Federal Highway Administration

Foundational Knowledge to Support a Long-Distance Passenger Travel Demand Modeling Framework

Implementation Report

Exploratory Advanced Research Program

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Notice

Quality Assurance Statement

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Technical Report Documentation

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AADT	Annual average daily traffic
AADTT	Average annual daily truck traffic
ACS	American Community Survey
BPR	Bureau of Public Roads
CSV	Comma-separated values
FAF	Freight Analysis Framework
FHWA	Federal Highway Administration
GISDK	Geographic Information System Developer's Kit
GTFS	General Transit Feed Specification
HBNW	Home-based non-work
HBW	Home-based work
HH	Household
LOS	Level-of-service
NAICS	North American Industrial Classification System
NHB	Non-home-based
NHPN	National Highway Planning Network
NHTS	National Household Travel Survey
NUMA	National Use Microdata Area
NW	Non-work
ODME	Origin-destination matrix estimation
QRM	Quick response methods
VisitFR	Visit friends and relatives purpose

CHAPTER 1. INTRODUCTION

Intercity travel is increasingly important in the United States. The Federal government and many states are faced with improving mobility and reducing impacts for these travelers. The Federal Highway Administration (FHWA) has invested in several studies to better understand intercity travel; this study is an extension of that interest, which began with exploratory research to develop a long-distance passenger travel demand model framework and grew to include implementation of that framework. The modeling framework is a tour-based microsimulation model of annual long-distance passenger travel for all households in the United States. The models schedule travel across one full year to capture work-related travel (employer's business and commute) and non-work travel (visiting friends and family, personal business and shopping, and leisure). The models are multimodal (auto, rail, bus, and air) and based on national networks for each mode. This provides opportunities for evaluation of intercity transportation investments or testing national economic, environmental, and pricing policies.

This technical report documents the third phase of the DTFH61-10-R-00036 Exploratory Advanced Research program to develop Foundational Knowledge to Support a Long-Distance Passenger Travel Demand Modeling Framework. The original work included two other phases: a design phase and a research phase. The third phase is an implementation phase, focused on moving the research into practice and providing a model that can be used by state and Federal agencies interested in long-distance passenger travel.

The design and research phases concluded with the following products:

- Long-Distance Passenger Travel Demand Modeling Framework Final Report.
- Long-distance passenger travel demand model framework, with models estimated from available data.
- Recommendations for future data collection.
- Demonstration of the implementation framework.

This long-distance passenger model research did not include any new data collection, so models were estimated based on long-distance surveys collected from several states (Ohio, Colorado, Wisconsin, California, and New York). A long-distance passenger travel survey for the United States is recommended to estimate these models on a comprehensive dataset.

1.1 Objectives

The objectives of the implementation phase were the following:

- To produce a working model for the 2010 base year, including a national highway network and zone system, with multimodal travel times for rail, bus, and air modes, and a highway assignment.
- To calibrate and validate this model against available national data sources.

- To test this model and provide assurances that the calibrated and validated models produce reasonable results under a select set of policy scenarios.
- To ensure stability and reasonable performance for the application software beyond the original demonstration software in the research phase.

The national calibration was compared against recent origin-destination (O-D) trip tables developed by FHWA (with CDM Smith and RSG). The validation compared long-distance travel with traffic counts for all 50 states.

1.2 Overview of the Model System

Methods for modeling long-distance passenger movements are in their infancy in the United States. Federal and state entities have recently become interested in modeling long-distance passenger movements as part of highway infrastructure planning; similarly, agencies studying high-speed rail, or those involved in airport planning, have also expressed interest due to their dependence on long-distance travel markets. This stronger interest at the Federal and state levels has created an intersection of policy needs for long-distance passenger modeling. In practice, some states and regions have expressed interest in long-distance passenger modeling for statewide models (e.g., California, Ohio, and Arizona) and for high-speed rail ridership studies (e.g., Florida, California, and the Northeast Corridor). However, these models rely on traditional travel demand forecasting methods rather than on a robust understanding of the underlying behavior and how and why it is different from other passenger travel. This research contributes to the development of a national passenger framework.

The goal of this research was to develop a framework for a long-distance passenger travel demand model that can be used to build a national model for the United States, one based on exploring new ways to simulate behavior of long-distance passenger movements. This framework includes model specifications based on statistical analysis of available data, recommendations for data collection that facilitate the development of the national model, and a demonstration that the framework can be reasonably implemented. In addition, this national model will be estimated, calibrated, and validated on current long-distance travel data in the United States during the next phase of work. Ultimately, success will be marked by transition of the research into use for planning applications across the country. These applications include:

- Testing national policies (e.g., modal investments, pricing, economics, environmental, livability, safety, and airport/rail planning);
- Measuring system performance;
- Evaluating the impacts of private-sector decisions;
- Providing input to statewide and regional planning; and
- Assessing regional differences.

The exploratory research was conducted from 2011 to 2014 and included a long-term goal to develop long-distance passenger models not constrained by traditional methods or existing data sources, in combination with making data recommendations to support these new models. An implementation phase was added to move the research into practice by calibrating and validating long-distance travel demand models that are practical for current use and implementing these models with software.

The long-distance passenger travel demand forecasting modeling system (Figure 1) synthesizes long-distance travel for each household in the United States (117 million households and 309 million people based on the 2010 US Census) using an annual scheduling of long-distance tours (round trips). Household and person characteristics are synthesized for the United States by Census Tract. The annual scheduling and joint mode and destination models are the centerpiece of the long-distance passenger models; these use advanced methods not previously applied in urban passenger demand travel models (e.g., activity-based models).

This long-distance passenger travel demand forecasting modeling system is implemented using software called rJourney™. For brevity, the long-distance passenger travel demand forecasting model is referenced in this report as rJourney.

1.3 Contents of the Report

This report comprises seven chapters. Chapter 1 includes the introduction and discusses the objectives of the original research and implementation phases of the work and an overview of the modeling system.

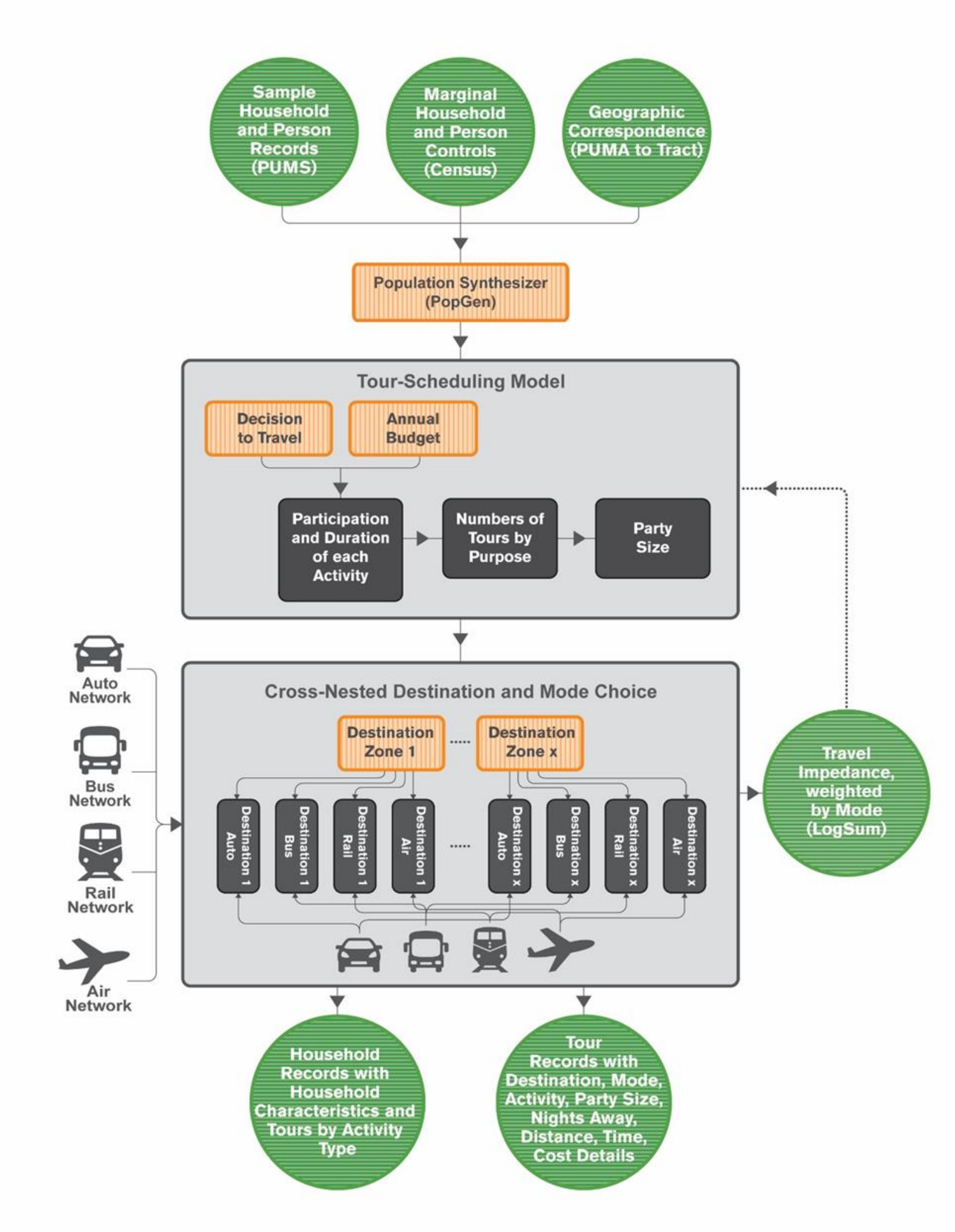
Chapter 2 discusses model calibration and reports the tour frequency, destination choice, and mode choice model calibration results. It also includes a description of the preparation of the average daily long-distance passenger travel model trip tables.

Chapter 3 describes the highway assignment parameters and the highway network. This chapter also includes a description of the background traffic estimation and the assignment application in TransCAD.

Chapter 4 describes the trip table and highway performance validation tests. There were five sensitivity tests performed (discussed in Chapter 5) in addition to the validation tests. These tests were conducted to explore the reasonableness of the models to changes in various inputs.

Chapter 6 presents details of the application software (rJourney), including the model structure and code, how to run the model, the input and out files, and the estimated model coefficients. A brief summary of the key findings for the implementation phase is presented in Chapter 7.

Figure 1: National Long-Distance Passenger Travel Demand Modeling System



CHAPTER 2. MODEL CALIBRATION

Model calibration is the process of applying the estimated models, comparing the results to observed values, and adjusting either the model specification or the alternative-specific constants. The various components of rJourney are vertically linked to ensure dependency between upper- and lower-level model components. As a result, calibrating one model component is likely to affect outcomes of other model components. In such cases, the general approach is to calibrate the model components in the order in which they are applied (i.e., the upper-level models are calibrated before the lower-level models). In this instance, the research team calibrated the tour generation-related model component first, followed by destination- and mode-choice models. The calibration process was applied in an iterative manner until the model, performing as a system, converged to a stable set of parameter values for all of the model components and the observed travel patterns were well represented. The following data sources were used to obtain observed target values, rates, and distributions:

1. 2007–2011 American Community Survey (ACS) 5-year estimate.
2. 2001 New York National Household Travel Survey (NHTS) add-on.
3. 2001 Wisconsin NHTS add-on.
4. 2003 Ohio Household Travel Survey.
5. 2010 Colorado Front Range Travel Survey.
6. 2012 California Household Travel Survey.

Target values and distribution from the ACS data were used for household vehicle ownership model. For other models, target distributions and rates obtained from expanded household travel survey data were used. Expansion factors were not available for 2012 California Household Travel Survey, so this survey was not used for any expanded targets. The use of these five statewide household travel surveys provided a range of target distributions and rates across the United States, but does not represent a true national household travel survey for long-distance passenger travel. As a result, calibration of these models was not intending to achieve a tight comparison between the model results and the five-state observed dataset.

Table 1 summarizes rJourney model components in the order in which they were calibrated, if required. Vehicle ownership[1] is the first model in the system and did not require any calibration since the model prediction matched ACS data reasonably well (see Figure 2). And, after tour frequency model was calibrated, it was not necessary to calibrate tour scheduling, tour duration, and travel party size models (please see Figure 3, Figure 4, and Figure 5 for tour scheduling, tour duration, and travel party size models, respectively). In these figures, the five-state merged household travel survey dataset was used to represent the observed data. Calibration process of tour frequency, tour destination, and tour mode choice models is discussed in subsequent sections.

[1] This report uses the terms "vehicle," "auto," and "car" interchangeably.

Table 1: Model Components that Required Calibration

rJourney Model Components	Calibration Required
Vehicle Ownership Model	No
Tour Generation/Frequency Models	Yes
Tour Scheduling and Duration Models	No
Travel Party Size Models	No
Tour Destination-Choice Models	Yes
Tour Mode Choice Models	Yes

Figure 2: Percentage of Households by Vehicle Ownership Level

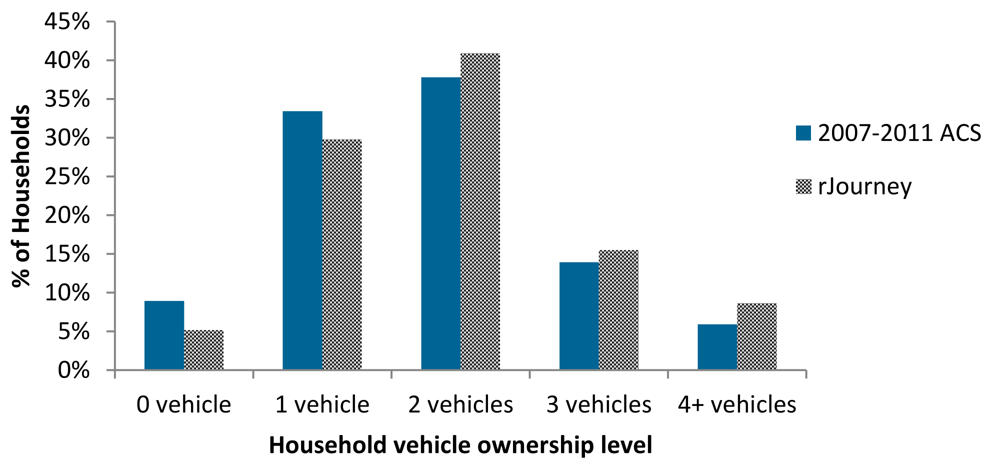


Figure 3: Percentage of Tours by Season of the Year

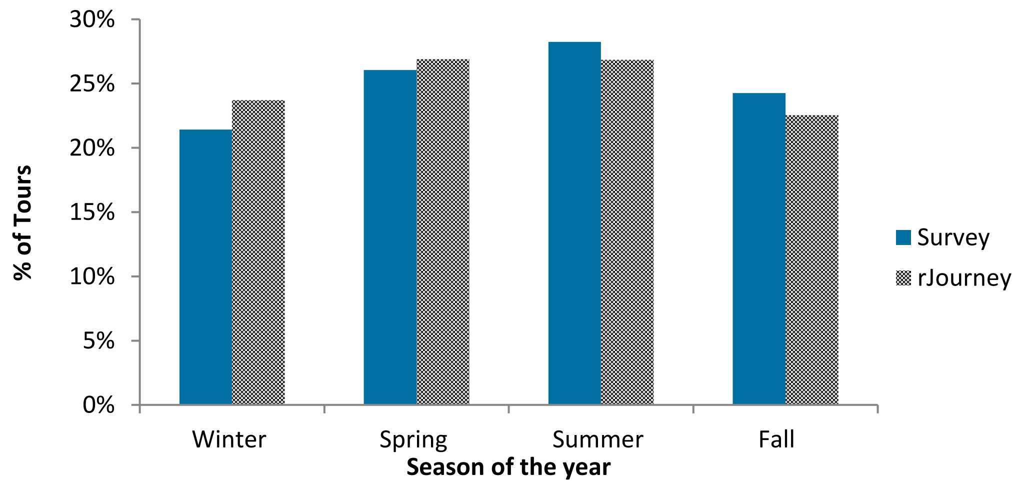


Figure 4: Percentage of Tours by Number of Nights Away from Home

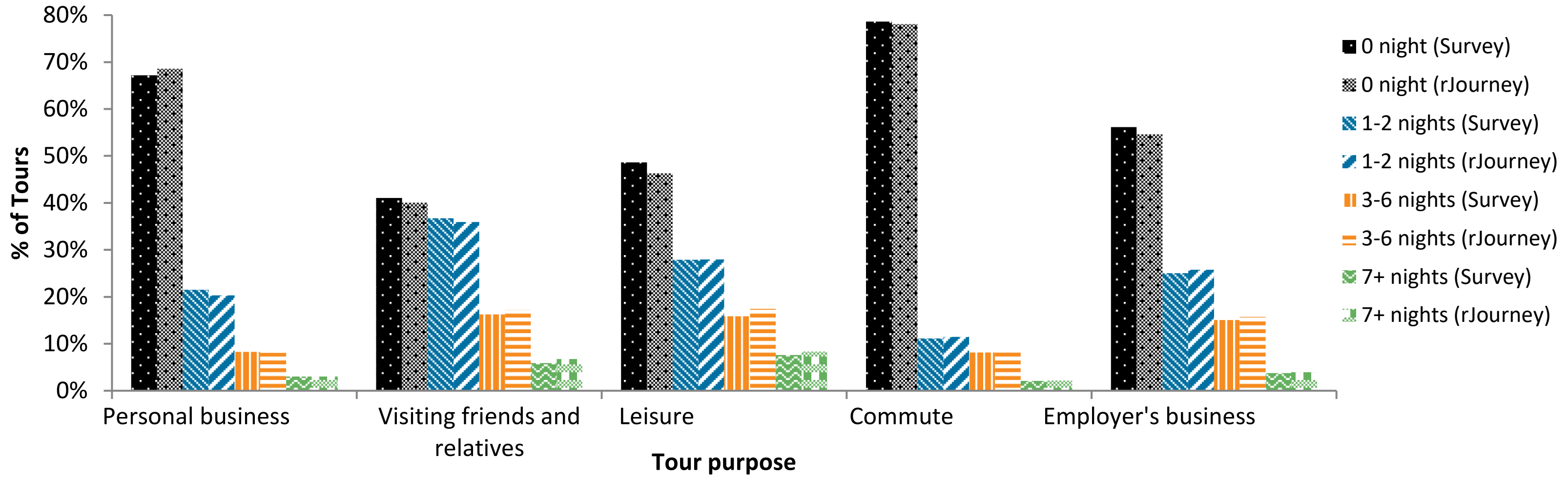
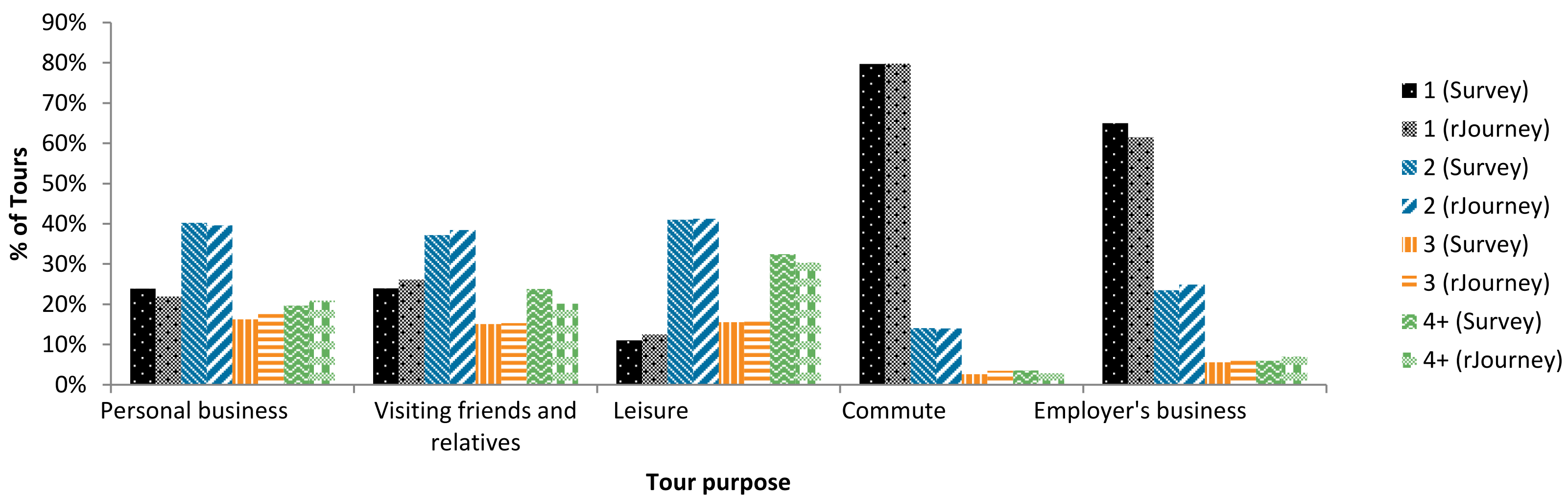


Figure 5: Percentage of Tours by Travel Party Size



2.1 Tour Frequency Models

Tour frequency models include two models applied sequentially: 1) for each tour purpose, the first model predicts whether or not a household undertakes a long-distance tour within a period of one week; and 2) the second model predicts whether or not a household undertakes more than one long-distance tour by purpose in one week. In application mode, these two models jointly predict number of tours by purpose generated by households over one year. The tour purposes are: personal business, visiting friends and relatives, leisure, commute, and employer's business. Many variables have significant effects on the likelihood of long-distance tour generation by purpose, including household size, presence of children, age of householder, household income, household auto ownership level relative to number of adults, distance between origin and primary destination, tour duration, and month of the year.

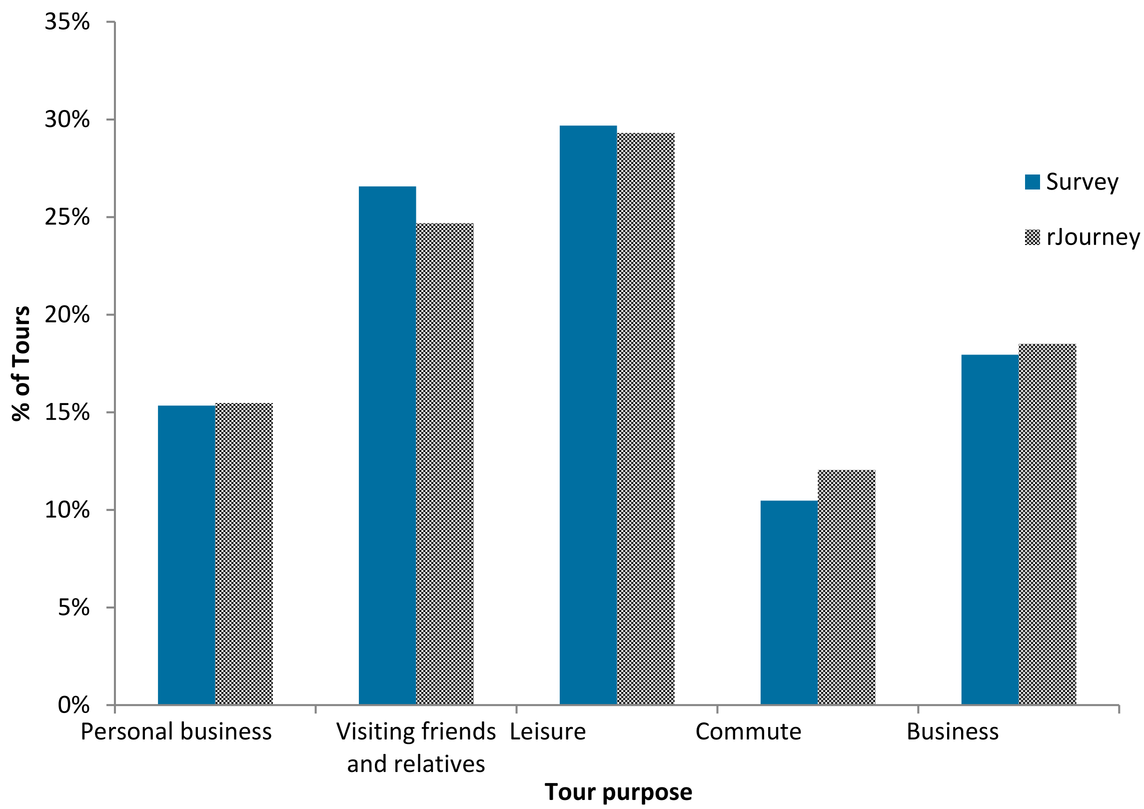
Calibration of the tour frequency model involved the change of the alternative-specific constants to match observed tour rates by purpose with model prediction. Table 1 shows weekly tour rates by tour purpose from survey data and calibrated model prediction. Survey tour rates were calculated using data from the aforementioned five household travel surveys.[2] In general, tour rates predicted by rJourney closely match observed data. While the frequency models do not control for tour distribution by purpose, Figure 6 shows there is significant alignment between observed and model-predicted tour distribution by purpose.

Table 2: Weekly Tour Rate by Purpose

Tour Purpose	Weekly Tours per Household		Difference
	Survey	rJourney	
Personal Business	0.034	0.031	-0.003
Visiting Friends and Relatives	0.057	0.049	-0.008
Leisure	0.066	0.058	-0.008
Commute	0.028	0.024	-0.004
Employer's Business	0.042	0.037	-0.005

[2] For brevity, all quantities that are derived using data from the household travel surveys will be referred to as "survey" instead of "five household travel surveys."

Figure 6: Percentage of Tours by Purpose



2.2 Destination-Choice Models

Destination-choice models are multinomial logit models used to choose the destination zones of the long-distance tours. These zones are based on the National Use Microdata Zones (NUMAs) established and described in the Final Report for the research phase. For this set of models, all destinations that are 50+ miles away from origins were considered available. There are five destination-choice models, one for each tour purpose. The models are primarily functions of opportunities (represented by employment and/or households) and travel impedance. Opportunities that have significant effects on long-distance destination choices vary by tour purpose. In general, number of employment in accommodation, entertainment, medical, other services, retail, and wholesale industry; park areas; number of households; and college/university enrollment played a large role in determining the attractiveness of a destination. In this model, travel impedance (such as distance) was used to offset attractiveness of a destination zone. Other significant variables include logsum parameters from mode-choice models, destination type (urban/rural), and tour duration.

The model calibration process revealed that for almost all purposes, there was some under-prediction of relatively short-distance tours and some over-prediction of relatively long-distance tours. To address this discrepancy, minor adjustments were made to relevant distance-related coefficients. Figure 7 to Figure 11 compare calibrated tour-length distribution for each purpose with survey data. In general, the model's predicted tour-length distributions are very similar to observed tour-length distribution. Where there are divergences between two distributions, the differences are within 4%. Table 3 presents average person-miles traveled, by purpose. While predicted average person-miles traveled for commute and employer's business tours match survey data very well, some variations between model prediction and survey data exist for non-work-related tours. These variations may be due to rJourney over-predicting tours within 1,000 to 2,000 mile tour lengths.

Figure 7: Round-Trip Distance-Band Distribution by Purpose—Personal business

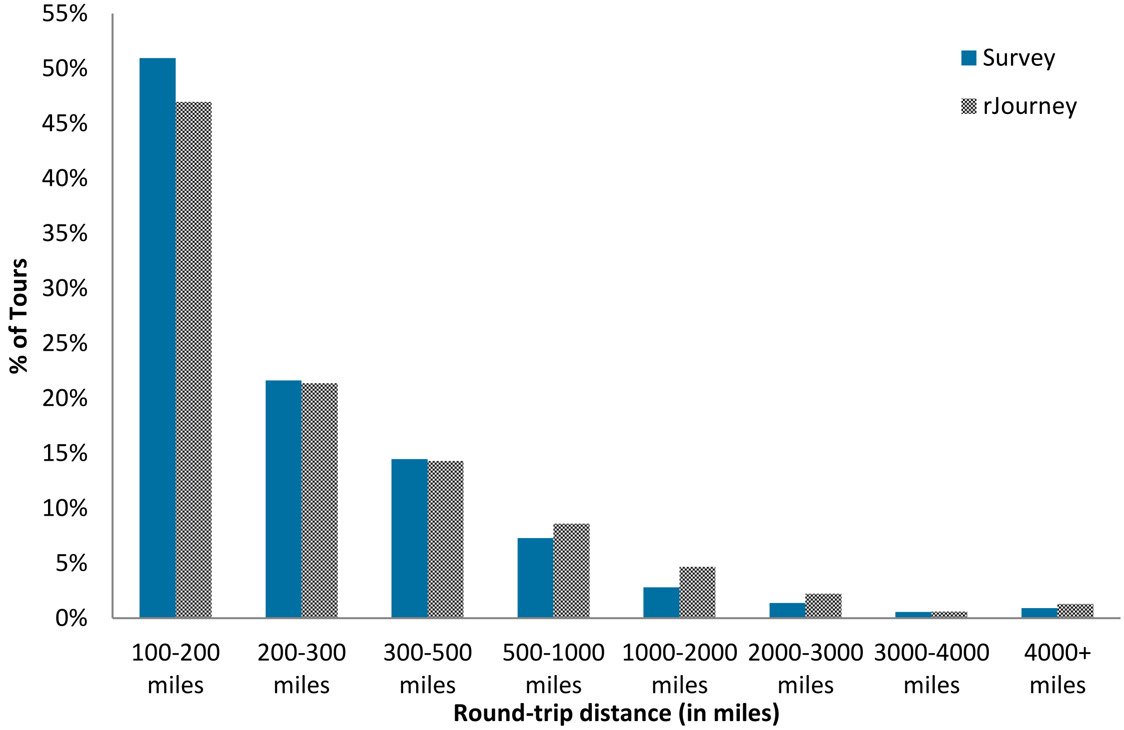


Figure 8: Round-Trip Distance-Band Distribution by Purpose—Visiting Friends and Relatives

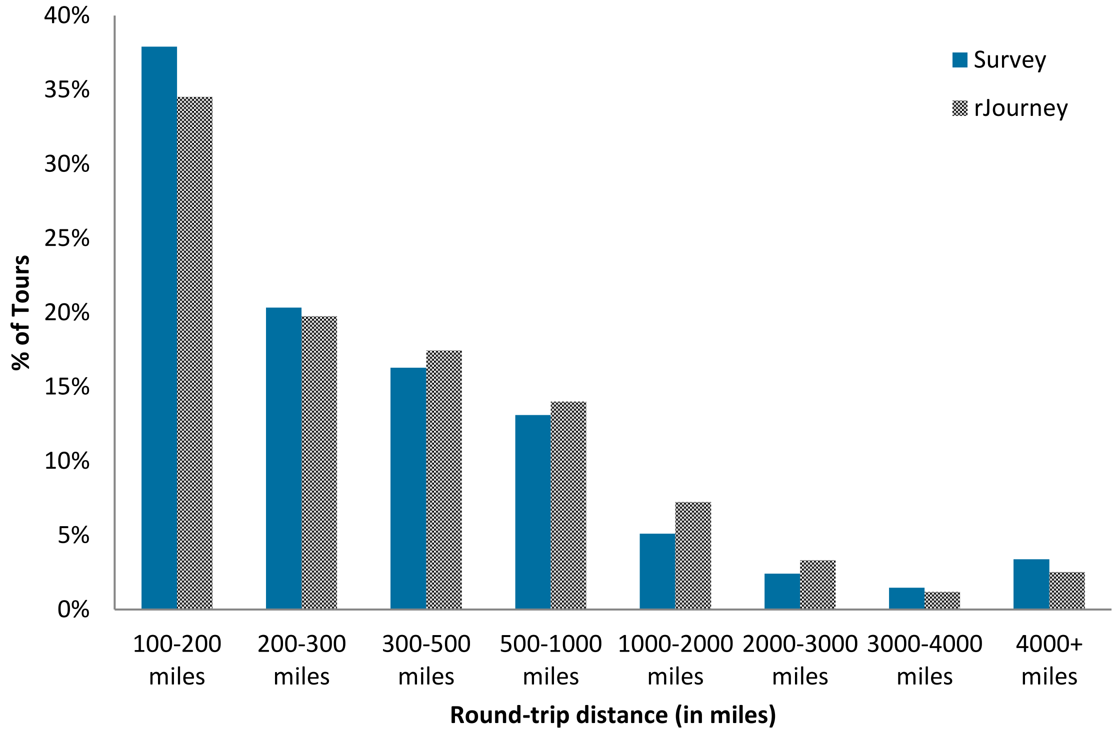


Figure 9: Round-Trip Distance-Band Distribution by Purpose—Leisure

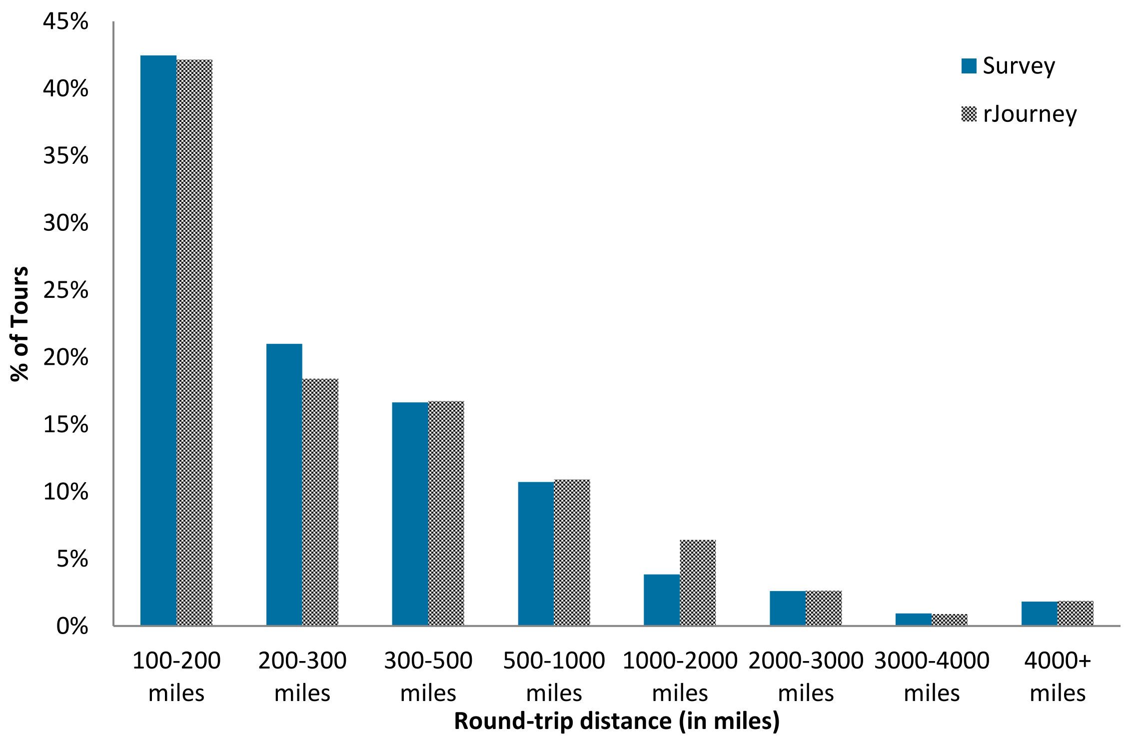


Figure 10: Round-Trip Distance-Band Distribution by Purpose—Commute

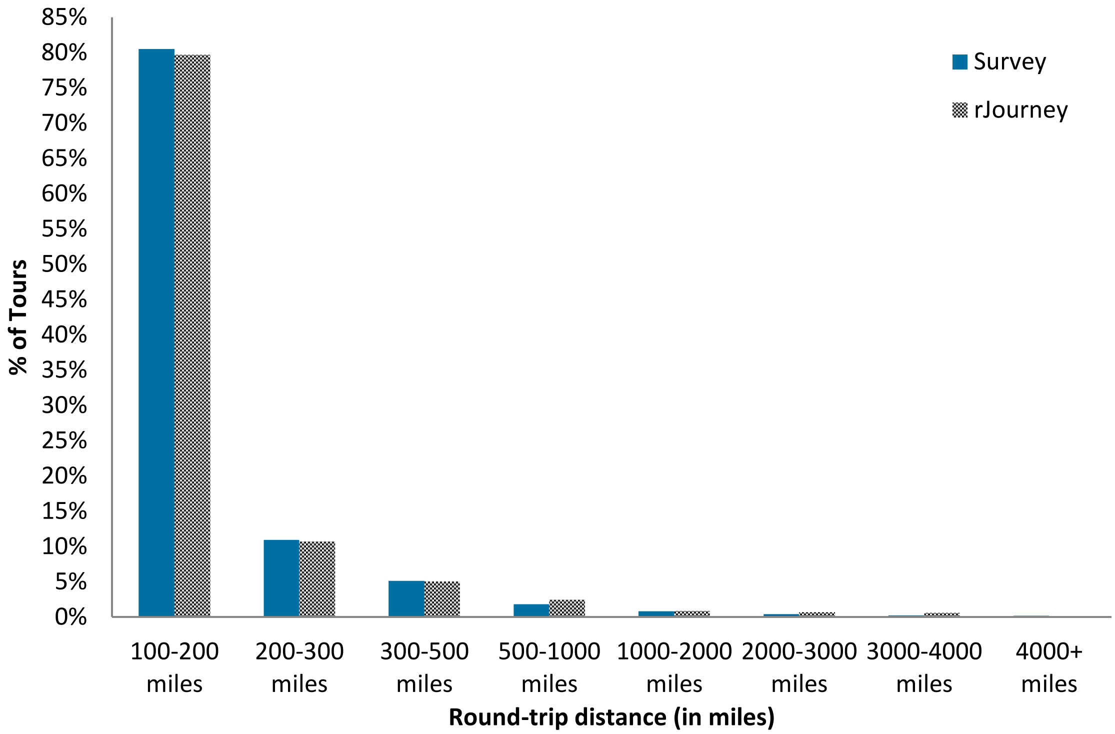


Figure 11: Round-Trip Distance-Band Distribution by Purpose—Employer's Business

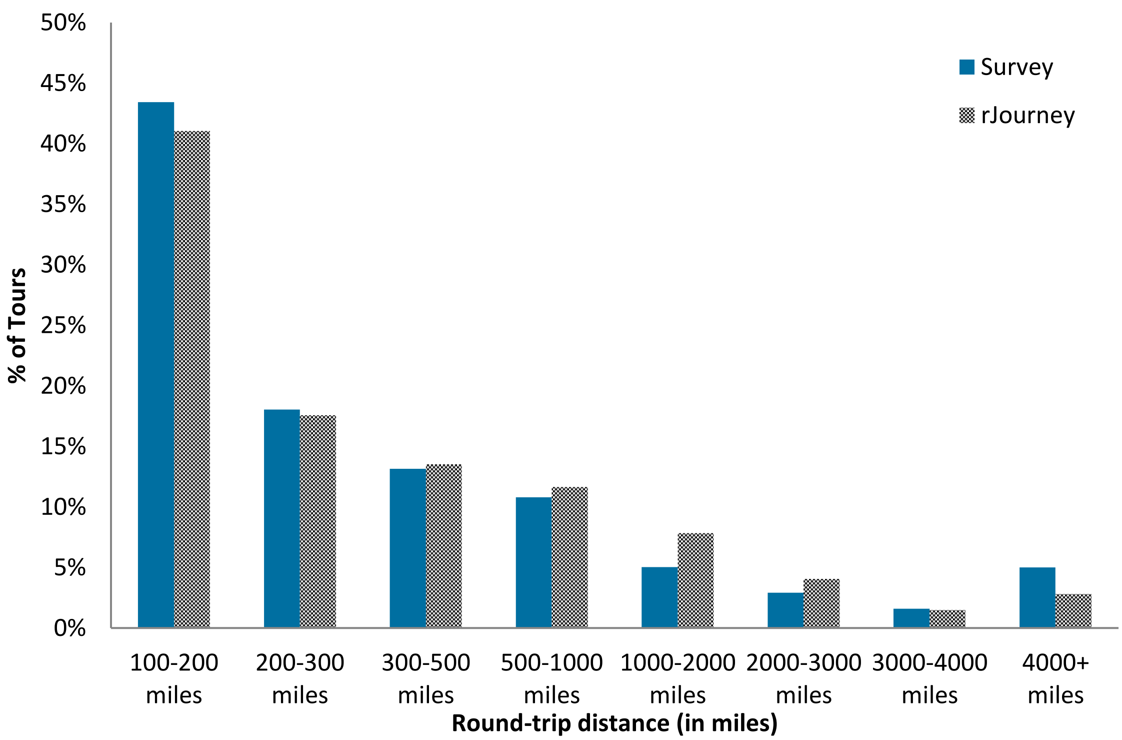


Table 3: Average Person-Miles Traveled

Tour Purpose	Survey	rJourney	Difference	% Difference
Personal Business	396.48	441.01	44.53	11.2%
Visiting Friends and Relatives	464.70	578.36	113.66	24.5%
Leisure	478.25	531.75	53.5	11.2%
Commute	219.25	219.62	0.37	0.2%
Employer's Business	673.02	641.17	-31.85	-4.7%

2.3 Mode-Choice Models

The tour mode choice model for each purpose is structured as a multinomial logit model with the following mode choices:

1. **Auto**: Available for all origin-destination (O-D) destination combinations that are 50+ miles apart, except:

- From/to destinations within contiguous United States to/from destinations within Alaska and Hawaii; and
- From/to destinations within Alaska to/from destinations within Hawaii.

2. **Bus**: Available for all O-D destination combinations that are 50+ miles apart and are connected to bus network.

3. **Rail**: Available for all O-D destination combinations that are 50+ miles apart and are connected to rail network.

4. **Air**: Available for all O-D destination combinations that are 50+ miles apart and are connected to the air network.

(The reader is referred to the Final Report for details on the development of the bus, rail, and air networks.)

Several household, person, tour-level, and destination-related attributes were found to have significant effects on tour mode choices. The calibration task was undertaken by adjusting mode-specific constants. Similar to destination-choice models, mode-choice models were calibrated for each purpose.

Figure 12 to Figure 17 present the calibrated mode-choice model results. Specifically, Figure 12 shows overall distribution of tour mode share for all purposes and Figure 13 to Figure 17 present tour mode share distribution for personal business, visiting friends and relatives, leisure, commute, and employer's business tour purpose, respectively. Regardless of tour purposes, the calibrated mode shares match observed mode shares reasonably well with a difference within 4%. Auto is the predominant mode for long-distance tours and has an overall mode share of

88%. Personal business tours have the highest auto share (92.8%) and employer's business tours have the lowest auto share (82.1%). The second most frequently used mode is air, with an overall share of about 8%. Air share is the highest for employer's business (14.6%) and the lowest for commute (0.9%). Compared to auto and air, bus and rail have relatively small mode shares, in most cases ranging from less than 1% to a little over 2% (exceptions are bus and rail shares for commute tours, these shares are 3.1% and 12.0%, respectively).

Figure 12: Overall Tour Mode Share

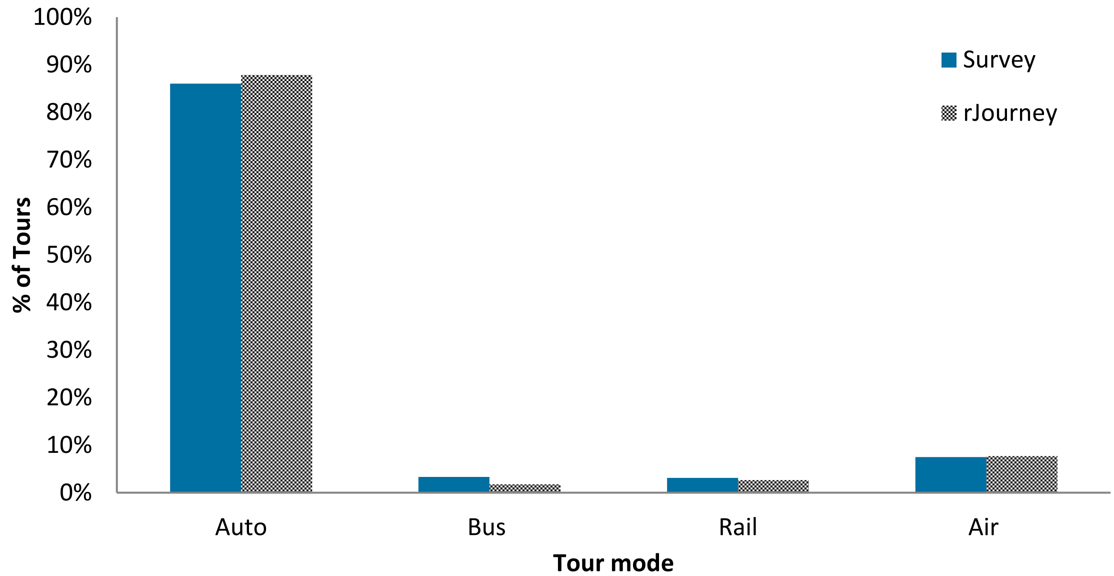


Figure 13: Tour Mode Share by Purpose—Personal Business

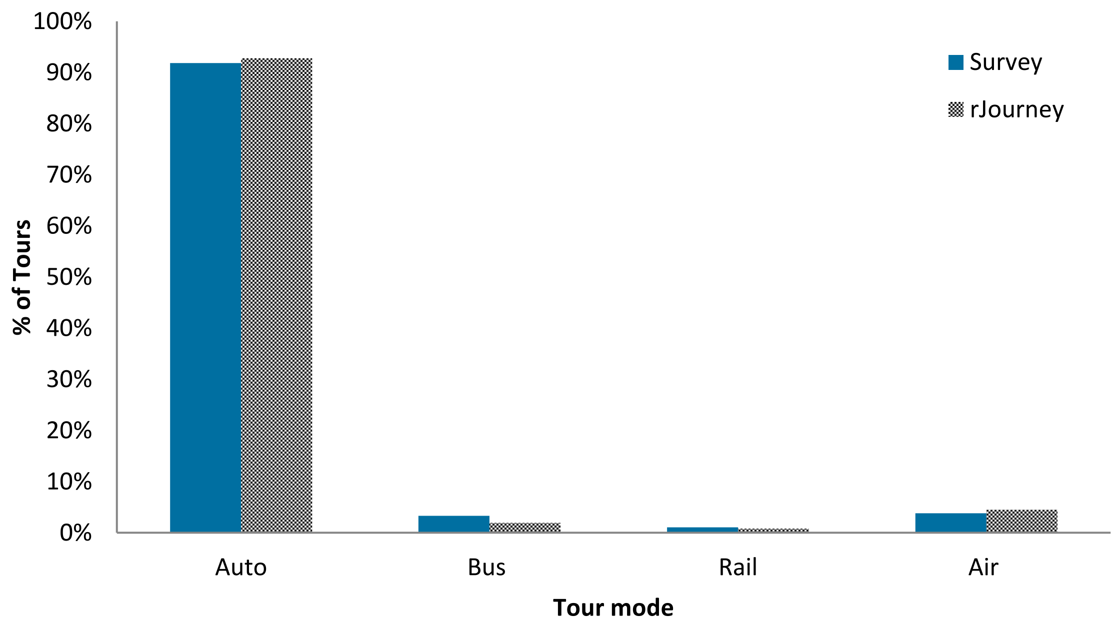


Figure 14: Tour Mode Share by Purpose—Visiting Friends and Relatives

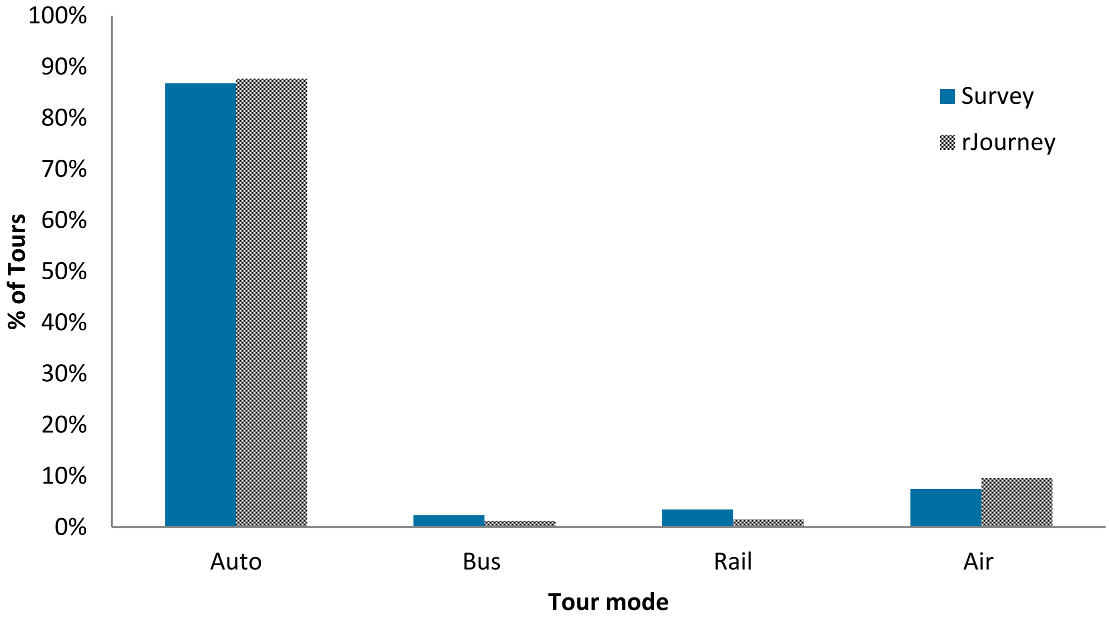


Figure 15: Tour Mode Share by Purpose—Leisure

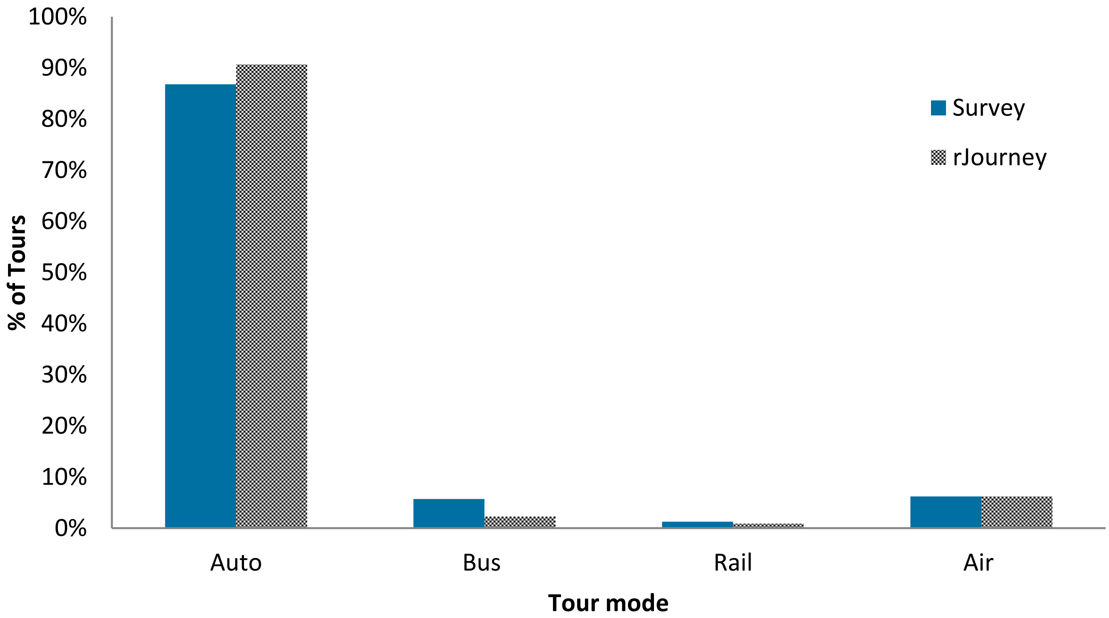


Figure 16: Tour Mode Share by Purpose—Commute

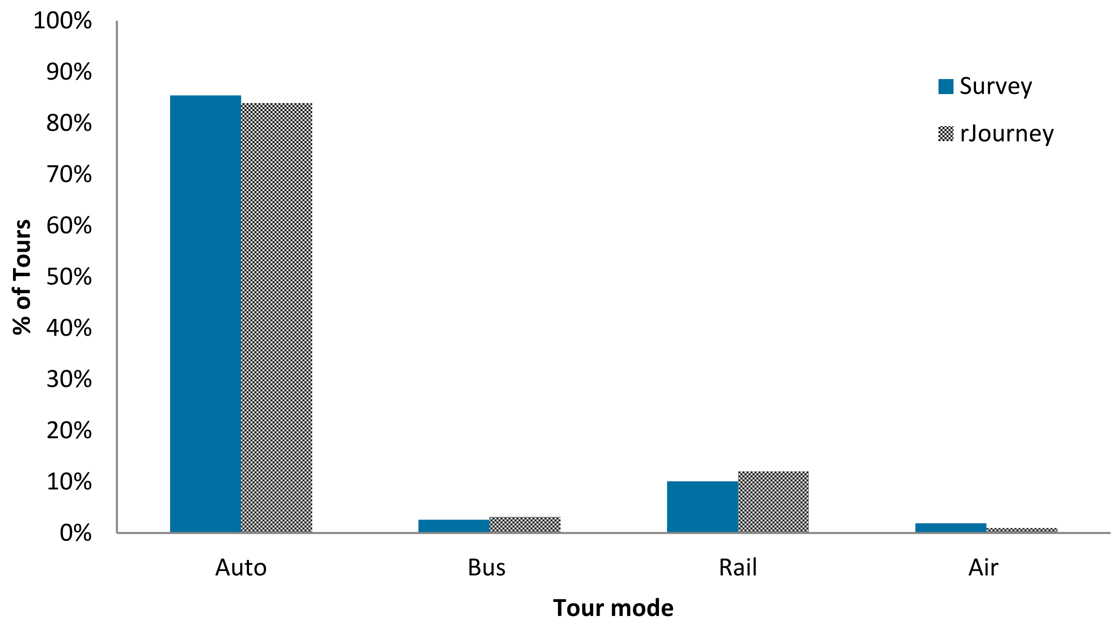
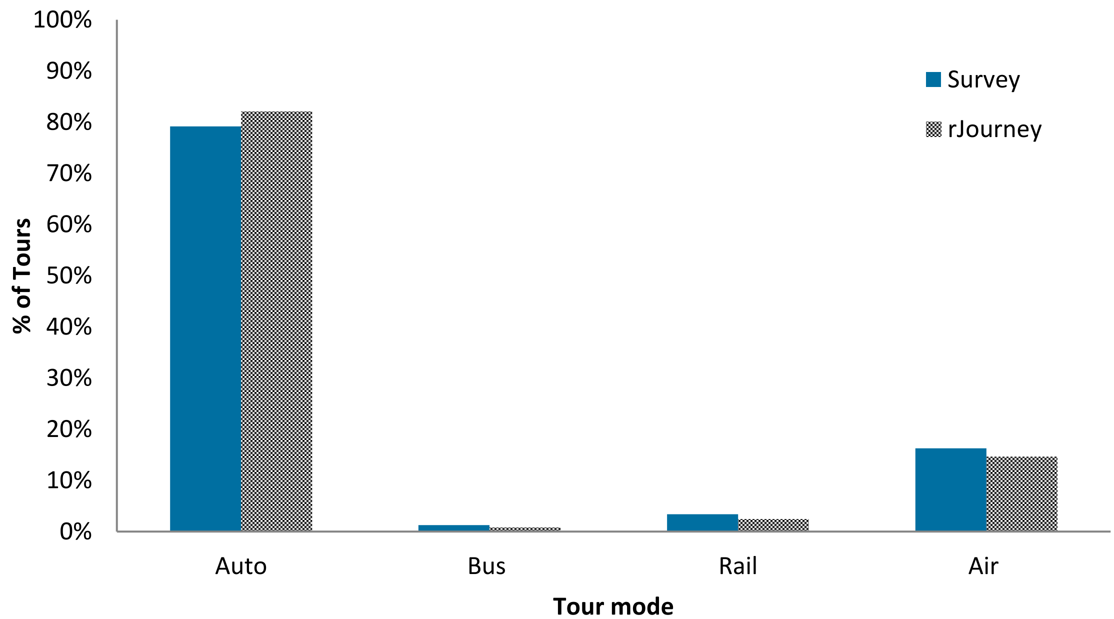


Figure 17: Tour Mode Share by Purpose—Employer's Business



2.4 Preparation of Average Daily Long-Distance Trip Tables

The final outputs generated by rJourney include a household file (includes household-level information), a tour file (includes tour-level information), and trip matrices by mode. The trip matrices contain average daily long-distance trips and are derived from the tour file as follows:

- First, tours are converted to half-tours/trips using tour O-D zones. Information on mode, party size, distance, and expansion factors are extracted from each tour and are appended to the corresponding trip records.
- Second, expansion factors are applied to obtain an expanded trip record file. The file includes all the trips undertaken over one year. The trip records are divided by a factor of 365 to convert the annual vehicle-trip table to an average daily vehicle-trip table. Mode information is used to separate the trips into trip tables for auto, bus, rail, and air mode.
- Third, for person trip tables, the trip records are multiplied by party size to convert vehicle-trip tables to person trip tables.

CHAPTER 3. HIGHWAY ASSIGNMENT

3.1 Overview of Highway Network

Highway assignment was completed in TransCAD. The National Highway Planning Network (NHPN) was the main source of the TransCAD network. NHPN, developed by FHWA, is a geospatial database that comprises interstates, principal arterials, and rural minor arterials (over 450,000 miles of existing and planned highways in the country). The most up-to-date highway network was downloaded from the FHWA's website. To build highway skims for the NUMA-level zonal system, centroid connecters were added to the NHPN network as additional links. Centroid connecters are not allowed to directly link to interstate facilities, since travelers have to access interstate facilities through other roads. The final highway network contains 198,634 links. TransCAD assigns long-distance and background traffic to this network to produce planning-level estimates of traffic volumes.

The key variables for building highway skims are speed and capacity. While speeds and capacities vary from facility to facility, the project team developed these based on the functional class of the highway links; this was due to a lack of facility-specific data. Table 4 and Table 5 are the look-up tables for the speed and capacity assumption.

Table 4: Urban roads' Speed and Capacity by Functional Class

Functional Classification	Urban	Posted Speed	Free-Flow Speed	Hourly Capacity Per Lane
Interstate	11	65	71.50	1,900
Other Freeway/Expressway	12	55	60.50	1,700
Principal Arterial	14	45	47.25	1,200
Minor Arterial	16	35	36.75	1,000
Collector	17	30	31.50	900
Local	19	25	26.25	600

Table 5: Rural Roads' Speed and Capacity by Functional Class

Functional Classification	Rural	Posted Speed	Free-Flow Speed	Hourly Capacity Per Lane
Interstate	1	70	73.50	2,000
Other Freeway/Expressway	2	60	63.00	1,800
Principal Arterial	6	50	52.50	1,400
Minor Arterial	7	45	47.25	1,200
Collector	8	40	42.00	1,000
Local	9	35	36.75	700

Centroid connectors also need speed and capacity constraints. Speed on centroid connectors was assumed to be the same as that for local roads. However, their capacities were set at an arbitrarily high level (999,999) to incorporate the fact that all demands have to flow through the centroid connectors.

A free-flow travel time highway skim was built for the NUMA zones. It is a 4486*4486 matrix—some NUMAs in Hawaii and Puerto Rico were not directly connected to the continental United States.

3.2 Estimation of Background Traffic

Long-distance trips are a small portion of the total demand on the national highway network. To obtain better assignment results, one should estimate the other trips taking up capacity on the road system so that congestion is adequately represented. These other trips include short-distance passenger trips and truck trips. At the link level, the total traffic is defined as follows:

Equation 1: Defining Total Traffic

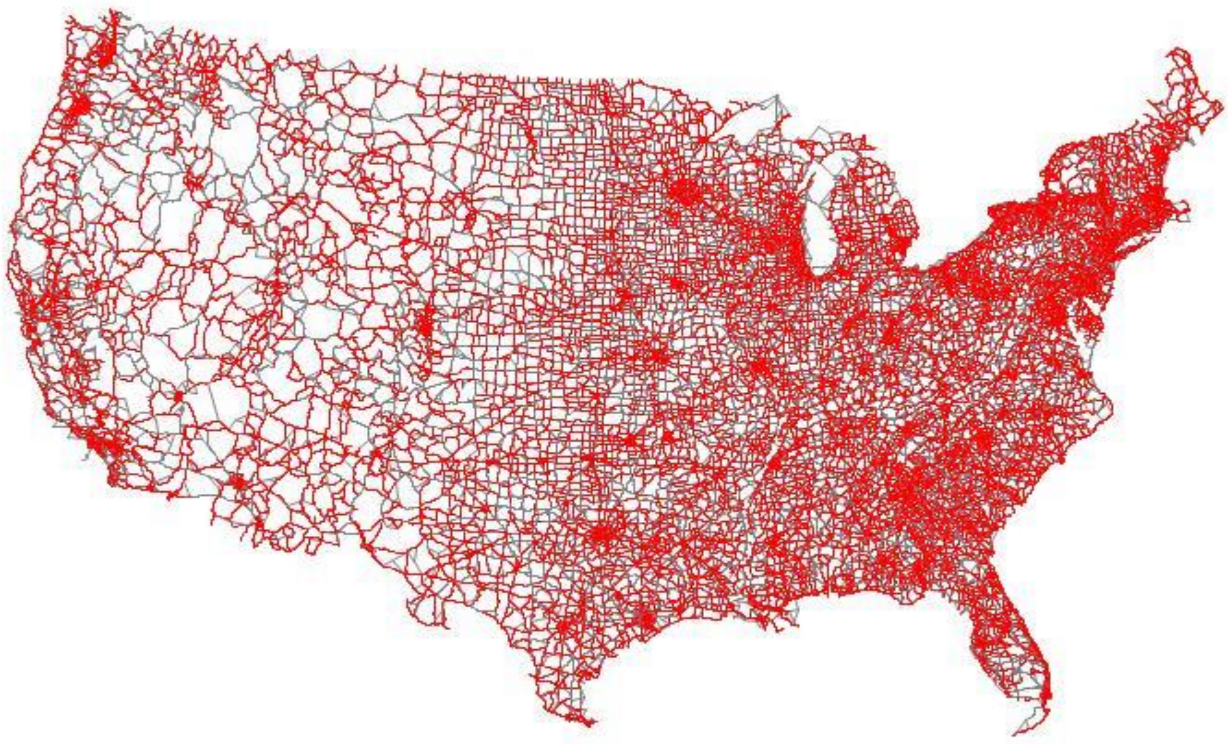
$$\begin{aligned}&Total\ Volume\\&\quad = Truck\ Volume + Long - Distance\ Passenger\ Volume + Short\\&\quad - distance\ Passenger\ Volume\end{aligned}$$

The original NHPN, while containing annual average daily traffic (AADT) data, does not have truck AADT. The Freight Analysis Framework (FAF) network is useful for this purpose. FAF estimates commodity movements by truck and weight for truck-only, long-distance moves over specific highways. It can also be downloaded from the FHWA website. The greatest advantage of the FAF network was that it was also based on NHPN, which makes it relatively easy to correlate the average annual daily truck traffic (AADTT) with the highway links. A total of 176,231 matches were found in the FAF network. The links in Figure 18 represent those with FAF traffic counts.

To estimate the background trip table, the long-distance passenger trip table was assigned with the truck trip table using the stochastic method and subtracted from total volumes to produce an estimate of short-distance passenger volumes. These volumes were used in combination with origin-destination matrix estimation (ODME) methods to produce a short-distance passenger trip table. The short-distance passenger trips, added to the truck trips, produced a “background” trip table.

This initial estimation of background trips did not produce a reasonable estimate of total volumes, because the “seed” matrix for the ODME process was not reasonable. The seed matrix is for initial assignment purposes and could take various values—as simple as a matrix of all ones. A more theoretically sound approach, which has been applied by the project team, was generating a seed matrix using the quick response methods (QRM) for passenger travel. This method assumes trip rates (per household) for three purposes: home-based work (HBW), home-based non-work (HBNW), and non-home-based (NHB). The QRM approach uses a cross-classification table, segmented by the size of the urban area, household income, and auto ownership. For each purpose, separated trip production and trip attraction rates were applied, and a final trip table was created by balancing both. A total QRM matrix was created by combining all three purposes.

Figure 18: Highway Network with FAF Truck Traffic Data



Since the background travel was focused only on short-distance travel, trips between any O-D pairs with greater than 50 miles of distance were eliminated from the QRM matrix. The final seed matrix contains 88,306 O-D pairs.

Table 6: Statistics of the QRM Seed Matrices

Matrix	Count	Mean	Std	Pct_Diag	Min	Max
HBW	19731666	15.6	1019.0	45.6	0	2279468
HBNW	19731666	27.9	1994.5	55.7	0	4084150
NHB	19731666	11.9	836.4	53.6	0	1740189
Total	19731666	55.4	3835.0	52.4	0	8103807
Less50	88306	12289.5	55998.3	52.8	1.13	8103808

QRM also produces intrazonal trips. Although these trips were never assigned to the network, a uniform 10 minutes of travel time is added to the diagonal cells of the skim to avoid invalid computational errors. The background traffic (a zonal trip matrix and link volumes) was successfully estimated using TransCAD's ODME process to assign the QRM seed matrix onto the network.

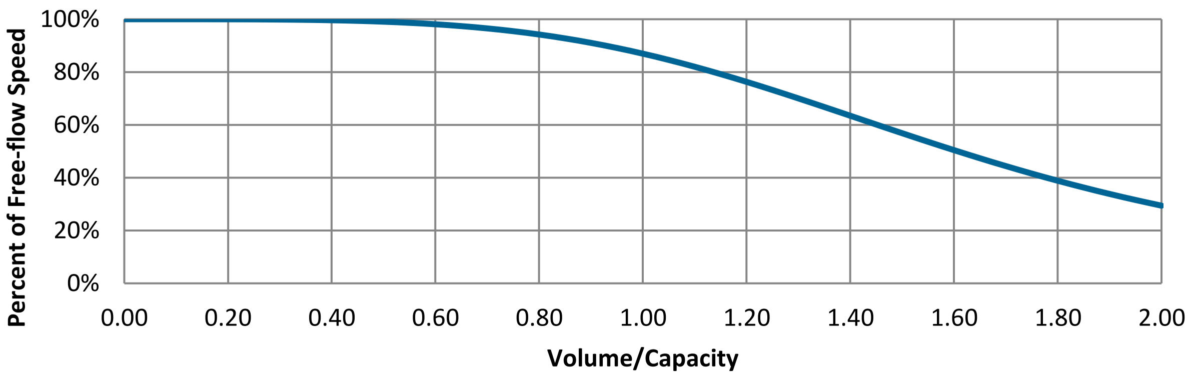
3.3 Highway Assignment Parameters

Background trip and long-distance trip matrices produced are assigned to the NHPN. Background trips are assigned first using a biconjugate Frank-Wolfe method. The biconjugate Frank-Wolfe method is a user equilibrium assignment, which is an iterative process to achieve a convergent solution where route changes would not improve individual users' travel times. The traditional Bureau of Public Roads (BPR) volume-delay function is used to determine the change in travel as congestion occurs (see Figure 19). This equation relates link travel times as a function of the volume/capacity ratio. The alpha and beta defined in the standard BPR function are globally assumed to be equal to their traditional values in rJourney. The background trip assignment is run with a relative gap of 0.003, with a maximum of 200 iterations.

$$t = t_f\,[1+\alpha\,(v/c)^{\beta}]$$

Where	t	=	congested link travel time
	t_f	=	link free-flow travel time
	v	=	link volume
	c	=	link capacity
	α,β	=	0.15, 4.0

Figure 19: Volume-Delay Curve



The resulting user equilibrium travel times from the background trips are applied to the network to provide congested travel times for long-distance trips. Due to the limited detail of the national network and the desire to utilize alternative routes, long-distance trips are assigned to the network using a stochastic assignment. A stochastic assignment distributes trips between multiple alternative paths that connect O-D pairs. The proportion of trips assigned to a path equals the choice probability for that path, which is calculated by a simple logit route choice model. Generally, a path with a lower overall travel time will have a higher choice probability. Only "reasonable" paths are considered in a stochastic assignment, so not every alternative path will be assigned. A path is determined "reasonable" if it takes the traveler farther away from the origin and/or closer to the destination. The stochastic error parameter is set at 40 and runs for 98 iterations.

3.4 Application in TransCAD

The rJourney assignment was implemented in TransCAD Version 6.0, a GIS-based travel demand modeling software, using the software's scripting language, GISDK (Geographic Information System Developer's Kit). TransCAD was chosen due to its ease of use and ability to handle large-scale traffic assignment algorithms within reasonable run times.

Some preprocessing is needed prior to assignment within TransCAD. While background trips were estimated in TransCAD, conversion was needed to bring the long-distance trip table into TransCAD's matrix (.mtx) format. Long-distance tabular data was converted into a comma-separated values (CSV) file. Once processed, the CSV file was imported and converted using TransCAD import tools so that long-distance trips were in an appropriate O-D format for the national network.

A single GISDK script was created to complete the assignment approach detailed in Section 3.2. The process was broken into four parts, outlined in Figure 20. This includes the creation of the TransCAD highway network file (.net), the biconjugate Frank-Wolfe assignment of the background trips, updates to network attributes, and the stochastic assignment of long-distance trips.

Figure 20: Application in TransCAD Process

CHAPTER 4. MODEL VALIDATION

4.1 Trip Tables by Mode

As part of model validation, the research team compared model-estimated trip tables by mode with mode-specific trip tables obtained from the following sources:

- **2008 National O-D trip tables**: These are 2008 county-to-county person trip tables for auto, bus, rail, and air. The tables include trips that are 100+ miles in length. The trip tables were developed as part of FHWA's Traffic Analysis Framework Multimodal Interregional Passenger Travel Origin-Destination Data project. The auto and bus O-D tables were developed using the 1995 American Travel Survey as the primary source, and the 2001 and 2009 NHTS data as additional sources. The 2008 rail O-D table was created by blending data on station-to-station trips provided by Amtrak with survey data on access/egress trips to stations. The 2008 air O-D table was developed by combining Airline Origin and Destination Survey Data (DB1B) and T-100 data with data from a number of airport ground-access surveys. In addition to 2008 O-D tables, the project also developed trip tables for the year 2040. Trip tables from these two years were used to produce base year 2011 trip tables for the current research.
- **2014 Intercity bus ridership table**[3]: This is a 2014 Core Based Statistical Area -to-Core Based Statistical Areas bus trip table for the top 200 markets. This bus trip table was developed as part of FHWA's Developing Refined Estimates of Intercity Bus Ridership project. The table utilized data from several sources, including GTFS data for intercity bus services compiled from several sources, intercity bus schedule data from Russell's Guide, and Northeast Corridor traveler survey. The 2014 bus ridership table was factored down to the 2011 level.

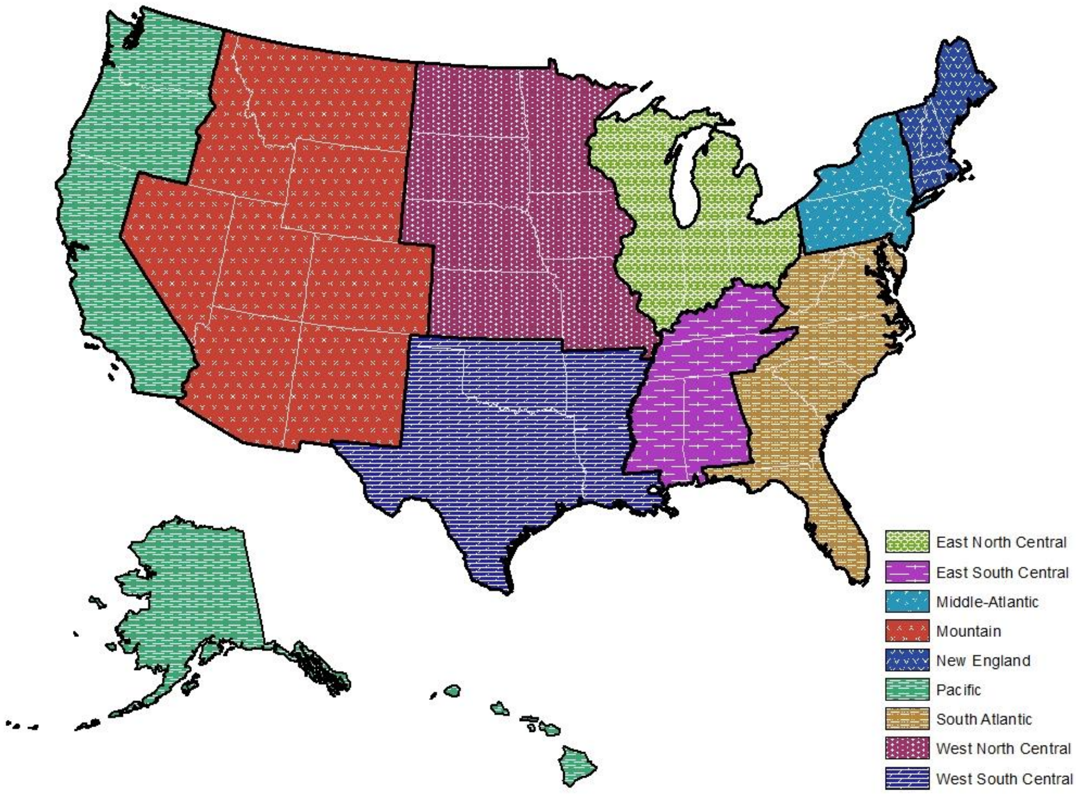
The 2008 national O-D tables and the 2014 intercity bus ridership table are not observed data and so are not used as conclusive sources for validation. The 2014 intercity bus ridership table also does not provide any information on the overall market share captured by the top 200 markets. Therefore, it is not feasible to treat these tables as benchmark values and use them for model validation. Rather, the research team compared the model-estimated trip tables with the 2011 national O-D tables and the 2011 intercity bus ridership table to obtain a general overview on the performance of the model. For this, the trip tables were summarized by nine Census Regions[4] shown in Figure 21. The results are presented in Table 7 and Table 8. Overall, the model-estimated auto and air trip tables align relatively well with national O-D tables. The variation is more pronounced for bus and rail modes. Relative to national O-D tables, the model under-predicts total daily bus trips and over-predicts total daily rail trips by approximately 25%. When the model-predicted bus ridership values are compared with the 2011 intercity bus ridership table, the over-prediction rate is 60%. This divergence between rJourney values and intercity bus ridership values may be due to the fact that the spatial resolution and other information available

[3] These are preliminary research data and information the research team obtained from FHWA. At the time of this report, FHWA has not performed any quality review of the data.

[4] The Census Bureau refers to these regions as Divisions, with larger aggregations of these Divisions as Regions.

on the definition of the top 200 markets were not detailed enough to enable a selection of the same bus markets from the model.

Figure 21: Regions in the US Census



Another potential data source for the current research is the long-distance component of the 2001 NHTS. Table 9 summarizes average daily long-distance trips by mode from rJourney, 2011 national O-D tables, and 2001 NHTS. The difference between the number of auto trips from rJourney and the NHTS data may be attributed to the followings:

a) To be consistent with the values in the national O-D tables, only auto trips with a length ≥ 100 miles were selected from rJourney, while the NHTS data includes all trips with a length ≥ 50 miles.

b) rJourney predicted values correspond to the year 2011 while NHTS data correspond to the year 2001.

Compared to NHTS data, the model over-predicts the number of air trips by more than 90%. This is not surprising since there was a significant decline in air travel in 2001 after September 11, 2001. Table 10, which shows overall mode share, also captures this decline. In contrast, mode share from rJourney and national O-D tables show similar distribution.

Table 7: Average Daily Person-Trips by Region by Mode (Trip Length ≥ 100 Miles)

Region	rJourney (includes only trips with a length ≥ 100 miles)				National O-D table (2011)				The top 200 bus ridership markets (2011)	
	Auto	Bus	Rail	Air	Auto	Bus	Rail	Air	rJourney[5]	Ridership table
New England	307,492	6,920	10,706	51,684	272,101	8,822	8,120	57,088	4,052	6,926
Mid-Atlantic	860,904	22,533	37,781	125,675	618,977	28,305	25,508	132,363	17,493	20,329
East North Central	1,300,657	28,841	12,352	130,370	955,474	26,317	9,034	135,017	21,092	5,044
West North Central	640,750	10,175	2,282	60,416	621,961	10,765	1,602	63,244	2,394	324
South Atlantic	1,487,693	30,254	18,221	200,458	1,267,450	37,227	14,629	281,225	17,598	7,435
East South Central	591,437	10,243	736	37,496	482,329	9,235	317	37,640	1,009	148
West South Central	856,572	16,474	3,899	116,627	1,053,825	22,906	934	125,255	8,597	4,839
Mountain	481,558	6,772	1,934	97,360	710,182	17,318	1,069	163,833	2,559	1,641
Pacific	694,852	13,053	13,956	191,769	1,003,079	34,321	20,065	270,918	10,692	6,156
Total	7,221,915	145,264	101,868	1,011,855	6,985,379	195,216	81,278	1,266,582	85,486	52,842

[5] Information available on the definition of the top 200 bus ridership markets were not detailed enough to select the corresponding 200 markets from rJourney.

Table 8: Model Estimates Over Trip Table Values Ratio

Region	Ratio: rJourney/National O-D table				Ratio: rJourney/Bus ridership table
	Auto	Bus	Rail	Air	
New England	1.13	0.78	1.32	0.91	0.59
Mid-Atlantic	1.39	0.80	1.48	0.95	0.86
East North Central	1.36	1.10	1.37	0.97	4.18
West North Central	1.03	0.95	1.42	0.96	7.38
South Atlantic	1.17	0.81	1.25	0.71	2.37
East South Central	1.23	1.11	2.32	1.00	6.81
West South Central	0.81	0.72	4.18	0.93	1.78
Mountain	0.68	0.39	1.81	0.59	1.56
Pacific	0.69	0.38	0.70	0.71	1.74
Overall Ratio	1.03	0.74	1.25	0.80	1.62

Table 9: Average Daily Long-Distance Trips by Mode

Travel Mode	rJourney (includes only trips with a length ≥ 100 miles)	2011 National O-D tables (trip length ≥ 100 miles)	2001 NHTS (trip length ≥ 50 miles)[6]	Ratio	
				rJourney/ National O-D table	rJourney/ NHTS
Auto/Personal Vehicle	7,221,915	6,985,379	6,400,274	1.03	1.13
Bus	145,264	195,216	151,781	0.74	0.96
Train	101,868	81,278	57,808	1.25	1.76
Air	1,011,855	1,266,582	529,589	0.80	1.91
Other	-	-	15,890		
Total	8,480,901	8,528,455	7,155,342	0.99	1.19

Table 10: Overall Mode Share

Transportation Mode	rJourney (includes only trips with length ≥ 100 miles)	2011 National O-D tables (trip length ≥ 100 miles)	2001 NHTS (trip length ≥ 50 miles)
Auto/Personal Vehicle	85.2%	81.9%	89.4%
Bus	1.7%	2.3%	2.1%
Train	1.2%	1.0%	0.8%
Air	11.9%	14.9%	7.4%
Other	-	-	0.2%
Total	100.0%	100.0%	100.0%

4.2 Highway Performance

Highway validation of passenger long-distance trips was completed by studying rural functional classes at the Census Division level. The Census Divisions are nine subdivisions of the four Census Regions (Northeast, Midwest, South, West), which provide groupings of the United States and the District of Colombia (see Figure 21).

Highway network validation is difficult at this national level for several reasons. Of necessity, the model has limited spatial resolution. Short-distance trips or background traffic are treated in an extremely simplified fashion, and limited data were available for the calibration of the long-distance demand patterns. However, an effort was made to analyze long-distance passenger trips with national data currently available. For national traffic count data, the Freight Analysis Framework Version 3 (FAF^3) database was applied to the NHPN, which resulted in adding HPMS AADT for 2007 to 98% of functionally classified links within the NHPN. For rural vehicle miles traveled (VMT) data, table VM-3 from the Highway Statistics 2013 manual, published by FHWA's Office of Highway Policy Information (OHPI), was aggregated from the

[6] 2001 NHTS annual long distance trips were divided by 365 to obtain daily long-distance trips.

state level into Census Divisions. Table 11 presents the long-distance rural volumes and VMT from rJourney with the percent distributions of traffic counts and VMT counts from available sources.

Table 11: Highway Model Validation Data by Region

Region	rJourney Rural Avg. Volume	rJourney Rural Total VMT	2007 AADT	2013 OHPI VMT
Pacific	3,650	18,472	19.8%	39.0%
Mountain	2,966	9,142	32.4%	50.5%
West South Central	3,928	12,091	32.5%	47.6%
East South Central	4,424	12,581	35.2%	46.9%
South Atlantic	5,255	16,771	31.3%	52.7%
West North Central	2,454	6,721	36.5%	48.8%
East North Central	5,096	12,194	41.8%	68.4%
Mid-Atlantic	4,296	13,253	32.4%	65.2%
New England	3,427	15,352	22.3%	38.8%

With the exception of the Pacific and New England regions, comparing these datasets illustrates that average long-distance passenger volumes are roughly 35% of the 2007 total traffic counts and 54% of the rural VMT (see Figure 22 and Figure 23). Looking closer at the Pacific and New England regions shows a decrease in both average count and VMT comparisons. This could be attributed to the small size and relatively fewer rural roadways of these regions.

Figure 22: Highway Model Validation Volumes by Region

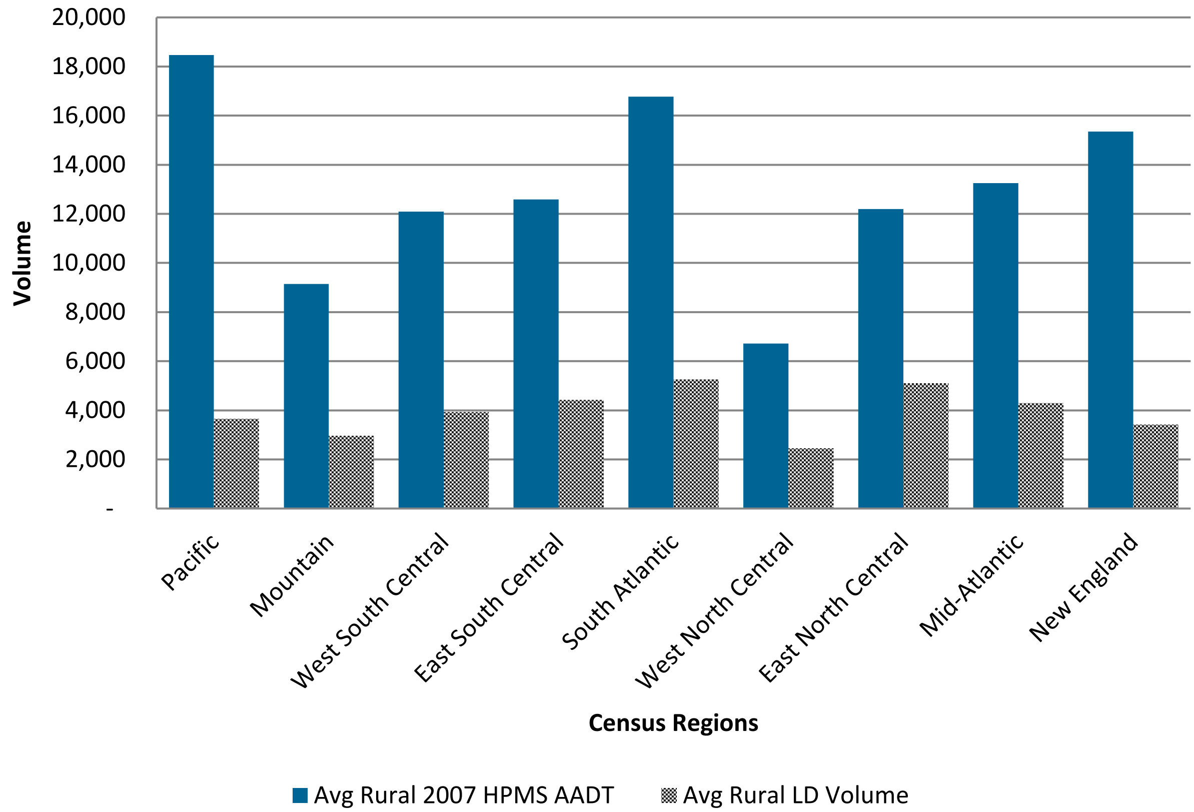
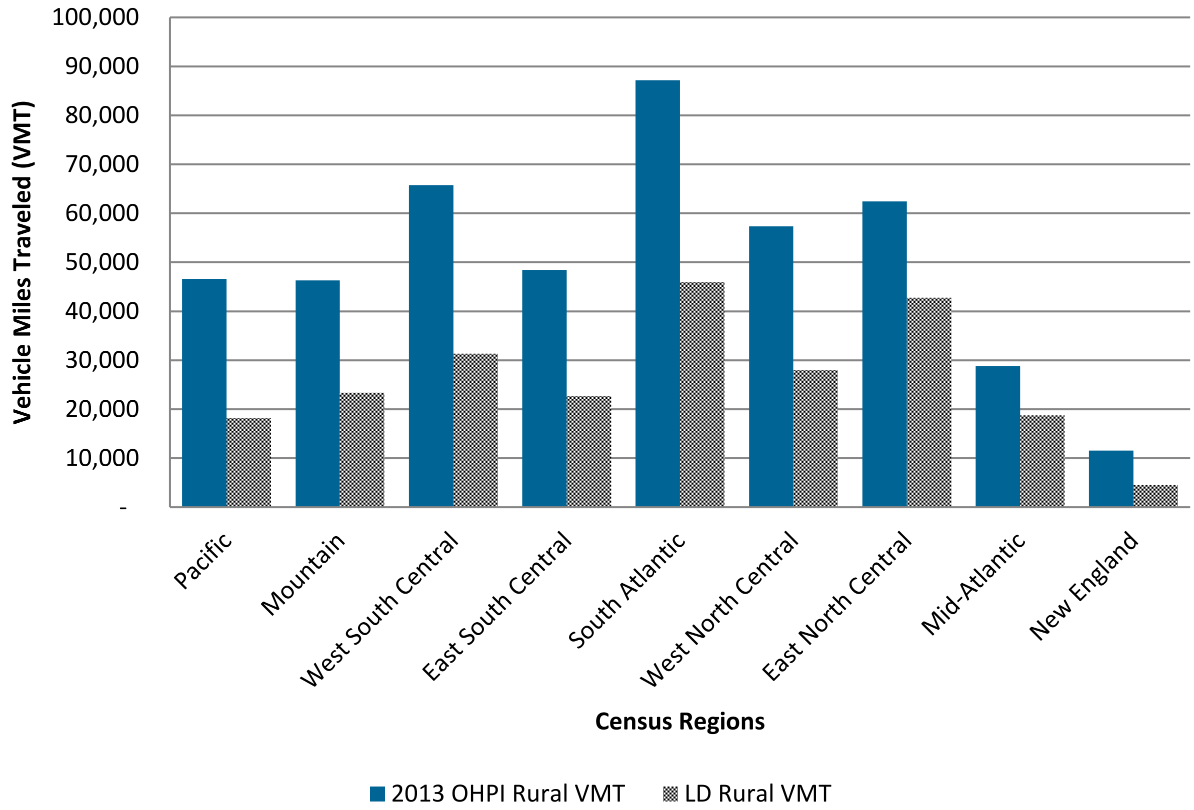


Figure 23: Highway Model Validation VMT by Region



Improvement in assignment validation is possible with further investments. The network itself could be improved by addressing remaining connectivity issues, further adjusting centroid connectors and perhaps improving assumptions regarding speeds and capacities. Several improvements could be made to handling short-distance trips or background traffic, and enhancements to the long-distance trip table estimates themselves could also potentially be made by incorporating additional data, including data from traffic counts or additional O-D data if and when it becomes available.

An overall view of the assignment of rJourney volumes on the national highway network confirms the reasonableness of the highway assignment (Figure 24 and Figure 25). These long-distance volumes are greater around metropolitan areas due to higher population concentrations; these volumes also represent smaller populations in rural areas who travel long distances.

Figure 24: rJourney Total Volumes by Count

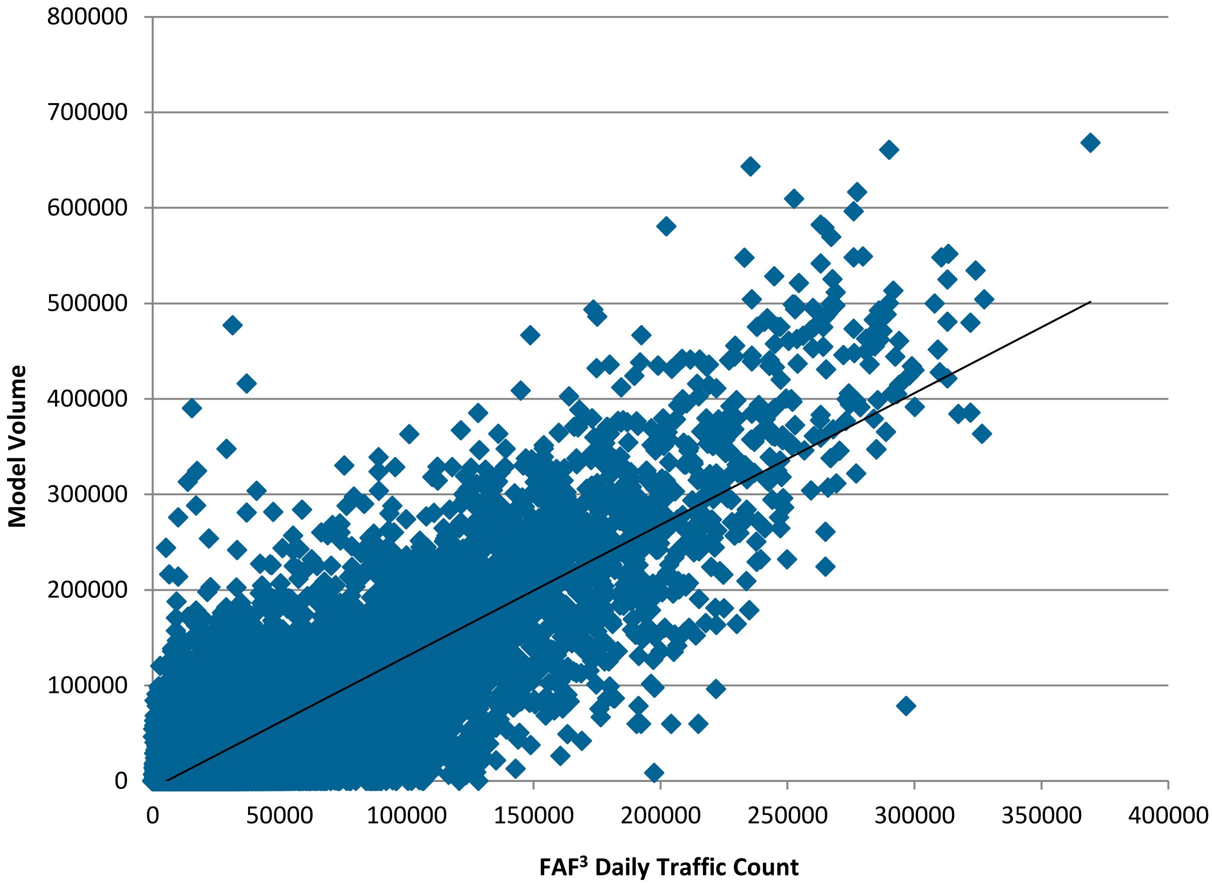
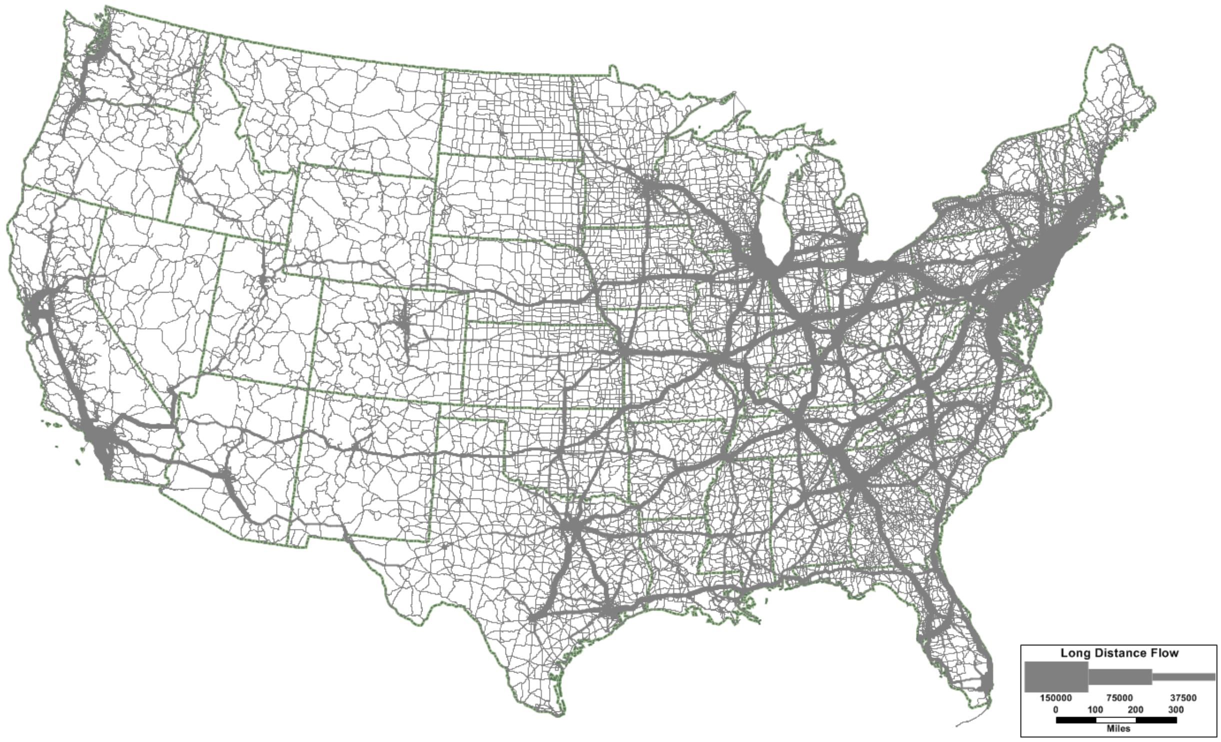


Figure 25: Long-Distance rJourney Volumes in the United States



CHAPTER 5. SENSITIVITY TESTS

Five sensitivity tests were undertaken to assess the model's responsiveness to changes in policy sensitive variables. The policy sensitive variables and the changes tested included:

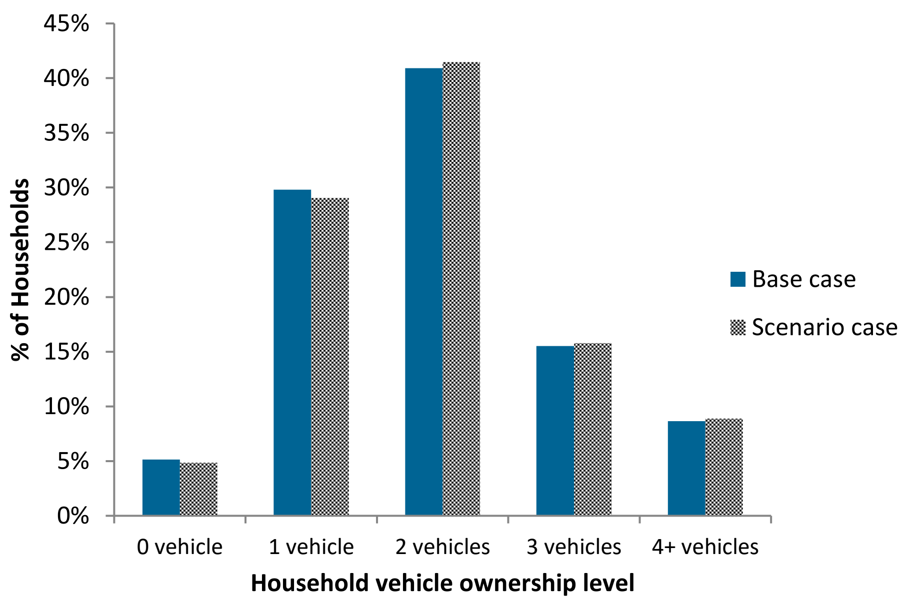
1. **Household income**: Increase all household incomes by 10%.
2. **Auto cost**: Increase all O-D car toll and operating costs by 50%.
3. **Auto travel time**: Increase all O-D car travel times by 25%.
4. **Air fare**: Increase all O-D air fares by 50%.
5. **Rail travel time**: Decrease all O-D rail travel times by 50%.

The sensitivity tests and key findings are discussed below.

5.1 Income Test

This test involved evaluating the impacts of changes in socioeconomic conditions on long-distance travel behavior. Specifically, this sensitivity test quantified changes in long-distance travel behavior due to a 10% increase in income. Figure 26 shows that a 10% increase in income is likely to increase household vehicle ownership level by shifting 0 and 1 vehicle households toward multivehicle households (income elasticities of vehicle ownership are -.58, -.25, .14, .17, and .26 for 0, 1, 2, 3, 4+ vehicles, respectively).

Figure 26: Percentage of Households by Vehicle Ownership Level (scenario case: income test)



An increase in income is also expected to encourage more travel. The model results show a 3.2% increase in tour generation, a significant portion of which may be attributed to leisure and employer's business tours, as shown in Figure 27. Income elasticity of tour generation for leisure, employer's business, and other tour purposes are presented in the last column of Table 12. The table also shows that income increase is likely to cause an almost proportional increase in air mode (overall elasticity .84).

Figure 27: Number of Tours by Purpose (scenario case: income test)

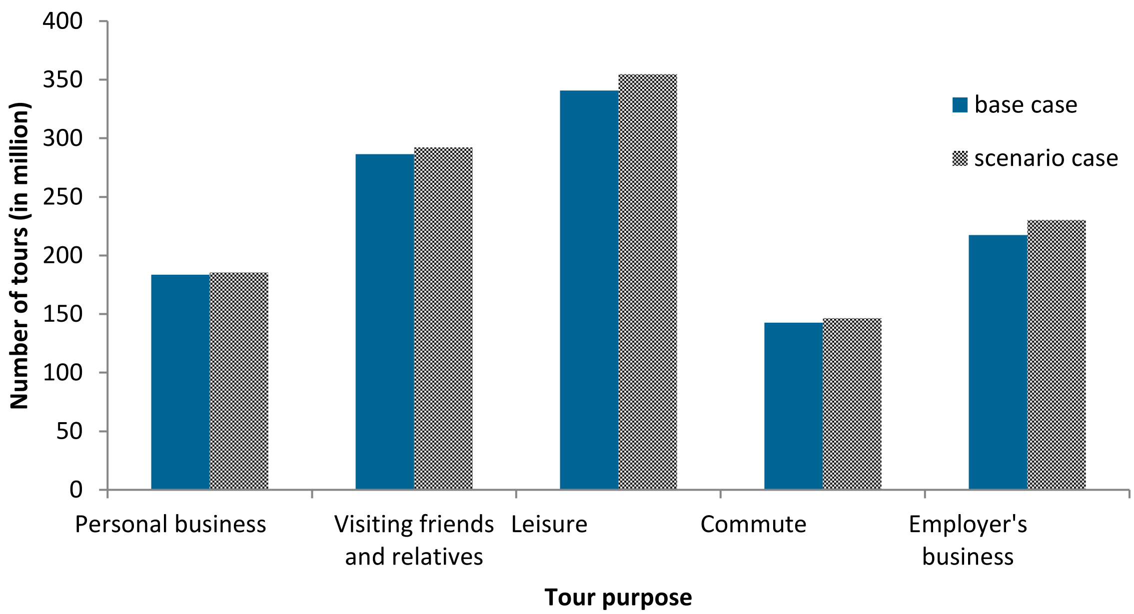


Table 12: Elasticity of Tour Mode by Purpose (scenario case: income test)

Purpose	Auto	Bus	Rail	Air	Total
Personal Business	0.09	0.06	0.10	0.57	0.11
Visiting Friends and Relatives	0.18	-0.17	-0.02	0.53	0.20
Leisure	0.39	-0.32	0.33	0.84	0.40
Commute	0.19	0.03	0.78	0.98	0.26
Business	0.49	0.26	0.35	1.17	0.58
Overall	0.28	-0.10	0.52	0.84	0.32

As expected, under this scenario, tours made by auto and rail are likely to increase as well, while tours by bus are likely to decrease. Unsurprisingly, similar proportional changes in total travel time, total travel cost, and total travel distance can be expected for each mode (Table 13). The table also shows that a 10% increase in income is likely to result in a 6.5% increase in travel expenditure. However, change in average person-miles traveled for each purpose and mode is expected to be none to minimal (Table 14 and Table 15).

Table 13: Elasticity of Total Travel Time, Cost, and Distance by Mode (scenario case: income test)

Mode	Total Travel Time	Total Travel Cost	Total Travel Distance
Auto	0.28	0.31	0.28
Bus	-0.14	-0.15	-0.14
Rail	0.27	0.32	0.28
Air	0.79	0.86	0.79
Total	0.30	0.65	0.45

Table 14: Elasticity of Average Person-Miles Traveled by Purpose (scenario case: income test)

Purpose	Average Person-Miles Traveled
Personal Business	0.14
Visiting Friends and Relatives	0.11
Leisure	0.15
Commute	0.02
Business	0.25

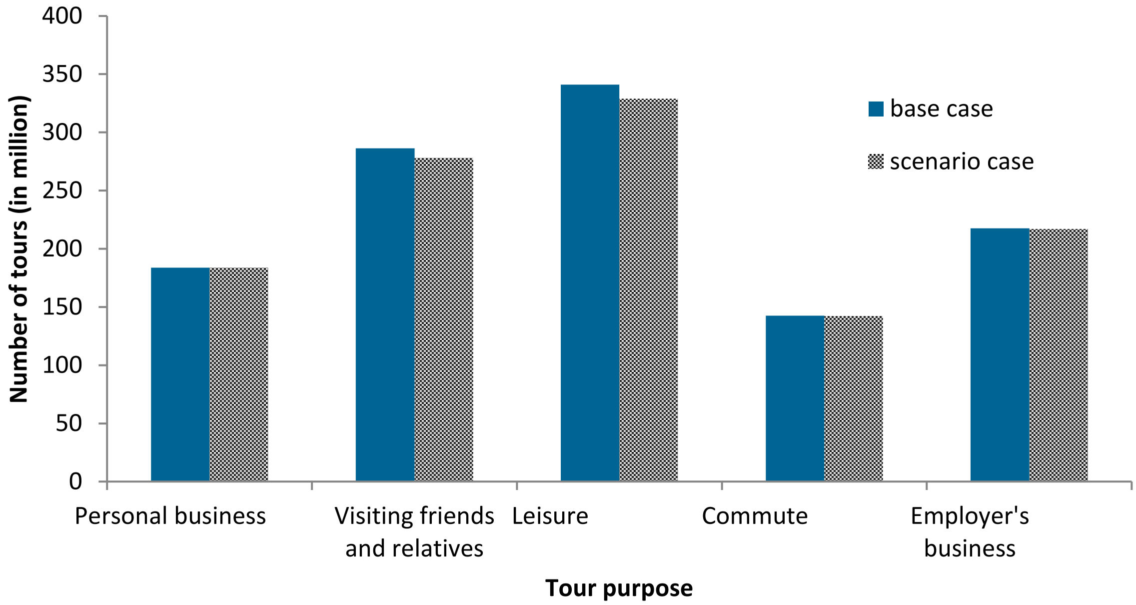
Table 15: Elasticity of Average Person-Miles Traveled by Mode (scenario case: income test)

Mode	Average Person-Miles Traveled
Auto	0.04
Bus	0.04
Rail	-0.09
Air	0.00

5.2 Pricing Test (Auto Costs)

For the Pricing Test scenario, auto costs were increased by 50% to test the effect of pricing on a household's long-distance travel pattern. Such a change in auto costs is likely to result in an approximately 1.8% reduction in long-distance tour generation, mostly from leisure and visiting friends and relatives tour categories (Figure 28).

Figure 28: Number of Tours by Purpose (scenario case: auto costs test)



The test indicated that households' long-distance travel behavior, in terms of mode choice, is fairly inelastic (Figure 28). Relative to base condition, a 50% increase in auto costs is likely to reduce auto tours by less than 2% (elasticity is -.04). This may be due to the fact that for almost 90% of long-distance tours, auto is the only viable mode option.

Table 16: Change in Mode Share (scenario case: auto costs test)

Tour Mode	Base Case	Scenario Case	Difference	Elasticity
Auto	87.88%	87.58%	-0.30%	-0.04
Bus	1.80%	1.84%	0.04%	0.01
Rail	2.66%	2.72%	0.06%	0.01
Air	7.66%	7.86%	0.20%	0.02

To offset increase in travel costs by auto, in some instances households/individuals are likely to visit destinations that are closer to home. Table 17 demonstrates that a 50% increase in auto costs is likely to reduce total distance traveled, and average person-miles traveled by auto, by a little over 5% and just under 3%, respectively. A similar reduction can be expected in total travel time by auto (Table 18). On the other hand, travel cost by auto is likely to increase by approximately 55% (Table 19). This indicates that despite a 50% increase, from a total travel cost standpoint, auto is still the preferred mode for most long-distance tours.

Table 17: Change in Distance Traveled (scenario case: auto costs test)

Tour Mode	Total Travel Distance (In Million Miles)				Average Person-Miles Traveled		
	Base Case	Scenario Case	% Difference	Elasticity	Base Case	Scenario Case	% Difference
Auto	896,814	850,546	-5.16%	-0.10	365	354	-2.91%
Bus	22,114	22,086	-0.13%	0.00	487	487	0.10%
Rail	15,305	15,295	-0.07%	0.00	300	300	-0.18%
Air	492,317	494,411	0.43%	0.01	2,642	2,638	-0.15%

Table 18: Change in Total Travel Time (scenario case: auto costs test)

Mode	Base Case	Scenario Case	% Difference	Elasticity
Auto	15,485	14,710	-5.00%	-0.10
Bus	546	545	-0.14%	0.00
Rail	324	323	-0.18%	0.00
Air	1,266	1,272	0.46%	0.01

Table 19: Change in Travel Cost (scenario case: auto costs test)

Tour Mode	Total Travel Cost (In Thousand $)				Average Travel Cost Per Mile (In $/Mile)		
	Base Case	Scenario Case	% Difference	Elasticity	Base Case	Scenario Case	% Difference
Auto	98,408,206	140,515,046	42.79%	0.86	0.11	0.17	54.55%
Bus	3,226,345	3,220,779	-0.17%	0.00	0.15	0.15	0.00%
Rail	4,696,937	4,705,946	0.19%	0.00	0.31	0.31	0.00%
Air	174,259,351	175,282,139	0.59%	0.01	0.35	0.35	0.00%

5.3 Safety Test (Auto Times)

The Safety Test scenario indicated that long-distance travel is more sensitive to an increase in auto travel time than to an increase in auto travel cost. Under this scenario, travelers are likely to make 3.2% fewer long-distance tours—mostly fewer visiting friends and relatives and leisure tours—if auto travel time is increased by 25% (Figure 29). Such an increase in auto travel time is not expected to make any significant changes in long-distance travel mode share. Table 20 shows a 0.6% decrease in auto mode share and a 0.4% increase in air mode share under this scenario. Relative to base scenario, in some cases individuals are likely to travel to destinations closer to home by auto and to destinations that are farther afield by non-auto modes (Table 21). Despite switching destinations for some tours, total travel time by auto is likely to increase, though not proportionately (Table 22). A 10% increase in auto travel time is expected to increase total travel time by auto by approximately 5% (elasticity 0.46). However, driving to destinations closer to home may decrease total auto cost by a little less than 10% (Table 23).

Figure 29: Number of Tours by Purpose (scenario case: auto times test)

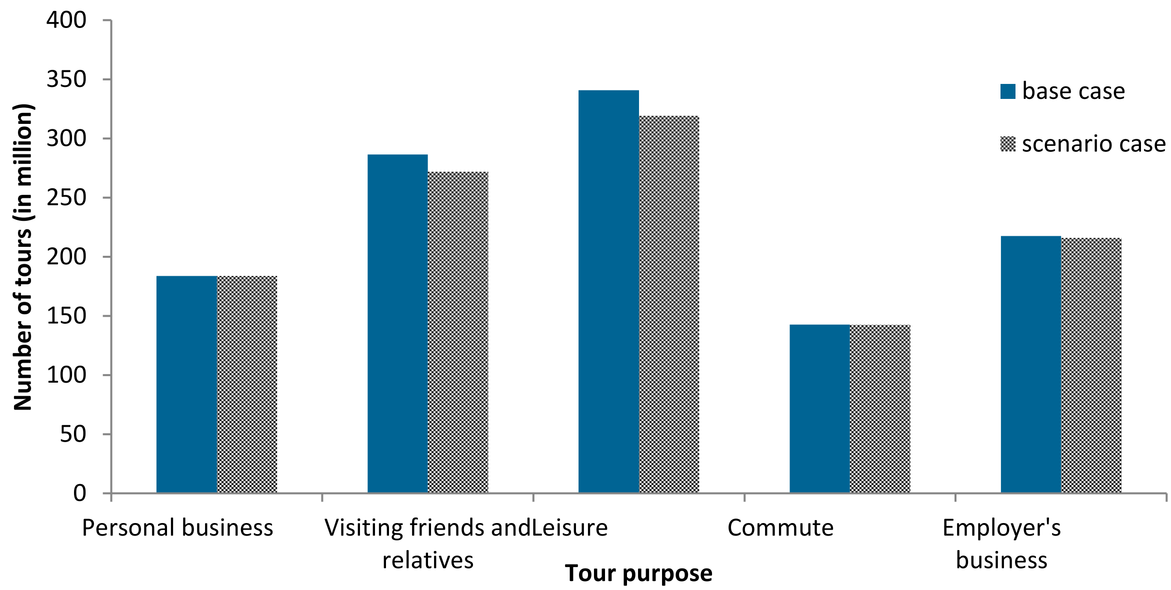


Table 20: Change in Mode Share (scenario case: auto times test)

Tour Mode	Base Case	Scenario Case	Difference	Elasticity
Auto	87.88%	87.27%	-0.61%	-0.16
Bus	1.80%	1.88%	0.08%	0.05
Rail	2.66%	2.78%	0.12%	0.04
Air	7.66%	8.07%	0.41%	0.08

Table 21: Change in Distance Traveled (scenario case: auto times test)

Tour Mode	Total Travel Distance (In Million Miles)				Average Person-Miles Traveled		
	Base Case	Scenario Case	% Difference	Elasticity	Base Case	Scenario Case	% Difference
Auto	896,814	796,177	-11.22%	-0.45	365	338	-7.16%
Bus	22,114	22,449	1.52%	0.06	487	490	0.68%
Rail	15,305	15,528	1.46%	0.06	300	301	0.29%
Air	492,317	501,542	1.87%	0.07	2,642	2,636	-0.24%

Table 22: Change in Total Travel Time (scenario case: auto times test)

Mode	Base Case	Scenario Case	% Difference	Elasticity
Auto	15,485	17,254	11.43%	0.46
Bus	546	554	1.54%	0.06
Rail	324	328	1.43%	0.06
Air	1,266	1,291	1.98%	0.08

Table 23: Change in Travel Cost (scenario case: auto times test)

Tour Mode	Total Travel Cost (In Thousand $)				Average Travel Cost Per Mile (In $/Mile)		
	Base Case	Scenario Case	% Difference	Elasticity	Base Case	Scenario Case	% Difference
Auto	98,408,206	89,045,193	-9.51%	-0.38	0.11	0.11	0.00%
Bus	3,226,345	3,268,319	1.30%	0.05	0.15	0.15	0.00%
Rail	4,696,937	4,772,735	1.61%	0.06	0.31	0.31	0.00%
Air	174,259,351	178,276,796	2.31%	0.09	0.35	0.36	2.86%

5.4 Air Fare Test

A 50% increase in air fare is likely to suppress long-distance tours by 4%, mostly leisure tours, followed by visiting friends and relatives and employer's business tours (Figure 30). This scenario indicates a modal shift primarily from air to auto (1.6%, see Table 24).

Figure 30: Number of Tours by Purpose (scenario case: air fare test)

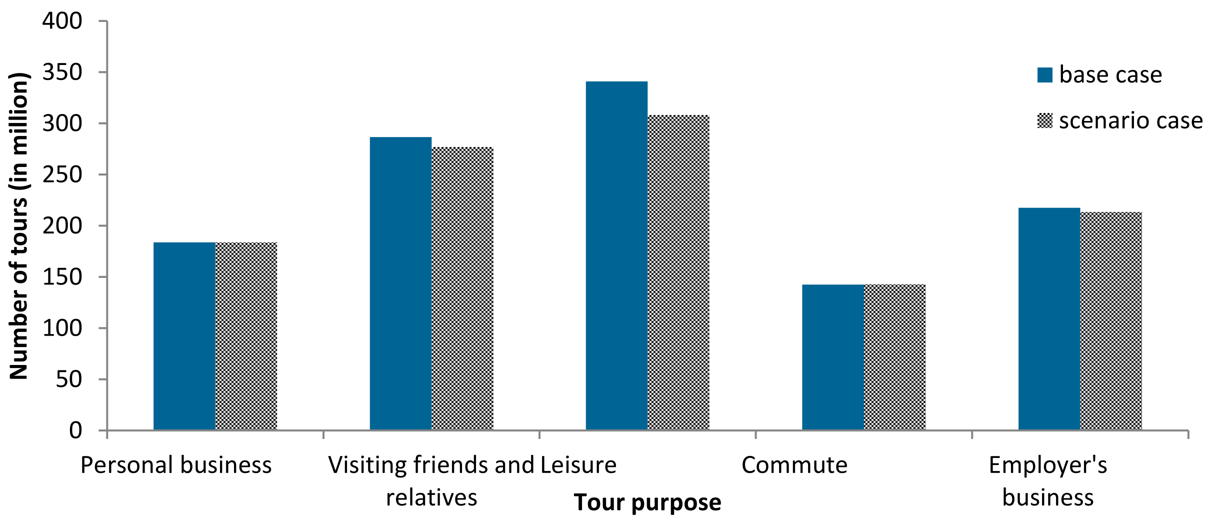


Table 24: Change in Mode Share (scenario case: air fare test)

Tour Mode	Base Case	Scenario Case	Difference	Elasticity
Auto	87.88%	89.48%	1.60%	-0.04
Bus	1.80%	1.82%	0.02%	-0.05
Rail	2.66%	2.75%	0.09%	-0.01
Air	7.66%	5.95%	-1.72%	-0.51

As a result, total distance traveled by air is likely to drop by almost 30%, though expected reduction in average person-miles traveled by air is more modest, approximately 1.9% (Table 25). In line with total travel distance, total travel time by air is also likely to decrease significantly (Table 26). In addition, the results indicate that, far from being proportionate, a 10%

increase in air fare is going to increase air expenditure by only 1.5% (elasticity of air travel cost with respect to air fare is .15, Table 27). This finding, together with other summary tables for this scenario, points to changes in long-distance travel patterns that are a combination of tour suppression, modal shift, and changes in destination choice.

Table 25: Change in Distance Traveled (scenario case: air fare test)

Tour Mode	Total Travel Distance (In Million Miles)				Average Person-Miles Traveled		
	Base Case	Scenario Case	% Difference	Elasticity	Base Case	Scenario Case	% Difference
Auto	896,814	875,697	-2.35%	-0.05	365	367	0.65%
Bus	22,114	21,425	-3.12%	-0.06	487	493	1.16%
Rail	15,305	15,161	-0.95%	-0.02	300	302	0.64%
Air	492,317	349,727	-28.96%	-0.58	2,642	2,591	-1.92%

Table 26: Change in Total Travel Time (scenario case: air fare test)

Mode	Base Case	Scenario Case	% Difference	Elasticity
Auto	15,485	15,116	-2.38%	-0.05
Bus	546	529	-3.08%	-0.06
Rail	324	321	-0.88%	-0.02
Air	1,266	898	-29.07%	-0.58

Table 27: Change in Travel Cost (scenario case: air fare test)

Tour Mode	Total Travel Cost (In Thousand $)				Average Travel Cost Per Mile (In $/Mile)		
	Base Case	Scenario Case	% Difference	Elasticity	Base Case	Scenario Case	% Difference
Auto	98,408,206	96,545,001	-1.89%	-0.04	0.11	0.11	0.00%
Bus	3,226,345	3,114,353	-3.47%	-0.07	0.15	0.15	0.00%
Rail	4,696,937	4,649,209	-1.02%	-0.02	0.31	0.31	0.00%
Air	174,259,351	187,384,824	7.53%	0.15	0.35	0.54	54.29%

5.5 Rail Time Test

The rail time test scenario measures the effect of a 50% reduction in rail travel time on long-distance travel. The results indicated that this scenario is likely to generate approximately 2.5 million more tours, mostly visiting friends and relatives, leisure, and employer's business tours (Figure 31). The results also indicate that a 50% faster rail system is likely to have no to a negligible effect on long-distance travel mode share (Table 30).

Figure 31: Number of Tours by Purpose (scenario case: rail time test)

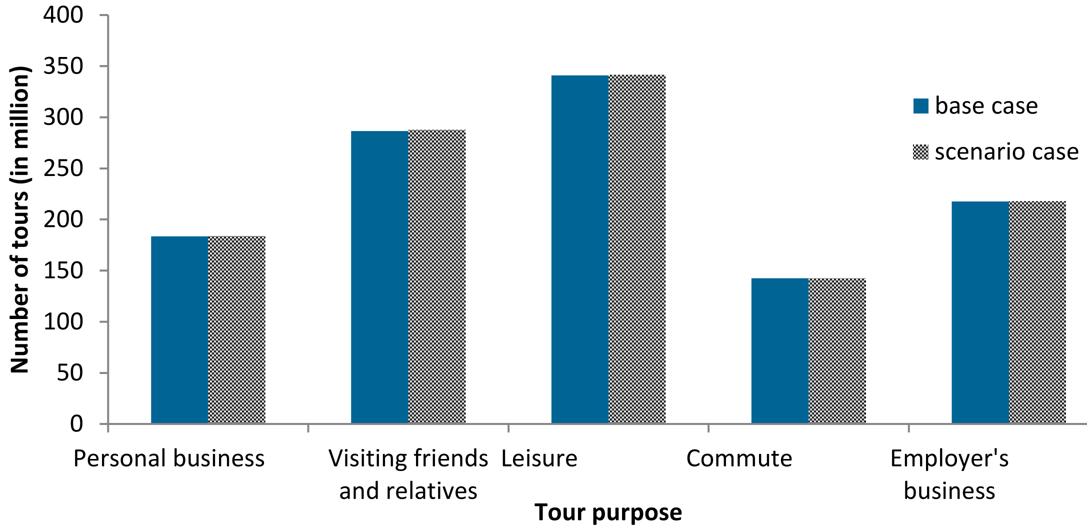


Table 28: Change in Mode Share (scenario case: rail time test)

Tour Mode	Base Case	Scenario Case	Difference	Elasticity
Auto	87.88%	87.70%	-0.18%	0.00
Bus	1.80%	1.79%	-0.01%	0.01
Rail	2.66%	2.88%	0.22%	-0.17
Air	7.66%	7.64%	-0.03%	0.00

This scenario is likely to encourage individuals to travel farther by rail, however. Table 29 shows that total distance traveled by rail is highly sensitive to rail travel time (elasticity -1.04). As a result, average person-miles traveled by rail can be expected to increase by almost 40%. Because of this significant increase in total travel distance, total travel time can be expected to result in a over 16% decrease (Table 30). Longer rail tours are also likely to contribute to higher travel costs (Table 31).

Table 29: Change in Distance Traveled (scenario case: rail time test)

Tour Mode	Total Travel Distance (In Million Miles)				Average Person-Miles Traveled		
	Base Case	Scenario Case	% Difference	Elasticity	Base Case	Scenario Case	% Difference
Auto	896,814	896,730	-0.01%	0.00	365	364	-0.09%
Bus	22,114	21,979	-0.61%	0.01	487	486	-0.12%
Rail	15,305	23,297	52.21%	-1.04	300	415	38.24%
Air	492,317	491,230	-0.22%	0.00	2,642	2,640	-0.07%

Table 30: Change in Total Travel Time (scenario case: rail time test)

Mode	Base Case	Scenario Case	% Difference	Elasticity
Auto	15,485	15,484	-0.01%	0.00
Bus	546	543	-0.60%	0.01
Rail	324	271	-16.35%	0.33
Air	1,266	1,263	-0.21%	0.00

Table 31: Change in Travel Cost (scenario case: rail time test)

Tour Mode	Total Travel Cost (In Thousand $)				Average Travel Cost Per Mile (In $/Mile)		
	Base Case	Scenario Case	% Difference	Elasticity	Base Case	Scenario Case	% Difference
Auto	98,408,206	98,351,951	-0.06%	0.00	0.11	0.11	0.00%
Bus	3,226,345	3,208,206	-0.56%	0.01	0.15	0.15	0.00%
Rail	4,696,937	6,059,240	29.00%	-0.58	0.31	0.26	-16.13%
Air	174,259,351	173,982,734	-0.16%	0.00	0.35	0.35	0.00%

5.6 Summary

A summary of the sensitivity test results is provided in Table 32. The test results indicate that:

- Higher incomes generate more tours, with some shift to longer distances and more expensive modes, mainly air;
- For auto, sensitivity to time changes is higher than sensitivity to cost changes—this may be due to the fact that current auto costs are low;
- For auto trips, changing destinations is much more likely than changing mode or changing number of tours—this is because, for shorter distances, there is often no reasonable alternative to auto;
- The air fare elasticity is higher than car cost elasticity, with the largest mode shift effect; and
- The rail time elasticity is higher than the car time elasticity, with substantial shifts in both mode and destination.

Table 32: Sensitivity Test Results Summary

Scenario	Income	Car Time	Rail Time	Car Cost	Air Fare
Change	Up 10%	Up 25%	Down 50%	Up 50%	Up 50%
Modes Included In Numbers Below	All	Car	Rail	Car	Air
Change in Total Tours Made	3.2%	-3.2%	0.2%	-1.8%	-4.0%
Change in Mode Share as a Percentage of Base Case Mode Share	n/a	-0.7%	8.2%	-0.3%	-22.4%
Change in Average Travel Distance per Tour	1.3%	-7.6%	40.4%	-3.2%	-4.7%
Change in Total Travel Distance in Mode(s)	4.5%	-11.2%	52.2%	-5.2%	-29.0%
Change in Average Travel Time per Tour	-0.2%	15.9%	-22.8%	-3.0%	-4.8%
Change in Total Travel Time in Mode(s)	3.0%	11.4%	-16.3%	-5.0%	-29.1%
Change in Average Travel Cost per Tour	3.2%	-5.8%	19.0%	45.9%	44.3%
Change in Total Travel Cost in Mode(s)	6.5%	-9.5%	29.0%	42.8%	7.5%
Elasticity of Travel Distance in Mode(s)	0.45	-0.45	-1.04	-0.10	-0.58
Elasticity of Travel Time Expenditure in Mode(s)	0.30	0.46	0.32	-0.10	-0.58
Elasticity of Travel Cost Expenditure in Mode(s)	0.65	-0.38	-0.58	0.86	0.15
Elasticity of travel distance by purpose					
Personal business	0.23	-0.25	-1.11	-0.06	-0.53
Visit friends or relatives	0.31	-0.49	-1.72	-0.13	-0.66
Leisure / vacation	0.54	-0.58	-1.15	-0.13	-0.75
Commuting	0.13	-0.13	-0.21	-0.05	-0.43
Employer's business	0.75	-0.31	-1.06	-0.03	-0.26

CHAPTER 6. APPLICATION SOFTWARE

6.1 Model Structure and Code

Model Structure

The structure of the long-distance tour-based microsimulation model system used for the initial application is depicted in Figure 32. The main inputs are the following:

- Synthesized population representing every household in the United States and all members of those households.
- Land-use file containing estimates of population, employment, and other key variables at the zone (NUMA) level.
- Zone-to-zone matrices containing travel times, costs, and other key O-D variables for auto, bus, rail and air.
- Files with estimated/calibrated coefficients for each choice model.

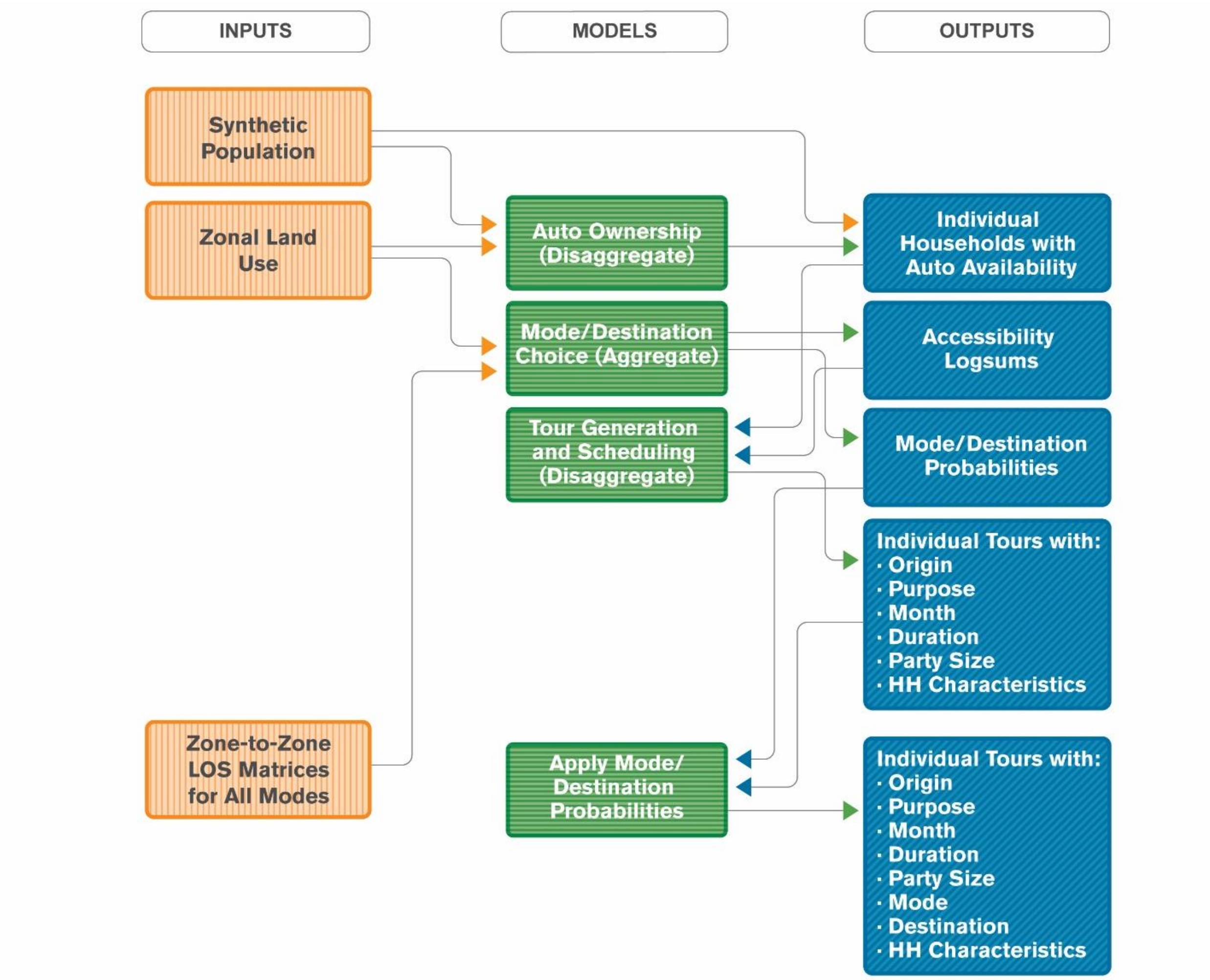
These input files are documented in Section 6.3.

The choice models include models of auto ownership, long-distance tour generation, tour duration of stay, tour party size, tour destination choice, and tour mode choice. The estimated models are documented in Section 6.4. Output records are written at both the household level and the tour level. Trip matrices can also be output, based on either mode/destination probabilities or stochastically simulated tours. The output file contents and formats are documented in Section 6.4.

A key aspect of the model structure is that the mode and destination probabilities and logsums are precalculated for all relevant combinations of income, auto availability, tour purpose, tour duration of stay, and tour party size. The probabilities are stored in memory and used to predict the outcome for each simulated tour, which eliminates the need to apply the mode and destination-choice models separately for each tour. This structure reduces the model run time by at least an order of magnitude, and makes it practical to predict long-distance travel over the period of one year for the entire US population.

The model is currently coded in Delphi (Pascal), which was selected for its fast run times. The Delphi language is similar to C++. The program code is fairly compact, with only 1,750 lines of Delphi code.

Figure 32: Application Model Process



Hardware Requirements

The program can run on a machine running any recent version of Windows with at least 4 GB of RAM and 10 GB of free disk space. The program runs on a single processor, so there is no need for multiple cores. The major requirement is free disk space for the output file generated, particularly if the user wishes to output individual tour records for several different scenarios.

Code Procedures

Below are listed the main procedures (classes) in the code, and their order of execution and iteration:

- ***GetConfigurationSettings***: Reads in the user configuration file.
- ***InitializeSummaryOutput***: Empties all counters for summary output tables.
- ***LoadZoneLandUseData***: Loads data from the zonal land-use file into memory.

- ***LoadRoadLOSMatrices***: Loads data from the auto and bus level-of-service file into memory.
- ***LoadRailLOSMatrices***: Loads data from the rail level-of-service file into memory.
- ***LoadAirLOSMatrices***: Loads data from the auto and bus level-of-service file into memory.
- ***OpenHouseholdInputFile***: Opens the synthetic population file for sequential input.
- ***OpenHouseholdOutputFile***: If specified by user, opens a new household-level file for output.
- ***OpenTourOutputFile***: If specified by user, opens a new tour-level file for output.
- ***OpenTripMatrixOutputFile***: If specified by user, opens a new trip matrix file output.
- *Loop on households in synthetic population:*
    - ***LoadNextHouseholdRecord:*** Reads the next household record into memory.
    - *Check if current household is from a new residence zone, if so**…***
        - ***CalculateModeDestinationProbabilitiies:*** Applies the tour mode and destination-choice models to calculate all probabilities and logsums from (and back to) the new residence zone.
    - *Check if current household is to be simulated, according to user settings. If so…*
        - ***ApplyAutoOwnershipModel:*** Applies the auto ownership model and simulates a single choice.
        - ***ApplyTourGenerationModel:*** Applies the tour generation models and simulates how many tours are made for each tour purpose on each simulated month and day.
        - ***For each generated tour (if any)…***
            - ***SimulateNewTour:*** Sets some variables and runs tour-level models.
            - ***ApplyTourNightsAwayModel:*** Applies the tour duration model and simulates a single choice.
            - ***ApplyTourPartySizeModel:*** Applies the tour party size model and simulates a single choice.
            - ***ApplyTourModeDestinationMode***l: Uses the mode/destination-choice probabilities for the relevant income, car ownership, purpose, duration, and party size segments to simulate a single mode and destination and/or add the probabilities to the predicted trip matrices, depending on user settings.
            - ***WriteTourRecord***: If specified by user, writes a new tour record to output file.

    - ***WriteHouseholdRecord:*** If specified by user, writes a new household record to output file.

- *End of loop on households*
- ***CloseHouseholdInputFile***
- ***CloseHouseholdOutputFil***e
- ***CloseTourOutputFile***
- ***WriteTripMatrixOutputFil***e: if specified by user, write the output trip matrix file
- ***WriteSummaryOutput:*** Writes summary prediction tables to the log print file

6.2 Running the Model

The software is a simple console application that can be run by double-clicking on the ***rJourney_1_1.EXE*** file in Windows Explorer. Windows will then open a console command window and ask the user to input the name of the relevant user configuration file. The user can also set up a batch file giving the name of the configuration file as a command argument and double-click on that. For example, the batch file ***rJourney.BAT*** could be created with the single line:

rJourney_1.1.exe inputs\scenario5_1_config.txt

Double-clicking on that batch file would run the program and use the specified configuration file as input.

Configuration File Options

Table 33 is a list of all of the user configuration options currently recognized by the software. Each option is specified by a specific text label that is given in the first column of the table. (The labels are not case-sensitive— any upper- and lower-case combination can be used.) If the user provides a configuration label that does not match one of these valid options in the table, the invalid input line is flagged for the user on the screen and also written to the log print file. Each configuration variable also has a default value that is used if the specific configuration label is not found in the configuration file (meaning that it is not necessary to include a line for a specific option if one wishes to use the default value).

A sample configuration text file containing all the possible labels with the default values is provided along with the software, and the user can edit this file to create new configurations.

Table 33: Configuration File Options

Configuration File Label	Default Value	Description
RunTitle	National_Long_Distance_Model	A text label identifying the run in the log print file - contains no spaces
RoadLOSFileName	inputs\zoneRoadLOS.dat	The path and filename of the input zonal auto and bus level-of-service data
RailLOSFileName	inputs\zoneRailLOS.dat	The path and filename of the input zonal rail level-of-service data
AirLOSFileName	inputs\zoneAirLOS.dat	The path and filename of the input zonal air level-of-service data
ZoneLandUseFileName	inputs\numa_2010_landuse.dat	The path and filename of the input zonal land-use data
HouseholdFileName	inputs\us_synpop_hh3_sorted.dat	The path and filename of the input synthetic population household file
DestChoiceCoefficientFile_1	inputs\pbusdest6_bxc.F12	The path and filename of the pers. business tour destination-choice coefficients
DestChoiceCoefficientFile_2	inputs\vfardest6_bxc.F12	The path and filename of the visit f & r tour destination-choice coefficients
DestChoiceCoefficientFile_3	inputs\leisdest6_bxc.F12	The path and filename of the leisure tour destination-choice coefficients
DestChoiceCoefficientFile_4	inputs\commdest6_bxc.F12	The path and filename of the commute tour destination-choice coefficients
DestChoiceCoefficientFile_5	inputs\ebusdest6_bxc.F12	The path and filename of the empl.business tour destination-choice coefficients
ModeChoiceCoefficientFile_1	inputs\pbusmode13_est.F12	The path and filename of the pers. business tour mode choice coefficients
ModeChoiceCoefficientFile_2	inputs\vfarmode13_est.F12	The path and filename of the visit f & r tour mode choice coefficients
ModeChoiceCoefficientFile_3	inputs\leismode13_est.F12	The path and filename of the leisure tour mode choice coefficients
ModeChoiceCoefficientFile_4	inputs\commmode13_est.F12	The path and filename of the commute tour mode choice coefficients

Configuration File Label	Default Value	Description
ModeChoiceCoefficientFile_5	inputs\ebusmode13_est.F12	The path and filename of the empl.business tour mode choice coefficients
PartySizeCoefficientFile_1	inputs\pbus_psize3.F12	The path and filename of the pers. business tour party size choice coefficients
PartySizeCoefficientFile_2	inputs\vfar_psize3.F12	The path and filename of the visit f & r tour party size choice coefficients
PartySizeCoefficientFile_3	inputs\leis_psize3.F12	The path and filename of the leisure tour party size choice coefficients
PartySizeCoefficientFile_4	inputs\comm_psize3.F12	The path and filename of the commute tour party size choice coefficients
PartySizeCoefficientFile_5	inputs\ebus_psize3.F12	The path and filename of the empl.business tour party size choice coefficients
NightsAwayCoefficientFile_1	inputs\pbus_dur3.F12	The path and filename of the pers. business tour duration of stay choice coefficients
NightsAwayCoefficientFile_2	inputs\vfar_dur3.F12	The path and filename of the visit f & r tour duration of stay choice coefficients
NightsAwayCoefficientFile_3	inputs\leis_dur3.F12	The path and filename of the leisure tour duration of stay choice coefficients
NightsAwayCoefficientFile_4	inputs\comm_dur3.F12	The path and filename of the commute tour duration of stay choice coefficients
NightsAwayCoefficientFile_5	inputs\ebus_dur3.F12	The path and filename of the empl.business tour duration of stay choice coefficients
TourFreqCoefficientsFile_1	inputs\freqest3a.f12	The path and filename of the primary tour generation coefficients
TourFreqCoefficientsFile_2	inputs\fsecest3a.f12	The path and filename of the secondary tour generation coefficients
AutoOwnCoefficientsFile	inputs\carown3.f12	The path and filename of the household car ownership coefficients
HouseholdOutputFileName	outputs\household_out_1.dat	The path and filename of the output household records

Configuration File Label	Default Value	Description
TourOutputFileName	outputs\tour_out_1.dat	The path and filename of the output tour records
TripMatrixOutputFileName	outputs\trip_out_1.dat	The path and filename of the output trip matrix records
OutputFileDelimeter	32	The delimiter character used in the output files (32=space, 9=tab, 44=comma)
MonthOfYear	0	The month of the year to simulate (0=all months, 1=Jan, 2=Feb, … , 12=Dec)
EachDayOfTheMonth	FALSE	True/False switch to simulate each day of each month separately
RandomSeed	12345	Initial seed value to use for random number generator
Sample1inX	1	Subsampling factor (e.g. 100 selects every 100th household for simulation)
SampleOffset	0	Subsampling offset (e.g. in above example, 3 selects the 3rd out of every 100 HH)
WriteHouseholdRecords	TRUE	Whether or not to write out household-level records
WriteTourRecords	TRUE	Whether or not to write out tour-level records
WriteCarTripMatrix	TRUE	Whether or not to write out zone-to-zone trip matrix for car trips
WriteBusTripMatrix	FALSE	Whether or not to write out zone-to-zone trip matrix for bus trips
WriteRailTripMatrix	FALSE	Whether or not to write out zone-to-zone trip matrix for rail trips
WriteAirTripMatrix	FALSE	Whether or not to write out zone-to-zone trip matrix for air trips
UseProbabilitiesinMatrices	FALSE	If true, uses mode/destination probabilities rather than single choices for matrices
UseADTUnitsInMatrices	FALSE	If true, writes out trip matrices as daily trips rather than total trips

Configuration File Label	Default Value	Description
PersonTripsInMatrices	FALSE	If true, writes out person-trips in matrices rather than party/vehicle-trips
TripMatrixMinimumDistance	50	The minimum one-way trip distance to include in the trip matrices
ScenarioPercentIncomeChange	0	For scenario tests - changes all household incomes by specified percentage
ScenarioPercentAutoCostChange	0	For scenario tests - changes auto toll and operating costs by specified percentage
ScenarioPercentAutoTimeChange	0	For scenario tests - changes all auto travel times by specified percentage
ScenarioPercentAirFareChange	0	For scenario tests - changes all air fares by specified percentage
ScenarioPercentRailTimeChange	0	For scenario tests - changes all rail travel times by specified percentage

The configuration options permit several methods for running the simulation, with some of the main options described below.

Subsampling on Households

One way to limit run time in the simulation is to not simulate travel for every household in the synthetic population, but only for a random subsample. The configuration settings ***Sample1inX*** and ***SampleOffSet*** facilitate subsampling. For example, if the values 20 and 7 are used, respectively, it would simulate only the seventh household out of every 20 households in the synthetic population file. The fraction sampled would then be equal to ***1 / Sample1inX*** , (a 5% sample in the example above). The household expansion factor for output is set equal to ***Sample1inX***.

Subsampling on Months and/or Days

Another way to influence run time and target the forecast to a particular month or season is to use ***MonthOfYear*** and ***EachDayOfTheMonth.*** By default, an entire year of travel is simulated by setting ***MonthOfYear*** to 0 to simulate all 12 months for each household. By default, only one representative travel day is simulated for each month by setting ***EachDayOfTheMonth*** to False. This means that the tour generation and subsequent models are only applied once for the month, and the expansion factor for each generated tour in the month is multiplied by the number of days in the month (31 for January, 28 for February, etc.). If ***EachDayOfTheMonth*** is set to true, every day of the month will be simulated separately, which will increase the number of tours simulated and tour records written by a factor of 30 or so, but this will not increase the expanded number of tours. The reason to simulate each day separately may be to add more variability (and thus less random simulation error) in the output. However, since each day of the month is simulated using identical probabilities (there is no conditionality from one day of the month to the next, so no intrahousehold-level consistency of travel scheduling), this does not add any true behavioral variability. In general, it is advisable to save run time by setting ***EachDayOfTheMonth*** to False rather than by subsampling households, since each household record is different. As a result, using more households in the simulation *does* add some true behavioral variability.

Options for Generating Trip Matrices

The models, being a simplification of reality based on the limited data available, assume that all long-distance tours consist of exactly two trips: one trip from the residence zone to the destination zone and a second trip back to the residence zone. (In reality, a small percentage of long-distance tours contain three or more long-distance trips connecting multiple destinations, other than simply stopping for gas or a meal. But simulating such complex tours would not be possible with this model structure, and would require a structure taking many times longer to run.)

In principle, one could simply post-process the tour file to generate trip matrices, accumulating one O-D and one D-O trip for each tour. To avoid the need for such post-processing, the software will accumulate and write out trip matrices for any specified modes. There are also a number user options provided for accumulating the trip matrices:

- ***UseProbabilitiesinMatrices****:* This is the most important option because it changes the ways that the mode/destination probabilities are used for the trip matrices. Instead of stochastically choosing a single mode and a single destination for each tour—which is done for the output tour records—this option adds the probability (times the expansion factor) to the matrix for every possible mode/destination alternative (four modes times approximately 4,500 zones, or 18,000 alternatives). This is analogous to the way that 4-step models work. Rather than resulting in integer numbers of trips in each cell of the matrix, there are fractions of trips—often tiny fractions. The advantage of this approach to generating matrices is that it adds variability—particularly spatial variability—and reduces random stochastic simulation error. The tradeoff is that it increases run times somewhat, and the trip outputs will not exactly match the tour outputs in terms of mode and spatial distribution.
- ***PersonTripsInMatrices****:* In most cases, it makes sense to set this to true, since passenger counts for air rail and bus are in units of person-trips. The exception is when one wishes to generate vehicle-trip matrices for the auto mode, in which case this can be left as False (and in which case it makes sense to write out trip matrices only for the auto mode, which is the default setting.)
- ***UseADTUnitsInMatrices****:* If this is true, the matrices are simply scaled to units of average daily trips instead of annual or monthly trips.
- ***TripMatrixMinimumDistance****:* Although the models use a (somewhat arbitrary) threshold of 50 miles one way to define a long-distance trip, it may be desirable to generate outputs that are comparable to other data sources that use a different threshold. For example, by setting this to 100, only trips between zones that are 100 or more miles apart (based on network auto distance) are counted in the matrices.

The Log Print File

Each time the software runs, it generates a log print file that is named automatically so as not to overwrite previous log files. For example, if ***inputs\test1_config.txt*** is the name of the configuration settings file, then the print file the first time it is run will be named ***inputs\test1_config_01.log.*** If the same configuration file is used again, the print file will automatically be named ***inputs\test1_config_02.log***, and so on.

The contents of the log file are the same as what appears on the screen during the run. The date and time the run starts and finishes are shown, along with an echo of all the configuration settings used for the run. In addition, a series of summary output tables are provided as a quick check on the results. An example of a log print file is provided in Section 0.

Comparison of Run Times and Output Characteristics

Table 34 provides an idea of the model run times and file sizes using different combinations of configuration settings. The runs were done on an HP workstation with 16 GB of RAM and four processors. (The software itself uses only 2 GB of RAM and a single processor, since it is not yet written to use multithreading on multiple processors.)

Run 1 uses ***Sample1inX*** = 100 to run only a 1% sample of households, so the expansion factors are 100. It simulates every month of the year and each day of the month separately and uses stochastic choices rather than mode/destination probabilities for the trip matrices. The run time is approximately 55 minutes. Out of a possible 20 million or so O-D pairs in the trip matrices, there is a positive number of auto trips for 3.64 million, or 18% of possible O-D pairs. There are 1.1 million household records in the output HH file, which is a size of 60 MB, and 17.5 million tour records, for a file size of just under 1 GB.

Run 2 uses ***Sample1inX*** = 1 to simulate every household, but uses ***EachDayOfTheMonth***= False to simulate only a single representative day per month. In this case, the expansion factors range from 28 to 31 depending on the month. Compared to Run 1, the run time increases slightly to 65 minutes, but the spatial coverage in the auto trip matrix increases by a factor of nearly two, with positive trips for 31% of possible OD zone pairs. Of course, the size of the output household file increases by a factor of 100 to 114.6 million records and almost 6 GB, while the size of the tour file increases by a factor of three or so,, to 55.1 million tour records and a 3.1 GB. (After expansion, the total numbers of households, tours, and trips are virtually identical in all runs. These are just different ways of generating them.)

The settings for Run 2 are recommended for users who mainly want to analyze the output at the level of individual tour records, rather than using the trip matrix file generated by the software.

Table 34: Comparison of Run Times and Output Characteristics under Different Settings

Run	1	2	3	4
HH Sampling Rate	1%	100%	100%	100%
Months Simulated	All	All	All	All
Each Day of Month Separately?	Yes	No	No	Yes
Use Probabilities in Trip Matrix?	No	No	Yes	No
Expansion Factors	100	28-31*	28-31*	1
Run Time	55 min	65 min	240 min	105 min
O-Ds In Car Trip Matrix (Million)	3.64	6.31	19.65	16.27
% Of Possible ODs In Matrix	18%	31%	98%	81%
HH Records (Million)	1.1	114.6	--	--
HH File Size (MB)	60	5,780	--	--
Tour Records (Million)	17.5	55.1	--	--
Tour File Size (MB)	992	3,128	--	--
* Days In The Month				

Run 3 is identical to Run 2, but the trip matrices use the mode/destination probabilities rather than stochastic trips. This extra computation of the matrices does increase run time by a factor of nearly four—to 240 minutes—but the spatial coverage of the car trip matrices has also increased by a factor of more than three, up to 98% of all O-D pairs. (The only zone pairs without car trips in this case are intrazonals and trips to or from Hawaii and Alaska, which are not connected by car to the other 48 states in the networks). If household and/or tour files were written in this run, they would be identical to Run 2, since only the method of calculating trips matrices was changed.

Finally, Run 4 shows an alternative way of increasing spatial coverage of the trip matrices while reducing run time. Unlike Run 3, this method uses simulated integer trips instead of mode/destination probabilities to accumulate the trip matrices, but it also simulates each day of each month separately. This run is effectively the same as Run 1, but using a 100% household sample instead of a 1% sample. The resulting run time is about twice as long as Run 1, but less than half as long as Run 3. The car matrix O-D coverage is 81%, which is nearly as high as Run 3, and may be just as useful for assignment, considering the matrices for Run 4 have at least one trip in each cell (all integer numbers), while the matrices from Run 3 have many cells with small fractions of trips. If a tour file had been generated from Run 4, it would be 100 times the size of the tour file from Run 1, with roughly 1.75 billion tour records and a file size of nearly 100 GB. Thus, the settings for Run 4 are good for generating trip matrices, but not practical for generating and analyzing detailed tour records.

The settings for Run 4 are recommended for users who mainly want to use the trip matrix file generated by the software (e.g., for highway assignment), but do not wish to write out or analyze individual tour records.

Adapting the Software for Different Zone Systems and/or Networks

The software could be used to run on data for other synthetic populations, networks, and/or zone systems, provided that all data input files keep the same formats and variable order as the current input files. In practice, this would mean generating new land-use and network skim files matching the new zone system. If the zone system is an aggregation of Census tracts, then data preparation could be made easier in two ways:

1. Provided with the software is a land-use file at the Census tract level, which could be aggregated up to a different zone system.

2. The synthetic population was controlled at the tract level, and the Census tract ID is included on each record; as a result, the zone ID field on the synthetic population records could be recoded to match a different tract-to-zone correspondence.

Note: Due to current Delphi memory limitations, the number of zones is limited to a maximum of 4,700. This is a limitation that may be improved in future versions of the code.

6.3 Input File Documentation

NUMA_2010_landuse.dat

Based on 2010 to 2012 Census tract-level population and employment data, aggregated to NUMA zones. Employment categories are mutually exclusive, broken down by NAICS code. The file is space-delimited text, with a header record:

1. ZoneID: NUMA ID
2. NTracts: The number of Census tracts in the zone
3. LandSqm" The land area in the zone (square miles)
4. NUMALat: The latitude of the NUMA centroid (degrees)
5. NUMALong: The longitude of the NUMA centroid (degrees)
6. StateFIP: The state FIPS code
7. ParkSqm: The land area in public parks (square miles)
8. TotHH: The number of households living in the zone
9. UnivEnr: The number of university students enrolled in the zone
10. TotalEmp: The total number of jobs in the zone
11. AgricEmp: The number of agricultural jobs in the zone
12. MininEmp: The number of mining jobs in the zone
13. UtiliEmp: The number of utility jobs in the zone
14. ConstEmp: The number of construction jobs in the zone
15. ManufEmp: The number of manufacturing jobs in the zone
16. WholeEmp: The number of wholesale trade jobs in the zone
17. RetaiEmp: The number of retail trade jobs in the zone
18. TransEmp: The number of transportation services jobs in the zone
19. InforEmp: The number of information services jobs in the zone
20. FinanEmp: The number of financial services jobs in the zone
21. RealeEmp: The number of real estate service jobs in the zone
22. ProfeEmp: The number of professional services jobs in the zone
23. ManagEmp: The number of managerial jobs in the zone
24. AdminEmp: The number of administrative jobs in the zone
25. EducaEmp: The number of education jobs in the zone
26. MedicEmp: The number of medical jobs in the zone
27. EnterEmp: The number of entertainment jobs in the zone
28. AccomEmp: The number of accommodation jobs in the zone
29. OServEmp: The number of other service category jobs in the zone
30. PubAdEmp: The number of public administration jobs in the zone
31. StateEmp: The number of state government jobs in the zone
32. FederEmp: The number of Federal government jobs in the zone
33. BusStats: The number of bus stations within 40 miles of the zone centroid
34. RailStats: The number of rail stations within 50 miles of the zone centroid

35. MinStDist: Distance from the zone centroid to the nearest rail station (miles)
36. Airports: The number of airports within 100 miles of the zone centroid
37. MinAPDist: Distance from the zone centroid to the nearest airport (miles)

zoneRoadLOS.dat

Based on the NHPN, with connectors added to NUMA zones, airports, and rail stations. The file is space-delimited text, with no header record:

1. OZoneID: Origin zone (NUMA ID)
2. DZoneID: Destination zone (NUMA ID)
3. CarTime: Car time (minutes, 0 indicates no road connection)
4. CarDist: Car distance (miles)
5. CarToll: Car toll (cents)
6. BusTime: Bus time (minutes, based on factoring car time)
7. BusFare: Bus fare (dollars, from equation based on car distance)

zoneRailLOS.dat

Based on Amtrak schedules and fares, and road access network, The least-generalized-cost station-pair is used for each zone pair. The file is space-delimited text, with no header record:

1. OZoneID: Origin zone (NUMA ID)
2. DZoneID: Destination zone (NUMA ID)
3. RailTime: Rail journey time, including stops (minutes, 0 indicates no rail connection)
4. RailXfers: Rail transfers * 100
5. RailFreq: Rail frequency (departures per week)
6. RailEconFare: Rail economy fare (dollars, from equation based on distance)
7. RailBusiFare: Rail business fare (dollars, from equation based on distance)
8. RailAccDist: Rail access distance (miles from NUMA to station, maximum is 50)
9. RailEgrDist: Rail egress distance (miles from station to NUMA, maximum is 50)
10. RailOStationID: Rail origin station ID #
11. RailDStationID: Rail destination station ID #
12. RailOStationCode: Rail origin station 3-letter code
13. RaiDStationCode: Rail destination station 3-letter code

zoneAirLOS.dat

Based on DB1B ticket database and on-time database, the least-generalized-cost airport pair is used for each zone pair. The file is space-delimited text, with no header record:

1. OZoneID: Origin zone (NUMA ID)
2. OzoneID: Destination zone (NUMA ID)
3. AirTime: Airport pair in-flight time (minutes, 0 indicates no air connection)

4. AXfers: Airport pair average transfers * 100
5. AirFreqDirect: Airport pair frequency of direct flights (departures per week)
6. AirFreq1Stop: Airport pair frequency of routes with one stop (departures per week)
7. AirFreq2Stop: Airport pair frequency of routes with two stops (departures per week)
8. AirPctOnTime: Airport pair percent of flights within 30 minutes of scheduled arrival time
9. AirEconFare: Airport pair average economy fare paid (dollars)
10. AirBusiFare: Airport pair average business fare paid (dollars, from equation based on distance)
11. AirAccDist: Air access distance (miles from NUMA to airport, maximum is 100)
12. AirEgrDist: Air egress distance (miles from airport to NUMA, maximum is 50)
13. AirOAirportID: Air origin airport ID #
14. AirDAirportID: Air destination airport ID #
15. AirOAirportCode: Air origin airport 3-letter code
16. AirDAirportCode: Air destination airport 3-letter code

US_SynPop_HH2_sorted.dat

The synthetic population file with roughly 115 million household records, sampled using the PopGen software with 2010 Census tract-level controls, and then sorted by residence zone ID. The file is space-delimited text, with a header record:

1. HHId: Household identification number
2. HHTract: 2010 residence Census tract FIPS code
3. HHZone: Residence zone # (NUMA ID)
4. HHSize: The number of persons in the household
5. HHWorkers: The number of employed persons in the household (full or part time)
6. HHNonWkrs: The number of non-employed adults (age 18+) in the household
7. HHHasKids: Whether or not the household has kids under age 18 (1=yes, 2=no)
8. HHHeadAge: The age of the head of the household, in years
9. HHIncome: The previous year total gross income, in dollars
10. HHExpFactor: The household expansion factor (always equals one on input)

Various Model Coefficient Files

These are kept in the .F12 text file format output by the ALogit model estimation software in order to minimize editing errors. For each variable, only the coefficient numbers and values are used by model code (not the labels or standard errors).

6.4 Output File Documentation

The Household File

A record written for each simulated household, if specified by the user.

1. HHId: Household identification number
2. HHZone: Residence zone # (NUMA ID)
3. HHState: Residence state (FIP code)
4. HHSize: The number of persons in the household
5. HHWorkers: The number of employed persons in the household (full or part time)
6. HHNonWkrs: The number of non-employed adults (age 18+) in the household
7. HHhHasKids: Whether or not the household has kids under age 18 (1=yes, 2=no)
8. HHHeadAge: The age of the head of the household, in years
9. HHIncome: The previous year total gross income, in dollars
10. HHVehicles: The number of vehicles predicted by the auto ownership model (4 = 4 or more)
11. HHPersBusTours: The number of personal business tours simulated for the household
12. HHVisitTours: The number of visit friends/relatives tours simulated for the household
13. HHLeisureTours: The number of leisure tours simulated for the household
14. HHCommuteTours: The number of commute tours simulated for the household
15. HHEmplBusTours: The number of employer's business tours simulated for the household
16. hhExpOut: The household expansion factor for output (depends on subsampling)

The Tour File

A record written for each simulated household, if specified by the user.

1. HHId: Household identification number
2. trNo: The tour sequence number for the household (1,2,3, etc.)
3. trMonth: The month the tour was generated (1=Jan, …., 12=Dec)
4. trPurpose: The main tour purpose (1=Pers.Bus, 2=Visit, 3=Leisure, 4=Commute, 5=Emp.Business)
5. trPartySize: The tour travel party size (1=1, 2=2, 3=3, 4=4 or more)
6. trNightsCategory: The tour duration (1=day trip, 2=1-2 nights, 3=3-6 nights, 4=7 or more nights)
7. trMode: The main tour mode (1=Car, 2=Bus, 3=Rail, 4=Air)
8. trOState: The tour origin state (FIP code)
9. trDState: The tour destination state (FIP code)
10. trOZone: The tour origin zone (NUMA ID)
11. trDZone: The tour destination zone (NUMA ID)
12. trAutoDistance: The tour round-trip distance if it were made on the auto network (miles)
13. trTravelTime: The tour round-trip travel time by the chosen main mode (minutes)
14. trTravelCost: The tour round-trip travel cost by the chosen mode (dollars, per person for non-auto)
15. trExpFactor: The tour expansion factor
16. trOrigStation: The tour origin rail station or airport ID #

17. trDestStation: The tour destination rail station or airport ID #

The Trip Matrix File

A record written for each zone pair with a non-zero number of trips, if specified by the user for a given mode

1. OrigZone: The trip origin zone (NUMA ID)
2. DestZone: The trip destination zone (NUMA ID)
3. Mode: The main trip mode (1=Car, 2=Bus, 3=Rail, 4=Air)
4. Trips: The number of trips predicted for the origin/destination/mode

6.5 Estimated Model Coefficients

Estimated model coefficients are provided in Table 35 through Table 40 for auto ownership, tour generation, tour party size, duration of stay, destination choice, and mode choice, respectively. All models indicate the coefficient number (as shown in the F12 coefficient input files and used in the model code) and the alternative name, the variable description, the estimated coefficient value, and the computed t-statistic. Some variables indicated by * were used in model estimation to allow for missing data or adjust for retrospective survey bias, and are not needed for model application.

Table 35: Auto Ownership Model

Coeff. #	Altern.	Variable	Coefficient	T-stat
10	0 cars	Constant	-2.98	-20.9
11	0 cars	1 adult HH	2.45	44
12	0 cars	3 adult HH	0.813	9.3
13	0 cars	4+ adult HH	1.14	8.1
14	0 cars	HH workers/adults	-0.442	-7
14	0 cars	HH has children	-0.877	-15.3
16	0 cars	Head of HH age 65+		
17	0 cars	Head of HH under 35	0.269	4.4
18	0 cars	Log of HH+job density	0.767	57.6
19	0 cars	Log of (HH income/1000)	-1.52	-50
61	0 cars	Missing HH income data*	-6.22	-41.8
20	1 car	Constant	0.726	10.9
21	1 car	1 adult HH	2.42	111.6
22	1 car	3 adult HH	-0.189	-4.5
23	1 car	4+ adult HH		
24	1 car	HH workers/adults	-0.224	-7.8
25	1 car	HH has children	-1	-44
26	1 car	Head of HH age 65+	0.184	6.6
27	1 car	Head of HH under 35	0.112	4.1
28	1 car	Log of HH+job density	0.243	43.9
29	1 car	Log of (HH income/1000)	-0.87	-55.4
62	1 car	Missing HH income data*	-3.65	-50.1
30	2 cars	Constant	0	base alt.
40	3 cars	Constant	-1.4	-21.6
41	3 cars	1 adult HH		
42	3 cars	3 adult HH	1.61	77.6
43	3 cars	4+ adult HH	1.95	47.9
44	3 cars	HH workers/adults	0.464	16.9
45	3 cars	HH has children		
46	3 cars	Head of HH age 65+	-0.218	-7.6
47	3 cars	Head of HH under 35	-0.278	-12.3
48	3 cars	Log of HH+job density	-0.103	-21.3
49	3 cars	Log of (HH income/1000)	0.114	7.7
64	3 cars	Missing HH income data*	0.487	6.7
50	4+ cars	Constant	-2.8	-31.2
51	4+ cars	1 adult HH		
52	4+ cars	3 adult HH	1.89	71.7
53	4+ cars	4+ adult HH	3.68	93.5

Coeff. #	Altern.	Variable	Coefficient	T-stat
54	4+ cars	HH workers/adults	1.09	27.5
55	4+ cars	HH has children		
56	4+ cars	Head of HH age 65+	-0.229	-5.5
57	4+ cars	Head of HH under 35	-0.144	-4.9
58	4+ cars	Log of HH+job density	-0.234	-35.9
59	4+ cars	Log of (HH income/1000)	0.276	13.8
60	4+ cars	Missing HH income data*	1.24	12.6

Model Fit Statistics

Observations	114103
Final log-likelihood	-118875.8
Rho-squared vs. 0	0.353
Rho-squared vs. constants	0.197

Table 36: Tour-Generation Models

		Models for …	First Tour of the Day		Second Tour of the Day	
Coeff. #	Altern.	Variable	Coefficient	T-stat	Coefficient	T-stat
0	No tour	Constant	0	base alt	0	base alt
100	Pers.Bus.	Constant	-4.13	-40.3	-4.59	-20.7
101	Pers.Bus.	January	-0.256	-4.4		
102	Pers.Bus.	February				
103	Pers.Bus.	March				
104	Pers.Bus.	April				
105	Pers.Bus.	May				
106	Pers.Bus.	June				
107	Pers.Bus.	July	-0.134	-2.6		
108	Pers.Bus.	August	-0.152	-3		
109	Pers.Bus.	September	-0.176	-3.6		
110	Pers.Bus.	October	-0.265	-5.1		
111	Pers.Bus.	November	-0.15	-2.8		
112	Pers.Bus.	December	-0.317	-5.2		
113	Pers.Bus.	Access. logsum under 50 miles	-0.218	-31.2	-0.136	-3.8
114	Pers.Bus.	Access.logsum 50-150 miles	0.0329	1.9	0.0461	0.6
115	Pers.Bus.	Access logsum 150-500 miles				
116	Pers.Bus.	Access logsum over 500 miles				
117	Pers.Bus.	No logsum for under 50 miles	0.342	6		
118	Pers.Bus.	Days before survey was taken*	-0.0141	-7.5		
119	Pers.Bus.	Log(days before survey taken)*	-0.131	-4.4	-0.073	-1.1
122	Pers.Bus.	Log of (HH income/1000)	0.0915	4.7		
123	Pers.Bus.	Missing HH income data*	0.339	3.5		
124	Pers.Bus.	HH has no cars	-0.757	-7.4		
125	Pers.Bus.	HH has car competition	-0.114	-3.2		
126	Pers.Bus.	HH has children	-0.0859	-2.6	0.274	1.8
127	Pers.Bus.	HH workers/adults	-0.456	-11.4		
128	Pers.Bus.	HH has one person	-0.339	-8.1		
129	Pers.Bus.	Head of HH is under age 35	-0.478	-8	-0.64	-1.8
130	Pers.Bus.	Head of HH is age 65+	-0.111	-3.3		
131	Pers.Bus.	HH size				
200	Visit F&R	Constant	-5.32	-24.7	-6.29	-9.2
201	Visit F&R	January	-0.456	-9.3		
202	Visit F&R	February	-0.273	-6.5		
203	Visit F&R	March	-0.18	-4.5		

		Models for …	First Tour of the Day		Second Tour of the Day	
Coeff. #	Altern.	Variable	Coefficient	T-stat	Coefficient	T-stat
204	Visit F&R	April				
205	Visit F&R	May				
206	Visit F&R	June	0.0556	1.6		
207	Visit F&R	July	0.0306	0.8		
208	Visit F&R	August	-0.0823	-2.2		
209	Visit F&R	September	-0.241	-6.1		
210	Visit F&R	October	-0.288	-6.9		
211	Visit F&R	November				
212	Visit F&R	December				
213	Visit F&R	Access. logsum under 50 miles	-0.0522	-6.7		
214	Visit F&R	Access.logsum 50-150 miles	0.0467	2.2	0.207	2
215	Visit F&R	Access logsum 150-500 miles	0.08	2.1		
216	Visit F&R	Access logsum over 500 miles	0.28	7.4		
217	Visit F&R	No logsum for under 50 miles	-0.267	-4		
218	Visit F&R	Days before survey was taken*	-0.013	-9.2		
219	Visit F&R	Log(days before survey taken)*	-0.097	-4.2		
222	Visit F&R	Log of (HH income/1000)	0.128	6.7	0.104	1
223	Visit F&R	Missing HH income data*	0.509	5.6	-0.0084	0
224	Visit F&R	HH has no cars	-0.323	-2.9		
225	Visit F&R	HH has car competition	-0.108	-3.4	-0.427	-2
226	Visit F&R	HH has children	-0.245	-6.8	-0.246	-1.5
227	Visit F&R	HH workers/adults	-0.111	-3.9		
228	Visit F&R	HH has one person	-0.0991	-2.9	-0.61	-2.5
229	Visit F&R	Head of HH is under age 35	0.0994	2.7		
230	Visit F&R	Head of HH is age 65+				
231	Visit F&R	HH size	-0.0425	-2.9		
300	Leisure	Constant	-6.33	-48.1	-6.94	-9
301	Leisure	January	-0.494	-9.6		
302	Leisure	February	-0.316	-7.1		
303	Leisure	March	-0.107	-2.7		
304	Leisure	April				
305	Leisure	May				
306	Leisure	June	0.161	4.6		
307	Leisure	July	0.365	10.7		
308	Leisure	August	0.21	6		
309	Leisure	September				
310	Leisure	October	-0.152	-3.8		

		Models for …	First Tour of the Day		Second Tour of the Day	
Coeff. #	Altern.	Variable	Coefficient	T-stat	Coefficient	T-stat
311	Leisure	November	-0.308	-6.8		
312	Leisure	December	-0.509	-9.8		
313	Leisure	Access. logsum under 50 miles	-0.0682	-6.5	-0.109	-1.5
314	Leisure	Access.logsum 50-150 miles	0.01	0.5	0.0029	0
315	Leisure	Access logsum 150-500 miles	0.167	4.8	0.108	0.4
316	Leisure	Access logsum over 500 miles	0.402	7.7	0.58	1.5
317	Leisure	No logsum for under 50 miles	-0.159	-2.4		
318	Leisure	Days before survey was taken*	-0.0096	-6.9		
319	Leisure	Log(days before survey taken)*	-0.13	-5.7		
322	Leisure	Log of (HH income/1000)	0.266	9	0.106	0.5
323	Leisure	Missing HH income data*	1.12	8.1	0.328	0.3
324	Leisure	HH has no cars				
325	Leisure	HH has car competition	-0.242	-7.7		
326	Leisure	HH has children	0.0613	1.9	0.28	1.8
327	Leisure	HH workers/adults	-0.134	-4.3		
328	Leisure	HH has one person	-0.301	-8.5		
329	Leisure	Head of HH is under age 35				
330	Leisure	Head of HH is age 65+	-0.0698	-2.6	-0.422	-2
331	Leisure	HH size	-0.0281	-2.1		
400	Commute	Constant	-4.91	-12.7	-7.17	-5.2
401	Commute	January	0.599	5.3		
402	Commute	February	0.598	5.5		
403	Commute	March	0.629	6		
404	Commute	April				
405	Commute	May	0.523	5		
406	Commute	June				
407	Commute	July				
408	Commute	August	0.386	3.5		
409	Commute	September				
410	Commute	October				
411	Commute	November	0.288	2.3		
412	Commute	December	0.277	2.1		
413	Commute	Access. logsum under 50 miles	-0.157	-12.8		
414	Commute	Access.logsum 50-150 miles	0.449	10.6		
415	Commute	Access logsum 150-500 miles				
416	Commute	Access logsum over 500 miles				
417	Commute	No logsum for under 50 miles	1.12	4.9		

		Models for …	First Tour of the Day		Second Tour of the Day	
Coeff. #	Altern.	Variable	Coefficient	T-stat	Coefficient	T-stat
418	Commute	Days before survey was taken*	0	(*)		
419	Commute	Log(days before survey taken)*	-0.412	-15	-0.319	-2
422	Commute	Log of (HH income/1000)	0.273	5.6	0.16	0.6
423	Commute	Missing HH income data*	1.46	6	-0.0557	0
424	Commute	HH has no cars	-1.6	-2.8		
425	Commute	HH has car competition	0.0812	1		
426	Commute	HH has children	0.195	3	1.03	2.7
427	Commute	HH workers/adults	0.175	1.4		
428	Commute	HH has one person				
429	Commute	Head of HH is under age 35	-0.426	-3.6		
430	Commute	Head of HH is age 65+	-0.365	-3.8		
431	Commute	HH size				
500	Empl.Bus.	Constant	-7.19	-43.7	-8.21	-8.7
501	Empl.Bus.	January	-0.125	-2.2		
502	Empl.Bus.	February	0.0945	2		
503	Empl.Bus.	March	0.242	5.5		
504	Empl.Bus.	April				
505	Empl.Bus.	May				
506	Empl.Bus.	June				
507	Empl.Bus.	July	-0.086	-1.8		
508	Empl.Bus.	August				
509	Empl.Bus.	September				
510	Empl.Bus.	October	0.13	3		
511	Empl.Bus.	November	-0.107	-2.1		
512	Empl.Bus.	December	-0.403	-6.4		
513	Empl.Bus.	Access. logsum under 50 miles	-0.0909	-7.9	-0.0589	-1
514	Empl.Bus.	Access.logsum 50-150 miles	0.0468	2.5	0.221	1.5
515	Empl.Bus.	Access logsum 150-500 miles			0.355	1.3
516	Empl.Bus.	Access logsum over 500 miles	0.134	3.4		
517	Empl.Bus.	No logsum for under 50 miles				
518	Empl.Bus.	Days before survey was taken*	-0.0076	-4.3		
519	Empl.Bus.	Log(days before survey taken)*	-0.176	-6.2	-0.131	-1.5
522	Empl.Bus.	Log of (HH income/1000)	0.521	14	0.288	1.5
523	Empl.Bus.	Missing HH income data*	2.5	14.4	0.74	0.8
524	Empl.Bus.	HH has no cars	-0.24	-2.1		
525	Empl.Bus.	HH has car competition	-0.106	-2.9		
526	Empl.Bus.	HH has children	-0.112	-3.8		

		Models for …	First Tour of the Day		Second Tour of the Day	
Coeff. #	Altern.	Variable	Coefficient	T-stat	Coefficient	T-stat
527	Empl.Bus.	HH workers/adults	0.584	10.1	0.758	1.9
528	Empl.Bus.	HH has one person	-0.134	-3.1	-0.351	-1
529	Empl.Bus.	Head of HH is under age 35	-0.251	-5.1		
530	Empl.Bus.	Head of HH is age 65+	-0.21	-5.5		
531	Empl.Bus.	HH size				

Model Fit Statistics

Observations	1478748		33307
Final log-likelihood	-198879		-4705.9
Rho-squared vs. 0	0.921		0.918
Rho-squared vs. constants	0.025		0.011

Table 37: Tour-Size-Party Models

		Models by Tour Purpose…	Personal Business		Visit F&R		Leisure		Commute		Employer Business	
Coeff. #	Altern.	Variable	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat
1	All	Party size=HH size	1.01	49.4	1.75	101.5	1.28	90.7	0.264	5.2	0.544	23.9
2	All	Party size=HH adults	-0.179	-7.8	-0.591	-28.4	-0.393	-22.2	-0.256	-5.7		
101	1 person	Constant	0	base alt	0	base alt	0	base alt	0	base alt	0	base alt
201	2 people	Constant	0.355	4.7	-0.089	-0.9	0.81	9.7	0.0226	0.1	0.203	1.4
202	2 people	HH workers/Adults	-0.187	-3.8	-0.266	-5.5	-0.113	-2.8			-0.501	-8
203	2 people	Log of (HH income/1000)			0.0502	2.3	0.0818	4.2	-0.424	-7.6	-0.151	-5
204	2 people	Missing HH income data*			0.0759	0.7	0.386	4.1	-1.7	-6.4	-0.739	-4.9
205	2 people	HH has 0 vehicles	-0.467	-3.9	0.216	1.8			-0.616	-2.5	0.78	4.6
206	2 people	HH has car competition	0.428	7.9	0.37	7.6	0.29	4.7				
207	2 people	0 nights away from home	0.259	4	0.526	10					-0.419	-8.5
208	2 people	1-2 nights away from home	0.284	3.6	0.286	5.5	0.132	4.2				
209	2 people	7+ nights away from home										
210	2 people	Missing nights away data*	-0.264	-3.5	-0.24	-4.6	-0.0538	-1.6			-0.6	-13.4
211	2 people	Month is June-August	0.118	2.2								
212	2 people	Month is Jan-March	-0.122	-2.5	-0.121	-2.8			0.38	3.5		
213	2 people	Month is Nov-December			0.129	2.7	-0.121	-3.2				
214	2 people	Missing month data*	-0.287	-4.5	0.0125	0.2	-0.136	-2.2	-0.054	-0.7		

		Models by Tour Purpose…	Personal Business		Visit F&R		Leisure		Commute		Employer Business	
Coeff. #	Altern.	Variable	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat
215	2 people	Head of hh under age 35	-0.237	-4.5					0.33	4.8	0.0619	1.3
216	2 people	Head of hh age 65+	0.107	2	0.115	2.5			-0.456	-2.9	0.411	7
301	3 people	Constant	-0.297	-4.4	-0.715	-5.3	0.0434	1.5	-0.172	-0.3	-0.0635	-0.3
302	3 people	HH workers/Adults	-0.135	-2.1	-0.225	-3.5						
303	3 people	Log of (HH income/1000)			-0.074	-2.6			-0.548	-4.8	-0.439	-8.6
304	3 people	Missing HH income data*			-0.401	-2.9			-3.53	-5	-2.14	-8.1
305	3 people	HH has 0 vehicles			0.612	4.5	0.526	4.7	1.6	6.5	0.948	3.8
306	3 people	HH has car competition	0.477	7.4	0.501	8.6	0.67	9.9	0.674	3.9		
307	3 people	0 nights away from home			0.689	10.5					-0.496	-5.9
308	3 people	1-2 nights away from home			0.447	6.8						
309	3 people	7+ nights away from home	-0.524	-3.1								
310	3 people	Missing nights away data*	-0.675	-10.6	-0.17	-2.4					-0.636	-6.8
311	3 people	Month is June-August	0.303	4.4	0.136	2.7	0.177	4.7	-1.02	-3.1		
312	3 people	Month is Jan-March	0.159	2.5	-0.141	-2.4			-0.981	-3.9		
313	3 people	Month is Nov-December	0.229	3.2	0.422	7			-1.43	-3.3	-0.221	-2
314	3 people	Missing month data*	-0.181	-2.1	0.205	2.5	-0.172	-2.6	-1.13	-6.6	-0.461	-4.3
315	3 people	Head of hh under age 35			0.203	4.4	0.104	2.3	-0.745	-4		

		Models by Tour Purpose…	Personal Business		Visit F&R		Leisure		Commute		Employer Business	
Coeff. #	Altern.	Variable	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat
316	3 people	Head of hh age 65+	-0.193	-2.6	-0.109	-1.7	-0.232	-4.6	-0.987	-2.6		
401	4+ people	Constant	-0.0688	-0.5	-0.845	-11.8	0.637	14.3	1.54	3.4	0.894	4.1
402	4+ people	HH workers/Adults			-0.261	-4.5	-0.179	-3.9	0.898	3.1	-0.315	-2.9
403	4+ people	Log of (HH income/1000)	-0.0933	-3.3					-1.5	-16.6	-0.594	-12.4
404	4+ people	Missing HH income data*	-0.623	-4.2					-6.22	-12.8	-3.04	-11.7
405	4+ people	HH has 0 vehicles			0.519	3.8			2.39	13		
406	4+ people	HH has car competition	0.254	4	0.346	6.4	0.361	5.7	1.48	9.5		
407	4+ people	0 nights away from home			0.746	12.4					-0.716	-8.9
408	4+ people	1-2 nights away from home	0.291	4.8	0.349	5.8						
409	4+ people	7+ nights away from home										
410	4+ people	Missing nights away data*	-0.776	-11.7	-0.292	-4.5					-0.636	-7.3
411	4+ people	Month is June-August	0.557	9.3	0.261	5.7	0.44	13.7			0.294	3.9
412	4+ people	Month is Jan-March			-0.139	-2.6	0.0795	2.2	-1.44	-3.9		
413	4+ people	Month is Nov-December	0.113	1.7	0.545	9.9			0.863	3.2		
414	4+ people	Missing month data*	-0.0725	-0.9	0.191	2.6	-0.597	-9.6	-0.491	-2.7	-0.941	-8.3
415	4+ people	Head of hh under age 35	0.325	5.9	0.36	9.2	0.287	8	0.575	4.2		
416	4+ people	Head of hh age 65+	-0.194	-2.7	-0.425	-6.2	-0.315	-6.8	-0.755	-2.1		

		Models by Tour Purpose…	Personal Business		Visit F&R		Leisure		Commute		Employer Business	
Coeff. #	Altern.	Variable	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat
		Model Fit Statistics										
		Observations	18833		31634		35998		9012		18626	
		Final log-likelihood	-22552		-33315.9		-39526.2		-5533.6		-16982.7	
		Rho-squared vs. 0	0.136		0.24		0.208		0.557		0.342	
		Rho-squared vs. constants	0.095		0.212		0.131		0.084		0.04	

Table 38: Tour Duration of Stay Models

		Models by Tour Purpose…	Personal Business		Visit F&R		Leisure		Commute		Employer Business	
Coeff. #	Altern.	Variable	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat
0	0 nights	constant	0	base alt.	0	base alt.	0	base alt.	0	base alt.	0	base alt.
20	1-2 nights	constant	-2.19	-13.7	-0.127	-1.3	-2.12	-18.4	-1.26	-2.5	-2.34	-12.3
21	1-2 nights	HH size	0	(*)	-0.0592	-5.1					-0.0275	-1.5
22	1-2 nights	Missing HH income data*	0.631	3.6	0.18	1.6	1.09	8.7	-3.19	-2.9	1.74	8.2
23	1-2 nights	Log of (HH income/1000)	0.155	4.4	0.0445	1.9	0.275	10.7	-0.152	-1.3	0.369	8.7
24	1-2 nights	Head of HH age 65+	-0.288	-4.3	-0.358	-7.7	-0.354	-7.8				
25	1-2 nights	Head of HH under age 35	0.419	6.7	0.361	9.3	0.141	3.8				
26	1-2 nights	Log zone HH+job density	0.0963	7.5			0.0873	9.5				
27	1-2 nights	Month is June-August	-0.0917	-1.7								
28	1-2 nights	Month is Jan-March	-0.348	-5.4	-0.102	-2.7	-0.105	-2.7				

		Models by Tour Purpose…	Personal Business		Visit F&R		Leisure		Commute		Employer Business	
Coeff. #	Altern.	Variable	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat
29	1-2 nights	Month is Nov-December	-0.263	-3.6			-0.224	-5.1				
30	3-6 nights	Constant	-3.48	-14.7	-1.51	-10.6	-3.93	-27.5	-3.88	-5.4	-3.37	-14
31	3-6 nights	HH size			-0.142	-8.9	-0.0517	-3.9			-0.0794	-3.3
32	3-6 nights	Missing HH income data*	0.875	3.5	0.383	2.6	1.88	12.3	2.31	3	2.2	8.3
33	3-6 nights	Log of (HH income/1000)	0.167	3.2	0.099	3.3	0.433	13.6	0.391	2.4	0.437	8.2
34	3-6 nights	Head of HH age 65+	0.239	2.8	0.141	2.6						
35	3-6 nights	Head of HH under age 35	0.217	2.2	0.15	2.8						
36	3-6 nights	Log zone HH+job density	0.134	7.2	0.0678	6.4	0.172	15.6			0.058	3.7
37	3-6 nights	Month is June-August			0.273	5.6	0.565	13.7				
38	3-6 nights	Month is Jan-March	-0.458	-4.9	-0.152	-2.7	-0.151	-2.7	-0.4	-2.1		
39	3-6 nights	Month is Nov-December	-0.357	-3.3	0.389	7.8	-0.178	-2.9				
40	7+ nights	Constant	-4.7	-12.7	-2.25	-16.6	-5.13	-25.9	-3.5	-8.9	-4.85	-11.4
41	7+ nights	HH size			-0.218	-8.5			-0.165	-1.4		
42	7+ nights	Missing HH income data*	1.65	4			2.29	11			1.59	3.4
43	7+ nights	Log of (HH income/1000)	0.361	4.2			0.524	12			0.263	2.7
44	7+ nights	Head of HH age 65+	0.313	2.4	0.32	4.3	0.334	5.2				
45	7+ nights	Head of HH under age 35			-0.275	-3.1						

		Models by Tour Purpose…	Personal Business		Visit F&R		Leisure		Commute		Employer Business	
Coeff. #	Altern.	Variable	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat
46	7+ nights	Log zone HH+job density			0.111	6.9	0.137	9.3			0.125	4.3
47	7+ nights	Month is June-August	0.173	1.5	0.482	7	0.629	10.9	1.19	3.7	0.504	3.9
48	7+ nights	Month is Jan-March					0.29	4.2			0.298	2.3
49	7+ nights	Month is Nov-December			0.348	4.6	-0.373	-4				
		Model Fit Statistics										
		Observations	11932		21829		25706		1967		9689	
		Final log-likelihood	-10710.8		-25730.6		-30052.8		-1387.3		-10355	
		Rho-squared vs. 0	0.352		0.15		0.157		0.491		0.229	
		Rho-squared vs. constants	0.014		0.014		0.021		0.018		0.01	

Table 39: Destination-Choice Models

		Models by Tour Purpose…	Personal Business		Visit F&R		Leisure		Commute		Employer Business	
Coeff. #	Altern.	Variable	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat
1	All	Mode choice logsum	1	constr	1	constr	1	constr	0.211	7.5	1	constr
2	All	Log (one-way distance)	-1.9	-39	-1.09	-30	-1.35	-38.2	-3.58	-46.7	-1.64	-34.3
3	All	One-way distance squared	0.006	11.7	0.0033	15.2	0.0045	16.5	0.0238	12.7	0.0035	15.5
4	All	Day trip*1-way dist. squared	-0.0192	-15	-0.023	-19.9	-0.0269	-70	-0.0032	-3.8	-0.0084	-13.2
5	All	1-2 nights*1-way dist squared	-0.004	-7.1	-0.0104	-17.5	-0.012	-38.3	-7.30E-04	-0.8	-0.0022	-12.2
6	All	Data missing*1-way dist.squ *	-0.003	-10.3	-0.0018	-15.5	-0.0021	-15.1	-0.0123	-7.5	-0.0017	-12.9
7	All	One-way dist 50-100 miles										
8	All	One-way dist 100-150 miles	-0.151	-4.4	-0.185	-7.2	-0.31	-12.8	-0.464	-7.6	-0.277	-7.9
9	All	One-way dist 150-250 miles	-0.704	-12.8	-0.719	-17.8	-0.862	-22.6	-0.784	-8	-0.887	-16.2
10	All	One-way dist 250-500 miles	-1.07	-13.1	-1.21	-20.2	-1.41	-24.2	-0.803	-5.3	-1.12	-14

		Models by Tour Purpose…	Personal Business		Visit F&R		Leisure		Commute		Employer Business	
Coeff. #	Altern.	Variable	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat
11	All	One-way dist 500-1000 miles	0.808	7.1	0.229	2.7	0.101	1.2	1.61	8.4	0.132	1.2
12	All	One-way dist 1000-1500 miles	0.959	6.1	0.389	3.6	0.633	6	-0.581	-1.6	0.151	1.1
13	All	One-way dist 1500-2000 miles	0.518	2.1	0.363	2.7	0.16	1.1	-2.44	-3.6	0.235	1.4
14	All	One-way dist over 2000 miles	-0.037	-0.1	0.184	1	-0.254	-1.3	-12.4	-6.9	0.376	1.9
15	All	Dest zone has urban density	-0.162	-7.4	-0.448	-26.5	-0.344	-21.8	-0.108	-3	-0.239	-10.7
16	All	Desti zone has rural density	0.486	11.7	0.471	16.5	0.573	23.5	0.0175	0.3	0.573	14
17	All	O and D zones have urban density	-0.261	-6.1	0.0783	2.9	-0.0675	-2.6	0.0618	0.7	0.31	8.3
18	All	O and D zones have rural density	-0.569	-6	-0.306	-3.3	-0.555	-7.9	0.581	3.9	0.393	3.9
19	All	Log-size function multiplier	0.715	63.8	0.688	66.3	0.689	106.9	0.611	37.5	0.79	79.6
20	All	Size variable 0	1	constr	1	constr	1	constr	1	constr	1	constr
20	All	Size variable 1 (log of coef)	0.273	3.1	-1.35	-5	-0.68	-7.5	0.327	2	-1.2	-5.1
21	All	Size variable 2 (log of coef)	-11.6	-0.1	-0.615	-8.4	-37.3	0	-30	(*)	-30	(*)
22	All	Size variable 3 (log of coef)	-4.36	-15.9	-20	(*)	-30	(*)	-5.45	-4	-2.93	-24.9
23	All	Size variable 4 (log of coef)	-0.908	-11.9	-5.25	-6.4	1.31	24.1	-15.2	-0.1	-2.2	-18.9

Model Fit Statistics

Observations	15130		27880		30865		6151		15987	
Final log-likelihood	-79405.8		-164121.7		-174552.1		-27130.8		-91013.5	
Rho-squared vs. 0	0.375		0.299		0.326		0.475		0.322	
Rho-squared vs. constants	0.14		0.118		0.078		0.119		0.088	

Table 40: Mode Choice Models

		Models by Tour Purpose…	Personal Business		Visit F&R		Leisure		Commute		Employer Business	
Coeff. #	Altern.	Variable	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat
1	All	Mode generalized cost	0.281	12.6	0.344	24.3	0.344	22.9	0.298	7.2	0.265	19.1
101	Car	HH has no cars	-2.03	-8.8	-2.2	-14.7	-1.22	-7.8	-0.538	-0.8	-1.59	-5.8
102	Car	HH has car competition	-0.571	-5.7	-0.269	-3.2	-0.313	-4.3	-0.182	-1.3	-0.161	-1.7
103	Car	Party size = 1	-0.821	-9	-0.894	-12.7	-0.467	-6.4				
104	Car	Party size = 3 or more			0.539	6.8					-0.515	-5.2
105	Car	0 nights away from home	0.332	2.3	0.412	2.7	-0.856	-9.2	-0.678	-2.4	0.366	2.2
106	Car	7+ nights away from home									0.502	2.9
107	Car	Missing nights data *	0.401	2.8	0.164	1.4	-0.112	-1.1	-0.786	-2.9	0.115	0.8
112	Car	One-way dist over 500 miles	-1.07	-8.1	-1.47	-17.6	-0.993	-12.3			-1.21	-12.6
200	Bus	Constant	-7.27	-14.8	-5.86	-12.3	-0.847	-3.1	-5.58	-6.3	-6.01	-7.9
207	Bus	Missing HH income data *	-0.0729	-0.1	-2.57	-5.2	-3.06	-12.7	-1.24	-1.3	-0.905	-1.2
208	Bus	Log of (HH income/1000)	0.101	1.2	-0.524	-6.3	-0.95	-17.5	-0.14	-0.8	-0.274	-1.8
209	Bus	Log of origin zone density	0.135	3.7	0.274	7.1	0.0425	1.7	0.129	1.9	0.175	3.3
210	Bus	Log of dest zone density	0.284	8.5	0.14	3.6	0.0416	2.3	0.336	6.7	0.239	4.9
215	Bus	One-way dist 50-150 miles	-0.236	-1.6	0	(*)	-0.41	-4.2	-2.08	-9.7	-0.682	-3.4
300	Rail	Constant	-12.9	-15	-7.78	-13.7	-11.6	-16.1	-19.5	-18.7	-12.6	-16.2
307	Rail	Missing HH income data *	-0.13	-0.2	-0.92	-2.1	-1.84	-2.1	6.56	9.1	-0.416	-0.7
308	Rail	Log of (HH income/1000)	0.12	1	-0.213	-2.5	0.0498	0.5	1.28	8.5	-0.132	-1.2
309	Rail	Log of origin zone density	0.274	5.2	0.256	6.9	0.179	4.2	0.24	4.5	0.186	4.8
310	Rail	Log of dest zone density	0.802	12.8	0.371	8.6	0.757	16.3	1.08	22	1.05	19.6
315	Rail	One-way dist 50-150 miles					-0.348	-2.1			-0.449	-3
400	Air	Constant	-5.6	-10	-6.18	-20.8	-4.17	-12.9	-8.51	-5.2	-8.04	-21.1
407	Air	Missing HH income data *	0.901	1.8	1.17	4.3	0.264	0.9	4.01	2.5	3.42	9.6
408	Air	Log of (HH income/1000)	0.197	2	0.0917	1.6	-0.0442	-0.7	0.745	2.2	0.65	9.2
409	Air	Log of origin zone density	0.153	4.6	0.151	8	0.0676	3.4	0.116	1.4	0.156	7.5

		Models by Tour Purpose…	Personal Business		Visit F&R		Leisure		Commute		Employer Business	
Coeff. #	Altern.	Variable	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat
410	Air	Log of dest zone density	0.178	5.7	0.15	8.4	0.188	11.5	0.305	3.5	0.221	11.1
411	Air	0 nights away from home	-2.26	-8.3	-1.8	-7.7	-3.04	-16.9	-4.06	-5.8	-1.19	-6
412	Air	1-2 nights away from home	-1.01	-6.1	-1.03	-9.6	-1.57	-12.7	-1.57	-3.2	-0.219	-2
413	Air	Missing nights data *	-0.946	-4.8	-0.546	-3.9	-1.12	-8.9	-1.91	-4.6	-0.795	-4.9
414	Air	Party size = 1									0.626	7.6
415	Air	One-way dist 50-150 miles	-3	-7	-2.52	-9.9	-1.7	-8.5	-5.01	-4.8	-3.19	-16.3
Model Fit Statistics												
		Observations	14743		27602		30077		6076		15824	
		Final log-likelihood	-2620.7		-4614.8		-6478.3		-1604.3		-3940.5	
		Rho-squared vs. 0	0.852		0.863		0.816		0.783		0.797	
		Rho-squared vs. constants	0.354		0.525		0.385		0.4		0.542	
Generalized Cost Coefficients												
10	All	Cost	-0.006		-0.006		-0.006		-0.006		-0.0025	
11	Car	Time	-0.002		-0.002		-0.002		-0.002		-0.002	
21	Bus	Time	-0.0015		-0.0015		-0.0012		-0.0015		-0.0015	
31	Rail	Time	-0.002		-0.0015		-0.0012		-0.0015		-0.0015	
32	Rail	Transfers	-0.3		-0.3		-0.3		-0.3		-0.5	
33	Rail	Frequency/week	0.06		0.06		0.06		0.06		0.06	
34	Rail	Access+egress distance	-0.025		-0.015		-0.02		-0.025		-0.015	
35	Rail	Acc+egr distance/car distance	-1.16		-3.04		-2.36		-1.16		-1.69	
41	Air	Time	-0.0015		-0.0015		-0.0015		-0.0015		-0.0015	
42	Air	Transfers	-0.3		-0.3		-0.15		-0.3		-0.5	
43	Air	Frequency/week	0.06		0.06		0.06		0.06		0.12	
44	Air	Access+egress distance	-0.005		-0.005		-0.009		-0.005		-0.006	
45	Air	Acc+egr distance/car distance	-1.86		-3.3		-0.46		-1.86		-4.93	
46	Air	On-time percentage	0.015		0.03		0.015		0.03		0.03	

6.6 Sample Log Print File

```
Reading configuration file inputs\test3_config.txt
RunTitle FHWA_Long_Distance_Model_Test_Run
RoadLOSFileName inputs\zoneRoadLOS.dat
RailLOSFileName inputs\zoneRailLOS.dat
AirLOSFileName inputs\zoneAirLOS.dat
ZoneLandUseFileName inputs\numa_2010_landuse.dat
HouseholdFileName inputs\us_synpop_hh3_sorted.dat
DestChoiceCoefficientFile_1 inputs\pbusdest6_bxc.F12
DestChoiceCoefficientFile_2 inputs\vfardest6_bxc.F12
DestChoiceCoefficientFile_3 inputs\leisdest6_bxc.F12
DestChoiceCoefficientFile_4 inputs\commdest6_bxc.F12
DestChoiceCoefficientFile_5 inputs\ebusdest6_bxc.F12
ModeChoiceCoefficientFile_1 inputs\pbusmode13_est.F12
ModeChoiceCoefficientFile_2 inputs\vfarmode13_est.F12
ModeChoiceCoefficientFile_3 inputs\leismode13_est.F12
ModeChoiceCoefficientFile_4 inputs\commmode13_est.F12
ModeChoiceCoefficientFile_5 inputs\ebusmode13_est.F12
PartySizeCoefficientFile_1 inputs\pbus_psize3.F12
PartySizeCoefficientFile_2 inputs\vfar_psize3.F12
PartySizeCoefficientFile_3 inputs\leis_psize3.F12
PartySizeCoefficientFile_4 inputs\comm_psize3.F12
PartySizeCoefficientFile_5 inputs\ebus_psize3.F12
NightsAwayCoefficientFile_1 inputs\pbus_dur3.F12
NightsAwayCoefficientFile_2 inputs\vfar_dur3.F12
NightsAwayCoefficientFile_3 inputs\leis_dur3.F12
NightsAwayCoefficientFile_4 inputs\comm_dur3.F12
NightsAwayCoefficientFile_5 inputs\ebus_dur3.F12
TourFreqCoefficientsFile_1 inputs\freqest3a.f12
TourFreqCoefficientsFile_2 inputs\fsecest3a.f12
AutoOwnCoefficientsFile inputs\carown3.f12
HouseholdOutputFileName outputs\household_out_13.dat
TourOutputFileName outputs\tour_out_13.dat
TripMatrixOutputFileName outputs\trip_out_13.dat
OutputFileDelimeter 32
MonthOfYear 0
EachDayOfTheMonth T
RandomSeed 12345
Sample1inX 100
SampleOffset 0
WriteHouseholdRecords T
WriteTourRecords T
WriteCarTripMatrix T
WriteBusTripMatrix T
WriteRailTripMatrix T
WriteAirTripMatrix T
UseProbabilitiesinMatrices F
UseADTUnitsInMatrices F

Run started at 5/24/2015 1:25:00 PM
Loading Zone Land Use Data from inputs\numa_2010_landuse.dat
Loading Road LOS Matrices from inputs\zoneRoadLOS.dat
Loading Rail LOS Matrices from inputs\zoneRailLOS.dat
Loading Air LOS Matrices from inputs\zoneAirLOS.dat

Total expanded households simulated = 114736800

Household car ownership distribution by income group
Income> Total 0-35 $k 35-65$k 65-100k 100-150 Over150
0 cars 5.13% 11.67% 2.97% 1.43% 0.89% 0.56%
1 car 29.75% 51.44% 28.56% 16.28% 10.47% 7.51%
2 cars 40.92% 26.06% 44.37% 49.70% 51.21% 53.61%
3 cars 15.53% 7.71% 16.04% 20.45% 22.59% 23.09%
4+ cars 8.67% 3.12% 8.06% 12.13% 14.84% 15.23%

Household tour rates by purpose and income group (for simulated period)
Income> Total 0-35 $k 35-65$k 65-100k 100-150 Over150
PersBus 2.7827 2.5804 2.8464 2.9167 2.9035 2.9062
VisitFR 6.4060 5.2268 6.5070 6.9750 7.3120 8.0412
```

```
Leisure 4.6567 2.6680 4.3955 5.5243 6.5317 8.3446
Commute 1.0016 0.4280 0.9643 1.3101 1.5545 1.8222
EmplBus 2.6798 0.7904 2.2291 3.4815 4.6272 6.5755

Total expanded tours simulated = 2010968300

Tour nights away distribution by purpose
Purpose Total PersBus VisitFR Leisure Commute EmplBus
Daytrip 50.71% 68.49% 40.11% 46.43% 78.12% 54.76%
1-2 nts 28.34% 20.45% 35.87% 27.87% 11.53% 25.65%
3-6 nts 15.07% 8.01% 17.30% 17.35% 8.16% 15.68%
7+ nts 5.88% 3.04% 6.71% 8.36% 2.19% 3.92%

Tour party size distribution by purpose
Purpose Total PersBus VisitFR Leisure Commute EmplBus
1 pers 30.36% 21.87% 26.28% 12.55% 79.77% 61.40%
2 pers 35.91% 39.73% 38.43% 41.14% 13.96% 25.03%
3 pers 13.81% 17.58% 15.27% 15.96% 3.45% 6.55%
4+ pers 19.92% 20.81% 20.02% 30.35% 2.82% 7.02%

Tour distance band distribution by purpose
Purpose Total PersBus VisitFR Leisure Commute EmplBus
50-99 m 42.36% 47.40% 35.27% 43.38% 74.57% 40.30%
100-149 18.50% 20.35% 19.94% 18.83% 8.96% 16.15%
150-249 14.34% 12.95% 17.35% 14.51% 3.73% 12.27%
250-499 10.66% 8.34% 13.85% 9.35% 1.81% 11.05%
500-999 9.03% 8.16% 9.09% 8.27% 8.89% 11.16%
-1999 m 3.32% 2.03% 3.05% 3.74% 1.39% 5.32%
2000+ m 1.78% 0.78% 1.47% 1.91% 0.66% 3.75%

Tour mode choice distribution by purpose
Purpose Total PersBus VisitFR Leisure Commute EmplBus
Car 90.80% 95.03% 92.63% 90.83% 94.48% 80.62%
Bus 1.33% 1.53% 0.74% 2.44% 1.24% 0.64%
Rail 1.28% 0.88% 0.83% 1.16% 3.16% 2.24%
Air 6.59% 2.56% 5.80% 5.57% 1.13% 16.49%

Tour distance band distribution by mode and purpose
Mode = Car
Purpose Total PersBus VisitFR Leisure Commute EmplBus
50-99 m 45.24% 48.58% 37.33% 46.04% 75.29% 48.19%
100-149 19.90% 20.97% 21.19% 20.06% 9.20% 19.43%
150-249 14.84% 13.13% 18.09% 14.93% 3.64% 12.70%
250-499 10.93% 8.43% 14.35% 9.60% 1.79% 11.21%
500-999 7.29% 7.37% 7.43% 7.09% 8.75% 6.53%
-1999 m 1.64% 1.40% 1.48% 2.06% 1.28% 1.69%
2000+ m 0.17% 0.13% 0.14% 0.21% 0.06% 0.23%
Mode = Bus
Purpose Total PersBus VisitFR Leisure Commute EmplBus
50-99 m 37.37% 43.63% 34.37% 35.64% 48.81% 33.32%
100-149 15.24% 16.42% 17.52% 15.38% 5.07% 12.39%
150-249 15.47% 12.41% 14.02% 17.48% 13.54% 15.07%
250-499 9.82% 7.45% 9.98% 10.65% 5.70% 12.70%
500-999 18.20% 16.71% 19.91% 17.13% 23.41% 20.53%
-1999 m 3.57% 3.12% 3.85% 3.40% 3.24% 5.26%
2000+ m 0.34% 0.26% 0.34% 0.32% 0.22% 0.73%
Mode = Rail
Purpose Total PersBus VisitFR Leisure Commute EmplBus
50-99 m 55.65% 61.15% 47.67% 49.97% 89.50% 47.82%
100-149 15.12% 17.96% 18.91% 15.67% 6.57% 14.59%
150-249 14.65% 11.29% 14.61% 18.66% 2.01% 19.07%
250-499 5.44% 3.48% 6.64% 6.03% 0.47% 7.24%
500-999 7.18% 5.05% 9.79% 7.16% 1.25% 8.86%
-1999 m 1.65% 0.99% 2.01% 2.01% 0.18% 2.03%
2000+ m 0.32% 0.08% 0.36% 0.50% 0.02% 0.39%
Mode = Air
Purpose Total PersBus VisitFR Leisure Commute EmplBus
50-99 m 1.13% 1.09% 0.69% 2.02% 0.86% 0.99%
100-149 0.55% 0.50% 0.41% 0.97% 0.10% 0.43%
150-249 7.23% 7.38% 6.22% 5.52% 5.41% 9.12%
250-499 8.15% 7.09% 7.38% 5.40% 3.16% 10.70%
```

```
500-999 31.59% 33.44% 34.16% 23.99% 25.34% 33.75%
-1999 m 26.79% 25.03% 28.14% 31.59% 12.19% 23.49%
2000+ m 24.56% 25.47% 23.00% 30.51% 52.92% 21.52%

Daily tours by mode and O-D Census divisions (thousands)
Mode = Car
O / D>> New Eng Mid Atl NE Cent NW Cent Sou Atl SE Cent SW Cent Mountn Pacific AK & HI
New Eng 160.6 83.4 4.2 0.8 8.9 1.1 0.6 0.3 0.3 0.0
Mid Atl 80.5 456.8 43.8 3.8 103.2 6.3 2.5 0.9 0.6 0.0
NE Cent 3.4 40.7 660.7 71.2 37.8 47.9 12.6 3.8 1.0 0.0
NW Cent 0.6 3.0 57.7 259.0 6.9 11.2 31.2 13.0 1.5 0.0
Sou Atl 7.8 86.1 38.3 7.4 797.7 72.8 14.1 1.7 1.0 0.0
SE Cent 1.0 5.4 46.8 12.2 70.9 182.7 32.6 1.5 0.5 0.0
SW Cent 0.4 1.7 9.2 26.8 12.3 28.7 440.6 15.0 1.8 0.0
Mountn 0.1 0.4 1.8 7.7 1.0 0.8 11.3 224.6 18.3 0.0
Pacific 0.2 0.4 0.8 1.3 1.0 0.4 2.5 46.3 539.8 0.0
AK & HI 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 5.4
Mode = Bus
O / D>> New Eng Mid Atl NE Cent NW Cent Sou Atl SE Cent SW Cent Mountn Pacific AK & HI
New Eng 2.1 1.7 0.2 0.0 0.3 0.0 0.0 0.0 0.0 0.0
Mid Atl 1.5 7.7 1.3 0.2 2.0 0.2 0.1 0.0 0.0 0.0
NE Cent 0.1 1.1 9.0 1.2 1.1 0.8 0.4 0.1 0.0 0.0
NW Cent 0.0 0.1 0.9 2.1 0.2 0.2 0.5 0.2 0.0 0.0
Sou Atl 0.2 1.7 1.1 0.2 9.7 1.1 0.4 0.0 0.0 0.0
SE Cent 0.0 0.2 0.8 0.2 0.9 1.5 0.6 0.0 0.0 0.0
SW Cent 0.0 0.1 0.3 0.4 0.4 0.5 5.2 0.3 0.1 0.0
Mountn 0.0 0.0 0.1 0.1 0.0 0.0 0.2 2.0 0.3 0.0
Pacific 0.0 0.0 0.0 0.0 0.0 0.0 0.1 1.0 7.8 0.0
AK & HI 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
Mode = Rail
O / D>> New Eng Mid Atl NE Cent NW Cent Sou Atl SE Cent SW Cent Mountn Pacific AK & HI
New Eng 2.3 2.0 0.1 0.0 0.2 0.0 0.0 0.0 0.0 0.0
Mid Atl 7.2 21.7 1.3 0.2 5.1 0.1 0.1 0.0 0.1 0.0
NE Cent 0.1 0.5 5.4 0.5 0.2 0.1 0.1 0.1 0.0 0.0
NW Cent 0.0 0.0 0.2 0.3 0.0 0.0 0.0 0.0 0.0 0.0
Sou Atl 0.2 1.9 0.2 0.0 5.0 0.1 0.1 0.0 0.0 0.0
SE Cent 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
SW Cent 0.0 0.0 0.1 0.0 0.0 0.0 1.4 0.0 0.0 0.0
Mountn 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.3 0.1 0.0
Pacific 0.0 0.0 0.0 0.0 0.0 0.0 0.1 0.5 11.6 0.0
AK & HI 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
Mode = Air
O / D>> New Eng Mid Atl NE Cent NW Cent Sou Atl SE Cent SW Cent Mountn Pacific AK & HI
New Eng 0.4 2.7 2.3 0.9 3.9 0.6 1.5 1.8 5.3 0.1
Mid Atl 3.3 4.0 8.2 3.0 13.7 2.2 4.6 4.6 12.0 0.3
NE Cent 1.9 5.7 7.4 4.4 11.6 2.3 5.9 4.7 5.7 0.3
NW Cent 0.6 1.8 3.1 1.5 3.5 0.9 2.9 2.7 2.4 0.1
Sou Atl 3.0 8.8 10.6 4.2 16.9 3.3 7.5 5.0 11.1 0.3
SE Cent 0.5 1.5 2.1 1.1 3.5 0.7 2.1 1.0 1.4 0.1
SW Cent 1.0 2.7 4.3 2.8 6.3 1.7 8.8 4.6 4.6 0.2
Mountn 0.9 2.0 2.6 1.8 3.3 0.6 3.2 4.7 5.5 0.2
Pacific 4.7 8.9 6.0 3.0 12.4 1.4 6.0 11.3 13.5 1.1
AK & HI 0.2 0.4 0.5 0.2 0.6 0.2 0.4 0.4 0.4 0.0

Run finished at 5/24/2015 2:18:53 PM with 114736859 households processed
```

CHAPTER 7. Summary

The implementation phase of the long-distance passenger travel demand modeling system moved the exploratory research of the modeling framework into a practical application that can be used by FHWA and adapted for use by state and regional agencies across the United States. This modeling system (rJourney) is multimodal and may be useful to other Federal agencies (e.g., Federal Railroad Administration, Federal Aviation Administration, or Federal Transit Administration).

The calibration and validation of rJourney was completed at a national scale using available data sources. These available data sources were somewhat restricted in scope or detail, which limited comparisons of model outputs to these observed data sources. The household travel surveys for long-distance travel represent 5 of the 50 states in the United States where a national long-distance survey would have provided a more representative sample for model calibration. The traffic counts on the highway system include a large amount of short-distance passenger travel and truck travel. As a result, comparisons of long-distance traffic volumes with counts were compared for reasonableness rather than a more traditional model validation of the results. Recognizing these limitations, the models perform well compared to these available calibration and validation data sources.

rJourney is currently useful for testing national policies, based on the outcomes of the sensitivity testing conducted in the implementation phase. These sensitivity tests included changes to cost, time, and household income, and produced intuitively reasonable results. Additional sensitivity tests may be useful prior to evaluating national policies that may engage other aspects of the modeling system.

The implementation phase required additional effort to build multimodal national networks, with travel time and cost details, and a zone system, with land-use and demographic data, which may prove useful in other national planning activities. These data may also be useful to statewide or regional planning agencies that must look beyond their borders, with additional attention to areas surrounding the region or state of interest.

rJourney will also be useful to regional and state agencies that want to represent long-distance passenger travel that cross their borders and test transportation investments that may affect these travelers. rJourney was designed with this objective in mind, but will require more detailed evaluation of the input data and a more detailed model validation surrounding the region or state of interest before these model outputs are ready to use.