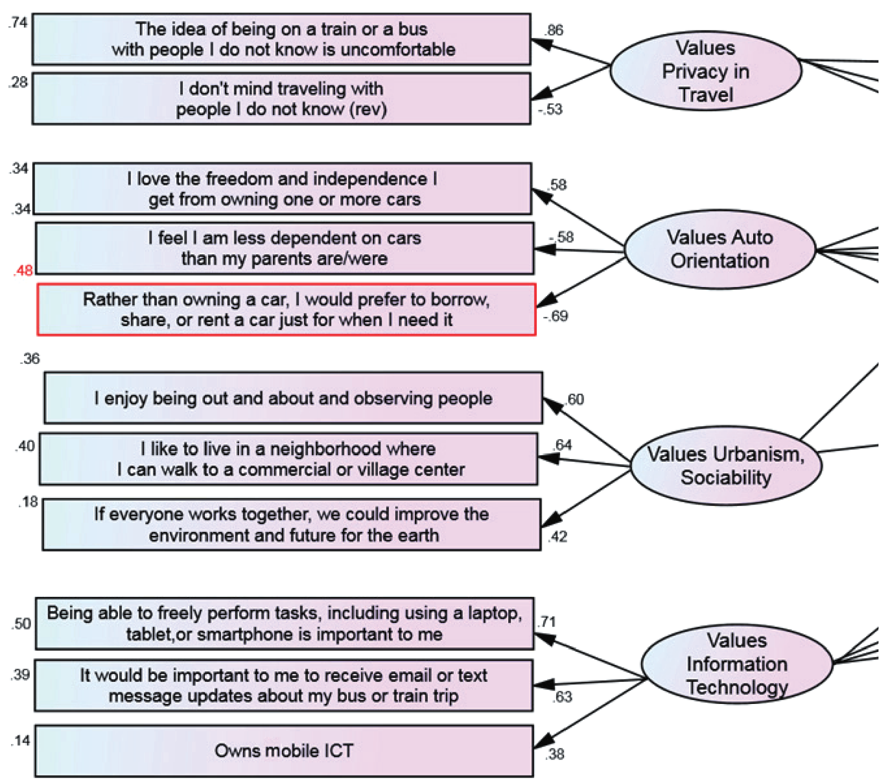


Figure 36. Four basic latent factors (ovals) and 11 observed variables (rectangles) in the NCRRP Attitudinal Model for Rail.

location of each respondent, taking the form of the logarithmic value of the actual density in persons per square mile.

Short-Term Attitudes and the Outcome Factor

Four short-term attitudes toward rail were created using the factor analysis process, as shown on the left side of Figure 37. Although it is preferred to have each latent factor associated with several observed variables, both the factors Rail Perceived Less Stressful and Rail Perceived As More Expensive were found to fit into the model best with only one observed factor. Concerning the factor Rail Perceived Unsafe, it is clear from testing alternative observed variables that this factor is about personal safety and disturbing behavior, not safety as related to accidents, etc. The factor Rail Perceived Inconvenient represents both the concern about schedules and the concern about access to and from the train.

The latent factor Propensity to Take Intercity Rail is associated with four observed variables, three of which reflect future intent and one on past behavior (i.e., having taken rail on the last reported trip). The factor loadings for the outcome factor are all statistically satisfactory.

4.1.2 Running the Attitudinal Model for Rail

The model was run using AMOS structural equation modeling (SEM) software (Version 22), which is part of the SPSS set of modeling software packages. The sample included 5,625 respondents, including those from both the NEC and the Cascade Corridor. Several calculations of the

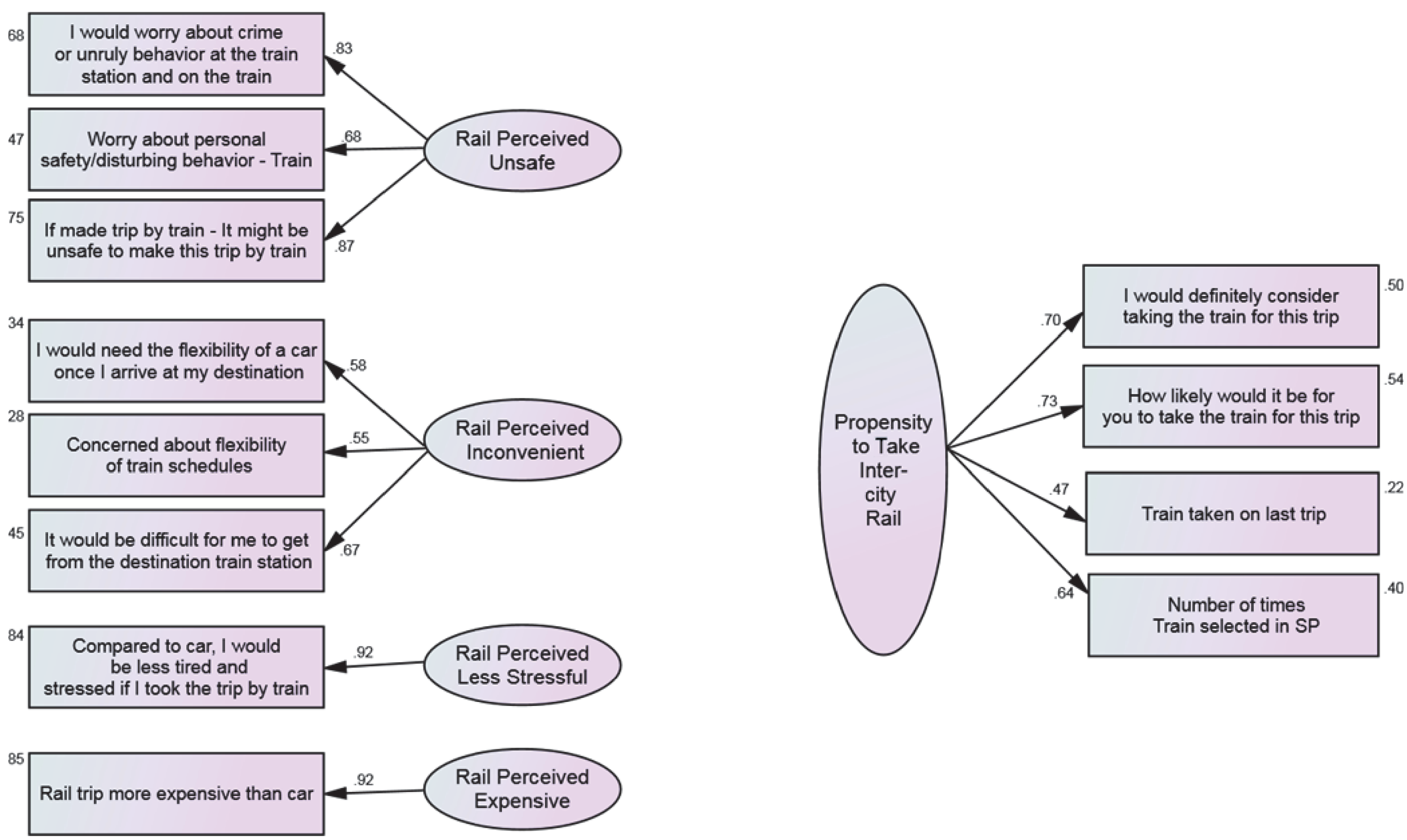


Figure 37. Four latent factors (ovals) for near-term attitudes, and outcome latent factor for propensity to take rail, with factor loadings (standardized coefficients).

quality of model fit are presented; its root mean standard error of approximation (RMSEA) was 0.046, where values under 0.05 are desired; its comparative fit index was 0.912, where values of over 0.90 are desired; and its Tucker-Lewis index was 0.891, where values of over 0.90 are desired. All coefficients are statistically significant, at $p < 0.05$. In addition, a "measurement model" was created in which the covariances among all nine latent factors were calculated, without the structural regression component of the model, which resulted in similar measures of model fit.

4.1.3 Interpreting the Results of the Attitudinal Model for Rail

Some of the highlights of the Attitudinal Model for Rail are presented first. As previewed in Chapter 1, Table 9 shows the relative importance of the nine factors and two demographic variables that were used in the creation of the full model (Figure 34).

Table 9 is based on the application of the standardized total effect (STE), which is used throughout each chapter covering the three attitudinal models. The STE represents the sum of both the direct and indirect standardized effects of the independent factor upon the outcome factor. 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,

- A 10% increase in the value of the factor Train Trip Inconvenient would be associated with a 7.3% **decrease** in the outcome factor, Propensity to Take Rail.
- A 10% increase in the value of the factor Values Auto Orientation would be associated with a 3.4% **decrease** in the outcome factor, Propensity to Take Rail.
- A 10% increase in the value of the factor Train Trip Less Stressful than Car would be associated with 3.3% increase in the outcome factor Propensity to Take Rail.

The consistent use of the STE as an indicator of the importance of candidate explanatory factors in the explanation of rail allows Table 9 to show the rank order of the 11 variables used in the model (rank of "importance" is based on the absolute value of the STE). The first observation from this is the lack of statistical significance of Residential Density in the explanation of rail, and the parallel lack of meaningful importance of Values Urbanism Sociability as a factor.

Table 9. Rank order of importance of explanatory factors.

Rank Order (by Absolute Value of STE)	Standardized Total Effect (STE)	Factor*
1	−0.73	Train Trip Inconvenient
2	−0.34	***Values Auto Orientation***
3	0.33	Train Trip Less Stressful than Car
4	−0.29	***Values Privacy in Travel***
5	−0.22	Train Trip Unsafe
6	0.19	***Values ICT***
7	−0.15	Train Trip More Expensive than Car
8	0.09	*Education*
9	0.03	*Employed*
10	0.03	***Values Urbanism/Sociability***
11	Not significant	*Residential Density*

* The four basic values are shown in ***italic bold***; the four short-term attitudes are shown in roman; and demographics are shown in *italic*.

Table 10. Standardized total effect from explanatory factors (columns) on impacted factors (rows).

Impacted Factors	Demographics		Basic Longer-Term Values				Location	Rail Trip Perceived as…			
	Employed	Education	*Privacy*	*Auto*	*ICT*	*Urbanism*	Density	Unsafe	Incon-venient	Expensive	Less Stressful
Privacy	0.00	–0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Auto	0.00	–0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ICT	0.15	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Urbanism	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Density	0.00	0.03	0.00	–0.39	0.00	0.16	0.00	0.00	0.00	0.00	0.00
Expensive	0.02	0.08	0.00	0.13	0.10	0.00	0.00	0.00	0.00	0.00	0.00
Unsafe	0.00	–0.23	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inconvenient	–0.01	–0.13	0.45	0.30	–0.04	0.01	0.08	0.47	0.00	0.16	0.00
Less Stressful	0.02	0.09	–0.26	–0.16	0.16	0.09	–0.03	–0.14	–0.30	0.03	0.00
Rail Propensity	***0.03***	***0.09***	***–0.29***	***–0.34***	***0.19***	***0.03***	***N.S.***	***–0.22***	***–0.73***	***–0.15***	***0.33***

N.S. = not significant

As shown in Table 9, the strongest explanatory factor in the explanation of rail choice is the idea that the rail service is inconvenient, which is influenced by finding the schedule frequency unacceptable. The reader will note that this factor is similar to the role of times and costs in more traditional demand modeling, and thus its high ranking is not unexpected.

Placing a strong value on privacy in travel and having a pro-auto orientation also negatively affect the propensity to consider rail. The concept that the car trip is more stressful than the rail trip is also a key explanatory factor.

4.1.4 Exploring the Interactions Between/Among Factors

Table 10 allows for the exploration of the STE of one factor on an outcome factor. For example, the bottom row "Rail Propensity" shows the same information as presented in Table 9. Using the same data as in the previous section

- The column Less Stressful has an STE on the row Rail Propensity of 0.33.
- The column Auto has an STE on the row Rail Propensity of –0.34.

Effect of Demographics

The higher one's level of **education,** the less likely one is to feel unsafe in the rail trip (–0.23) and to value privacy in travel in general, but the more likely one is to take rail (0.09). A person with a higher level of employment is more likely to value staying connected with ICT than a person with a lesser level of employment.

Effect of Longer-Term Values

- The more one values **privacy** in travel, the more likely one feels unsafe in the rail trip under consideration (0.64) and the more likely one feels that the rail option is inconvenient (0.45); higher value of privacy is associated with less propensity to feel that the rail option is less stressful than the auto option (–0.26). Higher value for privacy in travel is negatively[1] associated with propensity to take the train (–0.29).

[1] In this chapter, every attempt has been made to make the explanatory text follow the direction of the relationships reported in the tables. Unfortunately, the result is, very often, the use of double negatives in the text.

- Higher levels of **auto orientation** are associated with lower levels of density at the location of residence (–0.39); a higher propensity to feel that the rail service is inconvenient (0.30); and lower belief that rail is less stressful than auto for the trip (–0.16). Higher levels of auto orientation are negatively associated with propensity to take the train (–0.34).
- Higher levels of preference for **urbanism** are associated with higher residential density (0.16) and higher belief that the rail trip is less stressful than the auto trip (0.09). As noted previously, the level of belief in urbanism is only weakly associated with propensity to take the train (0.03).
- The need for **ICT** is positively associated with belief that the train is less stressful than the car (0.16) and with the perception that the train is more expensive than the car (0.10). This desire for productive connection is associated positively with the propensity to take rail (0.19).

Effect of Shorter-Term Attitudes

- The perception that the train trip is **unsafe** is strongly associated with stating the train trip is inconvenient (0.47), and negatively associated with reporting that the train trip is less stressful than the car (–0.14). The belief that the trip is unsafe is negatively associated with propensity to take the train (–0.22).
- The belief that the train trip is **inconvenient** in terms of schedules and access problems is the strongest factor in the explanation of propensity to take rail (–0.73). It is also *negatively* associated with perception that a rail trip is less stressful than car trip (–0.30).
- The more one perceives the train to be **expensive,** the more likely one is to report that the train is inconvenient (0.16), and the less likely one is to take the train (–0.15).
- The more one concludes that the rail trip is less stressful, the higher one's propensity to take rail (0.33).

4.1.5 Conclusion: Results of the Attitudinal Model for Rail

As shown in Table 9, and in more detail in Table 10, the structural equation modeling showed the importance of factors in addition to convenience, which reflects the relative quality of the rail service compared with its competitors. The next two highest ranking factors in the explanation of rail choice both concern attitudes toward the automobile, reflecting the nature of the competition in a society where automobile trips dominate for most travel purposes. Even in the project sample, which was *specifically and purposefully* designed to find travelers between well-served large metropolitan areas, about six times as many trips are reported for auto as are for rail. Thus, looking beyond the convenience issue, the next largest factors are about attitudes toward owning an automobile and attitudes about the level of stress associated with using an automobile.

Potentially more troubling is that the next two explanatory factors both concern feelings of discomfort or fear regarding train travel; discomfort or fear not only about crime per se, but also about disruptive behavior. All of these factors need to receive policy attention. These concepts will be explored in Section 4.2, with a new TPB model, and later in the discussion of intercity bus in Chapter 8.

4.2 The TPB Model for Rail

Building upon the results of the Attitudinal Model for Rail described in the first part of this chapter, the research team created a working application of the TPB for the intent to take intercity rail.

4.2.1 What is the Theory of Planned Behavior?

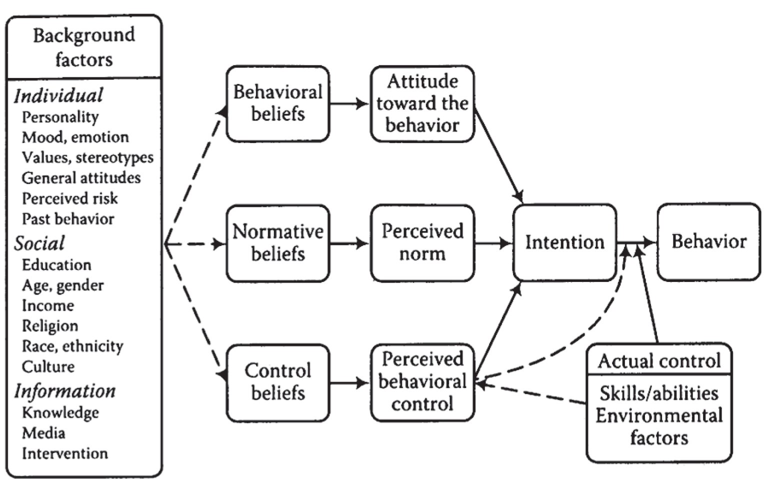
The TPB is the most applied social psychology model in the field of transportation behavior. The theory posits that change in behavior occurs after the formulation of intent, which is formed after the individual quickly reviews three categories of salient information. These three categories are considered direct predictors of intent and are as follows:

1. **Attitude toward the behavior (ATB)** concerns the individual's conclusions about the goodness of the proposed behavior for his/her own self, often determined on both rational and emotional bases.
2. **Perceived norm (Norm)** concerns the conclusion drawn by the individual that (a) the proposed behavior will be approved by persons important in his/her own social network (*injunctive norm*) and (b) such behavior is undertaken by those important persons themselves (*descriptive norm*).
3. **Perceived behavioral control (Control)** reflects the potential difficulty associated with carrying out the behavior, including the conclusion that she/he has the power to undertake the behavior.

The theory suggests that these three factors have to be taken into consideration to understand a person's **intent** to engage in a behavior. The theory posits that, after intent is established, the subject will revisit perceived behavioral control to reconsider the extent to which the behavior can actually be accomplished, given possibly increased understanding of the difficulty in doing so, as shown in the TPB diagram presented as Figure 38. In many ways, the TPB diagram is consistent with the logic of the analytical framework developed for this NCRRP project. In this diagram, the three kinds of near-term beliefs parallel the use of near-term attitudes and beliefs in the analytical framework. The list of background factors on the left side of Figure 38 contain both demographics and longer-term values, personality, and more general attitudes referenced in the value–attitude–behavior hierarchy discussed earlier in Chapter 1.

4.2.2 Factors in the TPB Model for Rail

Figure 39 presents a simplified conceptual diagram of the TPB Model for Rail in which longer-term background factors have an influence on near-term beliefs, which have an influence on the three direct predictors in the TPB. There are 11 latent factors, including an outcome factor, included in the TPB Model for Rail. The logic presented in the simplified diagram in Figure 39 is developed in further detail in Figure 40, which shows the interaction among factors as one-directional arrows.



Source: Fishbein and Ajzen (2010, Figure 1.1: Schematic presentation of the reasoned action model).

Figure 38. The Theory of Planned Behavior as presented by Fishbein and Ajzen in 2010.

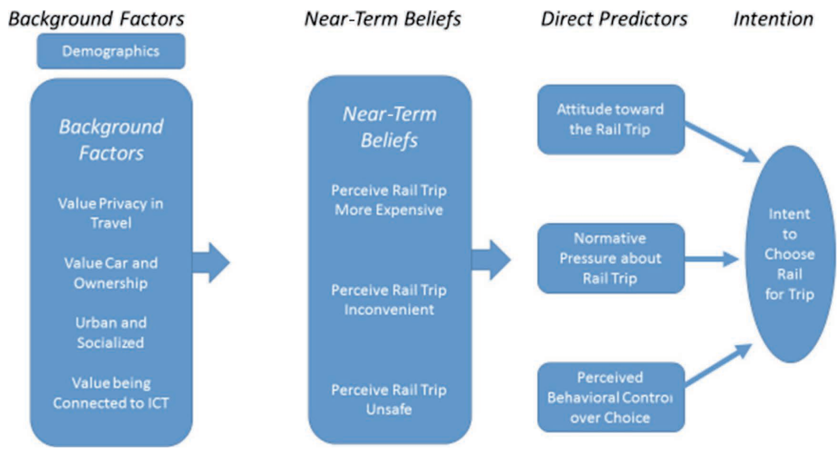


Figure 39. Conceptual diagram for the TPB Model for Rail.

As shown in Figure 41, each latent factor is depicted in an oval, and each is associated with a set of observed variables, of which there are 26, plus two demographic variables. Figure 41 shows that the three latent factors representing the direct predictors reflect seven observed variables (shown in rectangles); the outcome factor, Intention to Take Intercity Rail, is based on two observed variables. The latent factors representing the four basic values are the same as used in the Attitudinal Model for Rail, and were shown in Figure 36, earlier.

The model is designed to be run for two age groups (millennials and older respondents) to deal with questions of the impact of age. Income was deleted from earlier models after it was found to not have a statistically significant impact on the intent to choose rail (the lack of this *linear* relationship tends to reflect the fact that rail use tends to be somewhat higher for individuals under age 35,

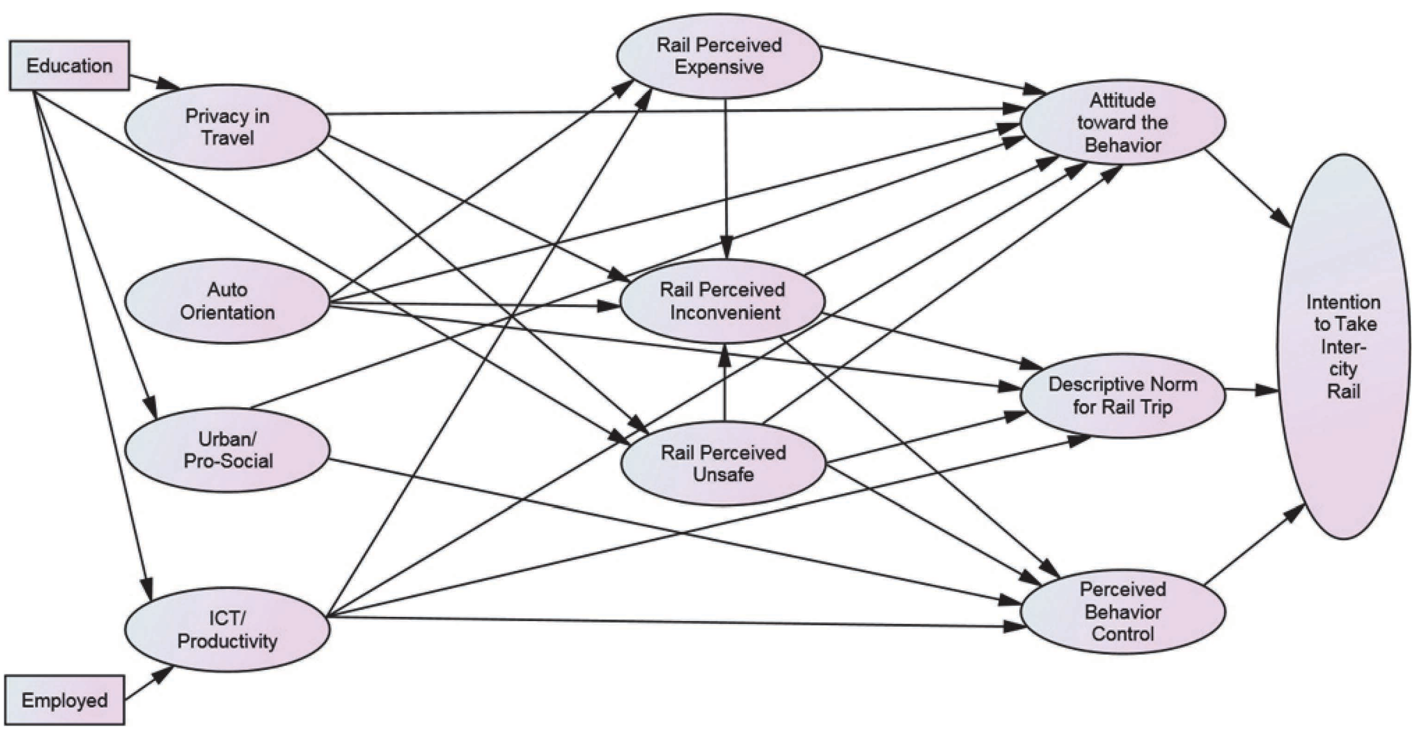


Figure 40. The TPB Model for Rail.

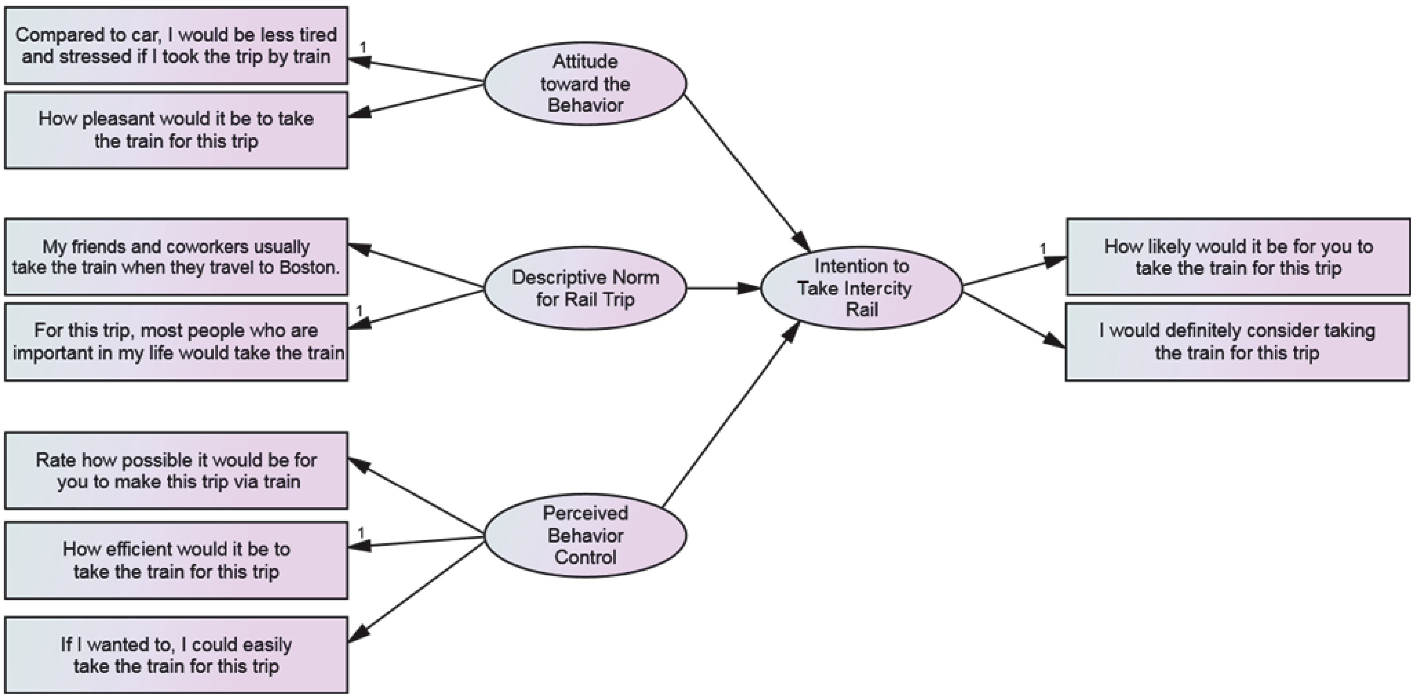


Figure 41. Relationship between observed variables (rectangles) and latent factors (ovals) in the prediction of Intention to Take Rail.

then somewhat lower from ages 35 to 45, then somewhat higher for those above age 45). Density was also deleted from the model to preserve its parsimony.

Model Fit

The model was run on the AMOS SEM program (Version 22), in which model estimation was accomplished with the maximum likelihood method. The model showed reasonable standards of performance. The model has a comparative fit index of 0.92, and a Tucker-Lewis index of 0.91; in both evaluative measures, a value of more than 0.90 is considered essential to be labeled a good fit. The model has a RMSEA of 0.045, where a value of under 0.05 is considered to be a good level of model fit. For the full model shown in Figure 40, all parameters were found to be statistically valid, and a lack of an arrow from any latent factor to any other latent factor signifies that the parameter had been tested, and rejected as not significant. Complete documentation of model performance, including the value of all coefficients for all attitudinal models in this report, is included in *NCRRP Web-Only Document 2* as Technical Appendix: Documentation for the Structural Equation Models.

4.2.3 Results of the TPB Model

Table 11 shows how the factors affect each other, expressed as the STE on the impacted (row) factor.

Consistent with the results of the Attitudinal Model in Table 10, Table 11 shows that the decision to choose rail is influenced by the *perception of inconvenience* of a rail trip. In addition, the TPB model reveals the following influences:

- The perception that a car trip is more stressful and less pleasant is powerful in explaining rail choice (ATB).

Table 11. Standardized total effect of each explanatory factor (column) on each impacted factor (row).

	Demographic		*Background Values*				*Near Term Beliefs*			*Theory Direct Predictors*		
	Employed	Education	Privacy	Car	Urbanism	ICT	Expensive	Inconvenient	Unsafe	ATB	Norm	Control
Expensive	0.02	0.01	0.00	0.13	0.00	0.11	0.00	0.00	0.00			
Inconvenient	0.00	-0.14	0.45	0.29	0.00	0.02	0.18	0.00	0.49			
Unsafe	0.00	-0.24	0.65	0.00	0.00	0.00	0.00	0.00	0.00			
Attitude	0.02	0.13	-0.47	-0.24	0.07	0.13	-0.05	-0.30	-0.30			
Normative	0.03	0.03	-0.09	-0.32	0.00	0.18	-0.12	-0.66	-0.01			
Control	0.03	0.06	-0.18	-0.24	0.11	0.14	-0.14	-0.80	-0.11			
Outcome: Intent to Choose Rail	***0.03***	***0.08***	***-0.29***	***-0.28***	***0.07***	***0.16***	***-0.10***	***-0.59***	***-0.17***	***0.43***	***0.30***	***0.33***

- The belief that friends and peers take rail is a strong predictor of rail choice (Norm).
- The value placed on privacy is a strong negative factor (Privacy).
  - This is associated with concern for personal safety on the rail trip (Unsafe).
- The value placed on auto ownership has a strong, negative relationship with rail choice (Car).
- The desire to have connected technology is positively associated with rail choice (ICT).
- Neither values about urbanism nor demographics have much explanatory power.

4.2.4 Interpretation of Results, Total Sample

The application of the TPB to the question of rail choice for intercity trips provides a broadened base for understanding how mode choice decisions are made. First, Table 11 shows that all three direct predictors (right three columns) influence intention to take rail. In the model, perceived behavioral control primarily reflects the perceived inconvenience of the train trip; stated differently, the column factor Inconvenient has a very high STE (–0.80) on Control.

Beyond the well-established importance of convenient service, the TPB model is examined for the potential influence of perceived norm and ATB.

Understanding Normative Influences in Mode Choice

Among the patterns that were revealed in the development of the model is that the sample as a whole, and the millennial group in particular, seems to be influenced more by descriptive rather than injunctive norms. Phrased more simply, this means that the decision to choose rail is more influenced by the observation that one's valued peers and equals are also using the train (or are not using the train) than by a belief that those valued individuals are making an evaluative judgment and approve or disapprove of the respondent taking the train.

The impact of normative pressure on intercity mode choice was not entirely anticipated at the time of the work plan development. In the literature of the TPB, it is often found that social pressure from peers is more important concerning emotional issues than for utilitarian issues (e.g., "what kind of dress do I wear to the dance" would be more susceptible to peer influence than "should I rotate my tires this week"). The results suggest that the choice of an intercity travel mode is somewhat less "utilitarian" in nature than perhaps expected and more subject to feelings of identification with one's peer group. Further research could be undertaken, for example, about the role of peer influences in the use of curbside buses, many of which serve college campus areas.

Finally, it should be re-iterated that the dimension of peer influence as a factor in the choice of mode applies in both directions. On the one hand, the feeling that "all the other students in my college are choosing the curbside bus" represents the positive context of application. On the other hand, the feeling that "no one in my country club would be caught dead on the bus" is simply a response at the opposite end of the same spectrum. The TPB model makes known the importance of normative influences in the selection of mode; at this point, the research has not clarified to which end of the spectrum is most powerful in the explanation of the positive or negative influence.

Understanding Hedonic Influence in Mode Choice

While all three direct predictors in the TPB model were found to be relevant to the choice of mode, ATB was found to have the strongest STE value of the three. As shown in Figure 41, ATB was formed from only two observed variables: the conclusion that a rail trip would be "pleasant" and less stressful than an auto trip. These individual observed variables describe the basic condition of personal pleasure on the part of the survey participant. The idea that basic decision such as choice of mode are influenced by hedonic considerations has been a major theme in the social psychology of transportation; see for example Figures 3 and 8 in Chapters 1 and 2, respectively.

The argument that seemingly utilitarian decisions are in fact influenced by a variety of motivations was explored in the landmark article "Car Use: Lust and Must. Instrumental, Symbolic and Affective Motives for Car Use" (Steg 2005). A more recent article by Steg et al. (2014) provides additional exploration of these kinds of motivations. The authors conclude that "interventions aimed to promote pro-environmental actions should consider hedonic consequences of actions, as these may be important barriers for behavior change."

In the TPB model, ATB (which is hedonic in nature) has an STE second only to that for the inconvenience of the rail trip, in the list of 12 explanatory factors in Table 11. Taken together, this supports the argument that factors *in addition* to times and costs need to be explored to better understand the nature of transportation demand.

4.2.5 Comparing Millennials with Older Respondents

Because the TPB model is designed so that it can be run for two age groups in a single combined model, the luxury of a high-level comparison between the sub-samples is possible. (Based on this same method, the model was run simultaneously for males vs females; in general, differences were less distinct than those revealed in the age-based comparison.) Table 12 shows how the factors affect each other, expressed as the STE on the impacted (row) factor.

Compared to the experience of the older group, the decision to choose rail by **millennials** may be based somewhat more on

- Feeling that rail is less stressful and more pleasant (ATB) and
- Feeling that their peers would take the train (descriptive norm), rather than feeling that their peers would *approve* of their taking the train (injunctive norm). (This observation was not derived directly from Table 12, but from the model testing process.)

Table 12. Standardized total effect on intent to choose rail for two age groups.

	Employed	Education	Privacy	Car	Urbanism	ICT	Expensive	Inconvenient	Unsafe	ATB	Norm	Control
Millennial Group												
Intent to Choose Rail	***n.s.***	***0.07***	***-0.27***	***-0.23***	***n.s.***	***0.17***	***-0.08***	***-0.49***	***n.s.***	***0.50***	***0.22***	***0.34***
Older Group												
Intent to Choose Rail	***0.03***	***0.09***	***-0.29***	***-0.28***	***0.06***	***0.15***	***-0.11***	***-0.61***	***-0.20***	***0.42***	***0.32***	***0.32***

Compared to the experience of the millennials, decisions not to choose rail by the **older group** may be based somewhat more on

- Perception that rail is inconvenient,
- Concern for personal safety on the trip (Unsafe),
- Perception that rail is more expensive, and
- Peer pressure about the mode choice (Norm).

4.2.6 Conclusion: The Theory of Planned Behavior

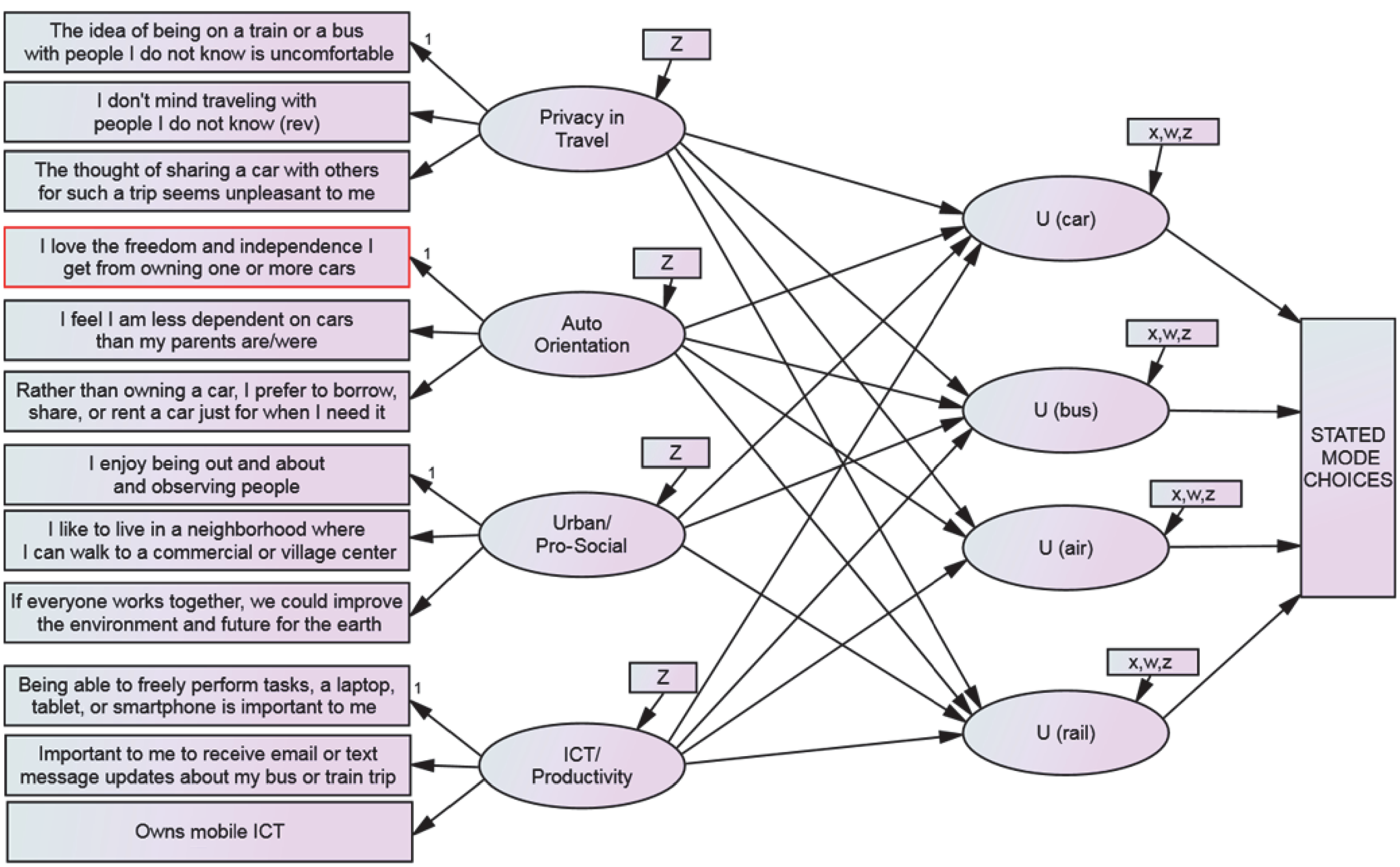
For the purposes of NCRRP 03-02, the TPB should be regarded as background information for further analyses of possible psychological factors relevant to the choice of intercity mode, and to transportation behavior more generally. Using the additional tools provided by the method, it becomes apparent that further research could investigate the idea (1) that individuals choose what they conclude to be, all in all, the more pleasurable option and (2) that the choice of the optimal mode might be very much influenced by what individuals see as a desired behavior by members of their social network.

These two concepts merit additional exploration above and beyond the scope of this project. Social psychologists, and other social scientists, are committed to exploring basic concepts such as quality of life and the related concept of "subjective well-being," which describe what people generally refer to as happiness. Others are exploring the concept that descriptive norms are a force which impacts much of our daily lives. Both are worth exploring because of their potential relationship to travel behavior.

CHAPTER 5

Merging Economic Modeling Theory with Analysis of Attitudes and Preferences

The NCRRP 03-02 amplified work plan called for the creation of two discrete choice models for the analysis of intercity travel. First, the data from the stated choice exercises were used to create a mode share model based on transportation level-of-service factors such as times, costs, and other traditional inputs such as demographics and party size. Then, additional models were run using attitudinal data as well as level-of-service factors from the same survey to estimate an ICLV model (Figure 42).



Z = demographics that predict the latent variable
w = trip characteristics
U = mode utility, predicted by x, w, and z
x = mode characteristics
z = demographic characteristics

Figure 42. The ICLV Model merges basic values and trip-specific variables.

5.1 A Mode Choice Model with No Attitudes or Preferences

5.1.1 Model Design

Stated preference (SP) and stated choice exercises incorporate a type of tradeoff analysis tool also used in choice-based conjoint analyses, but the latter method is more commonly used in market research, whereas the former is more common in the transportation literature. These types of exercises capture respondents' preferences when making choices and allow for the estimation of discrete choice models and systematic analysis of respondents' decisions.

The research team developed an advanced experimental design that was customized for each respondent (as discussed in Chapter 3 and later in this chapter). Experimental designs dictate how the experiments produce the different levels of the different attributes in the SP experiments. The team used Bayesian D-efficient designs, which are considered the best experimental design for this type of project. Then, the research team produced different designs for each trip purpose and major OD pair. It was a major undertaking to optimize the SP scenarios and is a state-of-the-art methodology. Most studies generate just one experimental design; for this project, 108 designs were generated. The goal of this experimental design was to ensure designs that were customized to the different sensitivities faced by different respondent types (based on trip purpose) and for different OD pairs (e.g., long versus short trips). Data coding and model building were undertaken by the research team in Ox, a software package used for advanced modeling.

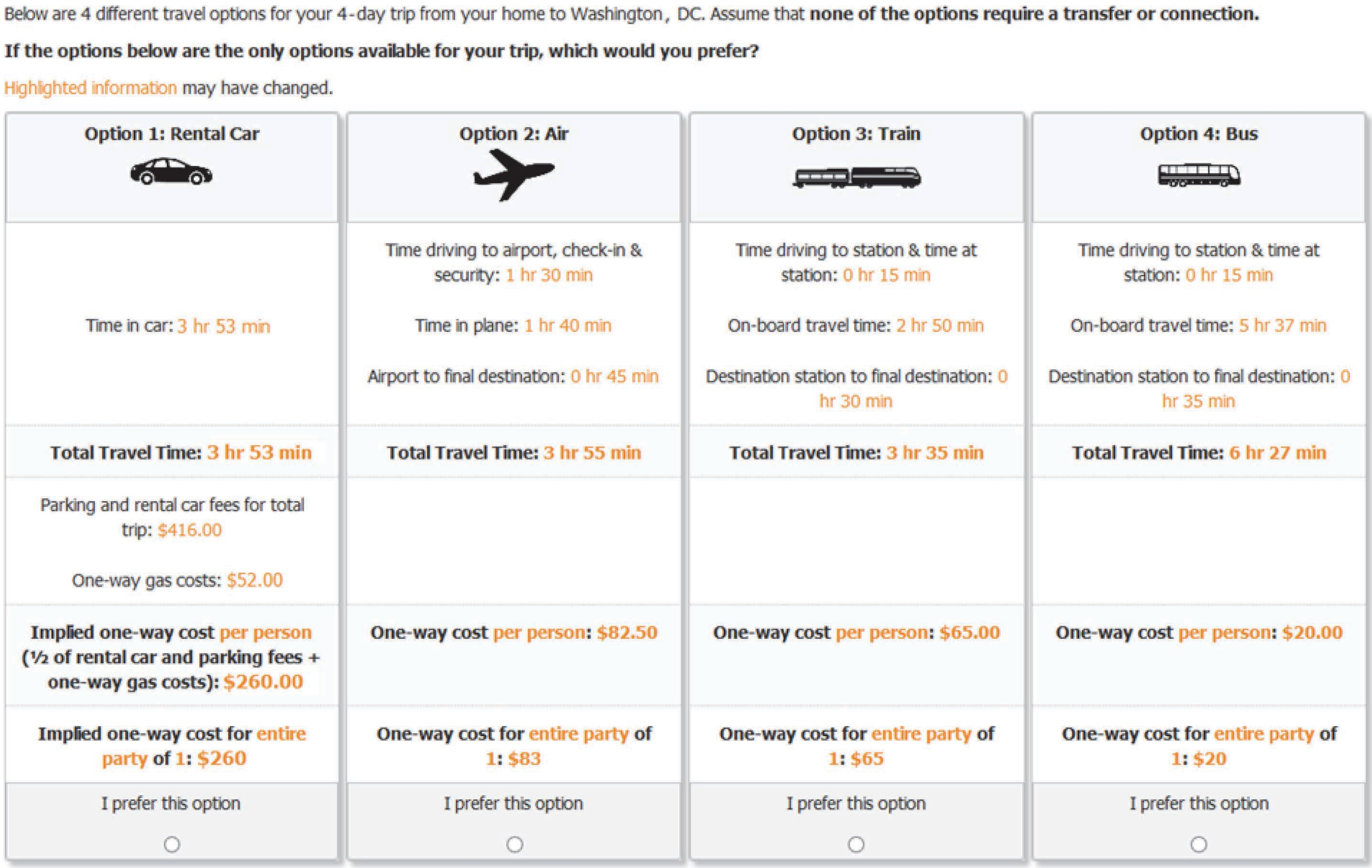
Once the designs were created, the actual SP exercises were developed. The SP experiments were created to emulate as clearly as possible the current choices for a trip that respondents had taken in the past, while at the same time minimizing the complexity of the choice. As part of the NCRRP survey, the research team used a stated choice exercise during which each respondent was presented with eight consecutive travel scenarios similar to the one that can be seen in Figure 43. Several aspects of the scenarios—such as the access time, travel duration, and costs for the different modes—changed from scenario to scenario and respondents had to choose a mode for each of them. The research team tried to simplify the exercises as much as possible to make the choices as simple as possible, while still collecting the necessary data to accomplish the project's goals. Therefore, trip characteristics like egress mode and egress travel time were either omitted or simplified, as they were not necessary for this project's purposes.

Respondents' choices in the exercises were the basis for the later estimation of the two discrete choice models.

5.1.2 Results: Times and Costs

First, a model was constructed using a traditional base of times and costs. The data from the stated choice exercise was used to develop multinomial logit models of intercity mode choice. These models were specified in a form that results in the coefficients having a monetary scale so that each value represents a "willingness to pay" for changes in the corresponding service variable. In addition, the effects of sociodemographic variables were represented as differences from a base group, arbitrarily selected as males under 35 years old. This results in coefficient values that are more easily interpreted than more conventional logit model utility coefficients. Table 13 shows the results of two alternative models that were developed in this form.

The two model forms shown here are different only in the assumed form of the utility function; one is the conventional additive utility function in which the factors are added together and the other is multiplicative in which the factors are multiplied together. Looking at the first column that represents the multiplicative model, the first value, –74.56, indicates that on average male



Below are 4 different travel options for your 4-day trip from your home to Washington, DC. Assume that **none of the options require a transfer or connection.**

If the options below are the only options available for your trip, which would you prefer?

Highlighted information may have changed.

Option 1: Rental Car	Option 2: Air	Option 3: Train	Option 4: Bus
Time in car: 3 hr 53 min	Time driving to airport, check-in & security: 1 hr 30 min Time in plane: 1 hr 40 min Airport to final destination: 0 hr 45 min	Time driving to station & time at station: 0 hr 15 min On-board travel time: 2 hr 50 min Destination station to final destination: 0 hr 30 min	Time driving to station & time at station: 0 hr 15 min On-board travel time: 5 hr 37 min Destination station to final destination: 0 hr 35 min
Total Travel Time: 3 hr 53 min	**Total Travel Time: 3 hr 55 min**	**Total Travel Time: 3 hr 35 min**	**Total Travel Time: 6 hr 27 min**
Parking and rental car fees for total trip: $416.00 One-way gas costs: $52.00			
Implied one-way cost per person (½ of rental car and parking fees + one-way gas costs): $260.00	**One-way cost per person: $82.50**	**One-way cost per person: $65.00**	**One-way cost per person: $20.00**
Implied one-way cost for entire party of 1: $260	**One-way cost for entire party of 1: $83**	**One-way cost for entire party of 1: $65**	**One-way cost for entire party of 1: $20**
I prefer this option ○	I prefer this option ○	I prefer this option ○	I prefer this option ○

Figure 43. Example of a travel scenario from the stated choice exercise presented to a respondent from Washington, DC.

travelers under the age of 35 would pay almost $75 more to travel by car than by bus. This value is reduced by $39.91, to about $35, for females under 35 years. The values increase successively for older travelers to a maximum of over $200 (–74.56 + –130.36) for males between the ages of 55 and 64. The pattern for air versus car is similar, but with younger males preferring air over car (evidenced by a positive willingness to pay and assuming all other service variables are equal) and females even more so, but with the preference shifting to car with older travelers. The sociodemographic patterns illustrated by the multiplicative model are less significant for rail versus car but show a pronounced pattern of younger travelers favoring rail over car compared to the rail versus car preference for older travelers.

The values of access, egress, and in-vehicle times are comparable to those obtained in previous intercity travel mode choice models and the income elasticity of 0.41 in the multiplicative models indicates that these values increase at rates approximately proportional to the square root (which would be an elasticity of 0.5) of the travelers' incomes.

Either the additive or multiplicative forms could be used directly as intercity mode choice models but of course the primary reason for developing these models here was to determine appropriate specifications for the more robust ICLV models. Such models incorporate both the SP and socio-demographic data used here as well as the attitudinal data that were also collected in the survey.

Importantly, these choice data in combination with the attitudinal and demographic data that were collected in the survey also allowed the research team to estimate more advanced and

Table 13. Results from preliminary models, based on times and costs only.

	Multiplicative		Additive	
log-likelihood	−33,337.60		−33,901.00	
Significance: *p*-value	0.3411		0.33	
Willingness to Pay	**Est.**	**Significant**	**Est.**	**Significant**
Bus vs car base ($)	−74.56	***	−42.10	*
Δ female	39.91	***	45.72	***
Δ age 35–44	−44.39	**	−113.25	***
Δ age 45–54	−107.89	***	−186.66	***
Δ age 55–64	−130.36	***	−203.82	***
Δ age 65+	−119.19	***	−178.76	***
Δ one additional service per day	1.07	***	1.10	***
Air vs car base ($)	44.72		21.43	
Δ female	37.82	***	41.22	***
Δ age 35–44	−93.00	***	−117.99	***
Δ age 45–54	−83.74	***	−111.11	***
Δ age 55–64	−127.75	***	−155.83	***
Δ age 65+	−155.87	***	−193.74	***
Δ one additional service per day	5.67	***	4.03	***
Rail vs car base ($)	0.37		35.91	
Δ female	−5.12		−2.75	
Δ age 35–44	13.97		−33.95	
Δ age 45–54	8.48		−41.84	*
Δ age 55–64	3.29		−45.23	*
Δ age 65+	−13.29		−57.80	**
Δ one additional service per day	0.94	***	0	
To reduce access time ($/h)	95.82	***	94.71	***
To reduce egress time ($/h)	46.80	***	57.46	***
To reduce in-vehicle time ($/h)	38.63	***	57.38	***
Income elasticity	*0.41*	***	*0.06*	

*$p < 0.1$ **$p < 0.05$ ***$p < 0.01$

sophisticated models, including the ICLV models that are summarized in Section 5.2 and presented in full detail in *NCRRP Web-Only Document 2*, Technical Appendix: ICLV and Hybrid Model Development.

5.2 Integrated Choice and Latent Variable Modeling

5.2.1 Background: Activities in the Development of the ICLV Model

As described previously, the research team undertook an ambitious survey effort designed to estimate ICLV models (also known as hybrid models) to help capture the attitudes and values that drive intercity mode choice, while accounting for level-of-service variables (e.g., time, cost, frequency, comfort) that also drive intercity mode choice. As summarized by Vij and Walker (2015),

> "Integrated Choice and Latent Variable (ICLV) models . . . [allow] for the incorporation of latent behavioral constructs within the framework employed by traditional models of disaggregate decision making. ICLV models were first proposed two-and-a-half decades ago by McFadden (1986) and expanded on by Ben-Akiva [Walker] et al. (2002). Rapid strides in optimization techniques and computational power and the ready availability of estimation software. . . . have since contributed to a veritable explosion in the number of studies estimating ICLV models. In the context of transportation and logistics, ICLV models have been applied to the study of travel mode choice (Paulssen et al. 2014), route choice (Prato et al. 2012), car ownership (Daziano and Bolduc 2013), . . . etc."

The gap between discrete choice models including only level-of-service variables and behavioral theory has encouraged different developments that attempt to enrich behavioral realism by explicitly modeling one or more components of the respondents' decision-making process (e.g., accounting for attitudes and perceptions). The most general framework proposed is the ICLV methodology (Ben-Akiva, Walker et al. 1999; Ashok et al. 2002; Ben-Akiva, McFadden et al. 2002; Bolduc et al. 2005), with some examples of recent applications given in Abou-Zeid et al. (2010), Glerum et al. (2014), and Hess et al. (2013). This hybrid modeling (aka ICLV) approach integrates latent variable and latent class models with discrete choice methods to model the influence of latent variables and classes on the choice process. Latent variable models capture the formation and measurement of latent psychological factors, such as attitudes and perceptions, which explain unobserved individual heterogeneity.

In other words, hybrid choice models allow the joining of models that can analyze both "hard" concepts like travel times, costs, comfort, frequency, etc. with "softer" concepts like how attitudes and values influence choice making. Most of the work to date has been academic with relatively small samples and little effort on understanding important policy implications.

5.2.2 Furthering the State of the Practice in ICLV Modeling

In this NCRRP project, the research team estimated the effects of attitudes and values (beyond times and costs) on mode choice using data from the NEC and the Cascade Corridor. For this modeling work, the research team obtained over 6,000 respondents—a very large data set for such an effort—for use in the development of hybrid choice models to better understand the demand for these two major US intercity rail corridors. As far as is known from the literature, this is the largest scale study of its kind using hybrid choice techniques. This is important due to the immense needs of the NEC, in particular, and the necessary investment that needs to be made.

The total sample size is roughly 5,112 respondents from the NEC recruited through online sample and a previous study of auto users in the NEC, with 513 respondents obtained from an online sample for the Cascade sample. Not only is this sample size much larger than in most typical studies using ICLV models, but also extensive work was done (as documented in *NCRRP Web-Only Document 2*, Technical Appendix: ICLV and Hybrid Model Development) on disentangling pure random heterogeneity from that which can be linked to underlying latent attitudes.

5.2.3 Model Specification

Separate models were estimated for four different trip-purpose segments:

- Work, composed of business travelers and conference attendees, with a total of 1,043 respondents
- Vacation, with a total of 2,062 individuals
- Visiting friends and relatives (VFR), with a total of 2,724 individuals
- Other purposes, with a total of 735 individuals.

A common specification was used as the starting point for all segments, and this was refined by excluding attributes that did not show a significant and meaningful influence in a given segment. The following subsections describe the individual components of the overall model structure, looking in turn at the role of explanatory variables, latent attitudes, attitudinal indicators, and modal constants.

Key Explanatory Variables

The components of utility that are related to explanatory variables are travel time (i.e., access time, in-vehicle time, and egress time) and travel cost. For air, bus, and rail, travel cost was defined as the per-person cost; for car, the research team recognized that the driver often pays a larger share and thus multiplied the total cost by a factor to deal with party size. For car, access time and egress time were set to zero.

To capture random heterogeneity in sensitivities across respondents, the research team defined the individual coefficients to follow a log-uniform distribution, i.e., allowing for different time and cost sensitivities across respondents. This distribution has a similar shape to a lognormal distribution (being the exponential of a uniform rather than a normal distribution) but with a less extreme tail and initial tests showed it to obtain not only more meaningful results but also a slightly better fit. Separate coefficients were used for travel time on different modes and also for access and egress time, allowing the capture of differences in the perceived onerousness of different time components.

For cost, the research team used a similar approach but additionally captured interactions with income, with separate effects for non-reporters. A complication arises, as a share of respondents did not report income. Rather than making an arbitrary assumption that these respondents had an average income, the research team used a separate mean effect for the random cost coefficient for these respondents but kept the level of the underlying heterogeneity for the uniform distribution (i.e., the log of the negative of the coefficient) the same.

Latent Attitudes

The latent attitude specification used in these models follows on from earlier factor analysis work carried out on the same data. In particular, the research team defined four latent variables:

- Attitude toward cars
- Attitude toward ICT
- Attitude toward urbanism/sociability
- Attitude toward privacy

Each of these four factors was based on the use of observed variables, which are summarized in Table 14.

Table 14. Attitudinal indicators used in the ICLV model.

Car Attitude	"Rather than owning a car, I would prefer to borrow, share, or rent a car just for when I need it."
	"I love the freedom and independence I get from owning one or more cars."
	"I feel I am less dependent on cars than my parents are/were."
ICT Attitude	"It would be important to me to receive e-mail or text message updates about my bus or train trip."
	"Being able to freely perform tasks, including using a laptop, tablet, or smartphone, is important to me."
	Respondent owns smart technology (at least one smartphone, tablet, GPS device, or laptop).
Urbanism Attitude	"I enjoy being out and about and observing people."
	"I like to live in a neighborhood where I can walk to a commercial or village center."
	"If everyone works together, we could improve the environment and future for the Earth."
Privacy Attitude	"The idea of being on a train or a bus with people I do not know is uncomfortable."
	"I don't mind traveling with people I do not know."
	"The thought of sharing a car with others for such a trip seems unpleasant to me."

Each of these latent attitudes is defined to have a deterministic and a random component, with latent attitude *l* for person *n* being:

$$\alpha_{l,n} = \gamma_l z_n + \xi_{l,n}$$

where the estimates of γ_l capture the impact of a range of sociodemographic characteristics of person *n* (z_n) on the latent attitude, and where ξ_l is a standard Normal variate (mean of 0, standard deviation of 1), distributed across respondents, capturing the random element of the latent attitude. The sociodemographic terms tested for effects on the latent attitudes were as follows:

- Gender (female dummy)
- Age (using five categories of which 35–45 served as base)
- Education: dummy for respondents without a graduate degree
- Employment: dummy for respondents who are not employed

Modal Constants

The mode-specific constants for respondent *n* were specified to follow a Normal distribution across respondents, allowing for differences across individual travelers in their baseline preferences for different modes. For identification purposes, the mean and standard deviation were set to zero for bus, on the basis of tests showing that the level of random heterogeneity was lowest for bus.

The demographic characteristics for interactions with constants included:

- Gender (female dummy): tested for the non-car modes
- Age (using five categories of which 35–45 served as base): interacted with the non-car modes
- Education: dummy for respondents without a graduate degree, interacted with the constant for non-car modes
- Employment: dummy for respondents who are not employed, interacted with the constant for non-car modes (employed as base)
- Households with fewer cars than adults: dummy interacted with the car constant (one or fewer cars per adult)
- Households with more cars than licenses: dummy interacted with the car constant (one or fewer cars per license)

While considerations for service quality were as follows:

- Frequency: daily service frequency, interacted with the constant for non-car modes (Note: Frequency was included here as opposed to being listed as an explanatory variable because it was not included as a variable in the survey, i.e., it was not explicitly shown to respondents. The aim behind including this here is to test whether respondents in corridors with higher frequency of service for a given mode are more likely to choose that mode also in the hypothetical scenarios.)
- West Coast dummy: interacted with the constant for non-car modes (East Coast as base)
- Party size: terms for one other person and two plus other people, interacted with the constant for non-car modes (single person as base)
- Trip length: terms of overnight, two nights, and three plus nights; interacted with the constant for non-car modes (day trip as base)
- Distance effects for air: dummy terms for trips under 200 miles and trips over 400 miles, interacted with the air constant (200–400 miles as base)

The combined utility specification now includes the following:

- The impacts of the explanatory variables, with randomly distributed time and cost coefficients, where the latter is also interacted with income

- The mode-specific constants, which include a deterministic component as well as a random part
- An impact on the modal constants by the latent attitudes, which again include a deterministic and random component.

Other Elements of Model Composition

Two observations are offered to help understand the composition of the model:

- Firstly, the sociodemographic terms included in the modal constants explained above relate to person as well as trip characteristics, while those sociodemographic terms mentioned earlier for the latent attitudes related only to person characteristics. This reflects the assumption that attitudes are stable for each person across different trips.
- Secondly, all respondent characteristics included in the deterministic component of the latent attitude have also been included in the modal constant as well, thus avoiding a situation where a sociodemographic effect is erroneously interpreted as relating to attitudes when it may just relate to underlying modal preferences, or vice versa. As an example, it may well be the case that younger respondents travel less by car for reasons unrelated to their attitude toward cars. If age was included as a covariate only on the latent attitude toward cars but not separately on the modal constants, this inherent modal preference may erroneously be captured as an attitudinal difference.

5.3 Model Results

The modeling effort undertaken for this work was substantial, with a total of 160 different parameters used across the different models. The results are in turn very detailed and are documented in a number of different tables in *NCRRP Web-Only Document 2*, Technical Appendix: ICLV and Hybrid Model Development. The following sections will look at selected parts of the results in turn.

5.3.1 Model Fit Statistics and Value of Travel Time Measures

The overall model fit statistics and headline value of travel time (VTT) are presented in Table 15; the VTT measures are presented for a mean income of $125,000 per year (this is a

Table 15. Model fit statistics and value of travel time measures at income of $125,000 per year: Impact of explanatory variables and mode constants.

	Work		Vacation		Visit Friends, Relatives		Other	
Respondents	1,043		2,062		2,724		735	
Log-likelihood (total)	−15,827.00		−30,867.10		−48,659.70		−20,354.90	
Log-likelihood (choice)	−5,065.95		−9,803.58		−12,041.90		−2,879.41	
ρ^2 for choice model only	0.56		0.57		0.60		0.65	
Value of Travel Time	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Access ($/h)	50.10	39.37	38.71	50.73	49.19	102.06	41.60	84.31
Egress ($/h)	58.37	98.27	25.86	28.70	14.75	47.36	18.02	45.89
Car in-vehicle ($/h)	44.15	34.61	23.48	28.75	27.39	32.15	27.93	32.19
Bus in-vehicle ($/h)	61.33	61.81	48.28	54.84	40.24	47.94	34.02	37.03
Air in-vehicle ($/h)	49.35	130.69	20.72	58.81	29.01	34.30	36.65	38.72
Rail in-vehicle ($/h)	46.08	43.81	22.96	21.96	23.96	23.58	26.31	29.20

high mean, but is not surprising due to the fact these are intercity travelers in two major US corridors making discretionary or business trips) and the mean and standard deviation of the distribution resulting from the ratio between the negative log-uniform distributions for the time and cost coefficients are reported.

The overall model fits are not directly comparable across purposes, not only given the differences in sample size, but also due to the use of different numbers of indicators across segments in the measurement models (details on this are given later). After estimation, it is possible to factor out the component of the overall log-likelihood relating to the stated choices alone, and the calculation of the ρ^2 measures shows very similar performance across segments, where the high values show the relative ease of explaining mode choices for intercity travel, especially after accounting for random heterogeneity and the role of attitudes.

The VTT measures, with the exception of access time (where VFR is very similar to work), are higher for work trips than for all other purposes. Even when remembering that these are calculated for a given income of $125,000, this is still not surprising giving the different time pressures faced on work trips. Egress time is valued substantially lower than access time for all purposes except work trips, where the opposite applies, potentially as a result of these trips being presented as outbound and respondents being more sensitive to the part of their journey relating to getting to their work location after exiting the main-mode station.

Major differences exist across modes in the way travel time is valued, and the orderings differ across purposes. While for work trips, car in-vehicle time (IVT) is valued the least highest, this is not the case for the three remaining purposes, where the least onerous type of IVT applies to air for vacation and to rail for VFR and other purposes. The highest VTT generally applies to bus, which is clearly a comfort factor, except for purposes other than work, vacation, and VFR, where the VTT for air is marginally higher than that for bus. Overall, rail IVT is valued the least high. Finally, the standard deviations show that there exists extensive variation across individual travelers in how they value travel time.

The actual values of time are calculated from the main estimates, which show that, with a few exceptions (access time for work, egress time, car travel time for work and air travel time for work), the estimates for the variance parameters are statistically significant, showing substantial heterogeneity, especially for the travel cost sensitivity. Also, across all four purposes, the sensitivity to travel cost is higher for income non-reporters than for a respondent at the mean income of $125,000. The impact of income on cost sensitivity is strongest for work travel and lowest for vacation and VFR travel.

5.3.2 Mode Constants

The mean values of the modal constants provide information on the underlying preference for different modes, all else being equal (i.e., same time, cost, etc.). The following estimates relate to a respondent in the base sociodemographic group (aged between 35 and 44, with a degree and employed, traveling alone on an East Coast day trip between 200 and 400 miles):

- Male respondents on work trips prefer rail ahead of air, car, and then bus (the base), where, for female respondents, the difference between car and bus becomes negligible.
- Male respondents on vacation trips prefer rail, ahead of bus, air, and car, where, for female respondents, air is ranked second.
- Both male and female respondents on VFR trips prefer rail, ahead of air, car, and bus.
- Both male and female respondents on trips for other purposes prefer rail, ahead of car, bus, and air.

Numerous shifts in the modal constants are also observed, as follows:

- Age has impacts for bus and air, where
  - On vacation trips, the likelihood of traveling by bus is higher for respondents under 35 and
  - The likelihood of traveling by air decreases for VFR purposes in the two highest age groups but increases in the highest age group for other purposes.
- Having more vehicles than licenses in a household increases the probability of traveling by car for work trips.
- Compared to respondents with a graduate degree, those without are
  - More likely to use bus on VFR and other trips and
  - More likely to use air on VFR trips.
- Compared to respondents in firm employment, those not are
  - More likely to travel by bus for work reasons and
  - Less likely to travel by air for other reasons.
- Compared to respondents on day trips, those who stay
  - Overnight are less likely to use bus or rail for VFR trips,
  - One or more nights away are less likely to use bus for other trips, and
  - Three or more nights away are more likely to use air for vacation trips and less likely to use rail for other trips.
- Compared to respondents traveling alone, those traveling with
  - One other person are less likely to use bus, air, or rail for vacation trips and less likely to use rail or air for VFR trips or air for work trips and
  - Two or more people are more likely to use bus for work trips, less likely to use air or rail for vacation and VFR trips, and less likely to use air for other trips.
- Increases in service frequency increase the likelihood of choosing bus for vacation and VFR trips and air for VFR and other trips.
- Compared to the East Coast, travelers on the West Coast are less likely to travel by bus for vacation, air for other purposes, or rail for work and vacation.
- Across all purposes, respondents on trips below 200 miles are less likely to use air than those traveling between 200 and 400 miles, where, above 400 miles, they are even more likely to travel by air.

5.3.3 Latent Attitudes

In the creation of the ICLV, the role of the four basic values developed in this project were incorporated.

Attitude Toward Privacy

The latent attitude toward privacy has an effect on mode choice behavior in all four trip-purpose segments. The signs of the attitudinal parameters show those respondents with a more positive latent attitude are more likely to agree with the statement "I don't mind traveling with people I do not know" and less likely to agree with the statements "The idea of being on a train or a bus with people I do not know is uncomfortable" and "The thought of sharing a car with others for such a trip seems unpleasant to me." This thus shows that respondents with a more positive value for this latent attitude are *less concerned about privacy*, in the operation of the ICLV model.

The demographic parameters show these respondents are more likely to be female for "other" purposes and are more likely to be older and less likely to be less educated (for work, vacation, and VFR) or to be unemployed (for all purposes other than work).

Looking finally at the impacts of this latent attitude on the mode choice behavior, the parameters show that respondents who are less concerned about privacy are less likely to choose car or air (for all purposes other than work), while, for work trips, they are more likely to choose rail. The negative coefficient of the latent attitude on the probability of choosing rail for "other" purposes needs to be put into the context that the impact is even more negative on car and air, showing simply that these respondents are more likely to choose bus than others, which is a reasonable result.

Attitude Toward Auto Orientation

The signs of the attitudinal parameters show those respondents with a more positive latent attitude toward cars are more likely to agree with the statements "Rather than owning a car, I would prefer to borrow, share, or rent a car just for when I need it" and "I feel I am less dependent on cars than my parents are/were" and to disagree with the statement "I love the freedom and independence I get from owning one or more cars." This thus identifies this latent attitude as an *anti-car attitude*, or at the very least as a reduced car lover attitude, in the operation of the ICLV model.

The demographic parameters show that these anti-car respondents are less likely to be female for non-work trips (perhaps due to personal security issues), are more likely to be young (as expected given the changes in car attitudes across generations), are more likely to be less educated (other than for vacation trips where there is no effect), and are less likely to be employed (for VFR trips only), where this is likely to be an income effect too, which the main income effect on cost fails to capture completely.

Looking finally at the impacts of this latent attitude on mode choice behavior, the mode-oriented parameters show that respondents with a less positive car attitude (i.e., a more positive value for this latent attitude) are less likely to choose car (not surprisingly), but there is also a reduced probability of choosing air for work and VFR trips, possibly due to environmental considerations, though again possibly also due to some confounding with income effects. There is also a reduced probability of choosing rail for VFR trips (with bus being the base), reinforcing the earlier point that for VFR, there are possibly confounding effects with income for this latent attitude.

Attitude Toward Urbanism

The latent attitude toward urbanism was found to have an effect only for the "other" purposes segment. The signs of the attitude parameters show that those respondents with a more positive latent attitude are more likely to agree with the statements "I enjoy being out and about and observing people," "I like to live in a neighborhood where I can walk to a commercial or village center," and "If everyone works together, we could improve the environment and future for the earth," identifying them as *more sociable respondents.*

The demographic parameters show that these respondents are more likely to be female and to have a graduate degree. Looking finally at the impacts of this latent attitude on the mode choice behavior, the relevant parameters show that respondents with a more positive social latent attitude are more likely to choose air and rail than those with a less positive attitude, compared to car and bus.

Attitude Toward Information Communications Technology

The latent attitude toward information communications technology was only included for VFR and "other" purposes after no impact on mode choice behavior was found for work and vacation. This may be seen as surprising for work especially but could be the result of a relatively homogeneous group of work travelers, who all have a heightened use of ICT, making it hard to find an impact on mode choice.

The signs of the attitude parameters show that those respondents with a more positive latent attitude are more likely to agree with the statements "It would be important to me to receive e-mail or text message updates about my bus or train trip" and "Being able to freely perform tasks, including using a laptop, tablet, or smartphone is important to me." This thus identifies this latent attitude as a *pro-ICT attitude*. The demographic parameters show that, for VFR trips, these respondents are more likely to be female, highly educated, or employed and are more likely to be younger (for both VFR and "other" purposes).

Looking finally at the impacts of this latent attitude on the mode choice behavior, the mode-based parameters show us that respondents with a more positive attitude toward ICT are less likely to choose car for VFR and "other" purposes, while, for "other" trips, they are also more likely to choose air. While the former effect is as expected, the latter is somewhat surprising as the use of ICT is less easy during air travel than for bus or rail, although that is starting to change with more abundant in-plane Wi-Fi, the ability to keep devices on during take-off and landing, etc.

5.3.4 Summary and Conclusions

When seen in the context of the amount of data presented by the ICLV model in *NCRRP Web-Only Document 2*, Technical Appendix: ICLV and Hybrid Model Development, it is clear that a great deal of "raw material" is created in the thorough incorporation of a wide variety of complex subject matter in the model's operation. Importantly, the research team has designed this ICLV model to create output material specifically designed to support the scenario testing tool to be introduced in Chapter 6.

The combination of Chapters 5 and 6 will demonstrate that the results obtained in this study have the ability to help formulate real policy implications using advanced (and formerly only academic) modeling techniques in a real-world setting. The results have been designed to be applied in a way that is easy for policy makers to interpret and use. This indicates that studies that can obtain significant sample size and which can then estimate and apply complex models in reasonable ways can provide results that are meaningful and relevant to policy makers. As shown in the model development process, measuring and estimating both hard and soft attributes means that a relatively complex model is necessary to describe these complex behaviors. Yet, Chapter 6 will show that this complexity can be exploited to generate good clear policy implications that are useful for transportation practitioners.

CHAPTER 6

Model Application for Scenario Analysis

6.1 Introduction

In the previous chapter was discussed the creation of a new ICLV model to better understand how demand for rail is influenced both by traditional times and costs and by cultural and psychological factors that are more difficult to quantify. Those trained in model building, and in economic analysis, will have no trouble interpreting the implications both from the level of detail in Chapter 5 and from the more complete set of tables presented in ICLV and Hybrid Model Development in *NCRRP Web-Only Document 2*. However, making that information directly applicable to the analysis of public policy is still a challenge for most transportation practitioners. For this reason, the research team has created a new analysis tool which serves to translate the vast amount of data created in the ICLV, into the form of possible scenarios for the future.

Toward this end, the new mode choice models with latent attitudinal variables have been implemented in the form of a Microsoft® Excel™ workbook used by the research team analysts in order to provide results for user-defined scenario changes. The implementation uses the sample enumeration method. Under this method, the appropriate model parameters are applied for each member of a sample of individual travelers, and the predicted mode shares are expanded and added across the sample to arrive at a total predicted number of trips made using each mode alternative for each travel segment (trip purpose). The resulting predictions can then be compared against a base scenario to determine the change in mode usage that is expected due to the change in the scenario inputs.

NCRRP has created a user-friendly version of the scenario testing tool, which will be available for downloading from the TRB website in June 2016 (by searching for "NCRRP Report 4").

6.1.1 Chapter Structure

Following upon this brief introduction, the chapter presents a description of the testing tool created in this NCRRP project. Then, (consistent with the content of Chapter 1) four illustrative scenarios are described, and the implications for rail ridership are discussed. The model is then applied to the question of demographic content of future scenarios, with five separate demographic changes explored. This is followed first with an exploration of changes in traditional times and costs, and second with possible changes in underlying cultural beliefs and attitudes, keyed to levels experienced by existing demographic segments of the population.

6.1.2 What Does the Tool Look Like?

The scenario testing tool created for NCRRP 03-02 takes the form of a series of interconnected Excel spreadsheets that make available to the analyst a wide variety of data and procedures needed in the application of quick-turn-around scenario testing.

The scenario testing tool builds directly on the results calculated in the NCRRP ICLV forecasting model. For each of the 5,625 persons analyzed in the stated choice exercise, over 40 separate coefficients are created to reflect mode share implications from various forms of travel times (in-vehicle, access, egress) for four trip purposes. Thus, the scenario spreadsheets provide over 230,000 coefficients as the tool user specifies various combinations of trip characteristics to be studied. Concerning the documentation of attitudes, 25 columns of attitudes stratified by several basic demographic groupings are arrayed against the 5,625 rows, representing respondents, with potentially 140,000 unique combinations of respondents and attitudes. An additional spreadsheet arrays the person rows against some 40 columns of (primarily) socioeconomic variables. The characteristics of networks (including the several forms of travel times) are included both in terms of the hypothetical trips that were displayed to the respondent in the stated choice exercise, and empirically calculated from national network data.

Notwithstanding the scale of the information contained in this free-standing Excel program, the entire program is packaged in a 20-megabyte file, allowing it to be run on local computers, with no need for network connections.

6.2 The Four Illustrative Scenarios

To help the reader understand the implications of the ICLV model presented in Chapter 5, four future scenarios for the market setting for rail were created in the project. While they were briefly summarized in Chapter 1 (shown again in Table 16), they are now presented here with more description and detail (Table 17).

Four combinations of the attitudinal shifts above were run to represent four possible future scenarios. Only the trends with age are varied—the attitudinal differences related to gender, education, and employment are assumed not to change in these scenarios. The most optimistic scenario for rail is that people will keep their current attitudes toward auto orientation and technology as they age ("Go with cohort" in Table 17) and that the next generation will have the same attitudes as current millennials, but that all age groups will adopt the current attitudes toward privacy of the current age 65+ group. The most pessimistic scenario for rail is that each age cohort will adopt the attitudes toward auto orientation and technology that the previous cohort had at that age ("Current trends with age" in Table 17): The next generation, Z, will not reflect the current

Table 16. Summary of the results from the four future scenarios (simplified).

Decreasing Role of Auto Orientation in Future →		*Decreasing Concern for Privacy in Travel in Future →*
Pessimistic for Rail • Bad future for auto rejection • Bad future for privacy tolerance • ICT need will decrease with age ***Rail decreases by 4%***	*Mixed Scenario B* • Good future for auto rejection • Bad future for privacy tolerance • ICT need will decrease with age ***Rail increases by 4%***	
Mixed Scenario A • Bad future for auto rejection • Good future for privacy tolerance • ICT need will continue with age ***Rail increases by 10%***	*Optimistic for Rail* • Good future for auto rejection • Good future for tolerance • ICT need will continue with age ***Rail increases by 18%***	

Table 17. Definitions of four scenarios, relative to base scenario.

Effect	Change in Values			
	Pessimistic for Rail	Mixed Scenario A	Mixed Scenario B	Optimistic for Rail
Age on auto orientation	• Current trends with age • Gen Z same as current 35–44	• Current trends with age • Gen Z same as current 35–44	• Go with cohort • Gen Z same as millennials	• Go with cohort • Gen Z same as millennials
Age on technology orientation	• Current trend with age	• Go with cohort	• Current trend with age	• Go with cohort
Age on privacy attitude	• Go with cohort	• All adopt attitude of 65+	• Go with cohort	• All adopt attitude of 65+
Gender, employment, education on all attitudes	• Current trends	• Current trends	• Current trends	• Current trends

millennials but will reflect the current post-millennial 35–44 age group, and the cohorts will keep their same attitudes toward privacy as they age. The mixed scenarios have different combinations of those assumptions.

The results are that the pessimistic scenario results in a 4% drop in total rail trips, while the optimistic scenario results in an 18% increase (Table 18). Mixed Scenarios A and B result in a 10% and 4% increase in rail trips, respectively. The "other" trip-purpose segment, which is the smallest segment, is the most volatile, while the business (work), vacation, and VFR trip purposes all show fairly similar trends across the scenarios.

6.3 Sample Expansion and Initial Model Calibration

Because the research team was using only a partial sample of trips in the NEC and Cascade Corridor, it was useful to first check the numbers of trips by mode and corridor against similar numbers from other corridors. Two sources were used: the *NEC Intercity Travel Summary Report* (RSG 2015a), which has estimates of annual trips by mode and city pair in the NEC, and the output from the national long-distance passenger travel demand model (RSG 2015b), which has synthetic estimates of annual trips by mode, trip purpose, and city pair in both the NEC and Cascade Corridor. Because these two sources use different definitions of geographic areas, and because the survey for this project used fairly vague city area definitions, the numbers are not exactly comparable between any of the estimates. The purpose of the scenarios is not to provide

Table 18. Change in rail trips under the four scenarios, relative to base scenario.

Trip Purpose	Change in Rail Trips			
	Pessimistic for Rail	Mixed Scenario A	Mixed Scenario B	Optimistic for Rail
Business	–5%	13%	3%	22%
Vacation	–4%	8%	2%	14%
Visit Friends/Relatives	–2%	9%	4%	15%
Other	–11%	14%	9%	35%
Total	**–4%**	**10%**	**4%**	**18%**

Table 19. Base scenario total trips by purpose and mode.

Mode	Base Scenario				
	Business	Vacation	VFR	Other	Total
	Predicted Trips (1,000/year)				
Car	6,114	19,891	19,765	7,641	53,411
Bus	1,812	6,130	2,900	697	11,539
Rail	3,290	4,260	3,551	1,189	12,290
Air	1,887	2,341	2,213	517	6,958
Total	13,104	32,622	28,428	10,044	84,198
	Mode Share				
Car	46.7%	61.0%	69.5%	76.1%	63.4%
Bus	13.8%	18.8%	10.2%	6.9%	13.7%
Rail	25.1%	13.1%	12.5%	11.8%	14.6%
Air	14.4%	7.2%	7.8%	5.2%	8.3%

precise forecasts but to begin with a reasonable representation of the current traveling population, so an approximate overall sample expansion was deemed acceptable.

Using an expansion factor of 6,000 annual trips per survey respondent gave a reasonable match against "observed" trips in total and by trip purpose. Compared to the observed data, the initial mode share was skewed a bit toward bus and away from rail, so slight changes were made to the mode constants in the models to better match the data.

The resulting initial expanded trips for the "base scenario" (no user-supplied changes) are shown in Table 19. Note that the overall rail and bus mode shares are near 14%, which is higher than the actual share for the NEC in total because the NCRRP 03-02 sample and the resulting models focus on trips with both ends near the major cities (Boston, New York, Philadelphia, Washington, DC), while the entire corridor also contains areas that are relatively distant from those city centers and thus tend to be more car oriented.

6.3.1 Changing the Demographic Distributions

One way that the user can define future scenarios is to adjust the population distribution by gender, age group, education level, employment status, and/or income level. Table 20 shows the base scenario distributions that result from the expanded sample of respondents.

The user can change the percentages in any of the green-shaded rows, and the percentages in the "base" categories (white unshaded rows) automatically adjust to maintain the total at 100%. In the model calculations, the expansion factors for each respondent are adjusted using the new scenario percentage divided by the base scenario percentage for the relevant category for each demographic variable. (For example, if the gender balance for business trips were adjusted to be 50%/50%, then the expansion factors for business trips made by females would be multiplied by 0.500/0.411, while the expansion factors for business trips made by males would be multiplied by 0.500/0.589.)

Table 21 shows the resulting changes in rail trips for five different scenarios changing the demographic distribution of the traveling population: (1) a shift toward more females, (2) a shift toward more senior citizens, (3) a shift toward fewer individuals who are not college graduates, (4) a shift toward fewer unemployed adults, and (5) a shift toward the extremes of the income range and away from the center. The shifts are all fairly modest, at 10% of the initial population share, and the resulting changes in rail trips in Table 21 are also modest, all below 1.5% change in total trips. (The scenarios assume no changes in attitudes within each demographic category.)

Table 20. Base scenario demographic distributions.

Demographics	Base Scenario			
	Business	Vacation	VFR	Other
GENDER				
Female	*41.1%*	*57.1%*	*55.4%*	*56.4%*
Male (base)	58.9%	42.9%	44.6%	43.6%
Total	100.0%	100.0%	100.0%	100.0%
AGE				
Under 35	*20.7%*	*24.1%*	*21.3%*	*12.6%*
35-44 (base)	22.0%	19.9%	16.4%	12.9%
45-54	*24.0%*	*18.5%*	*17.2%*	*24.7%*
55-64	*21.7%*	*18.8%*	*21.7%*	*20.8%*
65 and older	*11.6%*	*18.7%*	*23.4%*	*29.0%*
Total	100.0%	100.0%	100.0%	100.0%
EDUCATION				
Not a college graduate	*22.8%*	*33.9%*	*28.1%*	*35.8%*
College graduate (base)	77.2%	66.1%	71.9%	64.2%
Total	100.0%	100.0%	100.0%	100.0%
EMPLOYMENT				
Not employed	*14.5%*	*32.0%*	*34.2%*	*41.9%*
Employed (base)	85.5%	68.0%	65.8%	58.1%
Total	100.0%	100.0%	100.0%	100.0%
INCOME				
Under $25,000	*5.6%*	*6.3%*	*6.9%*	*8.9%*
$25,000 to $49,999	*10.4%*	*15.3%*	*14.0%*	*12.9%*
$50,000 to $74,999	*12.3%*	*16.9%*	*16.2%*	*15.3%*
$75,000 to $99,999	*19.0%*	*20.5%*	*20.5%*	*21.3%*
$100,000 to $149,999 (base)	23.7%	24.3%	22.3%	21.6%
$150,000 to $199,999	*12.7%*	*9.0%*	*9.3%*	*10.3%*
$200,000 and up	*16.3%*	*7.7%*	*10.8%*	*9.7%*
Total	100.0%	100.0%	100.0%	100.0%

Table 21. Change in rail trips by purpose for selected changes in demographic distributions.

Demographic Shift	Change in Rail Trips				
	Business	Vacation	VFR	Other	Total
Female share up 10%, male share down to compensate	−0.6%	−1.2%	−0.5%	−2.2%	−0.9%
Age over 65 share up 10%, under 35 down 5%	−0.1%	1.1%	−0.1%	−0.9%	0.1%
Not college grad share down 10%, college grad share up to compensate	1.4%	1.0%	1.5%	1.9%	1.4%
Unemployed share down 10%, employed share up to compensate	0.4%	−0.6%	0.5%	1.5%	0.3%
Income shares below $50k up 10%, income shares above $150k up 10%, incomes $50–100k down 10%	−0.4%	−0.5%	0.4%	0.7%	−0.1%

Table 22. Base indices for user-adjustable travel times and costs.

Times and Costs	Base Scenario Indices			
	Car	Bus	Rail	Air
Main-mode travel time	*100*	*100*	*100*	*100*
Access travel time		*100*	*100*	*100*
Egress travel time		*100*	*100*	*100*
Service frequency		*100*	*100*	*100*
Business trip cost	*100*	*100*	*100*	*100*
Non-business trip cost	*100*	*100*	*100*	*100*

6.3.2 Changing Mode Travel Times and Costs

Table 22 shows the travel times and costs that can be adjusted by the user for specific scenarios. The changes are quite general and are applied in the same percentage to each person in the sample (with the exception of cost changes, which can be specified separately for business trips and non-business trips to represent changes in business or economy fares separately). The base scenario values are given an index of 100, so entering a value of 110 would increase the value by 10% for every person, while entering a value of 90 would decrease the value by 10% for every person.

Tests were done increasing each of the values in Table 23 by 10% (entering an index of 110, one cell at a time). The largest influence was seen from increasing the rail non-business fare by 10%; a change in number of trips of –8.2% resulted (a direct fare elasticity of –0.82). The second largest change was from increasing rail IVT, which caused a direct travel time elasticity of –0.64. The cross-mode effect for a 10% increase in car IVT was the third largest with an increase of 5.5% in rail trips (a cross-elasticity of 0.55). In general, the cross-elasticities for changes in car times and costs are larger than for the other modes because of the larger base shares for car.

6.3.3 Changing Attitudinal Variables

The spreadsheet also allows the user to simulate predefined shifts in the four latent attitudinal variables, where one or more groups defined by age, gender, education, and/or employment status take on the attitudes of another group along that demographic dimension. Such a shift is simulated by entering a value greater than 0 in the cell for any of the four attitudes, as shown in Table 24.

The results of the attitudinal change for each of the cells in Table 24, in terms of total rail trips, are shown in Table 25. The final column also shows the result if all four attitudinal variables are shifted at once. The age variables tend to have the largest effect. If all age groups were to adopt the current

Table 23. Change in total rail trips when increasing each time and cost variable by 10%.

Times and Costs	Change in Total Rail Trips			
	Car	Bus	Rail	Air
Main-mode travel time	5.5%	2.7%	–6.4%	0.3%
Access travel time		0.5%	–2.8%	0.8%
Egress travel time		0.3%	–1.4%	0.4%
Service frequency		–0.4%	0.0%	–0.2%
Business trip cost	0.7%	0.2%	–2.0%	0.4%
Non-business trip cost	3.1%	0.8%	–8.2%	1.7%

Table 24. User-adjustable predefined shifts in attitudes.

Shifts in Attitude	Privacy	Auto-Oriented	Urbanism	Technology
All ages to under 35	*0*	*0*	*0*	*0*
Under 35 to 35-44	*0*	*0*	*0*	*0*
All ages to over 65	*0*	*0*	*0*	*0*
All ages one group younger	*0*	*0*	*0*	*0*
Female to male	*0*	*0*	*0*	*0*
Male to female	*0*	*0*	*0*	*0*
No college to college	*0*	*0*	*0*	*0*
College to no college	*0*	*0*	*0*	*0*
Unemployed to employed	*0*	*0*	*0*	*0*
Employed to unemployed	*0*	*0*	*0*	*0*

Table 25. Change in total rail trips when shifting attitudes, one at a time and all at once.

Shifts in Attitude	Change in Total Rail Trips				
	Privacy	Auto-Oriented	Urbanism	Technology	All at Once
All ages to under 35	−3.4%	17.9%	0.0%	2.5%	16.4%
Under 35 to 35-44	0.0%	−1.7%	0.0%	0.0%	−1.7%
All ages to over 65	10.4%	−11.9%	0.0%	−3.4%	−5.7%
All ages one group younger	−2.5%	6.1%	0.0%	1.4%	4.9%
Female to male	−0.4%	2.3%	−0.3%	−0.4%	1.2%
Male to female	0.4%	−1.8%	0.2%	0.3%	−1.0%
No college to college	2.7%	1.2%	0.1%	0.1%	4.2%
College to no college	−7.5%	−3.6%	−0.2%	−0.3%	−11.4%
Unemployed to employed	1.3%	−0.6%	0.0%	0.2%	0.9%
Employed to unemployed	−2.5%	1.2%	0.0%	−0.4%	−1.7%

attitudes of the "millennials" (under 35), then rail trips would increase by 16%, with the largest effect from a shift away from the "car-oriented" attitude, plus a positive effect from the technology aspect of being able to use devices in the train, but an offsetting negative effect from the relative lack of privacy in the train. On the other hand, if all age groups were to adopt the attitudinal tendencies of the current age 65+ group, rail trips would decrease by almost 6%, due to opposite offsetting effects as described for the shift to "younger" attitudes. The most realistic future trend in attitudes by age may be the "shift all ages one group younger." This would be the situation 10 to 15 years from now if attitudes for any given person stay the same and go together with the age cohorts, rather than changing with age. The result for that test is a 5% increase in total rail trips.

Other than age, the largest effect would be if all persons adopted the "no college education" attitude, regardless of education level. This would result in an 11% decrease in rail trips, but seems like a very unlikely scenario.

CHAPTER 7

The Role of Rail in a Rural Market

In the United States, Amtrak provides a range of services, including services that connect major metropolitan concentrations and services that consist of very long-distance routes with extremely sparse populations along the way. A third kind of service might be seen as something of a hybrid: moderate-volume corridors with major urban destinations at one end and communities of considerably less density at the other. Outside of its NEC service area, Amtrak operates service to Maine, New Hampshire, Vermont, and Western Massachusetts through a variety of specialized routes.

7.1 The University of Vermont Rural Intercity Transportation Survey

This chapter concerns mode choice behavior for travel between rural communities and large metropolitan centers in the Northeast. This work uses data from a significant travel survey designed and undertaken by members of the research team in the spring of 2014 for the UVM TRC in collaboration with the NETI. The project was designed and managed by Professor Brian Lee of the University of Vermont, also a member of the NCRRP 03-02 research team.

7.1.1 Setting for the Rural Study

In recent years, there have been several new research approaches developed for incorporating attitudinal and behavioral components to the travel demand forecast and analysis process. Many of these research efforts have focused on *intra*-metropolitan trips and were very often undertaken on behalf of stakeholders in the metropolitan planning process. While this NCRRP project is *primarily* concerned with travel behavior *between* metropolitan centers, there is a need to better understand travel to/from less populated areas to large metropolitan ones (for the lack of a better term, in this chapter these trips are called "intercity" trips, even though they include travel originating from or traveling to towns and rural areas not commonly considered cities). In other studies, these intercity trips have been found to be typically of a distance greater than 100 miles, which in the Northeast usually means crossing at least one state border and often having several travel mode options to consider. Thus, Chapter 7 now examines trips for residents across the northernmost states of the Northeast—Maine, New Hampshire, Vermont, and Western Massachusetts—to improve basic understanding of the challenges in encouraging more sustainable and efficient modes of intercity travel in a largely rural region.

7.1.2 Rural Intercity Survey Instrument

The survey asked questions about actual trips taken; a hypothetical trip to New York City; and attitudes about traveling by automobile, intercity bus, and passenger rail. There were a total of

98 questions plus a home zip code question that determined respondent eligibility for inclusion in the survey.

The travel survey sampling protocol relied on commercial sample providers to recruit residents from four New England states: Maine, New Hampshire, Vermont, and Massachusetts [outside of the Boston metropolitan area (Boston–Cambridge–Quincy Metropolitan Statistical Area)]. A total of 2,560 valid survey responses were collected.

The survey was organized into four parts. Part 1 of the survey asked 13 questions about recent intercity travel and general travel preferences. Part 2 included 35 statements about intercity travel preferences, many regarding a specific utility or disutility pertaining to a certain mode. The content of these questions was strongly influenced by the TPB and were subject to several rounds of pre-testing. Many of these questions were used several months later in the NCRRP survey instrument.

Part 3 presented a fictional scenario, in which the respondent has been asked to travel from his/her home to Manhattan, in New York City, for an important appointment during the following month and the respondent has decided to go. The respondent would stay one night at a hotel and travel alone. The host would pay for the hotel costs but not for travel. The respondent would be responsible for all costs of gas and parking or any fares. The respondent was asked to assume that, for one reason or another, she/he had already decided not to take any part of the trip by plane. She/he would then need to choose between taking the entire trip by car (whether or not it was his/her own vehicle) and taking at least part of the trip by intercity bus or train.

All respondents were asked to select what mode(s) of transportation they thought were available to them for this trip to New York City, how likely they would choose to take a bus or train for a trip like this to New York City, and whether learning that no Wi-Fi or electrical outlets were available on the bus or train would make them less likely to choose a bus or a train for this trip. The survey method also included an experimental design to test the effect of an advanced passenger information system, which was reported elsewhere.

Part 4 included questions about what personal technology devices respondents own, and their demographics: age group, gender, level of education, and annual household income level.

In addition to the information obtained from the survey data, several additional attributes were added, using available data and geographic information systems, for each zip code. These attributes included demographic information; land use; distances to destination cities; distances to the nearest urbanized areas within a metropolitan area; and distances to airports, rail stations, and bus stations of different sizes and types.

7.1.3 Intercity Travel Mode Distributions

Part 1 of the survey asked respondents about recent intercity travel trips; this included a question about their recent trips from their home town to four major metropolitan centers in the Northeast: Boston, New York City, Philadelphia, and Washington, DC. The vast majority of intercity trips ($N = 2,789$) involved only one mode and a much smaller portion ($N = 587$) involved multiple modes. Not surprisingly, a much higher proportion of trips made by only one mode involved autos (73.6%) while the comparable number for trips with multiple modes is lower (45.7%). As such, the respondents are more likely to identify having used multiple modes if bus or rail was involved. Table 26 shows the travel mode distributions of these trips.

As for comparisons between millennials and older age groups, there are differences for three distributions, as shown in Table 27. In general, older adults are more likely to use autos and air for their intercity trips, while younger adults are more likely to use bus and rail. This is similar to the

Table 26. Travel mode distributions for respondents' recent intercity trips.

	Auto	Bus	Rail	Air	Other	Total	Trips (*N*)
All	64.8%	8.2%	11.7%	12.9%	2.4%	(100%)	3,376

Table 27. Travel mode distributions for respondents' recent intercity trip by age group.

	Auto	Bus	Rail	Air	Other	Total	Trips (*N*)
Millennials	58.6%	12.9%	14.1%	12.2%	2.2%	(100%)	618
Older group	66.3%	7.0%	11.1%	13.1%	2.5%	(100%)	2,758

differences between males and females (not shown). It is worth noting that differences between the age groups are bigger for the bus and rail modes than the differences between genders.

7.1.4 Components of the Rural Attitudinal Model

The structural equation model (Figure 44) developed from the results of the rural surveying process focused on the Propensity to Take Rail or Bus as the outcome factor.

Like the derivation of the shorter-term attitudes, the four latent factors for the four basic values (Figure 45) were derived by a process of confirmatory factor analysis, building upon the earlier results of the NCRRP Attitudinal Model. In this case, the optimal model fit was found to result when the observed variable "I like to be able to walk to a commercial or village center" was allowed to load on two separate latent factors. The content of the survey allowed the creation of an outcome factor (oval) for Propensity to Take Bus or Rail supported by four separate observed variables (rectangles)

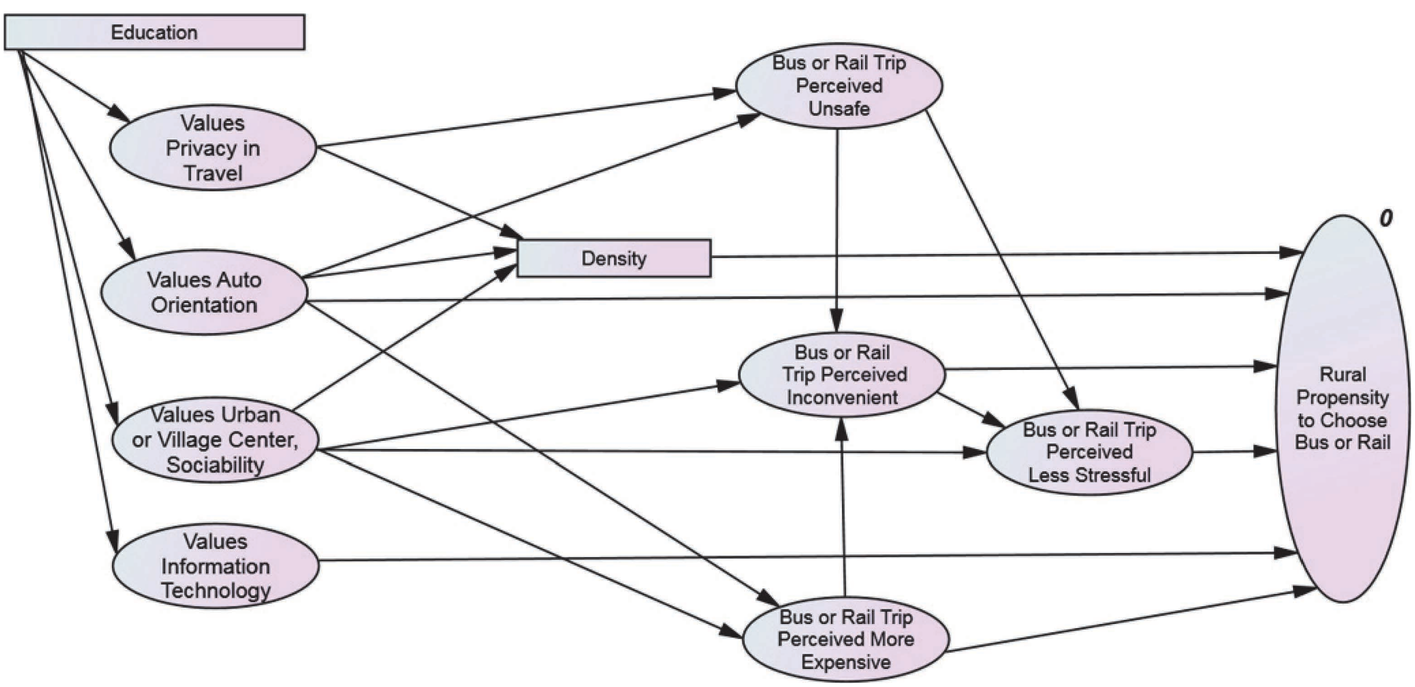


Figure 44. NCRRP Attitudinal Model, applied to a rural sample (2014,* n *= 2,560).

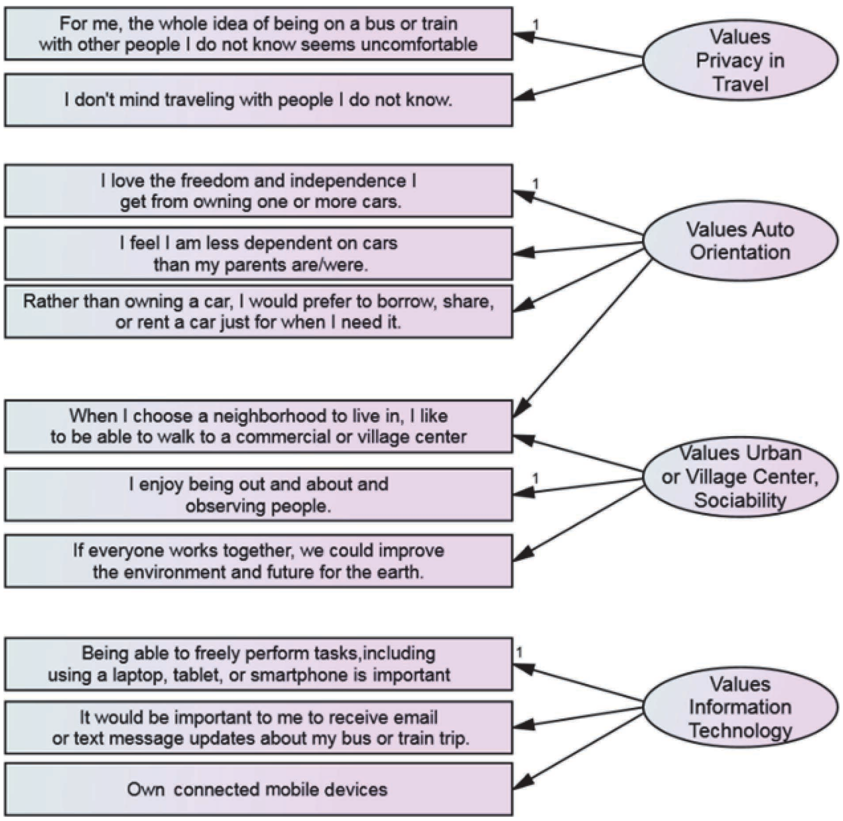


Figure 45. Four latent factors for basic values in the NCRRP Attitudinal Model, applied to a rural sample.

as shown in Figure 46. The shorter-term attitudes in the model reflect perceptions that the bus or rail option might be unsafe, inconvenient, and less stressful or more expensive than the auto trip.

The full rural model includes the nine latent factors described here, and the addition of an observed variable for education level, and for residential density.

7.1.5 Rural Attitudinal Model Estimation

The rural model was run on its full sample of 2,560 respondents, using the AMOS Version 22 software package, with maximum likelihood estimation. It had satisfactory levels of overall model fit, with a RMSEA of 0.044 (under 0.05 is considered good) and a comparative fit index of 0.94 and a Tucker-Lewis index of 0.92 (where values of over 0.90 are considered desirable for both). Details of the model output are included in the *NCRRP Web-Only Document 2*, Technical Appendix: Documentation for the Structural Equation Models.

7.1.6 Results

The examination of the STE of key factors upon the outcome factor allows the early summary of the relative rank of factors in the explanation of Propensity to Take Bus or Rail. Table 28 shows that, for this rural sample looking at both bus and rail together, the perceived inconvenience of public modes is the most powerful explanatory influence. This, of course, is consistent with the results from a very similar model of the NCRRP data set presented in Chapter 4 for rail only, and a model that will be presented in Chapter 8 for intercity bus only.

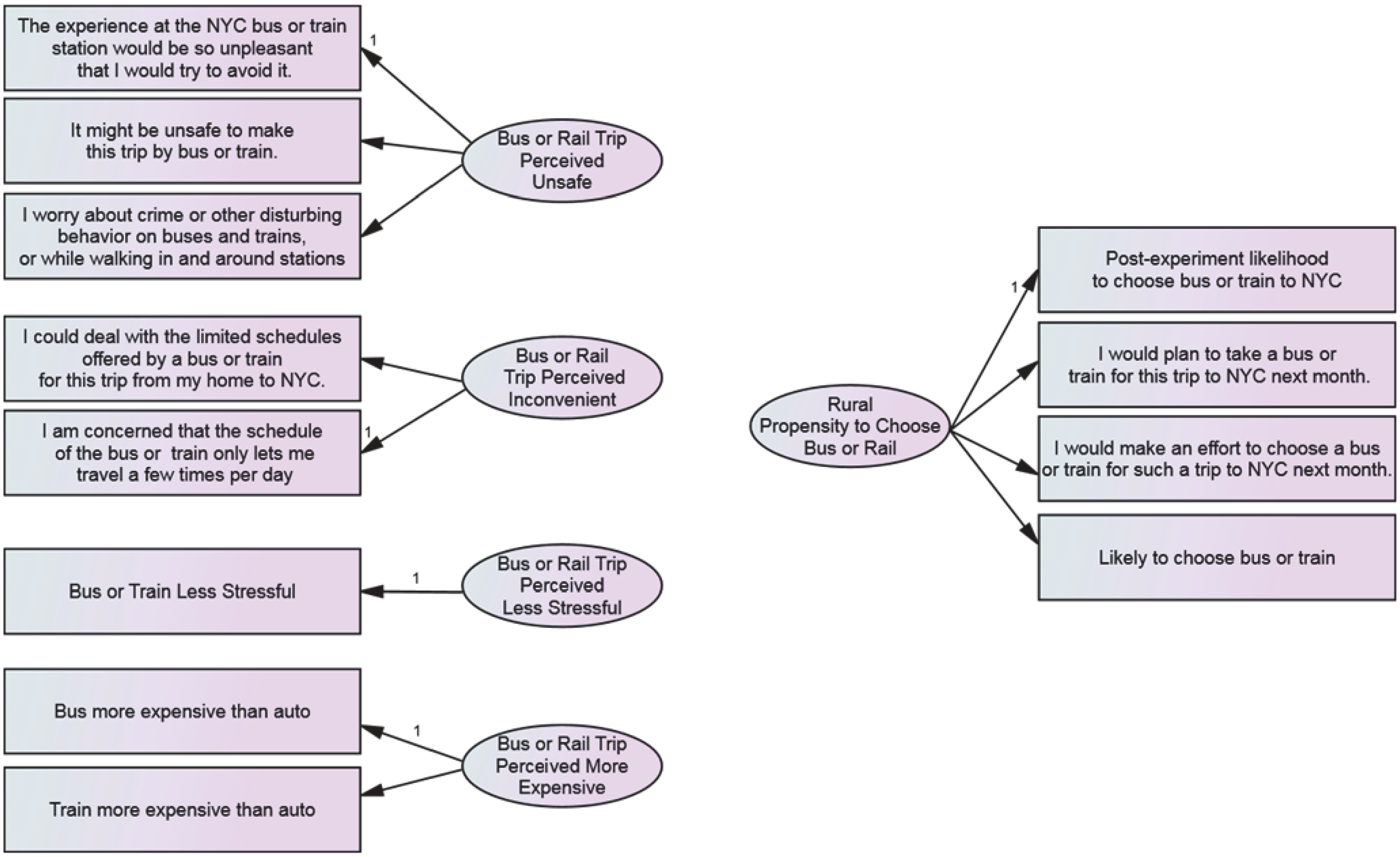


Figure 46. Latent factors (ovals) for the four short-term attitudes and outcome factor, based on observed variables (rectangles).

Table 28. Ranking of factors explaining rural propensity to choose bus or rail.

Rank	Factor*	STE
1	Rail or Bus Trip Inconvenient	−0.69
2	Rail or Bus Trip Unsafe	−0.43
3	Rail or Bus Trip Expensive	−0.31
4	***Values Privacy in Travel***	−0.29
5	Rail or Bus Trip Less Stressful	0.22
6	***Values Urbanism/Sociability***	0.17
7	***Values ICT***	0.13
8	*Education*	0.13
9	***Values Auto Orientation***	−0.08
10	*Density*	0.04

*The four basic values are shown in ***italic bold***; the four short-term attitudes are shown in roman; and demographics are shown in *italic*.

Exploring Privacy and Safety in the Rural Survey

Beyond the expected role of inconvenience in the rural study, the next two ranking factors both reflect concern with safety and the unpleasantness of traveling with people one does not know. It should be pointed out that the rural survey was undertaken earlier than the NCRRP survey, and it focused on a trip to New York City only. Thus, there may be several explanatory phenomena at play at once: First, the rural population itself may fear the trip to the big city more than those originating their trips from large metropolitan areas. Second, for the rural survey, the respondents were asked to think about New York City, not about Boston or Washington, DC, which might be seen as less intimidating destinations. For whatever reason, the calculated STE of "unsafe" is higher in the current survey than in the other two applications of the Attitudinal Model elsewhere in this report.

Similarly, the factor for auto orientation was a less important factor in the rural study than it was for the more metropolitan NCRRP sample, while increasing level of auto orientation is modestly associated with lower levels of bus/rail use (–0.08).

Summary for the Rural Sample

Based on the relationships between factors revealed in Table 29, the following observations can be made (in this summary, the column values are shown in **bold** or ***italic bold*** font and row values are shown in roman font, reflecting the direction of STE implied in the table):

- Higher levels of **education** are associated with lower need for privacy in travel (–0.26), less fear for personal safety on the trip (–0.17), and higher need for information technology (0.22).
- Higher levels of need for ***privacy in travel*** are associated with much higher levels of fear for personal safety in the trip (0.68), with higher propensity to report that the trip is inconvenient (0.33), lower propensity to report that the trip is less stressful than the car trip (–0.41), and higher levels of residential density (0.12).
- Higher levels of ***auto orientation*** are associated with lower levels of safety fear for the bus/rail trip (–0.14) and lower levels of residential density (–0.14).
- People who value ***urbanism*** live in higher-density locations (0.18) and are less likely to perceive that the bus/rail trip is either expensive (–0.30) or inconvenient (–0.21).
- People with the perception that the bus or rail trip is **unsafe** are much more likely to report that the trip is inconvenient (0.49) and much less likely to conclude that the trip less stressful (–0.61) than the car trip.

Table 29. Impact of explanatory factors (columns) on impacted factors (rows).

Impacted Factors	Demographic	Basic Longer-Term Values				Location	Rural Bus or Rail Trip Perceived as …			
	Education	Privacy	Auto	Urban	ICT	Density	Unsafe	Incon-venient	Less Stressful	More Expensive
Privacy	–0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Auto	–0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Urbanism	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ICT	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Density	0.00	0.12	–0.14	0.18	0.00	0.00	0.00	0.00	0.00	0.00
Unsafe	–0.17	0.68	–0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inconvenient	–0.10	0.33	–0.05	–0.21	0.00	0.00	0.49	0.00	0.00	0.28
Expensive	–0.03	0.00	0.07	–0.30	0.00	0.00	0.00	0.00	0.00	0.00
Less Stressful	0.10	–0.41	0.08	–0.02	0.00	0.00	–0.61	–0.36	0.00	–0.10
Rural Propensity	***0.13***	***–0.29***	***–0.08***	***0.17***	***0.13***	***0.04***	***–0.43***	***–0.69***	***0.22***	***–0.31***

- There is a positive association (0.28) between the bus/rail trip being seen as **Expensive** and seen as inconvenient.
- There is a negative association (–0.36) between the trip being seen as **Inconvenient** and its being less stressful than the car.

7.2 Conclusion for the Rural Corridor Market

The UVM TRC study of 2,560 residents of rural areas in the Northeast who have made trips to large cities concludes that the level of fear for personal safety for bus and rail trips is a significant factor in the explanation of the propensity to take bus or rail modes. This is, of course, in addition to the well-documented need for schedule convenience and quality of access to and from the terminals.

Compared to the more metropolitan sample used in all other chapters of this report, basic values toward auto orientation seem to play somewhat less of a role in this rural context. Values held about urbanism/sociability seem to be somewhat more relevant to the modal decision than they were for the less rural sample. Concerns for privacy and safety seem to diminish with higher levels of education. And, again, the density of one's residential location does not seem to be very much associated with the key determinant factors for choice of intercity mode.

CHAPTER 8

Competition to Rail from Intercity Bus

8.1 Introduction

Any study of the role of rail in a dynamic, competitive marketplace must include an analysis of how the recent evolution of intercity bus has changed the nature of the competition. And yet, the intercity bus, despite regaining prominence in many major U.S. corridors over the past decade, remains only sporadically researched and poorly understood by many transportation analysts. Much of the analysis conducted by public agencies to assess improved rail service ignores the sector's changing characteristics and market penetration. The absence of comprehensive data on prices and passenger volumes remains a major impediment to analysis of bus–rail competition.

8.2 Previous Research on Intercity Bus Service

This NCRRP project provides a variety of new forms of information about the market characteristics of the intercity bus industry. To some extent it builds upon an existing mass of research, but, in reality, research on the causes and effects of the industry's ups and downs has been comparatively thin, in part due to a lack of data. The federal government does not maintain numbers on ridership or fares, as are available for air and train travel. Carriers are not required to report ridership or passenger-mile data to a centralized authority, and Greyhound ceased systematically reporting its ridership several years ago.

In the last American Travel Survey, conducted in 1995, it was estimated that scheduled intercity buses accounted for around 40 million passenger trips annually. How much the sector has grown since then, however, remains unknown. Estimates by Schwieterman, Schulz et al. (2015) put the number close to 55 or 60 million (This estimate is based on the Chaddick Institute's Intercity Bus Data Set, which applies load factors to estimates of the number of daily bus operations on approximately 100 intercity bus lines).

While scarce compared to other modes, *some* research does exist on this industry, including an important study by the US General Accounting Office in 1992. A systematic analysis by the University of Delaware evaluates issues posed by the expansion of curbside service and safety issues (Scott et al. 2013). A much wider body of research explores rural and state-supported services (KFH Group Inc. 2002, Higgins et al. 2011). State governments have also been quite active in studying service levels within their jurisdictions. Comprehensive passenger surveys were undertaken in Florida, Michigan, and Minnesota (Florida DOT 2009, Grengs 2009, SRF Consulting Group 2010). This research documents the extent to which bus service, particularly service on rural and quasi-rural routes, caters to travelers without access to private vehicles. It also clearly shows that passengers using buses tend to be younger and have less income than the general population.

Table 30. Traffic generation and diversion of city-to-city express bus service.

How would you have traveled had this service not been available?	East	Midwest	Total
Air	6.1%	15.2%	10.6%
Drive	23.3%	31.9%	27.5%
Greyhound/other bus lines	17.9%	10.2%	14.1%
Rail	**34.0%**	**21.9%**	**28.0%**
Other	1.1%	1.9%	1.5%
Would not have traveled	22.0%	21.9%	22.0%
Sample size	258	393	651

Source: Schwieterman and Fischer (2012).

8.2.1 Bus Diversions from Rail?

Research by Schwieterman, Schulz et al. (2015) shows that the expansion of city-to-city service has resulted in an industry—dominated by BoltBus and Megabus—which now accounts for about 1,000 daily bus operations. Passenger surveys administered as part of this NCRRP research show that the expansion of this service has drawn passengers away from rail travel in both the East and Midwest, but to a much higher extent in the former (Table 30). Although 34% of travelers in the East reported they would have taken the train if the services of these bus lines were not available, only 21.9% indicated this in the Midwest, where the diversion from air service was much higher. Passengers were surveyed in 2011 in Chicago, Indianapolis, New York, Philadelphia, and St. Louis (Schwieterman and Fischer 2012). This same research showed that only about 17% of travelers indicated "business" as their trip purpose, with the rest indicating the purpose as "pleasure" (58%) or "personal business" (26%).

8.2.2 Understanding the Role of Price

Schwieterman, Kohl et al. (2014) also documented the price differences between modes in 2013 by evaluating fares in 55 city-pairs with travel distances between 90 and 400 miles. [Thirty-five of these city-pairs were (and continue to be) served by both Amtrak and city-to-city express bus lines. The analysis considers fares in three advance purchase scenarios—1 day, 7 days, and 28 days—on two different travel dates, with the lowest fare in the 3-hour period of the day being recorded.] The results show that the lowest bus fares over a designated 3-hour period were generally about 33% to 60% less than train tickets. Rail fares, in turn, undercut air fares (even with the assumption that travel is roundtrip with a Saturday minimum stay) by more than half. The difference between rail and bus fares is much larger in the NEC than in other parts of the country, particularly in high-frequency Amtrak corridors.

To better understand how recent changes have affected fares, fresh data were collected for this project in late June and July 2015. The results show that price differentials remained relatively constant between 2011 and 2015. Examples of fare and scheduled travel time differences are shown in Table 31. On most routes, buses are less expensive but markedly slower than trains. The difference in travel time would likely be greater if delays induced by traffic congestion were taken into account.

For the 35 corridors served by both bus and rail, the analysis showed:

- Average bus fares purchased 7 or 28 days in advance are about $30 less than train fares. In percentage terms, advance purchase bus fares are, generally, 30% to 60% less expensive, although the difference is less in markets without discount city-to-city express carriers. Rail fares remained less than half of airline fares.

Table 31. Travel times and minimum fares in selected corridors, June 29, 2015.

Corridor	Travel Time		Advance Purchase Fare			
			Train		Bus*	
	Bus	Train	1 day	28 day	1 day	28 day
Boston, MA – New York, NY	3:50	4:05	$107	$52	$25	$19
Chicago, IL – Indianapolis, IN	3:25	5:05	$24	$24	$29	$25
Chicago, IL – St. Louis, MO	5:30	5:30	$39	$39	$19	$17
Dallas, TX – Oklahoma City	5:10	3:58	$47	$37	$34**	$24**
New York, NY – Rochester, NY	7:35	6:38	$106	$62	$57	$38
New York, NY – Washington, DC	4:25	3:13	$123	$86	$25	$17
Portland, OR – Seattle, WA	3:50	3:40	$35	$27	$19	$18

*All bus fares shown are for either BoltBus or Megabus, whichever is lower, except for the Dallas–Oklahoma City corridor. Megabus and BoltBus fares are increased by $1.50 to reflect the booking fee they impose on one-way or round trips.

**Bus fares shown are for Greyhound Express and have been adjusted upward by $3.10, and rounded to the nearest dollar, to reflect the facility fees that carriers charge. (This was determined to be the average fee imposed for bus travel in the markets shown on the table.)

- The differences between bus and trains fares are greatest in the NEC, where they are often in the $60 to $80 range. The differences are smaller, about $20, in the Midwest, and smaller still on the Portland–Seattle corridor, where the gap is around $10 to $17, or about 40% to 33% less.
- In some instances, however, bus fares are *higher* than train fares. This is often the case, for example, on the Chicago–Indianapolis corridor.

8.3 NCRRP Attitudinal Model for Intercity Bus Travel

This project has created a new structural equation model which helps fill the void in understanding the dynamics of bus–rail competition. Of particular value are the STE coefficients, which show how the attitudes and preferences of a traveler affect her/his propensity to travel on the intercity bus. This section reviews these effects and illustrates the implications for policy makers and service providers.

8.3.1 Content of the Model

A diagram of the full bus model is shown in Figure 47, with the latent factors representing the four longer-term values on the left-hand side of the diagram. These four latent factors reflect the use of 11 observed variables, as originally shown in Figure 36 in Chapter 4. The latent factors concerning short-term attitudes and the outcome factor are shown in Figure 48; they are different from the earlier rail model, as they concern the propensity to take intercity bus.

8.3.2 Explanatory Factors for Taking Bus

The factors most important for bus travel, ranked with respect to their STE, are as follows:

- A belief that bus travel is inconvenient
- The extent to which a person has a strong auto orientation
- A belief that bus travel is less stressful than driving
- The value one places on privacy in travel
- Concern that the bus trip has issues of personal safety

A comparison of the STEs on the propensity to travel by bus and train appears in Table 32.

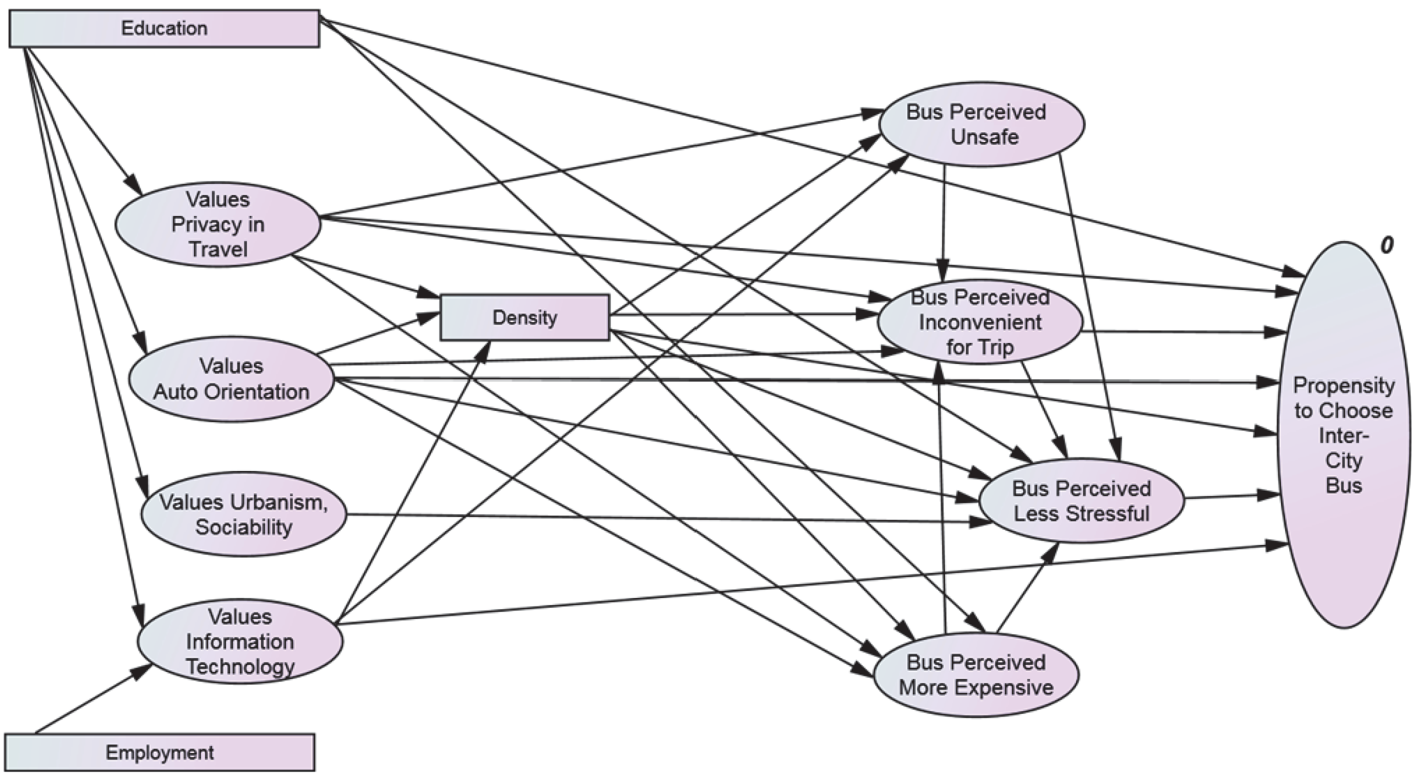


Figure 47. Attitudinal Model for Bus based on results of the NCRRP 03-02 survey (2014, n = 5,625).

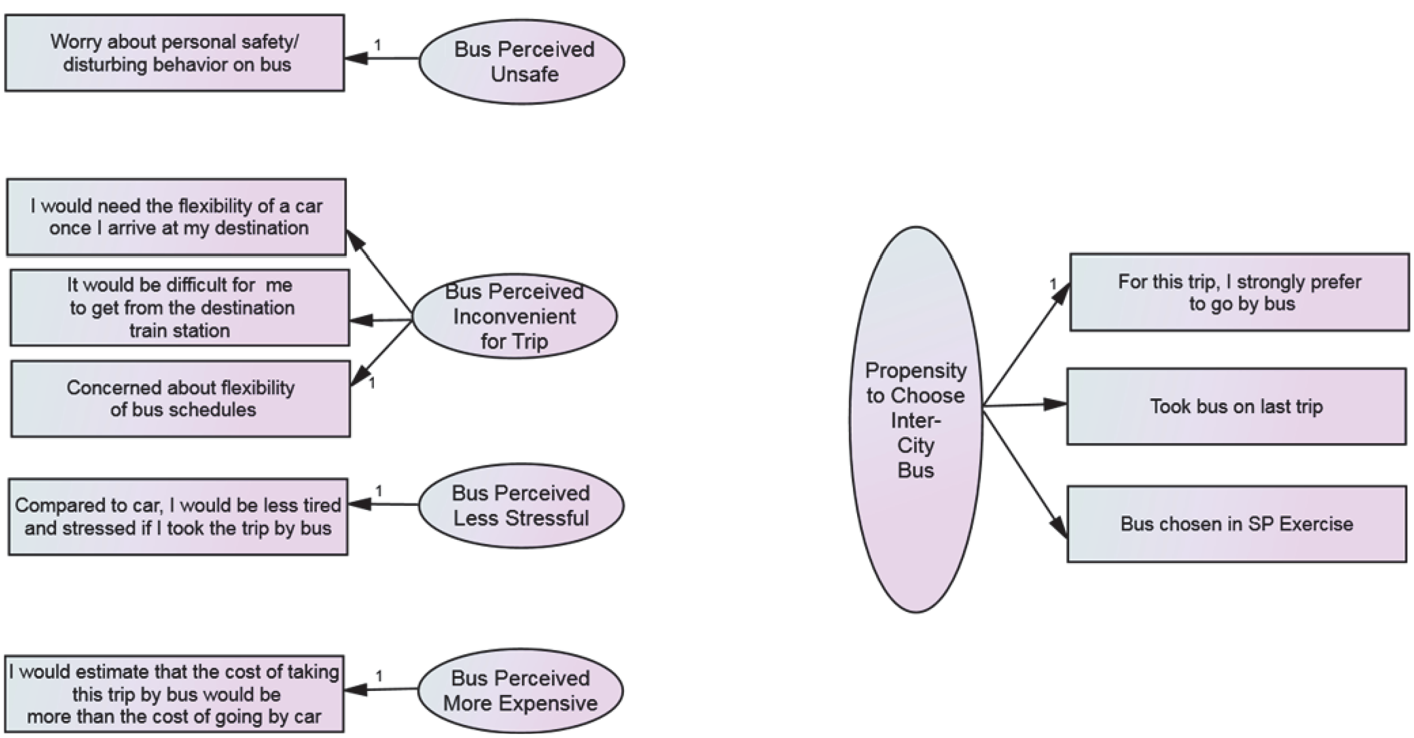


Figure 48. Four short-term attitudes and outcome factor based on observed variables for bus model.

Table 32. Comparison of predictors between bus and rail model.

Bus		Rail	
STE	Predictor*	STE	Predictor*
−0.46	Inconvenient	−0.73	Inconvenient
0.42	Less Stressful	−0.34	***Auto***
−0.39	***Auto***	0.33	Less Stressful
−0.13	***Privacy***	−0.29	***Privacy***
−0.10	Unsafe	−0.22	Unsafe
−0.10	*Education*	0.19	***ICT***
−0.09	Expensive	−0.15	Expensive
0.06	***ICT***	0.09	*Education*
0.06	***Urbanism***	0.03	*Employed*
0.05	*Density*	0.03	***Urbanism***
0.01	*Employed*	N.S.**	*Density*

*The four basic values are shown in ***italic bold***; the four short-term attitudes are shown in roman; and demographics are shown in *italic*.
**N.S. = not significant

8.4 Interpreting Results from the NCRRP Attitudinal Model for Intercity Bus Travel

8.4.1 Convenience and Cost

The Attitudinal Model for Bus provides some new evidence about how perceptions of convenience and cost affect bus travel.

Convenience

On the one hand, perceived convenience of taking the bus ranks as the highest predictor of the propensity to take the bus. However, even though perceptions about how bus schedules are inconvenient have the greatest STE in the bus model, it is markedly lower than that for rail travel (STE of −0.46 and −0.73 for the bus and rail model, respectively). Young travelers, who, on average, earn less than older travelers and are especially apt to travel by bus, may consider the opportunity cost of a couple extra hours onboard to be far less consequential than the typical Amtrak rider.

The extent to which the train is inconvenient is a far more powerful predictor of mode choice than is the extent to which the bus is inconvenient. While buses are often slower than trains, they go more places more directly, and more often. As discussed, the lower level of correlation between variation in perceived convenience with variation in choice with bus may reflect a lesser array of alternatives available for those who choose bus. But, for both modes, a perception that the service is inconvenient is a powerful factor in the prediction of mode selection.

Perceived Cost

The bus trip is seen as more expensive than the car trip by 33% of the NCRRP sample, while the train trip is seen as more expensive by 65%. For those who actually took the bus on their last trip, only 19% of them thought the bus was more expensive than the car.

The propensity to travel by bus is less closely linked to perceptions about cost than is train travel, although the effect for both modes is small (−0.09 for buses and −0.15 for trains). Consistent with the observations about convenience for the bus user, the small standardized effect on bus travel may reflect a pervasive belief that bus travel is generally the lowest-cost option when compared to trains and planes. Further, it may also reflect the fact that those who do choose bus are more constrained in their options. Consequently, few passengers are avoiding bus travel based on the perception that it is expensive.

Implications. The considerations about convenience and cost mentioned so far may have several notable implications:

- **Amtrak and other rail-passenger operators can invest in service improvements to attract passengers valuing convenience to a much greater extent than bus operators.** Whereas most rail routes hold the prospect of improved speed, bus companies have fewer opportunities to improve service in this way. Most major bus routes already operate either with nonstop or limited-stop service at high frequencies. The maximum speed of travel is determined by federal law. Amtrak, however, can make investments to allow gradual improvements to convenience with respect to both speed and frequency.
- **To the extent that Amtrak has been vulnerable to a shift to buses in the largest markets, the shift has probably already largely occurred.** Buses operate at least hourly service in most major NEC markets. For example, at least 60 buses operate daily in each direction between New York and Boston. Intercity bus frequencies are at least twice those of Amtrak in most routes in other parts of country. Between Portland (Oregon) and Seattle, BoltBus and Greyhound together operate 14 trips daily, whereas Amtrak operates five. Further improvements to the frequency of bus service will likely have only marginal effects on the perceived convenience of bus service.
- **Rail operators may be vulnerable to the establishment of bus service to and from new urban and suburban locations that are closer to a traveler's origin or destination.** New bus services to and from "neighborhood" locations can attract convenience-oriented travelers by offering pickup and drop-off locations that are easier than more centralized stations. As a result, passenger rail faces a greater traffic loss as a result of the expansion of bus services on NEC routes from lightly served locations, such as Bethesda and College Park, Maryland, and Lorton, Virginia, rather than from central Washington, DC, which is already saturated with service.
- **The advent of premium bus services can make bus travel more attractive to passengers, although the market potential of these services remains unclear.** Premium bus services are more costly to travelers but offer more spacious seating arrangements and make stops at luxury hotels and air terminals. The recent expansion by Vamoose Gold Bus, as well as Royal Sprinter's luxury service in the New York–Washington market, fall into this category. The marketing efforts of these companies, which offer first-class style seating and have onboard attendants, tend to focus squarely on trying to win the loyalties of existing airline and rail passengers. These carriers quite explicitly "sell" privacy to passengers who are wary of bus travel but can do little to eradicate the disadvantages of buses with respect to reliability. At present, these luxury carriers have only a small market niche, operating a handful of trips per day.

8.4.2 Privacy and Safety

The results of the NCRRP 03-02 survey should be of concern for advocates of *all* public modes in long-distance travel: *nearly half* of those in the total sample reported that they worried about personal safety or disturbing behavior on the bus trip. This is considerably higher than that reported for either the train or air, both at around 30%—but even these are worthy of further exploration. By contrast, most people do not worry about disturbing behavior when they take a trip by car (Figure 49).

Further, the overall level of concern is not strongly related to the propensity to use the bus. Table 32 shows that the effect of perceiving the bus as unsafe on the propensity to take the bus is

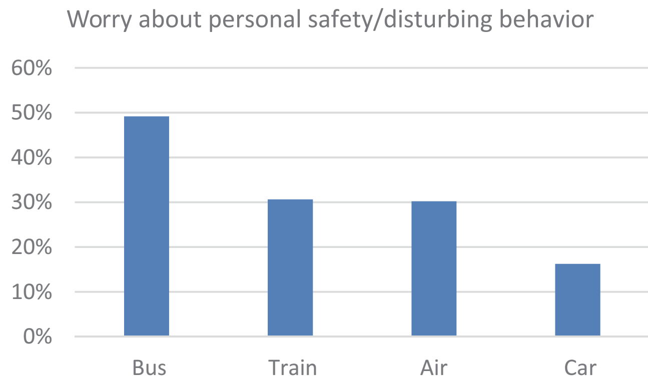


Figure 49. Concern about personal safety is highest for bus.

relatively small (–0.10), ranking fifth in the explanation of bus use. Perceptions of personal safety therefore have a much smaller effect on bus travel than rail travel (–10 and –0.22, respectively). Bus travelers are more likely to face severe budget constraints and may thus have few alternatives to bus travel. In the same way that bus riders, compared to train riders, are less likely to act on their concerns regarding perceived inconvenience, they are also less likely to act on their concerns regarding personal safety.

Perhaps more encouraging is that the high overall level of concern for personal safety stems mainly from those who do *not* use the bus. For those who did report using the bus, their propensity to worry about personal safety (Figure 49) was very similar to the general population's level of worry about the train and bus (approximately 30%).

Looking at the value of privacy in travel (derived from survey questions not specifically designed to elicit different responses between bus and rail), bus users have a somewhat lower need for privacy. They also report not minding traveling with people they do not know and report less discomfort when being with people they do not know (Figure 50).

For the public, concerns about personal safety in bus travel can loom large. These differences might be explained in part by concerns over the loss of privacy created by the need to "rub elbows" with less-affluent demographic segments when traveling by bus. Anecdotal reports also suggest

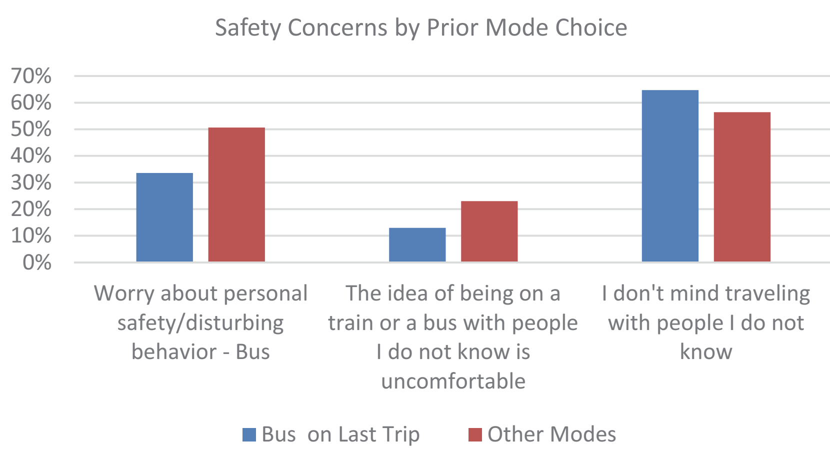


Figure 50. Individuals traveling by bus report less concern about personal safety.

that many older travelers harbor unpleasant memories of their interactions with fellow travelers on Greyhound and Trailways trips years ago. These travelers may remember invasions of privacy as one of the greatest perils of choosing this mode. However, as noted in Figure 50, these negative perceptions are in contrast to the evaluation of bus travel by those who actually took the bus recently.

The higher density of seating on buses may similarly add to public concerns about the lack of privacy with bus travel (Seat width on Amtrak is generally about 23 inches compared to about 18 inches on major bus lines). Crowding at curbside locations and conditions at bus terminals may further contribute to the negative perception of bus travel.

Implications. The high degree of concern about personal safety in the bus trip, and the more general desire for privacy in travel, could have several implications:

- **Bus ridership is negatively affected by the views—largely by those who have not experienced the bus recently—that the bus trip is unsafe.** While the reported standardized effects are lower than might be expected, they are negative and statistically significant.
- As reported earlier, **the millennial generation is more likely to hold these views about privacy and personal safety than the older generations.** Chapter 6 has explored alternative possible futures looking only at rail; the available results from the attitudinal modeling process suggest that such futures might also be relevant for the future of intercity bus.
- **Arguments that the quality of the hedonic experience at rail stations are not important are not supported by this analysis.** Years of debate over the expansion of passenger service facilities at the Moynihan Terminal may have contributed to prolonging an unacceptable level of passenger experience at the prime New York City rail terminal, as was reported in the UVM TRC rural sample, where New York City was the only city explicitly considered in that study.

8.4.3 Stress of Driving and Auto Orientation

Attitudes about cars and driving seem to affect decisions to travel by bus. Having a high level of auto orientation affects the propensity to travel by bus and train to a similar degree, but the perceived stress of driving has a slightly greater effect on a traveler's propensity to take the bus than the train. (The standardized effect concerning auto trip stress for bus travelers is 0.42, compared to rail's 0.33.)

Understanding why the perceived stress of driving has a greater effect on bus travel requires taking into account the different market segments that those modes serve. As previously noted, prior studies have documented that bus travelers are younger and have less disposable incomes than the population as a whole. For these passengers, the stress associated with driving may include (1) the difficulty of finding an available car (or renting one), (2) driving on an unfamiliar route, and (3) dealing with the complexities of parking the car in environments such as campuses and downtown metropolitan areas that are less conducive to this than rural and suburban areas.

The appeal of bus travel to passengers who consider driving stressful may explain why Megabus and other bus lines place more emphasis on promoting their service as an alternative to the car than as a substitute for air and train travel. Relatively few promotion efforts focus on the difference in fare or the added frequencies associated with bus travel.

Implications. These perceptions about autos and perceived stress from auto travel are important for bus–rail competition for several reasons:

- **Both intercity bus and train travel are poised to benefit from the continual shift in public attitudes about automobiles and driving.** Many factors contributing to the perceived stress of driving—congestion, tolls, and parking costs—appear to be on the rise. As a result, the portion of the population with higher levels of auto orientation do not appear likely to rise anytime soon, given the evident preferences of millennials.

- **Rising highway congestion is clearly beneficial for rail operators but will remain a double-edged sword for bus companies,** benefiting them by increasing driver stress but also hurting them by making their rides longer and less predictable. An increase in highway congestion will no doubt further add to the perceptions of bus travel as "more inconvenient" than rail.
- **Issues such as a society's view of auto ownership remain almost entirely beyond the control of rail and bus companies.** How quickly these factors might change remain difficult to predict. One might reasonably expect, however, that the trends will be most favorable in densely populated areas with severe congestion.

8.4.4 Urbanism and Urban Location

Neither a traveler's preference for urbanism/sociability nor the density of their residential setting has discernable effects on the propensity to travel by bus—a finding with several notable implications for bus–rail competition. The small standardized effect of urbanism/sociability for bus travel (0.06) and train travel (0.03) suggests instead that these considerations are largely inconsequential for the bus industry's—or Amtrak's—recent growth in ridership.

This result seems to run counter to the idea that many travelers choose buses and trains because these modes allow them to experience the full range of cultures, places, and experiences that urban living offers. Whereas their parents may have been pessimistic about bus and train travel due to their aversion to urban living, this logic goes, the new generation of bus/train riders would be attracted to it for this reason. The small coefficients, while being positive, suggest that this conclusion needs to be further explored with some caution and skepticism.

Implications. The issues concerning urbanism may shed light on several aspects of bus–rail competition:

- **The absence of a clear link between attitudes about urbanism and train and bus travel helps explain why Amtrak has experienced stronger traffic growth between smaller cities and more rural intermediate points than between certain major cities.** Much attention has been given, for example, in the large share of ridership on prominent Amtrak "string of pearls" networks that move between smaller cities, where an affinity toward urbanism may be less strong, than that of large terminals.
- **The results might shed light on why Megabus's expansion to cities with lower population density (such as those in Florida and Texas) has apparently been successful, in spite of the fact that these cities lack the robust transit systems and pedestrian-oriented neighborhoods of Northeast and Midwest cities.** Passengers in these less densely populated areas appear to have less aversion to the idea of bus travel than might have been anticipated several years ago, when major hubs for express city-to-city services were concentrated in dense transit-oriented cities.

8.4.5 Role of Information Communications Technology

Attitudes about the importance of using information technology have a greater effect on the propensity to ride trains (0.19) than to ride buses (0.06). This result may reflect the higher propensity for business travelers (who place a higher value on their time) to go by train than bus. On most routes, trains offer three tech-friendly amenities—tray tables, power outlets, and generous seat pitches—that allow for passengers to, in effect, create mobile offices while they travel. Research from 2011 shows that the Acela Express is effectively in a class of its own with respect to technology use, with more than 60% of passengers engaged with devices at randomly observed points in time, much higher than on buses (Schwieterman and Fischer 2011a).

The environment onboard standard intercity buses is generally less conducive to this level of technology engagement, although the free Wi-Fi is a "plus." Even the small effect of this variable on bus travel is noteworthy. Research by the Chaddick Institute shows that the share of time that bus and train travelers spend on portable electronic devices has grown dramatically in the past 5 years and that usage rates are similar between modes (Schwieterman and Fischer 2011b). Overall, technology appears to be a more important mode-influencing factor for train riders than for bus riders.

Implications. These observations suggest that several notable trends may be under way:

- **The small effect observed for both modes may reflect the sheer ubiquity of ICT in people's lives, particularly among the younger demographic segments.** This small coefficient for bus travel is largely consistent with the experiences of information technology enhancements on other modes, particularly air travel. Despite the push to install Wi-Fi on planes, relatively few passengers purchase this service, suggesting that few would change their mode choice decision if free Wi-Fi were offered.
- **The value of Wi-Fi appears to be falling as more passengers subscribe to 3G/4G services.** Several years ago, there was arguably a wider gulf in the ability to engage in digital communication on cars and buses due to the prevalence of Wi-Fi on the latter. The differences, however, appear to have diminished as more and more travelers subscribe to plans giving them access to the Internet on their smartphones.

8.4.6 Interpretation of Results from the Bus Attitudinal Model

Interpreted broadly, the results support the idea that Amtrak and intercity bus lines *both* are poised to attract a bigger piece of the market as attitudes about driving change. Rather than viewing themselves as being locked in a battle for an existing market, the modes should recognize that they have much to gain by sending a common message to prospective riders who are attracted to alternatives to the private automobile.

Moreover, the relatively low standardized effect of the cost ("expense") variable suggests that changing perceptions about cost may not result in dramatic shifts in travel behavior. Amtrak may be better off targeting its discounts and advertising to specific demographic segments that have chosen to travel by bus—especially young and "pleasure" travelers—than to lower fares across the board. The carrier should also take advantage of the enhanced privacy and conveniences that it offers; benefits that will likely persist even as the intercity bus industry grows.

Because rail travelers are more responsive than bus travelers to the service-quality variables used to forecast travel demand (e.g., convenience), Amtrak has a greater opportunity to gain ridership by improving its image in these areas than bus lines. Widening the advantage that trains have with respect to travel time would likely compel many bus riders to make the switch because convenience has the greatest effect on the propensity to choose either mode.

8.4.7 Lessons from the ICLV Model

Observations relevant to the study of intercity bus from the full ICLV model presented in Chapter 5 can be made concerning the modal constants.

The modal constants in the ICLV model in Chapter 5 provide important perspective on how the perceived desirability of traveling by bus differs from the other three modes when attitudinal factors and service characteristics (such as travel time and cost) are held constant. The most notable findings include the following:

- Regardless of gender, business travelers rank train travel first and bus travel last among the four modes. The fact that these passengers rank bus travel at the bottom is consistent with the common observation that briefcase-carrying business travelers are still relatively scarce on most intercity bus routes.
- For female business travelers, air and bus are essentially tied for last.

Travelers who are highly educated (i.e., have a graduate degree) are also less likely to go by bus than those who are not. Travelers who are employed are less likely to go by bus than by the other modes, regardless of the trip purpose. These results suggest that bus service generally behaves as an "inferior good," especially for business travel, diminishing in prevalence as income status rises when all other factors are held equal. High income or highly educated travelers will generally opt for bus travel only when latent factors (attitudes) render them predisposed to do so or when some aspect of that mode, such as cost or travel time, offsets the mode's perceived disadvantages.

On vacation trips, buses fare better, ranking second—behind only trains—for males and third—behind rail and air—for females. Both males and females nevertheless rank bus travel last for trips involving visits to family and friends. Similarly, travelers are more apt to avoid buses for visits that require an overnight stay than those that do not. Travelers in groups, and especially those with three or more travelers, also rank bus travel much lower than other modes.

Knowing a passenger's age can also help predict whether he/she will be inclined to travel by bus when, again, the attitudinal factors are included in the equation. Older travelers (those over 55) tend to reject bus travel for trips to visit friends and relatives. Young travelers, however, have a stronger affinity for bus travel than for rail. Respondents under 35 have a significantly higher aptitude to go by bus than older respondents. Attitudinal factors appear to magnify the propensity for youthful travelers to choose buses, illustrating why this sector has been a core constituency for bus lines in recent years.

CHAPTER 9

Competition Between Rail and Air

9.1 Introduction

This chapter gives a brief summary of new research done by NCRRP to better understand how the competition from air may be different from the competition from other modes. The chapter explores a newly documented interaction between *improvement of rail travel time* on the one hand and *variation in air price* on the other hand. The new implications of this interaction are summarized for the policy maker.

Passenger rail systems interact with aviation systems in several ways. This chapter will help the transportation community to understand the manner in which rail makes a contribution to the intermodal system by diverting traffic from congested airports. In this diversion process, the full system *may* become more efficient as airports become more focused on critical long-distance trip making; rail can efficiently transport people in shorter-distance contexts. For this exploration of rail in a competitive mode, the data, tools, and methods need to be in place to support the analysis of multimodal and intermodal systems and strategies—with particular attention to the day-to-day competition with air services. The NCRRP 03-02 research team examined the market-based performance of these competitive services, commenced the examination of the adequacy of the analytical tools available, and developed new tools in response to the gaps revealed.

Several models exist concerning forecast travel behavior involving mode choice decisions between rail and air. In some cases, those models are considered proprietary, such as those used by Amtrak for detailed market research in its competitive environment. On the West Coast, an elaborate model of rail demand has been developed in order to meet the very exacting requirements for the California High-Speed Rail Authority's project development and environmental documentation. While that model is extremely thorough in its approach, it was never designed to serve as an analysis tool for quick and cost-effective analyses of public policy options. Thus, a gap has existed in the ability of researchers and practitioners to model the interaction of air and rail.

The NCRRP 03-02 research team continued the development of the ACRP's air/rail diversion model to fill this gap. The continued work on this air/rail diversion model (Figure 51) was envisioned to produce a strategically designed analysis tool to address specific questions about consumer preferences and tradeoffs in response to conventional rail/high-speed rail (HSR) and air service modifications. The model was designed as an efficient, quick-response tool useful for realistic planning-level scenario analysis and it includes only tradeoffs between air service and both conventional rail and HSR, omitting tradeoffs with both auto travel and intercity bus. This NCRRP project has developed refinements to the model to help improve understanding of the relationship among several key factors in the explanation of the choice of mode between air and rail, which, when seen in a scenario of improved rail services, is associated with the diversion from air to rail. The model is best used as a learning tool at an early concept stage of planning to determine basic impacts

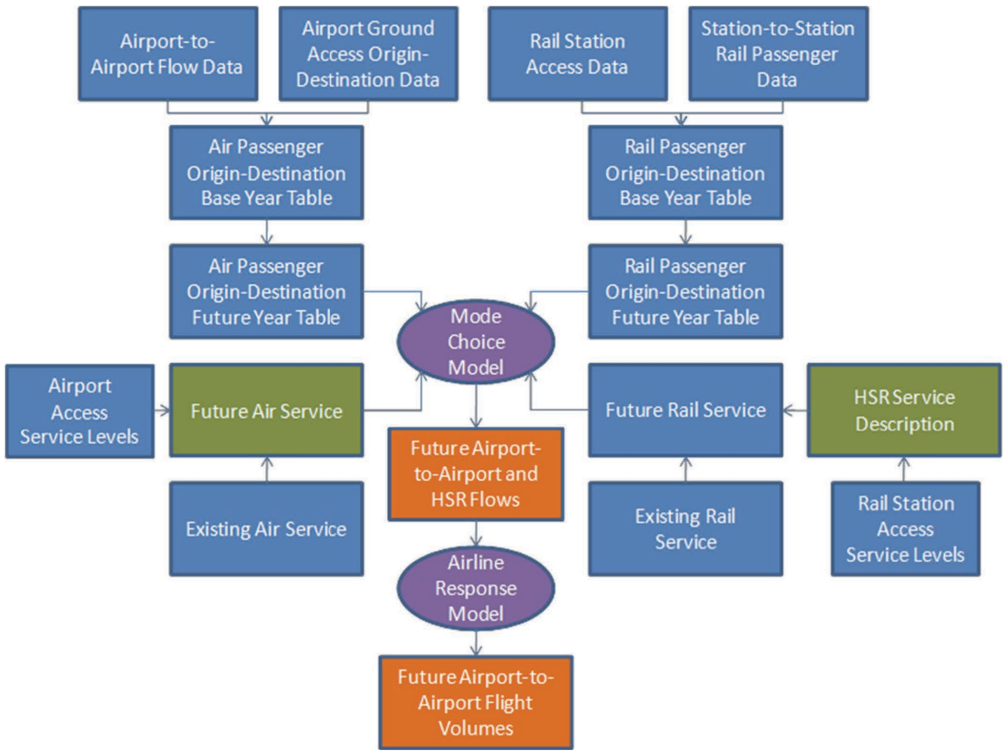


Figure 51. Model of air/rail diversion, expanded for NCRRP.

of a series of actions/investments so that a decision can be made on whether to engage in more detailed analysis.

9.2 Air/Rail Diversion Model

The air/rail diversion model allows policy analysts to study possible air and rail diversion for two study years (2008 and 2040) by altering seven global (system-wide) variables for rail/HSR and air service levels. These variables are *rail in-vehicle time* (IVT), *air IVT*, *auto IVT* for auto access to airport or rail station, *rail fare*, *air fare*, amount of *rail service* (frequency), and amount of *air service* (frequency). The model users can alter the scales or levels of service for each of these variables to analyze implications under different scenarios. The model has been applied in two North American study areas—the NEC ("East Coast") and California ("West Coast")—where there is considerable availability of both air and rail modes, meaning that many long-distance travelers have a reasonable choice between the modes.

There are largely five categories of data input for the model: socioeconomic data, rail station access data, airport access data, rail service description data, and air service description data. The model takes the input variable parameters and implements an eight-step model procedure to produce the output of rail and air trips by origin and destination.

9.2.1 Air/Rail Diversion Model Sensitivity Analysis

In order to understand how the global variables affect the outcome (number of rail trips) in the model, the research team conducted a sensitivity analysis. The basic idea behind sensitivity analysis is to measure how variations in the output can be attributed to variations in the input. The goal of sensitivity analysis in the context of the air/rail diversion model is to measure relative impact or importance of each of the seven global variables, i.e., *rail IVT*, *air IVT*, *auto IVT*, *rail fare*, *air fare*, *rail service* (frequency), and *air service* (frequency).

To complete the sensitivity analysis for the NCRRP 03-02 project, the research team chose to use partial inclination coefficients (PICs) because they allow any number of simulations to be run. PICs estimate a model response in relation with all model input variables (Chalom and de Prado 2015). It is important to keep in mind that the resulting coefficients only reveal *relative impact* among input variables rather than their absolute impact on the outcome. In other words, these coefficients cannot be interpreted the same way, for example, the coefficients of linear regression models would be interpreted. In addition, there is no measure of goodness of fit for PICs that linear regression models otherwise produce to indicate how close to the "truth" the models are. Instead, one can infer from PICs which of the input variables affects the outcome of the model the most relative to one another. For example, model inputs *A*, *B*, and *C* with PICs of 2, –10, and 5, respectively, would indicate the following:

- The input variable *B* impacts the outcome more strongly than *A* or *C* and has a negative relationship with the outcome variable.
- The input variable *C* has the strongest positive impact on the outcome, yet this impact is, in an absolute value sense, 50% as strong as the impact of *B*.

To implement PIC analysis, the research team first ran 200 simulations of East Coast air/rail diversion using random samples for each of the seven input variables. The input variables are in the units of percentage scales with their default values set to 1, indicating 100% of the existing values. For example, the default scale of the input variable *air fare* (scale = 1) means existing average air fares. As the scale moves up to 1.2, this indicates a 20% increase from the existing values. If the current average air fare for New York to Boston were $237, an input variable scale of 1.2 would mean a 20% fare increase, or $47 ($237 × 0.02, rounded), for a total of $284. Likewise, the default scale for *rail IVT* (scale = 1) means the current average in-vehicle times for rail. When a user sets the scale to 0.7, this indicates 30% reduction in IVTs or inversely a 30% increase in rail travel speeds. For the purpose of running simulations, all seven input variable scales were varied simultaneously by using values from random samples.

The PICs are shown in Table 33 in the descending order of relative magnitude. The corresponding confidence intervals and standard errors were estimated by using 100 bootstrap replicates. Bootstrap produces measures of accuracy to sample estimates by performing random sampling with replacement within the existing sample. The bootstrapped 95% confidence intervals indicate that a PIC value will fall within the confidence interval in 95% of simulations. For example, variable *air fare* has a confidence interval of 3.74 and 4.25 and its PIC falls squarely in the interval. Therefore, its PIC of 3.94 can be trusted with a high level of confidence. On the other hand, variable *auto IVT* has a confidence interval of –0.19 and 0.27. A confidence interval

Table 33. Partial inclination coefficients.

Input Variable	*PIC (std. error)*	Confidence Interval (CI)	
		Lower Bound	Upper Bound
Air Fare	3.94 (0.12)	3.74	4.25
Rail IVT	−3.26 (0.11)	−3.44	−2.98
Rail Fare	−1.77 (0.10)	−1.94	−1.55
Air IVT	1.03 (0.11)	0.81	1.23
Rail Service	0.94 (0.11)	0.70	1.18
Air Service	−0.91 (0.12)	−1.11	−0.64
Auto IVT	0.03 (0.12)	−0.19	0.27

that contains 0 brings into question the validity of the PIC value because the PIC could easily be a negative number as well as a positive. Since the confidence interval of –0.19 and 0.27 means that the true value lies within the range, the direction of impact is indeterminable. As mentioned before, the PIC values should be used only to analyze the relative impact of the input variables.

9.2.2 Sensitivity Analysis Results

Based on the results shown in Table 33, the following factors are found to be positively or negatively correlated with the number of rail trips.

Factors That Are Positively Related to the Number of Rail Trips

- *Air fare* seems to have the most impact on the number of rail trips. The impact of air fare on rail trips is positive, such that an increase in air fare will increase the number of rail trips by diverting passengers from air to rail. *Air fare* is explored more in Section 9.2.3.
- *Air IVT* has the next biggest positive impact on the number of rail trips. Its positive PIC indicates that as the IVT increases for air travel, more passengers will divert from air to rail. However, among the top four variables, which consists primarily of fare and travel time, *air IVT* has the least impact on the outcome. Specifically, *rail IVT* has far bigger impact on the number of rail trips than *air IVT*. In other words, improving rail speeds will divert plenty more passengers from air to rail than faster air speeds will divert passengers from rail to air. Considering that air travel is considerably faster than rail at the current level, this finding may imply that the speed improvements after a certain threshold have diminishing returns.
- *Rail service* also has a positive PIC with the least relative impact on the outcome among the positively related variables. Increased *rail service*, which means more frequent rail service, will divert some passengers from air to rail but with minimal impact among these positively related variables. Unlike intracity transit in which frequency plays a big role in determining ridership, intercity travel via air and rail seems to compete more on fare and travel time rather than frequency. Within their own modes, different service providers do compete on frequency. For example, it is well acknowledged in the literature that airlines compete with one another on frequency of service to attract passengers. However, frequency seems to be less of a factor in diverting passengers between air and rail.

Factors That Are Negatively Related to the Number of Rail Trips

- *Rail IVT* is the variable with the most negative impact on the number of rail trips. *Rail IVT* inversely indicates rail travel speed. In other words, rail travel speed is highly positively related to the number of rail trips. As rail speeds improve, the *rail IVT* becomes smaller.
- *Rail fare* has the third most overall impact on the outcome of the model after *air fare* and *rail IVT* and the second most negative impact after *rail IVT*. Including the fourth variable with most impact, *air IVT*, the top four input variables with the highest impact on the outcome of the number of rail trips are fare and travel time.
- *Air service* has the least negative impact on the number of rail trips. Along with *rail service*, these service frequency variables have the least impact on the competition between air and rail.

Factors That Have No Statistical Correlation with the Number of Rail Trips

The input variable with the least impact overall on the number of rail trips is *auto IVT*. This seems intuitive because the auto access/egress time is relatively small compared to the long travel time for intercity travel. A small benefit gained from faster auto access time to rail stations, for example, is likely to be overshadowed by slow travel speeds on rail for much longer distances.

Likewise, any loss of time due to traffic congestion on the way to airports is likely to be more than compensated by faster travel time on airplanes. Additionally, *auto IVT* is the only variable whose bootstrap confidence interval includes 0, which indicates unclear direction of impact.

9.2.3 Interpretation of the Variable Interactions

The top four input variables in the descending order of impact are *air fare, rail IVT*, *rail fare*, and *air IVT*. These variables indicate that air and rail for intercity travel compete largely on these two dimensions of fare and travel time. Notably, the analysis implies that air and rail compete mainly on *air fare* and *rail IVT*; their PICs are relatively high at around 3 in absolute terms while the PICs for the other two variables, *rail fare* and *air IVT*, are around 1. This finding is intuitive. In relative terms, air travel is typically faster and more expensive than rail trips. Given the existing superiority of speed for air, the factor that causes the most diversion from air to rail is the comparative price of air service. At the current rail speeds, rail cannot compete with air directly on speed. Passengers instead make tradeoffs between speed and price and the analysis indicates that passengers respond to air fares the most in deciding to divert to rail from air.

Rail speed improvements can change this dynamic. Rail speed improvements will shorten *rail IVT* and make rail travel highly competitive with air on speed. However, *rail IVT* interacts with *air fare* in complex ways. Figure 52 shows the relationship between *air fare* and number of rail trips categorized by *rail IVT* levels. Positive slopes of the graphs indicate the positive relationship between *air fare* and number of rail trips. Each of the four curves is for each category of *rail IVT*. The top graph shows the highest rail speed improvement (lowest *rail IVT* category) and the bottom graph shows the lowest level of rail speed (highest *rail IVT* category) where rail speeds have dropped below the current level. In general, the graphs show that, as *rail IVT* becomes smaller (i.e., rail speed improves), the number of rail trips increases for any given *air fare*. However, as *air fare* becomes too small or too large, the incremental gain in the number of rail trips for *rail IVT* categories becomes smaller. The tail ends of the four curves cluster closer together than the middle of the curves. The converging tails of the graphs indicate that the ability to divert passengers from air to rail by rail speed improvements depends largely on the level of competing air fare. In other words, the effect of *air fare* seems to become so significant at these extreme levels that the rate of diversion from air to rail due to *rail IVT* improvements becomes relatively smaller. This points to

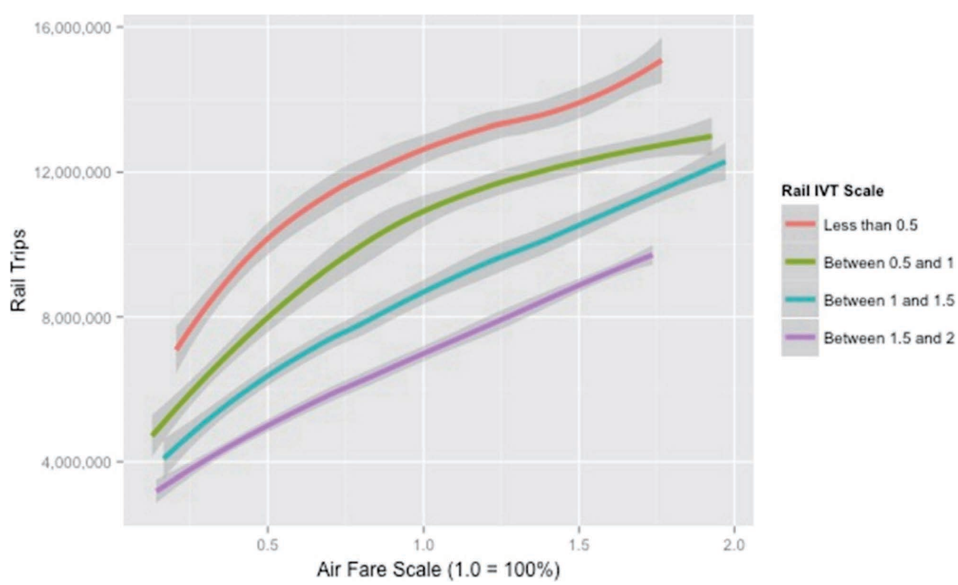


Figure 52. Interactions between air fare and rail in-vehicle time.

the dynamic relationship between fare and travel time since it shows that once speeds for air and rail have almost equalized, rail and air will compete on fare.

After *air fare* and *rail IVT*, *rail fare* has the third largest impact on the number of rail trips. As mentioned previously, the relative magnitude of *rail fare*'s PIC is considerably smaller than *air fare* and *rail IVT*. Cheaper rail fares make rail more competitive as it offsets slower speeds of rail. However, the analysis indicates that air fares command more influence than rail fares probably because air speed benefits are significantly higher than what cheaper rail fares can overcome. *Air IVT* also has a relatively small PIC. The subsequent analysis of elasticity in the following subsection shows that a 50% increase in *air IVT*, i.e., 50% reduction in air travel speed, only increases number of rail trips by 8% while holding all the other input variables at their default settings (scale = 1). Likewise, a 50% reduction in *air IVT* or 50% increase in air travel speed, with all other variables staying the same, reduces the number of rail trips (or increases air trips) by 8%. This may indicate that the current air travel speeds are so highly competitive that further air travel speed improvements or speed reductions will not divert passengers significantly.

9.2.4 Elasticity

Another way to think about these input variables relative to one another is to investigate their elasticities. Elasticity measures how responsive a variable is to a change in another variable. Applied to the model, elasticity for each variable measures how the outcome of the number of rail trips responds to changes in each of the input variables while holding the rest of the input variables at their default setting (scale = 1). Since it is unreasonable to assume a linear relationship between input variables and the outcome, elasticity is estimated at two different change points: 50% reduction (scale = 0.5) and 50% increase (scale = 1.5) of input variables. First, the model is run with one of the input variable scales changed to 0.5 while everything else is held at 1. This is then repeated for the same variable changed to 1.5. This is done for all of the seven input variables. The resulting outcome of numbers of rail trips is summarized in Table 34.

Second, the percentage changes of the resulting outcomes from their default settings are calculated. At the default setting where every input variable is set to their current existing level (scale = 1), the model estimates 9,584,950 rail trips. Elasticity is calculated by dividing the number of rail trips for 0.5 scale and 1.5 scale, respectively, for each variable by the default number of rail trips. Table 35 summarizes elasticity for each of the variables in the descending order of input elasticity.

The order of input variables according to elasticity corresponds to the ordering of variables by their PICs. *Air fare* has the highest elasticity; 50% reduction in air fares while holding everything else constant reduces the number of rail trips by 30% and 50% increase in air fares likewise increases the number of rail trips by 20%. *Rail IVT* has the second highest elasticity in the opposite direction;

Table 34. Number of rail trips for elasticity estimation.

Variable	Number of Rail Trips		
	Scale = 0.5	Scale = 1	Scale = 1.5
Air Fare	6,735,100	9,584,950	11,487,350
Rail IVT	11,899,600	9,584,950	7,795,250
Rail Fare	10,804,800	9,584,950	8,369,900
Air IVT	8,789,600	9,584,950	10,326,100
Rail Service	9,118,500	9,584,950	9,776,050
Air Service	10,032,100	9,584,950	9,429,300
Auto IVT	9,580,400	9,584,950	9,587,950

Table 35. Elasticity for input variables.

Variable	Change from Existing Values (Scale = 1)		
	Scale = 0.5	Scale = 1	Scale = 1.5
Air Fare	−30.00%	0%	20.00%
Rail IVT	24.00%	0%	−19.00%
Rail Fare	13.00%	0%	−13.00%
Air IVT	−8.00%	0%	8.00%
Rail Service	−5.00%	0%	2.00%
Air Service	5.00%	0%	−2.00%
Auto IVT	−0.05%	0%	0.03%

50% reduction in *rail IVT* increases the number of rail trips by 24% while 50% increase reduces it by 19%, everything else held constant. They are followed by *rail fare* with 13% and −13% elasticity for 0.5 scale and 1.5 scale, respectively. Elasticity for the remaining four input variables quickly drops below 10%. *Auto IVT* has the smallest elasticity of −0.05% and 0.03%; 50% reduction in auto in-vehicle time to access airports/rail stations results in 0.05% increase in the number of rail trips. Since *auto IVT* includes access time to both airports and rail stations, the direction of change is ambiguous. However, the negligibly small elasticity for *auto IVT* indicates auto access constitutes a very small part of the competitive decision between air and rail.

9.3 Case Study Example: New York City–Boston

For a case study, the research team simulated the New York City–Boston intercity corridor to illustrate the results of the sensitivity analysis. In Figure 53, the dotted line represents the level of rail trips between New York City and Boston when only *air fare* is changed while all the other variables are held at the existing level (scale = 1). Point A is therefore the default level of rail trips when all the variables are held at the existing level including *air fare.* Using the average air fare from US DOT ticket data for 2013 (around $237), the model predicts about 423,000 rail trips between New York City and Boston. Assume that in the near future Amtrak improves its average

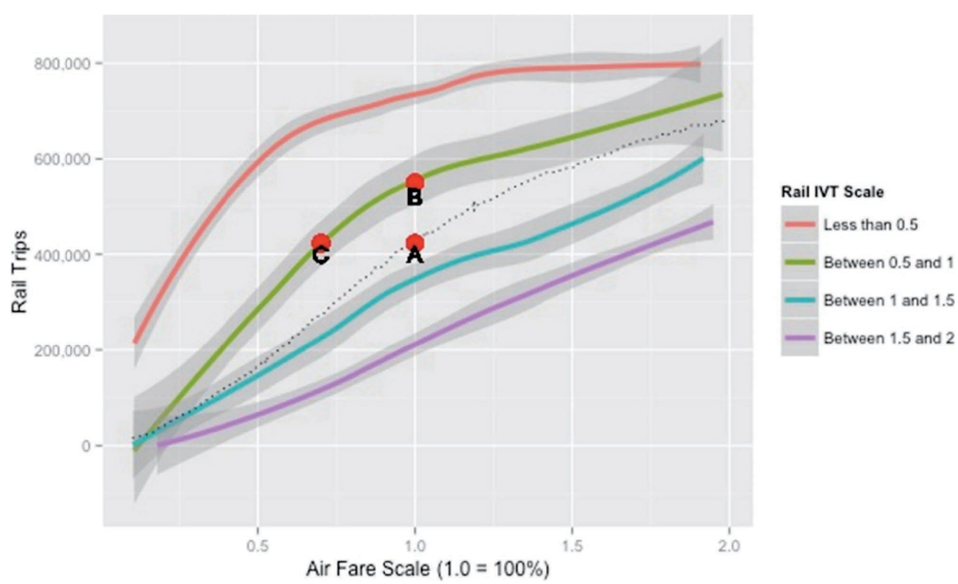


Figure 53. Impact of air fare on rail trips (NYC–BOS).

train speed by about 25%. In other words, now the *rail IVT* would be about 25% less than the existing level (scale = 0.75).

The model indicates that such reduction in *rail IVT* would move the number of rail trips from point A to B, about 550,000 rail trips including diversion from air. In this scenario, airlines can regain the diverted trips from rail by reducing air fare. By reducing air fares, the number of rail trips would move down along the graph to point C. The quick downward tail of the graph also indicates that as airlines keep reducing fares, the rate of diversion from rail to air increases. On the other end of the graph, there seems to be a saturation effect where increases in rail speeds result in smaller gains for each *rail IVT* scale category. In other words, as air fares increase to almost double their existing levels (scale = 2), the rail trips seem to hit a ceiling and flatten out around 800,000, indicating there is less and less to be gained from rail speed improvements when air fares become increasingly high to near prohibitive levels.

One implication is that, in the event that future air fares increase to pre-deregulation levels (maybe due to fuel shortage), most passengers will have already diverted to rail and rail speed improvements will only add incrementally to the diversion. Likewise, if air fares substantially decline from the current levels (maybe due to new fuel technology), passengers will divert from rail to air, but rail can retain some of the potential diverted passengers by improving rail speeds to be more competitive. In this case, rail improvements will potentially bear future benefits if air fares subsequently increase diverting passengers from air to rail. In all, air fare and rail speeds seem to be major factors that influence the dynamic relationship between air and rail passengers.

Rail IVT has a negative relationship with rail trips where increase in *rail IVT* (or decrease in rail speed) will decrease the number of rail trips, diverting passengers from rail to air. Both Figures 53 and 54 also show that as air fares become cheaper (*air fare* scale decreases), the overall number of rail trips decreases, as shown by the descending curves for each *air fare* scale category. The effect of decreased air fares can be counteracted by faster rail speeds. However, when air fares hit extremely low levels (see *air fare* category "Less than 0.5"), rail speed improvements will only recover a small portion of the diverted passengers. For the other three categories of *air fare* scale (0.5 to 2), rail speed improvements can divert a significant number of passengers from air to rail. Figure 54 suggests that, after a certain point in rail speed improvements (around *rail IVT* = 0.5), there appears to be a ceiling for number of rail trips, as is shown by the converging tails on the left end of the curves.

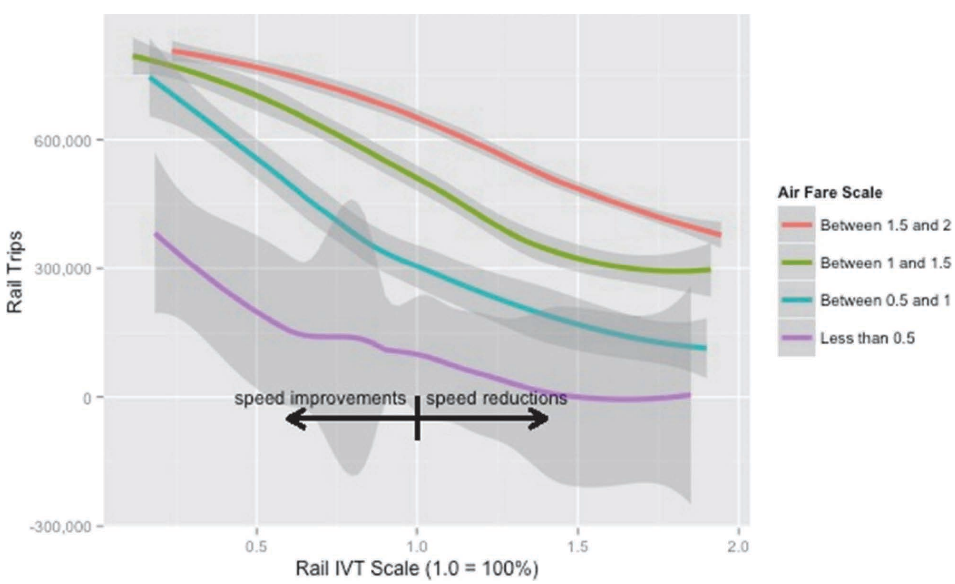


Figure 54. Impact of rail in-vehicle time on rail trips (NYC–BOS).

The only curve that does not converge is *air fare* scale category "Less than 0.5," again highlighting the drastic effect that extremely low air fares have on passenger diversion.

9.4 Conclusion

In this analysis, the research team employed the air/rail diversion model to study the interaction between air and rail/HSR service levels and how these service-level variables affect rail demand. The seven service variables included were *rail IVT*, *air IVT*, *auto IVT* for auto access to airport or rail station, *rail fare*, *air fare*, amount of *rail service* (frequency), and amount of *air service* (frequency). The variables affecting rail demand the most significantly were found to be *air fare* and *rail IVT*. The impact of air fare on rail trips is positive (such that higher air fares encourage air travelers to divert to rail), while the impact of *rail IVT* is negative. Compared with *air fare* and *rail IVT*, the remaining variables either had a small or nonstatistically significant effect on rail demand.

The implication of the sensitivity analysis result is that, when considering rail demand, there is significant interaction between rail speeds (or IVT) and air fare. A reduction in air fare can divert passengers from rail to air; however, the effect of decreased air fares can be counteracted by faster rail speeds. Yet the results of the analysis suggest that there are diminishing returns to rail speed improvements. Rail speed improvements in general divert passengers from air to rail as rail speeds become more competitive with air speeds. Yet competing air fare can significantly alter the level of diverted passengers. Specifically, low air fares, around 50% of existing average air fares, would significantly reduce the number of diverted passengers from air to rail. In addition, as rail speeds improve, there seems to be a ceiling where no further speed improvements will divert a substantial number of passengers from air to rail. Although the exact point of diminishing returns will be different depending on the routes, the result suggests that improving rail speed has a small effect on rail ridership when air fare is relatively low. When considering rail speeds, there may be a point after which further investment in rail speed improvements will start to divert fewer and fewer passengers from air to rail for each dollar spent.

In short, air fares, for which relative rail demand is highly responsive, may be more important to rail ridership than rail travel time. Overall, the results indicate that any initiative focused on increasing rail ridership must consider that the responses from competing modes of travel, especially air, can change the policy outcome. The findings underscore the criticality of analytical modeling tools through which the tradeoffs between modal service variables can be analyzed and for these modeling tools to be cross-modal. As the largest impact on rail ridership is a service-level variable pertaining to air service, it is clear that intercity planning must take place in a cross-modal context with high-fidelity analysis tools that provide actionable and policy-relevant information.

CHAPTER 10

Bringing It All Together: Where Do We Go from Here?

As detailed in Chapter 1, this research project employed several research methods to explore the concept of integrating both "hard" and "soft" factors in the analysis of intercity travel demand into one, unified approach—an approach that assumes the existence of several alternative scenarios for the background market conditions in the future. Central to this research is the concept that one, single vision of what the future holds cannot be predicted, but the research team can create alternative scenarios for different underlying markets—all of which directly acknowledges uncertainty as an integral part of the analysis of future travel behavior.

This final chapter seeks first to bring together several of the threads of research reported in the previous chapters and second to suggest the implications of this integrated approach on the nature of further research needed to bring this about.

10.1 Bringing Together the Separate Themes: What Was Learned

10.1.1 Incorporating Uncertainty into the Planning Process

In a recent article in the *Journal of the American Planning Association*, Noreen McDonald writes,

> "Failure to address uncertainty may also lead to increasing challenges to transport plans by the public and judiciary. For example, a federal court recently ruled that the North Carolina Department of Transportation had failed to meet National Environmental Policy Act requirements because they did not consider uncertainty in growth forecasts (Catawba Riverkeeper Foundation v. NC Dept. of Transportation, 2015). . . . *Planners concerned about uncertainty with millennial travel can use two strategies: Improve travel demand models and adopt a scenario planning approach* to consider how different trajectories for the travel of millennials could influence infrastructure needs." (McDonald 2015)

Perhaps going beyond the recommendation of McDonald, this project has suggested a new direction for analysis of intercity travel demand by applying improved travel demand **models** directly into creation of alternative **scenarios** for the future.

Chapter 6 presented four illustrative market settings for intercity travel created by the scenario testing tool, presented again as Table 36. In order to approach in the issue in cautious manner, those four scenarios reflected four possible resolutions of key unknowns in the future values of several cohort groups. Within Chapter 6, the scenarios included no variations in the quality of service characteristics nor variations in possible demographic mixes, for example.

This section of Chapter 10 provides an illustration of how more categories of variation could be brought together in a later application of this integrated process. Given that Table 36 specifically does not deal with variation in service characteristics of any kind, the interaction between such market scenarios now need to be explored with reasonable assumptions of candidate policies toward improved infrastructure, improved service levels, and alternative costs.

Table 36. Four scenarios with cultural change but no service changes.

Decreasing Role of Auto Orientation in Future →		*Decreasing Concern for Privacy in Travel in Future →*
Pessimistic for Rail • Bad future for auto rejection • Bad future for privacy tolerance • ICT need will decrease with age ***Rail decreases by 4%***	*Mixed Scenario B* • Good future for auto rejection • Bad future for privacy tolerance • ICT need will decrease with age ***Rail increases by 4%***	
Mixed Scenario A • Bad future for auto rejection • Good future for privacy tolerance • ICT need will continue with age ***Rail increases by 10%***	*Optimistic for Rail* • Good future for auto rejection • Good future for tolerance • ICT need will continue with age ***Rail increases by 18%***	

10.1.2 How Do the Factors Interact?

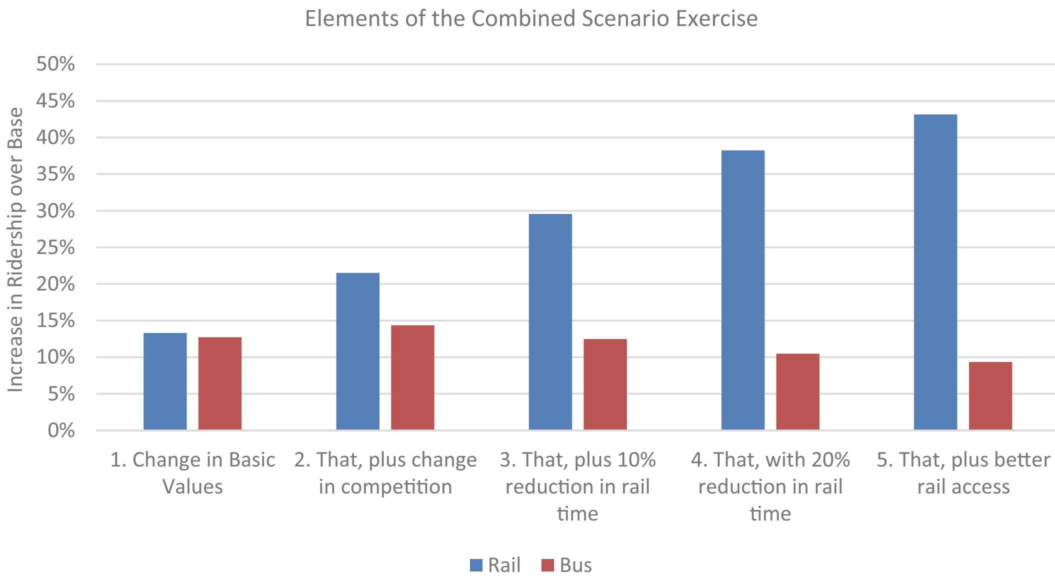
How cultural values interact with more traditional indices of transportation service levels and costs should be explored in some detail in further research. For the purposes of this section, the research team took one, and only one, "cultural future" (holding it constant) and examined four service levels applied to that future market, just to establish some sense of scale of the two themes in the research. The reader should be aware that all scenarios have been designed to reveal characteristics of interactions; there is no attempt in this section to propose a most likely forecast for rail in the study area.

The research team created a single, somewhat optimistic future cultural scenario for this exercise. It is optimistic in that the research team specifically assumed that with the passage of (say) 20 years, the millennial generation (now in a more senior age category) will have lessened its fear of traveling with others, and of traveling on rail, specifically. This level of concern for privacy is posited to drop to that of those presently in the 35–44 age group. Consistent with this optimism about fear of travel being dealt with, this scenario posits that attitudes about privacy for those with no college degree will come to mimic those with a college degree and that attitudes about privacy for those with less than full employment will come to mimic those will full employment. The research team further hypothesized that generation Z would also have less need for privacy in travel than the present occupiers of that age category, the millennials.

The single future cultural scenario hypothesizes that the current high feeling of independence from the auto held by the millennials will drop to that of those currently in the 35–44 age group, as they face the child-rearing decades, resulting in a moderately less favorable climate for rail (by way of example, if the level of auto dependence mimicked that of the current over 65 age group, the impact on rail would be more negative than assumed using the attitudes of the current 35–44 age group).

As shown in the first column of Figure 55, such a "culture" of values would be associated with a 12% increase in rail ridership, *ipso facto* in a world where all other variables were held constant.

Moving to the next step (the second column from the left in the graph), the examination of factors not under the control of the rail sector is continued. Here, the exercise assumed that, over time, highway travel times would increase by 10% and auto costs by 5%. Because buses might adopt different operating patterns (e.g., more non-stops) and more use of high-occupancy-vehicle lanes, bus times were hypothesized to increase by 5%. Consistent with general patterns in the US airline industry, non-work air fares were assumed to decrease, in this case by 5% (the lowering of non-work



Note: The set of columns on this chart were not ordered to represent progression over *time*, as the full values of Column 1, "Change in Basic Values" would presumably phase in slowly over the remaining four columns.

Figure 55. Changes in basic values and competition affect both rail and bus volumes.

air fare is also consistent with patterns reported in Chapter 9). Figure 55 shows that the combination of the culture change and the change from the competition together would be associated with about a 20% increase in rail ridership.

Finally, in the next three steps of the exercise, traditional improvements were assumed for rail: first with a 10% reduction in rail IVTs, then a 20% reduction, and finally with a 5% decrease in access and egress times to/from the rail stations.

There are several key implications for the results shown on Figure 55. The ability of the modeling procedure to deal with several kinds of input data at once, including the specified changes in basic values and the travel characteristics of the competition, reveals the extent to which those two input categories impact volumes on bus simultaneously with rail. Column 1 shows how the cultural changes in the importance of privacy and auto orientation impact bus and rail about the same amount. The model very clearly shows how an assumption of increases in *costs for the auto trip* will move some travelers to bus, which explains why the bus ridership in column 2 *increases* even when the travel times are hypothesized to get worse over time. Columns 3, 4, and 5 then show a more predictable subsequent decrease in bus ridership as the travel times of rail are hypothesized to improve significantly. However, bus ridership still registers a strong net *increase* (over the base) in column 5, which was designed to illustrate a fairly significant capital investment commitment to rail. The independent strength of the bus market, and the power of its lower fares for its loyal customers, is suggested in Figure 55. (The research team has explored the role of lower rail fares in the scenario testing tool, and the results are very powerful. These implications need to be addressed in appropriate detail in further research.)

Columns 4 and 5 shows that a future with much better travel times might result in a roughly 40% increase in rail ridership. Of that increase, it seems that about *half of the growth* would stem from factors *other than the times and costs of the rail operation itself* (e.g., from assumed changes in the environment not influenced by the actions of the rail managers). Although the results of this particular exercise are only illustrative in nature, they tend to support a basic premise of this study, that *factors above and beyond the control of the rail sector must be integrated into the analysis of rail in the context of dynamic travel markets.*

10.2 Major Conclusions from the Project

10.2.1 Major Themes Revealed

Are Millennials a Market That Can Be Taken for Granted?

The results of this research should pose an immediate warning against any broad assumption that the future preferences of the millennial generation will *automatically* facilitate a growth in rail as this cohort group proceeds through the life cycle. Far from it. Analysis of the direct results from the survey reported in Chapter 3 show that this group has a higher negative feeling about "traveling with people they do not know" than the older groups. Further, they report greater fear of crime and disturbing activity than older groups. For example, in our rural sample, 28% of the millennials agreed "*It might be unsafe to make this trip by bus or train*," compared with 17% of the older respondents; 23% of the millennials agreed that "*The experience at the New York City bus or train station would be so unpleasant that I would try to avoid it*," compared with 18% of the older respondents. (Both of these differences were significant at $p < 0.05$; analyzed separately, all four responses are causes for policy concern.)

As reported in Chapter 6 (the pessimistic scenario), if the millennial cohort group retains this set of values over time, and if their independence from the auto is diminished as they grow further into the child-educating years, the underlying market setting for rail growth becomes distinctly *negative*, *not positive.*

It is clear that those who set policy for investment in intercity public mode services (both bus and rail) should see the millennial generation as a positive market, but one with its own standards and its own demands. Issues of cleanliness, rowdiness, and general fear of unwanted behavior need to be addressed. The importance of investments that deal with *human values not associated with faster rail travel times* such as the new New York City Moynihan Station, an expanded Washington Union Station, or Boston South Station should not be underestimated.

Role of Auto Orientation

The ICLV model developed in Chapter 5, and applied in Chapter 6, suggests that the preferences expressed concerning alternatives to car ownership *are* directly related to variation in rail demand. This suggests that further research should be undertaken on this kind of connection—for instance, can we prove that new mobility solutions lead to lower auto ownership, which might lead to greater propensity to take the bus or rail? Would a world with more Uber and car-sharing support pro-sustainable intercity mode choices? Or, is this a statistical fluke involving this project only? Such future research would need to explore the (assumedly) negative impact on rail of long-distance trip sharing, such as the BlaBlaCar program (www.blablacar.com) in France.

Fundamental questions exist about the role of preference for auto ownership in a (future) world that includes driverless vehicles. Will the autonomous vehicle of the future be seen as something we "own" or something we "borrow"? Assuming that love of the private auto is retained in its new incarnation, will the convenience of auto automation undermine key market support for rail and bus?

Role of ICT

Although perhaps not as dramatically as with certain other factors, the research does link an orientation toward ICT devices in general, and being connected in specific, to the choice of rail and bus for intercity travel. In many of the future scenarios, the research team assumed that as present generations get older, they will not lose this orientation, which is seemingly so ubiquitous for the younger generations at this time. Perhaps more relevant is the question of the manner in which information technology will impact the modal patterns of the future, which is explored in the discussion of future research, in the following subsection.

Table 37. Five most important factors in the explanation of rail and bus choice from the attitudinal models.

Bus		Rail	
STE	Factor*	STE	Factor*
−0.46	Bus Trip Inconvenient	−0.73	Rail Trip Inconvenient
0.42	Less Stressful than Car	−0.34	***Value Auto Orientation***
−0.39	***Value Auto Orientation***	0.33	Less Stressful than Car
−0.13	***Value Privacy in Travel***	−0.29	***Value Privacy in Travel***
−0.10	Bus Trip Unsafe	−0.22	Rail Trip Unsafe

*The basic values are shown in ***italic bold*** and short term attitudes are shown in roman.

Future Markets for Intercity Rail

A major conclusion of this NCRRP project is that the next market for growth in intercity rail would come from diversion from the automobile—more than any diversion from bus, and more than any diversion from air.[2] As noted previously, this stems from the dominance of auto trip making in the study areas. The conclusion is supported by a wide range of early sensitivity testing exercises conducted with the scenario testing tool, which are not reported here. This strongly suggests that the next theme for future research in this area should focus on *those factors that aid in understanding the diversion from auto to rail.*

Given the large share of intercity trips made by car, it is not surprising that the largest "new market" for intercity rail is those who currently drive. Results from studies undertaken for the I-95 Corridor Coalition agree with others that congestion on the major alternative routes to rail will render them more and more degraded over time. Somewhat more surprising are the results of the illustrative exercise summarized in Figure 55 that, *with the specified pricing assumptions*, rail ridership could grow without a net decrease in bus volumes compared to the base case. As noted in Chapter 8, air outcome volumes vary with input assumptions; in all the scenarios tested, the major diversion is from the auto.

10.2.2 Understanding Market Factors and Segments

What Are the Factors That Influence Intercity Mode Choice and How Do They Interact

Without question, the dominant factor in the explanation of mode choice revealed in the three attitudinal models created for this project concerns the *inconvenience* of the trip by the specified mode (once for rail, once for bus, and once for both). The factor Inconvenience produced the most explanatory power for variation in mode choice for all three of the attitudinal models, and in the TPB model, which had a somewhat different structure. Because these models were *not* designed to reflect actual trip times and costs, this factor stood as a surrogate for travel times being competitive. In short, if rail (or bus) is not a convenient alternative, there is little chance it will be chosen.

Table 37 shows the top five factors for each mode from tables presented earlier in the text. After inconvenience, basic orientation toward the automobile, perceived stress of taking the car, valuing privacy, and fear for personal safety provide the most important predictors for mode

[2] The research team has explored the role of greater access and egress times to airports, and greater congestion in the air system; these factors tend to lower air volumes while other assumptions (e.g., degradation of the auto trip) tend to increase air volumes. These implications need to be addressed in appropriate detail in further research.

choice, though the exact ranking is somewhat different between modes. In the application of the scenario testing tool in Chapter 6, issues of privacy and issues of auto orientation dominated in the creation of the four underlying scenarios. (In the ICLV model, issues of convenience are dealt with through the modeling of actual comparative times and costs, and thus not included in the initial definition of the four background scenarios.)

The interaction between and among factors is expressed visually in the diagrams for the Attitudinal Models for Rail and Bus and the Attitudinal Model applied to a rural market in Figures 34, 47, and 44, respectively.

What Are the Key Market Segments?

Based on the conclusions of Chapter 3 (summarized in Figure 56), it is clear that a small minority of the population comprise the most supportive segment for intercity rail and bus use. In some of the popular press, young, sophisticated urbanites would represent the prime market for public modes; the problem with this loyal group of *Young Urbanites* is that they make up only about 11% of the study area population. At the other end of the market support spectrum, the combination of *Rail Rejecters* and *Cars for Convenience* show that 44% of the market may well be out of the reach of rail.

The mid-section of the market comprises 30% of the total population labeled *Open to Rail*, with another 15% *Curious but Cautious.* The latter group needs to see that their concerns with privacy and personal safety are being addressed before they become positive about rail—a scenario that this study finds plausible and worthy of policy attention, but not until their concerns have been addressed.

This allows the focus to be on the *Open to Rail* segment. As noted in Chapter 3, this group perceives rail to be superior to the car in that train travel makes for a less tiresome and stressful travel experience. Additionally, they reveal normative and social influences, as friends and family members of this segment use the train and approve of them doing the same. In short, they are ***not*** predisposed to dislike the rail choice, if and when it provides acceptable levels of convenience, etc. Perhaps this market segment best reflects the earlier conclusion that the *next additional market for intercity rail must come from those who currently drive.*

Thus, this quick review finds 41% of the population with generally positive predisposition to choosing the train, if its service is good enough. That same review finds 44% of the market

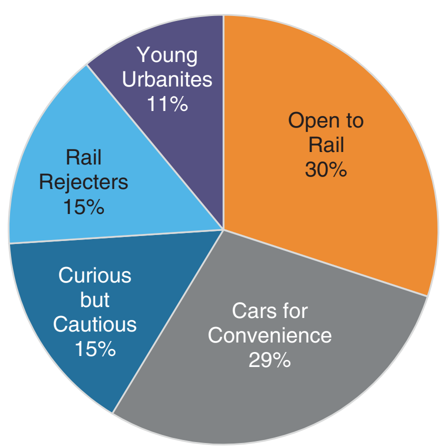


Figure 56. Definition of market segments from Chapter 3.

Table 38. Explanatory factors on rail choice from the TPB model.

Rank	STE	Explanatory Factor*
1	−0.59	Train Trip Inconvenient
2	0.43	Taking train would be pleasant (ATB)
3	0.33	I have the power to take the train (Control)
4	0.30	'People like me' would take the train (Normative)
5	−0.29	***Value Privacy in Travel***
6	−0.28	***Value Auto Orientation***

*The basic values are shown in ***italic bold*** and short-term attitudes are shown in roman.

satisfied with their auto-oriented lifestyles, and not very likely to become consistent rail customers in the future. The remaining 15% *might* become rail users if important issues about the perceived lack of privacy and personal safety were solved to their satisfaction.

Aspects of Rail Service to Improve or "Sell" to Targeting Market Segments

Given these market segmentation results, the research team believes that, for a great percentage of the population, the image of rail is already positive. The ICLV model in Chapter 5 documents in some detail the same argument–that when looking at modal constants, rail would be more preferred than the auto for most trip purposes, if and when its comparative service levels justify it as the final mode choice. Finally, a group such as the *Open to Rail* segment can be observed through the structure of the TPB. As reviewed in Table 38, the application of the TPB model suggests that a member of this segment wants to make the conclusion that taking the train would be *pleasurable* for him/her; that *others like him/her* would take the train; and that he/she has the *self-efficacy* to actually do it.

Areas to Target to Grow Market for Rail

The research team believes that the results of the scenario creation exercise in Chapter 6 are remarkably clear regarding target areas to grow the market for rail. As noted consistently in this report, as the millennial generation gets older, additional personal experience may lessen the extent of disliking travel with others, and the sense of fear of the public trip associated with it. Inversely, as the millennial generation gets older, the pressure will build to become more auto-dependent. In this chapter, the research team proposes that more research should be undertaken on both these markedly different social patterns, and on what could be done to better target strategies to deal with them.

Results That Challenge Conventional Wisdom

Prior descriptions that have appeared in the popular press about millennials uniformly liking urbanism, disliking suburbs, and wanting to act in order to improve the environment may have been oversimplified or misinterpreted. Ironically, these oversimplifications may ultimately be irrelevant as relates to intercity rail travel, as the current analyses suggest that having urban values, or pro-environmental values, *has little or nothing* to do with the propensity to choose intercity rail (The reader is reminded that for *metropolitan* travel, both attitudes toward urbanism and the density of the residence are powerful predictors of local travel mode). The research team strongly prefers the definition of relevant groups through advanced market segmentation techniques over the use of such a priori methods as grouping people together on the basis of their age, gender, or race. Market segmentation reveals that within such a category (e.g., age), there are definable groups with positive orientation to rail and those with negative orientation to rail. The research team would encourage further attention be paid to the Open to Rail market segment rather than to generic categories such as age group.

10.3 Recommendations for Further Research

This report concludes with a discussion of the way in which these findings suggest the need for further research in a manner most conducive to helping policy makers make prudent decisions about investing in intercity transportation. As FRA considers a next generation of policy analysis concerning the future of rail, how might the direction of this study affect future efforts to better understand intercity travel behavior?

10.3.1 Conclusions About New Directions for Modeling

A key question concerning priorities for future research involves the next steps in the applicability of the hybrid/ICLV model to the day-to-day transportation demand forecasting profession. The question turns to the best use for this kind of model. Vij and Walker (2015) argue

> "that studies that use ICLV models need to show . . . that the greater insights into the decision-making process offered by the ICLV model *can be used to inform policy* and generate forecasts in unobvious ways that would not be possible using choice models without latent variables."

Based on its experience, the research team would agree with the position taken by Vij and Walker that analysis of the quantitative complexity undertaken here is of most value when such "*model can be used to inform policy*." In this report, the new modeling process has flagged the importance of safety and privacy concerns for the millennial generation, and the overall need to monitor cultural patterns concerning attitudes to car ownership. In short the more complex model has shown its value in the improved understanding of public policy toward rail.

A separate question concerns the "need" to incorporate such additional complexity into the day-to-day travel forecasting process. The research team would propose a cautious, step-by-step process to transform what has been the subject of academic exploration into the main stream of demand modeling, taking into consideration the importance of the parsimonious approach–additional complexity should not be worshipped for its own sake. The ICLV models that were developed to capture the effects of attitudes on mode choice were estimated using techniques that, for a variety of reasons are very computationally demanding. Estimating coefficients for a single model took multiple days, limiting the team's ability to do the type of extensive specification testing that is typically done for travel forecasting models. There are alternative methods such as maximum approximate composite marginal likelihood (MACML) estimation and alternative model formulations that could more efficiently accomplish the same objectives. Further research is needed to explore the application of these approaches to this type of model application.

In sum, the research team believes that the merging of analysis involving cultures and values with analysis based on detailed trip characteristics (including times and costs) should be further developed for the purpose of understanding public policy without necessarily assuming that it would replace more conventional methods of travel forecasting in the near term.

10.3.2 Implications from the Project for Further Research

As discussed, the purpose of this project was to develop and demonstrate the feasibility of a comprehensive analytical framework to improve understanding of intercity travel demand. The continued *application* and further refinement of the tools developed will require more time and effort, and focused attention. For instance, the single strongest elasticity for rail share comes from a change in the *price* of the rail ticket, specifiable by work and non-work trip purpose. In this NCRRP project, the research team has focused on the interaction between cultural assumptions for the underlying characteristics of the market, and improvement in travel times, with fare *not yet* added as an additional dimension for analysis (This leads almost directly to the creation of three dimensional models, with background assumptions separate from service characteristics which are separate from pricing assumptions. Multidimensional models, are, by their nature, difficult to explain, diagram, and interpret). The same is true for alternative assumptions about the distribution of demographics, such as income, education, and employment status (e.g., comparing a future with higher income growth against one with lessened income growth).

10.3.3 Relationship to Issues in Rail Policy Planning

With the conclusion of this NCRRP project, the research team demonstrated that, with careful continued work, preferences of the customer(s) can be integrated into the most accepted format for travel demand forecasting (discrete choice modeling). Given the conclusion that a set of methods can be developed to specially incorporate values and attitudes into an integrated analysis process—one which emphasizes the appropriateness of scenario futures as a method to incorporate uncertainty—the research team has developed a list (discussed in the following subsections) of possible applications of such a process in the ongoing effort to improve rail demand analysis. (The order of the following list discussion is random.)

Research About Refining Future Scenario Applications

Dealing with Extremely Long-Range Time Frames. In a possible policy context, we might assume that one package of infrastructure investments is required first, and could reasonably take 10 to 15 years to complete (Quite possibly the first decade of expenditures might largely deal with situations of safety and state of good repair, rather than radical improvement in travel times, etc.). We could assume further, that a second decade of facility/service improvements might follow that make highly predictable incremental improvements in travel times, and capacity at key bottlenecks. For both of these planning settings, the analyst *might possibly* conclude that the addition of complicated alternative future scenarios is not needed to produce reliable, documentable forecasts.

However, as soon as the policy analyst is asked to consider infrastructures and services which are different both in the time of the implementation and in the qualitative details of their services, it would become entirely appropriate to insist on an approach based on alternative future scenarios (see, for example, Catawba Riverkeeper Foundation v. NC Department of Transportation 2015). Such an approach might require exploration of the concept that, over a several-decade planning horizon, the values and preferences of the market almost certainly will have shifted, in some direction and to some extent (both potentially unknowable). By way of simple illustration, if society spends two decades *actually* improving the terminals, the "culture" of attitudes toward terminals would be expected to evolve over time (Over such a multidecade time frame, it could be argued that the *cultural* attitude about travel behavior between Paris and Lyon actually changed over time).

Understanding the Mechanisms of Cultural Change. Such a future research effort might seek to better explain just how such an evolution of preferences might actually occur. Such a theory of change might start with the base case showing the rail rider skeptical of an attribute; in an early step, the customer begins to show credulity in the observed good intentions of the service provider; a key element in the evolution might find the customer routinely pleased about the attribute, moving toward final steps of sharing their enthusiasm with their peers and equals [Others have attempted the application of Prochaska's Transtheoretical Model to transportation. See Mundorf et al. (2013)]. In short, further research might explore just how these changes in preferences could actually come about [Others suggest that, by contrast, raising the customer's expectation about an attribute, and then failing to live up to that expectation, may be among the worst of possible outcomes. Personal communication with W. Brog. See Amrosell (2008)].

Research About the Tradeoffs in Rail System Design

Attitudes and Preferences About Directness or Frequency. In some cases, rail system designers must deal with design tradeoffs that pose a challenge to the rail demand analyst. Within an overall system design, one strategy might offer directness of service coverage: a small number of trains per day might provide no-change-of-train service from point A to point B. An alternative system design might emphasize service frequency, almost ensuring that transfers will be required between trip segments. Is it possible that travelers have strong pre-set preferences on the subject of transfer? Is the transfer assumed to be a pleasant experience, or a virtual guarantee that one *cannot* find good seats on the second segment? Would an analytical approach that integrates real times and costs with very focused attitudes be of help in such a question of system design? [A somewhat rare example of analysts having access to longitudinal data in such a focused study is provided in Hess and Adler (2009).]

Research About ICT and Rail Service

How ICT Might Be Used in the Service of Rail. Research could be undertaken to use analytical methods that integrate "hard" and "soft" variables to better understand the need for information technology to support the rail and bus user through all segments of the complex multimodal and intermodal trip. Technology currently being applied in Germany helps the public mode traveler with step-by-step (literally) information in support of the complicated transfer movements often required in the intermodal trip. Much of the current work in this area is simply based on assumptions that, of course, rail travelers want better information and would benefit from having that information. The new research tools could help in both exploring the need for such applications and making the case for the improved ICT systems needed.

How ICT Might Be Used to the Detriment of Rail. Without question, the private car will become more and more the location of a vast set of information and entertainment technologies. Research could help us understand the implications of these patterns on public mode use. In the nearer term, long-distance ride sharing will soon become a major mode of travel, as it has already become in Europe. In the long term, automation of private automobiles could alter some of the most basic factors that differentiate the auto experience from the rail and bus experience. Research into these areas will require the best tools of travel demand analysis that can be developed, over time.

10.3.4 Relationship with the Larger Question of Transportation Demand

Perhaps most importantly, it should be restated that this NCRRP project focused only on intercity transportation behavior. As is well documented, the number of miles of long-distance travel for a given person is a small percentage of her/his yearly travel, most of which takes place in or near the metropolitan area of residence. Future research into the question of integration of long-term cultural values, near-term attitudes, and mode choice needs to deal with *person travel in general*, in addition to further research about intercity travel. If and when this is done, this NCRRP research may suggest some direction.

Dealing with the Automobile

The key issue in understanding any mode of travel in the United States is its relationship with travel by private car. This is not an issue of preference or bias, but simply due to the fact that most trips are made by car in this country. There is a significant body of research on alternatives to the automobile in the European literature, much of which assumes that concerns about the environment are a near-universal motivation—a dimension which the research team was *not* able to replicate or confirm in this American study.

Given this, the question turns to how Americans make the decision to make trips by modes other than the private automobile. What are the key factors involved in such a mode choice? With the presence of newly improved research tools which combine "hard" and "soft" factors in the influence of travel behavior, these methods can be applied to the more general question of the choice to replace (single-occupancy vehicle) auto travel with more sustainable modes and patterns [Of course, increased levels of auto occupancy (by whatever strategy) falls into the latter category].

In this pursuit, a wide range of research methods should be applied. A considerable body of European research explores the decision to choose a mode other than the car by applying values such as hedonism, egoism, security, and need for power (see Figure 8). While in this project, the research team defined the basic values to support the development of certain future scenarios, in subsequent research, exploring motivations associated with basic psychological needs should not be ruled out. There are many theories currently being developed in the literature to guide the examination of the shift away from the car, which deserve future research attention.

Acknowledging the Bus

The research has provided considerable support for the concept that bus markets are largely separate from rail markets, at least with the pricing assumptions made in this research project. In fact, given that it may not be in the best interests of Amtrak to lower its fares, a vast market exists for bus travel even in scenarios where rail running times are significantly improved (Figure 55). Arguably, given the severe capacity constraints that impede increased train service, intercity bus could be seen as a *positive* complement to the rail system, and should be treated as such in public policy. Compared with any other major mode, it is the intercity bus which has lagged behind in terms of basic research about its potential.

Going Beyond Planning—Understanding Marketing and Advertising

And finally, connections between marketing strategies and the kind of integrated analysis approach used here should be better documented. In many instances throughout this project, it becomes clear that a given issue might be more related to the *marketing* of a set of services than to the service and infrastructure *planning* for them. Just how marketing and advertising relate to the series of serious challenges revealed in this research needs to be explored in more detail.

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Abbreviations

ATB	Attitude toward the behavior
CONNECT	Federal Railroad Administration software
GAO	US Government Accountability Office
HSR	High-speed rail
ICLV	Integrated Choice/Latent Variable
ICT	Information communications technology
IVT	In-vehicle time
LCC	Latent class cluster
MACML	Maximum approximate composite marginal likelihood
NEC	Northeast Corridor
NETI	New England Transportation Institute
NHTS	National Household Travel Survey
OD	Origin–destination
PIC	Partial inclination coefficient
RMSEA	Root mean standard error of approximation
SEM	Structural equation modeling
SP	Stated preference
STE	Standardized total effect
TPB	Theory of Planned Behavior
UVM TRC	University of Vermont Transportation Center
VFR	Visiting friends and relatives
VMT	Vehicle miles traveled
VTT	Value of travel time

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

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