Colorado Statewide Travel Model

Activity-Based Model Development Report

prepared for

Colorado Department of Transportation

prepared by

Cambridge Systematics, Inc.

with

CDM Smith, Inc.

Georgia Tech University

University of Texas - Austin

Revised

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1.0 Statewide Model Overview

Development of the Colorado Statewide Activity-Based Travel Model (StateFocus) was initiated in June 2014, but had its roots in previous data collection and model development efforts within the state. The StateFocus model is based in large part on the DRCOG Activity-Based Travel Model (Focus). Most model components use the same structure as the Focus model and the starting point for model estimation of each of the model components was based on Focus. There are several important deviations, other than the obvious extent of the geographic coverage, of the StateFocus model from the DRCOG Focus model:

- Estimation of all StateFocus model components was based on the 2010 FRTC data;
- The StateFocus model explicitly includes and accounts for longer distance travel than observed within the DRCOG region;
- The StateFocus model also explicitly includes and accounts for "non-closed" tours that extend beyond the start or end of a normal travel day (3:00 AM-2:59 AM); and
- The population synthesis process for StateFocus is based on PopGen2 developed by Dr. Ram Pendyala of Arizona State University (ASU)[1].

The StateFocus model was estimated and calibrated for 2010. The following section provides an overview of the data used for the estimation and calibration of the model.

1.1 StateFocus Model Data Sources

1.1.1 Household Travel Data

The model was estimated using data collected in the 2010 Front Range Travel Counts (FRTC) survey of travel made by residents of the four Front Range Metropolitan Planning Organizations (MPOs):

- North Front Range Metropolitan Planning Organization (NFRMPO)
- Denver Regional Council of Governments (DRCOG)
- Pikes Peak Area Council of Governments (PPACG)
- Pueblo Area Council of Governments (PACOG)

The fifth MPO in the state, the Grand Valley MPO (GVMPO) for the Grand Junction region, and rural areas outside of the four Front Range MPOs were not included in the FRTC survey. ***Table 1.1*** summarizes the numbers of households and persons available in the FRTC survey data for use in the StateFocus model development.

[1] Dr. Pendyala was with Georgia Tech University at the time of the development of the PopGen2 procedures for StateFocus.

Table 1.1 Household and Person Surveys Available for Model Development

MPO	Households	Persons
NFRMPO	1,505	3,686
DRCOG	7,302	16,934
PPACG	2,589	6,436
PACOG	989	2,332
Total	12,385	29,388

Source: Cambridge Systematics

1.1.2 Transportation Network Data

Highway Network Data

The 2010 StateFocus highway network was compiled by Colorado Department of Transportation (CDOT) staff based on highway networks provided by the five MPOs. CDOT staff knit together the MPO networks and supplemented them with network data developed from CDOT sources for the remainder of the state. All network data have been geo-rectified to correspond to actual roadway locations and are maintained in TransCAD[2] formats. ***Appendix A*** provides the highway network data dictionary listing all data required by StateFocus.

Transit Network Data

The 2010 StateFocus transit network was also compiled by CDOT staff based on transit networks provided by the five MPOs (for their regional models) or information provided by the transit operators. ***Table 1.2*** lists the transit systems included and their basic service areas.

Since each of the transit systems operate as independent entities, the requirement to knit together the transit networks similar to the process used for the highway networks was not required. The transit networks have been coded on the statewide roadway network and are maintained in TransCAD formats. The RTD system includes rail services coded on "non-highway" transit links. ***Appendix B*** provides the transit network data dictionary listing all data required by StateFocus.

1.1.3 Zonal and Socioeconomic Data

StateFocus uses a microsimulation approach for travel forecasting, meaning that travel decisions are made by individuals living in households (or group quarters) within the state. Thus, StateFocus uses a synthesized population (see ***Section 2.1.2***) for the state with individual households and employment being assigned to points throughout the state. Nevertheless, StateFocus also uses aggregate zonal based data for 6,440 Transportation Analysis Zones (TAZs).

[2] TransCAD is transportation planning software licensed from Caliper Corporation. TransCAD is designed specifically for use by transportation professionals to display, manage, and analyze transportation data.

Table 1.2 Transit Services Included in the 2010 StateFocus Model

Transit System	Basic Service Area	Number of Routes	Notes
CDOT Commuter	Colorado Springs–Denver	2	FREX
Colt	Loveland	2	
Eagle County Transit	Eagle County	8	
GET	Greeley	12	
GVRTA	Gunnison–Crested Butte	2	
Grand Valley Transit	Grand Junction Region	11	Grand Junction, Clifton, Fruita, and Palisade
Mountain Metro T	Colorado Springs Region	38	
Pueblo Transit	Pueblo Region	26	
RFTA	Roaring Fork Valley	6	Aspen, Glenwood Springs, Rifle
RTD	Denver Regional Transportation District	433	Boulder, Broomfield, Denver and Jefferson counties, parts of Adams, Arapahoe and Douglas Counties, and a small portion of Weld County
SUCAP	La Plata County	2	Bayfield, Durango, Ignacio
Steamboat Springs Transit	Steamboat Springs–Craig	2	
Summit Stage	Summit County	4	Breckenridge, Frisco, Leadville
Transfort	Fort Collins Region	19	

Source: Cambridge Systematics

TAZ definitions and data from existing MPO travel models have been used for the five MPOs in the state; CDOT staff defined the TAZs outside of the MPOs and compiled the zonal data for those TAZs. StateFocus zonal data includes control totals (e.g. total households, population in households, etc.), geographic information (e.g. zone centroid x- and y- coordinates, zonal area, etc.), and other zonal information used by various model components (e.g. zonal parking costs, ski area acres, etc.). Some of the zonal data are exogenous inputs to StateFocus and some are derived from other inputs. ***Table 1.3*** summarizes the numbers of TAZs for each of the five MPOs and the non-MPO area along with the numbers of households, population in households, group quarters' population, and employment in 2010 for each of the areas. ***Appendix C*** provides a list of all zonal data used by StateFocus.

Census Data

Data from the 2008-2012 American Community Survey (ACS) data collected by the US Census Bureau were used to develop marginal control totals for the population synthesis procedures. The ACS data comprise detailed estimates of household and population characteristics based on random samples taken in each of the years included in the five-year period. In this way, more statistically accurate estimates of household and population characteristics can be made for smaller geographic areas. The 2008-2012 ACS data were selected for use since the years center on the model estimation and calibration year. ***Table 1.4*** lists the county level household and person characteristics underlying the 2010 population synthesis used for model calibration. In addition to the county level characteristics listed in ***Table 1.4***, CDOT staff compiled or developed TAZ level information for households by three household income groups (low, medium, and high) based on MPO specific definitions, total non-group quarters population, and group quarters population.

Table 1.3 Selected Zonal Data Summaries

Region	Number of TAZs	Households	Population in Households	Population in Group Quarters	Employment
NFRMPO	1,030	191,310	484,352	13,466	253,924
DRCOG	2,798	1,158,223	2,836,703	43,311	1,672,814
PPACG	786	249,518	633,171	19,273	335,568
PACOG	206	62,937	154,742	4,321	68,498
GVMPO	529	58,008	142,580	3,631	73,523
Non-MPO	1,091	283,466	681,171	31,876	381,975
Total	6,440	2,003,462	4,932,719	115,878	2,786,302

Source: Cambridge Systematics

Table 1.4 2010 County Level Population and Household Characteristics Used for Population Synthesis

Household Characteristic	Household Strata	Person Characteristic	Person Strata
Household Size	1, 2, 3…7 or more	Gender	Male, Female
Vehicle Ownership	0, 1, 2…4 or more	Age	Less than 5, 5-14, 15-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75-84, 85 or older
Number of Workers	0, 1, 2, 3 or more	Education Level	12th Grade or Less; High School Graduate; Some College, No Degree; Associate's Degree; Bachelor's Degree; Graduate or Professional Degree
Householder Race	White; Black or African American; American Indian and Alaska Native; Asian; Native Hawaiian and Other Pacific Islander; Other Race; Two or More Races	Race/Ethnicity	White; Black or African American; American Indian and Alaska Native; Asian; Native Hawaiian and Other Pacific Islander; Other Race; Two or More Races
Hispanic Householder	Yes, No	Employment Status	Not Employed, Employed, Unemployed, Not in Labor Force
Home Ownership Status	Own, Rent	Occupation	Unemployed or Not Available; Management, Business, Science, and Arts; Service; Sales and Office; Natural Resources, Construction, and Maintenance; Production, Transportation, and Material Moving; Active Military
Presence of Own Children	Yes, No		

Source: Arizona State University PopGen2 Presentation, *PopGen2_CDOT_SDO.pptx*, January 2018.

Public Use Micro Sample (PUMS)

Similar to the ACS data, the 2008-2012 PUMS data were used for the 2010 population synthesis. The PUMS data provide detailed information for households and residents collected in conjunction with the ACS data. The PUMS data provide information for individual households but they cannot be used to identify specific households and persons. The PUMS households are geocoded to specific Public Use Microdata Areas (PUMAs)[3] which are larger than TAZs. The households and population included in the PUMS data provide the "raw" sample data for creating the synthesized population. In effect, households are randomly selected from Census Tracts in such a way that the resulting distributions of households and associated population match the specified county and TAZ level marginal distributions. The 2010 PUMS data will be used for future year population syntheses until a new StateFocus base year model calibration is performed. ***Appendix D*** lists the variables from the PUMS data used for the StateFocus model.

Quarterly Census of Employment and Wages (QCEW)

The QCEW data are reported by employers to the US Department of Labor, Bureau of Labor Statistics on quarterly basis. The data provide a count of over 95 percent of available jobs by location. The QCEW data were used by CDOT staff to estimate employment by TAZ outside of areas covered by MPOs. Within the MPOs, the QCEW data were used as a check and also provide the means to disaggregate TAZ level employment to the employment categories required by StateFocus and as the foundation for an address-level set of locations for jobs.

1.1.4 Other Data Sources

Travel To, From, and Through Colorado

Several national-level auto trip data were reviewed for use in the development of the Colorado external auto trip model. Based on an extensive review of all the data, it was concluded that the following four data sources were suitable for use in the development of the Colorado external auto trip model:

- The Traveler Analysis Framework (TAF) is a Federal database focusing on long-distance person trips greater than 100 miles at the county level. TAF trips were determined suitable for long distance auto trips, reflecting external-external (EE), or auto trips through Colorado;

- Journey-to-work (JTW) data from the Census captures person work commute trips at the county level. JTW trips were determined suitable for mainly short but also long distance business trips, reflecting external-internal (EI), or auto trips to Colorado, and internal-external (IE), or auto trips from Colorado;

- ***StreetLight Data*** focuses on Colorado, with a geography designed to capture trip frequencies internal to Colorado as well as border crossings at the state line. StreetLight data were determined suitable for origin-destination (OD) trip patterns including EI, IE, and EE trips; and

- A national-level toll study performed by CDM Smith was based on several sources including TAF for auto and Freight Analysis Framework (FAF) for trucks and reflects vehicle OD trips. The national-level toll study data were determined suitable to use as a means to scale the StreetLight frequency data to vehicle trips.

As noted above, FAF data for truck movements were used to develop OD trips. The FAF data are produced through a partnership between Bureau of Transportation Statistics (BTS) and the Federal Highway Administration (FHWA). The FAF integrates data from a variety of sources to create a comprehensive picture of freight movements among states and major metropolitan areas by all modes of transportation.

[3] PUMAs are geographic units used by the US Census for providing statistical and demographic information. Each PUMA contains at least 100,000 people. PUMAs do not overlap, and are contained within a single state.

Starting with data from the 2012 Commodity Flow Survey (CFS) and international trade data from the Census Bureau, FAF incorporates data from agriculture, extraction, utility, construction, service, and other sectors.

The actual data used for StateFocus were the 2012 FAF Version 4 (FAF4) data. FAF4 provided estimates for tonnage (in thousand tons) and value (in million dollars) by regions of origin and destination, commodity type, and mode. Data were available for the base year of 2012, the recent years of 2013 - 2016, and forecasts from 2020 through 2045 in 5-year intervals.

Commercial Vehicle Travel Data

In addition to commercial vehicle travel to, from, and through Colorado discussed previously, data from the 2015 FRTC Commercial Vehicle survey were used to update commercial vehicle travel models for trips made wholly within Colorado. The original plan for commercial vehicle travel modeling was to use the commercial vehicle model embodied within the DRCOG Focus model. However, initial validation results for truck counts on roadway facilities were substantially low. As a result, the DRCOG Focus model commercial vehicle trip rates were updated based on results from the 2015 FRTC Commercial Vehicle survey.

StreetLight Data

CDOT obtained passively collected Locational Based Services (LBS) data and Global Positioning System (GPS) data from StreetLight Data, Inc. The LBS data were collected from cellphone apps that collect locational data and were used to identify travel made in personal use vehicles. The GPS data were collected from commercial vehicles and were used to identify commercial vehicle travel. The data, collectively referred to as StreetLight data, were collected in 2014 and 2015 and used for the development of IE, EI, and EE travel models. In addition, the LBS personal use vehicle data were used in the validation of the StateFocus travel model.

The Streetlight data were used to develop OD trip tables for 160 StreetLight zones defined for Colorado. The zones included both pass-through zones representing one end of IE, EI, or EE travel at external stations and zones internal to Colorado. The raw StreetLight data provided the information necessary to develop OD trip tables for an average weekday (Monday-Thursday) or an average weekend (Saturday-Sunday) for both personal use vehicles and commercial vehicles. In addition, daily or time of day (based on the time at the origin zone) trip tables could be developed. Finally, tables of average travel times for the interchanges could be developed from the data provided.

Since StreetLight collected data from LBS devices or GPS equipped commercial vehicles, the raw data provided “frequency” factors that could be used to scale the relative numbers of trips between zones. The relative numbers related to the total numbers of devices in the LBS or GPS universes, not the actual traffic volumes on the interchanges. As noted above, the data were collected in 2014 and 2015. Thus, the results needed to be further scaled for comparison to 2010 traffic volumes.

Visitor Data

Initial model validation results showed low traffic volumes destined from Denver and the other Front Range MPOs to the mountains and Western Slope. Data from a Longwoods International survey performed for the Colorado Tourism Office for 2011 were acquired and used to develop a relatively simple (in comparison to other StateFocus model components) visitor trip model. This model improved the validation results.

1.1.5 Calibration / Validation Data

Longitudinal Employer-Household Dynamics (LEHD) Data

The LEHD program produces information combining federal, state and Census Bureau data on employers and employees. The Census Bureau combines unemployment insurance earnings data and QCEW data to create statistics on employment, earnings, and job flows at detailed levels of geography and industry and for different demographic groups. In addition, the LEHD program uses these data to create partially synthetic data on workers' residential patterns. The LEHD data were used along with data from the FRTC survey to calibrate and validate workplace location choice models.

Traffic Count Data

CDOT staff compiled traffic count data from MPOs and CDOT statewide traffic counts. Average weekday traffic counts for personal use and commercial vehicles were posted on the roadway network and used for model calibration and validation purposes. Traffic counts for 2010 were posted when available although any counts for 2008 through 2012 were selected and scaled to 2010 if specific 2010 counts were not available.

Speed Data

CDOT staff compiled speed limit, uncongested speed and congested roadway speed data from existing CDOT network information, MPOs, and statewide speed data purchased from INRIX. INRIX compiled the speed data from mobile devices and GPS units in vehicles and provided detailed average speeds on roadway links for 15 minute intervals throughout the day. The INRIX speed data were aggregated to peak and off-peak periods for model validation purposes. The speed limit data were used to develop look-up tables of free-flow (uncongested) travel speeds stratified by roadway function class, area type, and speed limit for traffic assignment purposes.

Transit Ridership Data

The 2010 StateFocus transit ridership data was compiled by CDOT staff based on ridership data provided by the five MPOs (for their regional models) or information provided by the transit operators. ***Table 1.2*** lists the transit systems included and their basic service areas.

1.2 DRCOG Focus and StateFocus Code Base Consistency

During the development of the Statewide Focus model, DRCOG converted their Focus model software from C# platform tightly integrated with SQL-Server to one that uses text files for inputs and outputs to enhance model performance. The StateFocus model uses this new platform, and has extended the C# platform as necessary to implement the statewide model. Efforts were coordinated with DRCOG to maintain a common codebase between Focus and StateFocus for all processing steps common to both models. The common codebase is currently maintained on a GitHub repository maintained by DRCOG.

2.0 Statewide Model Program Flow

Figure 2.1 shows the overall program flow for the statewide travel model as it would be applied for a new forecast year. When a different transportation alternative is tested for a given forecast year, there is no need to rerun the portions of the model associated with the population synthesis.

Brief descriptions of the transportation networks, land use and other zonal data, socioeconomic marginal distributions, and Census ACS PUMS data required as input by the StateFocus model were provided in ***Section 1.0***. Brief descriptions of TransCAD procedures, PopGen2, and the Truck, IE/EI/EE, and Airport models are provided below. There are several ancillary procedures not shown in ***Figure 2.1*** that must be performed whenever a new population synthesis is performed, employment forecasts are changed, or transit or highway network changes are made. The procedures are used to:

- generate actual locations (points) within TAZs for synthesized households or changes in employment,
- calculate virtual centroids of activity within TAZs,
- calculate distances from each household or employment point to the nearest transit stop, and
- calculate intersection densities within TAZs.

The ancillary procedures are also described in this section.

The backbone of the StateFocus model is formed by the activity-based model components identified in rounded rectangle at the center of ***Figure 2.1***. The models are logit-based choice models estimated using the FRTC survey data. ***Section 3.0*** describes the preparation of the data used to estimate the models and ***Section 4.0*** provides detailed descriptions of the StateFocus activity-based model components.

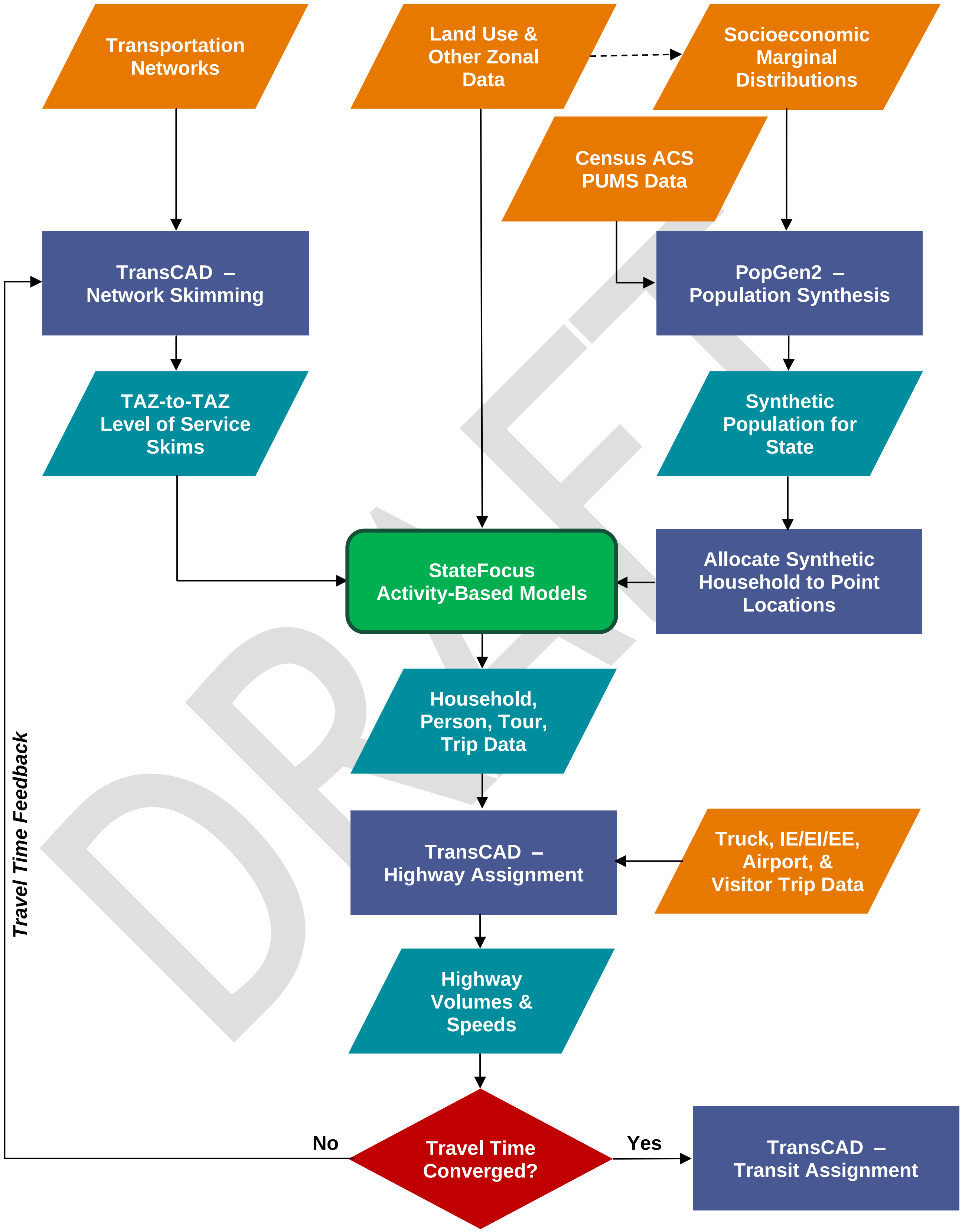
2.1 TransCAD Network Skimming Procedures

TransCAD is used to maintain and process transportation networks to provide input zone-to-zone highway, transit, bicycle, and walk travel skim information, highway traffic assignments, and traffic assignments. A model application "dashboard" for running the overall StateFocus model from TransCAD has been developed using Caliper's Geographic Information System Developer's Kit (GISDK). The TransCAD procedures were based on DRCOG's Focus model procedures. The DRCOG procedures were updated to take advantage of new TransCAD 7.0[4] procedures and improved techniques to streamline model application. Some TransCAD data structures were updated to help implement the improvements. Finally, the DRCOG procedures were adapted to make use of the new truck, IE/EI/EE, and airport models developed for StateFocus. The StateFocus TransCAD Users' Guide[5] provides detailed procedures for implementing StateFocus.

[4] The StateFocus model was developed using TransCAD 7.0. The model should be run using TransCAD 7.0, Build 12300 or later.

[5] Forthcoming.

Figure 2.1 Overall StateFocus Model Program Flow



Source: Cambridge Systematics

2.1.1 Roadway Network Path-Building and Skimming Procedures

The StateFocus activity-based models require zone-to-zone roadway travel times, distances, and cost information as input. The data are generated using TransCAD path-building and network skimming procedures based on peak and off-peak congested travel time information for ten time periods shown in ***Table 2.1***. The tour-based model components combine the roadway time, distance, and cost information for the outbound and return legs of the tour based on the times of day required.

Table 2.1 Time Periods for Roadway Network Path-Building and Skimming

Time Period	Designator	Time Period	Duration
Early Morning Peak	AM1	6:30 AM – 6:59 AM	½ Hour
Mid-Morning Peak	AM2	7:00 AM – 7:59 AM	1 Hour
Late Morning Peak	AM3	8:00 AM – 8:59 AM	1 Hour
Early Afternoon Peak	PM1	3:00 PM – 4:59 PM	2 Hours
Mid-Afternoon Peak	PM2	5:00 PM – 5:59 PM	1 Hour
Late Afternoon Peak	PM3	6:00 PM – 6:59 PM	1 Hour
Late Night	OP1	11:00 PM – 6:29 AM	7½ Hours
Morning Off-Peak	OP2	9:00 AM – 11:29 AM	2½ Hours
Midday Off-Peak	OP3	11:30 AM – 2:59 PM	3½ Hours
Evening	OP4	7:00 PM – 10:59 PM	4 Hours

Source: Cambridge Systematics

Since autos with different auto occupancies have different network choices, highway skims are built for drive alone, shared ride 2, and shared ride 3+ for each of time periods based on minimizing a generalized cost for the entire path where the generalized cost for each link is calculated as:

$$Generalized\ Cost = VOT \times Time + OpCost \times Length + Toll$$

Where: *Generalized Cost* is the link cost in 2010 dollars
VOT is the value of time, $0.4164 per minute, in 2010 dollars[6]
Time is the link travel time in minutes (this travel time may vary by time period due to congestion)
OpCost is the auto operating cost, $0.2776 per mile, in 2010 dollars[7]
Length is the link length in miles
Toll is the toll cost for the link in 2010 dollars

The cost components are not divided by auto occupancies for the shared ride 2 or shared ride 3+ paths and skims. Rather, the accounting for cost sharing is taken into account when the skim information is used (see, for example, ***Section 4.1.1***).

Initial speeds used for building paths for a model run may be obtained from one of two possible sources: a lookup table of estimated peak and off-peak period congested speeds (***Table A.2*** and ***Table A.3***) or from

[6] The VOT equates to $24.98 per hour and is consistent with the value of time used in the DRCOG Focus model.

[7] The OpCost is consistent with the auto operating cost used in the DRCOG Focus model.

final modeled speeds from a previous model run. For initial model runs for a new forecast year, the estimated congested speeds from the lookup tables are generally used while forecasts for a model year with previously performed model runs will typically use the congested speeds from a previous model run.

2.1.2 Transit Network Path-Building and Skimming Procedures

Transit paths and skims are built for four times of day as shown in ***Table 2.2***. Since StateFocus is a tour-based model, three sets of transit paths and skims must be are built: walk to transit, drive to transit, and drive from transit. The drive from transit paths are necessary for return legs from tours since different transit services and paths may be available by time of day and the drive times to and from park and ride lots may vary by time of day. Drive access and egress paths are allowed only to or from formal park and ride lots. The tour-based model components combine the outbound and return legs of the tour based on the appropriate times of day, as required. For drive access to transit, the same park and ride lot must be available for the return, drive egress, leg. If either leg does not have a transit path, the drive access mode is unavailable.

Table 2.2 Time Periods for Transit Network Path-Building and Skimming

Time Period	Designator	Time Period	Duration
Morning	AM	6:30 AM – 8:59 AM	2½ Hours
Midday	MD	9:00 AM – 2:59 PM	6 Hours
Afternoon	PM	3:00 PM – 6:59 PM	4 Hours
Evening-Late	EL	7:00 PM – 6:29 AM	11½ Hours

Source: Cambridge Systematics

Transit paths are based on minimizing a generalized cost for the entire path is calculated as:

$$Generalized\ Cost = [VOT \times (IVTT + 2.0 \times OVTT)] + (Fare + AutoOpCost)$$

Where: *Generalized Cost* is the cost in 2010 dollars
VOT is the value of time, $0.4164 per minute, in 2010 dollars[8]
IVTT is the in-vehicle travel time in minutes (this travel time may vary by time period for buses due to congestion on the roadway network); the following components comprise the IVTT:
Bus IVTT
Bus dwell time at stops
Rail IVTT × 0.8
Auto access (or egress) IVTT
OVTT is the out of vehicle travel time in minutes; the following components comprise OVTT:
Walk access time
Transfer walk time
Walk egress time
First wait time
Transfer wait time

[8] The VOT equates to $24.98 per hour and is consistent with the value of time used in the DRCOG Focus model.

AutoOpCost is the auto operating cost for drive access or egress calculated using the same procedure outlined in ***Section 2.1.1***
Fare is the transit fare in 2010 dollars

Table 2.3 summarizes the transit skim information stored for each path. All time and cost information is unweighted.

Table 2.3 Transit Skim Variables

Variable	Units	Notes
Local Bus In-Vehicle Time	Minutes	Excludes Dwell Time
Premium Bus In-Vehicle Time	Minutes	Excludes Dwell Time
Bus Dwell Time	Minutes	Total, not separately for local and premium
Rail In-Vehicle Time	Minutes	
Auto Access (Egress) In-Vehicle Time	Minutes	
Walk Access Time	Minutes	
Walk Egress Time	Minutes	
Walk Transfer Distance	Minutes	Can be multiplied by 20 minutes per mile to get walk transfer time
First Wait Time	Minutes	
Transfer Wait time	Minutes	
Transit Fare	Dollars	
Drive Access (Egress) Cost	Dollars	

Source: Cambridge Systematics

2.1.3 Bicycle and Walk Path-Building and Skimming Procedures

Bicycle and walk paths are built using the roadway network to minimize total impedance, where impedance is calculated as follows:

$$Impedance = Length \times \left(\frac{60}{BikeSpeed} + ImpPenalty\right)$$

Where: *Impedance* is the generalized non-motorized mode impedance
Length is the link length in miles
60 is for the conversion from hours to minutes
BikeSpeed is 12 miles per hour
ImpPenalty is a factor for encouraging or discouraging use of different facilities as shown in ***Table 2.4***

Distances in miles for the minimum impedance paths are stored in the non-motorized skim. When walk or bicycle times are required for a model component, the non-motorized distances are factored by 20 minutes per mile (3.0 miles per hour) for walk or 7.5 minutes per mile (8 miles per hour) for bicycle.

Table 2.4 Non-Motorized Mode Impedance Penalties

Roadway Facility Type	Impedance Penalty
Freeway, Expressway, Ramp	500.0
Principal Arterial	40.0
Minor Arterial	4.0
Collector, Centroid Connector	0.8
Cherry Creek Drive[1]	0.1

Source: Cambridge Systematics
Notes: [1] Cherry Creek Drive is used to represent the grade separated Cherry Creek bike path in Denver.

2.2 PopGen2 Population Synthesis[9]

PopGen2 is the population synthesis procedure developed for use for the StateFocus model. Population synthesis involves generating a synthetic population by expanding disaggregate sample data to mirror known or forecast aggregate distributions (marginal distributions) of household and person variables of interest. The output of PopGen2 is a synthesized population for Colorado for a specified base year (e.g. 2015) or forecast year (e.g. 2045). The synthesized population includes information for individuals along with characteristics of the households of which they are members. Individuals residing in group quarters are included. ***Appendix D*** lists household and population data items output from PopGen2.

For StateFocus, the disaggregate sample data are the 2008-2012 PUMS data (see ***Public Use Micro Sample (PUMS)*** in ***Section 1.1.3***). For the 2010 model calibration and validation process, the 2008-2012 ACS data (see ***Census Data*** in ***Section 1.1.3***) were used to develop the required marginal distributions. For future year forecasts, the required marginal distributions for individual counties are obtained from the Colorado State Demographer's Office (CSDO) and several additional marginal distributions for geographies smaller than counties are developed by CDOT.

2.2.1 Procedure Overview

The PopGen2 procedure is an iterative proportional fitting (IPF)[10] procedure used to match marginal distributions of households by household type and persons by person type at a county level and at a TAZ level for the StateFocus model using the following steps:

1. Initialize sample weights for all TAZs belonging to a given county

[9] PopGen2 is a population synthesis procedure developed by Dr. Ram Pendyala of ASU and adapted for use for the StateFocus. The material in this section has been adapted from the ASU PowerPoint presentation, *PopGen2_CDOT_SDO.pptx*, January 2018. Refer to that documentation for additional detail and information regarding the implementation of PopGen2 for the StateFocus model.

[10] IPF may also be referred to as marginal weighting or "Frataring." All three are heuristic procedures used to weight individual cells in a seed matrix to more closely match new marginal distributions (e.g. row totals and column totals for a two dimensional matrix).

2. Adjust the sample weights for households and persons in TAZs simultaneously so that the household- and person-level control marginals for the given county are matched (e.g. all households in each TAZ that fall in the same marginal for regional household type receive the same adjusted weight)

3. For each TAZ, adjust the sample weights to match the household- and person-level control marginals for the TAZ

Step 1 of the procedure is performed once for each county. Steps 2 and 3 are performed iteratively using IPF procedures until all marginal distributions are matched within specified tolerance limits.

Once the above three steps are completed for each county, the numbers of households and the populations for the various combinations of the household and person marginals are known for each TAZ. For example, at the end of the three steps, the results might show that there should be 16 households with the household and person characteristics shown in ***Table 2.5***. Of course, there could be numerous other households with different combinations of household characteristics populated by persons with different combinations of person characteristics.[11]

Table 2.5 Example PopGen2 Household and Person Characteristics After IPF Weighting

Characteristics	Marginal Source	Descriptions			
Household Level		***Household***			
Householder Type	County	More than one adult with children			
Householder Age	County	25-44			
Household Size	County	4 persons			
Household Income	TAZ	Medium			
Person Level		***Person 1***	***Person 2***	***Person 3***	***Person 4***
Age	County	35-44	45-54	15-24	5-14
Gender	County	Female	Male	Male	Female
Employment Status	County	Employed	Employed	Not in Labor Force	Not in Labor Force
Non-Group Quarters Population	TAZ	Yes	Yes	Yes	Yes

Source: Cambridge Systematics

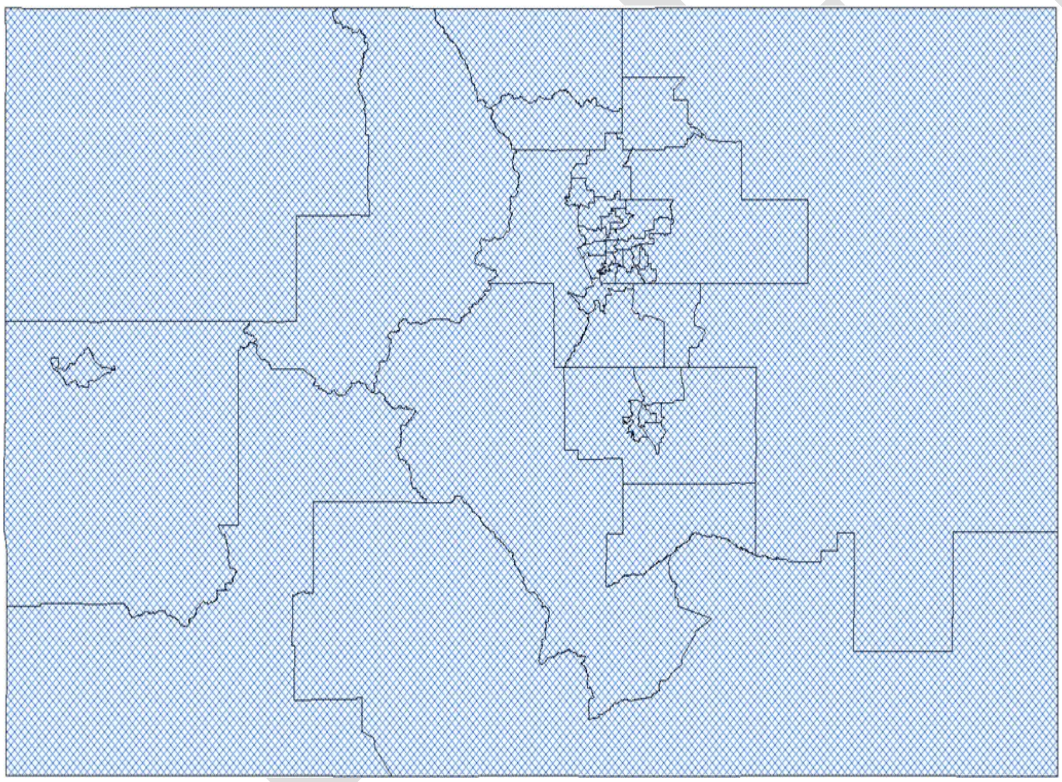
Once the various combinations of the household and person marginals for each TAZ are known, PopGen2 uses a random process to select households from the PUMS household data that match the varying household strata. PUMS sample households are selected from the PUMA within which the TAZ is located. This selection process continues until all households in the TAZ have been synthesized. At the same time, the person characteristics for each household member are synthesized in a similar manner.

[11] The household and person characteristics must, of course, be consistent. If the household size is “4 persons,” the householder type cannot be “one adult with no children.” Likewise, if the household type is “more than one adult with children,” there must be two or more adults and at least one child in the household.

2.2.2 Geographies

There are 42 PUMAs (***Figure 2.2***), 64 counties (***Figure 2.3***), and 6,440 TAZs (***Figure 2.4***) used for the PopGen2 process. All PUMS data are assigned to the PUMA2000 Census definition of PUMAs for Colorado. TAZs nest within counties and, generally, within PUMAs.[12] ***Figure 2.5*** shows the coverage areas of the five MPOs in Colorado as well as the non-MPO area. StateFocus TAZs have been defined by the MPO TAZs and, thus, nest to the six distinct areas. PopGen2 is applied separately for each MPO and for the non-MPO areas and the results are combined prior to running the StateFocus model.

Figure 2.2 Colorado PUMAs Used for Disaggregate 2008-2012 PUMS Data

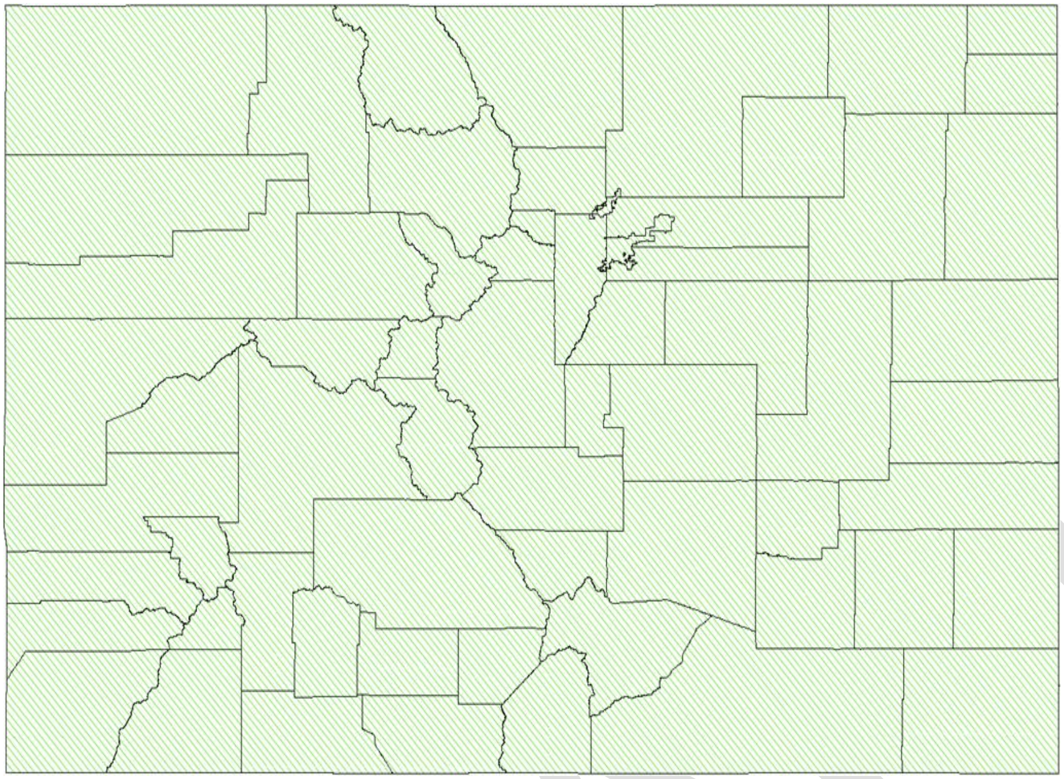


Source: Arizona State University, Slide 6, *CDOT_PopGen2.0_ComprehensivePresentation.xlsx*, June 30, 2017

[12] Technically, TAZs generally nest within Census Tracts and Census Tracts nest within PUMAs. There was some mismatch with the TAZs, Census Tracts, and PUMAs that were resolved in the development of the PopGen2 geographic data input files. In addition, variations in Census Tracts and PUMAs for 2008-2009 and those defined for the 2010 Census and used for the 2010-2012 PUMS data were resolved in the input geographic data files. The ASU PowerPoint presentation, *CDOT_PopGen2.0_ComprehensivePresentation.xlsx*, June 30, 2017, provides additional detail regarding the rectification of the geographies.

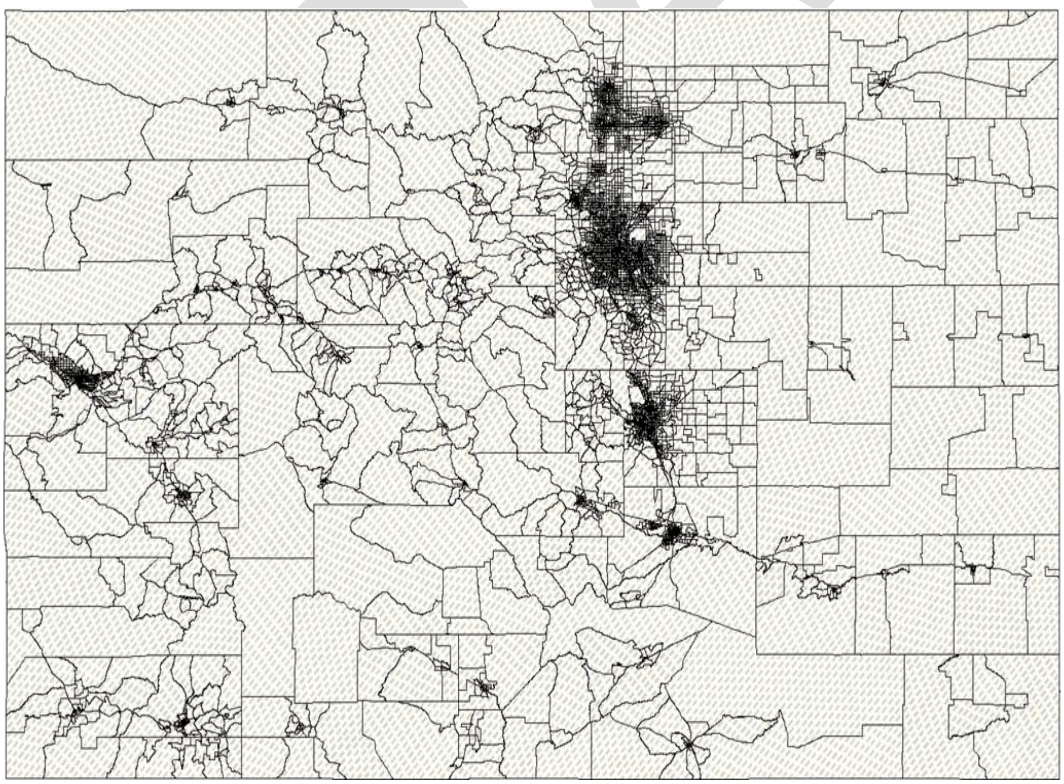
Since census geographies may change for each decennial census, the 2008-2012 PUMS data should continue to be used as the disaggregate sample data until a complete StateFocus model recalibration is performed. When the PUMS data source is, ultimately, updated (e.g. to a 2018-2022 time period), detailed checking of geographies as described by ASU in *CDOT_PopGen2.0_ComprehensivePresentation.xlsx* will need to be performed.

Figure 2.3 Colorado Counties



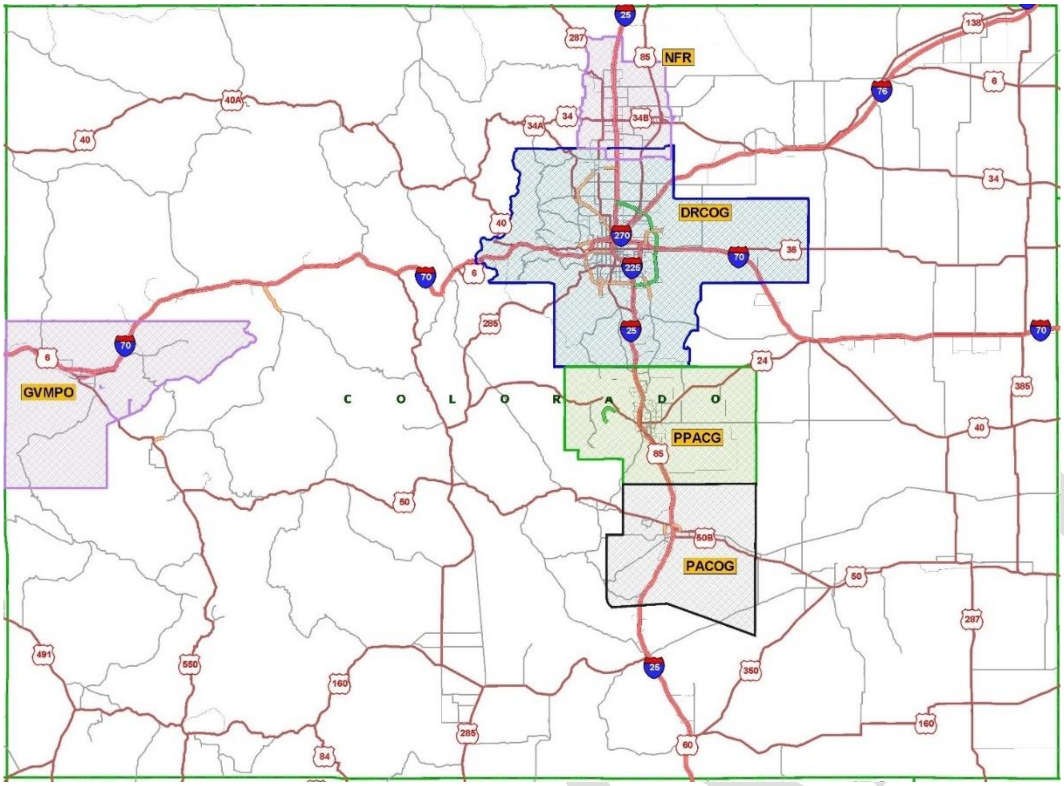
Source: Arizona State University, Slide 6, *CDOT_PopGen2.0_ComprehensivePresentation.xlsx*, June 30, 2017

Figure 2.4 StateFocus TAZs



Source: Arizona State University, Slide 6, *CDOT_PopGen2.0_ComprehensivePresentation.xlsx*, June 30, 2017

Figure 2.5 MPO and Non-MPO Areas



Source: Cambridge Systematics

2.2.3 Input Marginal Control Distributions

County Level Marginals

The StateFocus county level household and person marginal distributions required as control information for PopGen2 are shown in ***Figure 2.6***. Forecast householder type and householder age distributions by county may be obtained directly from the CSDO ("SDO" in ***Figure 2.6***). Likewise, the forecast age, gender, and employment status distributions may be obtained directly from the CSDO. In addition to the county level household and marginal distributions shown in ***Figure 2.6***, county level control totals of the number of persons in group quarters are obtained from the CSDO.

County Adjustments for MPO Geographies

As noted in ***Section 2.2.2***, PopGen2 is applied six times for the StateFocus model, once each for the areas covered by each of the five MPOs in Colorado and a sixth time for the remaining non-MPO area. Portions of three counties, Elbert, Larimer, and Weld, fall in more than one MPO/non-MPO area. Marginal distributions for the three counties are allocated to the MPO/non-MPO areas as shown in ***Table 2.6*** in the PopGen2 input preparation Python scripts included with the PopGen2 implementation package.[13]

[13] The distributions were based on 2010 household and population data and were hard coded in the Python scripts. If desired, the Python scripts can be updated for future year population syntheses.

Figure 2.6 County Level PopGen2 Household and Person Marginal Control Data

HOUSEHOLD LEVEL	
Householder Type ▪ One adult with no children ▪ One adult with children ▪ More than one adult with no children ▪ More than one adult with children	Source: SDO
Householder Age ▪ 18-24 ▪ 25-44 ▪ 45-64 ▪ 65 & Over	Source: SDO
Household Size ▪ 1 Person ▪ 2 Persons ▪ 3 Persons ▪ 4 Persons ▪ 5 Persons ▪ 6 Persons ▪ ≥ 7 Persons	Source: SDO & ACS

PERSON LEVEL	
Age ▪ < 5 Years ▪ 5 - 14 Years ▪ 15 - 24 Years ▪ 25 - 34 Years ▪ 35 - 44 Years ▪ 45 - 54 Years ▪ 55 - 64 Years ▪ 65 - 74 Years ▪ 75 - 84 Years ▪ ≥ 85 Years	Source: SDO
Gender ▪ Male ▪ Female	Source: SDO
Employment Status ▪ Employed (15+, in labor force) ▪ Unemployed (15+, in labor force) ▪ Not in Labor Force (15+) ▪ Children (0-14)	Source: SDO

Source: Arizona State University, Slide 9, *PopGen2.0_CDOT_SDO(2019-08-27).xlsx*, January 2018 as updated by Cambridge Systematics in August 2019.

Table 2.6 County/MPO Household and Population Allocation Percentages

County	MPO	Household Allocation[1]	Population Allocation[2]	Group Quarters Population Allocation[3]
Elbert	DRCOG	75.65%	76.74%	58.90%
	Non-MPO	24.35%	23.26%	41.10%
Larimer	NFRMPO	99.06%	99.13%	99.28%
	Non-MPO	0.94%	0.87%	0.72%
Weld	DRCOG	23.78%	24.35%	15.23%
	NFRMPO	75.55%	75.05%	84.77%
	Non-MPO	0.67%	0.60%	0.00%

Source: PopGen2 Data Input Python Script "Script.py" developed by Arizona State University

Notes: [1] Factors are applied uniformly to all household strata in each county household marginal.
[2] Factors are applied uniformly to all person strata in each county person marginal.
[3] Factors are applied to group quarters population in the county.

TAZ Level Marginals

The StateFocus TAZ level household and person marginal distributions required as control information for PopGen2 are shown in ***Figure 2.7***. There are two constraints that should be observed in the development of the TAZ level marginals:

- The sum of the households by income group for all TAZs in a county should match the total households for the county as specified in the county level marginals.
- The sum of the population in the non-group quarters and group quarters marginal for all TAZs in a county should match the total population for the county as specified in the county level marginals.

Figure 2.7 TAZ Level PopGen2 Household and Person Marginal Control Data

HOUSEHOLD LEVEL	
Household Income ▪ Low ▪ Medium ▪ High	Source: CDOT
PERSON LEVEL	
Total Non-GQ Population ▪ Non Group Quarter Population	Source: CDOT
GROUP QUARTER LEVEL	
Total GQ Population ▪ Population in Group Quarters	Source: CDOT

Source: Arizona State University, Slide 11, *PopGen2.0_CDOT_SDO.xlsx*, January 2018

MPO Income Groups for TAZ Marginals

As noted in ***Section 2.2.2***, PopGen2 is applied six times for the StateFocus model, once each for the areas covered by each of the five MPOs in Colorado and a sixth time for the remaining non-MPO area. Each MPO in Colorado used different break points for income grouping and, possibly, different numbers of income groups. For consistency in the application of PopGen2 for each MPO, only three income groups are input for TAZ marginal distributions.

Data summaries from the 2008-2012 ACS were reviewed to identify income ranges that would provide the best match possible with the income distribution breakpoints by MPO. This approach provides for more consistent sampling from the 2008-2012 PUMS data for matching TAZ level income marginals in the production of the final synthesized population for each MPO. Note, however, that each MPO may have different proportions of the households in each income level and may use different income breakpoints. ***Table 2.7*** shows the proportions of households by income group for each MPO for 2010 and ***Table 2.8*** shows the low, medium, and high income ranges used for the TAZ household income marginals for each MPO.

Table 2.7 Percentages of Households by Income Group in 2010 TAZ Household Income Marginals by MPO

MPO	Low	Medium	High	Total
NFRMPO	17%	45%	38%	100%
DRCOG	11%	64%	25%	100%
PPACG	15%	63%	22%	100%
PACOG	31%	46%	22%	100%
GVMPO	24%	47%	29%	100%
NonMPO	18%	53%	30%	100%
Total	14%	59%	27%	100%

Source: Cambridge Systematics based on Slide 31 of *CDOT_PopGen2.0_ComprehensivePresentation.xlsx*, June 30, 2017, prepared by Arizona State University.

Table 2.8 Income Group Ranges in 2010 Dollars for TAZ Household Income Marginals by MPO

MPO	Low	Medium	High
NFRMPO	Less than $20,000	$20,000 to $74,999	$75,000 or more
DRCOG	Less than $15,000	$15,000 to $99,999	$100,000 or more
PPACG	Less than $20,000	$20,000 to $99,999	$100,000 or more
PACOG	Less than $25,000	$25,000 to $74,999	$75,000 or more
GVMPO	Less than $25,000	$25,000 to $74,999	$75,000 or more
NonMPO	Less than $20,000	$20,000 to $74,999	$75,000 or more

Source: Arizona State University, Slide 34 of *CDOT_PopGen2.0_ComprehensivePresentation.xlsx*, June 30, 2017.

2.2.4 Output Files

PopGen2 outputs a household file and a person file for each region for which input marginals are provided. For StateFocus, PopGen2 is run six times, once for each MPO and once for the non-MPO area.[14] The output files are comma separated variable (CSV) files with the variable names provided in the first record of each file. The household and person files for each of the areas are combined prior to input to the StateFocus choice models. The variable definitions for the household and person files are shown in ***Appendix D***.

2.3 Allocate Households and Employment to Point Locations

For StateFocus, socioeconomic data can be found in a number of input files (see ***Appendix C*** and ***Appendix D***). ***Figure 2.8*** graphically shows the process for developing the socioeconomic data and the

[14] It is possible to change the number of regions by providing the proper input files. If another MPO was defined for the state or there was a desire to subdivide the non-MPO area, input marginals could be created and PopGen2 implemented more than six times.

relationships between key steps and files. For future year scenarios, household and employment growth is initially forecast at the county level based on information from the CSDO. Zonal level forecast data are sometimes available from MPOs, but are forecast to match the county level totals specified by the CSDO. This section describes the processes to:

- Allocate county or TAZ level growth to individual points (***Section 2.3.1***);
- Match points to households from the synthetic population (***Section 2.3.2***);
- Prepare zonal data files input to StateFocus (***Section 2.3.3***); and
- Create household and person files that are input to StateFocus (***Section 2.3.4***).

Special consideration must be given to each of the state's MPOs since each may have some level of forecast data available. The StateFocus model must produce a statewide dataset consistent with the MPO datasets while also providing the level of detail required for input to the statewide model.

The point generation/allocation process produces longitude and latitude for each new household and establishment in the state. These values are fed to the statewide model as individual point locations and will facilitate disaggregation of county-level growth forecasts to the TAZ level. Information about each household and employee such as income and employment category is generated by PopGen2 (see ***Section 2.2***). A computer script matches the points to the households generated by PopGen2 and creates the input files as required by the StateFocus model.

The following information is currently available to support generation of point locations for new household and employment within the state:

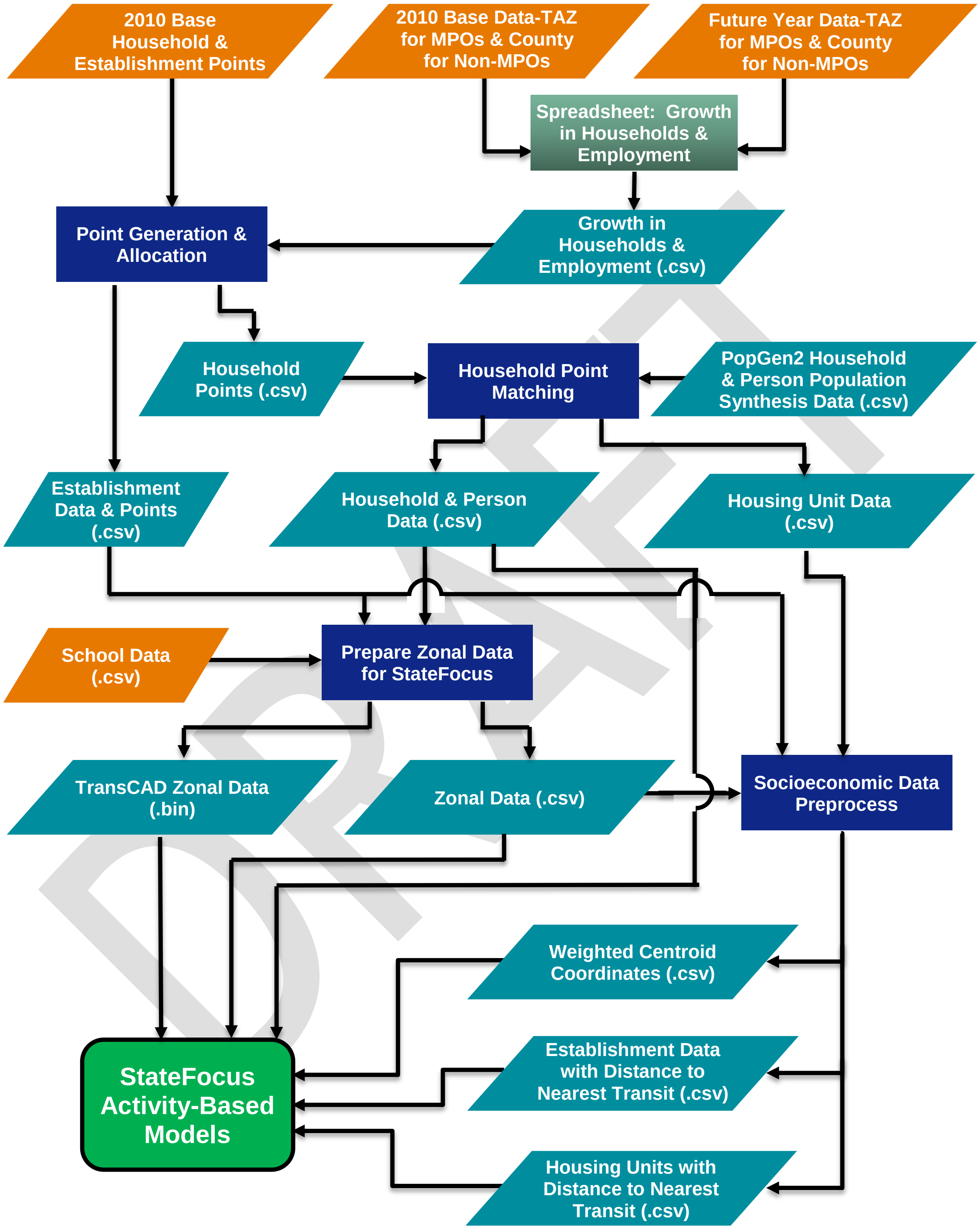
- Existing household and employment at the point and TAZ level;
- An inventory of non-developable lands, where new household and employment growth cannot occur; and
- Projected household and employment growth for each county or TAZ in the state.

In addition, several MPOs can provide additional data. The data available from each MPO is listed below.

- DRCOG: Point locations are available for all households and employees,
- NFRMPO: TAZ and parcel level data are available for all new households and employees,[15]
- PPACG: Forecasts are available at the TAZ level,
- PACOG: Forecasts are available at the TAZ level, and
- GVMPO: Forecast are available at the TAZ level.

[15] Parcel level data could be converted to individual points for each new household and employee based on parcel centroids. However, in the current version of the StateFocus procedures, only control totals at the TAZ level are used in this process.

Figure 2.8 CDOT Socioeconomic Data Processing Flowchart



Source: Cambridge Systematics

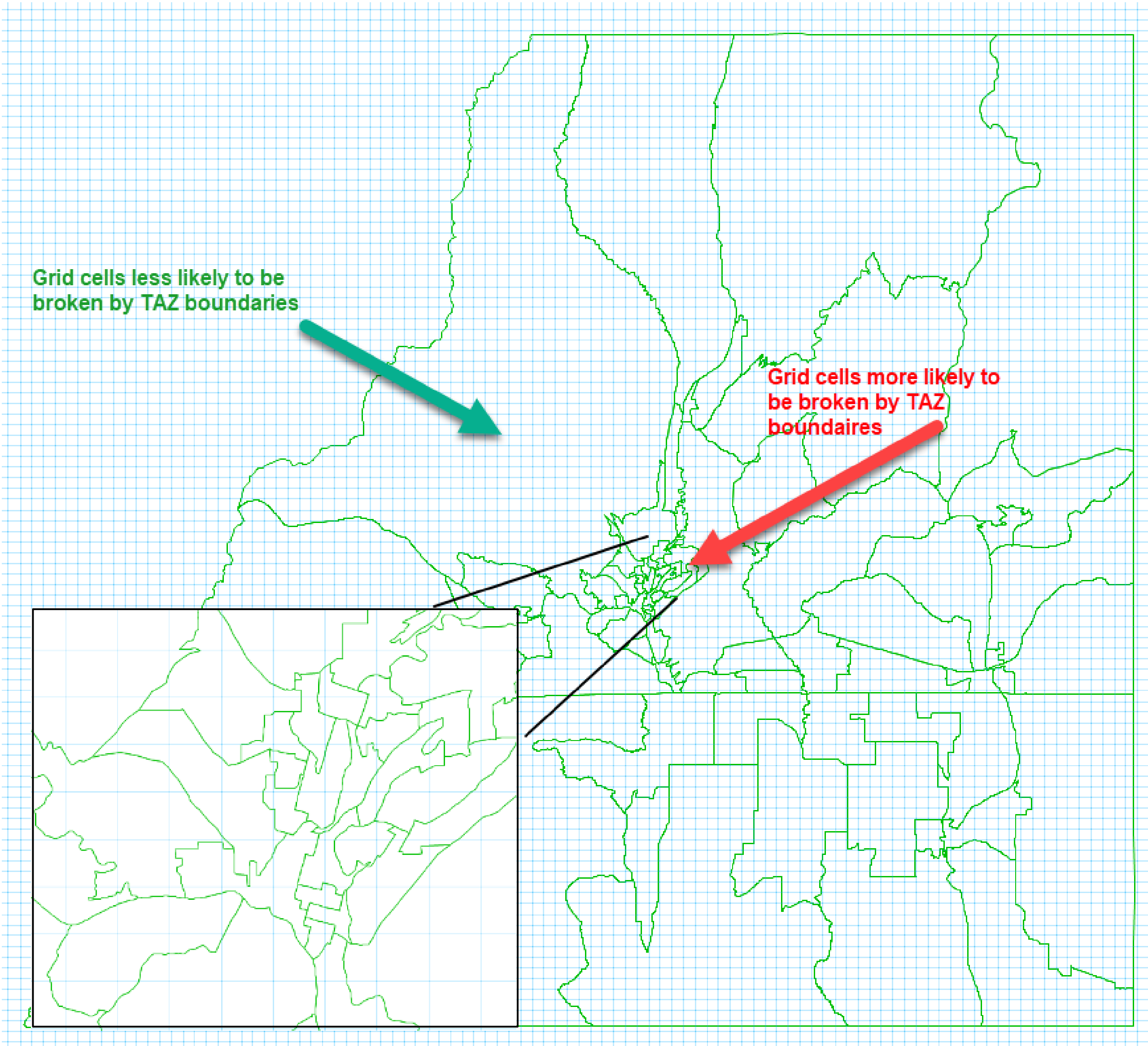
2.3.1 Developing Point Locations

Since future year scenarios or transportation network ("build") scenarios may include some zones where the number of households or jobs has increased from the base scenario, the Allocate Points utility is used to create additional housing unit and establishment points. Housing unit points are then available to be assigned to synthetic households during the Python Point Placer script execution.

Distance-Based Attractiveness Factor

The process uses a gravity model approach to allocate new growth to a processed grid within each county outside of MPO's, or each TAZ within MPO's that forecast growth by TAZ but do not have point estimates already available. Grids are created by overlaying a grid over the target county or TAZ with a sufficient buffer around the greatest latitudinal and longitudinal extents, and then intersecting that grid with the TAZ boundaries, or for counties, all TAZ boundaries in the county. This method automatically achieves higher grid density in developed areas of more rural counties since those developed areas have smaller TAZ's and the final grid cells are the intersection (combination) of the grid cell and TAZ boundaries. ***Figure 2.9*** illustrates this for La Plata County.

Figure 2.9 Example Grid Cells for La Plata County



Source: Cambridge Systematics.

Grid cells will then be converted to points by using grid cell centroids. (If the grid cells are sufficiently small, the exact point location within the grid cell will not be consequential.) The gravity model is used to determine the attractiveness of each grid cell using the following equation:

$$x_i = \sum_{j=1}^{n} A_j \times e^{-\alpha D_{ij}} \times da_j$$

Where: x_i is a factor defining relative attractiveness of each grid cell;

A_j is the total activity in grid cell j;

α is a calibration factor,

D_{ij} is the distance or right-angle distance between grid cells i and j;

and da_j is the total developable area of grid cell j.

The α factor controls for "smoothness" of the attractiveness factors (smaller values create more smoothing as distance from existing activity matters less, and thus also some more sprawl). For the household growth model, activity for each grid cell can be calculated as follows:

$$A_j = Households_j + \beta_{employment} \times Employment_j$$

while within the employment growth model, activity for each grid cell can be calculated in the opposite manner:

$$A_j = Employment_j + \beta_{households} \times Households_j$$

The $\beta_{employment}$ and $\beta_{households}$ parameters can be calibrated as desired to drive new household growth toward (or away from) employment, and vice-versa. By setting both β to zero, the household and employment models can be made independent.

Maximum Grid Cell Density

Identification of developable grid cells requires identification of a maximum allowable density at which a cell is considered fully built. Any grid cell meeting or exceeding this density will not be subject to allocation of new household or employment points. Furthermore, the allocation model must be limited so that allocation of new household and employment points to grid cells do not exceed the maximum allowable density in any cell.

Maximum allowable density at the grid cell level may vary based on a large number of factors. For example, urban areas may allow more density than suburban areas and different counties may have different allowable densities in rural areas. A simplified approach to maximum density identification is to use a specified maximum for each jurisdiction (e.g. a draft model has been coded to identify 98th percentile density among TAZs in the county or DRCOG sub-county district) based on existing household and employment points. Jurisdictions can be defined as individual cities and towns, along with the remaining unincorporated portions of each county. This approach is sufficiently general to be applied on a statewide level, but is intended to avoid potential problems that might arise from treating all areas within the state in the same manner.

Non-Developable Lands

The non-developable (or conversely, developable) layer will be intersected with the TAZ layer, to generate a layer indicating only the developable area within each TAZ. This process can be undertaken as a separate pre-processing step. Non-developable lands will include areas such as public lands, conservation easements, and steep slopes.

Allocation Methods

Point allocations will be made with a proportional iterative approach. With this method, new households are allocated to each grid cell using the equation below, with employment being allocated in a similar manner:

$$Household_i = \frac{x_i \times \delta_i}{\sum_{j=1}^{n} x_j \times \delta_j} \times Households_{unassigned,county}$$

Where: x_i is the ***Distance-Based Attractiveness Factor*** of a grid cell as defined above

δ_i is a binary indicator for whether a grid cell is already at or above the developable capacity for the cell (determined by the density cap and the developable area in the cell). In the first iteration of this formula, some grid cells may already be over the cap based only on existing development.

This approach requires iterative application, because new growth in the most attractive cells is likely to exceed the maximum allowable density. At each iteration, any cell that reaches the development cap has any excess growth returned to the "unassigned" pool for assignment in the next iteration. Between iterations the values of δ_i are updated to ensure that over-allocated growth does not get reallocated to the same over-capacity cells. The procedure is repeated until all new growth has been successfully allocated without exceeding the existing or maximum allowable density in any cell.

In the unlikely but possible event that all cells reach the development cap before all projected growth is allocated, the algorithm removes the caps entirely and allocates all remaining growth in one final un-capped iteration. This might occur, for example, in a scenario evaluating the construction of a new resort or ski attraction in or near a small town in the mountains, where no such facility existed before, or in a scenario where a new office tower is added to a small urban TAZ.

This approach ensures that less attractive grid cells receive some growth, while still allocating the majority of growth to areas near existing development. The tendency of this approach to allocate growth near existing activity can be controlled by adjusting the alpha parameter in the activity factor calculation.

Other Considerations

The methodology proposed above is fairly simplistic, improving the chances that it can be successfully applied at the state level. However, there are several areas of concern, noted below.

- **Households versus employment activity factors**: The attractiveness factor described above is defined separately for household and employment allocation. It is not clear from available data sources how to estimate or calibrate the β parameters.

- **Development caps on households, employment, or a combination**: If households and employment are treated separately it is relatively straightforward to implement separate development caps for each category, but it is not clear how to specify a joint cap, whereby the total of households and employment is limited. Nor is it clear a priori if such a cap would be advisable. But, to some extent very high densities of one category tends to preclude very high density of the other.

- **Grid cell size**: Selection of grid cell size will affect both model resolution and model run time. It is preferable to use a larger grid cell size for rural or unincorporated areas and a smaller grid cell size for denser areas or incorporated cities/towns, but exactly how small is needed is to be determined.

- **Application by areas**: This model will most likely be applied independently for various regions, either counties or TAZs. However, many such regions may have activities near the region border. When computing attractiveness factors, it will be necessary to include a buffer area around each county or TAZ so that nearby activities are properly accounted for. If the buffer is too large, there will be an excessive amount of pointless computation. If the buffer is too small, edge effects will intrude upon the modeled area, distorting the results.

- **Allocation within TAZs for selected MPOs**: Outside of the MPOs, population and employment forecasts are available at the county level, and so it makes sense to conduct this process for counties.

Inside all MPOs, forecasts are available at the TAZ level. Thus it makes sense to conduct the point allocation process by TAZ instead of by county in those cases. This increases initial processing time, as the quantity of non-assigned buffer area that needs to be processed will be comparatively large compared to the area actually assigned. However, it will reduce the extra processing time necessary to adjust points within TAZs. Possible alternatives include:

- Allocate points at the county level, then scale/adjust results to match TAZ data;
- Randomly assign points within TAZs, but while considering non-developable and maximum density information.

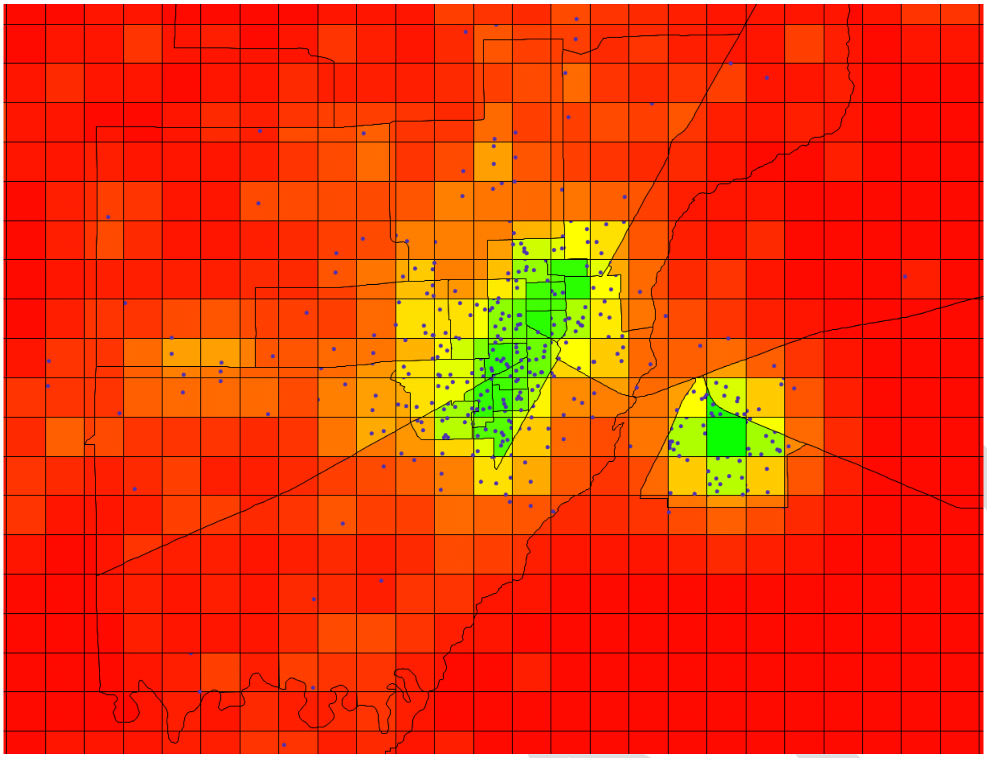
- **Growth beyond saturation**: It is unlikely in a “base case” but possible that total projected growth for a TAZ may be such that it would exceed the calculated development cap in every cell in that TAZ. The algorithm as proposed would allow cap violation for any cell only after caps are met in every cell in the TAZ or County. This may lead to odd results, with very homogeneous development in most of the areas.
- **Usage of existing point forecasts**: DRCOG already has an existing point-level forecast for growth within that region, and NFRMPO has parcel level forecasts, which can be functionally equivalent. However, the effort required to ensure those separate forecasts can be successfully incorporated into the Colorado statewide model may not be worth the effort, compared to simply using this developed algorithm to regenerate appropriate TAZ-level forecast for those MPO’s. Using the same algorithm statewide ensures internal consistency for the statewide model.

Illustrative Examples

Figure 2.10 shows the housing model as applied in the area around Sterling, Colorado. The baseline grid is defined at half mile increments for all of Logan County (much larger than the area depicted) although grid cells are broken apart along TAZ boundaries so smaller cells in Sterling proper can be seen. Map colors scale from red to green with the raw propensity for future development. Dots represent new households, when 500 new households are generated in Logan County (most appear in town). TransCAD allows for random dot placement as a display theme, but for ease of computational analysis all new households are assigned to the grid cell centroid. The non-developable layer was not yet incorporated into this analysis, so all areas are considered developable. Some cells were already over the 98th percentile housing density for Logan County, so while they appear very green, there were no new households assigned.

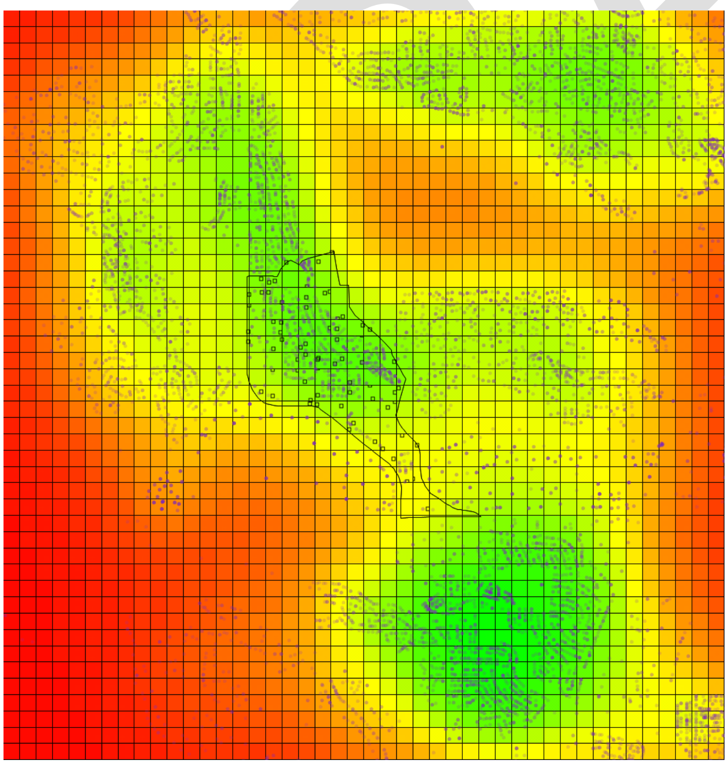
Figure 2.11 shows the entire grid, including a 1.5 mile buffer around the TAZ bounding box, of a single TAZ in Colorado Springs. Pale purple dots mark existing households, and small squared dots mark newly generated households. The base grid is demarcated at approximately 0.05 miles. Since this is a model for a single TAZ, grid cells are broken on the TAZ boundary only. Only cells contained within the TAZ are eligible for household generation, but all cells have computed growth factors. Note that cells near the outer edges show decreased growth factor calculations, but it is clear that any edge effects are completely dissipated well outside the TAZ boundaries. In fact, the buffer here was arguably much larger than necessary to insulate the TAZ.

Figure 2.10 Grids Near Sterling, Colorado



Source: Cambridge Systematics

Figure 2.11 Grids at a TAZ Near Garden of the Gods, Colorado Springs, Colorado



Source: Cambridge Systematics

2.3.2 Matching Households and Employment Locations to Points

The process to match households and employment (or establishment) locations for each TAZ to appropriate points within the TAZ:

- Randomly attaches each household to a point to generate housing units file. The process recycles points if the number of available points in a TAZ is less than the number of households in the TAZ,
- Post-processes synthetic population data from PopGen2 into StateFocus input data and formats the data to generate persons files, and
- Randomly attaches each establishment to a point to generate employer units file. The process recycles points if the number of available points in a TAZ is less than the number of establishments in the TAZ.

Appendix D lists the household and person data from PopGen2 matched to the individual household points as well as the establishment data for each employer matched to each individual employment point..

2.3.3 Prepare Input Zonal Data Files

The process to prepare input zonal data files for the StateFocus activity based files aggregates household, person, and establishment data to TAZ level totals and combines the data with school enrollment data.

2.3.4 Socioeconomic Data Preprocessing

The socioeconomic data preprocessing step actually takes place within the standard StateFocus modeling stream. The previous three steps dealt solely with socioeconomic data files and, thus, were forecast year specific. This step also considers transportation network information which might vary by alternative within a specific forecast year.

Calculating Weighted Zonal Centroids

In addition to the geographic centroid assigned to each of the 6,440 TAZs, the StateFocus model uses weighted household and employment centroids to identify "centers of gravity" or "virtual centroids" for households and employment within each TAZ. The household and employment centroids may move by forecast year (or socioeconomic alternative within a forecast year) based on the point locations of households within a TAZ and employment within a TAZ. All coordinates are expressed as x- and y-coordinates based on the North American Datum of 1983 (NAD 83) State Plane-Colorado Central coordinate system. The weighted household and employment centroids are estimated as follows:

- Household weighted centroids are estimated as the simple average of all individual housing unit x-coordinates and y-coordinates in a TAZ since each household has a weight of one;
- Employment weighted centroids are estimated as the weighted average of all individual establishment x-coordinates and y-coordinates in a TAZ with the weighting factor being the establishment size (i.e., number of employees).

Distance to Transit Calculations

The socioeconomic data preprocessing step also determines the straight line distance between each household and its nearest transit stop and each establishment and its nearest transit stop. While not shown in ***Figure 2.8***, transit network data are also input to the socioeconomic data preprocessing step.

2.4 Truck, IE/EI/EE, Airport, and Visitor Trips and Models

2.4.1 Truck Model

Truck Trip Generation

Trucks were initially modeled using the existing DRCOG truck model. While there was no comprehensive set of truck counts available at the time for truck trip model validation, truck counts were obtained for a few locations at key interregional boundaries to check the overall reasonableness of truck volumes for the base year. Comparison of modeled truck trips and actual counts showed that the model over predicted truck trips. It was decided to test updating the truck trip rates to reflect the latest data available from the 2015 Front Range Commercial Vehicle Survey (FRCVS).

Truck travel was estimated based on the borrowed structure from the existing DRCOG model and updated to reflect truck trip rates based on 2015 Front Range Commercial Vehicle Survey (FRCVS) data.[16] These 2015 truck trip rates are provided in ***Table 2.9***.

Table 2.9 Expanded Commercial Vehicle Trip Ends per Employee (or Household) by Truck Type and Area Type

Area Type	Households or Employees	Light Trucks (LT)	Medium Trucks (MT)	Heavy Trucks (HT)
Central Business District (CBD)	Households	0.052	0.003	0.0004
	Basic	0.056	0.003	0.0004
	Retail	0.055	0.003	0.0004
	Service	0.352	0.021	0.0024
CBD Fringe	Households	0.040	0.040	0.0007
	Basic	0.024	0.024	0.0004
	Retail	0.028	0.028	0.0005
	Service	0.121	0.121	0.0022
Urban	Households	0.157	0.157	0.0058
	Basic	0.094	0.094	0.0035
	Retail	0.110	0.110	0.0041
	Service	0.480	0.480	0.0179
Suburban	Households	0.106	0.106	0.0055

16 Technical Memorandum, *DRCOG CV Survey - Truck Model Parameters -v2*, to Hamideh Etimadnia (DRCOG) from Dan Beagan, Srinath Ravulaparthy, Aayush Thakur, and Arun Kuppam (Cambridge Systematics), revised May 19, 2016)

Area Type	Households or Employees	Light Trucks (LT)	Medium Trucks (MT)	Heavy Trucks (HT)
	Basic	0.064	0.064	0.0033
	Retail	0.075	0.075	0.0039
	Service	0.326	0.326	0.0169
Rural	Households	0.013	0.013	0.0019
	Basic	0.008	0.008	0.0012
	Retail	0.009	0.009	0.0014
	Service	0.040	0.040	0.0059

Source: Cambridge Systematics

Since the current DRCOG model adopted for StateFocus does not stratify truck trip generation rates by truck size, the 2015 FRCVS truck trips were aggregated to get total raw truck trip rates as shown in ***Table 2.10***. DRCOG's truck trip rates reflect averages summed over various groupings area type groupings. To stay consistent with those groupings, the 2015 FRCVS truck trip rates were applied to 2010 socioeconomic data and the total number of generated truck trips were summed to the DRCOG groupings and divided by the appropriate aggregated explanatory variables. The resultant composite truck trip rates, matching DRCOG's aggregations, are provided in ***Table 2.11***. The 2015 FRCVS Composite Truck Trip Rates are the final rates applied for the Colorado Statewide Model. Trip attractions by TAZ are assumed to equal trip productions estimated using the rates shown in ***Table 2.11***.

Table 2.10 DRCOG and 2015 FRCVS Total Truck Trip Rates by Area Type

Area Type	DRCOG Model				2015 FRCVS Raw Trip Rates			
	Households	Basic Employment	Retail Employment	Service Employment	Households	Basic Employment	Retail Employment	Service Employment
CBD	0.099	0.361	0.787	0.427	0.0554	0.0594	0.0584	0.3754
CBD Fringe					0.0807	0.0484	0.0565	0.2442
Urban		0.755	0.886	0.787	0.3198	0.1915	0.2241	0.9779
Suburban	0.230	1.017			0.2175	0.1313	0.1539	0.6689
Rural					0.0279	0.0172	0.0194	0.0859

Source: Cambridge Systematics

Table 2.11 StateFocus Composite Total Truck Trip Rates by Area Type

Area Type	Households	Basic Employment	Retail Employment	Service Employment
CBD	0.295	0.051	0.057	0.275
CBD Fringe				
Urban		0.192	0.172	0.748
Suburban	0.162	0.085		
Rural				

Source: Cambridge Systematics

Truck Trip Distribution

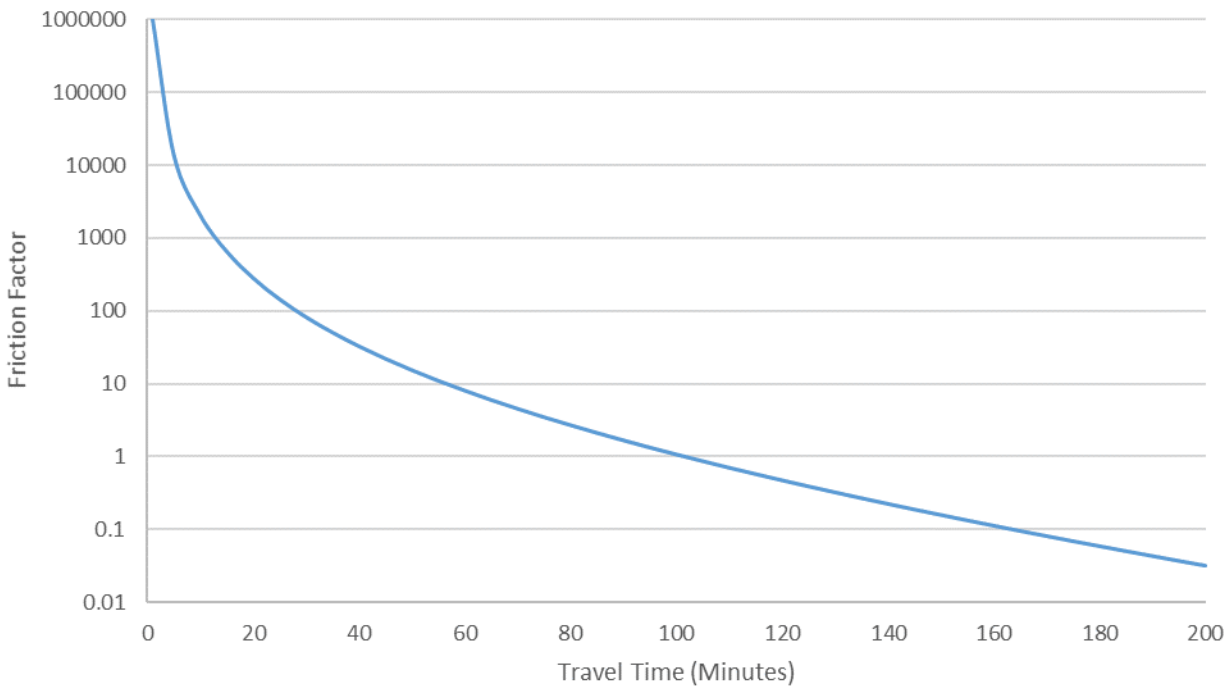
The truck trip distribution model originally calibrated for the DRCOG Compass model was used without modification for StateFocus. The model is a gravity-based trip distribution model that uses a gamma function to determine the friction factors for the distribution:

$$Friction\ Factor_{ij} = a \times time_{ij}^{b} \times exp\left(c \times time_{ij}\right)$$

Where: *Friction Factor*$_{ij}$ is the friction factor used for zone i to zone j
a, b, and c are calibrated parameters equal to 1,017,171, -2.619, and -0.017 for the truck trip distribution model
time$_{ij}$ is the congested travel time between zone i and zone j

The resulting friction factors are plotted against travel time in ***Figure 2.12***.

Figure 2.12 Truck Trip Distribution Friction Factors



Source: DRCOG Compass Model Documentation

Truck Time of Day Factors

Since truck trip attractions are set equal to the truck trip productions for each TAZ in truck trip generation, the trip tables resulting from truck trip distribution are, by definition, in origin-destination format. For the initial StateFocus model, truck factors from the DRCOG Focus model for the AM peak, PM peak, and off-peak periods were used as a starting point for time of day factors. They were then adjusted to match overall volumes of traffic by each of the detailed times of day used by StateFocus. The effective time of day factors for shown in ***Table 2.12*** can be applied to the total daily truck origin to destination trip table.

Table 2.12 Truck Time of Day Factors

Time Period	Designator	Time Period	Percent of Trips
Early Morning Peak	AM1	6:30 AM – 6:59 AM	1.0%
Mid-Morning Peak	AM2	7:00 AM – 7:59 AM	4.0%
Late Morning Peak	AM3	8:00 AM – 8:59 AM	4.0%
Early Afternoon Peak	PM1	3:00 PM – 4:59 PM	14.0%
Mid-Afternoon Peak	PM2	5:00 PM – 5:59 PM	12.0%
Late Afternoon Peak	PM3	6:00 PM – 6:59 PM	5.0%
Late Night	OP1	11:00 PM – 6:29 AM	9.0%
Morning Off-Peak	OP2	9:00 AM – 11:29 AM	15.0%
Midday Off-Peak	OP3	11:30 AM – 2:59 PM	25.0%
Evening	OP4	7:00 PM – 10:59 PM	12.0%

Source: Cambridge Systematics

2.4.2 Internal-External, External-Internal, and External-External Trips

The external auto trip model was developed for base year 2012 as a separate model for input to the StateFocus travel modeling system.[17] The external auto trips were based on national and Big Data sources such as the Traveler Analysis Framework, Census Journey-to-Work, StreetLight and a national-level toll study performed by CDM Smith. Considering the national level data sources, a national level model was developed with a focus on Colorado. Subarea analysis was performed to window out trips for Colorado reflecting the seed origin-destination trip tables. The seed origin-destination trips were adjusted to reflect the 2012 auto count data and validated for reasonable origin-destination movements. The final product was the year 2012 origin-destination vehicle trips for autos split by business and non-business for external-external movements as well as external-internal and internal-external movements for an average weekday. Future year vehicle trips may be estimated using a Fratar process to match forecasts of external-external, external-internal, and internal-external vehicle trips at external stations.

The CDM Smith analysis did not stratify trips by time of day. For the initial StateFocus model, internal-external and external-internal time of day factors from the DRCOG Focus model for the AM peak, PM peak, and off-peak periods were used as a starting point for time of day factors. They were then adjusted to match overall volumes of traffic by each of the detailed times of day used by StateFocus. The effective time of day factors for internal-external, external-internal, and external-external trips are shown in ***Table 2.13***.

[17] See the CDM Smith report, *External Auto Model Documentation 20160511.pdf*.

Table 2.13 Internal-External, External-Internal, and External-External Time of Day Factors

Time Period	Designator	Time Period	Internal-External Trip Percent	External-Internal Trip Percent	External-External Trip Percent
Early Morning Peak	AM1	6:30 AM – 6:59 AM	1.4%	1.1%	1.0%
Mid-Morning Peak	AM2	7:00 AM – 7:59 AM	3.7%	3.0%	4.0%
Late Morning Peak	AM3	8:00 AM – 8:59 AM	2.9%	2.3%	4.0%
Early Afternoon Peak	PM1	3:00 PM – 4:59 PM	6.2%	7.5%	14.0%
Mid-Afternoon Peak	PM2	5:00 PM – 5:59 PM	3.6%	4.3%	12.0%
Late Afternoon Peak	PM3	6:00 PM – 6:59 PM	2.7%	3.2%	5.0%
Late Night	OP1	11:00 PM – 6:29 AM	3.2%	3.1%	9.0%
Morning Off-Peak	OP2	9:00 AM – 11:29 AM	7.2%	7.0%	15.0%
Midday Off-Peak	OP3	11:30 AM – 2:59 PM	13.4%	13.0%	25.0%
Evening	OP4	7:00 PM – 10:59 PM	5.6%	5.4%	12.0%

Source: Cambridge Systematics

2.4.3 Modeling Airport Trips

While the FRTC data included observations of travel to and from Denver International Airport (DIA), too few observations were available to assume that the StateFocus model could reliably model to and from that major destination. Instead, airport trips are modeled to Denver International Airport (DIA) using the DRCOG Focus airport model. The DRCOG airport model was originally developed for their trip-based Compass model. A summary of the model components is provided in the following sections. The airport trip modeling procedure assumes that DIA operates as a special generator for resident air passenger travel and air cargo truck trips.

Air passenger travel and air cargo truck trips originate or are destined to areas outside of the DRCOG region. The StateFocus model applies the DRCOG DIA modeling procedures for all TAZs within the state although the numbers of trips between those areas and DIA are relatively negligible.[18] The StateFocus model forecasts resident travel to and from other airports within Colorado using procedures outlined in ***Section 4.0***. Commercial vehicle trips are modeled to other airports using the procedures outline in ***Section 2.4.1***. Visitor trips to and from DIA and other airports in the state are modeled using procedures outlined in ***Section 2.4.4***.

DIA Trip Generation

Total air passenger trips are calculated from the total population and employment. The home-based non-work (HBNW) resident passenger trip rate is 0.01157 per person. The non-home-based work-related (NHB) passenger trip rate is 0.01392 per employee based on the assumption that they were mainly made by visitors from outside the region. Additional NHB trips representing trips made in taxis, limos, shuttles, pick-

[18] The nuanced implication of this statement is that the entire DRCOG Compass model must be applied for the state even though only the trips to and from DIA are used in StateFocus. While this is somewhat inefficient, it is meant to be a temporary solution until an updated airport model (possibly handling all commercial airports in the state) can be developed. Trips made by visitors to and from DIA are modeled separately (see ***Section 2.4.4***).

ups, and drop-offs are modeled using a rate of 0.00809 trips per employee. The HBNW trips are modeled as person trip attractions at DIA. The NHB person trips are modeled as one-half productions and one-half attractions at DIA. These HBW airport trip attractions at DIA added to those generated from the household- and employment-based rates applied for all zones. HBW trip productions, HBNW trip productions, and NHB trip productions and attractions at non-DIA TAZs are modeled using the familiar Compass/Tripod modeling procedures.

The total number of air passenger trips are scaled to match the greater of the total number of originating enplanements forecast by DIA or the modeled air passenger trips using the above formulae.[19] This way, if the analyst fails to update the originating enplanements for the forecast year, a reasonable estimate will still be provided.

The air cargo trips are calculated from the total population and employment in the DRCOG region using a cargo vehicle trip rate of 0.00156 per person and 0.00270 per employee. The resulting air cargo vehicle trips are counted as one-half commercial vehicle trip productions and one-half commercial vehicle attractions meaning that the resulting trip distribution is, by definition, in origin-destination format.

The special generator (HBNW and NHB) trips at DIA are divided among DIA TAZs as shown in ***Table 2.14***. For the base year (for the Compass model), the special generator trips were calibrated such that the modeled traffic on Peña Boulevard matches traffic counts.

Table 2.14 Division of DIA Special Generator Trips Among DIA TAZs

Location	TAZ	Trip Allocation
Employee Parking	1852	No trips
Overflow Parking	1236	No trips
Runways	1847	No trips
Cargo	1850	All cargo trips
Main Terminal and Parking	1851	67 percent of NHB productions and NHB attractions 75 percent of HNW attractions
Rental Cars	1853	33 percent of NHB productions and NHB attractions
Remote Parking	1854	25 percent of HNW attractions

Source: "Integrated Regional Model – Model Refresh Project, Chapter 11: Final Model State," prepared by the Denver Regional Council of Governments, January 2005, with TAZ numbers updated to reflect StateFocus TAZs.

DIA Trip Distribution

A special procedure is used for the distribution of HNW and NHB to and from DIA. This procedure is necessary because it would be unreasonable to assume that a person's frequency of air travel depends on how close they live to DIA. In reality, it is probably more a function of income than of anything else. The travel times between DIA and all other TAZs for the off-peak highway skim matrices used for trip distribution are modified and given a representative travel time based not upon a direct function of distance, but rather

[19] In the original Compass model, this total was based on the zones in the DRCOG region only. Substantially more trips are forecast using the statewide population. However, in the application of the trip distribution portion of the airport model, TAZs outside of the DRCOG region and 34 TAZs in the NFRMPO region were set to have zero travel times which precluded any travel between those TAZs and DIA.

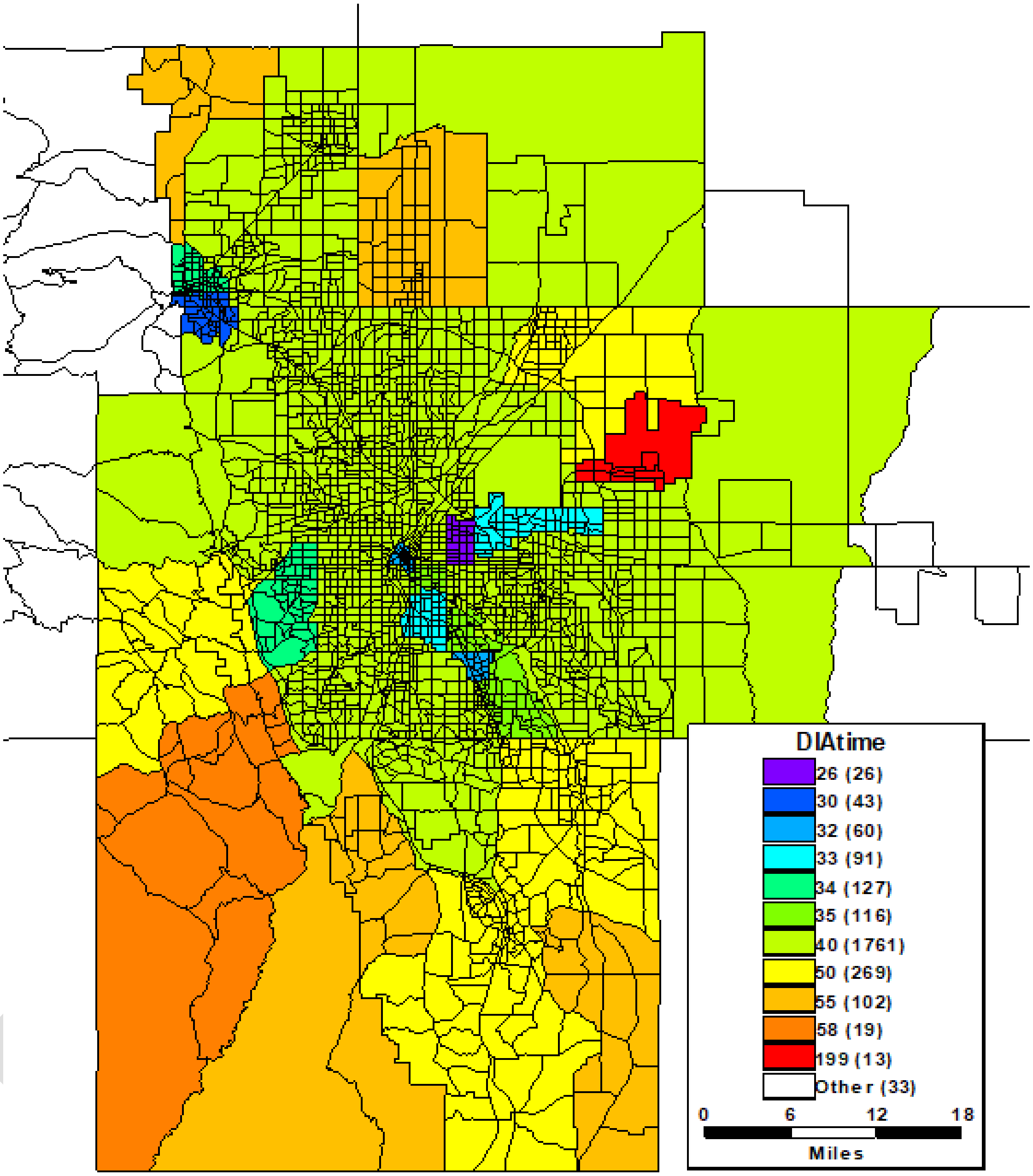
upon the zone's observed distribution of trips to DIA. This process produces results similar to those produced by the K-Factor matrices used for other trip purposes. A map of the representative travel times from TAZs to and from DIA is shown in ***Figure 2.13***. In addition to the DIA interchanges with DRCOG TAZs, interchanges with 34 TAZs in the NFRMPO are are given non-zero pseudo-travel times; interchanges between DIA and all other StateFocus TAZs are given zero travel times. The DRCOG Compass model uses the gravity model with friction factors estimated using a gamma function:

$$f_{ij} = \alpha \times t_{ij}^{\beta} \times \exp(\gamma \times t_{ij})$$

Where: f_{ij} is the friction factor between *i* and *j*
t_{ij} is the travel time between *i* and *j*
$\alpha,\ \beta,\ \gamma$ are calibrated parameters

The gamma function becomes undefined when travel time is zero and β is negative or zero when travel time is zero and β is positive. As a result, no trips will be distributed between non-DIA TAZs and DIA for the interchanges with 0 travel times. The lower the pseudo-travel time shown in ***Figure 2.13***, the higher the probability of someone living or working in that TAZ making a non-work trip to DIA. The psedo-travel times are used only for trip distribution, not for mode choice or any other step.

Figure 2.13 DRCOG Compass/Tripod Model Representative Travel Time to DIA



Note: The representative travel time is based upon observed airport trip-making frequencies. Shorter times (purple and cooler shades) represent more airport trips, while longer times (red and warmer shades) represent less frequent airport trips.

Source: "Integrated Regional Model – Model Refresh Project, Chapter 11: Final Model State," prepared by the Denver Regional Council of Governments, January 2005

DIA Mode Choice

The DRCOG Compass trip mode choice model uses the multinomial logit formulation as given by the following formula:

$$P_i = \frac{exp(U_i)}{\sum_{j=1}^{n} exp(U_j)}$$

Where:

P_i = probability of choosing alternative *i*
U_i = utility of alternative *i*

The utility function epresents the worth of an alternative and is expressed as a linear function of calibrated model coefficients and attributes of the alternative, the decision maker, or the environment in which the choice is made as well as calibrated constants representing the unobserved attributes of the alternative. In the case of logit mode choice models, the alternatives are the modes while the attributes may include attributes of the modes (e.g., travel time), the decision maker (e.g., income group), and the environment (e.g., whether or not the destination is DIA).

The DRCOG mode choice model is applied for HBW, HBNW, and NHB person trips to estimate person trips made by drive alone, shared ride 2, shared ride 3+, walk to transit, and drive to transit.

DIA Trip Time of Day Factors

For the initial StateFocus model, DIA time of day factors from the DRCOG Focus model for the AM peak, PM peak, and off-peak periods were used as a starting point for time of day factors. They were then adjusted to match overall volumes of traffic by each of the detailed times of day used by StateFocus. The effective time of day and direction split factors for all DIA related trip purposes are shown in ***Table 2.15***. The time of day factors are applied to all mode specific trips for each trip purpose.

Table 2.15 Airport Trip Time of Day Factors

			Home-Based Work		Home-Based Non-Work		Non-Home-Based	Truck	Internal-External	
Time Period	**Designator**	**Time Period**	**P→A**	**A→P**	**P→A**	**A→P**	**O→D**	**O→D**	**P→A**	**A→P**
Early Morning Peak	AM1	6:30 AM – 6:59 AM	3.0%	0.5%	0.7%	1.0%	1.7%	2.8%	1.4%	1.1%
Mid-Morning Peak	AM2	7:00 AM – 7:59 AM	8.2%	1.2%	2.0%	2.6%	4.6%	7.5%	3.7%	3.0%
Late Morning Peak	AM3	8:00 AM – 8:59 AM	6.3%	0.9%	1.5%	2.0%	3.5%	5.7%	2.9%	2.3%
Early Afternoon Peak	PM1	3:00 PM – 4:59 PM	1.6%	8.9%	5.9%	5.2%	11.1%	17.4%	6.2%	7.5%
Mid-Afternoon Peak	PM2	5:00 PM – 5:59 PM	0.9%	5.1%	3.4%	3.0%	6.4%	10.1%	3.6%	4.3%
Late Afternoon Peak	PM3	6:00 PM – 6:59 PM	0.7%	3.8%	2.5%	2.2%	4.8%	7.5%	2.7%	3.2%
Late Night	OP1	11:00 PM – 6:29 AM	3.2%	3.2%	3.7%	3.7%	7.4%	5.3%	3.2%	3.1%
Morning Off-Peak	OP2	9:00 AM – 11:29 AM	7.2%	7.3%	8.3%	8.3%	16.7%	12.0%	7.2%	7.0%
Midday Off-Peak	OP3	11:30 AM – 2:59 PM	13.3%	13.5%	15.5%	15.5%	30.9%	22.3%	13.4%	13.0%
Evening	OP4	7:00 PM – 10:59 PM	5.6%	5.7%	6.5%	6.5%	13.0%	9.4%	5.6%	5.4%

Source: Cambridge Systematics

As noted at the beginning of ***Section*** *Error! Reference source not found.*, the results of the trip-based modeling procedures are used to replace all trips to and from DIA zones (see ***Table 2.14***) estimated using the StateFocus modeling procedures described in ***Section 4.0*** prior to traffic and transit assignment.

2.4.4 Visitor Trips

Visitor travel likely makes a significant impact on total travel in Colorado, particularly near tourist destinations like ski resorts. Longwoods International conducts an annual visitor survey for Colorado. In 2015, Longwoods International estimated 77.7 million annual visitors to Colorado, 36 million of which were overnight visitors[20], which suggests an average of 98,630 daily overnight visitors to Colorado. The average party size of Colorado visitors in 2015 was 2.90[21], meaning there was an average of 34,010 visitor groups per day. Since detailed mode use information was not available, the visitor parties were all assumed to travel by car (i.e. with an average auto occupancy of 2.90).[22]

The survey of visitors to Colorado provided some information about those trips. Information that was applicable to estimating travel by out-of-state visitors included the following:

- How they entered Colorado;
- If they entered Colorado by plane, which airport did they use;
- What was their main destination; and
- What places did they visit.

The survey was weighted but not expanded. With no better information, an expansion factor of 22 was applied to the survey data records. The expansion factor was based on the 1,521 weighted records (1 record per travel party) and assumed 34,010 visitor groups per day.

The survey data were filtered to exclude visitors who arrived to Colorado by car (these persons are included in the external travel model for StateFocus) and those who arrived to Colorado by airplane via DIA and whose main destination was in the DRCOG model region (these visitors are included in DRCOG's Compass model for DIA trips adopted for StateFocus). After filtering, 11,508 visitor groups remained for the development of the StateFocus visitor model.

Given the information available, the methodology chosen to model visitor travel included estimating: 1) trips between an airport and a main destination, and 2) local trips originating from the main destination.

To distribute those overnight visitors from an airport to destinations in Colorado, a crosstab of reported arrival airports and main destinations provided distributions, as shown in ***Table 2.16***. While major airports were

[20] https://industry.colorado.com/sites/default/files/Colorado2015VisitorFinalReport_0.pdf

[21] https://www.colorado.com/sites/default/master/files/ColoradoLongwoodsReport2016.pdf

[22] Visitors to the Denver region might be more likely to use transit. Since the airport model described in Section 2.4.3 implicitly includes visitor trips in the trip generation, distribution, and mode choice components. While some visitors to locations outside of the Denver region might use private van services to and from DIA, the amount of use was assumed to be minimal in comparison to travel by rental car.

listed as an option in the survey, a number of visitors reported arriving at airports for which the specific name was not provided. Based on their reported main destination and the number of enplanements for 2015 for airports across the state (to identify frequently used "other" airports), the "other airport" visitor trips were distributed to a likely regional airport. ***Table 2.17*** provides the assumed number of trips by visitors for each airport and the associated TAZ.

As shown in ***Table 2.16***, the main destination options in the survey were provided at a regional level. To assign those airport trips to model TAZs, distributions of likely destinations (within each region reported as a main destination) were derived from a survey question that asked respondents to report the places that they visited. ***Table 2.18*** provides those distributions, which were mapped to a single TAZ in a downtown or likely tourist destination within those local destinations within each region.

Table 2.16 Number of Surveyed Records for Overnight Visitors by Arrival Airport and Main Destination in Colorado

Arrival Airport	**Main Destination in Colorado**						
	Denver Metro Area	Eastern Plains	Mountain Towns and Ski Resorts	Northern Front Range	Pike's Peak Region	San Luis Valley	Western Slope
Denver International Airport	64	1	54	132	57	7	16
Aspen	7	3	7	3	0	0	0
Colorado Springs	4	8	6	2	45	4	9
Durango	4	0	1	0	1	1	14
Eagle/Vail	0	1	8	1	0	0	0
Grand Junction	3	1	3	1	5	0	10
Steamboat Springs	0	0	3	0	0	0	0
Telluride Airport	0	2	0	0	0	0	2
Other Commercial Airports	4	5	16	18	23	4	13
General Aviation (private aircraft/local airports)	12	5	13	16	10	7	3

Source: Cambridge Systematics analysis of Longwoods International data

Table 2.17 Number of Visitor Trips by Arrival Airport

Airport	TAZ	Number of Trips	Airport	TAZ	Number of Trips
Denver International Airport	1851	4,635	Gunnison	5963	178
Aspen	5651	445	Pueblo	5190	224
Colorado Springs	4011	2,483	Lamar	6407	0
Durango	5481	492	Loveland/Fort Collins	3151	760
Eagle/Vail	5628	220	Alamosa	5551	246
Grand Junction	4663	509	Centennial Airport	2290	358
Steamboat Springs	6200	66	Boulder Airport	80	0
Telluride Airport	5759	89	Cortez	5430	45
Montrose	5769	758	**Grand Total**		**11,509**

Source: Cambridge Systematics analysis of Longwoods International data

Table 2.18 Distributions of Destinations within Main Destination Regions

Region	Destinations within Region	Percent	Region	Destinations within Region	Percent	Region	Destinations within Region	Percent
Eastern Plains	Burlington	7%	Mountain Towns and Ski Resorts	Aspen	8%	Pikes Peak	Canon City	10%
	Fort Morgan	0%		Breckenridge	19%		Colorado Springs	64%
	Julesburg	0%		Copper Mountain	3%		Canon City	10%
	La Junta	13%		Crested Butte	4%		**Total[1]**	**100%**
	Lamar	7%		Eldora	0%			
	Pueblo	60%		Frisco	10%	Western Slope	Cortez	13%
	Sterling	7%		Keystone	8%		Delta	3%
	Trinidad	7%		Leadville	3%		Durango	22%
	Total[1]	**100%**		Loveland	2%		Glenwood Springs	4%
				Ouray	0%		Gunnison	5%
North Front Range	Boulder	35%		Silverton	6%		Grand Junction	20%
	Estes Park	20%		Steamboat	11%		Montrose	4%
	Fort Collins	20%		Vail	19%		Ouray	8%
	Greeley	6%		Winter Park	6%		Pagosa Springs	14%
	Longmont	10%		**Total[1]**	**100%**		Telluride	5%
	Loveland	8%	San Luis Valley	Alamosa	75%		**Total[1]**	**100%**
	Total[1]	**100%**		South Fork	25%			
				Total[1]	**100%**			

Source: Cambridge Systematics analysis of Longwoods International data

Note: [1] Values may not sum to 100 percent due to rounding.

To distribute local trips for each main destination, an assumed production of 3.36 trips per visitor travel party was assumed. Given no better information, these trips were distributed to other TAZs based on the distribution of resident trips from that origin TAZ.

The resulting visitor trip table includes trips between airports and a primary destination plus local trips from that primary destination to other local destinations. The resulting visitor trips were split into trips by time of day using the factors shown in ***Table 2.19***. The results of the visitor modeling procedures are added to the results of the StateFocus modeling procedures described in prior to traffic and transit assignment (see ***Section 4.4***).

This methodology is meant to be a placeholder for visitor travel forecasting. An improved model might be transferred from a different state or developed using more detailed data collected from Colorado visitors. The 2015 visitor trip table can be factored up for future year scenarios based on expected growth rates in population and, possibly, entertainment and service employment.

Table 2.19 Visitor Trip Time of Day Factors

Time Period	Designator	Time Period	Trip Percent
Early Morning Peak	AM1	6:30 AM – 6:59 AM	3.1%
Mid-Morning Peak	AM2	7:00 AM – 7:59 AM	9.2%
Late Morning Peak	AM3	8:00 AM – 8:59 AM	8.0%
Early Afternoon Peak	PM1	3:00 PM – 4:59 PM	16.4%
Mid-Afternoon Peak	PM2	5:00 PM – 5:59 PM	9.6%
Late Afternoon Peak	PM3	6:00 PM – 6:59 PM	5.8%
Late Night	OP1	11:00 PM – 6:29 AM	9.3%
Morning Off-Peak	OP2	9:00 AM – 11:29 AM	13.0%
Midday Off-Peak	OP3	11:30 AM – 2:59 PM	15.9%
Evening	OP4	7:00 PM – 10:59 PM	9.7%

Source: Cambridge Systematics

2.5 Highway Assignment Procedures

2.5.1 Multi-Modal Multi-Class Assignment Procedure

The StateFocus model performs traffic assignments of vehicle trips to the highway network for ten times of day (see ***Table 2.1***). Each time of day assignment process first assigns heavy trucks using an all-or-nothing assignment (AON) procedure followed by an assignment of single occupant vehicles (SOV), two-person vehicles (SR2), three or more person vehicles (SR3+), and light commercial vehicles using TransCAD's Multi-Modal Multi-Class (MMA) assignment procedure.

The heavy trucks are assumed to be 30 percent of the total trucks generated using the truck model (see ***Section 2.4.1***). The heavy trucks are assigned assuming free-flow speeds on the network. In the MMA assignment of personal use vehicles and light commercial vehicles, the pre-loaded heavy trucks are included as fixed volumes on network link with each truck contributing an equivalent of 3.0 passenger cars in volume-delay calculations. The 70 percent of the trucks assumed to be light commercial vehicles each have a passenger car equivalency (PCE) of 1.0. That is, for purposes of the State-Wide Model, light commercial vehicles (such as taxis, restaurant delivery vehicles, plumbing or HVAC service vehicles, or police cars) are not distinguishable from passenger vehicles; the same makes and models are used for both personal and commercial purposes.

MMA uses an origin user-equilibrium (OUE) algorithm that considers:

- Different network links available for use by different vehicle types (i.e., single occupant vehicles, two person vehicles, and three or person vehicles),
- Different passenger car equivalency factors for personal use vehicles and commercial vehicles when determining the vehicles' impacts on link travel times, and
- Different costs per mile of travel for the different vehicle types.

Shortest paths for both the AON and MMA assignments are calculated using a generalized cost for each link on the path where the generalized cost is calculated as:

$$Generalized\ Cost = VOT_{Class} \times Time + (OpCost_{Class} + Toll_{Class}) \times Length$$

Where: *Generalized Cost* is the link cost in 2010 dollars

VOT_{Class} is the value of time by class of vehicle in 2010 dollars:

$0.4164 per minute for personal use vehicles

$1.2492 per minute for trucks

Time is the link travel time in minutes which varies based on the link volume from the previous iteration and the volume-delay function used for the link

$OpCost_{Class}$ is the operating cost by class of vehicle in 2010 dollars:

$0.2776 per mile (all vehicle classes)

$Toll_{Class}$ is the toll cost per mile by class of vehicle and time of day for toll links in 2010 dollars, Default toll rates are shown below if link-specific rates are not coded:

Vehicle Class	Peak Toll per Mile	Off-Peak Toll per Mile
Single occupant vehicles	$0.51356	$0.11798
Two person vehicles	$0.51356	$0.11798
Three or more person vehicles	$0.00000	$0.00000
Light trucks	$0.51356	$0.11798
Heavy trucks	$0.51356	$0.11798

Length is the link length in miles

The *VOT_{Class}*, *OpCost*, and *$Toll_{Class}$* parameters are input parameters used for StateFocus model calibration and validation. They may be changed as warranted for future model runs (e.g., if toll policies or operating costs of vehicles change) but caution should be used.

The MMA procedure uses a BPR-type volume-delay function to determine the link travel time for each iteration of the equilibrium assignment process:

$$Time_i = FW\left(Time_{i-10} \times \left[1 + \alpha \times \left(\frac{Volume_i}{Capacity}\right)^{\beta}\right]\right) + (1 - FW) \times Time_{i-1}$$

where: *Time$_i$* is the link travel time for iteration *i*

Time$_0$ is the link free-flow travel time

Time$_{i-1}$ is the link travel time for the previous iteration i-*1*

FW is a factor between 0 and 1 calculated by the N-Conjugate Frank-Wolfe algorithm to smooth travel time fluxuations that may occur between iterations of the assignment algorithm

Volume$_i$ is the assigned link volume for the iteration *i*

Capacity is the link capacity (see Table A.4)

α and *β* are factors that vary by facility type and area type (see ***Table A.5***)

2.5.2 3-D Free-Flow Speeds

Link free-flow speeds are used in the estimation of average travel time, including intersection delay, needed to traverse a network link with little or no traffic (i.e., no congestion effects). In the MMA traffic assignment process, free-flow speeds are used to calculate link travel times for the initial iteration of the OUE assignment process. These speeds are generally similar to the speed limit and are calculated as a function of link facility type and area type. Free-flow speeds are typically lower than speed limits on arterials, collectors, and ramps to account for intersection delay; free-flow speeds often exceed speed limits on freeways and expressways due to the tendency of many drivers to drive five to ten miles per hour over the posted speed limit.

The model's free-flow speeds are based on the results of a previous analysis of free-flow speeds in the Denver area.[23] As part of that effort, a detailed analysis of the DRCOG Focus model traffic assignment results in the project study area was performed. Initial comparisons to observed counts indicate the model was under-predicting travel demand not only on East Colfax Avenue but also on many of the parallel facilities. Subsequently, speed data from the Colorado Department of Transportation (CDOT) Speed Study were processed and a revised free-flow speed table was developed, stratified by facility type, area type, and posted speed limit. Finally, the traffic assignment procedures were then tested with these new 3-D free-flow speeds and compared with the 2-D free-flow speeds run. The results were evaluated and compared to reported travel time data from the Front Range Travel Counts (FRTC) and the CDOT Speed Study. The results of the analysis showed that the 3-D free-flow speeds resulted in interchange specific congested travel times that more closely reproduced reported travel times. ***Table A.6*** shows the 3-D free-flow speed lookup table implemented in the CDOT Statewide Model.

2.5.3 Convergence Criteria

User equilibrium is an interative procedure where the travel time on each link is updated based on the traffic volume assigned to the link on the previous iteration. When the user equilibrium converges, no vehicle can improve its travel time between its origin and destination by unilaterally changing its path. In practice, it is not practical to iterate to total equilibrium. The equilibrium assignment procedure in TransCAD uses a calculation that compares the "relative gap" between the current assignment and the equilibrium solution:

$$Relative\ Gap = \frac{\sum_{l=1}^{Links}\left(Vol_l^{UE_i} \times Time_l^i\right) - \sum_{l=1}^{Links}\left(Vol_l^{AON_i} \times Time_l^i\right)}{\sum_{l=1}^{Links}\left(Vol_l^{UE_i} \times Time_l^i\right)}$$

where: $Vol_l^{UE_i}$ is the user equilibrium volume on link l for iteration i

$Time_l^i$ is the user equilibrium time on link l for iteration i

[23] The work was performed in 2012 under subcontract for the City and County of Denver, RTD, and DRCOG by Cambridge Systematics as part of the East Colfax Corridor Alternatives Analysis–Model Assessment.

$Vol_l^{AON_i}$ is the volume on link l for iteration i using all-or-nothing assignment procedures

The model uses a relative gap convergence criteria of 0.0001 for each assignment period with a maximum of 100 iterations if the convergence criteria have not been met. They may be changed for future model runs. Caution should be used if the values are made less restrictive since the further away from an equilibrium solution, the more likely a small change on one link for an alternative will have an outsized impact on links far from the change. The major impact of making the values more restrictive will be an increase in model run times.

2.6 Transit Assignment Procedures

Transit assignment procedures are somewhat simpler than highway assignment procedures since they are not capacity constrained. For this reason, the four sets of time of day paths generated in the transit path-building step can be saved and used for the assignment of transit trips. Four time of day transit trip tables in origin-destination format are created from the results of the trip mode choice (see ***Section 4.2.18***) and trip time of day choice models (see ***Section 4.2.19***) as described in the procedures for creating time of day trip tables for trip assignment (see ***Section 4.4.2***). Airport trips by transit are added to transit trips modeled by the ABM.

2.7 Travel Time Convergence Feedback Procedures

The State-Wide Model includes functionality to perform "speed feedback" iterations to achieve consistency between the travel times assumed for generating the travel time matrices used by most model components, and the travel times resulting from the most recent traffic assignment. If a previous iteration or model run is available, those travel times are assumed at the beginning of a successive iteration. If no such travel times are available (for instance, of a new link added as part of a project scenario), default values are provided by lookup tables. Typically, five speed feedback iterations are sufficient to reach consistency between input and output travel times.

3.0 Model Estimation Data Preparation

3.1 Data Groupings

3.1.1 Household Income Groups

Incomes for the StateFocus model are expressed in 2010 dollars. While PopGen2 posts actual household incomes from the 2010 PUMS data on the synthesized household data, the choice models use income aggregated into groups based on the income groupings from the 2010 FRTC survey. The original intent was to use the five "standard" income groups for all choice models, but maintaining consistency with the DRCOG Focus model dictated the use of the parking cost groupings. The work tour type groupings resulted from an overlooked grouping in the SQL Server code used to summarize the model estimation data. ***Table 3.1*** shows the various income groupings used within the models.

Table 3.1 Household Income Groupings Used for Choice Models

Group Number	2010 FRTC Income Range (2010 $)	Standard Income Groups for Choice Models	Income Groupings Affected by Parking Cost	Income Groupings for Work Tour Type Choice Model
1	$0 - $14,999	Lower Income	Lower Income	Lower Income
2	$15,000 - $19,999	Lower Income	Lower Income	Lower Income
3	$20,000 - $29,999	Lower Income	Lower Income	Lower Income
4	$30,000 - $39,999	Modest Income	Lower Income	Lower Income
5	$40,000 - $49,999	Modest Income	Middle Income	Lower Income
6	$50,000 - $59,999	Modest Income	Middle Income	Middle Income
7	$60,000 - $74,999	Middle Income	Middle Income	Middle Income
8	$75,000 - $99,999	Middle Income	Middle Income	Middle Income
9	$100,000 - $134,999	Upper Income	High Income	Middle Income
10	$135,000 - $149,999	Upper Income	High Income	High Income
11	$150,000 or More	Top Income	High Income	High Income
99	Refused	Missing Income	Missing Income	Missing Income

Source: Cambridge Systematics

3.1.2 Person Types

Different population groups, even within households, have vastly different activity and travel characteristics. StateFocus uses a person type classification to distinguish among workers and non-workers; children and adults; and, students and non-students. The cascading logic used to identify eight unique person types is shown in ***Table 3.2***. For model estimation, the person types had to be classified using information collected in the FRTC. For model application, the person types must be classified using information generated by PopGen2 which is based on 2008-2012 ACS data (this classification is performed within the C# code used to implement StateFocus).

Table 3.2 Person Type Classification Procedures

Cascading logic	Person Type	Definition	FRTC Logic / Variables[1]	ACS Logic / Variables for Consistency with PopGen2[2]	Notes
IF person is age 0-4	=8	pre-school child	AGE<=4	AGEP<=4	
ELSE IF person is age 5-15	=7	pre-driving age student	AGE<=15	AGEP<=15	
ELSE IF the person is a full-time student, age 16-24, in grade K-12	=6	driving age student	AGE<=24 and SCHOL<=4	AGEP<=24 and SCHG <= 14	
ELSE IF the person is a full time worker	=1	full time worker	EMPLY=1 and HOURS>= 35 and HOURS<998	WKHP >= 35 and WKHP < 98	For consistency with ACS (which includes only those working for salary, wages, or commission), EMPLY = 1 includes only employed persons, not volunteers; ACS has no way to identify volunteers.
ELSE IF the person is a full time student, age 16+, grade post-K-12	=5	university student	AGE>=16 and SCHOL>=5 and SCHOL<=8 and STUDE=1	AGEP>=16 and AGEP<100 and SCHG > 14 and WKHP = 0	ACS will be an approximation of full-time students since it's based on whether or not the person specified non-zero (non-blank) work hours. In effect, it will trap both full- and part-time students at this point.
ELSE IF the person is a part time worker	=2	part time worker	EMPLY =1 and HOURS<35	WKHP>=1 and WKHP < 35	For consistency with ACS (which includes only those working for salary, wages, or commission), EMPLY = 1 includes only employed persons, not volunteers; ACS has no way to identify volunteers.
ELSE IF the person is a part-time, non-working student	=5	university student	AGE>=16 and SCHOL>=5 and SCHOL<=8 and STUDE=2	AGEP>=16 and AGEP<100 and SCHG > 14	
ELSE IF the person is age [SSRetAge]	=3	non-worker age [SSRetAge]	AGEB=2 and AGE>=[SSRetAge]	AGEP >= [SSRetAge]	No actual change since 65 has been used as SSRetAge for the estimation dataset. This impacts only future year PopGen2 datasets if a different retirement age is tested.
ELSE…	=4	other non-worker	–	–	

Source: Cambridge Systematics

Notes: [1] See DRCOG's Front Range Travel Counts Data Dictionary for codes.

[2] See American Community Survey Data Dictionary for codes.

3.1.3 Residents in Group Quarters

The FRTC did not include surveys of residents in group quarters. Nevertheless, PopGen2 and the StateFocus model explicitly include residents in group quarters to more completely account for travel within the state. Population in group quarters are identified separately from population in households in PopGen2. In StateFocus, population in group quarters are modeled as one-person households. Note that incarcerated persons are not (and should not be) considered group quarters residents since they are not free to travel.

3.1.4 Person Age Groups

Age was collected as a integer variable in the FRTC (0-98 with 99 representing "Refused") and is posted as an integer variable on the PopGen2 population synthesis data. As noted in ***Table 3.2***, a person's age is an important variable in determining person type. Different age groups have been used in some StateFocus model components (see, for example, ***Section 4.2.6***). When different age groupings are used, they are determined within the C# model implementation code.

3.2 Activity and Tour Types

The StateFocus model forecasts out-of-home activities performed by residents of the state including work, school, escorting others, personal business such as doctor visits or banking, shopping, eating meals, and social/recreation such as visiting friends or attending a hockey game. In-home activities are not forecast.

3.2.1 Tours, Stops, and Trips

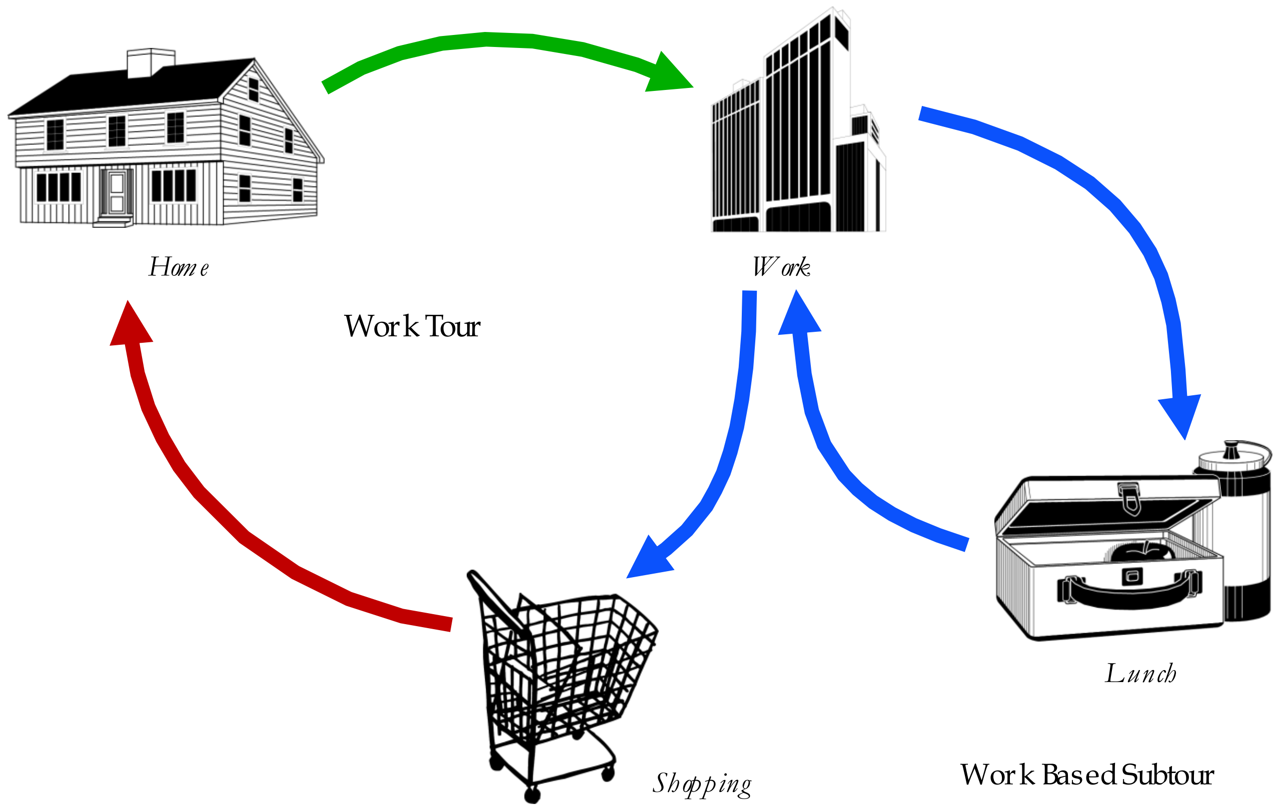
Out-of-home activities are performed on "tours." A tour is defined by travel from home to perform an activity, performance of the activity, and return travel to the person's home. Each tour is made up of two half-tours: the outbound (from home) tour and the inbound (to-home) tour. Home-based tours are defined by the main activity performed at the tour destination:

- Home-based work
- Home-based school
- Home-based escort
- Home-based personal business
- Home-based shopping
- Home-based meal
- Home-based social-recreation

Tours may also be made from a person's work location; these tours are designated work-based sub-tours regardless of the actual activity performed at the tour destination.

People often perform multiple activities on a home-based tour. Stops may be made on the outbound or inbound half-tour. Travel between each location where a stop or activity takes place forms a trip. ***Figure 3.1*** provides an example of tours and stops. In the example, one home-based work tour is represented with no stops on the outbound half-tour and one shopping stop on the inbound half-tour. The person also made one work-based sub-tour for a meal. In total, the person generated five trips on their home-based tour and work-based sub-tour to perform three activities: work, meal, and shopping.

Figure 3.1 Example of Tours and Stops



Source: Cambridge Systematics.

3.2.2 Modeled Tour Distances

Some travel models have used a specified breakpoint to stratify tours or trips into short and long distance travel. Typically, a breakpoint such as 50 or 100 miles from the home location is used based on the observation that travel to locations less than the specified breakpoint to perform activities occurs much more frequently and regularly that travel to locations greater than the specified breakpoint. Separate models are then estimated for short and long distance travel.

Arbitrary breakpoints have not been used in the StateFocus model. Rather, all activities and tours are modeled in each of the StateFocus model components. ***Table 3.3*** shows the percentages of tours for different distance ranges from the home or work locations to the tour activity locations summarized from the FRTC data (expanded to represent all tours made by Front Range residents). While the percentages of tours by purpose that are made to locations 50 or more miles from the home or work location is small (no more than two percent), such tours can add a substantial amount of vehicle-miles of travel to the roadway system because of their length. In addition, there is an increasing amount of travel greater than 50 miles between the Front Range MPOs.

Table 3.3 Percentage of Tours by FRTC Residents by Distance from Home or Work Locations

Distance Range (in Miles)	Home-Based Work	Home-Based School	Home-Based Escort	Home-Based Personal Business	Home-Based Shopping	Home-Based Meal	Home-Based Social-Recreation	Work-Based Sub-Tour
0 – 9.9	57.2%	83.2%	90.7%	80.6%	91.3%	85.9%	79.1%	87.3%
10 – 19.9	27.6%	11.5%	6.5%	12.9%	6.1%	10.6%	14.0%	8.2%
20 – 29.9	9.9%	3.6%	1.4%	3.6%	1.8%	1.8%	3.5%	2.4%
30 – 39.9	3.3%	0.9%	0.5%	1.4%	0.5%	1.1%	1.3%	0.7%
40 – 49.9	0.9%	0.4%	0.3%	0.4%	0.2%	0.5%	0.5%	0.5%
50 or more	1.2%	0.5%	0.6%	1.1%	0.1%	0.1%	1.7%	0.8%

Source: Cambridge Systematics.

3.2.3 Closed and Non-Closed Tours

The FRTC survey collected activity and tour information from each survey participant for a specified travel day defined as 3:00 AM on the travel day to 2:59 AM the following day. Tours are defined as being "closed" from the standpoint that they begin and end at the home location (or work location for work-based sub-tours). Of course, since some people are not at home at 3:00 AM, the concept of "non-closed" tours has been developed to fully account for their travel and activities.

In brief, a non-closed tour has been defined as a half-tour that begins or ends the day (3:00 AM) at a non-home location. Originally, the characteristics of these tours were investigated to see if they could serve as a "replacement" for the 50-mile definition frequently used for long distance travel. However, summaries of non-closed tours from the FRTC indicated a substantial number to locations less than 50 miles from a person's home.

In the original DRCOG Focus model, non-closed tours were dropped from the modeling process. Other approaches have been used elsewhere. For example, one option used in Houston was to artificially close these tours and assign the time period of travel as either the first or last period of the day. Neither of these approaches seemed reasonable for the StateFocus model since (1) there is a substantial number of non-closed tours and (2) some of the tours are to distant destinations effectively precluding travel in both directions during a day.

Table 3.4 summarizes the expanded numbers of FRTC residents making non-closed by straight-line distance from the home location by number of closed tours made by the residents. About 85 percent of the non-closed tours were made to locations less than 50 miles from the home and about 40 percent of the non-closed tours were made by people also making closed tours during the day regardless of the distance from the travelers' homes.

Table 3.4 Expanded Numbers of Persons with Non-Closed Tours from FRTC

Straight Line Distance from Person's Home (in Miles)	Number of Persons Making Non-Closed Tours by Number of Closed Tours Made During the Day				
	None	1	2	3 or more	Total
0 – 24.99	77,151	34,974	12,839	2,864	127,827
25 – 49.99	5,433	3,177	712	225	9,548
50 – 74.99	3,592	3,793	1,037	306	8,728
75 – 99.99	1,078	428	96	42	1,643
100 – 149.99	1,235	710	192	0	2,137
150 – 199.99	380	86	0	0	467
200 – 299.99	622	2,030	163	0	2,816
300 or more	8,267	824	200	0	9,291
Total	97,759	46,023	15,239	3,437	162,457

Source: Cambridge Systematics.

Further analyses of the FRTC data showed:

- About 15 percent of the total non-closed tours were made to the same location at the beginning and ending of the travel day and over 99 percent of those matching non-closed tours were to locations less than 50 miles from the travelers' homes. These non-closed tours were probably tours made on a regular basis such as those made by residents who work a night shift. Matching non-closed tours were considered to be non-traditional closed tours and modeled as closed tours.

- A small number of residents who made non-closed tours at both the beginning and end of their travel day made the two non-closed tours to different locations.

- About 80 percent of the non-closed tours seemed to be "periodic" tours in that they were made only at the beginning or end of the travel day. The majority of non-closed tours to or from locations 50 or more miles from the traveler's home were of this type. About 60 percent of the residents making these non-closed tours did not make any other tours on the travel day.

Based on the analysis of the FRTC data, two special types of tours were added to the modeled tour types:

- Work non-closed tours, and

- Non-work, non-closed tours.

3.3 Network and Skim Preparation and Verification

3.3.1 Highway Skims

Substantial work was performed to develop the highway networks and the resulting skimmed travel times to verify that they reasonably matched reported travel times from the FRTC survey.[24] The resuting skims were used for model estimation.

Terminal Time

Auto terminal times, or the time to get from the origin to an auto or from where the auto is parked to the actual destination were determined as part of the development of highway skims for model estimation. Auto terminal times vary by origin and destination area type as shown in ***Table 3.5***.

Table 3.5 Auto Terminal Times

Area Type	Origin Terminal Time (Minutes)	Destination Terminal Time (Minutes)
CBD	3	6
Fringe	2	4
Urban	1	2
Suburban	1	1
Rural	1	1

Source: Cambridge Systematics.

Intrazonal Travel Time

Zone sizes vary greatly in the StateFocus zone structure. For this reason, procedures to estimate intrazonal times were developed using data from the FRTC. Intrazonal travel distances will continue to be estimated according to the practice used for the DRCOG Focus model:

$$IntraDist = 0.5 \times \sqrt{Area}$$

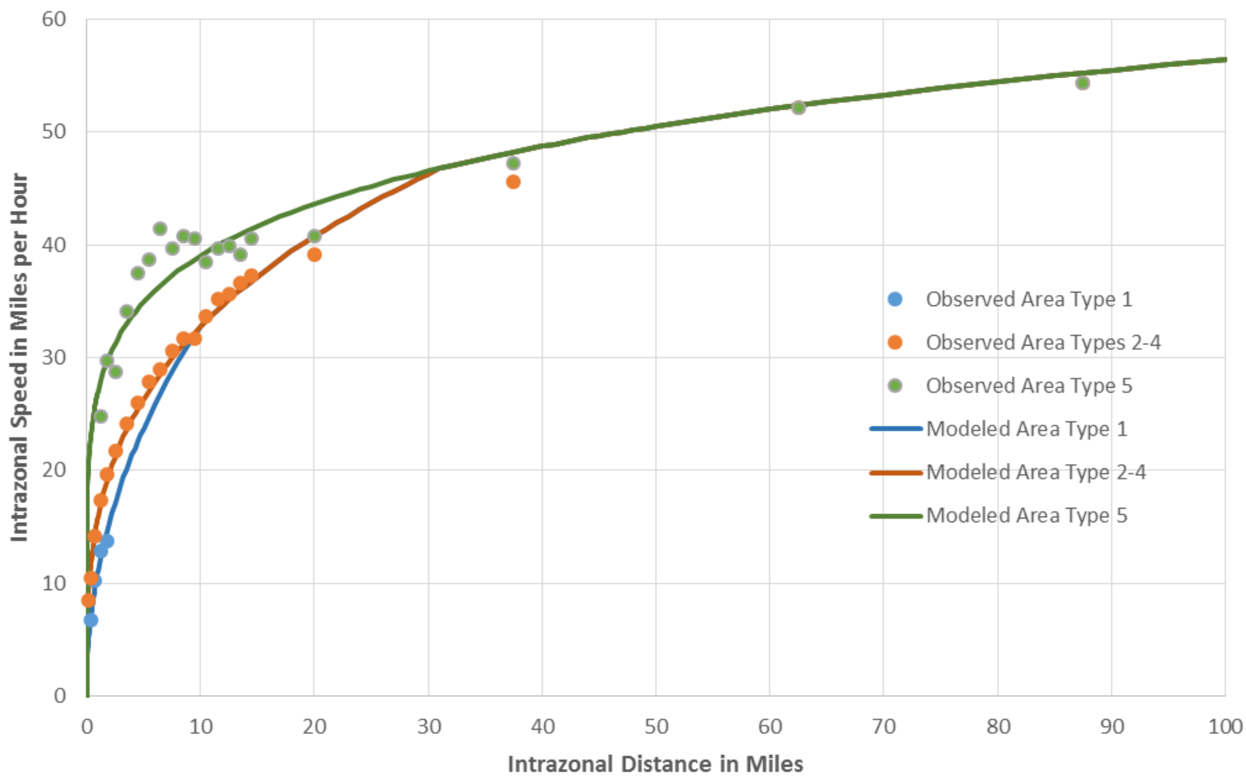
Where: *IntraDist* is the average intrazonal travel distance in miles
Area is the area of the TAZ in square miles

Equations for intrazonal travel times as a function of distance were developed from the adjusted interchange travel speeds developed from the comparison of skimmed travel times to reported travel times documented previously in this section. Information for trips made by auto drivers from the FRTC were used. Too few observations of intrazonal speeds by distance and by area type were available in the FRTC data. To address this issue, interchanges where the destination area type matched the origin area type were used for the analysis. Further, due to the variation in travel speeds, averages of speeds in the various distance

[24] See memorandum to Erik Sabina and Shahida Mirza from David Kurth and Aayush Thakur dated January 7, 2016, "*Travel Time Comparison and Adjustment_Revised.docx*."

ranges were developed to "average out the error." ***Figure 3.2*** shows the resulting observed data and models.

Figure 3.2 Intrazonal Speed by Distance and Area Type



Source: Cambridge Systematics.

Equations for intrazonal speeds by area type are as follows:

Area Type 1: $IntraSpeed = \min(11.5 \times IntraDist^{0.47}, Area\ Type\ 2-4\ IntraSpeed)$

Area Type 2-4: $IntraSpeed = \min(15.9 \times IntraDist^{0.314}, Area\ Type\ 5\ IntraSpeed)$

Area Type 5: $IntraSpeed = \min(27.0 \times IntraDist^{0.16}, 65)$

Where: *IntraSpeed* is the intrazonal speed in miles per hour
IntraDist is the intrazonal distance in miles

Once intrazonal distances and speeds have been estimated, they are used to calculate intrazonal travel times. Intrazonal travel times in hours are, of course, converted to times in minutes for consistency with interzonal travel time reporting.

3.3.2 Transit Skims

Similar to the highway skim preparation for model estimation, transit walk and drive networks and the resulting skimmed travel times were checked to ensure that they reasonably matched reported travel times from the FRTC survey.[25] Two factors impacted the verification:

- bus travel times in the transit skims are based, in part, on highway travel times on links traversed by the buses, and
- there were relatively few observations of trips made by transit in the FRTC data and the variation in the reported travel times for interchanges was substantial.

3.3.3 Walk and Bicycle Skims

Walk and bicycle skims used for model estimation were also checked against reported walk and bicycle travel times from the FRTC survey.[26] Unlike the transit skims, walk and bicycle skims are unaffected by highway travel times on links. In addition, the numbers of observations of trips made by walk and bicycle were substantially greater than the transit observations and showed less variation in reported travel times for interchanges.

3.3.4 Representing Travel Costs

StateFocus activity-based model components were estimated using 2010 data. Travel costs represented to StateFocus must be consistent with the costs used to estimate the travel models[27].

There are two components to this issue:

- representing the appropriate costs for the forecast year, and
- representing the costs to the model in constant, “base year dollars.”

An example to emphasize the second point is that 2045 travel costs should be represented in 2010 dollars (2010$).

The StateFocus model components were estimated using 2010 travel costs represented in 2010$. Travel skims and costs were developed using DRCOG Focus information which represented 2010 travel costs in 1996$. Within the model estimation files, the costs in 1996$ were converted to 2010$ based on the ratio of the 2010 Consumer Price Index (CPI) for the Denver region to the 1996 CPI, 1.388.

For the DRCOG region, the travel related costs included:

[25] See “*4 period Walk Access Transit histograms for FRTC – 04112016.docx*” and “*4 period Drive Access Transit histograms for FRTC – 04112016.docx.*”

[26] See “*Walk histograms for FRTC - revised walk speed (0.66 of original) - 04132016.docx*” and “*Bike histograms for FRTC - revised bike speed (0.66 of original) -04132016.docx.*”

[27] The overall model still includes several of the original DRCOG Compass model components (see ***Section 2.3***) that require information to be presented in 1996$.

- Auto operating cost per mile,
- Toll costs,
- Parking costs, and
- Transit fares.

Auto operating cost is an input parameter for the TransCAD transit path skimming process and can be easily adjusted through the control file. Toll costs are network specific and, thus, must be updated in the networks. Transit fares are typically specified via look-up tables but may also have network specific coding. Parking costs are zonal specific and must be updated in the input zonal files.

For the 2010 model calibration, the auto operating cost for 2010 was $0.2776 per mile in 2010$ (corresponds to $0.20 per mile in 1996$ for comparison to the DRCOG Focus procedures). The auto operating cost is a global parameter applied to travel (link) distance so no checking is necessary. Toll costs, parking costs, and transit fares coded on the network and in the zonal file in 1996$ were simply factored by 1.388 to update them to 2010$. Parking costs and transit fares outside of the DRCOG area were checked to verify that they were 2010 costs coded in 2010$. E-470 was the only facility in the state with toll costs in 2010, so no checking outside of the DRCOG area was necessary.

Table 3.6 below lists all of the places in the model that refer to costs and the fields that were changed, where applicable, to reflect 2010$. ***Table 3.7*** provides a list of all the parameters used in TransCAD processing steps (editable in the Scenario Manager or the DefaultScenario.ini file).

Table 3.6 Model Input Files with Costs

Model Input	File	Fields
Roadway Network	Input\TransCAD\Network\ CDOT_Network_2010.dbd	TollCost, TollCost_HOV, TollCost_Pk, TollCost_OP, TollCost_HOV2_PK, TollCost_HOV2_OP, TollCost_HOV3_PK, TollCost_HOV3_OP
Transit Network	Input\TransCAD\Network\ FARETABLE.bin	All fields
Shadow Pricing	Input\TransCAD\Network\ ShadowPrice.bin	No change since shadow prices are given in minutes
Parking Costs	Input\TransCAD\TAZ\ DTD_zone6480.bin	PkgCost_LI, PkgCost_MI, PkgCost_HI, PkgCost_Short
	Input\Focus\ DTD_zone6480.bin	
	Input\TransCAD\TAZ\ ZonalData_DTD.csv	PkgCost_LI, PkgCost_MI, PkgCost_HI, PkgCost_Short

Source: Cambridge Systematics

Table 3.7 Model Parameters with 2010 Costs

TransCAD Step	TransCAD Parameter	1996$ (DRCOG Assumptions)	2010$ (CDOT Assumptions)
INI	PK_VOT	0.3	0.4164
	OP_VOT	0.3	0.4164
	PK_TRKVOT	0.9	1.2492
	OP_TRKVOT	0.9	1.2492
	PK_SOV_Toll	0.37	0.51356
	OpCost_GP	0.2	0.2776
	OpCost_Manag	0.12	0.2776
	OpCost_Intra	0.15	0.2082
	OP_SOV_Toll	0.085	0.11798
	Year_OP_HOV2_Toll	2025	2025
	PK_HOV2_Toll	0.37	0.51356
	PK_HOV2_Toll_Escl	0	0
	Year_OP_HOV2_Toll	2025	2025
	OP_HOV2_Toll	0.085	0.11798
	OP_HOV2_Toll_Escl	0	0
	Year_OP_HOV3_Toll	2049	2049
	PK_HOV3_Toll	0	0
	PK_HOV3_Toll_Escl	0	0
	Year_OP_HOV3_Toll	2059	2059
	OP_HOV3_Toll	0	0
	OP_HOV3_Toll_Escl	0	0
SKM	VOT_PK	0.3	0.4164
	VOImp_PK	0.3	0.4164
	VOT_OP	0.3	0.4164
	VOImp_OP	0.3	0.4164

Source: Cambridge Systematics

3.4 Zonal Data

3.4.1 Area Type

The five standard area types used in most of the MPOs in Colorado have been used for StateFocus: CBD, CBD Fringe, Urban, Suburban, Rural. Each MPO's designations of area type were used for the StateFocus TAZs. In areas outside of MPOs, CDOT staff assigned area types based on comparison of the development in the non-MPO TAZs to development in MPO TAZs. ***Table 3.8*** summarizes the numbers of TAZs by area type for each MPO and the non-MPO area.

Table 3.8 Number of TAZs by Area Type by Region

Region	CBD	CBD Fringe	Urban	Suburban	Rural	Total
NFRMPO	0	21	164	399	446	**1,030**
DRCOG	141	253	1,007	841	556	**2,798**
PPACG	0	66	231	290	199	**786**
PACOG	0	11	38	116	41	**206**
GVMPO	0	16	91	225	197	**529**
Non-MPO	0	0	57	365	669	**1,091**
Total	**141**	**367**	**1,588**	**2,236**	**2,108**	**6,440**

Source: Cambridge Systematics.

3.4.2 Mountain / Non-Mountain

During the estimation of the tour primary destination choice model (see ***Section 4.2.11***, ***Tour Destination Zone Variables***), it was discovered that stratifying the TAZs by mountainous and non-mountainous areas improved the model estimation. At the outset of the tour destination choice model estimation, TAZs had not been characterized as mountain or non-mountain so all TAZs with centroids west of longitude -105.3 E were considered mountain TAZs. Subsequently, 1,595 TAZs were marked as “Mountain” in the zonal data file (see “PlainMountain” in ***Appendix C***). ***Figure 4.27*** graphically illustrates the mountains and plains regions. Note that some of the plains regions extend into the mountains due to the topography of the Front Range coupled with some large, irregularly shaped TAZs.

3.4.3 Ski Areas

Ski areas are major attractors of home-based social/recreation tours. The number of acres of each ski area has been used as a variable in the tour primary location choice model (see ***Section 4.2.11***, ***Quantitative (Size) Variables***). CDOT staff identified the Colorado ski areas in 2010 and measured the number of acres of ski area for each. If new ski areas are developed or skiable areas for existing ski areas change in the future, the updated information should be input to the model.

Table 3.9 lists each ski area in Colorado along with the associated TAZ and the number of acres of ski area.

Table 3.9 Ski Areas in Colorado

Ski Area	TAZ	Ski Area Acres
Arapahoe-Basin/Keystone	5950	4,108
Aspen-Highlands	6002	1,028
Aspen-Mountain	5656	675
Breckenridge	6078	2,908
Buttermilk Snowmass	5608	3,602
Copper Mountain	5988	2,465
Crested Butte	5604	1,547
Echo	2631	226
Eldora	10	680
Howelsen	5674	50
Loveland	2632	1,670
Monarch	5962	800
Powderhorn	4984	1,600
Purgatory	5490	1,360
Silverton	5375	1,819
Ski Granby Ranch	6178	406
Ski Cooper	5662	400
Steamboat	6202	2,965
Sunlight	5877	470
Telluride	5764	2,000
Vail	5992	5,289
Winter Park	5990	3,081
Wolf Creek	5355	1,600

4.0 StateFocus Activity-Based Model Descriptions

The StateFocus model is based on the DRCOG Focus model. ***Figure 4.1*** shows the program flow for the StateFocus activity-based model components. In addition to extending the modeling area to cover the entire state, the individual model components were re-estimated using the 2010 FRTC data and adjustments were made to account for long distance and overnight (non-closed) travel. ***Table 4.1*** summarizes key changes to the DRCOG Focus model for the development of the StateFocus model.

Table 4.1 Key Changes to DRCOG Focus Model Components for StateFocus

Model Name	Level	What is predicted	Changes for Statewide Model
Regular Workplace Location Choice	Long-Term Choice	• Workplace location zone and point	• Different distance formulations to accommodate long-distance and interregional travel.
Daily Activity Pattern	Tour Generation	• Number of tours by tour purpose • Presence of stops by stop purpose	• Overnight (non-closed) tours incorporated into the modeling framework • Overnight tours distinguished from closed tours.
Tour Destination Choice	Tour-Level Choice	• Primary destination zone and point	• Different distance formulations to simultaneously accommodate short- and long-distance travel • Adjustments for impacts of overnight travel
Tour Mode Choice	Tour-Level Choice	• Main tour mode	• Adjustments for starting and ending times for overnight travel
Tour Time of Day Choice	Tour-Level Choice	• The time period arriving and the time period leaving primary destination	• Adjustments for impacts of overnight travel

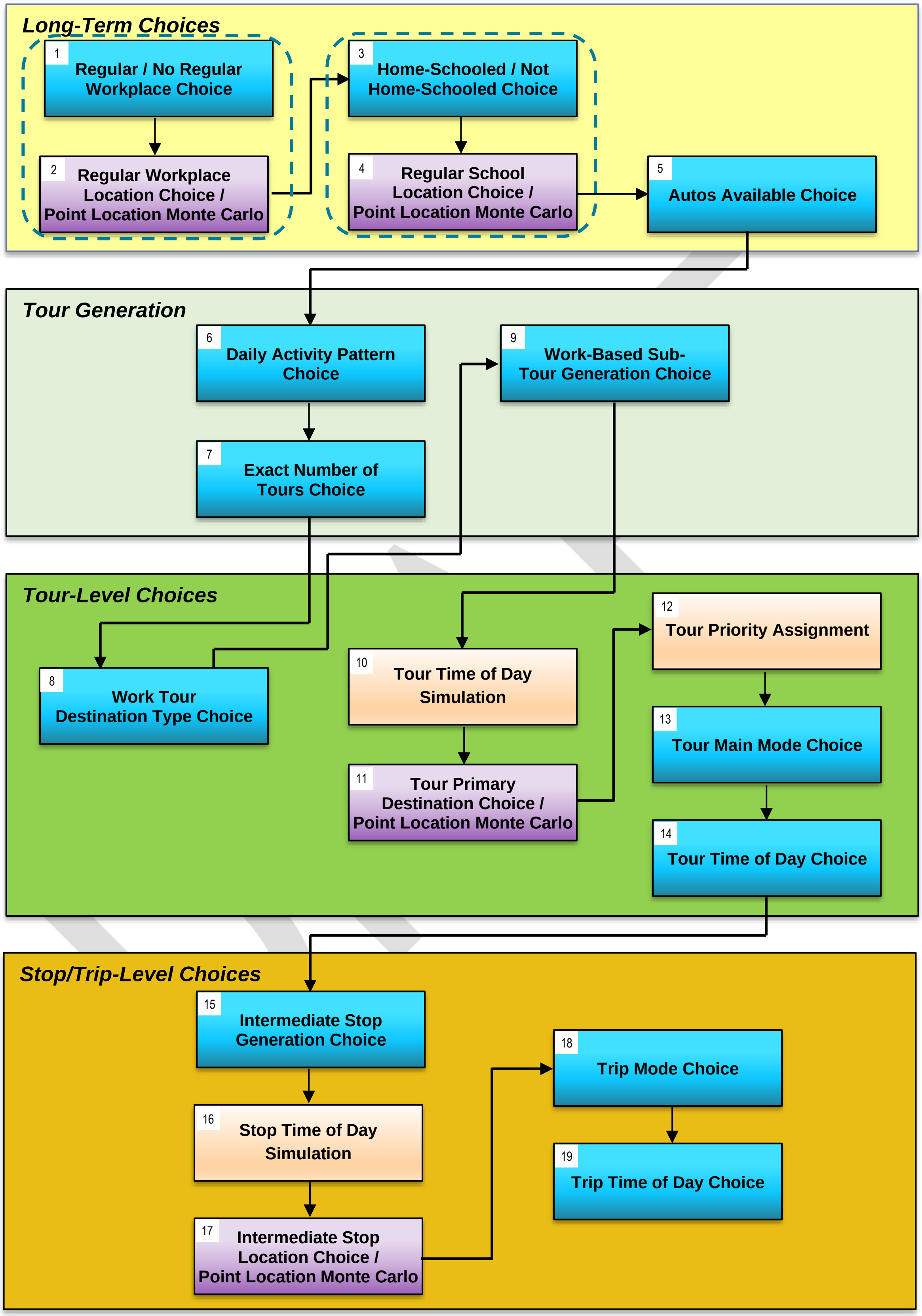
Source: Cambridge Systematics

Most of the choice models in StateFocus that are performed prior to the tour mode choice model use logsum information to provide composite impedance information regarding accessibility based on travel times and costs by the various modes of travel available (see ***Sections 4.1.1 and 4.1.2*** for logsum formulae). ***Section 2.1*** provides an overview of the path-building and skimming procedures for auto, shared ride, transit, bicycle, and walk modes of travel that provide the interchange specific travel time and cost information used in the logsums. ***Section 4.1*** below describes the use of logsums to represent composite impedance and accessibility to model components documented in ***Section 4.2***.

4.1 Logsums for Choice Models

There are two major types of logsums used for the choice models: disaggregate tour main mode choice logsums and aggregate accessibility logsums. Disaggregate tour main mode choice logsums provide composite impedance information for a specific interchange made by a traveler while aggregate accessibility logsums provide composite impedance information across all possible interchanges for a traveler. Disaggregate logsums are unique for each individual traveler considering both the individual's characteristics and the interchange travel impedances. Aggregate accessibility logsums are used for those situations where it is too computationally burdensome to calculate disaggregate logsums and are based on groupings of types of travelers and other simplifications. ***Table 4.2*** lists the model components preceding tour main mode choice and the type of logsum used. Only model components using logsums are listed.

Figure 4.1 StateFocus Activity-Based Model Component Flow



Source: Cambridge Systematics

Table 4.2 Logsums for Models Run Prior to Tour Main Mode Choice

StateFocus Model Component	Uses Fully Disaggregate Tour Mode Choice Logsums	Uses Disaggregate Work or School Location Mode Choice Logsums	Uses Special Logsums Derived from Disaggregate Work Tour Mode Choice Logsums	Uses Aggregate Accessibility Logsums for Non-Work and Non-School Purposes
1) Regular/No Regular Workplace[1]	x			
2) Regular Workplace Location	x			
4) Regular School Location	x			
5) Autos Available			x	
6) Daily Activity Pattern		x	x	x
7) Exact Number of Tours		x		x
8) Work Tour Destination Type			x	
11) Tour Primary Destination	x			

Source: Cambridge Systematics.
Notes: [1] Uses aggregation of fully disaggregate tour mode choice logsums over all destinations.

In addition to the mode choice and accessibility logsums, the tour main mode choice models (except escort tours) are nested logit models that use logsums from lower level nests in the top-level, main mode choice calculations. The tour main mode choice logsums are disaggregate logsums. The development of the logsums is performed within the C# model implementation code.

4.1.1 Disaggregate Tour Main Mode Choice Logsum Computations

Disaggregate logsums are computed directly from the tour mode choice model. These logsums are called disaggregate because they are computed for each individual person from their home location to every other zone. This type of logsum may be thought of as a calculation of how “hard” (or costly) it is to make a given tour summed across all modes that the traveler has available for the tour. The disaggregate tour main mode choice logsums can be calculated prior to running the tour main mode choice model since travel impedances for all available modes are available prior to applying the StateFocus Activity-Based Models (see ***Figure 2.1***). However, some of the variables used in the tour main mode choice models are not available (i.e. have not been forecast) when the logsum information is required. For example, the time of day for the tour is simulated is the tenth model component in StateFocus so prior model components requiring logsums to be based on an assumed time of day that best represents travel impedances that would be seen for activities and tours. The assumptions and simplifications used for the logsums are described for the various model components using logsums in the following sub-sections.

The disaggregate logsums for each tour purpose are computed as follows:

$$Logsum = ln \sum_{i=1}^{n} exp(U_i)$$

where: U_i = the utility for mode i in the tour main mode choice model
n = the number of mode alternatives in the tour mode choice model

Note that for the tour purposes that use nested logit mode choice models (all except escort tours), the logsums are computed using the utilities of the upper level nest alternatives, which may themselves be the logsums computed from the utilities of the lower level nest alternatives multiplied by the appropriate nest coefficient. For example, for home-based work tours, auto submodes (drive alone, shared ride 2, and shared ride 3+) are nested under auto while the other modes (walk, bike, walk to transit, and drive to transit) are all in the upper level nest. The home-based work tour mode choice logsum is computed as follows:

$$Logsum = ln[exp(U_{Auto\ Nest}) + \exp(U_{Walk}) + \exp(U_{Bike}) + \exp(U_{Walk\ to\ Transit}) + \exp(U_{Drive\ to\ Transit})]$$

where: $U_{Auto\ Nest}$ = NestCoef × ln[exp($U_{Drive\ Alone}$) + exp($U_{Shared\ Ride\ 2}$) + exp($U_{Shared\ Ride\ 3+}$)]
NestCoef is the nesting coefficient for the auto mode

The tour main mode choice models are described in ***Section 4.2.13***. Model coefficients and assumptions for disaggregate tour mode choice logsum computations are shown in ***Appendix E***.

Regular/No Regular Workplace, Workplace Location, School Location Choice, and Tour Primary Destination Choice Logsums

Regular/no regular workplace, workplace location, school location, and tour primary destination choice model components use disaggregate tour main mode choice logsums for every person from the person's home location to every other zone. The regular/no regular workplace and workplace location choice models use the logsums for the work purpose and the school location choice model uses the logsums for the school purpose. The tour primary destination choice models use the logsums corresponding to the purpose.

The regular/no regular workplace model uses the disaggregate logsums aggregated over all zones. The workplace location, school location, and tour primary destination choice models also use the aggregation of the disaggregate logsums over all zones as the denominator of the choice models in effect comparing the accessibility of a specific zone to the overall accessibility to all zones. The number of disaggregate tour mode choice logsums that must be calculated are:

$$State\ Population\ \times TAZs\ \times Purposes$$

where: State Population varies by forecast year or alternative
TAZs = 6,440
Purposes = 5 (home-based work logsums are used for regular and non-regular workplace; home-based school; escort; home-based other logsums are used for home-based shop, home-based personal business, home-based social/recreation, and home-based meal purposes; and, work-based sub-tours)

These logsums are calculated within the C# code for the model components as needed. There are several important considerations and simplifications used for the development of the regular/no regular workplace, workplace location, and school location choice model component logsums:

- The auto availability status of a person is unknown at the time that the disaggregate mode choice logsums are generated since the auto availability choice model has not been run, but the tour mode choice logsums include variables related to auto availability. For development of these logsums, full auto availability, meaning that there are as many cars as drivers, is assumed. In effect, this means that all variables related to auto availability drop out of these computed logsums.

- Some other variable values are also unknown at the time that all the logsums for these models are run (for example, the number escort tours/tours remaining is used in the home-based school tour main mode choice model, but the daily activity and exact number of tours model components have not been run). For these variables, the values used are sample averages from the FRTC.

- The work and school location choice logsums that are calculated within the work and school location choice model components from the home location to the work TAZ for workers and from the home location to school TAZ for students are stored for each person for use by later components.

- The skim periods used are AM2 (7:00-7:59 AM) for highway skims and AM (6:30-8:59 AM) for transit skims. These periods have the highest percentages of observed tours in the FRTC arriving in them for the corresponding purposes.

- The cost component of the utility function is broken into two parts for auto modes that have the same coefficient: Auto Operating + Toll Cost (a skim variable) and Parking Cost (a zonal variable). For the parking cost components of the utility functions for the regular workplace location and regular school location choice models, the costs are simply the average daily parking cost of the zone.

- Times of day for tour primary destination arrival and departure times are simulated[28] for all tours prior to running the tour primary destination choice model. All skim values used in the disaggregate logsums in the tour primary destination choice model will correspond to the time-of-day from the tour destination arrival time of the simulated tour. Furthermore, variables such as "arrive at destination in the AM peak" will be created using this simulated time. Additionally, each part of the cost is multiplied by a factor for the following modes to account for possible cost-splitting, such as if the carpoolers are members of different households:

  - SR2: 0.67

  - SR3+: 0.5

- The home-based other mode choice purpose logsums are used for non-mandatory purposes (home-based personal business, meal, shop and social/recreation purposes) in the tour primary destination choice model.

- In the tour mode choice model, bike and walk skim times depend on the tour destination X-Y coordinates and are calculated based on those coordinates in the actual run of the tour mode choice model. However, these X-Y coordinates are unknown during the calculation of the disaggregate mode choice logsums for the tour primary destination choice model. Further, a weighted average of skimmed network distance and X-Y distance is used to caluclate the auto in-vehicle times for trips less than 2.5 miles. Of course, the X-Y coordinates are unknown during the calculation of the disaggregate destination choice

[28] The tour time of day simulation destination arrival and departure times are based on observed tours by purpose summarized from the FRTC. The simulation process randomly draws a time from a time of day distribution taken from the FRTC data. Note that the simulated times are replaced after tour main mode choice using the tour time of day choice model.

(Footnote continued on next page...)

logsums. For these reasons, the origin to destination zone skims[29] (rather than the full tour skims – origin to destination plus destination to origin) are used directly with the simplifications shown below:

- Cost: 2 × Skimmed Cost
- In-Vehicle Time: 2 × Skimmed In-Vehicle Time
- Terminal Time: 2 × Terminal Time
- Transit Walk Time: 2 × Skimmed Transit Walk Time
- Transit Drive Access/Egress Time: 2 × Skimmed Transit Drive Access Time
- Transit Wait Time: 2 × Skimmed Transit Wait Time
- Bike Time: 2 × Skimmed Bike Time
- Walk Time: 2 × Skimmed Walk Time
- Local Bus In-Vehicle Time/O-D Distance: 2 × (Local Bus In-Vehicle Time)/O-D Distance
- Drive to Transit/Drive Alone – 0.5: 2 × ((Drive Access Time/Drive Alone Time) – 0.5)
- School Bus Distance: 2 × School Bus Distance

Daily Activity Pattern and Exact Number of Tours Choice Logsums

The daily activity pattern and exact number of tours choice models use the disaggregate logsums calculated for the work and school location choice models. The daily activity pattern and exact number of tours choice models are run after the work and school location choice models and, thus, can use the actual destinations selected for each individual. Since the determination of whether a closed or non-closed tour is made is part of the daily activity pattern choice model, the disaggregate home-based work mode choice logsums for closed tours as described for the regular/no regular workplace, workplace location, and school location choice models are used (i.e. based on 2 times origin to destination skim data).

Some variable values are unknown at the time the disaggregate logsums are used by the daily activity pattern and the exact number of tours choice models. For example, Escort Stops/Tours Remaining is not known until the actual mode choice model is run. Sample averages from the FRTC were used for the unknown variables. The averages are shown in the model coefficients and assumptions for disaggregate tour mode choice logsum computations are shown in ***Appendix E***.

In addition to the disaggregate work and school location mode choice logsums, the daily activity pattern and exact number of tours models use aggregate accessibility logsums (see ***Section 4.1.2***).

29 Tours are for the round trip from origin to tour destination and back to the origin. While the best path from the destination to the origin might not be the mirror image of the best path from origin to destination, simply doubling the origin to destination skim information is a reasonable simplification.

Autos Available and Work Tour Destination Type Choice Logsums

The auto available choice model uses a special disaggregate logsum variable. The home-based work tour mode choice logsum between home and usual work location is calculated in two ways for each worker in a household having an out-of-home usual work location. The first is based on the assumption that each driver in the household has an auto available and the second is based on the assumption that the household has no autos. For each person who has a usual work location, the difference between the two logsums is calculated, and then this difference is summed for all people in the household. This sum of differences is a measure of transit quality since, if transit is good to the workplace locations, then each household member's logsum with no cars will be comparatively close in value to the logsum with cars available. There will be a larger difference between the two logsums when transit service is sparser.

4.1.2 Aggregate Accessibility Logsum Computations

Aggregate mode/destination choice logsums are used as accessibility measures in the daily activity pattern and exact number of tours models. These logsums represent the accessibility of <u>all</u> non-mandatory activity locations for different population segments living in a given zone. For example, there may be numerous close-by retail locations to a person living in an urban or suburban area but few close-by retail locations for someone living in a rural area. Thus, having a shopping activity during the day might be more likely for the person living in the urban or suburban area than for the person living in the rural area.

The general formula to calculate the aggregate accessibility logsums is:

$$AggAccLogsum_i = ln\left\{\sum_{TAZ\ j=1}^{6440} exp\left[SimpDestUtil_j + ln\left(\sum_{Mode=1}^{m} exp\left(SimpMCUtil_{m,j}\right)\right)\right]\right\}$$

where: *AggAccLogsum*$_i$ = the aggregate accessibility logsum for origin TAZ *i*
SimpDestUtil$_j$ = the simplified destination utility, not including the mode choice logsum, for destination TAZ *j*; the utilities are simplified by using demographic segmentation, and sample average values as noted in the following sections
SimpMCUtil$_{m,j}$ = the simplified main mode choice utility for mode *m* for destination TAZ *j*; the utilities are simplified by using demographic segmentation, sample average values, and pre-selected skim values as noted in the following sections

Demographic Segments for Aggregate Accessibility Logsums

Ideally, the daily activity pattern choice and exact number of tours choice models would use fully disaggregate logsums calculated from the relevant lower level models in the StateFocus activity-based model system. This is possible for work and school purposes since the regular workplace and school location choice models are run prior to the daily activity pattern choice model. As a result, the "true" mode choice logsums between home and the usual work and school locations for each person can be calculated. For other travel purposes there is no usual location so the composite logsum across all possible locations is used to represent the accessibility.

The theoretically correct measure would be the logsum from the destination choice model. Because the destination choice model uses the logsum from mode choice, we can think of it as the logsum from a nested mode/destination choice model. Computationally, it would be quite a burden to calculate these accessibility measures separately for every single person and household in the population for every non-mandatory purpose. As a simplification, these measures are calculated for each residence TAZ as they vary across several important demographic dimensions:

- Household income (see ***Section 3.1.1***):
- Household vehicle availability:
  - No vehicles
  - Vehicles, but fewer than workers
  - Vehicles, but fewer than drivers
  - Vehicles for all workers, but fewer vehicles drivers

Pre-Selected Skim Values for Simplified Mode Choice Utilities

The mode choice logsums are included in the aggregate accessibility logsums as variables. The mode choice logsums are calculated using the tour-level main mode choice models, using all of the same input files for transit and auto skims and zonal data. For simplification purposes, however, the mode choice utilities used in the logsum do not rely on full person-level or tour-level information. Instead, the following approximations are made:

- Income dummy variables (also called indicator, Boolean, or flag variables) are based on the five income segments noted previously.
- Vehicle availability dummy variables are based on the four household auto availability segments noted previously.
- Rather than using specific walk access times from a person's x- and y-coordinate for their place of residence, walk access times to transit are based on the proximity to transit for three segments:
  - 2.5 minutes for distances less than ¼ mile to nearest stop
  - 12.5 minutes for distances between ¼ mile and 1 mile to nearest stop
  - unavailable for more than 1 mile to nearest stop
- The skim periods used are OP3 (11:00 AM-2:59 PM) for highway and MD (9:00 AM-2:59 PM) for transit. These periods have the highest percentages of observed tours in the FRTC arriving in them for each of the non-mandatory purposes.
- The cost component of the utility function is broken into two parts for auto modes that have the same coefficient: Auto Operating + Toll Cost (a skim variable) and Parking Cost (a zonal variable).
- For the parking cost component of the utility function, the average daily (that is, for an eight-hour work day) parking cost is multiplied by one of two factors based on the average duration of stay. Factors from the DRCOG Focus model were used:[30]

[30] This approach and the factors are based on procedures used for the DRCOG Focus model based on data collected in the Denver region in 1997. The factors appear to have been based on whether the average duration was less than 80 minutes (0.167) or more than 80 minutes (0.333). The durations could be updated in the future based on the 2010 FRTC (summarized in the Tour Time of Day Summary Sheets used for model validation). The following table compares the durations from the 2010 FRTC with the DRCOG durations:

(Footnote continued on next page...)

- Escort Factor = 0.167
- Personal Business Factor = 0.333
- Shop Factor = 0.167
- Meal Factor = 0.167
- Social/Recreation Factor = 0.333

by tour purpose shares observed in FRTC (since the tour time of day simulation is not applied until later in the model stream):

- The home-based personal business, meal, shop and social/recreation purposes use the home-based other tour main mode choice purpose utility equations.
- In the tour mode choice model, bike and walk skim times depend on the tour destination X-Y coordinates and are calculated based on those coordinates in the actual run of the tour main mode choice model. However, these X-Y coordinates are unknown during the calculation of the aggregate mode choice utilities for the aggregate accessibility logsums. Further, complex variables are used to represent the drive in-vehicle times for trips less than 2.5 miles and for transit walk access and egress times based on X-Y coordinates for origins and destinations. Of course, the X-Y coordinates are unknown during the calculation of the aggregate accessibility logsums. For these reasons, the origin to destination zone skims[31] (rather than the full tour skims – origin to destination plus destination to origin) are used directly with the simplifications shown below:
  - Cost: 2 × Skimmed Cost
  - In-Vehicle Time: 2 × Skimmed In-Vehicle Time
  - Terminal Time: 2 × Terminal Time
  - Transit Walk Time: 2 × Skimmed Transit Walk Time
  - Transit Drive Access/Egress Time: 2 × Skimmed Transit Drive Access Time
  - Transit Wait Time: 2 × Skimmed Transit Wait Time

	DRCOG Focus Duration (in Minutes)	Factor Based on DRCOG Focus Model	2010 FRTC Survey Duration (in Minutes)	Factor Based on 2010 FRTC Data
Escort	20.0	0.167	11.4	0.167
Personal Business	84.8	0.333	76.8	0.167
Shop	33.7	0.167	46.8	0.167
Meal	68.4	0.167	79.8	0.167 or 0.333
Social/Recreation	125.0	0.333	126.0	0.333

[31] Tours are for the round trip from origin to tour destination and back to the origin. While the best path from the destination to the origin might not be the mirror image of the best path from origin to destination, simply doubling the origin to destination skim information is a reasonable simplification.

- Bike Time: 2 × Skimmed Bike Time
- Walk Time: 2 × Skimmed Walk Time
- Drive Access Time/Total IVTT: (2 × Drive Access Time)/Total IVTT

Sample Average Values for Aggregate Accessibility Logsums

Sample average values are used for several variables. These values are shown ***Appendix E***.

Tour Purposes for Aggregate Accessibility Logsums

As noted previously, the home-based other tour main mode choice model is used in the development of the aggregate accessibility logsums. However, the simplified destination utilities used in the aggregate accessibility logsums are purpose specific. The aggregate accessibility logsums are calculated for the following six tour purposes:

- Home-based escort
- Home-based personal business
- Home-based shopping
- Home-based meal
- Home-based social/recreation
- Work-based sub-tours[32]

The above groupings result in 5 Income Groups × 4 Auto Availability Groups × 3 Transit Access Groups × 5 Tour Purposes, or 300 different aggregate accessibility logsums for each of the 6,440 TAZs in the state.

Some variable values are unknown at the time the aggregate accessibility logsums are used by the daily activity pattern and the exact number of tours choice model components. For example, Escort Stops/Tours Remaining is not known until the actual intermediate stop generation model component is run. Sample averages from the FRTC were used for the unknown variables. The averages are shown in the model coefficients and assumptions for aggregate tour mode choice logsum computations are shown in ***Appendix E***.

Destination Choice Models for Aggregate Accessibility Logsums

The destination choice models for the non-mandatory tour purposes documented in ***Appendix F*** are used for the calculation of the aggregate accessibility logsums. Skim distances used in the models are based on the

[32] The original DRCOG documentation states that work-based sub-tour aggregate accessibility logsums are generated and, thus, are generated for StateFocus. There is some question regarding whether the work-based sub-tour aggregate accessibility logsums are actually used since the daily activity pattern and exact number of tours models don't generate work-based sub-tours and the StateFocus work-based sub-tour generation choice model does not use aggregate accessibility logsums.

OP3 highway skims. The aggregate accessibility logsums were calculated by aggregating destination specific logsums across all available destinations.

The daily activity pattern choice model also uses an aggregate accessibility logsum for the non-closed work tour purpose. This variable is simply the average of the aggregate accessibility logsums for the escort, personal business, shop, meal, and social-recreational tour purposes.

4.1.3 Tour Mode Choice Logsums and Travel Distances in Location Choice Models

Tour mode choice logsums and travel distances are both used to provide measures of spatial separation in tour-based models that estimate location, or destination, choice. Location choice models include regular workplace location choice (***Section 4.2.2***), regular school location choice (***Section 4.2.4***), and tour primary location choice (***Section 4.2.11***). Intermediate stop location choice (***Section 4.2.17***) uses information on the added generalized time for diversion to an intermediate stop location on an inbound or outbound leg of the tour rather than logsum and travel distance information.

Tour mode choice logsums generally represent decreasing utility as the spatial separation between an origin an destination increases; more distant destinations are generally less attractive than closer destinations as represented by larger negative values of the logsums. There are localized exceptions due to network characteristics such as interchange locations and transit stops. Nevertheless, logsums and their effects are generally monotonically decreasing as spatial separation increases since the logsum variables are multiplied by a single coefficient.

In many regions, it has been found that modifiers to the monotonically decreasing impact of the tour mode choice logsums on location choice models models are required[33]. To address this issue, distance-based functions are typically used to modify the total separation utility represented to the model. For example, the DRCOG Focus model uses distance, distance-squared, distance-cubed, and the natural log of distance as variables in the location choice models with the possibility of both positive and negative model coefficients on the variables.[34] Such coefficients can help account for the "knowledge base" regarding optional destinations. Up to certain distances such as one or two miles, people may be very knowledgeable regarding optional locations that can satisfy the activity performed at the destination. However, as the distance increases, the knowledge base may decrease more rapidly due to unfamiliarity with the optional destinations.

The StateFocus model uses smoothed stepwise linear functions of distance to modify the impacts of the mode choice logsum utility on location choice. These functions have been used since the range of distances considered in the statewide location choice models are substantially greater than those encountered in most regional location choice models. For example, the greatest travel distance in the DRCOG region is about 70 miles while the distance between Fort Collins and Durango is about 400 miles. The smoothed stepwise linear functions of distance are calculated as:

[33] This does not imply that the logsums themselves are necessarily monotonically decreasing as spatial separation increases. Some of the mode choice logsums include destination variables (e.g. "Destination Retail Density") with positive coefficients that may make a destination with more spatial separation from an origin more attractive in terms of the logsum. Nevertheless, in the location choice models, the logsums are multiplied by a singular coefficient meaning that as the logsum value decreases, the attractiveness of the destination decreases.

[34] An unfortunate misunderstanding caused by the use of distance-squared and distance-cubed as spatial separation modifiers is that some may try to interpret those variables as representing the area or volume of separation distance. Area and volume are not the implied meanings of those variables; they are, simply, easily calculated variables.

$$SSLF_{Dist} = \frac{\{ln[exp(0) + \exp\,(Damp \times \langle Dist - Thresh\rangle)]\}}{Damp}$$

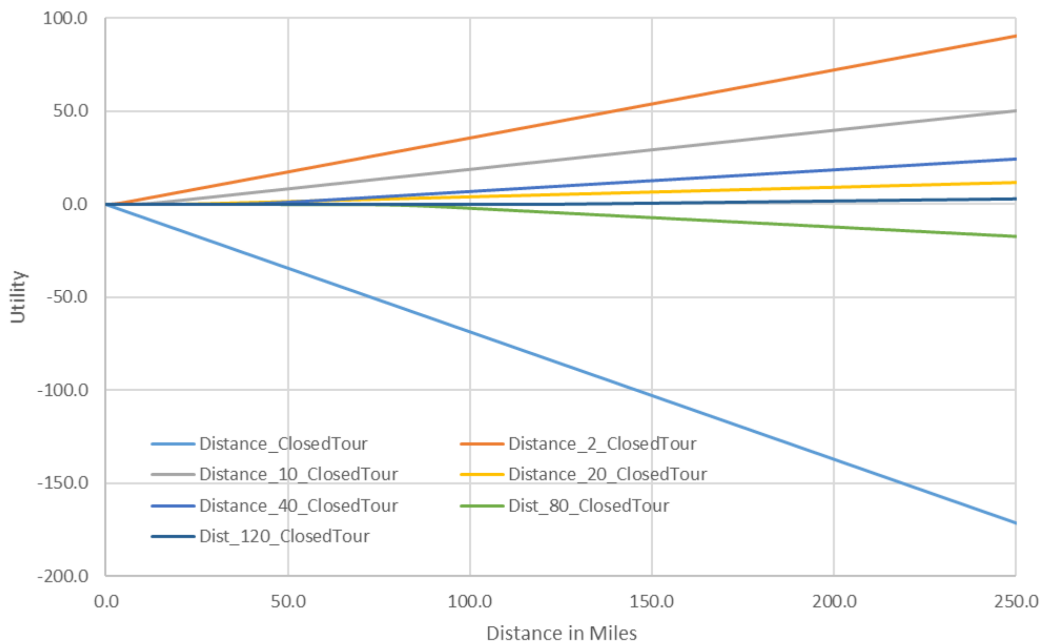
Where: *SSLF*

Where:	$SSLF_{Dist}$	is the value of the smoothed stepwise linear function for distance *Dist*
	Dist	is the distance in miles on the shortest travel impedance path from the tour origin to tour destination (this is a one-way distance, not round-trip distance)
	Damp	is a damping factor (e.g. 2.0, 1.0, 0.5, 0.3333, 0.25, and 0.2); different levels of damping are used at different parts of the distance curve with generally more damping being applied (via smaller values of *Damp*) at longer distances to keep the utility function more stable – the change in slope should be slower at longer distances
	Thresh	is the distance threshold in miles used for stepwise linear function

The smoothed stepwise linear functions might be combined with a linear function of distance (i.e. coefficient × distance) and/or a natural log function of distance (i.e. coefficient × ln[1+distance]).

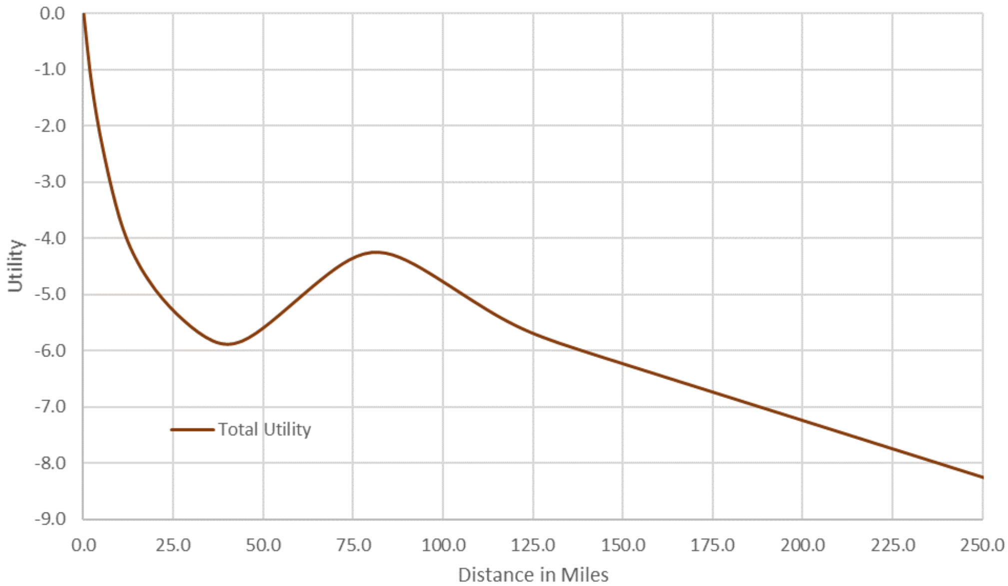
Figure 4.2 shows the utility values of the linear distance function and the smoothed stepwise linear functions of distance for the home-based social/recreation location choice model (see ***Section 4.2.11***) for the distance range 0 to 250 miles. The model is complex in that in addition to the linear function of distance, there are six distance thresholds (at 2, 10, 20, 40, 80, and 120 miles) that contribute to the total utility. The damping values for the six distance thresholds are 1.0, 0.5, 0.3333, 0.25, 0.2, and 0.2. ***Figure 4.3*** shows the composite utilities obtained through the sums of the linear distance function and the smoothed stepwise linear functions as the distance varies from 0 to 250 miles. As shown in ***Figure 4.3***, this allowed the StateFocus model to capture some of the nuances of social/recreation travel from Front Range communities to mountain locations since the smoothed stepwise linear functions of distance actually increase the utility of travel as distance increases from about 40 miles to 80 miles.

Figure 4.2 Distance-Based Utilities for Home-Based Social/Recreation Location Choice



Source: Cambridge Systematics.

Figure 4.3 Composite Distance-Based Utililites for Home-Based Social/Recreation Location Choice



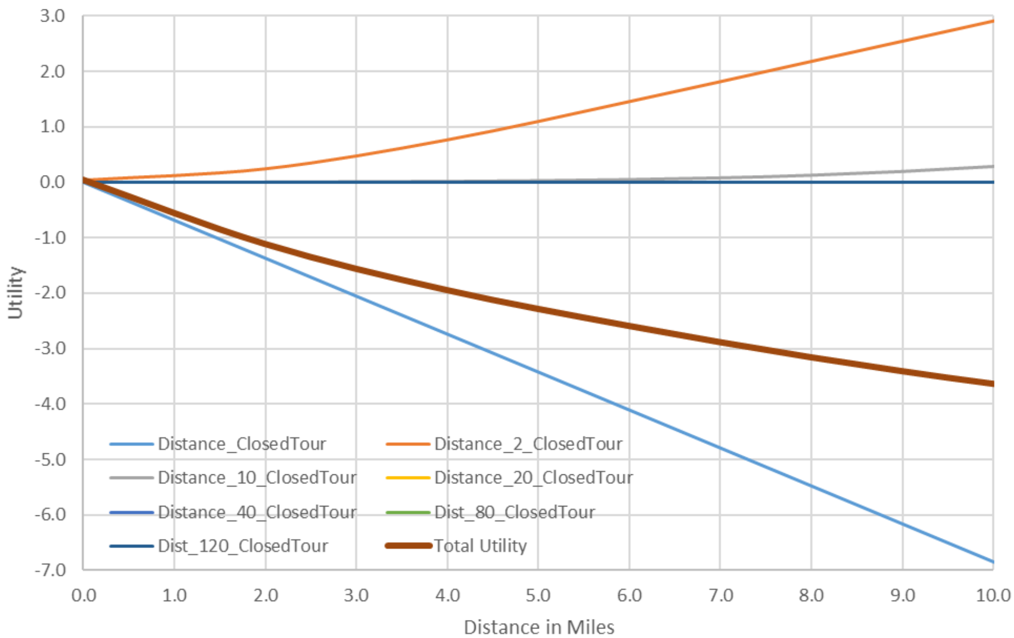
Source: Cambridge Systematics.

Figure 4.4 shows the utility values of the linear distance function and the smoothed stepwise linear functions of distance for the home-based social/recreation location choice model along with the composite total distance-based utilities for the 0 to 10 mile distance range. The figure illustrates three points regarding the smoothed stepwise linear functions of distance as applied using the formula shown above:

- The impacts are not truly linear as can be seen by the utilities shown for the "Distance_2_ClosedTour" component.
- The thresholds are not sharp inflection points; rather, the impact of the functions actually begin before the thresholds as can be seen by the utilities shown for the "Distance_2_ClosedTour" and "Distance_10_ClosedTour" components.
- The impacts for distances substantially lower than the thresholds are minimal as shown by the fact that the utilities shown for the smoothed stepwise linear functions with thresholds of 20, 40, 80, and 120 miles are essentially 0 for the 0 to 10 mile range.

Figure 4.4 illustrates some of the nuances of the linear distance function and the smoothed stepwise linear functions of distance that are not obvious in ***Figure 4.2*** due to the scaling used for that figure.

Figure 4.4 Distance-Based Utilities for Home-Based Social/Recreation Location Choice for 0 to 10 Miles



Source: Cambridge Systematics.

4.2 StateFocus Activity-Based Model Components

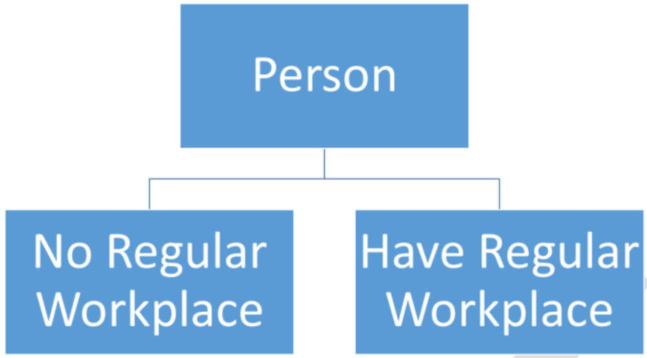
The following sections describe the various model components and model variables used in those components. These sections have been adapted from the original DRCOG Focus model documentation. Definitions common to multiple components are described in ***Section 3.0*** (e.g. ***Section 3.1.2*** describes the definition of person types used in most model components). The estimated and final model parameters for each model component are provided in ***Appendix F***.

4.2.1 Regular / No Regular Workplace Choice

Model Structure

The regular/no regular workplace model is a binary logit choice model (see ***Figure 4.5***) used to determine whether each person age 16 or older in the synthetic population has a regular work location to which they usually (or regularly or customarily) go for work:

Figure 4.5 Regular / No Regular Workplace Choice Structure



Source: Cambridge Systematics

Utility Function

The general form of the binary logit model for the regular / no regular workplace choice model is:

$$Prob_{RegWork} = \frac{1}{1 + exp(U_{RegWork})}$$

where: $U_{RegWork}$ = the utility for having a regular place of work

= $\beta_0 + \beta_{p1} \times p_1 + \beta_{p2} \times p_2 \ldots \beta_{pn} \times p_n + \beta_{h1} \times h_1 + \beta_{h2} \times h_2 \ldots \beta_{hn} \times h_n + \beta_{accls} \times accls$

β_0 = model constant for having a regular workplace

$\beta_{p1} - \beta_{pn}$ = model coefficients for person characteristics

$p_1 - p_n$ = 0/1 person characteristics where p_n is 1 if the person has the characteristic and 0 otherwise

$\beta_{h1} - \beta_{hn}$ = model coefficients for household characteristics of the person

$h_1 - h_n$ = 0/1 household characteristics where h_n is 1 if the household for the person has the characteristic and 0 otherwise

β_{accls} = model coefficients for the accessibility logsum

accls = the accessibility logsum for the person's home location to all other locations

Variables

The model variables outlined above are further described below:

- Accessibility as defined by the aggregation of home-based work tour mode choice logsums over all possible work locations in the state (see ***Section 4.1.1*** and ***Appendix E.1.1***);
- Person type variables as defined in ***Section 3.1.2***;
- Other person type variables based on:
  - age,
  - highest educational attainment;

- Household variables based on:
  - whether or not the person is the only adult in the household,
  - for male adults, whether there are any children in the household in the 5-15 age range,
  - for female adults:
    - » whether there are any children in the household in the 0-4 age range,
    - » whether there are any children in the household in the 5-15 age range,
  - the household income.

Relationship to Other Models

The StateFocus model differs from the DRCOG Focus model by inserting this regular/no regular workplace choice model before the regular workplace location choice model. In addition, the StateFocus model considers all persons 16 or older, including retired persons and other non-workers, since they may perform volunteer work or periodic paid work (even though they are not considered part-time employees). In contrast, the DRCOG Focus model considers only persons designated as workers in the synthesized population.

The regular/no regular workplace model works in conjunction with several other models in StateFocus:

- The Regular Workplace Location Choice model (***Section 4.2.2***) forecasts the actual work location, including work at home, for those persons with a regular workplace.
- The Work Tour Destination Type Choice model (***Section 4.2.8***) forecasts whether a person with a regular workplace and making a home-based work tour on the travel day makes that tour to their regular workplace or to a different location.
- Home-based work tour destinations for persons without a regular workplace or who have a regular workplace but are not traveling to that workplace on the travel day are forecast in tour primary location choice model (***Section 4.2.11***).

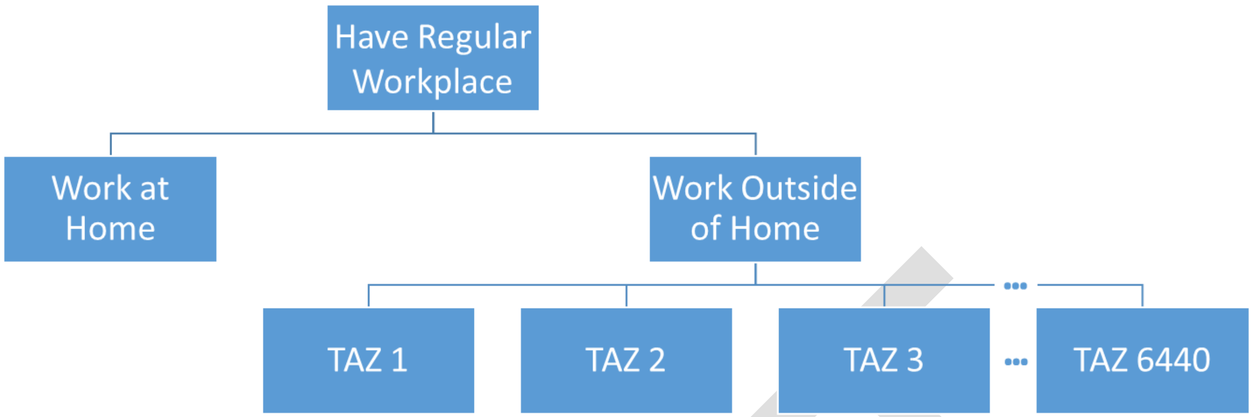
Estimated and final calibrated model coefficients for the regular/no regular workplace choice model are shown in ***Appendix F.1***.

4.2.2 Regular Workplace Location Choice / Point Location Monte Carlo

Model Structure

The workplace location choice model is a nested logit model that assigns regular work locations, including work at home, for all persons having a regular workplace location as determined by the regular/no regular workplace choice model (see ***Section 4.2.1***). The structure of the model is shown in ***Figure 4.6***.

Figure 4.6 Regular Workplace Location Choice Structure



Source: Cambridge Systematics

Utility Function

The general form of the utility equation for the workplace location in TAZ$_j$ outside the home is:

$$U_j = \sum_{x=1}^{NS}(NonSizeCoeff_x \times NonSizeVar_x) + \beta_{lsm} \times Ln\left[\sum_{y=1}^{S} exp(SizeCoeff_y) \times SizeVar_y\right]$$

Where: U_j is the utility of a workplace location in TAZ j
$NonSizeCoeff_x$ are the coefficients applied to the non-size variables, $NonSizeVar_x$
β_{lsm} is the logsum multiplier applied to the natural log of the size variable component of the model
$SizeCoeff_x$ are the coefficients applied to the size variables, $SizeVar_x$

Since the work at home alternative does not include zonal alternatives with size variables, the work at home alternative takes the simpler form shown below:

$$U_{Home} = \sum_{x=1}^{NS}(NonSizeCoeff_x \times NonSizeVar_x)$$

Variables

Two general types of variables are used in the workplace location choice model:

- Non-size variables which may include:
  - continuous variables such as distance or logsum measures between the home zone and the alternative work zone,
  - 0/1 dummy variables that take on the value of 1 if the variable possesses the characteristic defined (e.g. person is in the 35-44 age range) and 0 otherwise,
  - continuous or integer variables describing characteristics of the traveler (e.g. number of children under the age of 5 in the person's household)

- Size variables that describe the quantity of opportunities available at the alternative work zone such as the number of employees in the restaurant industry. The coefficients for the size variables also consider the educational attainment of the person choosing the work location. Two educational levels are considered:

  - Persons without a bachelor's or graduate degree (lower education)

  - Persons with a bachelor's or graduate degree (higher education)

  For example, for production employees in the work zone, two different coefficients for that size variable were estimated: one for persons with lower educational levels and one for persons with higher educational levels.[35]

The model was estimated using non-normalized nested logit (NNNL) estimation procedures due the number of alternatives (i.e. TAZs) in the work outside the home nest. Since there were no common variables between the work at home and the work outside the home nest, a dummy nest under "work at home" was not required. All model coefficients are reported at the top level of the nesting structure so, in application, coefficients applied in the lower level nest (i.e. the choice among the alternative work zones) must be divided by the nesting coefficient prior to application.

During model calibration, it was discovered that some zones in general and some county to county home zone to work zone interchanges were overestimated or underestimated. To correct for these differences, additional 0/1 dummy variables were added. ***Table 4.3*** lists the variables used in the workplace location choice model; ***Appendix F.2*** lists the estimated and final model coefficients.

Table 4.3 Regular Workplace Location Choice Variables

Variable	Work Outside of Home Nest	Work at Home Nest	Comments
Size Variables			
Beta Logsum Multiplier	x		Size variable logsum multiplier
Service Employment – Education Level	x		Separate coefficients for two educational levels are considered: • Persons without a bachelor's or graduate degree (lower education) • Persons with a bachelor's or graduate degree (higher education)
Educational Employment – Education Level	x		
Retail Employment – Education Level	x		
Restaurant Employment – Education Level	x		
Production Employment – Education Level	x		
Entertainment Employment – Education Level	x		
Work at home size dummy		x	This value was constrained to 0, effectively removing the size variables from the work at home nest.

[35] The DRCOG Focus model is based on the 1997 Travel Behavior Inventory for the DRCOG region and considered the industry of the person making the trip rather than the educational level, thus more closely matching the type of worker with employment in his or her industry. The FRTC survey did not ask respondents to identify the industry in which they were employed, obviating the use of this variable in workplace location choice.

Variable	Work Outside of Home Nest	Work at Home Nest	Comments
Non-Size Variables			
Work at home constant		x	
Work at home – person aged 35 to 44		x	
Work at home – person aged 45 or older		x	
Work at home – person is a part-time worker		x	
Work at home – female with no children under 5		x	
Work at home – female; number of children under 5		x	
Distance from home to work zone in miles[1]	x		
Distance from home to work zone greater than 2 miles[1]	x		Applied to distance from home to work.
Natural log of 1+distance[1]	x		
Mode Choice Logsum	x		Applied to round trip logsum.
Nesting Coefficient	x		
Work zone is at Denver International Airport	x		
Added Calibration Variables			
CBD destination	x		
Home County to Work County	x		Specific county to county interchanges identified; the variables are directional.

Source: Cambridge Systematics.
Note: [1] The use of these three distance variables and their associated model coefficients form a smoothed stepwise linear distance function (see ***Section 4.1.3***).

Regular Workplace Point Location Monte Carlo

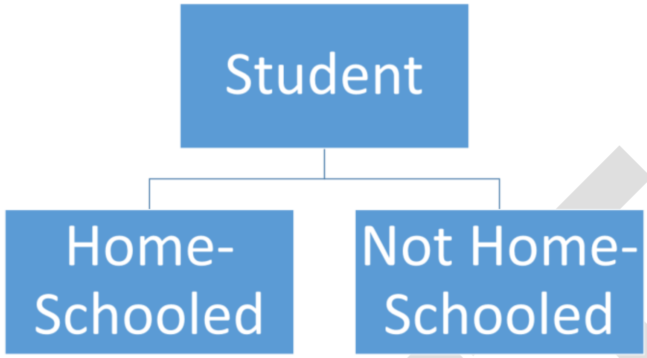
The regular workplace location choice model is used to forecast a destination TAZ for each person with a regular workplace. The household location for each person has already been assigned to an actual point location within the home TAZ and each employment establishment within a TAZ has also been assigned to a point location (see ***Section 2.3.2***). The regular workplace point location Monte Carlo uses a simple random selection process to select an actual establishment and its point location from the set of all establishments within the TAZ chosen for the regular workplace for each person.

4.2.3 Home-Schooled/Not Home-Schooled Choice

Model Structure

The home-schooled/not home-schooled choice model is a binary choice model to forecast whether a person who is a student is home-schooled (see ***Figure 4.7***). For every person who is a full-time or part-time student, the choice to be home-schooled may include traditional home-school activities (e.g. children being taught by parents) and, in addition, may include on-line coursework (e.g. for college credit). The alternate choice for students is to attend traditional out-of-home classes at an educational facility. Students who are not home-schooled will then be assigned a usual school location in the subsequent regular school location choice model (see ***Section 4.2.4***).

Figure 4.7 Home-Schooled / Not Home-Schooled Choice Structure



Source: Cambridge Systematics

Utility Function

The form of the home-schooled/not home-schooled choice model is as follows:

$$Prob_{HomeSchool} = \frac{1}{1 + exp(U_{HomeSchool})}$$

where: $U_{HomeSchool}$ = the utility for being home-schooled
= $\beta_0 + \beta_{p1} \times p_1 + \beta_{p2} \times p_2 \ldots \beta_{pn} \times p_n + \beta_{h1} \times h_1 + \beta_{h2} \times h_2 \ldots \beta_{hn} \times h_n$

β_0 = model constant for being home-schooled

$\beta_{p1} - \beta_{pn}$ = model coefficients for person characteristics

$p_1 - p_n$ = 0/1 person characteristics where p_n is 1 if the person has the characteristic and 0 otherwise

$\beta_{h1} - \beta_{hn}$ = model coefficients for household characteristics of the person

$h_1 - h_n$ = 0/1 household characteristics where h_n is 1 if the household for the person has the characteristic and 0 otherwise

Variables

The model variables outlined above are further described below:

- Person type variables as defined in ***Section 3.1.2***;
- Household variables based on:
  - number of children under 16,
  - number of non-working adults,
  - household income, and
  - student status.

All students are included in this model, regardless of age. While student status is used in the determination of person type, whether or not a person is a student is also a characteristic included for each person in the population synthesis data. Thus, a person who is a full-time employee (person type 1) may also be a student.[36]

Unlike the regular/no regular workplace choice model (***Section 4.2.1***), there is no accessibility variable in the home-schooled/not home-schooled choice model. Thus, all decisions regarding home schooling are made based on household and person characteristics. It might be argued that there should be an accessibility measure since persons living in remote parts of the state might be more likely to home-school children or take on-line courses than people living in more urban areas. However, since the four Front Range MPOs comprised the FRTC survey area, there were relatively few surveys from rural areas and the rural areas were not truly remote. As a result, there was insufficient information to estimate a statistically significant coefficient for an accessibility variable. Since it might also be argued that home-schooling decisions are, primarily, personal choices, it was decided that a coefficient for an accessibility variable should not be asserted.

Relationship to Other Models

The StateFocus model differs from the DRCOG Focus model by inserting this home-schooled/not home-schooled choice model before the regular school location choice model. The DRCOG Focus model does not explicitly identify home-schooling but, rather, includes home-schooled students in the regular school location choice as those students selecting the home zone as the regular school location.

The home-schooled/not home-schooled choice model works in conjunction with regular school location choice model (***Section 4.2.4***) which forecasts the actual school location for those persons who are not home-schooled.

Estimated and final calibrated model coefficients for the home-schooled/not home-schooled choice model are shown in ***Apppendix F.1***.

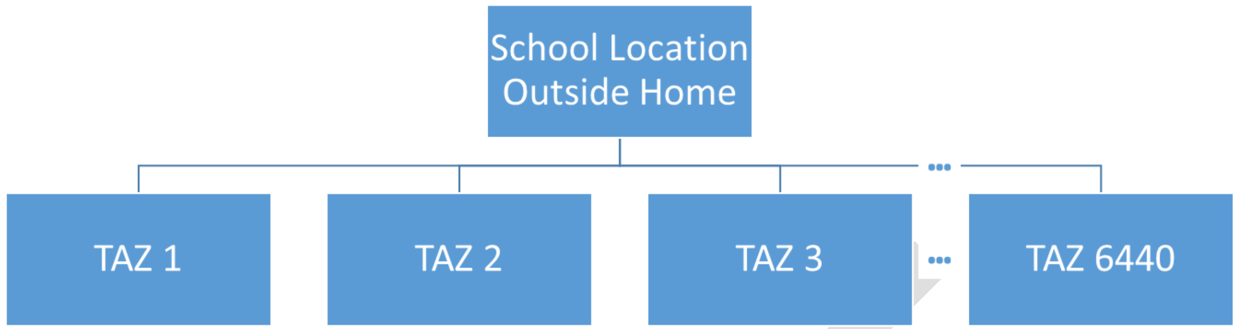
4.2.4 Regular School Location Choice / Point Location Monte Carlo

Model Structure

The regular school location choice model is a multinomial logit model that assigns regular school locations for all students who are not home-schooled as determined by the home-schooled/not home-schooled choice model (see ***Section 4.2.3***). The structure of the model is shown in ***Figure 4.8***.

[36] The FRTC estimation data did not contain any observations of part-time workers (person type 2) who were also students. Thus, the parameter for this person-type was undefined. In application, this part-time workers who are also students can exist and should not automatically be assigned as a not being home-schooled.

Figure 4.8 Regular School Location Choice Structure



Source: Cambridge Systematics

Utility Function

The general form of the utility equation for the regular school location in TAZ_j for non-home schooled persons is:

$$U_{j|p} = \sum_{x=1}^{NS} \left(NonSizeCoeff_{x|p} \times NonSizeVar_{x|p} \right) + \beta_{lsm} \times Ln \left[\sum_{y=1}^{S} exp\left(SizeCoeff_{y|p} \right) \times SizeVar_{y|p} \right]$$

Where: $U_{j|p}$ is the utility of a school location in TAZ *j* for person type *p*
$NonSizeCoeff_{x|p}$ are the coefficients applied to the non-size variables that are applicable for person type *p*, $NonSizeVar_{x|p}$
β_{lsm} is the logsum multiplier applied to the natural log of the size variable component of the model
$SizeCoeff_{x|p}$ are the coefficients applied to the size variables that are applicable for person type *p*, $SizeVar_{x|p}$

Variables

Two general types of variables are used in the regular school location choice model:

- Non-size variables which may include:
  - continuous variables such as distance or logsum measures between the home zone and the alternative school zone,
  - 0/1 dummy variables that take on the value of 1 if the variable possesses the characteristic defined (e.g. person in school up to grade 8 has an older sibling attending school in the same zone) and 0 otherwise.

  The non-size variables are conditional on the school type attended by the student. For example, the distance from the home zone to a zone with pre-kindergarten enrollment is not considered for a person in high school.

- Size variables that describe the quantity of opportunities available at the alternative school zone[37]:
  - the school enrollment, and
  - the educational employment.

  As with the non-size variables, the size variables are conditional on the school type attended by the student. For example, pre-kindergarten school enrollment is not considered for a person in high school.

Table 4.4 lists the variables used in the workplace location choice model; ***Appendix F.4*** lists the estimated and final model coefficients.

Table 4.4 Regular School Location Choice Variables

Variable	Applied for Students in grades:				Comments
	Pre-K	K-8	9-12	Post-High School	
Size Variables					
Beta Logsum Multiplier	x	x	x	x	Size variable logsum multiplier
Pre-school enrollment	x				
K-8 enrollment		x			
High school enrollment			x		
College/university enrollment				x	
Pre-school educational employment	x				
K-8 educational employment		x			
High school educational employment			x		
College/university educational employment				x	
Non-Size Variables					
Pre-school Students					
Distance from home to school zone in miles[1]	x				Applied to one-way distance.
Distance from home to school zone greater than 1 mile[1]	x				Applied to one-way distance.
Natural log of 1+distance	x				Applied to one-way distance.
K-8 Students					
Distance from home to school zone in miles[1]		x			Applied to one-way distance.
Distance from home to school zone greater than 1 mile[1]		x			Applied to one-way distance.
Natural log of 1+distance		x			Applied to one-way distance.

[37] During model calibration, it was discovered that the model was illogically sensitive to the size variables. As a result, the influence of the size variables was effectively zeroed out by adjusting the estimated coefficients.

Variable	Applied for Students in grades:				Comments
	Pre-K	K-8	9-12	Post-High School	
High School Students					
Distance from home to school zone in miles[1]			x		Applied to one-way distance.
Distance from home to school zone greater than 3 miles[1]			x		Applied to one-way distance.
Distance from home to school zone greater than 10 miles[1]			x		Applied to one-way distance.
College/University Students					
Distance from home to school zone in miles[1]				x	Applied to one-way distance.
Distance from home to school zone greater than 7 miles[1]				x	Applied to one-way distance.
Mode Choice Logsum	x	x	x	x	Applied to round trip logsum.
Older sibling attends school in the same zone – pre-school or K-8 student	x	x			
Older sibling attends school in the same zone – high school student			x		
Destination zone is in the same school district as the home zone	x	x	x		

Source: Cambridge Systematics.
Note: [1] The use of these distance variables and their associated model coefficients form a stepwise linear distance function.

Regular School Point Location Monte Carlo

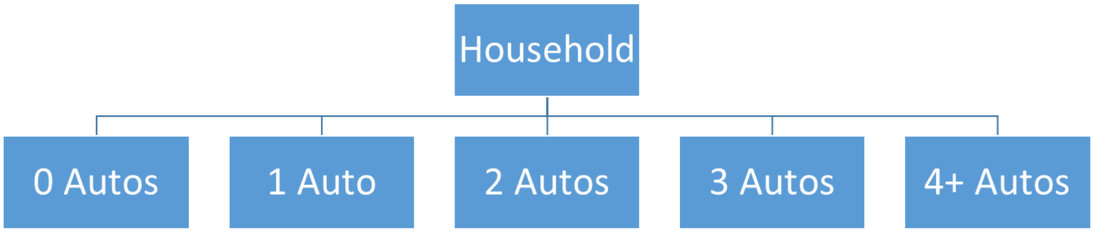
The regular school location choice model is used to forecast a destination TAZ for each person with a regular school location. The household location for each person has already been assigned to an actual point within the home TAZ and each school in a TAZ has also been assigned to a point (see ***Section 2.3.2***). The regular school point location Monte Carlo uses a simple random selection process to select an actual school and its point location from the set of all schools within the TAZ chosen for the regular school location for each person. This process is performed using a grade-segmented process to ensure that pre-school students travel to pre-school locations, K-8 students travel to elementary schools, high school students travel to high schools, and adult students travel to colleges or universities.

4.2.5 Autos Available Choice

Model Structure

This autos available choice model represents the long term choice of the number of vehicles owned for each household. This choice is modeled using a multinomial logit model, with the alternatives being the number of cars owned from zero up to four. Households with more than four are rare and consolidated into the four-auto alternative.

Figure 4.9 Autos Available Choice Structure



Source: Cambridge Systematics.

Utility Function Structure

The general form of the utility equation for the household auto availability choice model is:

$$U_a = \sum_{h=1}^{H} (HHCoeff_{h|a} \times HHVar_h) + \sum_{z=1}^{Z} (ZoneCoeff_{z|a} \times ZoneVar_z) + WLSCoeff_{w|a} \times WLSDiff_w$$

Where: U_a is the utility of a autos available to the household for a = 0, 1, 2, 3, or 4+
$HHCoeff_{h|a}$ are the coefficients for autos available, a, applied to variables characterizing the household, $HHVar_h$
$ZoneCoeff_{z|a}$ are the coefficients for autos available, a, applied to variables characterizing the zone where the household is located (also considering the point location for the household within the zone), $ZoneVar_z$
$WLSCoeff_{w|a}$ are the coefficients for autos available, a, applied to home-based work tour mode choice to logsum differences between 0 autos and autos for all drivers summed over all workers, w, in the household, $WLSDiff_w$ (see ***Variables*** for an expanded explanation)

Variables

Three general types of variables are used in the auto availability choice model:

- Household based variables:
  - number of drivers,
  - number of workers,
  - number of part-time workers per driver,
  - number of children under 5 per driver,
  - number of driving age children per driver,
  - number of elderly (75+) adults per driver,
  - number of university students per driver,
  - number of non-working adults,
  - household income group (five standard groupings – see ***Section 3.1.1***)

- Characteristics of the zone and the location within the zone where the household is located:
  - natural logarithm of service employment density in the home zone (greater service employment in the immediate area makes owning more cars less important)
  - amount by which orthogonal (XY) distance from home location point to nearest transit stop is less than 0.5 miles, capped at .25 (the closer a local, premium, or rail stop is to the home, the bigger this variable will be (in the range of .25 to 0). If the distance is greater than 0.5 miles, then this variable will be equal to zero)

$$TSDist = max[min(0.5 - XYDist, 0.25), 0]$$

where: TSDist is transit stop distance variable
XYDist is the orthogonal distance in miles from the home location point to nearest transit stop

- Difference between work mode choice logsums assuming the household has no cars and the household has cars for all drivers:
  - Each worker in the household who has an out-of-home usual work location has a home-based work tour mode choice logsum between home and usual work location calculated in two ways: assuming that each driver in the household has an auto available, and assuming that the household has no autos. For each person who has a usual work location, the difference of these two logsums is calculated, and then these differences are summed over all workers in the household.
  - This is a measure of transit quality, because if transit is good to the workplace locations, then the logsum with no cars will be comparatively better in comparison to the other logsum than if transit service is poor. If transit service improves, this value goes down.
  - The difference in logsums variable is, in effect, associated with a dummy variable since it is applied only for households having fewer cars than workers. The expected coefficient is negative so that better transit service (i.e. the difference in the logsums goes down) means fewer autos will be needed by the household. Moreover, a coefficient of greater negative value is expected for lower income households than for higher income households.

Coefficients for the model variables listed above may be different for different auto availability options and may also differ based on the number of workers or drivers in the household compared to the auto availability option. ***Table 4.5*** lists the variables used in the auto availability choice model; ***Appendix F.5*** lists the estimated and final model coefficients.

Table 4.5 Auto Available Model Choice Variables

Variable	0 Autos	1 Auto	2 Autos	3 Autos	4+ Autos
Household Variables					
Low income	AA Specific[1]	AA Specific	–	AA Specific	AA Specific
Modest income	AA Specific	AA Specific	–	AA Specific	AA Specific
Upper income	AA Specific	AA Specific	–	AA Specific	AA Specific
Top income	AA Specific	AA Specific	–	AA Specific	AA Specific
1 driver in household	AA Specific	–	AA Specific	AA Specific	AA Specific
2 drivers in household		AA Specific	–	AA Specific	AA Specific
3 drivers in household	} AA Specific	AA Specific	AA Specific	–	AA Specific
4+ drivers in household		AA Specific	AA Specific	AA Specific	–
Adults age 75 or older per driver	AA Specific	AA Specific	–	–	AA Specific
Children under 5 per driver	AA Specific	AA Specific	–	AA Specific	AA Specific
Part-time workers per driver	–	–	–	–	AA Specific
Children age 16 or older per driver	–	–	–	–	AA Specific
At least as many autos as workers	Common Coefficient Across Auto Availability Levels				
Zonal Variables					
Log (1+Service Employment Density)					
Autos < Drivers	Common Coefficient Across Auto Availability Levels				
Autos ≥ Drivers	Common Coefficient Across Auto Availability Levels				
No autos	AA Specific	–	–	–	–
Transit Stop Distance Variable					
Autos < Drivers	Common Coefficient Across Auto Availability Levels				
Autos ≥ Drivers	Common Coefficient Across Auto Availability Levels				
Home-Based Work Mode Choice Logsum Variables					
Sum of Differences Between 0 Autos Logsums and 1 Auto / Driver Logsums Across All Full-Time Workers with a Regular Workplace					
Low & modest income	Common Coefficient Across Auto Availability Levels				
Middle income	Common Coefficient Across Auto Availability Levels				

Source: Cambridge Systematics and CDOT.
Note: AA Specific means that separate coefficients are estimated for each auto availability level.

4.2.6 Daily Activity Pattern Choice

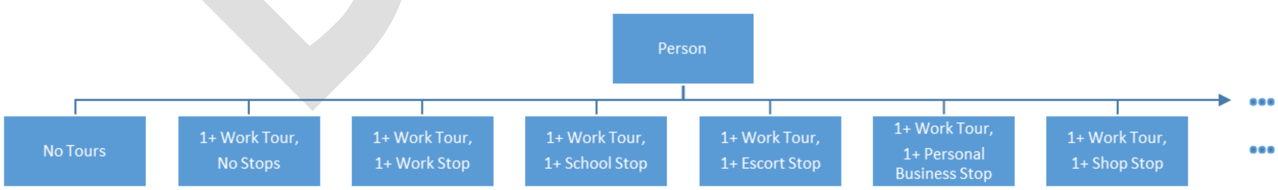
Model Structure

The StateFocus daily activity pattern (DAP) choice model is structured to determine the presence of tours by purpose and the presence of stops by purpose in a person's overall activity schedule. It does not determine the number of tours and stops for each person, but only the presence of tours or stops for each purpose for each person. The exact number of tours for each purpose, conditional on making 1+ tours as forecast by this model, is forecast in the Exact Number of Tours Choice model (see ***Section 4.2.7***). The actual number of stops made on a tour for each stop purpose, conditional on 1+ stops being forecast by this model, is forecast in the Intermediate Stop Generation Choice model (see ***Section 4.2.15***). For each tour purpose, a person may have 0 or 1+ tours for that purpose. For each stop purpose, a person may have 0 or 1+ stops for that purpose. There are seven activity purposes for closed tours allowed in the model:

- Work
- School
- Escort
- Personal Business
- Shop
- Meal
- Social/Recreation

The DAP model is a multinomial logit model enumerating all combinations of 0 or 1+ tours and stops for each purpose (see ***Figure 4.10***). With 14 tour/stop purposes (seven tour purposes and seven stop purposes) each having two possible values, there are 2^{14}, or 16,384 alternative tour/stop combinations for closed tours. The StateFocus model must also account for non-closed tours (see ***Section 3.2.3***). Two new non-closed purposes, non-closed work tours and non-closed other tours, have been added to the 14 closed tour/stop alternatives described above, for a total of 16 tour/stop purposes. With 16 tour/stop purposes, the number of alternatives increases to 2^{16}, or 65,536.

Figure 4.10 Daily Activity Pattern Choice Model



Source: Cambridge Systematics

Many of these alternatives were eliminated from the model by restrictions on valid combinations of the variables (e.g. 1+ tours must exist for any stops to exist). The restrictions used for DRCOG's Focus model formed the starting point to reduce the number of alternatives for closed tours/stops and additional restrictions were added to reduce the number of alternatives when the non-closed tours were added. In general, restrictions arose either from simple logic (such as the first restriction) or were based on analysis of the FRTC survey data. Restrictions were added for tour and stop patterns that were not observed or were observed very infrequently in the data (e.g. restrictions 2 and 8). The restrictions used are listed below:

- Closed tour/stop model restrictions:

  4. There can be no intermediate stop purpose with 1+ stops unless there is at least 1 tour purpose with 1+ tours (there can be no stops if there are no tours).

  5. The maximum number of tour purposes with 1+ tours is 3.

  6. The maximum number of stop purposes with 1+ stops is 4.

  7. The maximum number of tour purposes with 1+ tours plus stop purposes with 1+ stops is 5.

  8. The pattern cannot include both intermediate work stops and school stops (if one is 1+, the other must be 0).

  9. There can be no intermediate work stops or school stops unless there are 1+ work tours (closed or non-closed) and/or 1+ school tours.

- Additional model restrictions to reduce alternatives due to the inclusion of non-closed tours:

  10. If there are non-closed work tours, then non-closed other tours must be 0, and vice versa.

  11. If non-closed tours are present, then the maximum number of tour purposes is reduced to 2.

  12. If non-closed tours are present, then the maximum number of stop purposes is reduced to 3.

  13. If non-closed tours are present, then the maximum number of tour purposes with 1+ tours plus stop purposes with 1+ stops is reduced to 4.

  14. The maximum number of (work tours and school tours) plus (work stops and school stops) is 2.[38]

  15. If there are 1+ school tours, then work stops must be 0.

  16. If there are 1+ non-closed work tours, then school tours must be 0 and school stops must be 0.

Based on the 13 restrictions, the number of alternatives in the model are reduced from 65,536 to 2,146.[39]

[38] Four tour and stop purposes can be generated: 1) work tour, 2) school tour, 3) work stop, 4) school stop. Only two of these can be 1. So, if a work tour and school tour are generated, there must be no work or school stops. Other non-mandatory purposes can still accompany whatever is generated for work/school.

[39] For model estimation, 541 (1.8 percent) of the 29,388 total observations (persons in the model estimation file) violated one or more of the 13 restrictions. Those observations were recoded into the most similar pattern that did not violate the restrictions.

Utility Function

The main utility component for each set of purpose-specific tour and/or stop purposes is a vector of person-specific and household-specific characteristics and accessibility measures. In addition to the person-specific and household-specific characteristics and accessibility measures, there are numerous constants based on tour purpose, stop purpose, numbers of tours and stops during the day, and combinations of tours and stops. The base alternative, stay at home for the entire day, has 0.0 utility. The utility for other 2,145 alternatives making 1+ tours (for a specific purpose) combined with making either 0 or 1+ stops (for a specific purpose) on the tour is calculated as follows:

$$
\begin{aligned}
U_{DAP} = \Bigg\{ \sum_{t=1}^{9}\sum_{s=1}^{7} \Bigg[& (TI_t \times BPtk_t) + (SI_s \times BPsk_s) + TI_t \times \left(\sum_{pc=1}^{PC} \left(BPphc_{pc|t} \times PHC_{pc}\right) + \sum_{i=1}^{n} \left(BPls_t \times LS_{i|t}\right) \right) \\
& + SI_{s|s\neq t} \times \left(\sum_{pc=1}^{PC} \left(BPphc_{pc|s} \times PHC_{pc}\right) + \sum_{i=1}^{n} \left(BPls_s \times LS_{i|s}\right) \right) \Bigg] \Bigg\} \\
& + \left[ln(NT) \times \left(\sum_{pc=1}^{PC} \left(BTphc_{pc} \times PHC_{pc}\right) + \left(BTls_i \times HAALS_i\right) \right) \right] \\
& + \left[ln(NS) \times \left(\sum_{pc=1}^{PC} \left(BSphc_{pc} \times PHC_{pc}\right) + \left(BSls_i \times HAALS_i\right) \right) \right] + \sum_{t=1}^{9} \sum_{t2=t+1}^{9} \left(TI_t \times TI_{t2} \times X_{t,t2}\right) \\
& + \sum_{s=1}^{7} \sum_{s2=s+1}^{7} \left(SI_s \times SI_{s2} \times Y_{s,s2}\right) + \sum_{t=1}^{9}\sum_{s=1}^{7} \left(TI_t \times SI_s \times Z_{t,s}\right) + C_{NT,NS}
\end{aligned}
$$

Where:

- U_{DAP} is the utility of a specific Daily Activity Pattern comprising 1+ tours for specific purpose(s) combined with 0 or 1+ stops for specific purpose(s)
- t & $t2$ are indices that range from 1 to 9 for the different purposes representing work, school, escort, personal business, shop, meal, social/recreation, non-closed work, and non-closed other
- s & $s2$ are indices that range from 1 to 7 for the different purposes representing work, school, escort, personal business, shop, meal, social/recreation (note that non-closed purposes apply only to tours)
- TI_t is 1 if there are 1+ tours in the alternative for purpose *t* and 0 otherwise
- SI_s is 1 if there are 1+ stops in the alternative for purpose *s* and 0 otherwise
- $BPtk_t$ is a purpose-specific constant related to making 1+ tours for a specific purpose *t*[40]
- $BPsk_s$ is a purpose-specific constant related to making 1+ stops for a specific purpose *s*
- *pc* is an index for person characteristics or characteristics of the household in which the person is a member (e.g. person type, household income); *pc* ranges from 1 to *PC* characteristics
- $BPphc_{pc|\bullet}$ is a purpose-specific array of coefficients based on person characteristics or characteristics of the household in which the person is a member to making 1+ tours or 1+ stops for a specific purpose • (where • refers to either tour purpose *t* or stop purpose *s*) provided the stop purpose is not the same as the tour purpose (the coefficients are

[40] The original DRCOG Focus model and the C# implementation code include seven coefficient arrays: BP, BT, BS, X, Y, Z, and $C_{NT,NS}$. The original equation has been expanded to increase mathematical correctness while attempting to maintain a correspondence to the original DRCOG Focus model and the C# implementation code. Thus, BPtk, BPsk, BPphc, and BPls all relate to the original BP coefficient array, BTphc and BTls relate to the original BT coefficient array, and BSphc and BSls relate to the original BS coefficient array.

applied only once for stops and tours of same purpose as indicated by the conditional index $SI_{s|s \neq t}$)

PHC_{pc} is 1 if the person has the person characteristic or is a member of a household with the specified household characteristic and 0 otherwise

$BPls_{\bullet}$ is an array of coefficients based on the mode choice logsum for the person's work tour to their regular work location or school tour to their regular school location or, for other purposes, the aggregate accessibility logsum associated with the home zone of the person for a specific purpose ● (where ● refers to either tour purpose *t* or stop purpose *s*), again provided the stop purpose is not the same as the tour purpose (the coefficients are applied only once for stops and tours of same purpose as indicated by the conditional index $SI_{s|s \neq t}$)

$LS_{i|\bullet}$ is the mode choice logsum for the person's work tour to their regular work location or school tour to their regular school location or, for other purposes, the aggregate accessibility logsum associated with the home zone, *i*, of the person for a specific purpose ●, where ● is either tour purpose *t* or stop purpose *s*

NT is the minimum of the sum of TI_t across the 9 tour purposes and 3; ($1 \leq NT \leq 3$)

$BTphc_{pc}$ is an array of coefficients based on person characteristics or characteristics of the household in which the person is a member related, *pc,* related to making more tours; since the sum of the coefficients are multiplied by ln(count of tours), this component does not become active unless there are two or more tour purposes in the daily activity pattern

$BTls_i$ is a coefficient for additional tours based on the home average aggregate accessibility logsum, $HAALS_i$, associated with the home zone, *i,* of the person

$HAALS_i$ is the home average accessibility logsum for zone *i*; $HAALS_i$ is the average across aggregate accessibility logsums for the escort, personal business, shop, meal, and social/recreation tour purposes (i.e. the aggregate accessibility logsums are summed and divided by 5)

NS is the maximum of 1 and the minimum of the sum of SI_s across the 7 stop purposes and 4; ($1 \leq NS \leq 4$)

$BSphc_{pc}$ is an array of coefficients based on person characteristics or characteristics of the household in which the person is a member related, *pc,* related to making more stops; since the sum of the coefficients are multiplied by ln(count of stops), this component does not become active unless there are two or more stop purposes in the daily activity pattern

$BSls_i$ is a coefficient for stops based on the home average aggregate accessibility logsum, $HAALS_i$, associated with the home zone, *i,* of the person

$BX_{t,t2}$ is a matrix of coefficients for making tours for BOTH of a given pair of tour purposes, *t* and *t2*. Only a half-matrix is estimated, with the diagonal constrained to 0.

$BY_{s,s2}$ is a matrix of coefficients for making stops for BOTH of a given pair of stop purposes, *s* and *s2*. Only a half-matrix is estimated, with the diagonal constrained to 0.

$BZ_{t,s}$ is a matrix of coefficients for making a stop, *s*, of a given purpose in combination with a tour, *t*, of a given purpose. Here, a nearly full matrix can be estimated, as all stop purposes and tour purposes can occur together in the same pattern.

$C_{NT,NS}$ is a set of constants related to making tours for exactly NT different purposes and stops for exactly NS different purposes

The variables used in the equation outlined above are described in the following section and the utility equations for several alternative daily activity patterns are provided in the ***Example Utility Equations*** section.

Variables

Person and Household Characteristics

These variables come from the characteristics of the traveler being modeled and his or her household based on information from PopGen2, the regular/no regular workplace choice model, the regular workplace location choice model, the home-schooled/not home-schooled choice model, and the autos available choice model.

Table 4.6 lists the person and household characteristics used along with the coefficient arrays with which they are associated.

Table 4.6 Person and Household Characteristic Variables Used in the Daily Activity Pattern Choice Model

Variable	Source	Used with Coefficient Arrays	Notes
Person Type			
Part-time worker	PopGen2	BPphc, BTphc, BSphc	0/1 variable
Non-worker age 65+	PopGen2	BPphc, BTphc, BSphc	0/1 variable
Other non-worker	PopGen2	BPphc, BTphc, BSphc	0/1 variable
University student	PopGen2	BPphc, BTphc, BSphc	0/1 variable
Student age 16+	PopGen2	BPphc, BSphc	0/1 variable
Student age 5-15	PopGen2	BPphc, BTphc, BSphc	0/1 variable
Child age 0-4	PopGen2	BPphc	0/1 variable
Household			
Lower income	PopGen2	BPphc, BTphc, BSphc	0/1 variable
Modest income	PopGen2	BPphc, BTphc, BSphc	0/1 variable
Upper income	PopGen2	BPphc	0/1 variable
Top income	PopGen2	BPphc	0/1 variable
Derived Household & Person Variables			
Autos per adult	PopGen2 & Autos available	BPphc, BTphc, BSphc	Continuous
Autos per (workers + 1)	PopGen2 & Autos available	BPphc	Continuous
Only adult in household	PopGen2	BPphc, BSphc	0/1 variable
Only worker in household	PopGen2	BPphc, BTphc	0/1 variable
Adult female-no children	PopGen2	BPphc	0/1 variable
Adult female with child age 0-4	PopGen2	BPphc	0/1 variable
Adult female with child age 0-15	PopGen2	BPphc	0/1 variable
Adult male with child age 0-4	PopGen2	BPphc	0/1 variable
Adult male with child age 0-15	PopGen2	BPphc, BTphc, BSphc	0/1 variable
Adult, age 18-25	PopGen2	BPphc, BTphc, BSphc	0/1 variable
Adult, age 26-35	PopGen2	BPphc	0/1 variable
Adult, age 51-65	PopGen2	BPphc, BTphc, BSphc	0/1 variable
Adult, age 66+	PopGen2	BPphc, BTphc, BSphc	0/1 variable
Other Person & Household			
Work at home	Regular work location	BPphc	0/1 variable
No regular workplace	Regular/no regular workplace	BPphc	0/1 variable
Non-student	PopGen2	BPphc	0/1 variable
Home-schooled	Home-schooled/not home-schooled	BPphc	0/1 variable

Source: Cambridge Systematics

No set of variables used in the vector can cover the entire sample, so each characteristic used must have a base group. For the estimation, persons with the following "base" characteristics are assumed to have coefficient 0, with other person- and household-specific variables estimated relative to these:

- Person type: Full-time worker
- Age group: 36-50
- Gender/role: Male adult with no children under age 16
- Household composition: Family household with 2+ adults and 2+ workers.
- Household income: Middle Income

Zonal Variables

Each household is associated with a zonal variable, home retail employment density which is calculated as:

$$HRED = \frac{RetailDensHHCentroid}{1000}$$

Where: *RetailDensHHCentroid* is the number of retail employees in 0.5 mile buffer around the zone household virtual centroid (see ***Section 2.3.4*** and ***Appendix C***).

The variable is used in association with the model coefficient array *BPphc*.

Transportation Level of Service Variables

The two transportation level of service are continuous variables obtained from the disaggregate and aggregate logsum data:

- The **mode choice logsums** are disaggregate logsums used for determining the utility of making one or more work tours or school tours as well as the utility of making one or more work stops or school stops (see ***Daily Activity Pattern and Exact Number of Tours Choice Logsums*** in ***Section 4.1.1***) during the day. The disaggregate logsums can be used since the daily activity pattern choice model follows the regular workplace location choice and regular school location choice models meaning that the regular workplace and the regular school locations are known. The logsums are for out of home locations only (i.e. they exclude the work at home alternative). The disaggregate logsums are associated with the model coefficient array *BPls*.

- **Aggregate accessibility logsums** (see ***Section 4.1.2***) are used for determining the utilities of making one or more escort, shop, meal, or non-closed work tours as well as the utility of making one or more escort, shop, or meal stops during the day. Aggregate logsums are purpose specific and provide a measure of the overall average accessibility of the home location to all locations that can serve the tour purpose since actual destinations for the non-work and non-school tours are determined after the daily activity choice model. In order to simplify the model application, the aggregate accessibility for non-closed work tours is the average of the aggregate accessibilities for escort, personal business, shop, meal, and social-recreation. The aggregate accessibility logsums are associated with the model coefficient arrays *BPls*.

- **Household average accessibility logsums** are used for determining the utilities of making more tours during the day. Household average aggregate accessibility logsums are the average across aggregate accessibility logsums for the escort, personal business, shop, meal, and social/recreation tour purposes (i.e. the aggregate accessibility logsums are summed and divided by 5). The aggregate accessibility logsums are associated with the model coefficient arrays *BTls* and *BSls*.

Constants and Dummy Variables

Purpose specific tour and stop constants, tour combination dummy variables (e.g. make 1+ work & 1+ school tours), stop combination dummy variables (e.g. make 1+ work & 1+ escort stops), tour and stop combination dummy variables (e.g. make 1+ work tour & 1+ school stops), and tour/stop frequency dummy variables (e.g. 1 tour purpose & 2 stop purposes) are used in the model. The constants and dummy variables are defined by that actual alternative being considered. ***Table 4.7*** lists the constants and dummy variables along with the coefficient arrays where they are used.

Table 4.7 Constants and Dummy Variables Used in the Daily Activity Pattern Choice Model

Variable	Used with Coefficient Arrays	Notes
Purpose Constants		
Tour	BPtk	Used if alternative includes 1+ tours for the purpose specified (tour purposes are work, school, escort, personal business, shop, meal, social/recreation, non-closed work, and non-closed other)
Stop	BPsk	Used if alternative includes 1+ stops for the purpose specified (stop purposes are work, school, escort, personal business, shop, meal, and social/recreation)
Tour & Stop Combination Dummy Variable Constants		
First Tour Purpose & Second Tour Purpose	X	Used if alternative includes 1+ tours for Tour Purpose 1 and 1+ tours for Tour Purpose 2; if there are three tour purposes, coefficients for all possible two purpose combinations are used (TP1-TP2, TP1-TP3, TP2-TP3)
First Stop Purpose & Second Stop Purpose	Y	Used if alternative includes 1+ stops for Stop Purpose 1 and 1+ stops for Stop Purpose 2; if there are three stop purposes, coefficients for all possible two purpose combinations are used (SP1-SP2, SP1-SP3, SP2-SP3)
Tour Purpose & Stop Purpose	Z	Used if alternative includes 1+ tours for the specified Tour Purpose and 1+ stops for the specified Stop Purpose; if there is more than one tour purpose or more than one stop purpose for the alternative, coefficients for all possible two purpose combinations are used (e.g. TP1-SP1, TP1-SP2…, TP2-SP1, TP2-SP2…)
Tour/Stop Purpose Count	$C_{NT,NS}$	Used if the alternative is for the number of tour purposes combined with the number of count purposes (e.g. 1 tour purpose & 1 stop purpose, 1 tour purpose & 2 stop purposes…, 3 tour purposes & 2 stop purposes). The maximum number of tour purposes + stop purposes is 5.

Source: Cambridge Systematics

Example Utility Equations

Several examples of the 2,146 daily activity patterns evaluated for each person are shown below. All of the coefficients and constants in the examples are based on the original model estimation so that they can be compared to the estimated parameters for the entire model shown in ***Appendix F.6*** (the final calibrated parameters also shown in the appendix might be updated if StateFocus is calibrated/validated to a new base year possibly resulting in a conflict between what is shown below and the calibrated parameters). The example equations shown below are in a reduced form in that the estimated parameters for only those parameters that are non-zero are shown. For example, if the alternative is one with no stops, none of the stop related parameters are shown.

Examples of the resulting utilities for the four daily activities for four example person types are shown in ***Table 4.8*** after the equation listings. The utility function for any other alternative daily activity pattern can be determined using the complete model estimation results shown in the ***Appendix F.6***.

No Tours, No Stops

$U_{DAP} = 0$

1+ Work Tours ("1+ WT"), No Stops

$U_{DAP} = 1.134$	[*BPtk* – 1+ WT constant]
$-1.023 \times$ *Part-time worker*	[*BPphc* for 1+ WT]
$-2.607 \times$ *Non-worker age 65+*	[*BPphc* for 1+ WT]
$-2.138 \times$ *Other non-worker*	[*BPphc* for 1+ WT]
$-1.562 \times$ *University student*	[*BPphc* for 1+ WT]
$-2.491 \times$ *Student age 16+*	[*BPphc* for 1+ WT]
$-20.00 \times$ *Student age 5-15*	[*BPphc* for 1+ WT]
$-20.00 \times$ *Child age 0-4*	[*BPphc* for 1+ WT]
$+0.075 \times$ *Autos per adult*	[*BPphc* for 1+ WT]
$-0.036 \times$ *Only worker in household*	[*BPphc* for 1+ WT]
$-0.279 \times$ *Adult female with child age 0-4*	[*BPphc* for 1+ WT]
$-0.203 \times$ *Adult age 51-65*	[*BPphc* for 1+ WT]
$-0.307 \times$ *Adult age 66+*	[*BPphc* for 1+ WT]
$-2.458 \times$ *Work at home*	[*BPphc* for 1+ WT]
$-5.026 \times$ *No regular workplace*	[*BPphc* for 1+ WT]
$+0.299 \times$ *Mode choice logsum*	[*BPls* for 1+ WT]

1+ Work Tours (1+WT), 1+ Escort Stops (1+ ES)

$U_{DAP} = 1.134$	[*BPtk* – 1+ WT constant]
-2.303	[*BPsk* – 1+ ES constant]
$(-1.023 +0.000) \times$ *Part-time worker*	[*BPphc* for 1+ WT & 1+ ES]
$(-2.607 -0.315) \times$ *Non-worker age 65+*	[*BPphc* for 1+ WT & 1+ ES]
$(-2.138 -0.181) \times$ *Other non-worker*	[*BPphc* for 1+ WT & 1+ ES]
$(-1.562 -0.612) \times$ *University student*	[*BPphc* for 1+ WT & 1+ ES]
$(-2.491 +0.346) \times$ *Student age 16+*	[*BPphc* for 1+ WT & 1+ ES]
$(-20.00 +1.085) \times$ *Student age 5-15*	[*BPphc* for 1+ WT & 1+ ES]
$(-20.00 +1.396) \times$ *Child age 0-4*	[*BPphc* for 1+ WT & 1+ ES]

(+0.000 +0.138) × Upper income	[*BPphc* for 1+ WT & 1+ ES]
(+0.000 +0.138) × Top income	[*BPphc* for 1+ WT & 1+ ES]
(+0.075 −0.097) × Autos per adult	[*BPphc* for 1+ WT & 1+ ES]
(−0.036 −0.434) × Only worker in household	[*BPphc* for 1+ WT & 1+ ES]
(+0.000 +0.258) × Adult female, no children	[*BPphc* for 1+ WT & 1+ ES]
(−0.279 +0.000) × Adult female with child age 0-4	[*BPphc* for 1+ WT & 1+ ES]
(−0.000 +2.461) × Adult female with child age 0-15	[*BPphc* for 1+ WT & 1+ ES]
(−0.000 +2.069) × Adult male with child age 0-15	[*BPphc* for 1+ WT & 1+ ES]
(−0.203 −0.300) × Adult age 51-65	[*BPphc* for 1+ WT & 1+ ES]
(−0.307 −0.335) × Adult age 66+	[*BPphc* for 1+ WT & 1+ ES]
(−2.458 +0.132) × Work at home	[*BPphc* for 1+ WT & 1+ ES]
(−5.026 +0.000) × No regular workplace	[*BPphc* for 1+ WT & 1+ ES]
(+0.299 +0.000) × Mode choice logsum	[*BPls* for 1+ WT & 1+ ES]
(+0.000 +0.078) × Aggregate accessibility logsum	[*BPls* for 1+ WT & 1+ ES]
+1.205	[*Z* for 1+ WT & 1+ ES]
−2.164	[$C_{NT,NS}$ for 1 tour & 1 stop purpose]

1+ Work Tours (1+ WT), 1+ Shop Tours (1+ ST), 1+ Escort Stops (1+ ES)

U_{DAP} = *1.134*	[*BPtk* – 1+ WT constant]
−3.249	[*BPtk* – 1+ ST constant]
−2.303	[*BPsk* – 1+ ES constant]
(−1.023 +0.293 +0.000) × Part-time worker	[*BPphc* for 1+ WT, 1+ST, & 1+ ES]
(−2.607 +0.324 −0.315) × Non-worker age 65+	[*BPphc* for 1+ WT, 1+ST, & 1+ ES]
(−2.138 +0.372 −0.181) × Other non-worker	[*BPphc* for 1+ WT, 1+ST, & 1+ ES]
(−1.562 +0.000 −0.612) × University student	[*BPphc* for 1+ WT, 1+ST, & 1+ ES]
(−2.491 −0.568 +0.346) × Student age 16+	[*BPphc* for 1+ WT, 1+ST, & 1+ ES]
(−20.00 +0.000 +1.085) × Student age 5-15	[*BPphc* for 1+ WT, 1+ST, & 1+ ES]
(−20.00 +0.000 +1.396) × Child age 0-4	[*BPphc* for 1+ WT, 1+ST, & 1+ ES]
(+0.000 +0.000 +0.138) × Upper income	[*BPphc* for 1+ WT, 1+ST, & 1+ ES]
(+0.000 +0.000 +0.138) × Top income	[*BPphc* for 1+ WT, 1+ST, & 1+ ES]
(+0.075 +0.000 −0.097) × Autos per adult	[*BPphc* for 1+ WT, 1+ST, & 1+ ES]
(+0.000 +0.028 +0.000) × Autos per (workers + 1)	[*BPphc* for 1+ WT, 1+ST, & 1+ ES]
(+0.000 +0.028 +0.000) × Only adult in household	[*BPphc* for 1+ WT, 1+ST, & 1+ ES]
(−0.036 +0.000 −0.434) × Only worker in household	[*BPphc* for 1+ WT, 1+ST, & 1+ ES]
(+0.000 +0.251 +0.258) × Adult female, no children	[*BPphc* for 1+ WT, 1+ST, & 1+ ES]
(−0.279 +0.100 +0.000) × Adult female with child age 0-4	[*BPphc* for 1+ WT, 1+ST, & 1+ ES]
(−0.000 +0.000 +2.461) × Adult female with child age 0-15	[*BPphc* for 1+ WT, 1+ST, & 1+ ES]
(−0.000 −0.204 +0.000) × Adult male with child age 0-4	[*BPphc* for 1+ WT, 1+ST, & 1+ ES]
(−0.000 +0.137 +2.069) × Adult male with child age 0-15	[*BPphc* for 1+ WT, 1+ST, & 1+ ES]
(−0.203 −0.084 −0.300) × Adult age 51-65	[*BPphc* for 1+ WT, 1+ST, & 1+ ES]
(−0.307 −0.154 −0.335) × Adult age 66+	[*BPphc* for 1+ WT, 1+ST, & 1+ ES]
(−2.458 +0.099 +0.132) × Work at home	[*BPphc* for 1+ WT, 1+ST, & 1+ ES]
(−5.026 +0.000 +0.000) × No regular workplace	[*BPphc* for 1+ WT, 1+ST, & 1+ ES]
(+0.299 +0.000 +0.000) × Mode choice logsum	[*BPls* for 1+ WT, 1+ST, & 1+ ES]
(+0.000 +0.045 +0.078) × Aggregate accessibility logsum	[*BPls* for 1+ WT, 1+ST, & 1+ ES]
[ln(2) × (+0.708 × Part-time worker)]	[*BTphc* for 2 tour purposes]
[ln(2) × (+0.418 × Non-worker age 65+)]	[*BTphc* for 2 tour purposes]

[ln(2) × (+0.453 × Other non-worker)]	[*BTphc* for 2 tour purposes]
[ln(2) × (+0.574 × University student)]	[*BTphc* for 2 tour purposes]
[ln(2) × (−0.572 × Student age 5-15)]	[*BTphc* for 2 tour purposes]
[ln(2) × (−0.399 × Lower income)]	[*BTphc* for 2 tour purposes]
[ln(2) × (−0.132 × Modest income)]	[*BTphc* for 2 tour purposes]
[ln(2) × (+0.089 × Autos per adult)]	[*BTphc* for 2 tour purposes]
[ln(2) × (+0.093 × Only worker in household)]	[*BTphc* for 2 tour purposes]
[ln(2) × (−0.414 × Adult female, no children)]	[*BTphc* for 2 tour purposes]
[ln(2) × (−0.830 × Adult female with child age 0-4)]	[*BTphc* for 2 tour purposes]
[ln(2) × (+0.266 × Adult female with child age 0-15)]	[*BTphc* for 2 tour purposes]
[ln(2) × (−0.673 × Adult male with child age 0-4)]	[*BTphc* for 2 tour purposes]
[ln(2) × (+0.200 × Adult male with child age 0-15)]	[*BTphc* for 2 tour purposes]
[ln(2) × (−0.997 × Adult age 18-25)]	[*BTphc* for 2 tour purposes]
[ln(2) × (+0.202 × Adult age 51-65)]	[*BTphc* for 2 tour purposes]
[ln(2) × (+0.173 × Adult age 66+)]	[*BTphc* for 2 tour purposes]
[ln(2) × (+0.290 × Home average accessibility logsum)]	[*BTls* for 2 tour purposes]
−0.699	[*X* for 1+ WT & 1+ ST]
+1.205	[*Z* for 1+ WT & 1+ ES]
−0.510	[*Z* for 1+ ST & 1+ ES]
−1.771	[$C_{NT,NS}$ for 2 tour & 1 stop purpose]

Summary of Example Utilities for Four Members of a Household

The above four daily activity pattern utility equations have been applied for each member of an example four person family consisting of a 55 year-old adult male with a full-time job, a 54 year-old adult female who works from home at a part-time job, a 19 year-old university student without a job, and a 15 year-old high school student. The family is in the upper income group and owns two cars. The adult male's mode choice logsum to his regular workplace is -2.4 and the escort aggregate accessibility logsum applicable to all household members is 3.5. ***Table 4.8*** shows the four daily activity pattern utilities for each of the household members.

Table 4.8 Example Daily Activity Pattern Utilities for Four Members of a Household

Daily Activity Pattern Alternative	Utility for 55 Year-Old Adult Male	Utility for 54 Year-Old Adult Female	Utility for 19 Year-Old University Student	Utility for 15 Year-Old High School Student
Make No Tours or Stops	0.000	0.000	0.000	0.000
Make 1+ Work Tours with No Stops	0.263	-2.500	-1.096	-19.534
Make 1+ Work Tours with 1+ Escort Stops	-0.883	-3.123	-4.623	-21.364
Make 1+ Work Tours, 1+ Shop Tours, and 1+ Escort Stops	-3.384	-4.832	-7.058	-24.593

Source: Cambridge Systematics.

As shown in ***Table 4.8***, the highest utility for the adult male family member is to make 1+ work tours with no stops and the highest utilities for the other three members is to make no tours or stops. Of course, in the StateFocus model application, each of the members would have utilities for 2,142 additional daily activity pattern choices. In addition, the selected daily activity pattern choice would be affected by the process to simulate the choice based on the estimated choice probabilities and the reproducible random seed (see ***Section 4.3.2***).

Non-Closed Tour Purpose Assignments

For alternatives including a non-closed tour, the presence of a non-closed tour indicates exactly one non-closed tour in the day for the person rather than 1+ non-closed tours (only one non-closed tour is allowed in a person's daily activity pattern). For other (i.e. non-work) non-closed tours, the specific purpose of the tour is randomly assigned based on the frequency of other non-closed tour purposes in the estimation data as shown in ***Table 4.9***.

Table 4.9 Other Non-Closed Tour Frequency

Tour Purpose	Frequency of Occurrence	Percent of Occurrences
School	92	17%
Escort	43	8%
Personal Business	85	16%
Shop	7	1%
Meal	11	2%
Social/Recreation	302	56%
Total	540	100%

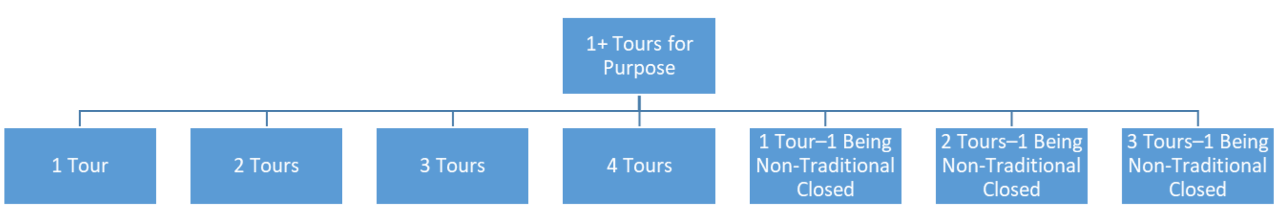
Source: Cambridge Systematics

4.2.7 Exact Number of Tours Choice

Model Structure

The exact number of tours model is a multinomial logit model to forecast the exact number of closed tours for each tour purpose, conditional on making 1+ tours for that purpose (***Figure 4.11***) as determined by the daily activity pattern choice model (see ***Section 4.2.6***). A separate model is applied for each tour purpose.

Figure 4.11 Exact Number of Tours Choice Structure



Source: Cambridge Systematics

As shown in ***Table 4.10***, the possible choice alternatives for number of tours vary by the tour purpose.

Table 4.10 Exact Number of Tours Choice Alternatives by Tour Purpose

Possible Tour Choices	Work	School	Escort	Personal Business	Shop	Meal	Social Recreation
1 tour (reference for all models)	x	x	x	x	x	x	x
2 tours	x	x	x	x	x	x	x
3 tours	x	x	x	x	x		x
4 tours			x				
1 tour, 1 Non-traditional closed tour	x			x			x
2 tours, 1 Non-traditional closed tour	x			x			x
3 tours, 1 Non-traditional closed tour	x			x			x

Source: Cambridge Systematics

Accounting for Non-Traditional Closed Tours

As noted in ***Section 3.2.3***, about 15 percent of the surveyed non-closed tours were made to same location at the beginning and ending of the surveyed travel day and are being modeled as non-traditional closed tours. The inclusion of non-traditional closed tours in the modeling process added three alternatives to the model for 1, 2, or 3 tours with 1 being non-traditional closed. The non-traditional closed tour alternative is included in the total number of tours; 1 tour–1 being non-traditional closed means that there is only one tour and it is a non-traditional closed tour; the "1 tour–1 being non-traditional closed" alternative is a separate alternative from the "1 tour" alternative. Two restrictions have been added regarding non-traditional closed tours:

- If the daily activity pattern choice model resulted in a non-closed tour being forecast for an individual, that individual is precluded from having a non-traditional closed tour.
- An individual may have a non-traditional closed tour for one and only one tour purpose.

Non-traditional closed tours receive a special code so that they can be accounted for properly in tour priority assignment and tour time of day choice processing (see ***Sections 4.2.12*** and ***4.2.14***).

Utility Function

The utility component for each purpose-specific number of tours alternative is comprised of:

- a vector of person-specific and household-specific characteristics,
- a vector of logsum or accessibility measures,
- a vector identifying 1+ tours for other purposes to be made during the day,
- a vector identifying 1+ stops for other purposes as well as the total number of stop purposes to be made during the day, and
- constants for the number of tours to be made.

The base alternative for each purpose, make one tour, has 0.0 utility. The utility function for making two or more tours for each tour purpose is as follows:

$$U_{N|t} = \sum_{pc=1}^{PC}(BX_{pc|t} \times PHC_{pc}) + L_{N|t} \times Logsum_t + \sum_{z=1}^{7}(BYt_{z|t} \times OTN_{z\neq t})$$
$$+ \sum_{z=1}^{7}(BYs_{z|t} \times OS_z) + \sum_{i=1}^{3}(BYcs_{i|t} \times OSN_i) + C_{N|t}$$

Where:

- $U_{N|t}$ is the utility of making *N* tours for the day for the given tour purpose *t*; *N* includes the final six alternatives shown in ***Figure 4.11*** and *t* includes the seven tour purposes: work, school, escort, personal business, shop, meal, and social/recreation
- t is an index indicating which of the seven different tour purposes is being processed
- pc is an index that ranges from 1 to PC for the different person/household characteristics
- $BX_{pc|t}$ is a purpose-specific array of coefficients based on person characteristics or characteristics of the household in which the person is a member related, *pc,* to making 2+ tours for a specific tour purpose *t*
- PHC_{pc} is a 0/1 array indicating whether the person possesses the indicated person/household characteristic or providing a continuous variable associated with the person or household
- $L_{N|t}$ is an array of coefficients based on the person's mode choice logsum associated with the tour interchange for work and school tours (since the regular workplace or school is known) or the person's aggregate accessibility logsum for other tour purposes
- $Logsum_t$ is the mode choice logsum or aggregate accessibility logsum, as appropriate, associated with the home zone of the person for a specific tour purpose *t*
- $BYt_{z|t}$ is an array of coefficients based on each of the seven tour purposes for tour purpose *t*
- $OTN_{z\neq t}$ is an array indicating the numbers of tours for purpose *z* made during the day[41]
- $BYs_{z|t}$ is an array of coefficients based each of the seven stop purposes for tour purpose *t*
- OS_z is a 0/1 array indicating whether the daily activity pattern for a person includes 0 or 1+ stops for purpose *z*
- $BYcs_{i|t}$ is a three element array of coefficients for the number of stop purposes included in the daily activity pattern for the person for tour purpose *t*; the three coefficients relate to making 2+ closed tours or one non-traditional closed tour for each tour purpose
- OSN_i is a three element array with the following information based on the person's daily activity pattern: total number of stop purposes, total number of non-work and non-school stop purposes, and total number of stop purposes (repeated variable used with the coefficient for making one non-traditional closed tour)
- $C_{N|t}$ is a set of constants related to making one of the final six number of tours/tour combinations shown in ***Figure 4.11*** for tour purpose *t*

The variables used in the equation outlined above are described in the following section and the utility equations for two different tour purposes are provided in the ***Example Utility Equations*** section.

Variables

Table 4.11 lists the variables used in the exact number of tours model by the different component groupings shown in the utility equation shown above. The source of the variable, the alternative choices affected, and the variable type are also shown. Regarding alternative choices affected, two separate coefficients, one

[41] The exact number of tours choice model is applied in priority order of tour purposes: work, school, escort, personal business, shop, meal, and social recreation. When higher priority tour purposes are processed, only the existence of 0 or 1+ tours for lower level purposes is known from the results of the daily activity pattern model and are represented in the exact number of tour choice model as a 0 or 1. As subsequent tour purposes are modeled, the modeled numbers of tours for higher level purposes are known and represented in the exact number of tour choice model for the purpose being processed.

relating to making two or more tours and one relating to making a non-traditional closed tour, might be estimated. Additional information regarding the variables is provided in the sections following ***Table 4.11.*** All of the originally estimated and final calibrated model coefficients and constants are shown in ***Appendix F.7***.

Person and Household Characteristics

These variables come from the characteristics of the traveler being modeled and his or her household based on information from PopGen2, the zonal data file for the zone in which the person's home is located, the regular/no regular workplace choice model, the regular workplace location choice model, and the autos available choice model.

Table 4.11 Variables Used in the Exact Number of Tours Choice Model

Variable	Source (Data File or Choice Model)	Alternative Choices Affected	Variable Type
Array BX – Associated Person & Household Characteristics (PHC_{pc})			
Person Type			
Full-time worker	PopGen2	2+ tours, 1 non-traditional closed tour	0/1 variable
Part-time worker	PopGen2	2+ tours, 1 non-traditional closed tour	0/1 variable
Non-worker age 65+	PopGen2	2+ tours	0/1 variable
Other non-worker	PopGen2	2+ tours	0/1 variable
University student	PopGen2	2+ tours	0/1 variable
Student age 16+	PopGen2	2+ tours, 1 non-traditional closed tour	0/1 variable
Student age 5-15	PopGen2	2+ tours, 1 non-traditional closed tour	0/1 variable
Child age 0-4	PopGen2	2+ tours, 1 non-traditional closed tour	0/1 variable
Adult Age Group			
Adult, age 18-25	PopGen2	2+ tours, 1 non-traditional closed tour	0/1 variable
Adult, age 26-35	PopGen2	2+ tours, 1 non-traditional closed tour	0/1 variable
Adult, age 51-65	PopGen2	2+ tours, 1 non-traditional closed tour	0/1 variable
Adult, age 66+	PopGen2	2+ tours, 1 non-traditional closed tour	0/1 variable
Adult Gender/Children			
Adult male with child age 0-15	PopGen2	2+ tours, 1 non-traditional closed tour	0/1 variable
Adult female-no children	PopGen2	2+ tours	0/1 variable
Adult female with child age 0-4	PopGen2	2+ tours	0/1 variable
Adult female with child age 0-15	PopGen2	2+ tours, 1 non-traditional closed tour	0/1 variable
Household Composition			
Only adult in household	PopGen2	2+ tours	0/1 variable
Only worker in household	PopGen2	2+ tours	0/1 variable

Variable	Source (Data File or Choice Model)	Alternative Choices Affected	Variable Type
Household Income			
Lower income	PopGen2	2+ tours, 1 non-traditional closed tour	0/1 variable
Modest income	PopGen2	2+ tours	0/1 variable
Upper income	PopGen2	2+ tours, 1 non-traditional closed tour	0/1 variable
Top income	PopGen2	2+ tours, 1 non-traditional closed tour	0/1 variable
Other			
Home retail employment density[1]	Zonal data file	2+ tours	Continuous variable
Autos per adult	PopGen2 & *Autos available*	2+ tours	Continuous variable
Autos per (workers + 1)	PopGen2 & *Autos available*	2+ tours	Continuous variable
Work at home	*Regular work location*	2+ tours, 1 non-traditional closed tour	0/1 variable
No regular workplace[2]	*Regular/no regular work location*	2+ tours, 1 non-traditional closed tour	0/1 variable
L (Associated with Logsum Data)			
Mode Choice Logsum			
To regular work location	*Regular work location*	2 tours, 3 tours	Continuous variable
To regular school location	*Regular school location*	2+ tours	Continuous variable
Aggregate Accessibility Logsum			
By non-work & non-school purpose	See ***Section 4.1.2***	2 tours, 3+ tours	Continuous variable
Array BYt – Number of Tours by Purpose (Associated with OTN)			
Other tours in day (counted)[3]			
Work tours	*Exact number of tours*	2+ tours	Integer (0-3)
School tours	*Exact number of tours*	2+ tours	Integer (0-3)
Other tours in day (0/1+ or counted)[3]			
Escort tours	*Daily activity pattern or Exact number of tours*	2+ tours	0/1 or Integer (0-4)
Personal business tours	*Daily activity pattern or Exact number of tours*	2+ tours	0/1 or Integer (0-3)
Shop tours	*Daily activity pattern or Exact number of tours*	2+ tours	0/1 or Integer (0-3)
Meal tours	*Daily activity pattern or Exact number of tours*	2+ tours	0/1 or Integer (0-2)
Social/recreation tours	*Daily activity pattern or Exact number of tours*	2+ tours	0/1 or Integer (0-3)

Variable	Source (Data File or Choice Model)	Alternative Choices Affected	Variable Type
Arrays BYs and BYcs – Stops by Purpose and Number of Stops (Associated with OS and OSN)			
Other stops in day (0/1+)			
Work stops	*Daily activity pattern*	2+ tours	0/1 variable
School stops	*Daily activity pattern*	2+ tours	0/1 variable
Escort stops	*Daily activity pattern*	2+ tours	0/1 variable
Personal business stops	*Daily activity pattern*	2+ tours	0/1 variable
Shop stops	*Daily activity pattern*	2+ tours	0/1 variable
Meal stops	*Daily activity pattern*	2+ tours	0/1 variable
Social/recreation stops	*Daily activity pattern*	2+ tours	0/1 variable
Count of stop purposes			
Total stop purposes	*Daily activity pattern*	2+ tours, 1 non-traditional closed tour	Integer (0-7)
Total non-work and non-school stop purposes	*Daily activity pattern*	2+ tours	Integer (0-5)
Array C – Constants			
2 tours	–	2 closed tours	–
3 tours	–	3 closed tours	–
4 tours	–	4 closed tours	–
1 tour with 1 being non-traditional closed	–	1 non-traditional closed tour	–
2 tours with 1 being non-traditional closed	–	1 closed+1 non-traditional closed tour	–
3 tours with 1 being non-traditional closed	–	2 closed+1 non-traditional closed tour	–

Source: Cambridge Systematics

Notes: [1] $Home\ retail\ employment\ density = \frac{RetailDensHHCentroid}{1000}$, where *RetailDensHHCentroid* is the number of retail employees in 0.5 mile buffer around the zone household virtual centroid (see ***Section 2.3.4*** and ***Appendix C***).

[2] 0 means there is a regular work location and 1 means there is no regular work location for the person.

[3] The exact number of tours choice model is applied in priority order of tour purposes: work, school, escort, personal business, shop, meal, and social recreation. When higher priority tour purposes are processed, only the existence of 0 or 1+ tours for lower level purposes is known from the results of the daily activity pattern model and are represented in the exact number of tour choice model as a 0 or 1. As subsequent tour purposes are modeled, the modeled numbers of tours for higher level purposes are known and represented in the exact number of tour choice model for the purpose being processed.

Transportation Level of Service Variables

The two transportation level of service are continuous variables obtained from the disaggregate and aggregate logsum data that are associated with the model coefficient array *L*:

- The **mode choice logsums** are disaggregate logsums used for determining the utility of making two or more work tours or school tours (see ***Daily Activity Pattern and Exact Number of Tours Choice***

Logsums in ***Section 4.1.1***). The disaggregate logsums can be used since the exact number of tours model follows the regular workplace location choice and regular school location choice models meaning that the regular workplace and the regular school locations are known. The logsums are for out of home locations only (i.e. they exclude the work at home alternative).

- **Aggregate accessibility logsums** (see ***Section 4.1.2***) are used for determining the utilities of making two or more escort, personal business, shop, meal, or social/recreation tours during the day. Aggregate logsums are purpose specific and provide a measure of the overall average accessibility of the home location to all locations that can serve the tour purpose since actual destinations for the non-work and non-school tours are determined after the daily activity choice model.

Example Utility Equations

Examples of the exact number of tours choice alternatives are shown in ***Table 4.12*** below. The examples are based on daily activity pattern choice example for ***1+ Work Tours (1+ WT), 1+ Shop Tours (1+ ST), 1+ Escort Stops (1+ ES)*** shown in ***Section 4.2.6***. The utility function for any other alternative exact number of tours can be determined using the complete model estimation results shown in the ***Appendix F.7***.

All of the coefficients and constants in the examples below are based on the original model estimation so that they can be compared to the estimated parameters for the entire model shown in ***Appendix F.7*** (the final calibrated parameters also shown in the appendix might be updated if StateFocus is calibrated/validated to a new base year possibly resulting in a conflict between what is shown below and the calibrated parameters).

The example equations shown in ***Table 4.12*** are in a reduced form in that only the non-zero estimated parameters are are shown. For example, the alternative includes 1+ stops for only the escort purpose so none of the 1+ stop parameters for other stop purposes are shown. The utilities are shown in the following order considering the example is for the 1+ Work Tours, 1+ Shop Tours, 1+ Escort Stops daily activity pattern:

- Utilities for making 1 tour for work and for shop,
- General utilities for making 2+ tours for work and for shop based on person/household charateristics
- Utilities for making 2 or 3+ tours based on logsum variables,
- Added utilities for making 2+ tours for work and for shop based on daily activity pattern outcomes and exact number of tours outcomes for higher priority tour purposes, and
- Added utilities from constants for making specific numbers of tours.

Table 4.12 Example Utility Calculations for Exact Number of Tours

Work Utility Coefficient	Shop Utility Coefficient	Variable	Coefficient Array
Utilities for Making 1 Tour			
0.000	0.000	–	–
General Utilities for Making 2+ Tours Based on Person/Household Charateristics and Logsum Variables			
+0.258	+0.425	× Part-time worker – 2+ tours	$BX_{pc\|t}$
+1.030	–	× Other non-worker – 2+ tours	$BX_{pc\|t}$
−1.497	–	× University student – 2+ tours	$BX_{pc\|t}$
–	−2.319	× Student age 5-15 – 2+ tours	$BX_{pc\|t}$
–	−0.342	× Child age 0-4 – 2+ tours	$BX_{pc\|t}$
+2.289	–	× Full-time worker – 1 non-traditional closed tour	$BX_{pc\|t}$
+1.314	–	× Part-time worker – 1 non-traditional closed tour	$BX_{pc\|t}$
−0.204	−0.583	× Age 18-25, adult – 2+ tours	$BX_{pc\|t}$
+0.252	–	× Age 66+, adult – 2+ tours	$BX_{pc\|t}$
+0.475	–	× Age 18-25, adult – 1 non-traditional closed tour	$BX_{pc\|t}$
−0.611	–	× Age 51-65, adult – 1 non-traditional closed tour	$BX_{pc\|t}$
−0.611	–	× Age 66+, adult – 1 non-traditional closed tour	$BX_{pc\|t}$
−0.388	−0.477	× Female / age 0-4 – 2+ tours	$BX_{pc\|t}$
–	−0.449	× Only adult in HH – 2+ tours	$BX_{pc\|t}$
−0.308	–	× Only worker in HH – 2+ tours	$BX_{pc\|t}$
+0.063	–	× Lower income – 2+ tours	$BX_{pc\|t}$
+0.058	–	× Modest income – 2+ tours	$BX_{pc\|t}$
−0.254	–	× Upper income – 2+ tours	$BX_{pc\|t}$
−0.605	–	× Top income – 2+ tours	$BX_{pc\|t}$
+0.955	–	× Lower income – 1 non-traditional closed tour	$BX_{pc\|t}$
−0.382	–	× Upper income – 1 non-traditional closed tour	$BX_{pc\|t}$
−1.217	–	× Top income – 1 non-traditional closed tour	$BX_{pc\|t}$
–	−0.418	× Home retail employment density – 2+ tours	$BX_{pc\|t}$
+0.095	+0.224	× Cars per adult in HH – 2+ tours	$BX_{pc\|t}$
+1.262	–	× Work at home – 2+ tours	$BX_{pc\|t}$
−0.736	–	× Work at home – 1 non-traditional closed tour	$BX_{pc\|t}$
−1.523	–	× No regular workplace – 2+ tours	$BX_{pc\|t}$
−20.000	–	× No regular workplace – 1 non-traditional closed tour	$BX_{pc\|t}$

Work Utility Coefficient	Shop Utility Coefficient	Variable	Coefficient Array
Utilities for Making 2 or 3+ Tours Based on Logsum Variables			
+0.394	–	*× Mode choice logsum to regular workplace – 2 tours*	$L_{N\|t}$
+0.476	–	*× Mode choice logsum to workplace – 3 tours*	$L_{N\|t}$
–	*+0.312*	*× Shop accessibility logsum – 2 tours*	$L_{N\|t}$
–	*+0.675*	*× Shop accessibility logsum – 3+ tours*	$L_{N\|t}$
Added Utilities for Making 2+ Tours for Work Based on Daily Activity Pattern Outcomes[1]			
+0.227	–	*× 0/1+ shop tours from DAP choice – 2+ tours*	$BYt_{z\|t}$
+0.255	–	*× Number of non-work & non-school stop purposes – 2+ tours*	$BYcs_{i\|t}$
−0.815	–	*× Total stop purposes – 1 non-traditional closed tour*	$BYcs_{i\|t}$
Added Utilities for Making 2+ Tours for Shop Based on Daily Activity Pattern Outcomes and Exact Number of Tours Outcomes for Higher Priority Tour Purposes[2]			
–	*−0.877*	*× Exact number of work tours – 2+ tours*	$BYt_{z\|t}$
–	*+0.144*	*× Number of non-work & non-school stop purposes – 2+ tours*	$BYcs_{i\|t}$
Constants			
−2.735	*−3.288*	*2 tours*	$C_{N\|t}$
−5.083	*−6.432*	*3 tours*	$C_{N\|t}$
−8.670		*1 tour with 1 being non-traditional closed*	$C_{N\|t}$
−3.937		*2 tours with 1 being non-traditional closed*	$C_{N\|t}$
−4.250		*3 tours with 1 being non-traditional closed*	$C_{N\|t}$

Source: Cambridge Systematics.

Notes: [1] Determining the exact number of work tours is the highest priority so only the existence of 1+ tours and 1+ stops for other tour and stop purposes will be known based on the results from the daily activity pattern choice model for the person.

[2] Determining the exact number of shop tours is the fifth highest priority. The determination of the exact number of work tours for the person will be known prior to the application of the model for shop tours so the exact number of work tours will be used. The existence of 1+ stops for all purposes will be known based on the results from the daily activity pattern choice model for the person (stops are counted independently of tours so this example has only one stop purpose–escort).

Summary of Example Utilities for Four Members of a Household

The resulting utilities from applying the exact number of work tours and the exact number of shop tours utility equations shown in ***Table 4.12*** are shown for the same four person family used for the example daily activity pattern calculations. The family consists of a 55 year-old adult male with a full-time job, a 54 year-old adult female who works from home at a part-time job, a 19 year-old university student without a job, and a 15 year-old high school student. The family is in the upper income group and owns two cars. The adult male's mode choice logsum to his regular workplace is -2.4. For this example, the shop aggregate accessibility logsum applicable to all household members is 2.5 and the home retail employment density is 0.32. Finally, for the sake of comparison, it is assumed that the daily activity pattern choice for each member of the household is identical (1+ work tours, 1+ shop tours, 1+ escort stops), even though the adult female works from home and the university student and the high school student do not have jobs. Such a result is possible since the university student and high school student could be performing volunteer work or performing some casual work for the day.

Table 4.13 summarizes the resulting utilities as well as the probabilities for making each of the choices of numbers of tours for the example family members. Since the exact number of shop tours is determined after the exact number of work tours, the work tour choices and probabilities are shown first. For the exact number of shop tours calculations in this example, it is assumed that the number or work tours with the highest probability is chosen for each household member (see ***Section 4.3*** for the actual procedure that is used for selecting a choice).

In the example summarized in ***Table 4.13***, the highest probabilities are for each person from the household to make one work tour and one shop tour during the day given that the daily activity pattern for each person was assumed to be 1+ work tours, 1+ shop tours, and 1+ escort stops. The impact of the differences in person characteristics and work location characteristics (household characteristics such as income level are the same for each person) can be seen in the different probabilities estimated for the different numbers of tours.

Table 4.13 Example Exact Number of Tours Utilities and Choice Probabilities for Four Members of a Household

	Utility/*Probability* for 55 Year-Old Adult Male		Utility/*Probability* for 54 Year-Old Adult Female		Utility/*Probability* for 19 Year-Old University Student		Utility/*Probability* for 15 Year-Old High School Student	
Number of Tours Choice	Utility	*Prob-ability*	Utility	*Prob-ability*	Utility	*Prob-ability*	Utility	*Prob-ability*
Work Tours								
1 Tour	0.000	*0.83*	0.000	*0.74*	0.000	*0.98*	0.000	*0.93*
2 Tours	-2.093	*0.10*	-1.339	*0.19*	-4.052	*0.02*	-2.826	*0.05*
3 Tours	-4.638	*0.01*	-3.687	*0.02*	-6.400	*0.00*	-5.174	*0.01*
1 Tour with 1 Being Non-traditional closed	-9.485	*0.00*	-9.485	*0.00*	-9.485	*0.00*	-9.485	*0.00*
2 Tours with 1 Being Non-traditional closed	-3.165	*0.04*	-3.356	*0.03*	-6.069	*0.00*	-4.843	*0.01*
3 Tours with 1 Being Non-traditional closed	-3.478	*0.03*	-3.669	*0.02*	-6.382	*0.00*	-5.156	*0.01*
Shop Tours								
1 Tour	0.000	*0.96*	0.000	*0.94*	0.000	*0.98*	0.000	*1.00*
2 Tours	-3.272	*0.04*	-2.847	*0.05*	-3.855	*0.02*	-5.591	*0.00*
3 Tours	-6.416	*0.00*	-5.991	*0.00*	-6.999	*0.00*	-8.735	*0.00*

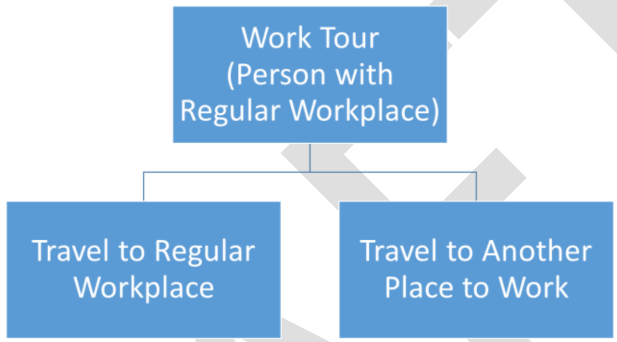
Source: Cambridge Systematics.

4.2.8 Work Tour Destination Type Choice

Model Structure

The work tour destination type choice model is a binary logit model to forecast if a person with a regular work location[42] (see ***Section 4.2.2***) and making a work tour on a given day travels to the regular workplace or an alternate work location (see ***Figure 4.12***). The work tour destination type choice operates on each work tour made by a person during the day. Work tour to locations other than the regular workplace are modeled in the tour primary location choice model (see ***Section 4.2.11***).

Figure 4.12 Work Tour Destination Type Choice Structure



Source: Cambridge Systematics.

Non-traditional closed tours (i.e. non-closed tours with matching non-home work locations at beginning and end of the day) are modeled as closed tours (see ***Sections 3.2.3*** and ***4.2.7***). "True" non-closed work tours are, by caveat, to locations other than the usual workplace. There may be people who live in, say, Vail and maintain an apartment in Denver, traveling to work one day and returning home several days later. However, these types of tours are relatively rare occurrences. (Also, there was uncertainty regarding whether such a worker reported their normal workplace as work at home in the survey.)

Utility Function

The general form of the binary logit model for the work tour destination type choice model is:

$$Prob_{Regular} = \frac{1}{1 + exp(U_{Regular})}$$

The utility of making the work tour to the regular workplace is calculated as follows:

[42] The DRCOG Focus model is applied only full-time and part-time workers with a regular workplace. Unlike that model, the StateFocus work tour destination type model applies to everyone with a usual workplace and a work tour on the given day.

$$U_{Regular} = C_{Regular} + LS \times Logsum_{ij} + D_1 \times Dist_{ij} + D_2 \times ln(Dist_{ij}) + \sum_{Inc=1}^{3} [CIWE_{Inc3} \times FTW_{Inc3} \times ln(Emp_j + 1)] + PC_{WLoc} \times WLoc + PC_{Student} \times Student + \sum_{t=1}^{3} TSeq_t \times TSDum_t$$

where: $U_{Regular}$ = the utility for traveling to the regular place of work
$C_{Regular}$ = model constant for traveling to the regular workplace
LS = mode choice logsum coefficient
$Logsum_{ij}$ = work tour mode choice logsum from home zone, *i*, to regular work zone, *j*
D_1 & D_2 = distance-based model coefficients
$Dist_{ij}$ = total tour distance (in miles) between home zone, *i*, to regular work zone, *j*
$CIWE_{Inc3}$ = full-time worker-household income-regular workplace employment interaction coefficient
FTW_{Inc3} = 1 if the person is a full-time worker from a household with the specified income level and 0 otherwise
Emp_j = is the total employment in the person's regular work zone, *j*
PC_{WLoc} = model coefficient if person's regular workplace is home
$WLoc$ = 1 if the person's regular workplace is home, 0 otherwise
$PC_{Student}$ = model coefficient if the person is a student
$Student$ = 1 if the person is a student, 0 otherwise
$TSeq_t$ = tour sequence coefficients for multiple tours
$TSDum_t$ = is a 0/1 dummy variable regarding the sequence and/or primacy of the work tour

Variables

The following provides a description of the variables used in the work tour destination choice model:

Logsum$_{ij}$ is the disaggregate mode choice logsum for the work tour purpose between the home zone and the regular work location zone. The mode choice logsum is for the total tour from home to regular workplace to home. The logsum will either be for households having autos for all workers if the household has one or more autos (since autos are not assigned to specific household members) or for zero vehicles.

Dist$_{ij}$ is the maximum of the total tour roadway distance from home to regular workplace to home in miles and 0.01 (to prevent taking the natural log of zero). The distances are based on the late night (OP1) skims to provide uncongested travel distances (see ***Table 2.1***).

FTW$_{Inc}$ is a dummy variable indicating whether the person making the work tour under consideration is a full-time employee (based on person type – see ***Section 3.1.2***) from a household with income level *Inc3* where *Inc3* is a special, 3-level, income grouping for the work tour destination type choice model (see ***Section 3.1.1***). FTW_{Inc3} is interacted with 1 plus the natural log of Emp_j.

Emp$_j$ is the total employment in the regular work location zone for the person making the work tour under consideration.

WLoc is 1 if the person's regular workplace is home and 0 otherwise (see ***Section 4.2.2***).

Student is a variable derived from the PopGen2 data as follows:

- 1 = Primary or secondary school student three years of age or older,
- 2 = Post-secondary school student, and
- 3 = Not a student.

$TSDum_t$ is a set of three dummy variables regarding the sequence and/or priority of the work tour being considered:

- ***$TSDum_1$*** is 1 if there are other work tours made by the traveler and the current tour is the first simulated and 0 otherwise,
- ***$TSDum_2$*** is 1 if there are other work tours made by the traveler and the current tour is not the first simulated and 0 otherwise, and
- ***$TSDum_3$*** is 1 if the tour being simulated is **not** the primary tour of the day and 0 otherwise. For this model, the first work tour is the primary tour unless the person is also a ***Student***, in which case the school tour is considered the primary tour.

All of the originally estimated and final calibrated model coefficients and constants are shown in ***Appendix F.8***.

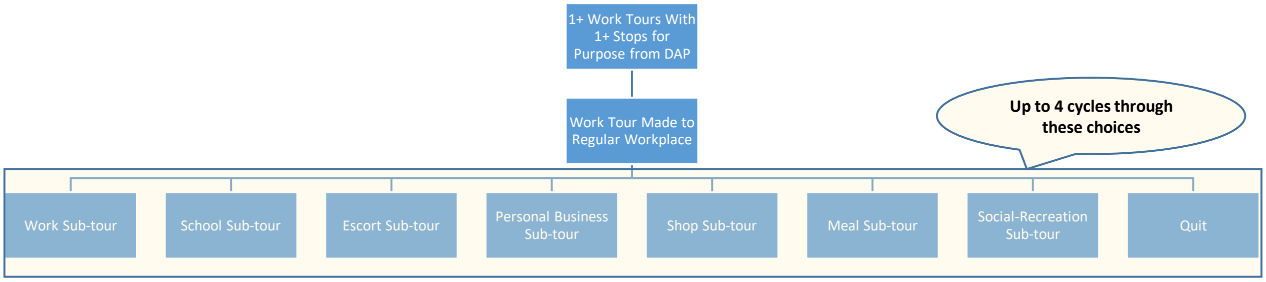
4.2.9 Work-Based Sub-Tour Generation Choice

Model Structure

The work-based sub-tour generation choice model is a multinomial logit model applied for each possible work-based sub-tour from the person's regular workplace to satisfy a forecast stop purpose. The application of the model for a possible sub-tour is conditional upon a person making 1+ work tours with 1+ stops for a specific purpose as determined in the daily activity pattern choice model (see ***Section 4.2.6*** and ***Figure 4.10***). For example, if the person's daily activity pattern did not include a meal stop, the choice of work-based sub-tour for a meal would be precluded (precluding a work-based sub-tour for a purpose is accomplished by replacing the calibrated model constant by -20). In addition, by caveat, work based sub-tours are modeled only from the person's regular workplace location, so the generation of a work-based sub-tour is conditional upon the work tour in question being made to the person's regular work location as determined in the work tour destination type choice model (see ***Section 4.2.8***). If the person makes two or more tours to the regular workplace duing the day, the work-based sub-tour generation model is applied for each work tour.

As shown in ***Figure 4.13***, the model has eight alternatives, one for each of the seven possible sub-tour purposes plus a "quit" alternative meaning that there are no further sub-tours. The choice model is run iteratively for up to four cycles (i.e. there is a maximum of four work-based sub-tours for each person for the day). If the model application for a cycle results in the choice of a sub-tour for one of the seven purposes (i.e. the choice is not the "quit" alternative), the model is applied again to obtain the choice of whether to make a second sub-tour and, if so, the purpose of that sub-tour. It is possible for the quit alternative to be chosen on the first cycle, resulting in no work-based sub-tours for the person.

Figure 4.13 Work-Based Sub-Tour Choice Structure



Source: Cambridge Systematics.

Table 4.14 summarizes the distribution of the choices for the eight alternatives in the data set created from the FRTC survey and used for model estimation. The table summarizes only the existence of a sub-tour for the purpose, not whether the sub-tour was the first, second, third, or fourth sub-tour of the day. About 12 percent of respondents' daily activity patterns that included 1+ work tours to the regular work location and 1+ stops during the day included at least one work-based sub-tour; about 88 percent of those daily activity patterns did not include work-based sub-tours. Work-based sub-tours for work and meal purposes were the most likely purposes with each comprising about four percent of the total work-based sub-tours.

Table 4.14 also shows the propensity of persons with 1+ work tours to the regular work location with 1+ stops during the day to satisfy the stops during their work activity via a work-based sub-tour. Work stops and meal stops were the stop purposes most frequently satisfied by work-based sub-tours with 23 and 22 percent of the daily activity patterns, respectively. The remaining 77 or 78 percent of the stops were satisfied on either an outbound or inbound half-tour for work at the regular work location. The percentages are not percentages of stops. It is possible that a person with 1+ work tours to the regular work location with 1+ stops for a specific purpose to make a work-based sub-tour and another stop on either the outbound or inbound subtour. For example, a person could make a work-based sub-tour to eat lunch and then meet someone on the half-tour from the work location to home for dinner.

Utility Function

The general utility function for making a work-based sub-tour for a specific purpose is:

$$U_p = K_p + \sum_{pc=1}^{PC} \left(CPT_{pc|p} \times PHC_{pc}\right) + \sum_{t=1}^{T} \left(CDen_{t|p} \times WPD_t\right)$$

The utility function for the quit alternative is:

$$U_{quit} = \sum_{stc=1}^{4} (CSTN_{stc} \times CND_{stc}) + \sum_{pc=1}^{PC} \left(CPT_{pc|quit} \times PHC_{pc}\right) + [CHBT \times Ln(HBT)] + (CWT \times WTDum)$$

Where: U_p is the utility of making a work-based sub-tour for purpose *p* (representing work, school, escort, personal business, shop, meal, social/recreation)

U_{quit} is the utility of "quit" for the given cycle through the choice model

K_p is the constant for purpose *p*

$CPT_{pc|p}$ is an array of coefficients for different person characteristics and characteristics of the person's household for a given purpose *p*

PHC_{pc} is 1 if the person making the work tour has the person characteristic or is a member of a household with the specified household characteristic and 0 otherwise
$CDen_{t|p}$ is an array of coefficients for land use or employment densities for type *t* for sub-tour purpose *p*
WPD_t is the land use or employment density for type *t* in the person's regular workplace zone
$CSTN_{stc}$ is the coefficient for the cycle, *stc*, through the work-place sub-tour generation choice model for the person
CND_{stc} is 1 if the the cycle through the work-place sub-tour generation choice model for the person equals *stc* and 0 otherwise
$CPT_{pc|quit}$ is an array of coefficients for different person characteristics and characteristics of the person's household for the quit purpose *quit*
CHBT is the coefficient for the number of home-based tours made by the person during the day
HBT is the total number of home-based tours from the exact number of tours model for the person
CWT is the coefficient for the number of work tours made by the person during the day
WTDum is 1 if there are two or more work tours as determined by the exact number of tours model, zero otherwise. If there are two or more work tours, the other work tours may be to locations other than the person's regular workplace.

Table 4.14 Distribution of Work-Based Sub-Tour Purposes and the "Quit" Alternative

Stop Purpose	Number of Choices for Persons with Daily Activity Patterns Including Work Tour to Regular Work Location and 1+ Stops by Stop Purpose		Work-Based Sub-Tour Choices by Purpose		Work-Based Sub-Tours as Percent of Daily Activity Patterns with 1+ Possible Stops by Purpose
	Number	Percent	Number	Percent	
Work	2,633	8.7%	594	4.1%	22.6%
School	133	0.4%	4	0.0%	3.0%
Escort	2,165	7.2%	45	0.3%	2.1%
Personal Business	3,543	11.7%	255	1.8%	7.2%
Shop	2,949	9.8%	160	1.1%	5.4%
Meal	2,451	8.1%	538	3.7%	22.0%
Social/recreation	1,921	6.4%	140	1.0%	7.3%
"Quit"[1]	14,376	47.6%	12,640	87.9%	87.9%
Total	30,171	100.0%	14,376	100.0%	

Source: Cambridge Systematics.

Notes: [1] Each person with a daily activity pattern that included a work tour to the regular work location and 1+ stops for at least one stop purpose always had the "Quit" option. Thus, if a person made no work-based sub-tours, their work-based sub-tour choice was "Quit;" if they made one or more work-based sub-tours, they had one or more work-based sub-tour for the specified purposes and a work-based sub-tour choice of "Quit." Up to four work-based sub-tours were possible.

Only the utility of the quit option varies by cycle through the work-based sub-tour generation choice model; the utilities for the different sub-tour purposes do not vary by cycle. This fact would suggest that if the daily activity pattern model forecast making 1+ stops for more than one purpose, only that purpose would be chosen on each interation when "quit" is not chosen. However, as described in ***Section 4.3***, the StateFocus model uses a process to generate a "reproducible" random seed to generate a random number for each choice model for each person and uses that random number to determine the alternative chosen or, in this case, the work-based sub-tour purpose.

Variables

Table 4.15 summarizes the variables used in the work-based sub-tour generation choice model by sub-tour purpose.

Table 4.15 Work-Based Sub-Tour Variables by Purpose

Variable	Work	School	Escort	Personal Business	Shop	Meal	Social / Recreation	"Quit"
Constant	x	x	x	x	x	x	x	
Person & Household Characteristics								
30 years old or younger				x				x
Over 50 years old			x					
Full-time worker				x	x	x	x	
Adult female with children under 18 in household						x		
Low income household								x
Single person household	x							
Regular Workplace Zone Densities								
Restaurant density						x		
Residential density							x	
Tour Counts								
Ln(total home-based tours)								x
2 or more work tours								x
Cycle Through Work-Based Sub-Tour Generation Choice Model								
Second cycle								x
Third cycle								x
Fourth cycle								x

Source: Cambridge Systematics.

The definitions of the variables in ***Table 4.15*** are as follow:

- **30 years old or younger** is 1 if the traveler is 30 years old or younger, zero otherwise
- **Over 50 years old** is 1 if the traveler is older than 50 years old, zero otherwise
- **Full-time worker** is 1 if the traveler is a full-time worker, zero otherwise
- **Adult female with children under 18 in household** is 1 if the traveler is female, over age 18 and there are children under age 18 in the household

- **Low income household** is 1 if the household income is low income where income levels use the same 3-level income grouping used for the work tour destination type choice model (see ***Section 3.1.1***) and zero otherwise

- **Single person household** is 1 if the traveler is the only person in his or her household

- **Restaurant density** is the number of restaurant employees within ½ mile of zone centroid of the regular workplace divided by 1,000

- **Residential density** is the number of households within ½ mile of the regular workplace divided by 1,000

- **Ln(total home-based tours)** is the natural log of the total number of home-based tours for all purposes from the exact number of tours model

- **2 or more work tours** is 1 if there are two or more work tours as determined by the exact number of tours model, zero otherwise

- **Second, third, fourth cycle** is a sequence number for the cycle through the work-based sub-tour choice model for the person's work tour being modeled

Example Utilities and Probabilities

Table 4.16 shows the resulting utilities and probabilities from applying the work-based sub-tour generation choice model for the adult male from the four person family used for the example daily activity pattern (***Section 4.2.6***) and exact number of tours choice model (***Section 4.2.7***) calculations. The family consists of a 55 year-old adult male with a full-time job, a 54 year-old adult female who works from home at a part-time job, a 19 year-old university student without a job, and a 15 year-old high school student. The family is in the upper income group and owns two cars. For this example, it is assumed that the adult male makes two work tours and one shop tour (from the exact number of tours choice model) in addition to the 1+ escort stops from the daily activity pattern model. The restaurant density at the person's regular work location is 0.59 and the residential density is 1.68.

Table 4.16 Example Utilities and Probabilities for Work-Based Sub-Tours

<table>
<tr><th>Work-Based Sub-Tour Purpose</th><th>Work</th><th>School</th><th>Escort</th><th>Personal Business</th><th>Shop</th><th>Meal</th><th>Social/ Recreation</th><th>"Quit"</th></tr>
<tr><td>Utility–1st Cycle</td><td rowspan="4">-20.000</td><td rowspan="4">-20.000</td><td rowspan="4">-2.403</td><td rowspan="4">-18.942</td><td rowspan="4">-18.972</td><td rowspan="4">-18.888</td><td rowspan="4">-19.150</td><td>1.118</td></tr>
<tr><td>Utility–2nd Cycle</td><td>2.548</td></tr>
<tr><td>Utility–3rd Cycle</td><td>2.459</td></tr>
<tr><td>Utility–4th Cycle</td><td>3.436</td></tr>
<tr><td>Probability–1st Cycle</td><td>0.000</td><td>0.000</td><td>0.029</td><td>0.000</td><td>0.000</td><td>0.000</td><td>0.000</td><td>0.971</td></tr>
<tr><td>Probability–2nd Cycle</td><td>0.000</td><td>0.000</td><td>0.007</td><td>0.000</td><td>0.000</td><td>0.000</td><td>0.000</td><td>0.993</td></tr>
<tr><td>Probability–3rd Cycle</td><td>0.000</td><td>0.000</td><td>0.008</td><td>0.000</td><td>0.000</td><td>0.000</td><td>0.000</td><td>0.992</td></tr>
<tr><td>Probability–4th Cycle</td><td>0.000</td><td>0.000</td><td>0.003</td><td>0.000</td><td>0.000</td><td>0.000</td><td>0.000</td><td>0.997</td></tr>
</table>

Source: Cambridge Systematics.

As can be seen in ***Table 4.16***, the utilities for the work, school, escort, personal business, shop, meal, and social/recreation sub-tour purposes are identical for the four cycles through the work-based sub-tour generation choice model; only the utilities for the "Quit" option vary. Further, since the daily activity pattern choice model resulted in 1+ stops for only the escort purpose, the constants for the utilities for work, school, personal business, shop, meal, and social recreation were set to -20 resulting in very large negative utilities for those purposes. The resulting probabilities for each cycle are largely skewed to the quit alternative suggesting that it would be unlikely for the person to make a work-based escort sub-tour during the day. Since the StateFocus model uses the reproducible random seed and determines actual choices based on estimated choice probabilities and random number generation (see ***Section 4.3***), although unlikely, it is possible that one or more work-based escort sub-tours could be made by the person during the day.

4.2.10 Tour Time of Day Simulation

All daily tours for each person have been forecast at the completion of the work-based sub-tour generation choice model component (see ***Section 4.2.9***) of StateFocus. The next set of model components relate to tour level choices for each tour (see ***Figure 4.1***): tour primary destination choice for tours not destined to the regular workplace or regular school location, tour mode choice, and tour time of day choice. However, tour primary destination choice and tour mode choice are impacted travel times by mode (and mode availability), which, in turn, are impacted by the times of day of travel on the outbound and return portions of the tour. While it might seem logical to simply apply the tour time of day choice prior to tour primary destination choice, tour time of day choice is, itself, affected by the choice of mode used for the tour. In order to avoid the estimation of an exceedingly complex joint tour destination / tour mode / tour time of day choice model, a preliminary tour time of day simulation is performed to assign likely tour arrival and tour departure times (from the primary activity location). Using this tour time of day simulation approach, reasonable times of day for tour arrivals and tour departures from the primary activity locations can be selected in order to select auto and transit skim information for the tour primary destination choice and tour mode choice model components.

Model Structure

The tour time of day simulation process is implemented using a Monte Carlo simulation to select joint tour arrival and tour departure times from the primary activity location for each tour. The joint tour arrival and departure times have been summarized from the FRTC survey data for 11 tour purposes:

- Work tours to the regular work location
- Work tours to other work locations
- School tours
- Escort tours
- Personal business tours
- Shop tours
- Meal tours
- Social recreation tours

- Work-based sub-tours
- Non-closed work tours (see ***Table 4.10***)
- Non-closed non-work tours (personal business and social recreation – see ***Table 4.10***)

The tour arrival and departure time periods are each one hour long starting at 3:00 AM–3:59 AM and ending the next day at 2:00 AM–2:59 AM. For closed tours, there are 24, one-hour time periods in the model, starting with 3:00 AM–3:59 AM:

1. 3:00 AM – 3:59 AM
2. 4:00 AM – 1:59 AM

….

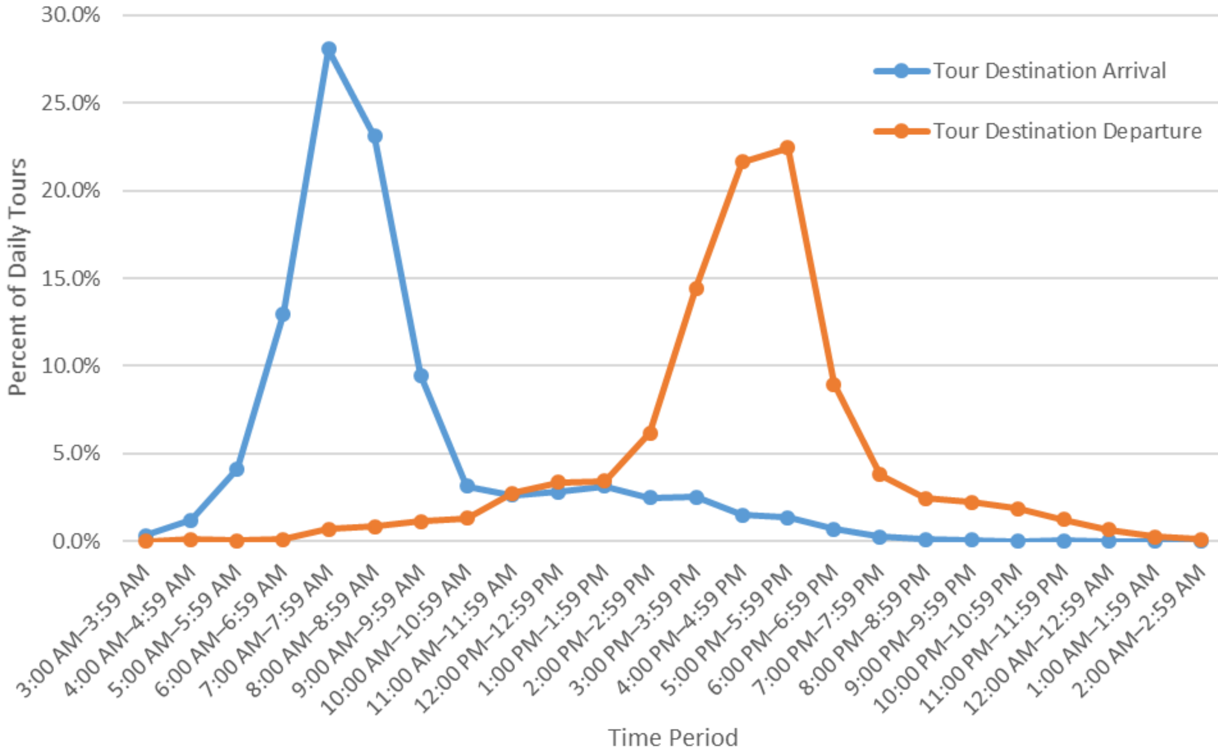
23. 1:00 AM – 1:59 AM
24. 2:00 AM – 2:59 AM

The tour arrival and departure time simulation assigns the time arriving at the primary destination of the tour and the time leaving the primary destination, both to within 1-hour periods. The departure period is always greater than or equal to the arrival period, and less than or equal to 24, so there are (24 + 23 + … + 2 + 1) alternatives, for a total of 300 alternatives.[43] The probabilities for each of the 300 arrival-destination hour period pairs for each possible hour combination in a 24 hour day are given for each of the 11 tour purposes, producing 3300 different probabilities.

Figure 4.14 through ***Figure 4.24*** show the tour arrival and tour departure times for each of the 11 tour purposes. While the figures do not show the distributions of the 300 combinations of of arrival and departure times, they provide some insights to the typical patterns of tours. ***Appendix F.10*** lists the probabilities for 300 arrival / departure time combinations for each of the 11 tour purposes.

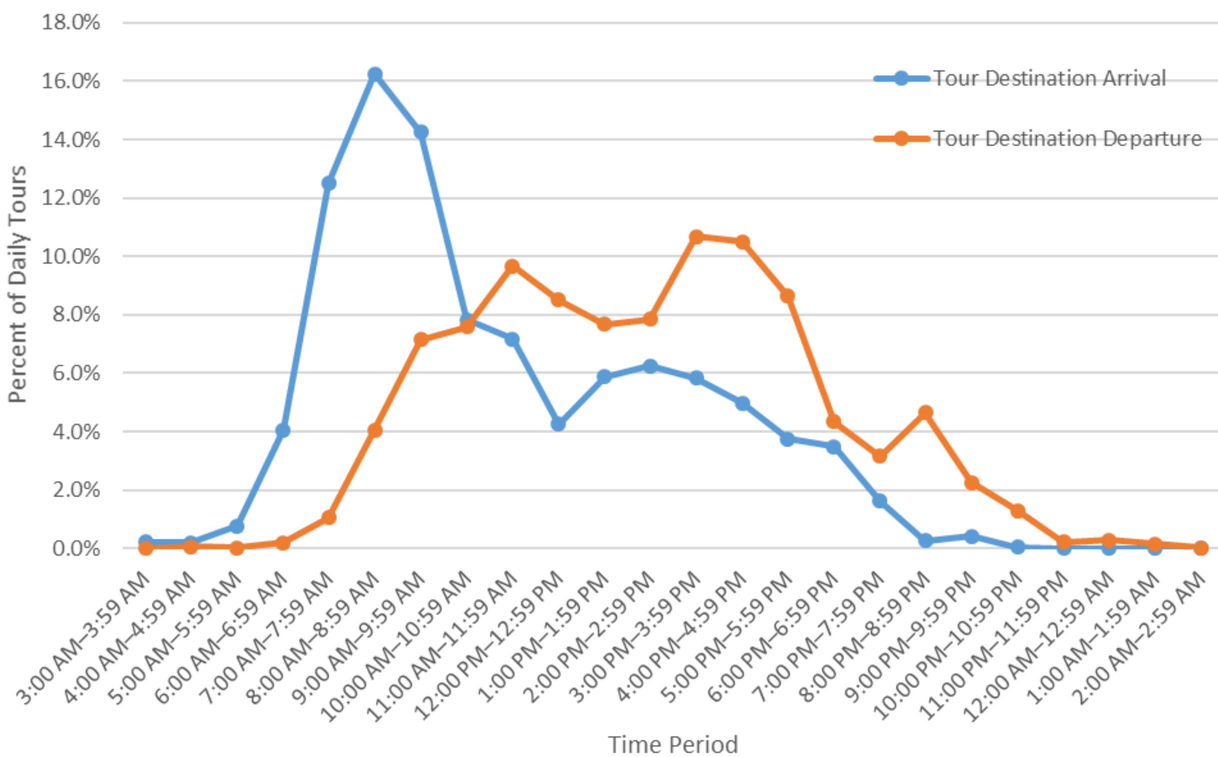
[43] For the tour time of day simulation process, non-closed tours that start the day at the non-home location have a tour arrival in the first time period and a tour departure at some other time of day; non-closed tours that end the day at the non-home location have a tour arrival during one of the 24 time periods and a tour departure at 24th time period of the day. This approach is a simplification of the approach used in the tour time of day choice model (see ***Section 4.2.14***).

Figure 4.14 Tour Arrival and Departure Times – Regular Work Location Tours



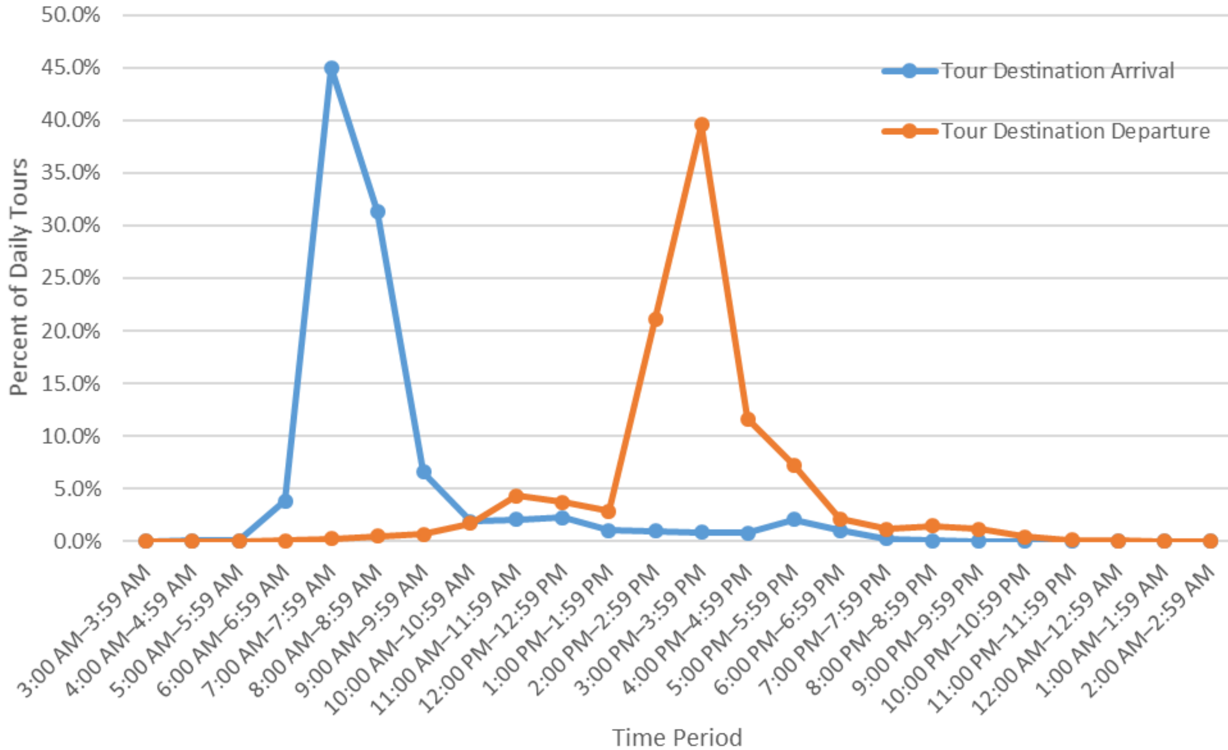
Source: Cambridge Systematics.

Figure 4.15 Tour Arrival and Departure Times – Other Work Location Tours



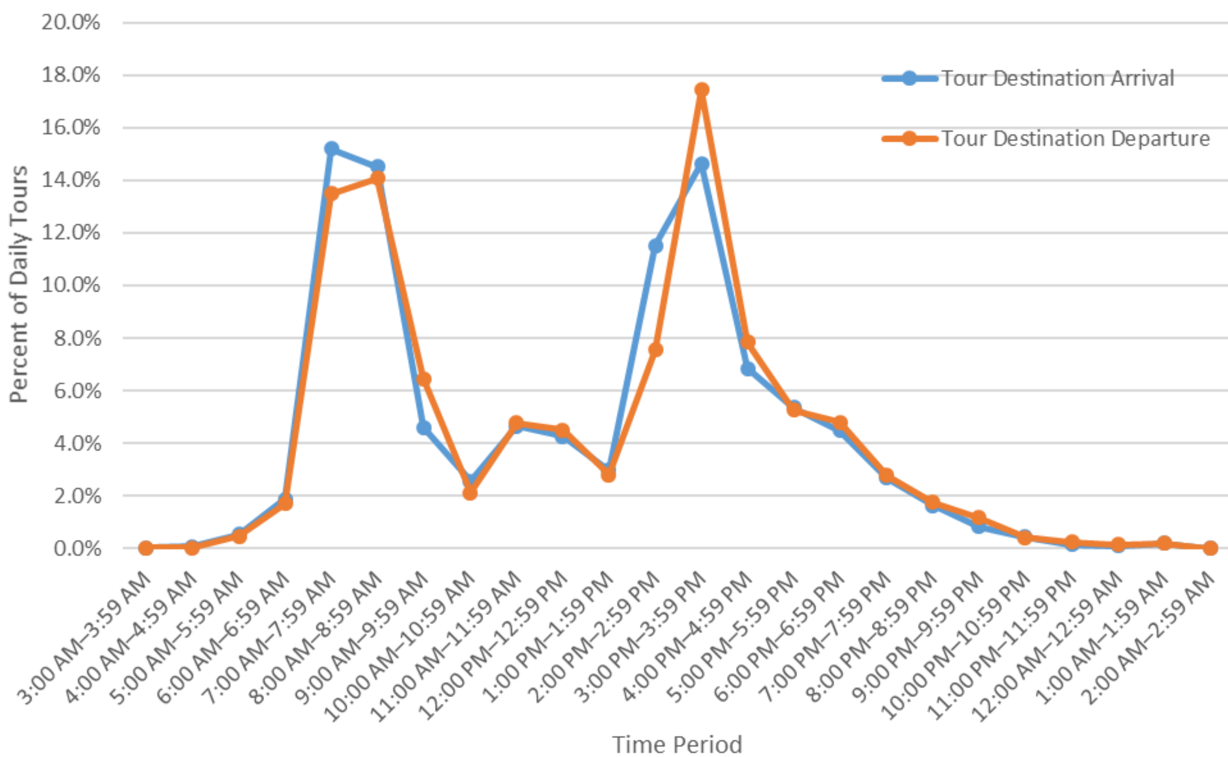
Source: Cambridge Systematics.

Figure 4.16 Tour Arrival and Departure Times – School Tours



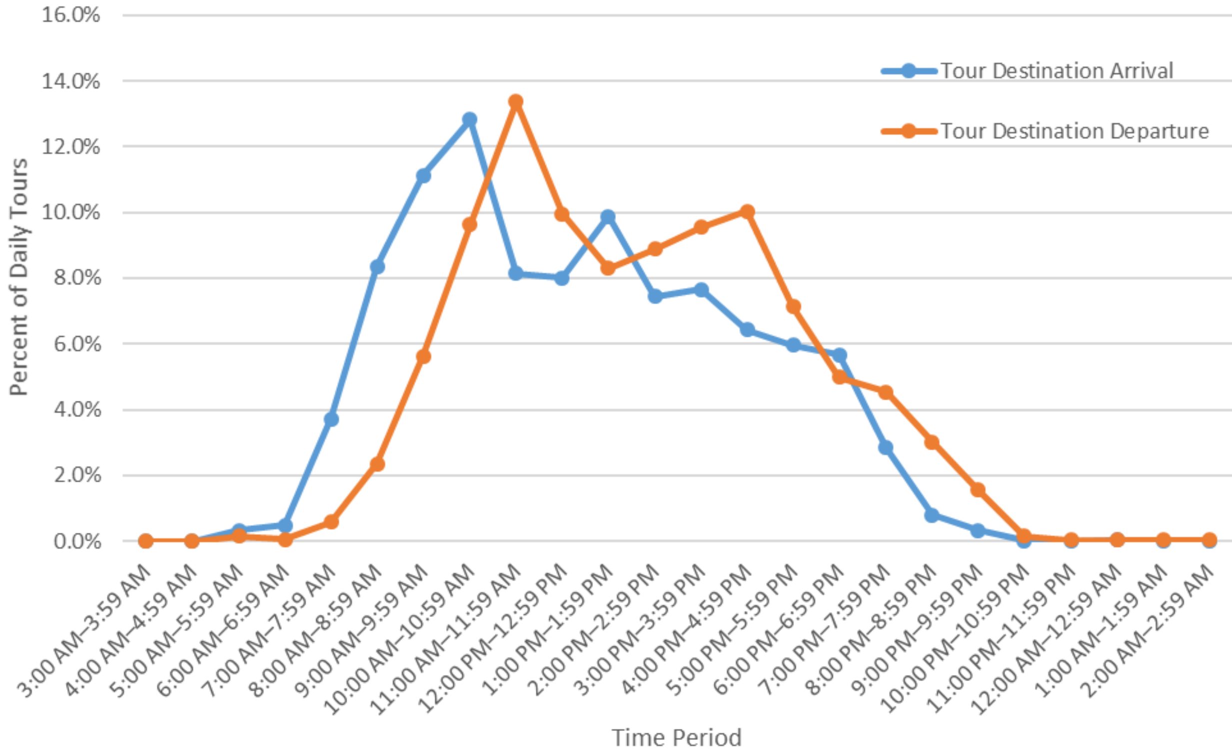
Source: Cambridge Systematics.

Figure 4.17 Tour Arrival and Departure Times – Escort Tours



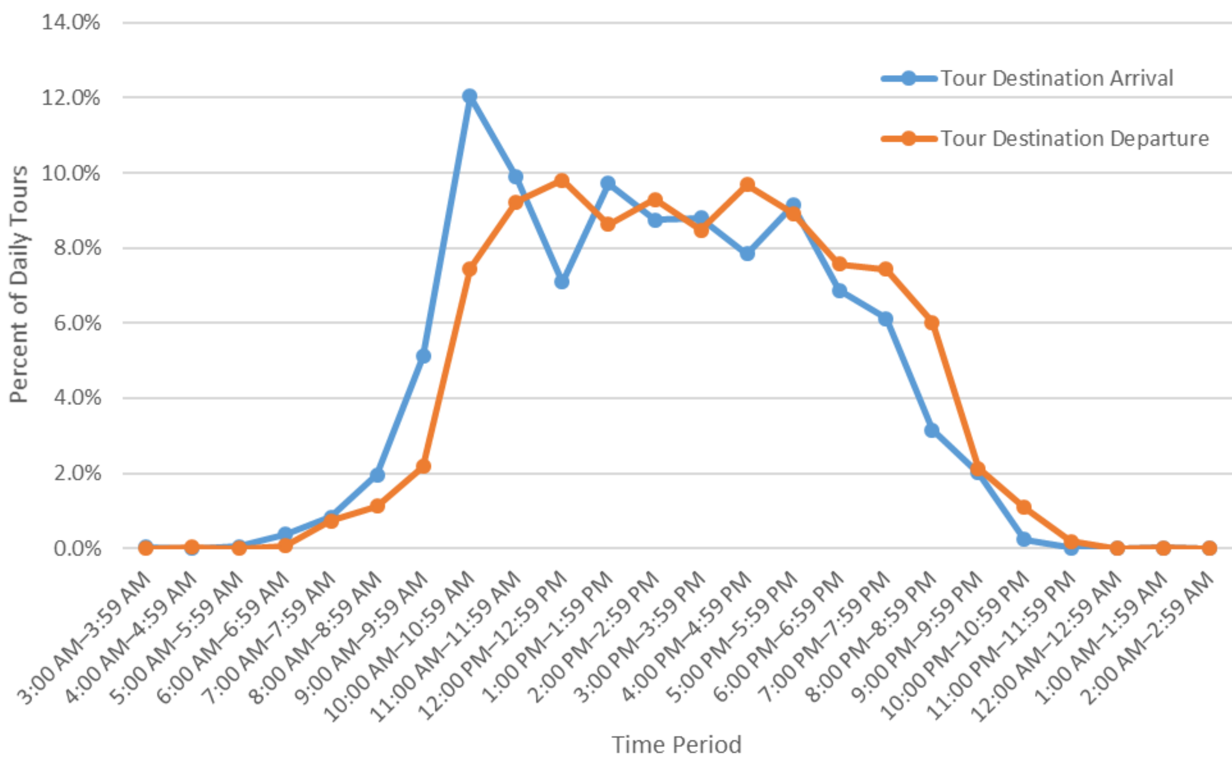
Source: Cambridge Systematics.

Figure 4.18 Tour Arrival and Departure Times – Personal Business Tours



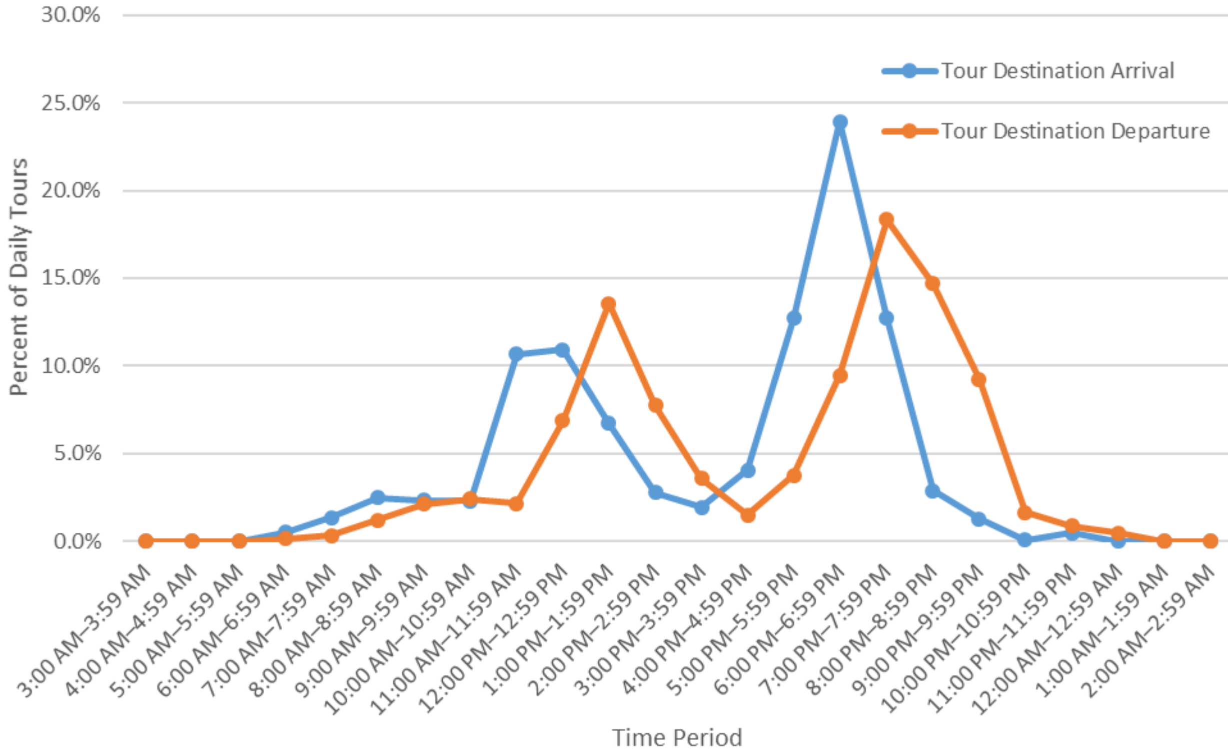
Source: Cambridge Systematics.

Figure 4.19 Tour Arrival and Departure Times – Shop Tours



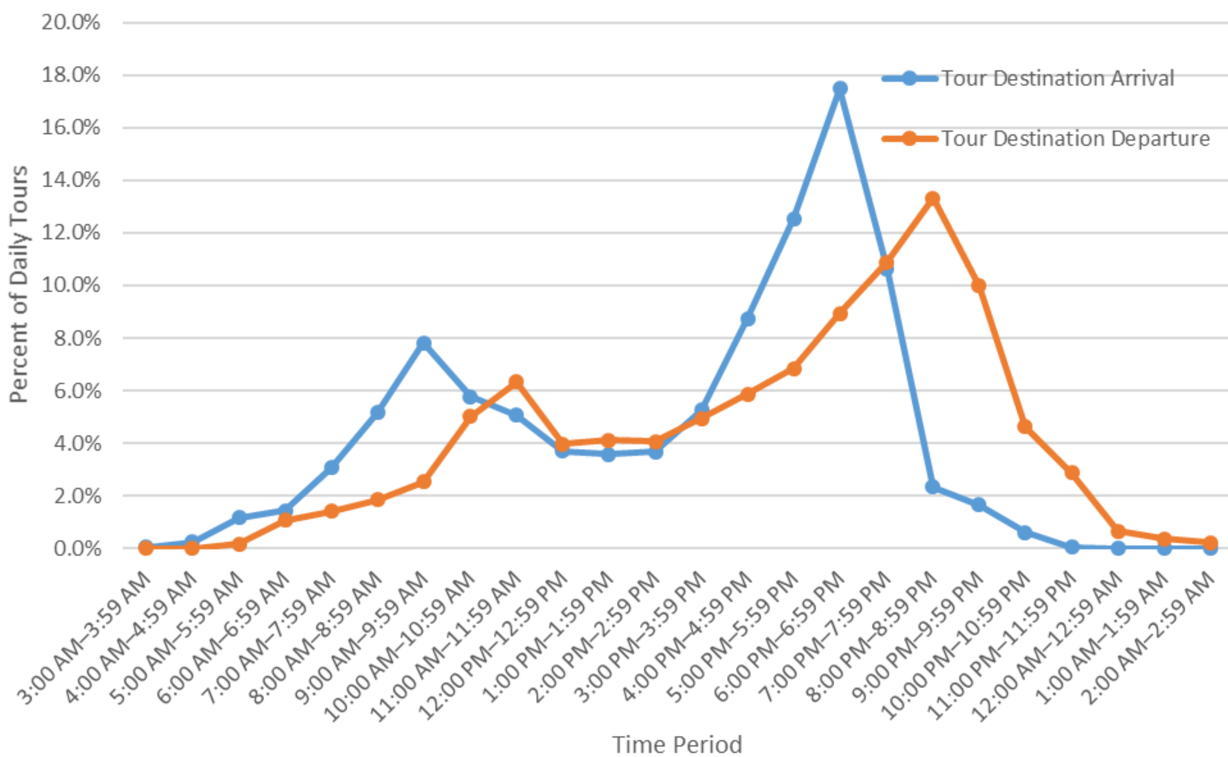
Source: Cambridge Systematics.

Figure 4.20 Tour Arrival and Departure Times – Meal Tours



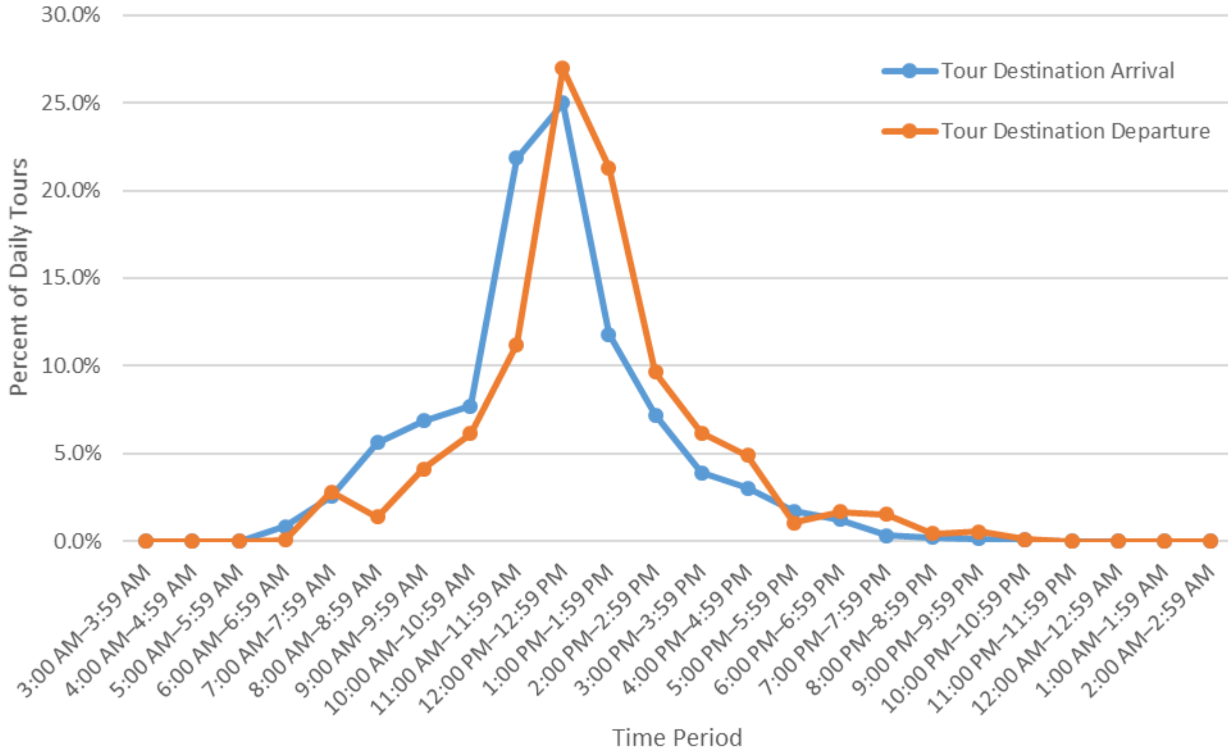
Source: Cambridge Systematics.

Figure 4.21 Tour Arrival and Departure Times – Social/Recreation Tours



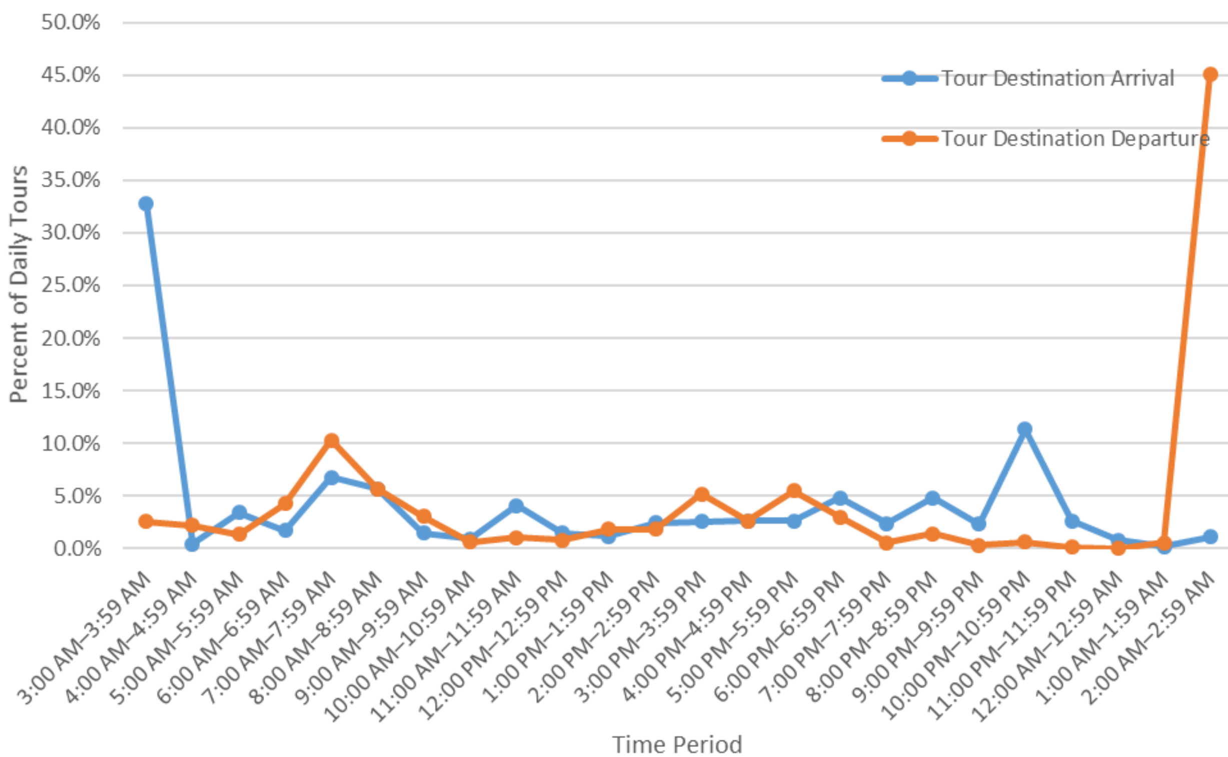
Source: Cambridge Systematics.

Figure 4.22 Tour Arrival and Departure Times – Work-Based Sub-Tours



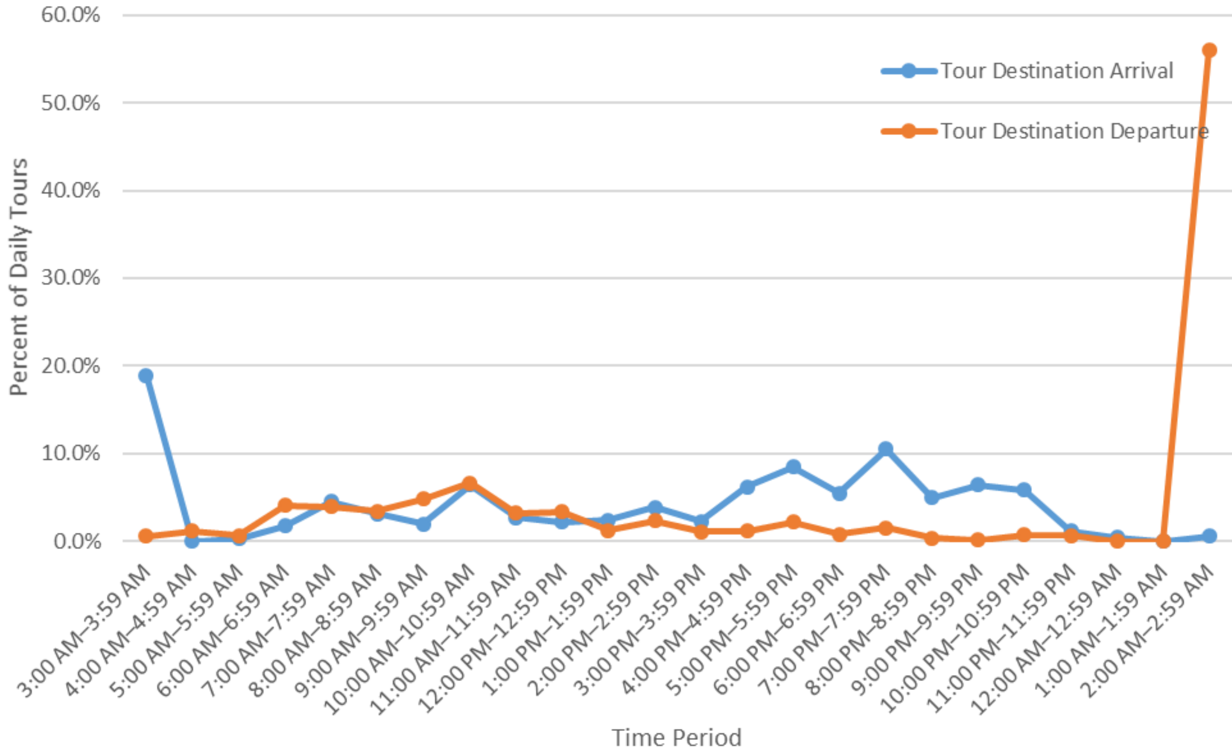
Source: Cambridge Systematics.

Figure 4.23 Tour Arrival and Departure Times – Non-Closed Work Tours



Source: Cambridge Systematics.

Figure 4.24 Tour Arrival and Departure Times – Non-Closed Non-Work Tours



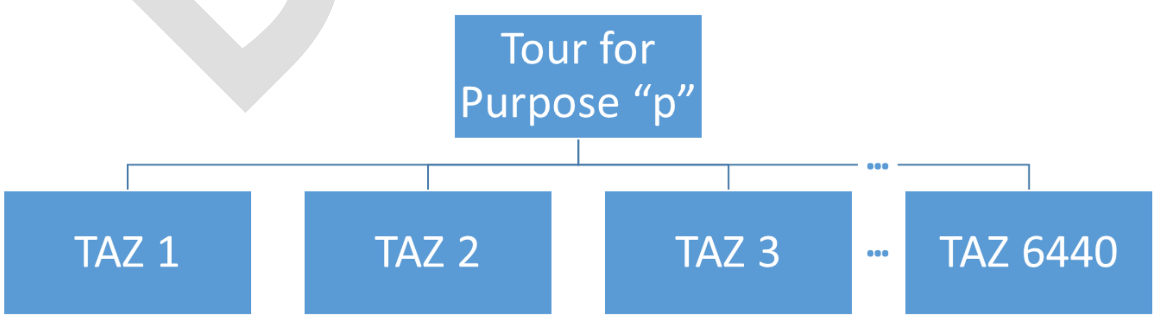
Source: Cambridge Systematics.

4.2.11 Tour Primary Location Choice / Point Location Monte Carlo

Model Structure

At this point of the StateFocus model, the numbers of tours are known for each purpose for each person along with initial estimates of the arrival times and departure times from the locations where the activity take place. The tour primary location choice models are multinomial logit models that forecast the actual TAZs for each tour destination where the primary tour activity takes place as illustrated in ***Figure 4.25***.

Figure 4.25 Tour Primary Location Choice Model Structure



Source: Cambridge Systematics.

Separate tour primary location choice models are estimated for the following tour purposes:

- Home-based work (to work locations other that the regular place of work)
- Home-based escort
- Home-based personal business
- Home-based shop
- Home-based meal
- Home-based social recreation
- Work-based sub-tour

The tour primary location choice models are applied for each tour made by a person. For example, if there are two home-based shop tours made during the day, the tour primary location choice model is applied for each tour and may result in two tours to the same TAZ or two tours to different TAZs.

Utility Function

The general form of the utility equation for the tour primary location choice models for a tour activity to occur in TAZ_j is:

$$U_{j|p} = \left\{\theta_p \times Ln\left[\sum_{x=1}^{X} exp\left(SC_{x|p}\right) \times SV_{x|p}\right]\right\} + \sum_{y=1}^{Y}\left(CIX_{y|p} \times DIX_{y,p|j}\right) + \sum_{z=1}^{Z}\left(CZ_{z|p} \times DZ_{j|z,p}\right)$$

Where: $U_{j|p}$ is the utility of a destination location in TAZ *j* for tour purpose *p* given an origin location of TAZ *i*

Θ_p is the multiplier for the logsum of the quantitative (size) variables

$SC_{x|p}$ are the coefficients applied to the size variables that are applicable for tour purpose *p*

$SV_{x|p}$ are the size variables that are applicable for tour purpose *p*

$CIX_{y|p}$ are coefficients for interchange variables, *y*, for tour purpose *p*

$DIX_{y|p}$ are interchange specific values between origin TAZ *i* and destination TAZ *j* for interchange variable, *y*, for tour purpose *p*

$CZ_{z|p}$ are coefficients for tour destination zone variables, *z*, for tour purpose *p*

$DZ_{z|p}$ are destination specific values for destination TAZ *j* for destination zone variable, *z*, for tour purpose *p*

Variables

Table 4.17 identifies the variables used in the tour location choice models for each tour purpose. Explanations of the variables follow the table; ***Appendix F.11*** lists the estimated and final model coefficients.

Table 4.17 Variables Included in Tour Primary Location Choice Models

Variable	Home-Based Work[1]	Home-Based Escort	Home-Based Personal Business	Home-Based Shop	Home-Based Meal	Home-Based Social / Recreation	Work-Based Sub-Tour
Quantitative (Size) Variables							
Households	x	x	x	x	x	x	x
Production Employment	x	x					x
Service Employment	x	x	x			x	x
Education Employment	x	x	x				x
Retail Employment	x	x	x	x	x	x	x
Restaurant Employment	x	x	x	x	x	x	x
Entertainment Employment	x					x	x
Pre-school Enrollment[2]		x					
K-8 Enrollment[2]		x					
High School Enrollment[2]		x					
College/University Enrollment[2]		x					
Ski Area Acres						x	
Interchange Related Variables[3]							
Distance (Miles)[4]	x	x	x	x	x	x	x
Smoothed Stepwise Linear Distance Functions (Miles)[4,5]	x	x	x	x	x	x	x
Ln(Distance+1)[4]	x	x		x	x		x
Mode Choice Logsum[6]	x	x	x	x	x	x	x
Intrazonal Tour	x	x	x	x	x	x	x
Intraregional Tour						x	
Tour Destination Zone Variables							
CBD	x	x	x	x	x	x	x
CBD Fringe	x	x		x	x	x	x
Rural	x						x
DIA[7]		x	x			x	
Mountains[7]						x	
Mixed Use			x			x	
Regular Work Location for Any Household Member		x					
Regular School Location for Any Household Member		x					

Source: Cambridge Systematics

Notes: [1] Home-based work tour primary location choice is applied for all work tours not destined to the regular place of work.

2 Two sets of model coefficients for school enrollment size variables are used based on the household income group of the person making the tour. The products of the coefficients multiplied by the enrollment for the appropriate grades for the lower and modest income groups are added to the products of the coefficients multiplied by the enrollment for the appropriate grades independent of the income group of the traveler (see ***Table 3.1*** for the standard five income groupings used for this model).

3 Interchange may be for closed tours or non-closed tours for the tour purposes that allow either to occur (home-based personal business and home-based social/recreation). Each tour being considered will be identified as closed or non-closed (see ***Section 4.2.7***). Different coefficients might apply for the same variable for closed and non-closed tours.

4 Distances are one-way based on the shortest uncongested impedance path from origin to destination expressed in miles.

5 Smoothed stepwise linear distance functions are described in ***Section 4.1.3***. Multiple functions might exist for each purpose.

6 The mode choice logsum is for the total tour (outbound plus inbound legs), even for non-closed tours.

7 Different coefficients might apply for closed and non-closed tours and/or by income group.

Quantitative (Size) Variables

Size variables provide a means to quantify the amount of activity and, thus, attractiveness, of a zone being considered as a destination. The amount of activity is generally a function of the number of households and the numbers of employees by employment type in a zone. For home-based escort tours, the numbers of enrolled students by grade level are included as size variables with the model coefficients stratified by household income group of the person making the tour (with separate coefficients for the lower income group and all other income groups as defined in ***Table 3.1***). Finally, the home-based social/recreation tour location choice model considers the number of acres of ski area in the zone.

As noted in the ***Utility Function*** section, each size variable is multiplied by an exponentiated size variable coefficient. The total attractiveness of the size variables is the sum of the results. Finally, the natural log of the total attractiveness of the size variables is taken and multiplied by a model coefficient in the utility function.

Interchange Related Variables

Distance is the one-way highway distance in miles from origin to destination based on the single-occupant vehicle uncongested (OP4, see ***Table 2.1***) highway skims. To provide a non-linear relationship with distance, smoothed stepwise linear distance functions as described in ***Section 4.1.3*** are used. Multiple smoothed stepwise linear distance functions might be used for a single tour purpose. In addition, the logarithm of one plus the distance was used for some tour purposes. Thus, the distance-based interchange utilities may consist of three or more components:

- Distance multiplied by a purpose specific coefficient,
- Distance as part of one or more smoothed stepwise linear distance functions multiplied by purpose specific coeffient(s), and
- The natural log of distance+1 multiplied by a purpose specific coefficient.

Mode choice logsum is the disaggregate mode choice logsum for the same tour purpose. Logsums are for the total tour (for both the outbound and return portions of the tour, even for non-closed tours). The times of day used for the outbound and return legs of the tour are based on the tour time of day simulation (see

Section 4.2.10). The home-based other logsum is used for the home-based personal business, home-based shop, home-based meal, and home-based social/recreation purposes (see ***Section 4.1.1*** for details on disaggregate mode choice logsums).

Intrazonal tours is a dummy variable that takes the value of 1 when the tour destination TAZ is the same as tour origin TAZ and 0 otherwise.

Intraregional tours is a dummy variable that takes the value of 1 when the tour destination TAZ is in the same region as tour origin TAZ and 0 otherwise. Regions are defined as zonal attributes for:

- DRCOG
- NFRMPO
- PPACG
- PACOG
- Grand Valley MPO
- Plains
- Eastern Slope
- Western Slope

Figure 4.26 graphically illustrates the above eight regions as defined in the zonal data file (see ***Appendix C***).

Tour Destination Zone Variables

CBD, **CBD Fringe**, and **Rural** are straightforward dummy variables that take on the value of 1 when the area type of the destination zone is of the area type specified and 0 otherwise.

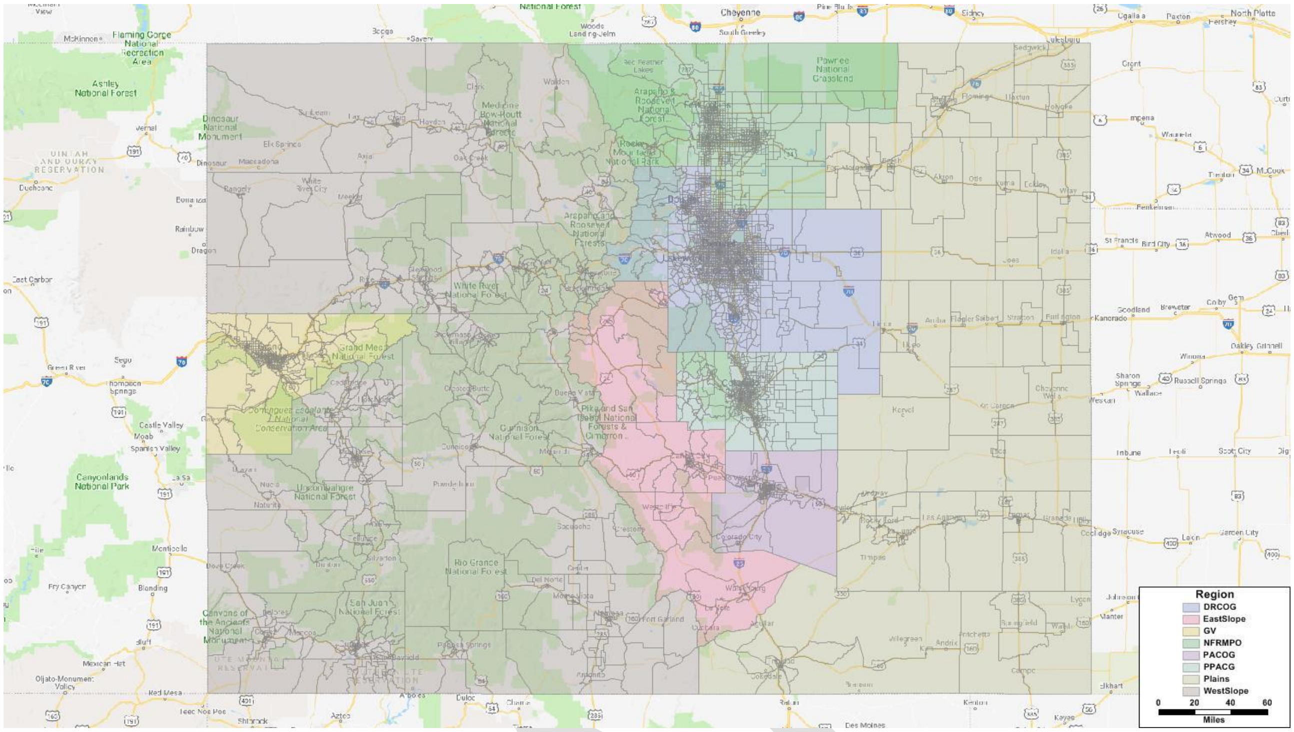
DIA is a dummy variable that takes on the value of 1 when the destination zone is one of the 15 TAZs comprising the Denver International Airport and 0 otherwise.

Mountains is a dummy variable that takes on the value of 1 when the destination zone is one of the 1,595 TAZs marked as "Mountain" in the zonal data file (see "PlainMountain" in ***Appendix C***) and 0 otherwise. During model estimation, TAZs had not been characterized as mountain or plain so all TAZs with centroids west of longitude -105.3 E were considered mountain TAZs. ***Figure 4.27*** graphically illustrates the mountains and plains regions. Note that some of the plains regions extend into the mountains due to the topography of the Front Range coupled with some large, irregularly shaped TAZs.

Mixed Use is a continuous variable based on the numbers households and entertainment, restaurant, and retail employees in the destination zone and calculated as:

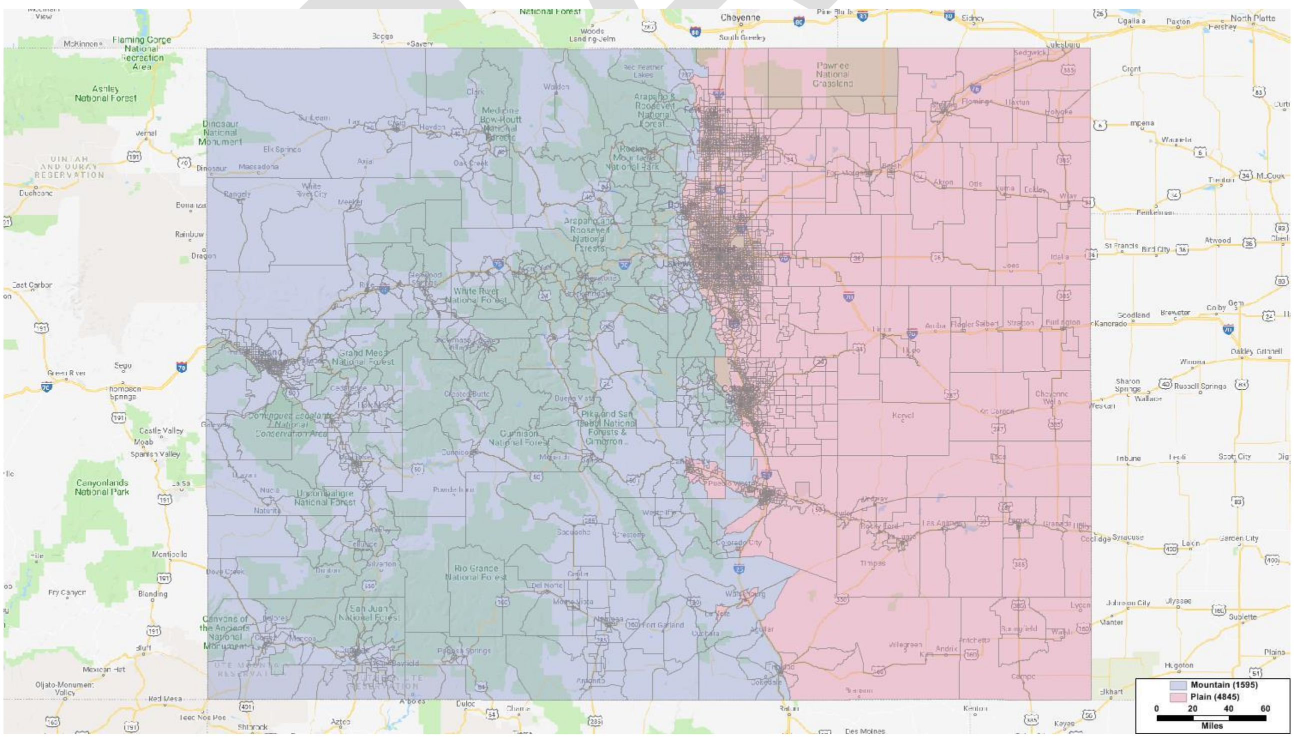
$$Mixed\ Use = \frac{(Entertainment + Restaurant + Retail) \times Households}{(Entertainment + Restaurant + Retail + Households + 1)}$$

Figure 4.26 Regions Used for Tour Primary Location Choice



Source: Cambridge Systematics

Figure 4.27 Mountains/Plains Used for Tour Primary Location Choice



Source: Cambridge Systematics

Mixed Use will be zero in zones with either 0 employees in the three employment categories or 0 households. ***Table 4.18*** shows the minimum non-zero, maximum, and average *Mixed Use* values by MPO and by area type based on the 2015 zonal data. As can be seen in the table, there is a wide range of values for the zones with non-zero mixed uses (0.3 to 1,603.4) but that the values for mixed use are relatively independent of the MPO or area type.

Table 4.18 2015 Mixed Use Summaries

Summary Unit	Percent "Zero" TAZs	Minimum Non-Zero	Maximum	Average (Including "Zero" TAZs)	Average (Excluding "Zero" TAZs)
MPO					
NFRMPO	55%	0.8	634.3	26.0	58.2
DRCOG	26%	0.6	911.4	63.3	85.4
PPACG	38%	0.3	1,603.4	43.3	69.6
PACOG	33%	1.0	371.5	36.9	55.6
GVMPO	68%	0.8	213.2	8.8	27.3
Non-MPO	21%	0.9	411.1	42.8	54.2
Area Type					
CBD	58%	1.0	366.4	29.2	68.7
CBD Fringe	22%	0.9	911.4	73.6	117.0
Urban	20%	0.3	1,603.4	85.0	105.7
Suburban	6%	0.7	630.8	43.4	61.6
Rural	50%	0.6	408.7	15.1	32.3

Source: Cambridge Systematics.

Regular Work Location for Any Household Member is a dummy variable that takes on the value of 1 when the destination zone is the regular work location for any member of the traveler's household and 0 otherwise.

Regular School Location for Any Household Member is a dummy variable that takes on the value of 1 when the destination zone is the regular school location for any member of the traveler's household and 0 otherwise.

Tour Point Location Monte Carlo

The tour primary location choice model is used to forecast a destination TAZ for each tour made by each person. The household location (or work location for work-based sub-tours) for each person has already been assigned to an actual point location within the origin TAZ. Each household and employment establishment within a TAZ has also been assigned to a point location (see ***Section 2.3.2***). Since tours may be made to either households or establishments, the tour primary location choice point location Monte Carlo uses a simple random selection process to select an actual household or establishment and its point location from the set of all households and establishments within the TAZ chosen for each tour.

4.2.12 Tour Priority Assignment

Tour priority assignment is a rule-based rather than a choice-based model. The tour priority assignment model component assigns a primary order 1…*n* to each person's home-based tours with *n* being the number of home-based tours made by the person during the day. The tour priority is used in the tour main mode choice model (***Section 4.2.13***) for the determination of several of the ***Schedule and Day Pattern Variables*** and in the tour time of day choice model (***Section 4.2.14***) for the determination of several of the ***Day Pattern Variables*** and ***Schedule Pressure Effects*** variables.

The overall tour priority order by tour purpose for non-students is:

1. Non-closed tours and non-traditional closed tours (for any purpose)[44]
2. Home-based work (at regular workplace)
3. Home-based work (at other than regular workplace)
4. Home-based school
5. Home-based escort
6. Home-based personal business
7. Home-based shop
8. Home-based meal
9. Home-based social/recreation

For students, the priority order is changed to place home-based school tours before work tours:

1. Non-closed tours and non-traditional closed tours (for any purpose)
2. Home-based school
3. Home-based work (at regular workplace)
4. Home-based work (at other than regular workplace)
5. Home-based escort
6. Home-based personal business
7. Home-based shop
8. Home-based meal
9. Home-based social/recreation

[44] According to restrictions used in the daily activity pattern choice model, a person can have only one non-closed tour during the day. The non-closed tour may be either a work or non-work tour. By caveat, a person may not have a non-closed tour and a non-traditional closed tour (see ***Accounting for Non-Traditional Closed Tours*** model).

If there are multiple tours of the same purpose, the first one listed is given a higher priority number. For example suppose a student had one school tour, two escort tours, and a social/recreation tour. The priority the tours would be:

1. Home-based school,
2. Home-based escort (first escort tour)
3. Home-based escort (second escort tour)
4. Home-based social/recreation

Work-based sub-tours are not included in the priority assignment since the must occur within the time period(s) covered by the home-based work tour(s).

4.2.13 Tour Main Mode Choice

Model Structure

The tour main mode choice models have been estimated for the following tour purposes (modes used in parentheses):

- Home-based work (drive alone, shared ride 2, shared ride 3+, walk, bike, walk to transit, drive to transit)
- Home-based school (drive alone, shared ride 2, shared ride 3+, walk, bike, walk to transit, drive to transit, school bus)
- Home-based escort (shared ride 2, shared ride 3+, walk)
- Home-based other[45] (drive alone, shared ride 2, shared ride 3+, walk, bike, walk to transit, drive to transit)
- Work-based sub-tour (drive alone, shared ride 2, shared ride 3+, walk, bike, walk to transit)

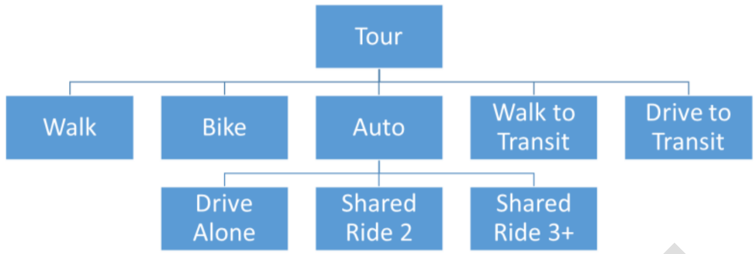
All of the models are nested logit with the exception of the escort model, which is multinomial logit. ***Figure 4.28*** through ***Figure 4.32*** show the choice structures for the five models. ***Appendix F.13*** shows the model estimation results and statistics along with the StateFocus C# variable names and the final calibrated model parameters.

Mode Availability

The drive alone mode is unavailable to persons under age 16 for all tour purposes. Transit modes are available only if there is an in-vehicle time in the matrix zone pair corresponding to the tour and transit access mode (walk to transit or drive to transit).

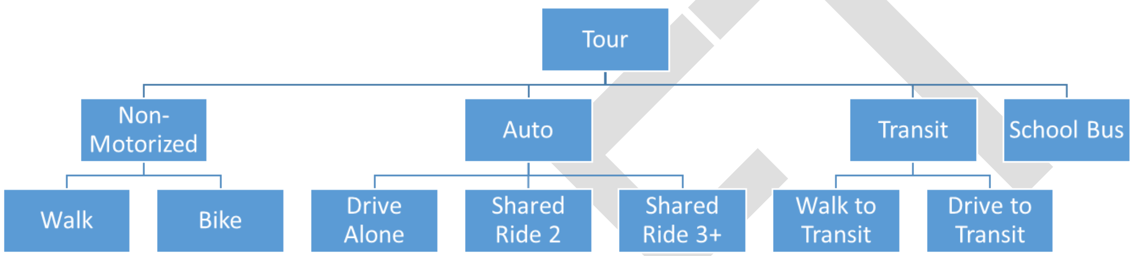
[45] For tour mode choice, home-based other encompasses home-based personal business, home-based shop, home-based meal, and home-based social/recreation tour purposes.

Figure 4.28 Home-Based Work Tour Mode Choice Structure



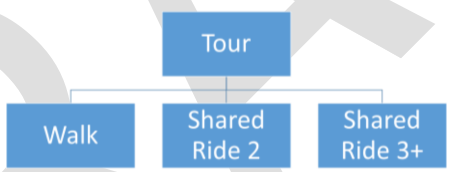
Source: Cambridge Systematics.

Figure 4.29 Home-Based School Tour Mode Choice Structure



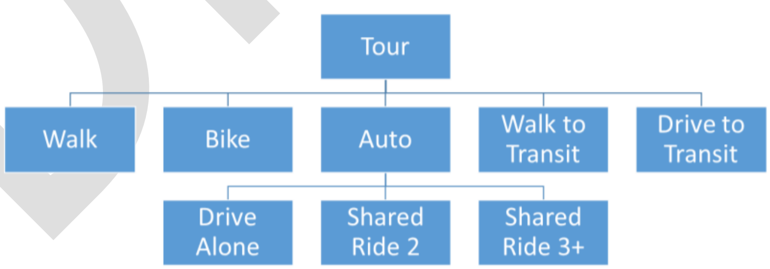
Source: Cambridge Systematics.

Figure 4.30 Home-Based Escort Tour Mode Choice Structure



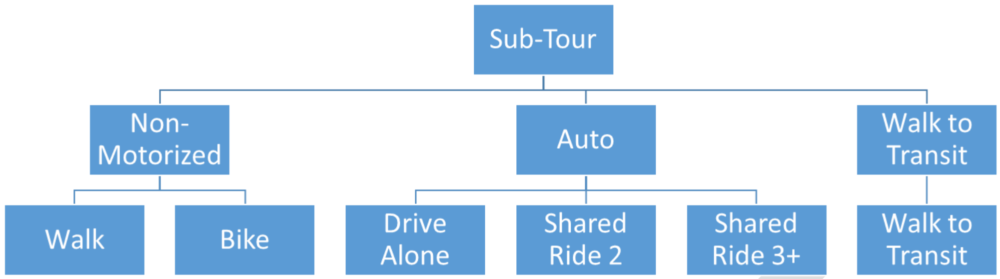
Source: Cambridge Systematics.

Figure 4.31 Home-Based Other Tour Mode Choice Structure



Source: Cambridge Systematics.

Figure 4.32 Work-Based Sub-Tour Mode Choice Structure



Source: Cambridge Systematics.

Variables

Table 4.19 lists the variables used in the tour main mode choice models by tour purpose. Each named variable has a common definition across all tour purposes although transportation level of service variables may be based on skims for different times of day depending on the tour purpose. For example, "Cost, Lower Income" is the total tour cost for each mode and is common to all tour purposes. However, the cost may be based on the AM1 and PM1 time periods for a home-based work tour and PM3 and OP4 for a subsequent home-based other tour made by the person (see ***Table 2.1*** for time period definitions). The variables are described below. ***Appendix F.13*** shows the model estimation results and statistics along with the StateFocus C# variable names and the final calibrated model parameters.

Table 4.19 Tour Main Mode Choice Variables by Tour Purpose

Variable	Home-Based Work	Home-Based School	Home-Based Escort	Home-Based Other	Work-Based Sub-Tour
Level of Service					
Travel Cost (Specified in 2010$)					
Cost, Lower Income	x	x	x	x	x
Cost, Modest Income	x	x	x	x	x
Cost, Middle Income	x	x	x	x	x
Cost, Upper Income	x	x	x	x	x
Cost, Top Income	x	x	x	x	x
Cost, Missing Income[1]	x	x	x	x	x
Travel Time (Specified in Minutes)					
Auto In-Vehicle Time	x	x	x	x	x
Auto Terminal Time	x	x	x	x	x
Transit Rail In-Vehicle Time	x	x		x	x
Transit Non-Rail In-Vehicle Time	x	x		x	x
Transit Walk Time	x	x		x	x
Transit Drive Time	x	x		x	x
Transit Initial Wait Time	x	x		x	x

Variable	Home-Based Work	Home-Based School	Home-Based Escort	Home-Based Other	Work-Based Sub-Tour
Transit Transfer Wait Time	x	x		x	x
Walk Time	x	x	x	x	x
Bike Time	x	x		x	x
Travel Time Related					
Total Travel Time, Lower Income					x
Local Bus In-Vehicle Time / O-D Distance	x	x		x	x
Transit Drive Access Time / Drive Alone Time Ratio Amount Exceeding 0.5	x	x		x	
Distance Related					
Distance (exp(-SBusDist)): School Bus		x			
Distance (exp(-SBusDist/2)): School Bus		x			
Distance (exp(-SBusDist/4)): School Bus		x			
Household and Traveler Characteristics					
Income Group					
Lower Income: Shared Ride[2]	x			x	
Lower Income: Non-Motorized[2]	x				
Lower Income: Transit[2]				x	x
Modest Income: Shared Ride[2]	x				
Modest Income: Non-Motorized[2]	x				
Modest Income: Transit[2]					x
Upper Income: Shared Ride[2]				x	
Upper Income: Non-Motor				x	
Top Income: Drive Alone	x				
Top Income: Shared Ride[2]	x			x	
Top Income: Non-Motor				x	
Missing Income: Shared Ride[1,2]	x			x	
Missing Income: Non-Motor[1]				x	
Missing Income: Transit[1,2]	x			x	
Automobile Ownership					
No Cars: Drive Alone				x	
No Cars: Shared Ride[2]	x				
No Cars: Non-Motorized[2]	x	x	x	x	
No Cars: Transit[2]	x	x		x	
No Cars: Transit[2]	x				
Cars But Less Than Drivers: Drive Alone				x	
Cars But Less Than Drivers: Non-Motorized[2]				x	

Variable	Home-Based Work	Home-Based School	Home-Based Escort	Home-Based Other	Work-Based Sub-Tour
Cars But Less Than Drivers: Transit[2]				x	
Cars But Less Than Workers: Shared Ride[2]	x				
Cars But Less Than Workers: Non-Motorized[2]	x	x			
Cars But Less Than Workers: Transit[2]	x	x			
Cars For Workers But Not All Drivers: Shared Ride[2]	x				
Cars For Workers But Not All Drivers: Non-Motorized[2]	x	x			
Cars For Workers But Not All Drivers: Transit[2]	x	x			
Household Size					
One Person Household: Shared Ride[2]	x	x		x	
Two Person Household: Shared Ride[2]	x	x		x	
Traveler Age					
Pre-School Aged: Non-Motorized[2]		x			
Pre-School Aged: Transit[2]		x			
Pre-School Aged: School Bus		x			
Age Under 20: Non-Motorized[2]				x	
Age Over 50: Non-Motorized[2]	x			x	
Educational Status					
University Student: Non-Motorized[2]		x			
University Student: Transit[2]		x		x	
University Student: School Bus		x			
University Student: Drive Alone (DRCOG)		x			
University Student: Drive Alone (Not DRCOG)		x			
High School Student: Drive Alone		x			
High School Student: Non-Motorized[2]		x			
High School Student: Transit[2]		x		x	
High School Student: School Bus		x			
Other Adult: Non-Motorized[2]		x			
Other Adult: Transit[2]		x			
Any Adult: School Bus		x			
Gender					
Female: Shared Ride[2]	x			x	
Female: Non-Motorized[2]	x			x	

Variable	Home-Based Work	Home-Based School	Home-Based Escort	Home-Based Other	Work-Based Sub-Tour
Other Parameters					
Number of Full-time Workers in the Household: Shared Ride[2]			x		
Number of Part-time Workers in the Household: Shared Ride[2]			x		
Number of Children Under 5 in the Household: Shared Ride[2]			x		
Number of Children Age 5 to 15 in the Household: Shared Ride[2]			x		
Geographic					
Land Use					
Destination Retail Density: Transit[2]	x			x	
Origin & Destination Mixed Use Density: Non-Motor	x			x	
Rural Origin: Shared Ride[2]		x			
Rural Origin: Non-Motorized[2]		x			
Origin Intersection Density: Transit[2]	x	x		x	
Destination Intersection Density: Transit[2]	x	x		x	
O & D Intersection Density: Non-Motorized[2]	x			x	x
O & D Intersection Density: School Bus		x			
MPO Specific Constants					
DRCOG: Non-Motorized[2]	x				
DRCOG: Transit[2]	x				
Tour Level					
Non-Closed Tour Indicator					
Non-Closed Tour: Shared Ride[2]	x				
Non-Closed Tour: Non-Motorized[2]	x			x	
Non-Closed Tour: Transit[2]	x	x		x	
Tour Purpose					
Meal Tour: Drive Alone				x	
Meal Tour: Shared Ride[2]				x	x
Meal Tour: Non-Motorized[2]					x
Shopping Tour: Shared Ride[2]					x
Shopping Tour: Transit[2]				x	
Social/recreation Tour: Shared Ride[2]				x	
Social/recreation Tour: Non-Motorized[2]				x	

Variable	Home-Based Work	Home-Based School	Home-Based Escort	Home-Based Other	Work-Based Sub-Tour
Parent Tour Mode					
Used Drive Alone to Work: Drive Alone					x
Used Drive Alone to Work: Shared Ride[2]					x
Used Shared Ride to Work: Drive Alone					x
Used Shared Ride to Work: Shared Ride[2]					x
Used Transit to Work: Transit[2]					x
Schedule and Day Pattern					
Arrive Destination in AM Peak: Auto	x			x	
Depart Destination in PM Peak: Auto	x			x	
Escort Stop Flag By Tours Remaining: Drive Alone		x			
Escort Stop Flag By Tours Remaining: Shared Ride[2]	x	x	x	x	
Other Stop Flag By Tours Remaining: Drive Alone	x				
Other Stop Flag By Tours Remaining: Shared Ride[2]	x	x	x	x	
Sampling Bias					
FREX: Transit[1,2]	x	x		x	
OtherNonRandom: Non-Motorized[1,2]	x			x	x
OtherNonRandom: Transit[1,2]	x	x		x	x
Nesting Coefficients					
Logsum: Non-Motorized		x			x
Logsum: Transit		x			
Logsum: Auto	x	x		x	x
Alternative Specific Constants					
Shared Ride 2	x	x		x	x
Shared Ride 3+	x	x	x	x	x
Walk	x	x	x	x	x
Bike	x	x		x	x
Walk to Transit	x	x		x	x
Drive to Transit	x	x		x	
School Bus		x			

Source: Cambridge Systematics

Notes: [1] Variable used for model estimation purposes only and is not used in model application.

[2] Shared Ride, Transit, and Non-Motorized variables may refer to any or all of the choices in lower level nests.

Level of Service Variables

All level of service variables are obtained directly from the appropriate TransCAD skim for the mode and time periods for the travel (see ***Section 2.1.1*** for details of path-building and skimming procedures).

Costs

Costs are the total costs for the entire tour from tour origin to destination plus from destination to origin expressed in 2010 dollars (see ***Section 2.1.1*** for details of path-building and skimming procedures). Parking costs at the tour destination are included for auto modes.

- Tolls and transit fares are obtained from the appropriate skim matrices.

- Shared ride auto costs are multiplied by 0.67 for the shared ride 2 mode and by 0.50 for the shared ride 3+ mode to reflect a level of cost sharing for the occupants.

- Parking cost at the primary destination is obtained from the zonal database. For duration of stay under 6 hours, the daily parking cost is factored by the activity duration/6 hours, with a minimum of 1 hour:

  $$ParkingCost = DailyCost \times min\{max[60, (ActivityDeparture - ActivityArrival) \times 60], 360\}/360$$

  where:
  ParkingCost is the tour parking cost
  DailyCost is the daily parking cost
  ActivityDeparture is the departure hour from the activity using a 24-hour clock
  ActivityArrival is the arrival hour to the activity using a 24-hour clock

  For example, if the *ActivityDeparture* − *ActivityArrival* was 5 (hours), the *DailyCost* would be factored by 300/360, or 0.8333.

- Coefficients on the cost variables are stratified by the five standard household income groupings defined in ***Section 3.1.1***. In model estimation, a cost coefficient was also estimated for travelers in households that did not report an income. In model application, household incomes will be assigned for all travelers so the cost coefficient for missing income will not be used.

Time Variables

Times are expressed in minutes. The sum of origin to destination plus destination to origin times by time of day must be used because in-vehicle times vary greatly by time of day due to congestion effects or transit routing or scheduling (see ***Table 2.1*** for roadway time of day skim times and ***Table 2.2*** for transit time of day skim times). The outbound and inbound half-tour times of day for each traveler used for determining which skim data are used are based on the tour time of day simulation step.

- **Auto in-vehicle time** is the in-vehicle time by auto submode (drive alone, shared ride 2, or shared ride 3+) as appropriate. For tours where the skim distance is less than 2.5 miles from tour origin to tour destination, the auto in-vehicle time is replaced by a combination of skimmed distance and the orthogonal distance between the actual tour origin point location and destination point location as follows:

$$TT_{Model} = TT_{Skim} \times \frac{max\left\{0.05, \left[min\left({}^{Dist_{Skim}}/_{2.5}, 1\right) \times Dist_{Skim} + \left\{1 - min\left({}^{Dist_{Skim}}/_{2.5}, 1\right)\right\} \times Dist_{Orth}\right]\right\}}{max(0.001, Dist_{Skim})}$$

Where: TT_{Model} is the travel time used by the model in minutes
TT_{Skim} is the skimmed network travel time in minutes
$Dist_{Skim}$ is the skimmed network travel distance in miles
$Dist_{Orth}$ is the orthogonal distance from the tour point origin to the tour point destination in miles

The modeled auto in-vehicle travel times are calculated by direction and added together to get the total tour in-vehicle travel time. As the skimmed distance approaches 0, the travel time is based primarily on the orthogonal distance times the implied skimmed travel speed; as the skimmed distance approaches (or exceeds) 2.5 miles, the travel time is based primarily (or exclusively) on the skimmed travel time.

For the special case where the destination TAZ is the same as the origin TAZ ("intrazonal" tours) with 0 skimmed distance, the formula above is replaced by the orthogonal distance multiplied by 3 minutes/mile (20 miles/hour):

$$TT_{Model} = Dist_{Orth} \times 3$$

The intrazonal origin to destination in-vehicle time is doubled under the assumption of symmetry.

- **Auto terminal time** is the time spent at the beginning or end of a trip to access the auto. Auto terminal time is based on the area type at the origin and destination of the tour and ranges from one to six minutes as documented in ***Section 3.3.1***. Since terminal time does not vary by direction or time of day, the origin to destination terminal time is doubled to represent the total tour terminal time.

- **Transit rail in-vehicle time** is the transit travel time spent on the rail mode for the tour.

- **Transit non-rail in-vehicle time** is the transit travel time spent on non-rail modes (local bus, express bus, etc.) for the tour.

- **Transit walk time** is the sum of the walk access, transfer, and walk egress times. Transfer distances are stored on the skimmed transit network and are multiplied by 20 minutes per mile (3 miles per hour) to determine the transfer walk time.

- **Transit drive time** is the drive time from the tour origin to the drive access park and ride lot on the outbound portion of the tour and from the park and ride lot to the tour origin on the return portion of the tour. The park and ride lot used on the return portion of the tour must be the same as the park and ride lot used on the outbound portion for the drive to transit submode to be a valid choice.

- **Transit initial wait time** is the waiting time for first transit vehicle used for the origin to destination leg of the tour plus the waiting time for first transit vehicle used for the destination to origin leg of the tour.

- **Transit transfer wait time** is the total waiting time for transit transfers for the origin to destination and destination to origin legs of the tour.

- **Walk time** is calculated using the same formula and procedures as described for auto in-vehicle time (TT_{Model}) above. The skim distance used in the formula is the skimmed distance for bicycle (see ***Section 2.1.3***) and the is based an assumed 20 minutes/mile (3.0 miles/hour) walk speed. The origin to destination and destination to origin walk times are summed for the total tour walk time. For intrazonal tours, the origin to destination walk time is:

$$TT_{Model} = Dist_{Orth} \times 20$$

The intrazonal origin to destination walk time is doubled under the assumption of symmetry.

- **Bike time** is calculated using the same procedure as outlined for walk time with the exception that bike travel times for all tours are based on bicycle speeds of 7.5 minutes/mile (8.0 miles/hour).

Travel Time Related Variables

- **Total travel time, lower income** is the sum of all travel times by mode for the tour (i.e. auto in-vehicle time and terminal times for auto modes; transit in-vehicle travel time, walk access/egress times, transfer walk time, initial wait, and transfer wait time for transit; walk time for walk; and bike time for bike). The variable is used if the traveler is from a lower income household.

- **Local bus in-vehicle time / o-d distance** is total in-vehicle travel time spent on local buses (including dwell time on local buses) on the outbound leg of the tour divided by the origin to destination distance. The shared ride 2 distance was used in the StateFocus C# code. Note that the model estimation used the doubled outbound travel time and doubled outbound distance but there's not impact since the variable is a ratio.

- **Transit drive access time / drive alone time ratio amount exceeding 50%** is the sum of the origin to park and ride lot drive access time on the outbound leg of the tour and the park and ride lot to the origin drive egress time on the return leg of the tour divided by the total time if the drive alone mode is used for the entire tour. The variable used is the excess of the ratio exceeding 0.5:

$$RatioExcess = \max(ratio - 0.5,0)$$

Where: *RatioExcess* is the transit drive access time / drive alone time ratio amount exceeding 50%
Ratio is tour transit drive access and egress time / tour drive alone time

Distance Related Variables

- **Distance** variables are applicable only for home-based school tour mode choice to represent the level of service available from the school bus mode. School bus networks are not coded in StateFocus. Rather, the assumption is that some level of school bus service is provided for home-based school tours to the regular school location. Three "distance" variables are calculated using the following equation:

$$Distance = exp(-SBusDist/DistFac)$$

Where: *SBusDist* is the distance in miles representing how far a school bus would travel on both the outbound and return legs of the tour; the bicycle mode distance (see ***Section 2.1.3***) is used to represent the *SBusDist*;
DistFac is a factor that takes on a value of 1, 2, or 4 depending on the specific distance variable.

Household and Traveler Characteristics Variables

These variables come from the characteristics of the traveler being modeled along with his or her household characteristics. These variables include the following household information for each traveler:

- **Income Group** – these variables take on values of 0 or 1 depending on the income group of the traveler's household. The five standard income groups identified in ***Section 3.1.1*** are used based on the income assigned to the household by the population synthesis (see ***Section 2.2***). The income group variable is applied to different mode choices, effectively modifying the alternative specific constants by income and mode. In model estimation, the household income level was not reported for some households, so coefficients for "missing household income" were also estimated. In model application, all households will have an income group assigned.

- **Automobile Ownership** – like income group, these variables take on values of 0 or 1 depending on the autos available to the traveler's household (see ***Section 4.2.5*** for information on the autos available choice model). The automobile ownership variable is applied to different mode choices, effectively modifying the alternative specific constants by household auto availability and mode.

- **Household Size** – these variables take on values of 0 or 1 depending on the number of members in the traveler's household. The household size is assigned by the population synthesis (see ***Section 2.2***). The household size variable is applied to different mode choices, effectively modifying the alternative specific constants by household size and mode.

- **Traveler Age** – these variables take on values of 0 or 1 depending on the traveler's age: pre-school or under age 5, under 20 years old, or over 50 years of age. The traveler's age is assigned by the population synthesis (see ***Section 2.2***). The traveler age variable is applied to different mode choices, effectively modifying the alternative specific constants by the traveler's age and mode. Age under 20 and pre-school age variables could be ambiguous since a four year old would be both pre-school age and under 20 years old. However, the pre-school age variable is used only for home-based school tours and age under 20 years old is used only for home-based other tours.

- **Educational Status** – these variables take on values of 0 or 1 depending on the traveler's age and school attendance status as assigned by the population synthesis (see ***Section 2.2***):

    - *University Student* is a traveler who is a student in a college or university undergraduate program or a student in a graduate or professional program (PopGen2 variable SCHG equals 15 or 16).

    - *High School Student* is a traveler who is a high school student (PopGen2 variable SCHG equals 11, 12, 13, or 14).

    - *Other Adult* is a traveler who is age 18 or older and not a high school or university student.

    - *Any Adult* is any traveler age 20 or older.

  The educational status variable is applied to different mode choices, effectively modifying the alternative specific constants by the traveler's educational status and mode. Note that coefficients for university students using drive alone are also stratified by whether or not the student resides in the DRCOG region.

- **Gender** – these variables take on values of 0 or 1 depending on whether or not the traveler is female. The traveler's sex is assigned by the population synthesis (see ***Section 2.2***). The traveler gender variable is applied to different mode choices, effectively modifying the alternative specific constants by the traveler's sex and mode.

- **Other Parameters** – these household variables take on discrete values based on the person types (see ***Section 3.1.2***) of the members of the traveler's household:

  - *Number of Full-time Workers in the Household* is the number of members of the traveler's household identified as full-time workers (person type = 1).

  - *Number of Part-time Workers in the Household* is the number of members of the traveler's household identified as part-time workers (person type = 2).

  - *Number of Children Under 5 in the Household* is the number of members of the traveler's household identified as under age 5, or pre-school students (person type = 8).

  - *Number of Children Age 5 to 15 in the Household* is the number of members of the traveler's household identified as age 5 to 15, or pre-driving age students (person type = 7).

  Unlike the other household and traveler characteristics variables, the "other parameters" take on discrete, integer numbers.

Geographic Variables

These variables are used to describe conditions at the origin and/or destination locations of the tour that affect mode choice.

- **Land Use** – these variables describe the density of development near the origins or destinations of the tour:

  - *Destination Retail Density* is the number of retail employees within 0.5 miles of the centroid of the destination zone divided by 1000

  - *Origin & Destination Mixed Use Density* variables are mixed use densities at the tour origin and destination zones. Mixed use density is calculated as:

$$MixedUseDensity = \left[\frac{(RetailDensity + RestaurantDensity) \times ResidentialDensity}{max[0.001, (ResidentialDensity + RetailDensity + RestaurantDensity)]}\right]$$

Where: *RetailDensity* is the number of retail employees within 0.5 miles of the centroid of the zone divided by 1000
RestaurantDensity is the number of restaurant employees within 0.5 miles of the centroid of the zone divided by 1000
ResidentialDensity is the number of households within 0.5 miles of the virtual centroid of the zone based on households divided by 1000

The same formula is used for both the tour origin and tour destination.

  - *Rural Origin* is a 0/1 variable defined by whether or not the tour origin is in a TAZ defined as a rural area type.

  - *Origin & Destination Intersection Density* variables are intersection densities at the tour origin and destination zones. The intersection density variables are input zonal level variables determined exogenously to the StateFocus modeling process using GIS information. Intersections may be of three types:

» *4-way intersections* are normal intersections, signalized or unsignalized, formed by two or more intersecting roadways,

» *3-way intersections* are formed by two intersecting roadways where one of the roadways does not extend beyond the intersection ("T-intersections"), and

» *1-way intersections* are not truly intersections but are formed by nodes on a single roadway.

Intersection density is calculated as follows:

$$IntersectionDensity = \frac{(4\text{–}\,way\ intersections + 0.5 \times 3\text{–}\,way\ intersections - 1\text{–}\,way\ intersections)}{1000}$$

Where: *4-way intersections* is the number of 4-way intersections within 0.5 miles of the virtual centroid of the zone based on households
3-way intersections is the number of 3-way intersections within 0.5 miles of the centroid of the zone
1-way intersections is the number of 1-way intersections within 0.5 miles of the virtual centroid of the zone based on households.

- **MPO Specific Constants** take on values of 0 or 1 depending on whether or not the tour origin zone is within the specified MPO.

Tour Level Variables

- **Non-Closed Tour** variables take on a value of 1 if the tour is designated as a non-closed tour and are 0 otherwise.
- **Tour Purpose** variables are used for only home-based other tour and work-based sub-tour mode choice to identify the sub-purpose of the tour (i.e. meal, shopping, or social-recreation). The variables take on a value of 1 if the tour being modeled matches the type of tour purpose variable and a value of 0 otherwise.
- **Parent Tour Mode** variables are defined based on the home-based work tour within which the work-based sub-tour is taking place. The variables take on a value of 1 if the mode being considered for the work-based sub-tour is the same main mode (previously) selected for the home-based work tour and 0 otherwise. Thus, for example, if drive alone was used for the home-based work tour, separate "Used Drive Alone to Work" parent tour mode variables are defined for the drive alone mode and the shared ride modes for the work-based sub-tours made within the time period covered by the home-based work tour.

Schedule and Day Pattern Variables

Schedule and day pattern variables are developed for each individual based on the person's daily activity pattern and exact number of tours choices, the tour time of day simulation, and tour priority assignment. In effect, at this point of the choice process, daily activities and whether those activities will take place as a primary tour or as a stop on a tour are known. In addition, the arrival time at the tour destination and departure time from the destination have been initially simulated and the tour priority has been assigned.

- **Arrive Destination in AM Peak** is 1 if the trip is simulated to arrive in the AM peak period (see ***Table 2.1***) and is 0 otherwise.

- **Leave Destination in PM Peak** is 1 if the trip is simulated to leave in the PM peak period (see ***Table 2.1***) and is 0 otherwise.

- **Escort Stop Flag by Tours Remaining** is 0 if a person has no intermediate escort stops (as determined by the daily activity pattern choice model–see ***Section 4.2.6***), or 1 divided by the number of tours remaining to be simulated in the model, including the current tour, if a person has one or more intermediate escort stops during the day. As described in ***Section 4.2.12***, tour priority assignment, tours are simulated in priority order. As an example, if a person has a work tour, an escort tour, and a meal tour, they are simulated in that order. If the person also has one or more intermediate escort stops, then the escort stop flag by tours remaining value will be ⅓ for the work tour, ½ for the escort tour, and 1 for the meal tour.

- **Other Stop Flag by Tours Remaining** is defined in a manner similar to escort stop flag by tours remaining except that the numerator is based on stops for purposes other than those for escort or shop[46] (i.e. work, school, meal, social/recreation, or personal business).

Sampling Bias Variables

The FRTC data used for model estimation included two intercept oversamples: one for households of travelers using the Front Range Express (FREX) between Colorado Springs and Denver and one for households of travelers using park-and-ride lots in Denver. Since mode choice observations from the two oversamples were based on non-random sampling, 0/1 variables were used to identify households from each of the oversamples and coefficients were estimated for those households in order to remove some of the bias introduced by the non-random sampling. The variables and associated model coefficients are not used in model application.

Nesting Coefficients

Nesting coefficients are coefficients applied to lower level mode choice logsums (see ***Figure 4.28*** through ***Figure 4.32*** for tour mode choice nesting structures and ***Section 4.1.1*** for a discussion of logsums).

Alternative Specific Constants

Alternative specific constants account for the unexplained variation in mode choices. While the constants are estimated as part of the model estimation process, they are typically updated during model calibration / validation to match overall shares by mode.

[46] Shop stops are not included in this calculation since a separate variable for "shop stop flag by tours remaining" was also developed in the model estimation dataset but model coefficients for the variable were not significant for any of the tour mode choice models.

4.2.14 Tour Time of Day Choice

Model Structure

The tour time of day choice models are estimated for the following tour purposes:

- Non-closed tours (work or non-work)
- Home-based work
- Home-based school
- Home-based social/recreation
- Home-based other[47]
- Work-based sub-tours

The tour arrival and departure time model predicts the time arriving at the primary destination of the tour and the time leaving the primary destination, both to within 1-hour periods. For closed tours, there are 24, one-hour time periods in the model, starting with 3:00 AM–3:59 AM:

1. 3:00 AM – 3:59 AM
2. 4:00 AM – 1:59 AM

….

23. 1:00 AM – 1:59 AM
24. 2:00 AM – 2:59 AM

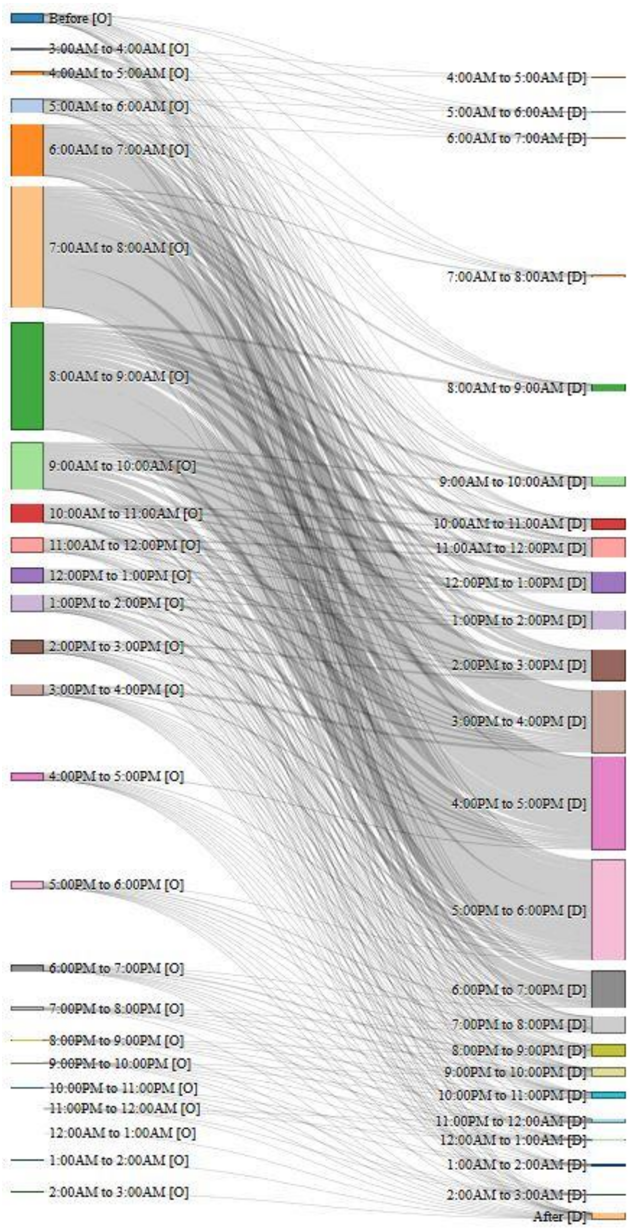
The departure period is always greater than or equal to the arrival period, and less than or equal to 24, so there are (24 + 23 + … + 2 + 1) alternatives, for a total of 300 alternatives. In the presence of non-traditional closed and non-closed tours, two extra time periods must be included: "before" (for non-traditional closed or non-closed tours not starting at home) and "after" (for non-traditional closed or non-closed tours not ending at home), increasing the number of alternatives to a total of 348.[48] Note that only closed tours are modeled for work-based sub-tours.

Figure 4.33 through ***Figure 4.37*** show the sample distribution of arrival and departure time for the different purposes from the FRTC data. There are some important differences in the time of day patterns for the purposes. Most of the home-based work and home-based school tours start in the morning and finish in the afternoon. On the other hand, home-based social/recreation and home-based other tours are distributed throughout the day. Also, home-based social/recreation tours tend to be longer in duration than home-based other tours. Finally, work-based sub-tours take place mainly during the midday, lunch time period.

[47] For tour time of day choice, home-based other encompasses home-based escort, home-based personal business, home-based shop, and home-based meal tour purposes.

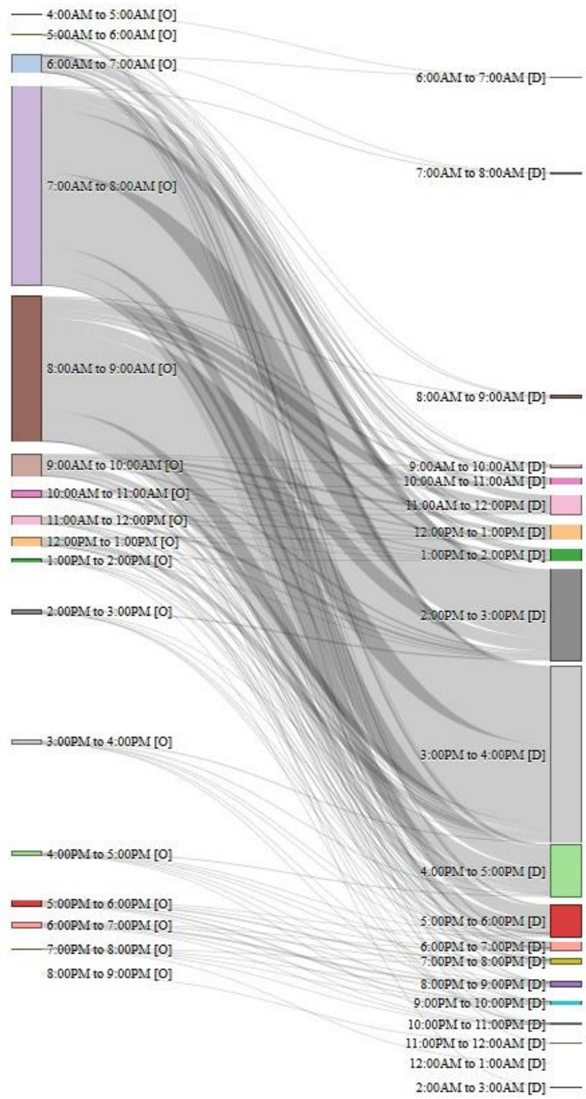
[48] The FRTC survey and the StateFocus model use a travel day defined as 3:00 AM to 2:59 AM the following day. Before represents any time before 3:00 AM on the start of the travel day and after represents any time after 2:59 AM of the following day.

Figure 4.33 Observed Arrival and Departure Times of Home-Based Work Tours



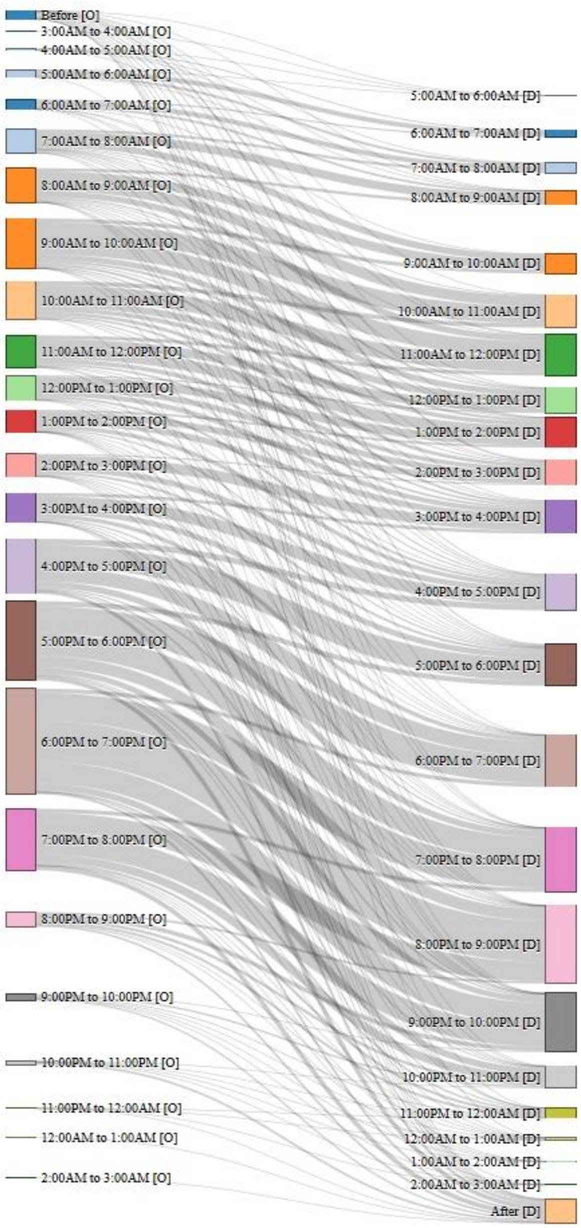
Source: Arizona State University analysis of FRTC data.

Figure 4.34 Observed Arrival and Departure Times of Home-Based School Tours



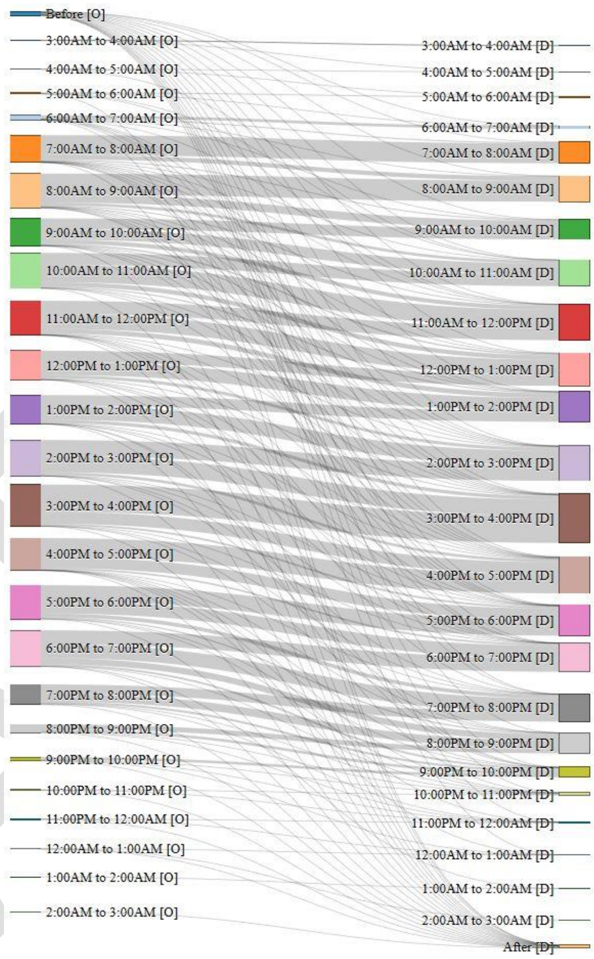
Source: Arizona State University analysis of FRTC data.

Figure 4.35 Observed Arrival and Departure Times of Home-Based Social/Recreation Tours



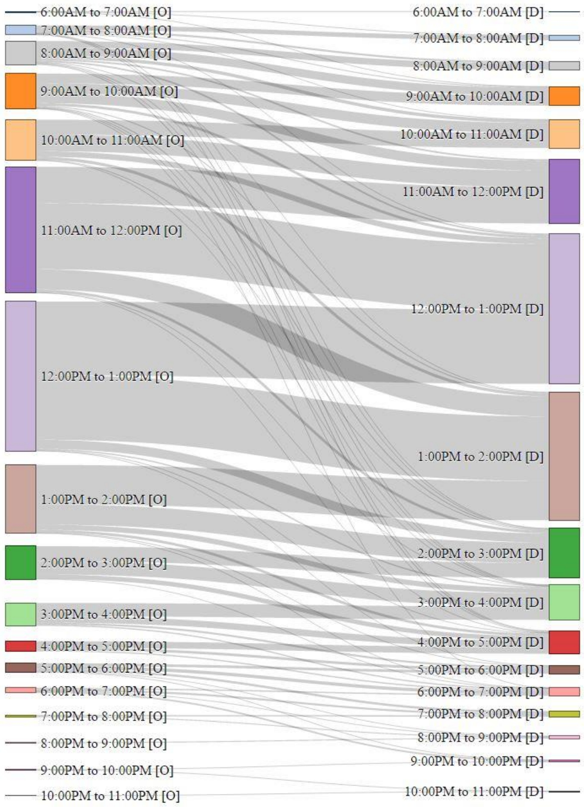
Source: Arizona State University analysis of FRTC data.

Figure 4.36 Observed Arrival and Departure Times of Home-Based Other Tours



Source: Arizona State University analysis of FRTC data.

Figure 4.37 Observed Arrival and Departure Times of Work-Based Sub-Tours



Source: Arizona State University analysis of FRTC data.

All of the tour time of day choice models are multinomial logit with 348 alternatives (only 300 are valid for the work-based sub-tour model). The primary approach to modeling time of day is to use constants for various groupings of arrival periods, departure periods and durations, plus shift effects that push arrivals earlier or later and durations of stay longer or shorter (as a result, shifting the departure period as well). This is the same basic approach used in the tour time of day choice model for the DRCOG activity based model system.

The tour time of day models were estimated and are applied conditional on tour mode choice. For auto and transit tours, ***Generalized Time Variables*** are used to estimate the effects of road congestion and transit scheduling on time of day choice. The models also use the concept of available time windows for scheduling tours (see ***Schedule Pressure Effects***). As each tour is simulated, the periods that are used by the tour are made either fully or partially unavailable for any other tours, and the total duration of remaining time windows available during the day is calculated.

Time of Day by Tour Priority

Times of day for each person's tours are modeled in order of priority of the tours (see ***Section 4.2.12***). As the times of day for each tour are modeled, the time periods during which the tour activity are taking place are made unavailable for subsequent tours. Note that the hours when a tour arrives at the activity and departs from the activity are "partially" available for other tours (see ***Schedule Pressure Effects***).

Adjustments for Non-Closed Tours

Non-closed tours either start or end the day at a non-home location. Thus, tours that both arrive and depart from the activity location during the day must be excluded from the choice set. In effect, this can be accoumplished by estimating utilities for all 348 tour time of day alternatives and then making the utilities of the 300 alternatives that arrive and depart during the normal travel day unavailable (e.g. very large negative numbers).

Adjustments for Non-Traditional Closed Tours

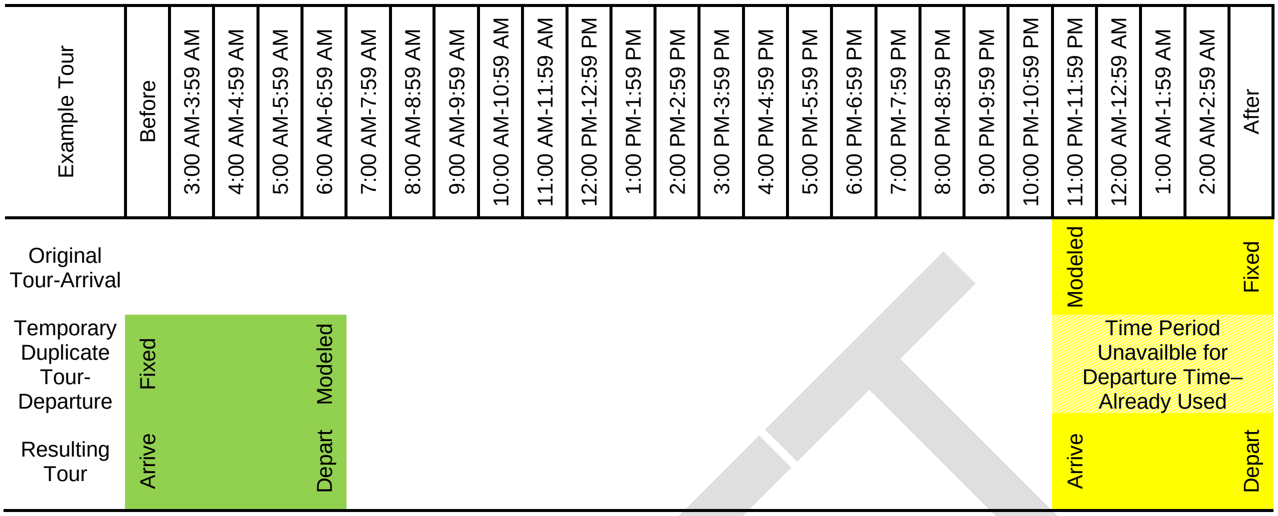
Non-traditional closed tours are those tours that start and end the day at the same non-home location. Those tours, to this point in the modeling process, have been modeled as closed tours. For model estimation, the observed non-traditional closed tours were split into two non-closed tours so that the information was not "lost" to the estimation software. The following adjustments for all of the observed non-closed tours were made for model estimation purposes:

- The destination arrival hour for non-closed tours starting the day at the non-home location was set to 1:00 AM (this was considered the "before" time period).
- The destination departure hour for non-closed tours ending the day at the non-home location was set to 4:00 AM (this was considered the "after" time period).
- Duration was modified by adding 3 hours to the total of time reported in the data. For example, if an individual started an activity at 7:00 PM, and by definition, the survey day ended at 3:00 AM while the person was still at the non-home location, the duration was calculated as 9 hours for the 7:00 PM to 3:00 AM time period (durations are calculated as Activity Start Time – Activity End Time + 1) plus the 3 additional hours for a total of 12 hours. Similarly, if an individual was at the non-home location performing the activity at 3:00 AM of the survey day and departed during the 7:00 AM time period, the duration was 8 hours (5 hours + 3 added hours).

In model application, the addition of the "before" and "after" time periods provides the mechanism for accounting for the non-traditional closed tours (example shown in ***Figure 4.38***):

- A temporary duplicate tour is effectively created.
- The arrival time at the activity destination is modeled for the original tour restricting available alternative choices to those with a departure time of "after" (e.g. all of the 324 alternatives with departure times other than "after" are given very large negative numbers)
- The departure time from the activity destination is modeled for the temporary duplicate tour using restricting available alternative choice to those with an arrival time of "before." Since the departure time is modeled after the arrival time for the original tour, the time period from arrival at the destination through "after" is precluded from being used for the departure time from the activity destination. This will result less than 24 valid alternatives for departure time.
- The results for the original and temporary duplicate tours are combined (i.e. so the correct numbers of tours are maintained) to show an actual arrival time for the outbound half-tour (based on the original tour results) and an actual departure time for the inbound half-tour (based on the temporary duplicate tour results).

Figure 4.38 Example Non-Traditional Closed Tour Time of Day Modeling



Source: Cambridge Systematics.

Utility Equations

The utility equation for any of the 348 arrival and departure time alternatives for a specific tour can be derived from the model coefficients shown in ***Appendix F.14***. Each utility equation is the sum of:

- The three relevant constants for the arrival period, the departure period, and the implied activity duration;
- The person type and household income characteristic dummy variables (1 if the traveler has the characteristic and 0 otherwise) multiplied by the coefficients for the variable;
- The day pattern variables (both 0/1 dummy variables and integer variables) multiplied by the coefficient for the variable;
- The sub-tour purpose shift effects variables (both 0/1 dummy variables and integer variables) multiplied by the coefficient for the variable (work-based sub-tours only);
- The appropriate transportation generalized time for the given the traveler characteristic, sub-purpose (for home-based other tours), and travel mode (auto/transit) multiplied by the coefficient for the variable; and
- The schedule pressure effects variables (either 0/1 dummy variables, integer variables, or real number variables) multiplied by the coefficient for the variable.

Variables

Table 4.20 lists the variables used in the tour time of day choice models by tour purpose. Each named variable described below has a common definition across all tour purposes. ***Appendix F.14*** shows the model estimation results and statistics along with the StateFocus C# variable names and the final calibrated model parameters.

Table 4.20 Tour Time of Day Choice Variables by Tour Purpose

Variable	Home-Based Work	Home-Based School	Home-Based Social/ Recreation	Home-Based Other	Work-Based Sub-Tour
Person Type Shift Effects					
Full-time worker – Arrival			x	x	
Full-time worker – Duration	x		x	x	
Part-time worker – Arrival	x		x	x	
Part-time worker – Duration	x		x	x	
Other non-worker – Arrival	x		x	x	
Other non-worker – Duration	x		x	x	
University student – Arrival	x	x	x	x	
University student – Duration	x	x	x	x	
Driving Age Student – Arrival	x	x			
Driving Age Student – Duration	x	x			
Pre-driving Age Student – Arrival		x		x	
Pre-driving Age Student – Duration		x		x	
Pre-school Child – Arrival		x	x		
Pre-school Child – Duration		x	x		
Income Group Shift Effects (Incomes in 2010 $)					
Income <$25,000 – Arrival	x		x	x	
Income <$25,000 – Duration	x		x	x	
Income ≥ $75,000 – Arrival	x		x	x	
Income ≥ $75,000 – Duration	x		x	x	
Day Pattern Variables					
Any Escort Tour in Day – Arrival		x			
Any Escort Tour in Day – Duration		x			
Escort stops in day – Arrival	x		x	x	
Escort stops in day – Duration	x		x	x	
Escort tour – Arrival				x	
Escort tour – Duration				x	
Higher Priority of 2+ different tours – Arrival	x	x			
Higher Priority of 2+ different tours – Duration	x	x	x	x	
Higher Priority of 2+ same tours – Arrival			x	x	
Higher Priority of 2+ same tours – Duration			x	x	
Higher Priority of 2+ school tours – Arrival		x			
Higher Priority of 2+ school tours – Duration		x			
Lower Priority of 2+ different tours – Arrival		x			

Variable	Home-Based Work	Home-Based School	Home-Based Social/ Recreation	Home-Based Other	Work-Based Sub-Tour
Lower Priority of 2+ different tours - Duration		x			
Lower Priority of 2+ same tours – Arrival			x	x	
Lower Priority of 2+ same tours – Duration			x	x	
Lower Priority of 2+ school tours – Arrival		x			
Lower Priority of 2+ school tours - Duration		x			
Lower Priority of 2+ work tours – Arrival	x				
Lower Priority of 2+ work tours – Duration	x				
Meal tour – Arrival				x	
Meal tour - Duration				x	
Number of stop purposes/multiple tours – Arrival	x	x	x	x	
Number of stop purposes/multiple tours – Duration	x	x	x	x	
Number of stop purposes/only tour – Arrival	x	x	x	x	
Number of stop purposes/only tour – Duration	x	x	x	x	
Number of sub-tours in tour – Arrival	x				
Number of sub-tours in tour – Duration	x				
Only tour of day – Arrival	x	x	x	x	
Only tour of day – Duration	x	x	x	x	
Shopping tour – Arrival				x	
Shopping tour – Duration				x	
Sub-Tour Purpose Shift Effects					
Escort – Arrival					x
Escort - Duration					x
Meal – Arrival					x
Meal – Duration					x
Shop – Arrival					x
Shop - Duration					x
Social / Recreation – Arrival					x
Social / Recreation – Duration					x
Any Escort in Day – Arrival					x
Any Escort in Day – Duration					x
Arrival period partially used					x
Departure period partially used					x
Number of stop purposes/only tour – Arrival					x
Number of stop purposes/only tour – Duration					x

Variable	Home-Based Work	Home-Based School	Home-Based Social/ Recreation	Home-Based Other	Work-Based Sub-Tour
Number of stop purposes/multiple tours – Arrival					x
Number of stop purposes/multiple tours – Duration					x
Generalized Time Variables					
Auto			x		x
Auto, Full-time worker	x				
Auto, Part-time worker	x				
Auto, University Students		x			
Auto, Escort Tours				x	
Auto, Meal Tours				x	
Auto, Personal Business Tours				x	
Auto, Shop Tours				x	
Auto, Social/Recreation Tours				x	
Transit			x		x
Transit, Transit Tours	x	x		x	
Schedule Pressure Effects					
Empty window remaining before – 1st tour	x	x	x	x	
Empty window remaining after – 1st tour	x	x	x	x	
Empty window remaining before – 2nd + tour	x	x	x	x	
Empty window remaining after – 2nd + tour	x	x	x	x	
Remaining tours/total remaining window	x	x			
Remaining tours/maximum remaining window	x		x	x	
Arrival period partially used	x	x	x	x	
Departure period partially used	x	x	x	x	
Arrival Constants					
Before	x		x	x	
Arrival – 00:00-00:59	x	x	x	x	x
Arrival – 01:00-01:59	x	x	x	x	x
…	x	x	x	x	x
Arrival – 23:00-23:59	x	x	x	x	x
Departure Constants					
Departure – 00:00-00:59	x	x	x	x	x
Departure – 01:00-01:59	x	x	x	x	x
…	x	x	x	x	x
Departure – 23:00-23:59	x	x	x	x	x
After	x		x	x	

Variable	Home-Based Work	Home-Based School	Home-Based Social/ Recreation	Home-Based Other	Work-Based Sub-Tour
Duration					
Duration – 00:00-00:59 Hours	x	x	x	x	x
Duration – 01:00-01:59 Hours	x	x	x	x	x
...	x	x	x	x	x
Duration – 23:00-23:59 Hours	x	x	x	x	x

Source: Cambridge Systematics

Shift Effects

Shift variables are a key feature of the model specification used to approximate a continuous time of day/duration model structure. In brief, these variables are linear interactions of the various dummy variables with the ordinal numbers defining arrival time, departure time or duration (i.e. 1 to 24). For example, the variable "Part time worker-arrival shift" is a dummy variable for part-time workers multiplied by the arrival hour of each alternative. If the estimated coefficient is positive, later arrival times during the 3:00 AM to 2:59 AM travel day, which have higher ordinal numbers[49], will have a higher utility and be more likely to be chosen. If the coefficient is negative, the shift will be towards earlier arrival times with the lower ordinal numbers. Similarly, the variable "Part time worker-duration shift" is again a dummy variable for part-time workers, this time multiplied by the hours of activity duration of each alternative[50]. In this case, the estimated coefficient is negative, meaning that shorter durations will have a higher utility and be more likely to be chosen for part time workers. If the coefficient were positive, the shift would be towards longer durations.

Person Type Shift Effects

These variables come from the characteristics of the traveler being modeled. The variables in this group are shift effects that push arrivals earlier or later in the day along with variables that increase or decrease the durations of stay which, as a result, shift the departure period as well. The person types are variables take on values of 0 or 1 depending on the person type of the traveler as defined in ***Section 3.1.2***. Thus, if a person is a part-time worker, the coefficient for "Part-time worker – Arrival" would be multiplied by the hour of the day (an integer value ranging from 1 to 24 for each hourly alternative). Likewise, the coefficient for "Part-time worker – Duration" would be multiplied by alternative number of hours for the duration of the activity (again, an integer value ranging from 1 to 24 for each duration alternative).

Income Group Shift Effects (Incomes in 2010 $)

As noted in ***Section 3.1.1***, PopGen2 posts forecasts of actual household incomes based on the PUMS. While income groups have been defined and used for other models, the income groups for the tour time of day choice are based on the posted household income to maintain consistency with the DRCOG Focus model. The income group shift variables take on values of 0 or 1 depending on the household income of the

[49] The modeled travel day is from 3:00 AM to 2:59 AM the following day, the ordinal numbers 1-24 represent the hours starting with 3:00 AM – 3:59 AM and ending with 2:00 AM – 2:59 AM.

[50] Duration for closed tours is calculated as Tour End Hour-Tour Start Hour+1, with the tour start and end hours being defined by the 1-24 ordinal hours.

traveler. Thus, if a traveler is from a household making less than $25,000 per year in 2010 dollars, the coefficient for “Income <$25,000 – Arrival” would be multiplied by the hour of the day (an integer value ranging from 1 to 24 for each hourly alternative). Likewise, the coefficient for “Income <$25,000 – Duration” would be multiplied by alternative number of hours for the duration of the activity (again, an integer value ranging from 1 to 24 for each duration alternative).

Day Pattern Variables

Activities may be scheduled differently depending on the complexity of the tour and how many stops need to be scheduled. The tour time of day models are applied after the daily activity pattern model but before the exact number and purpose of stops for a tour are determined (see ***Figure 4.1***). At this stage, the following information for each traveler is known:

- The number of tours, by purpose, for which one or more intermediate stops must be made (see ***Section 4.2.6***);
- The number of work-based sub-tours for each work tour (see ***Section 4.2.9***).

In addition, since the tour time of day model cycles through all tours for each traveler, the remaining number of tours to be made during the day is known.

With the exception of variables beginning with “Number of,” all day pattern variables take on values of 0 or 1 depending on the response to the implied question defining the variable. For example, “Any Escort Tour in Day” takes on the value of 1 if the traveler is making one or more escort tours during the day. See ***Section 4.2.12*** for tour priority assignments for variables beginning with “Higher Priority of” or “Lower Priority of.”

Variables beginning with “Number of” take on integer values based on the response to the implied question. For example, if a traveler has three different stop purposes to make during the day and is making multiple tours, variables beginning with “Number of stop purposes/multiple tours” take on the value of 3.

Sub-Tour Purpose Shift Effects

Sub-tour purpose shift effects variables apply only to the work-based sub-tour model. The variables are based only on the work-based sub-tour generation choice model (see ***Section 4.2.9***), on the daily activity pattern model (see ***Section 4.2.6***), or on a combination of information from the two choice models as follows:

- **Escort**, **meal**, **shop**, and **social/recreation** arrival and duration shift variables are based on the type of sub-tour being modeled;
- **Number of stop purposes/only tour** and **Number of stop purposes/multiple tours** arrival and duration shift variables are based on the number of different stop purposes from the daily activity pattern model and the number of work-based sub-tours; and
- **Any escort in day** arrival and duration shift variables are based on the daily activity pattern model.

The arrival period “partially used” and departure period “partially used” variables vary as the tour time of day model cycles through the process of assigning the work-based sub-tours to different times of day:

- **Arrival period partially used** – takes on a value of 1 if a previously modeled tour departs in the one hour arrival period being considered for the current tour and 0 otherwise;

- **Departure period partially used** – takes on a value of 1 if a previously modeled tour arrives in the one hour departure period being considered for the current tour and 0 otherwise.

Generalized Time Variables

The generalized time for the period is based on the network travel times and costs for the ten highway level of service periods (see ***Table 2.1***) and four transit level of service periods (see ***Table 2.2***), multiplied by the relevant level of service coefficients from the tour mode choice models, and then divided by the auto travel time coefficient to convert back to units of minutes. These variables are not applied for walk, bike, or school bus tours. Generalized times are the sums from origin to destination and destination to origin since this model operates on tours. Time periods are based on the arrival time to and departure time from the activity location. The generalized time coefficients are negative, implying that greater generalized times for roadway skim time periods or transit skim time periods will discourage that time of day option for a tour. While generalized time variables are considered in the tour time of day model, the actual travel times from a home (or work location for work-based sub-tours) to the tour destination or from the destination to home (or back to work) are not directly considered when assigning the one-hour time slots for tour arrivals or departures (see also ***Schedule Pressure Effects***).

The equation for calculating generalized time is as follows:

$$\begin{aligned} Generalized\ Time &= \left[\frac{\left(Ccost_{p,m,i} \times Cost_{o,d,p,m,ta} + Covt_{p,m} \times OVT_{o,d,p,m,ta} + Civt_{p,m} \times IVT_{o,d,p,m,ta}\right)}{Civt_{p,m}}\right] \\ &+ \left[\frac{\left(Ccost_{p,m,i} \times Cost_{d,o,p,m,td} + Covt_{p,m} \times OVT_{d,o,p,m,td} + Civt_{p,m} \times IVT_{d,o,p,m,td}\right)}{Civt_{p,m}}\right] \end{aligned}$$

where: $Ccost_{p,m,i}$ = the coefficient of cost from the tour main mode choice model for purpose *p*, mode *m*, and income group *i*

$Cost_{o,d,p,m,ta}$ = the travel cost from origin *o* to destination *d* for purpose *p*, mode *m*, and arrival time of day *ta* (for travel from home, or work for work-based sub-tours, to activity location)

$Covt_{p,m}$ = the coefficient of out of vehicle travel time from the tour main mode choice model for purpose *p*, mode *m*

$OVT_{o,d,p,m,ta}$ = the out of vehicle time, including terminal times for auto modes or walk times and wait times for transit modes, from origin *o* to destination *d* for purpose *p*, mode *m*, and arrival time of day *ta* (for travel from home, or work for work-based sub-tours, to activity location)

$Civt_{p,m}$ = the coefficient of in-vehicle travel time from the tour main mode choice model for purpose *p*, mode *m*

$IVT_{o,d,p,m,ta}$ = the in-vehicle travel time from origin *o* to destination *d* for purpose *p*, mode *m*, and arrival time of day *ta* (for travel from home, or work for work-based sub-tours, to activity location)

$Cost_{d,o,p,m,td}$ = the travel cost from destination *d* to origin *o* for purpose *p*, mode *m*, and departure time of day *td* (for travel from activity location to home, or work for work-based sub-tours)

$OVT_{d,o,p,m,td}$ = the out of vehicle time, including terminal times for auto modes or walk times and wait times for transit modes, from destination *d* to origin *o* for purpose *p*, mode *m*, and arrival time of day *td* (for travel from activity location to home, or work for work-based sub-tours)

$IVT_{d,o,p,m,td}$ = the in-vehicle travel time from destination *d* to origin *o* for purpose *p*, mode *m*, and arrival time of day *td* (for travel from activity location to home, or work for work-based sub-tours)

The generalized time variables may be applied to all travelers or, for some trip purposes, to subsets of travelers. For example, for the home-based work tour purpose, the auto generalized times are applied only for full-time and part-time workers while the transit generalized times are applied generally for all work tours made by transit.

For the home-based other tour purpose, the auto generalized times are applied by sub-purpose included in the overarching home-based other purpose. Since the tour mode choice model for home-based escort tours has different coefficients than those for the sub-purposes included in the home-based other tour mode choice model, the home-based escort tours will have different sensitivities to generalized cost than the other sub-purposes included in the home-based other tour time of day model.

Schedule Pressure Effects

Schedule pressure effect variables are defined with respect to an empty window, which is a time period in which no tour arrivals, departures, or durations have yet been scheduled as the tour time of day model processes through the various tours being made by the traveler in hierarchical order (see ***4.2.12***). The following seven values are calculated for each time period for scheduling a tour:

1. Duration of the adjacent empty window before the period being considered for arrival at the tour activity location
2. Duration of the longest empty window before the period being considered for arrival at the tour activity location
3. Total duration of all empty windows in the day before the period being considered for arrival at the tour activity location
4. Duration of the adjacent empty window after the period being considered for departure from the tour activity location
5. Duration of the longest empty window after the period being considered for departure from the tour activity location
6. Total duration of all empty windows in the day after the period being considered for departure from the tour activity location
7. The remaining number of tours to be scheduled in the day after scheduling the current tour

The following model variables are derived for each period from the above seven values:

- **Empty window remaining before – 1st tour** – Value from Number 1 (above) if the tour is the first tour of the day, 0 otherwise
- **Empty window remaining after – 1st tour** – Value from Number 4 (above) if the tour is the first tour of the day, 0 otherwise

- **Empty window remaining before – 2nd+ tour** – Value from Number 1 (above) if the tour is <u>not</u> the first tour of the day, 0 otherwise
- **Empty window remaining after – 2nd+ tour** – Value from Number 4 (above) if the tour is <u>not</u> the first tour of the day, 0 otherwise
- **Remaining tours/total remaining window** – Value from Number 7 (above) divided by the sum of the values from Number 3 (above) and Number 6 (above)
- **Remaining tours/maximum remaining window** – Value from Number 7 (above) divided by the maximum of the values from Number 2 (above) and Number 5 (above)

While the schedule pressure effects variables consider the hours in the "empty windows remaining" before or after a tour, the tour time of day model can assign the same one hour time slot to the departure from a location of one tour and the arrival at the location of a subsequent tour on the assumption that any given tour may not take up all of the hour of its arrival or departure.

The following example demonstrates how the variables work:

- Suppose that the tour is the first tour being modeled in this person's day, the person will be making three tours during the day, and the specific alternative is: Arrive at the destination during the 9:00 AM-9:59 AM time period and depart from the destination during the 2:00 PM-2:59 PM time period is being considered. The duration of this tour would be the number of hours between start of tour destination arrival time period and end of tour destination departure period (inclusive), or six hours. The diagram below illustrates the option:

Empty Window Remaining Before – 1st Tour (6 Hours)						Tour 1 Option (6 Hour Duration)						Empty Window Remaining After – 1st Tour (12 Hours)											
3:00 AM-3:59 AM	4:00 AM-4:59 AM	5:00 AM-5:59 AM	6:00 AM-6:59 AM	7:00 AM-7:59 AM	8:00 AM-8:59 AM	9:00 AM-9:59 AM	10:00 AM-10:59 AM	11:00 AM-11:59 AM	12:00 PM-12:59 PM	1:00 PM-1:59 PM	2:00 PM-2:59 PM	3:00 PM-3:59 PM	4:00 PM-4:59 PM	5:00 PM-5:59 PM	6:00 PM-6:59 PM	7:00 PM-7:59 PM	8:00 PM-8:59 PM	9:00 PM-9:59 PM	10:00 PM-10:59 PM	11:00 PM-11:59 PM	12:00 AM-12:59 AM	1:00 AM-1:59 AM	2:00 AM-2:59 AM

The variables would take on the following values:

- **Empty window remaining before – 1st tour** = number of hours before assumed tour destination arrival time hour and day start, or the hours from the 3:00 AM-3:59 AM period to 8:00-8:59 AM period: 6 hours;
- **Empty window remaining after – 1st tour** = number of hours after assumed tour destination departure time hour and day end or the hours from the 3:00 PM-3:59 PM period to the 2:00 AM-2:59 AM period: 12 hours;
- **Empty window remaining before – 2nd+ tour** = 0
- **Empty window remaining after – 2nd+ tour** = 0
- **Remaining tours/total remaining window** = 2/(6+12)= 0.111
- **Remaining tours/maximum remaining window** = 2/max(6,12)= 0.166

- For the person's second tour of the day, suppose that the time period for the first tour was the period selected above (9:00 AM-9:59 AM arrival and 2:00 PM-2:59 PM departure) and the alternative for the tour being considered is arrive at the destination during the 4:00 PM-4:59 PM time period and depart from the destination during the 6:00 PM-6:59 PM time period for a tour duration of three hours.

						Tour 1 Selection						*	Tour 2 Option			Empty Window Remaining After – 2^{nd}+ Tour (8 Hours)							
3:00 AM-3:59 AM	4:00 AM-4:59 AM	5:00 AM-5:59 AM	6:00 AM-6:59 AM	7:00 AM-7:59 AM	8:00 AM-8:59 AM	9:00 AM-9:59 AM	10:00 AM-10:59 AM	11:00 AM-11:59 AM	12:00 PM-12:59 PM	1:00 PM-1:59 PM	2:00 PM-2:59 PM	3:00 PM-3:59 PM	4:00 PM-4:59 PM	5:00 PM-5:59 PM	6:00 PM-6:59 PM	7:00 PM-7:59 PM	8:00 PM-8:59 PM	9:00 PM-9:59 PM	10:00 PM-10:59 PM	11:00 PM-11:59 PM	12:00 AM-12:59 AM	1:00 AM-1:59 AM	2:00 AM-2:59 AM

Note: * Empty Window Remaining Before – 2^{nd}+ Tour (1 Hour)

The variables would take on the following values:

- **Empty window remaining before – 1st tour** = 0
- **Empty window remaining after – 1st tour** = 0
- **Empty window remaining before – 2nd+ tour** = number of hours before assumed tour destination arrival time hour and first empty hour after departure time from the first tour, or the hour from the 3:00 PM-3:59 PM period to 3:00 PM-3:59 PM period: 1 hour;
- **Empty window remaining after – 2nd+ tour** = number of hours after assumed tour destination departure time hour and day end or the hours from the 7:00 PM-7:59 PM period to the 2:00 AM-2:59 AM period (inclusive): 8 hours;
- **Remaining tours/total remaining window** = 1/(6+1+8)= 0.067
- **Remaining tours/maximum remaining window** = 1/max(6,1,8)= 0.125

- Finally, for the person's third tour of the day, suppose that the time periods for the first two tours above were selected and the alternative for the tour being considered is arrive at the destination during the 6:00 AM-6:59 AM time period and depart from the destination during the 8:00 AM-8:59 AM time period for a tour duration of three hours.

Empty Window Remaining Before – 2^{nd}+ Tour (3 Hours)			Tour 3 Option			Tour 1 Selection							Tour 2 Selection										
3:00 AM-3:59 AM	4:00 AM-4:59 AM	5:00 AM-5:59 AM	6:00 AM-6:59 AM	7:00 AM-7:59 AM	8:00 AM-8:59 AM	9:00 AM-9:59 AM	10:00 AM-10:59 AM	11:00 AM-11:59 AM	12:00 PM-12:59 PM	1:00 PM-1:59 PM	2:00 PM-2:59 PM	3:00 PM-3:59 PM	4:00 PM-4:59 PM	5:00 PM-5:59 PM	6:00 PM-6:59 PM	7:00 PM-7:59 PM	8:00 PM-8:59 PM	9:00 PM-9:59 PM	10:00 PM-10:59 PM	11:00 PM-11:59 PM	12:00 AM-12:59 AM	1:00 AM-1:59 AM	2:00 AM-2:59 AM

The variables would take on the following values:

- **Empty window remaining before – 1st tour** = 0
- **Empty window remaining after – 1st tour** = 0
- **Empty window remaining before – 2nd+ tour** = number of hours before assumed tour destination arrival time hour and the start of the day, or the hours from the 3:00 AM-3:59 AM period to 5:00 AM-5:59 AM period: 3 hours;
- **Empty window remaining after – 2nd+ tour** = number of hours after assumed tour destination departure time hour and start time of the first tour, or the hours from the 9:00 AM-9:59 AM period to the 9:00 AM-9:59 AM period: 0 hours;
- **Remaining tours/total remaining window** = 0/(3+0+1+8) = 0
- **Remaining tours/maximum remaining window** = 0/max(3,0,1,8) = 0

The arrival period partially used and departure period partially used variables vary as the tour time of day model cycles through the process of assigning tours to different times of day:

- **Arrival period partially used** – takes on a value of 1 if a previously modeled tour departs in the one hour arrival period being considered for the current tour and 0 otherwise;
- **Departure period partially used** – takes on a value of 1 if a previously modeled tour arrives in the one hour departure period being considered for the current tour and 0 otherwise.

Arrival Constants, Departure Constants, and Duration Constants

Arrival and departure constants are calibrated for each of the 24 one-hour time slots during the travel day and also for “before” the travel day begins or “after” the travel day ends to account for non-closed tours. Constants may be positive or negative with positive constants encouraging the use of a time slot and negative constants discoursing the use of a time slot. In addition, constants are calibrated for each of the 24 possible tour durations (00:00-00:59 hours to 23:00-23:59 hours) with positive constants producing more tours for the one-hour duration being considered and negative constants producing fewer tours for the one-hour duration.

4.2.15 Intermediate Stop Generation Choice

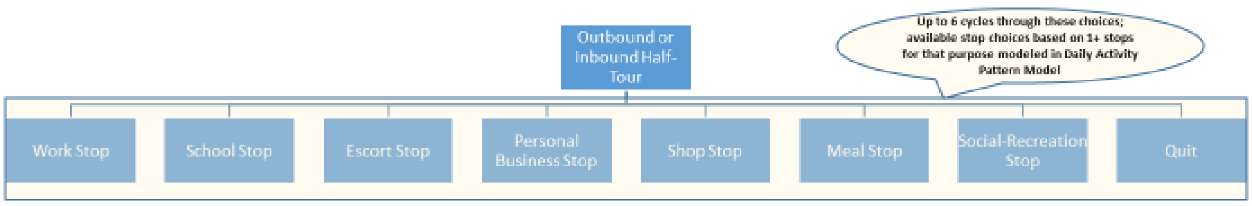
Model Structure

The intermediate stop generation choice model is a multinomial logit model applied repeatedly to each half-tour made by an individual, provided the individual’s daily activity pattern includes 1+ stops for at least one purpose.[51] A half-tour is defined as the portion of a tour from the home to the primary activity location, or the portion from the primary activity location back to the home; each closed tour can be divided into exactly two half-tours. Non-closed tours are, by definition, half-tours.

[51] If there are no stops in the person’s daily activity pattern, large negative terms are used for all stop purposes in the stop utility function to cause the “quit” alternative to be selected in the first iteration. See ***Utility Function*** for details.

As shown in ***Figure 4.39***, the model has eight alternatives, including the seven possible stop purposes (work, school, escort, personal business, shopping, meal and social/recreational) plus a "quit" alternative meaning that no further stops will be added to the half-tour. The individual's daily activity pattern choice (***Section 4.2.6***) indicates which stop purposes may be available to add as an intermediate stop on any of the individual's half-tours.[52] If the application results in the choice of a stop for one of the seven purposes (i.e., the choice is not the "quit" alternative), the model is applied again to obtain the choice of whether to make a second stop and, if so, the purpose of that stop. This process continues until the "quit" alternative is chosen or until the maximum number of six stops on each half-tour is reached.

Figure 4.39 Intermediate Stop Generation Choice Structure



Source: Cambridge Systematics.

Table 4.21 summarizes the distribution of the choices for the eight alternatives in the data set created from the FRTC survey and used for model estimation. FRTC respondents reported making 28,239 intermediate stops on 79,069 half-tours. To estimate this repeated choice model, a "quit adding stops" record was added to the list of each half-tour's list of stop purpose choices. This results in there being 28,239 + 79,069 = 107,308 records in the estimation data set. For example, if a person had no intermediate stops on an outbound half-tour, there was one record for the half-tour with the choice of quit. Likewise, if there were two stops on the inbound half-tour, there were three records, one each for the two stops (in stop order) and a third record for the choice of quit.

Each choice record – including the ones where "quit adding intermediate stops" was chosen – contains information about which stop purposes were available based on the individual's observed daily activity pattern and the rules for classifying stops on tours. For example, if a survey tour made work and shopping stops, it would be classified as a work tour – with the work stop becoming the tour's primary destination – rather than as a shopping tour. As a result of this rule, intermediate stops for work can only occur on home-based work tours or work-based sub-tours. (See ***Table 4.22*** for a description of which intermediate stop purposes are allowed based on the tour purpose.)

Since the daily activity pattern choice model limits the number of stop purposes for which stops are made to four, no choice record has all eight alternatives (make a stop for each of the seven purposes plus the quit alternative) available. The second column of ***Table 4.21*** shows how many times each of the eight alternatives is available in the choice records. (The first column is the alternative names.) Note that only the "quit" alternative appears in all 107,308 choice records.

The third column of ***Table 4.21*** shows the number of times each alternative was chosen. For the first seven rows, where the alternative is to add a stop for one of the seven purposes, the entry matches the number of

[52] The daily activity pattern choice model forecasts whether there are one or more stops by stop purpose. The actual numbers of stops are not forecast in that model. Thus, even if there was a work-based sub-tour made for the stop purpose being considered for the current tour, the stop for that purpose is not precluded. In fact, the stop could be made even if the tour under consideration was a work-based sub-tour for the same purpose.

intermediate stops for that purpose from the FRTC. In this repeated-choice model system, the "quit adding stops" alternative is chosen once for each of the 79,069 half-tours. The fourth column has the percent that each "add a stop" alternative was chosen, which is also the distribution of intermediate stops by purpose from the FRTC. The seven percentages in the fourth column add to 100 percent.

The fifth and final column of ***Table 4.21*** shows the percent of the time an alternative was chosen when it was available: the number of times it was chosen (from the third column) divided by the number of times it was available (shown in the second column).

In ***Table 4.21***, the work stop purpose row may be interpreted as follows:

- There were 6,851 Choice Options of making an intermediate stop for any purpose or to quit making intermediate stops on tours with at least one intermediate work stop on either the outbound or inbound half-tour. Remember that work stops were valid only on home-based work or work-based other tours.

- Of the 6,851 Choice Options available, 2,133 stops or 31.1 percent of the total Choice Options were actually made for an intermediate stop for a work purpose.

Stops on half-tours for personal business and shop purposes were the most likely, with about 28.3 percent of the actual intermediate stops being for a personal business purpose and 24.5 percent of the stops being for a shop purpose.

Table 4.21 Distribution of Stop Purposes and the "Quit" Alternative

	Total Number of Choice Options on Half-tours for Persons for Stop Purpose Listed[1]	Number and Percent of Times Listed Stop Purpose Was Chosen on Half-Tours		Percent of Stop Choices for Listed Stop Purpose
Stop Purpose	Number	Number	Percent	
Work	6,851	2,133	7.6%	31.1%
School	1,525	375	1.3%	24.6%
Escort	15,924	4,250	15.1%	26.7%
Personal Business	34,845	7,981	28.3%	22.9%
Shop	30,770	6,910	24.5%	22.5%
Meal	15,499	2,585	9.2%	16.7%
Social/recreation	21,935	4,005	14.2%	18.3%
"Quit"	107,308	79,069	–	73.7%
Total		107,308	100.0%	

Source: Cambridge Systematics summary of FRTC data for model estimation.

Notes: [1] A "Choice Option" was counted for each intermediate stop or "Quit" on a half-tour. For the stop purposes listed, choice options were counted only when there were intermediate stops for that stop purpose on the tour represented by the two half-tours. Thus, if a person made stops only on an inbound tour, the choice options included the quit option on the outbound portion of the tour.

Utility Function

The intermediate stop generation choice model cycles through each tour made by an individual during the day. For each half-tour on the tour, the model is applied to estimate the utilities for making a stop for each stop purpose and also for the "quit" (cycling through the model for the half-tour) alternative. This process continues until the "quit" alternative is chosen or until the maximum number of six stops is reached. The order in which the tours (and half-tours) are processed is determined by the tour priority (see ***Section 4.2.12***).

The general utility function for making a stop for a specific purpose is:

$$U_p = \sum_{pc=1}^{PC} \left(CPT_{pc|p} \times PHC_{pc}\right) + \sum_{x=1}^{X} \left(CDTS_{x|p} \times DTS_x\right) - 50000 \times NoStops_p$$

The utility function for the quit alternative is:

$$U_{quit} = \sum_{x=1}^{X} \left(CDTS_{x|p} \times DTS_x\right) + \sum_{stc=1}^{6} \left(CSTN_{stc} \times CND_{stc}\right)$$

Where:

U_p	is the utility of making a stop for purpose *p* (representing work, school, escort, personal business, shop, meal, social/recreation)
U_{quit}	is the utility of "quit" for the given cycle through the choice model
$CPT_{pc\|p}$	is an array of coefficients for different person characteristics and characteristics of the person's household for a given stop purpose *p*
PHC_{pc}	is 1 if the person making the half-tour has the person characteristic or is a member of a household with the specified household characteristic and 0 otherwise
$CDTS_{x\|p}$	is an array of coefficients for the daily activity pattern/tour type/stop for the half-tour *x* for stop purpose *p* or *quit*
DTS_x	is the daily activity pattern/tour/stop characteristic for the half-tour *x* being considered; the variable may be a 0/1 variable defining whether the half-tour has the characteristic (e.g. the half-tour is part of a home-based work tour, an integer variable (e.g. a count of occurences), or a real variable (e.g. the natural log of the half-tour distance)
$NoStops_p$	is 1 if the daily activity choice model did not forecast 1+ stops for the given stop purpose and 0 if 1+ stops for the purpose was forecast
$CSTN_{stc\|dir}$	is the coefficient for the cycle, *stc*, through the intermediate stop generation choice model for the half-tour by direction, *dir*, (outbound or inbound) being considered
CND_{stc}	is 1 if the the cycle through the intermediate stop generation choice model for the person equals *stc* and 0 otherwise

The availability of each of the seven stop purposes is dependent on whether there is at least one stop for that purpose forecast by the daily activity pattern choice model (***Section 4.2.6***). A maximum of four stop purposes with 1+ stops is forecast by the daily activity pattern choice model. In addition, based on assumptions in the daily activity choice model and tour priorities, some stop purposes are precluded for some tour purposes. ***Table 4.22*** shows the stop purposes allowed by tour purpose. For those purposes with no stops or where stops are precluded, the generation of intermediate stops for the purpose is precluded by adding a highly negative terms to the utility function for that stop purpose.

Variables

Table 4.23 summarizes the variables used in the intermediate stop generation choice model by stop purpose. The definitions of the variables follow. ***Appendix F.15*** shows the model estimation results and statistics along with the StateFocus C# variable names and the final calibrated model parameters.

Table 4.22 Allowable Stop Purposes by Tour Purpose

	Allowable Stop Purposes						
Tour Purpose	**Work**	**School**	**Escort**	**Personal Business**	**Shop**	**Meal**	**Social/ Recreation**
Home-Based Work	x	x	x	x	x	x	x
Home-Based School	x	x	x	x	x	x	x
Home-Based Escort			x	x	x	x	x
Home-Based Personal Business				x	x	x	x
Home-Based Shop				x	x	x	x
Home-Based Meal				x	x	x	x
Home-Based Social/ Recreation				x	x	x	x
Work-Based Sub-Tour	x		x	x	x	x	x

Source: Cambridge Systematics.

Table 4.23 Variables by Stop Purpose for Intermediate Stop Generation Choice

Variable	**Variable Type**	**Work**	**School**	**Escort**	**Personal Business**	**Shop**	**Meal**	**Social/ Recreation**	**Quit**
Person/Household Characteristics									
Single Person Household	0/1				x				
Other Non-Worker (18-65)	0/1					x			
Pre-School Child (0-4)	0/1						x		
Pre-Driving Age Child (5-15)	0/1						x		
Female with Child Age 0-15	0/1			x					
Daily Activity Pattern/Tour/Stop[1]									
Work-Based Sub-Tour	0/1	x		x	x	x	x	x	
Non-Closed Tour	0/1	x	x	x	x	x	x	x	
Non-Traditional Closed Tour	0/1	x	x	x	x	x	x	x	
Home-Based Work Tour	0/1	x	x	x	x	x	x	x	
Home-Based School Tour	0/1		x	x	x	x	x	x	
Home-Based Escort Tour	0/1			x	x	x	x	x	
Home-Based Personal Business Tour	0/1				x	x	x	x	

Variable	Variable Type	Work	School	Escort	Personal Business	Shop	Meal	Social/ Recreation	Quit
Home-Based Shop Tour	0/1				x	x	x	x	
Home-Based Meal Tour	0/1				x	x	x	x	
Home-Based Social/Recreation Tour	0/1				x	x	x	x	
Outbound Half-Tour	0/1	x	x	x	x	x	x	x	
Number of Remaining Tours	Integer	x	x	x	x	x	x	x	
Available Time Window	Integer	x			x	x	x	x	
Natural Log of Half-Tour Distance (Miles)	Real	x	x	x	x	x	x	x	
Half-Tour In Time Period 7:00 AM-9:00 AM	0/1	x	x	x	x	x	x	x	
Half-Tour In Time Period 9:00 AM-11:00 AM	0/1	x	x	x	x	x	x	x	
Half-Tour In Time Period 3:00 PM-5:00 PM	0/1	x	x	x	x	x	x	x	
Half-Tour In Time Period 5:00 PM-7:00 PM	0/1	x	x	x	x	x	x	x	
Half-Tour In Time Period 7:00 PM-10:00 PM	0/1	x	x	x	x	x	x	x	
Half-Tour In Time Period 10:00 PM-7:00 AM	0/1	x	x	x	x	x	x	x	
Tour Mode is Drive Alone	0/1	x		x		x			
Tour Mode is Shared Ride 2	0/1	x		x		x	x	x	
Tour Mode is Shared Ride 3+	0/1	x		x		x	x	x	
Stop for Same Purpose on Previous Tour	0/1	x	x	x	x	x	x	x	
Stop for Same Purpose Earlier on This Tour	0/1	x	x	x	x	x	x	x	
First Simulated Stop	0/1		x						
No Stops	0/1	x	x	x	x	x	x	x	
Home-Based Work Tour With a Sub-Tour	0/1								x
Secondary Tour	0/1								x
Outbound Half-Tour – Iteration 2	0/1								x
Outbound Half-Tour – Iteration 3	0/1								x
Outbound Half-Tour – Iteration 4	0/1								x
Outbound Half-Tour – Iteration 5	0/1								x
Outbound Half-Tour – Iteration 6	0/1								x
Inbound Half-Tour – Iteration 2	0/1								x
Inbound Half-Tour – Iteration 3	0/1								x
Inbound Half-Tour – Iteration 4	0/1								x
Inbound Half-Tour – Iteration 5	0/1								x
Inbound Half-Tour – Iteration 6	0/1								x

Source: Cambridge Systematics.

Notes: [1] These are characteristics of the daily activity pattern, tour, or half-tour on which the intermediate stop is being considered.

Person/Household Characteristics

Single Person Household is 1 if the person is the only person in the household and 0 otherwise

Other Non-Worker (18-65) is 1 if the person is a non-worker and is age 18-65 and 0 otherwise

Pre-School Child (0-4) is 1 if person is pre-school aged child (age 0-4) and 0 otherwise

Pre-Driving Age Child (5-15) is 1 if person is a pre-driving aged child (age 5-15) and 0 otherwise

Female with Children Age 0-15 is 1 if the person is female and there are children in the 0-15 age range in the household and 0 otherwise

Daily Activity Pattern/Tour/Stop Characteristics

Work-Based Sub-Tour is 1 if the half-tour under consideration is part of a work-based sub-tour and 0 otherwise

Non-ClosedTour is 1 if the half-tour under consideration is part of a non-closed tour (for any purpose) and 0 otherwise

Non-Traditional Closed Tour is 1 if the half-tour under consideration is part of a non-traditional closed tour (i.e. the tour starts and ends the day at the same non-home location and is at home during some period of the day) and 0 otherwise

Home-Based Work Tour is 1 if the half-tour under consideration is part of a home-based work tour and 0 otherwise

Home-Based School Tour is 1 if the half-tour under consideration is part of a home-based school tour and 0 otherwise

Home-Based Escort Tour is 1 if the half-tour under consideration is part of a home-based escort tour and 0 otherwise

Home-Based Personal Business Tour is 1 if the half-tour under consideration is part of a home-based personal business tour and 0 otherwise

Home-Based Shop Tour is 1 if the half-tour under consideration is part of a home-based shop tour and 0 otherwise

Home-Based Meal Tour is 1 if the half-tour under consideration is part of a home-based meal tour and 0 otherwise

Home-Based Social/Recreation Tour is 1 if the half-tour under consideration is part of a home-based work tour and 0 otherwise

Outbound Half-Tour is 1 if the half-tour under consideration is the outbound leg (i.e. away from the home for home-based tours or workplace for work-based sub-tours) of the tour and 0 otherwise

Number of Remaining Tours is the number of tours (not half-tours) remaining to be considered for the person; the intermediate stop generation model is applied to tours for each person in order of tour priority (see ***Section 4.2.12***)

Available Time Window is the number of hours available for stops to be scheduled on the appropriate half-tour for the tour under consideration; the hours available by half-tour are obtained from the results of the tour time of day choice model with the number of hours for outbound tours based on empty windows before arrival at the tour destination and the number of hours for inbound tours based on empty windows after departure from tour destination

Natural Log of Half-Tour Distance is the natural log of the half-tour distance in miles between the half-tour origin and destination; the distance is based on the appropriate shortest impedance path auto distance for the outbound tour used in the tour mode choice model

Half-Tour In Time Period… is 1 if the primary tour activity starts or ends between hours listed and 0 otherwise; for stops on the outbound half-tour, the time is based on the modeled tour arrival time at the primary activity location (from the tour time of day choice model) while for stops on the inbound half-tour, the time is based on the tour departure time from the primary activity location

Tour Mode is… is 1 if the modeled tour mode is drive alone, shared ride 2, or shared ride 3+, as appropriate and 0 otherwise

Stop for Same Purpose on Previous Tour is 1 if there have been other stops on either leg (outbound or inbound) of previously modeled tours for the person for the same purpose for which utility is being calculated and 0 otherwise

Stop for Same Purpose Earlier on This Tour is 1 if there have been other stops on the current tour being modeled for the person for the same purpose for which utility is being calculated and 0 otherwise; for inbound half-tours, the stops may have occurred on the outbound half-tour

First Simulated Stop is 1 if the stop is the first stop to be modeled in the half-tour and 0 otherwise; stops are modeled in order from the primary tour destination towards the tour origin (the home or, in the case of work-based sub-tours, the workplace)[53]

No Stops is 1 if the person's daily activity pattern does not include 1+ stops for the specified purpose and 0 otherwise

Home-Based Work Tour With a Sub-Tour is 1 if the half-tour being modeled is from a home-based work tour with a work-based sub-tour (see ***Section 4.2.9***) embedded in the tour during the day and 0 otherwise

Secondary Tour is 1 if half-tour currently being modeled is not part of the primary tour of the day (see ***Section 4.2.12***) and 0 otherwise

Outbound Half-Tour – Iteration x is 1 if the cycle through the intermediate stop generation choice model for the specific outbound half-tour is "x" and 0 otherwise

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[53] This means that stops on the outbound half-tour are predicted in reverse chronological order.

Inbound Half-Tour – Iteration x is 1 if the cycle through the intermediate stop generation choice model for the specific inbound half-tour is "x" and 0 otherwise

Example Utilities and Probabilities

Table 4.24 shows the resulting utilities and probabilities from applying the intermediate stop generation choice model[54] for the adult male from the four person family used for the example daily activity pattern (***Section 4.2.6***), exact number of tours choice (***Section 4.2.7***), and work-based sub-tour generation choice (***Section 4.2.9***) model calculations. The family consists of a 55-year-old adult male with a full-time job, a 54-year-old adult female who works from home at a part-time job, a 19-year-old university student without a job, and a 15-year-old high school student. The family is in the upper income group and owns two cars. For this example, it is assumed that the adult male makes two work tours and one shop tour (from the exact number of tours choice model) in addition to the 1+ escort stops from the daily activity pattern model. Further, based on the work-based sub-tour generation model results, it is assumed that the individual does not make any work-based sub-tours. Assumptions regarding tour modes and tour time of day choice for each of the three tours are shown in ***Table 4.24***. Since only 1+ escort stops were forecast for the person in the daily activity pattern choice, the only stop options available and shown in ***Table 4.24*** for the two work tours are escort and quit. Escort stops are precluded from shop tours (see ***Table 4.22***), so the stop purpose for the third tour has been changed to shop for the example. To simplify the table, only results from the outbound half-tour are shown.

Table 4.24 Example Utilities and Probabilities for Intermediate Stop Generation

	Work Tour 1		Work Tour 2		Shop Tour	
	Make Escort Stop	Quit	Make Escort Stop	Quit	Make Shop Stop[1]	Quit
Tour Mode	Auto SR2		Drive Alone		Auto SR3+	
Outbound Time of Day for Arrival at Tour Destination	8:00 AM-8:59 AM		1:00 PM-1:59 PM		7:00 PM-7:59 PM	
Available Time Window	5		1		1	
Full Tour Distance (Miles)	12		12		4	
Utility–1st Cycle	-0.242	0.000	-6.649	-0.188	0.02	-0.188
Utility–2nd Cycle	-2.804	-0.300	–	–	-1.854	-0.489
Utility–3rd Cycle	–	–	–	–	-1.854	-0.823
Utility–4th Cycle	–	–	–	–	-1.854	-0.745
Utility–5th Cycle	–	–	–	–	–	–
Utility–6th Cycle	–	–	–	–	–	–
Probability–1st Cycle[2]	44.0%[3]	56.0%	0.2%	99.8%	60.5%	39.5%%
Probability–2nd Cycle[2]	7.6%	92.4%	–	–	20.3%[3]	79.7%
Probability–3rd Cycle[2]	–	–	–	–	26.3%[3]	73.7%
Probability–4th Cycle[2]	–	–	–	–	24.8%	75.2%
Probability–5th Cycle[2]	–	–	–	–	–	–

[54] Originally estimated model parameters, not final calibrated parameters, have been used.

	Work Tour 1		Work Tour 2		Shop Tour	
	Make Escort Stop	Quit	Make Escort Stop	Quit	Make Shop Stop[1]	Quit
Probability–6th Cycle[2]	–	–	–	–	–	–

Source: Cambridge Systematics

Notes: [1] Since escort stops are precluded from shop tours, the stop purpose for the third tour has been changed to shop for the example.

[2] Shaded cells show selected alternative. Once the quit alternative is selected, no more iterations are of the intermediate stop generation choice model are processed for the selected half-tour.

[3] While the probabilities are not the highest probabilities, it has been assumed they were selected based on the process for simulating choices using the reproducible random seed process (see ***Section 4.3***).

As can be seen in ***Table 4.24***, the utilities for making a stop for the stop purpose and for the quit alternative can vary for the six cycles through the intermediate stop generation choice model. Since the StateFocus model uses the reproducible random seed and determines actual choices based on estimated choice probabilities and random number generation (see ***Section 4.3***), it is possible that a stop for the selected purpose may chosen for an iteration (as shown in the example) even though it does not have the highest probability. However, once the quit alternative is chosen, intermediate stop generation processing for the half-tour under consideration is stopped.

4.2.16 Stop Time of Day Simulation

All intermediate stops for half-tour made by each person have been forecast at the completion of the intermediate stop generation choice model component (see ***Section 4.2.15***) of StateFocus. While information on tour time of day was used in the forecasting of intermediate stops and the half-tour during which they occur, only the sequencing of stops on the half-tours was forecast; actual times of day for the stops was not forecast. For example, in the illustration provided in ***Section 4.2.15***, ***Example Utilities and Probabilities***, the individual had a five hour window from 3:00 AM to 7:59 AM to serve the escort stop being made on the outbound half-tour for his first home-based work tour of the day. Depending on the actual location and duration of the stop (although escort stops, by definition, should be short), the person might have to leave earlier or later in the available time period. Duration could be even more important if the stop was for a different purpose such as personal business such as a dentist appointment.

The next set of model components relate to trip level choices for each tour (see ***Figure 4.1***): intermediate stop location choice, which defines the locations of stops on half-tours and the resulting sequencing of trips, trip mode choice, and trip time of day choice. Intermediate stop location choice and trip mode choice are impacted by travel times by mode (and mode availability), which, in turn, are impacted by the times of day of travel on half-tour where the stops occur as constrained by the available time periods for travel between the departure from the previous activity and the arrival at the subsequent activity. While it might seem logical to simply apply the trip time of day choice prior to intermediate stop location choice, trip time of day choice is, itself, affected by the stop locations and choice of mode used for the trips (which might not be the same as the tour mode choice). In order to avoid the estimation of an exceedingly complex joint intermediate stop location / trip mode / trip time of day choice model, a preliminary trip time of day simulation is performed to assign likely stop arrival and stop departure times (from the stop locations). Using this trip time of day simulation approach, reasonable times of day for trip arrivals and trip departures from the stop locations can be selected in order to select auto and transit skim information for the intermediate stop location choice and trip mode choice model components.

Model Structure

The tour time of day simulation process is implemented using a Monte Carlo simulation process to select the arrival time for stops made on the outbound half-tour from home (or regular workplace for work-based sub-tours) to the primary tour location and the departure time for stops made on the inbound half-tour from the primary tour location to home (or regular workplace for work-based sub-tours). The stop arrival and departure times have been summarized from the FRTC survey data for seven stop purposes:

- Work
- School
- Escort
- Personal business
- Shop
- Meal
- Social recreation

The stop arrival and departure time periods are each one hour long for 24 one-hour time periods, starting with 3:00 AM–3:59 AM:

1. 3:00 AM – 3:59 AM
2. 4:00 AM – 1:59 AM

….

23. 1:00 AM – 1:59 AM
24. 2:00 AM – 2:59 AM

The stop arrival and departure time simulation assigns the time arriving or departing from the stop (depending on the half-tour direction), both to within 1-hour periods. The simulation also must consider the time period available for the stop. ***Figure 4.40*** expands on the illustration provided in ***Section 4.2.15***, ***Example Utilities and Probabilities***, where the individual had a five hour window from 3:00 AM to 7:59 AM to serve the escort stop being made on the outbound half-tour for his first home-based work tour of the day. The escort stop arrival time percentages sum to 100 percent over the 24-hour day from 3:00 AM to 2:59 AM. The daily percentages can be normalized to sum to 100 percent over the available time period for the escort stop on the outbound tour. Based on the Monte Carlo simulation, the 7:00 AM-7:59 AM time period would have an 80.6 percent chance of being selected as the stop arrival time for the escort stop with the corresponding AM2 period for highway skim data and the AM period for transit skim data. If the Monte Carlo simulation process had resulted in the 6:00 AM-6:59 AM time period being selected for the arrival time (a 15.48 percent chance), either the OP1 and AM1 highway skim data and the EL and AM transit skim data would have been selected. Each would have had a 50/50 chance, although the comparable periods for highway skims and transit skims would have been selected (e.g., the EL transit period would not have been used with the AM1 highway skim).

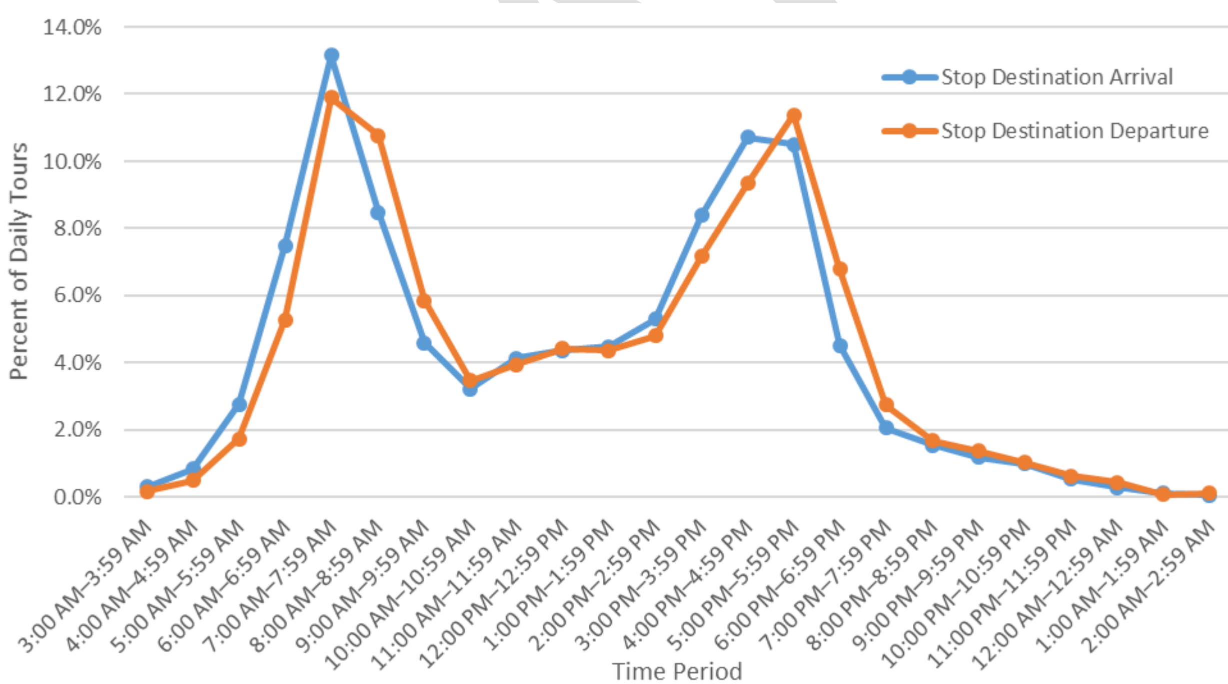
Figure 4.40 Example Assignment of Stop Arrival Times

Tour & Time Periods	Avialable Time Period					Work Tour 1 (Time of Day at Primary Location)			
Time Period	3:00 AM-3:59 AM	4:00 AM-4:59 AM	5:00 AM-5:59 AM	6:00 AM-6:59 AM	7:00 AM-7:59 AM	8:00 AM-8:59 AM	9:00 AM-9:59 AM	10:00 AM-10:59 AM	11:00 AM-11:59 AM
Escort Stop Arrival Time Percentage	0.04%	0.12%	0.68%	3.30%	17.18%	12.04%	4.03%	1.99%	4.15%
Normalized Arrival Time Percentage for Available Time Period	0.20%	0.54%	3.19%	15.48%	80.60%	–	–	–	–
Highway Skim Time Period	OP1			AM1	AM2	AM3	OP2		OP3
Transit Skim Time Period	EL			AM			MD		

Source: Cambridge Systematics.

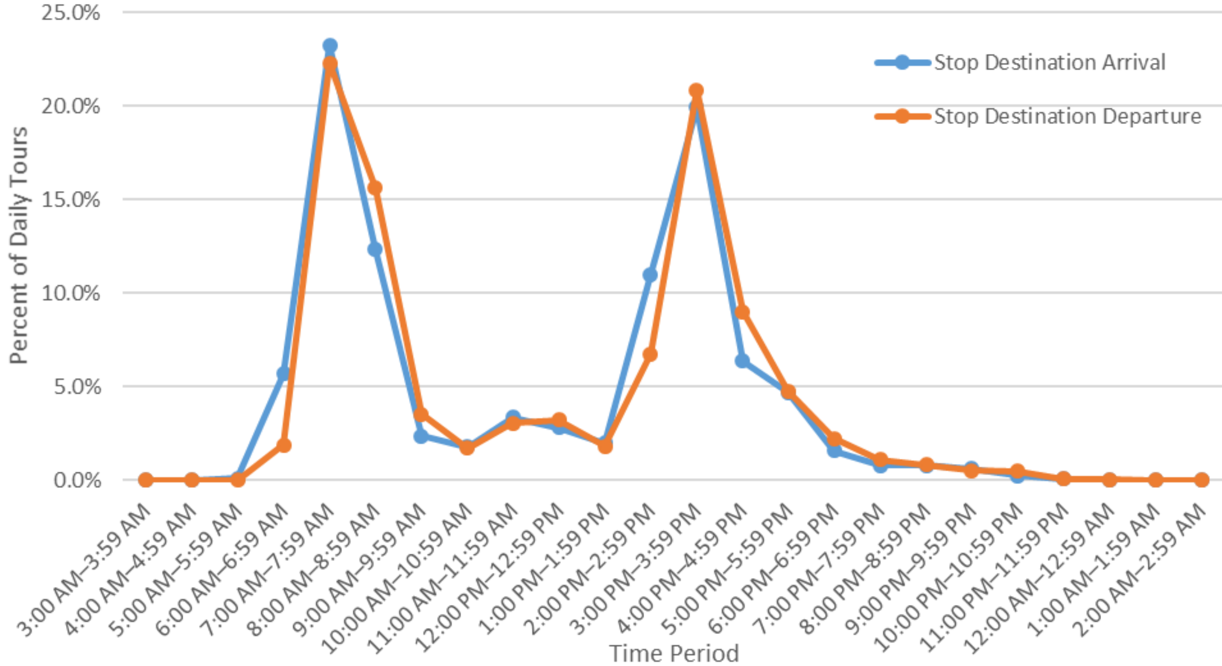
Figure 4.41 through ***Figure 4.47*** show the stop arrival and stop departure times for each of the seven stop purposes. As should be expected, the stop departure times for each of the seven purposes closely track the arrival times for each of the purposes. Unlike the tour arrival and tour departure times for each of the comparable tour purposes shown in ***Figure 4.14*** and ***Figure 4.16*** through ***Figure 4.21***, stop durations tend to be relatively short for each of the stop purposes since they are made either on the half-tour to or from the primary tour location.

Figure 4.41 Work Stop Arrival and Departure Times



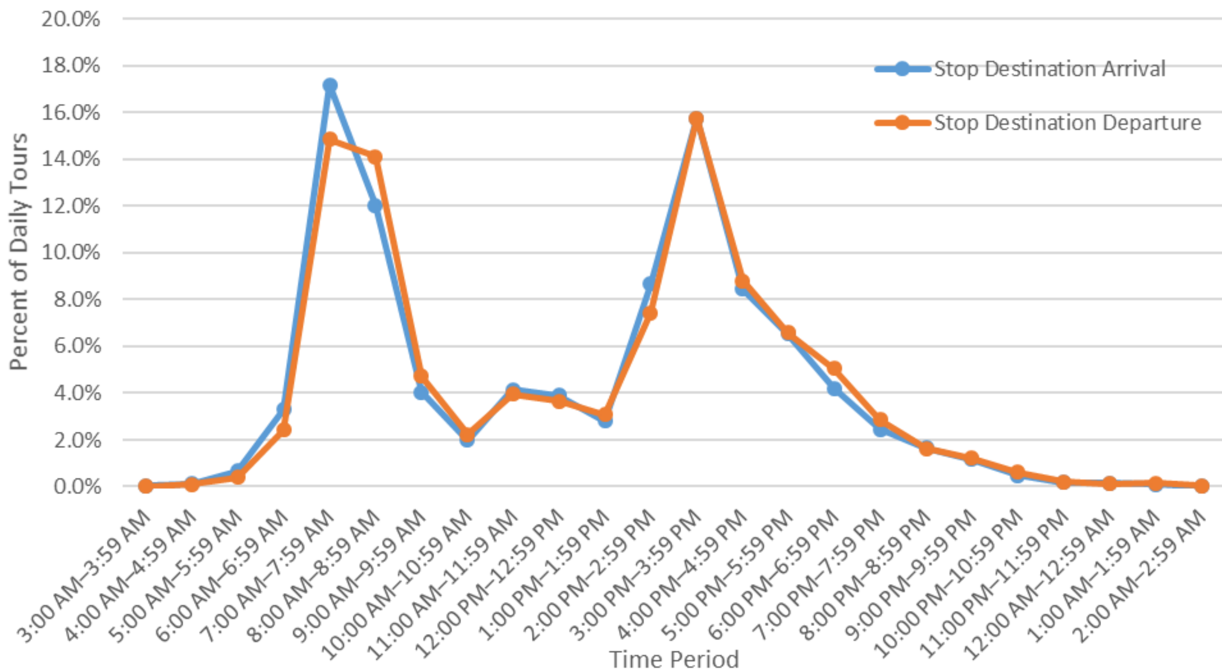
Source: Cambridge Systematics.

Figure 4.42 School Stop Arrival and Departure Times



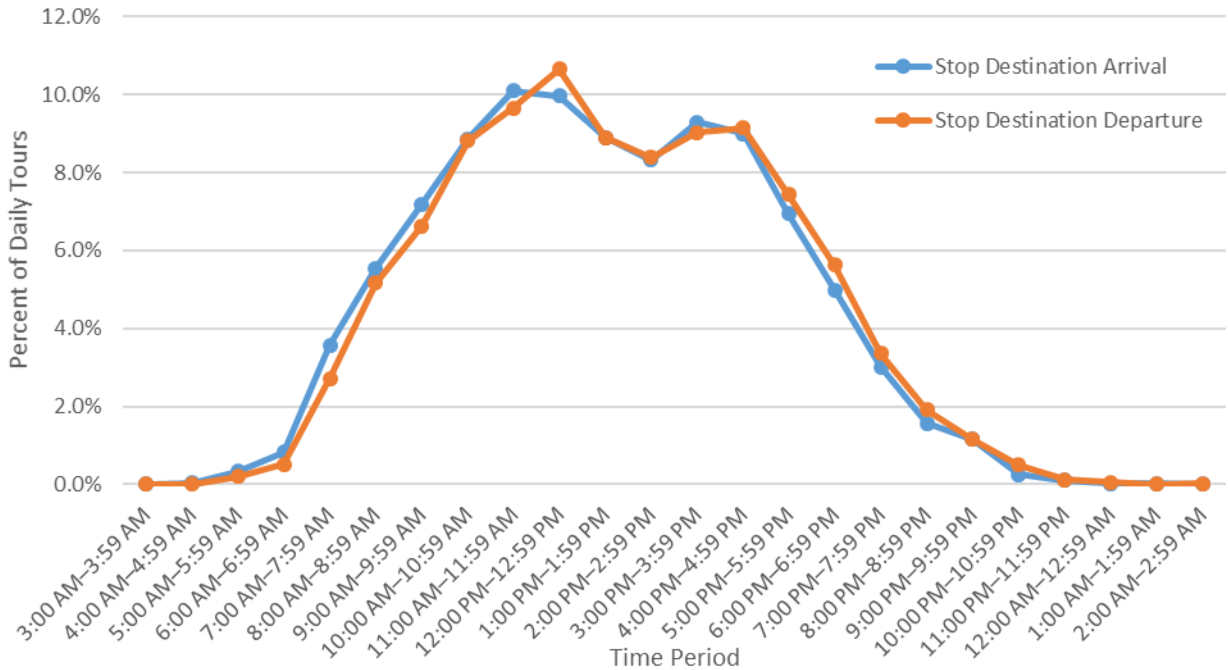
Source: Cambridge Systematics.

Figure 4.43 Escort Stop Arrival and Departure Times



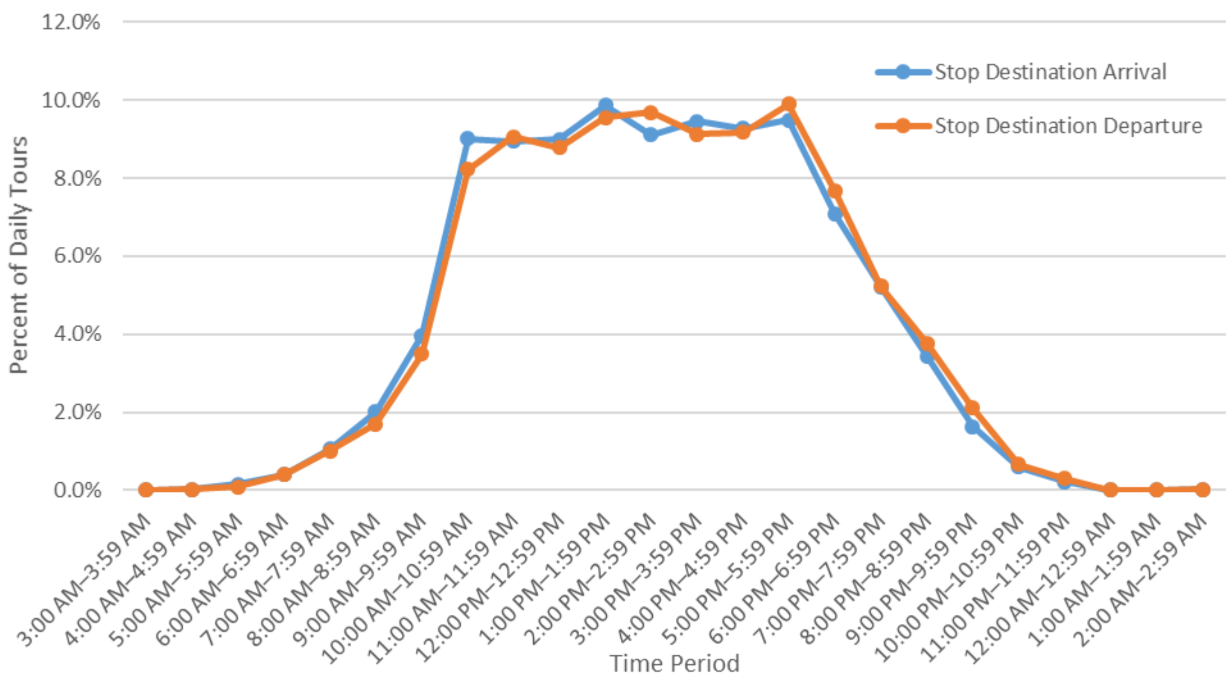
Source: Cambridge Systematics.

Figure 4.44 Personal Business Arrival and Departure Times



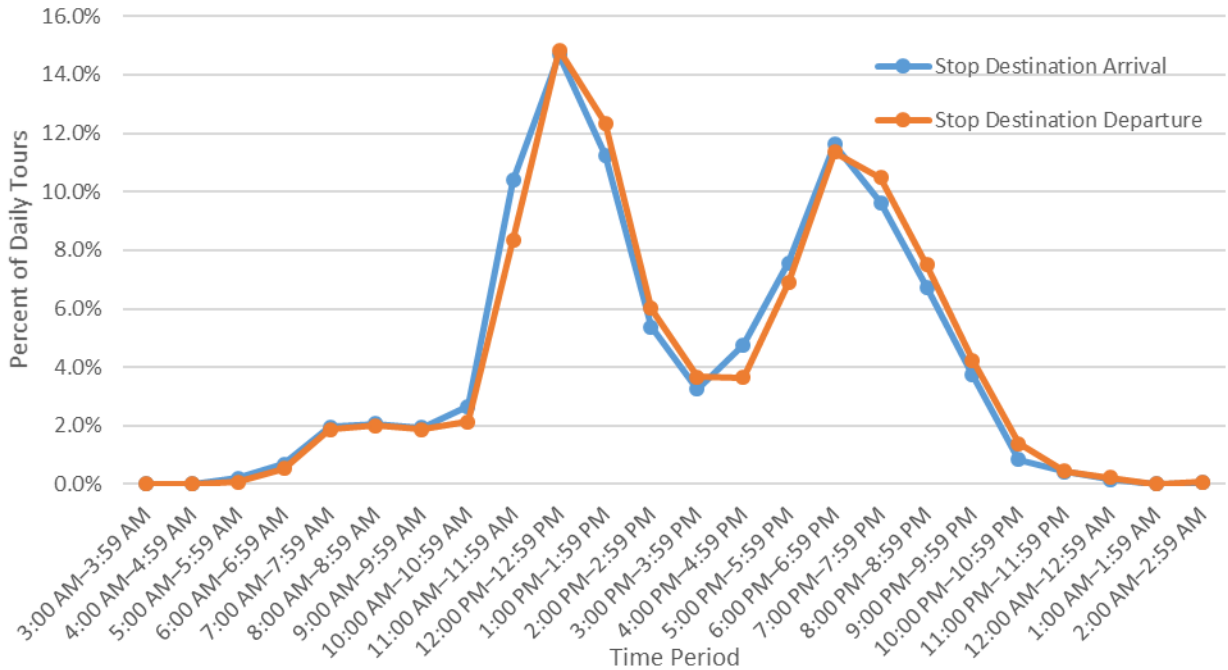
Source: Cambridge Systematics.

Figure 4.45 Shop Stop Arrival and Departure Times



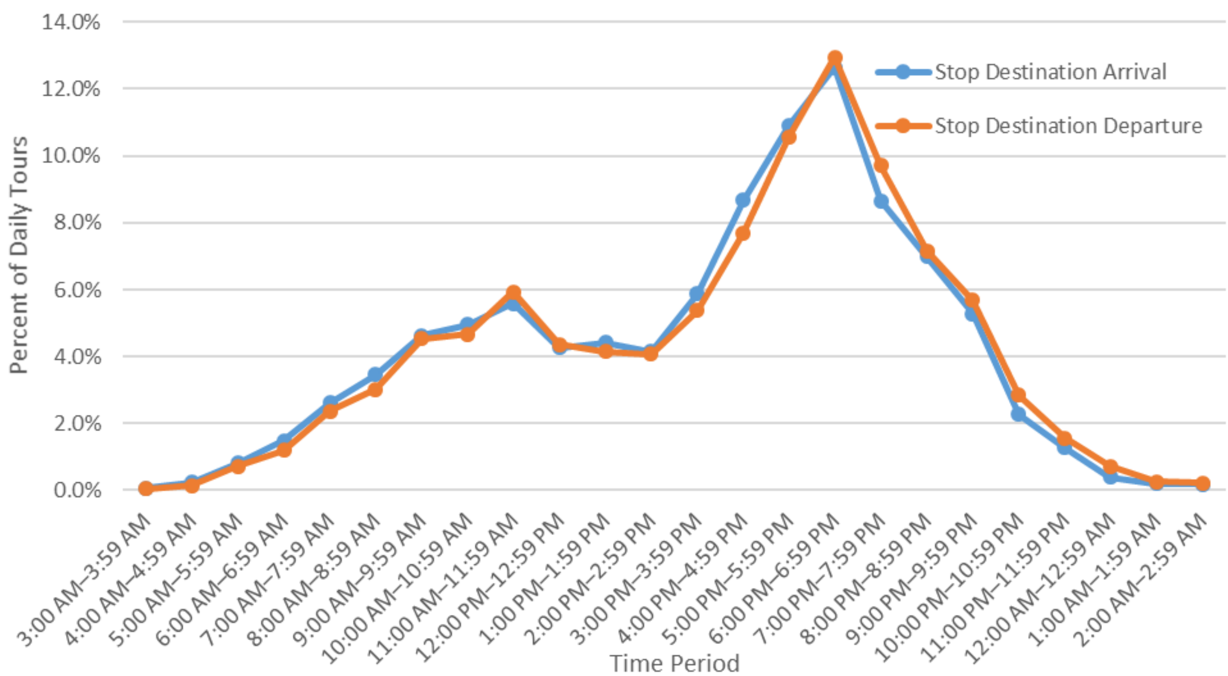
Source: Cambridge Systematics.

Figure 4.46 Meal Stop Arrival and Departure Times



Source: Cambridge Systematics.

Figure 4.47 Social/Recreation Stop Arrival and Departure Times



Source: Cambridge Systematics.

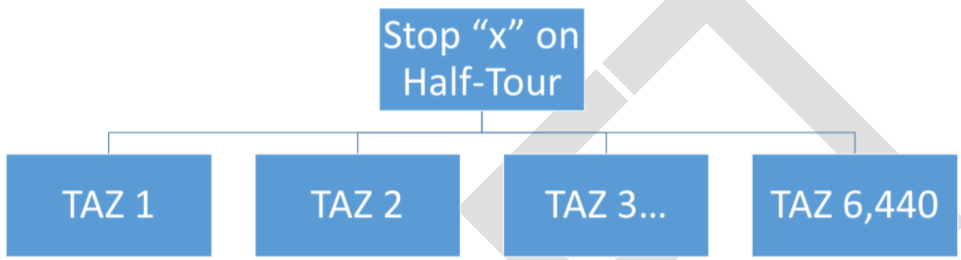
Appendix F.16 lists the probabilities for 24 arrival and departure times for each of the seven stop purposes.

4.2.17 Intermediate Stop Location Choice / Point Location Monte Carlo

Model Structure

The intermediate stop location choice model uses a multinomial logit structure as shown in ***Figure 4.48***. The locations of all intermediate stops on tours are modeled one at a time, first for stops made on the outbound half-tour (from home to the primary activity) and then for stops made on the inbound half-tour (from the primary activity to home). For both half-tours, however, stops are modeled from the tour destination back toward the tour origin (i.e. in reverse sequence for outbound half-tours).

Figure 4.48 Intermediate Stop Location Choice Structure



Source: Cambridge Systematics

When each stop location is modeled the following information is known:

- tour origin and destination locations,
- tour arrival time at the primary tour activity location or tour departure time from that location,
- tour mode,
- the number and sequence of stops on the half-tour,
- the location of the previous stop modeled on the half-tour (for the second and subsequent stops),
- the purpose for each stop.

The following information is not known when a stop is modeled:

- the trip mode between stops,
- the arrival and departure times from the stop.

Trip modes and trip time of day choice are modeled after stop location choice.

Utility Function

The general form of the utility equation for the intermediate stop location choice models for a stop to occur in TAZ_j is:

$$U_{sj|i,sp} = \left\{\theta \times Ln\left[\sum_{x=1}^{X} exp(SC_{x|sp}) \times SV_{x|sp}\right]\right\} + \delta \times \left[GT_{si,sj|P,M} + GT_{sj,TI|P,M} - GT_{si,TI|P,M}\right]$$
$$+ \gamma \times \left\{min\left[\sum_{sj=1}^{NZ}(GT_{si,sj|P,M}), \sum_{si=1}^{NZ}(GT_{sj,TI|P,M})\right]\right\} + \sum_{v=1}^{V}(CZ_{v|sp} \times DZ_{v|sj,sp})$$

Where: $U_{sj|si,sp}$ is the utility of a stop location in TAZ *sj* for stop purpose *sp* given a stop origin of TAZ *si*
Θ is the multiplier for the logsum of the quantitative (size) variables
$SC_{x|sp}$ are the coefficients applied to the size variables that are applicable for stop purpose *sp*
$SV_{x|sp}$ are the size variables that are applicable for stop purpose *sp*
δ is the coefficient for the generalized time of diversion
$GT_{i,j|P,M}$ is the generalized time for the specified interchange given tour mode *M* for tour purpose P; *i* and *j* may take on values of the current stop location, *si*, the stop destination being considered, *sj*, or the tour origin, *TI* (with *TI* being either the home location for stops being made in home-based tours or the work location for work-based sub-tours)
γ is the coefficient for the generalized time for proximity to an end of a trip
$CZ_{v|sp}$ are coefficients for tour destination zone variables, *z*, for tour purpose *p*
$DZ_{v|sp}$ are destination specific values for destination TAZ *sj* for destination zone variable *v* for tour purpose s*p*

Appendix F.17 shows the model estimation results and statistics along with the StateFocus C# variable names and the final calibrated model parameters.

Variables

Quantitative (Size) Variables

Size variables provide a means to quantify the amount of activity and, thus, attractiveness, of a zone being considered as a stop location. The amount of activity is generally a function of the number of households and the numbers of employees by employment type in a zone. As noted in the ***Utility Function*** section, each size variable is multiplied by an exponentiated size variable coefficient. The total attractiveness of the size variables is the sum of the results. While one general intermediate stop location model has been estimated, different size variables are used based on the purpose of the stop being considered. Finally, the natural log of the total attractiveness of the size variables is taken and multiplied by a model coefficient in the utility function.

Base Size varies by stop purpose being considered as follows:

- Work stops – total employment
- School stops – this variable is based on the appropriate school enrollment in the destination zone considering the school age of the traveler:
  - K-8 enrollment for K-8 aged student travelers
  - High school enrollment for high school aged student travelers
  - University enrollment for post-high school aged student travelers
- Escort stops – sum of K-8, high school, and university enrollment
- Personal business stops – total employment

- Shop stops – retail employment
- Meal stops – restaurant employment
- Social/recreation stops – total employment

Total Households is used for work stops, personal business, and social/recreation stops (the size variable coefficient for work stops is different from the size variable coefficient used for personal business and social/recreation stops)

Education Employment is used for school stops and escort stops (size variable coefficients are different for the two stop purposes)

Retail Employment is used for meal stops

Stop Location Utility Variables

Generalized Time of Diversion

The generalized time of diversion is a crucial component for the intermediate stop location choice model. Three components comprise the generalized time of diversion:

$\boldsymbol{GT_{si,sj|P,M}}$ is the generalized time, in minutes, between the current stop origin, *si*, and the alternative stop destination zone for the stop under consideration. Since intermediate stop locations are modeled from the tour destination back toward the tour origin for both outbound and inbound tours, the current stop origin is the tour destination for the first stop or the most recently modeled stop location on the half-tour.

$\boldsymbol{GT_{sj,TI|P,M}}$ is the generalized time, in minutes, between the intermediate stop location, *sj*, being considered and the tour origin, *TI*.

$\boldsymbol{GT_{si,TI|P,M}}$ is the generalized time, in minutes, between the current stop origin, *si*, and the tour origin, *TI*. Since intermediate stop locations are modeled from the tour destination back toward the tour origin for both outbound and inbound tours, the current stop origin is the tour destination for the first stop or the most recently modeled stop location on the half-tour.

The generalized times are tour purpose specific and based on the mode chosen for the tour. The time of day used to determine the generalized time is based on the stop time of day simulation (applied prior to this model component). The generalized times consider only the level of service variables for the chosen mode (see ***Table 4.19***) and divide the resulting utility from the variables and their associated model coefficients by the purpose and mode specific coefficient of in-vehicle travel time. For example, suppose the chosen tour mode for a home-based work tour for which stop locations were being modeled was drive alone. Further, suppose that the traveler was from a modest income household, and the cost and travel time components for the interchange being considered were:

- Cost: 1.2 miles at $0.2776 per mile, in 2010 dollars
- In-vehicle time: 4.2 minutes
- Terminal time: 3.0 minutes

Using the originally estimated mode choice model coefficients (see ***Table F.33***), the generalized time for the interchange would be:

$$\begin{aligned} GT &= [(-0.03114 \times 1.2 \times 0.2776) + (-0.00675 \times 4.2) + (-0.02701 \times 3.0)] / -0.00675 \\ &= -0.11975 / -0.00675 \\ &= 17.7 \text{ minutes} \end{aligned}$$

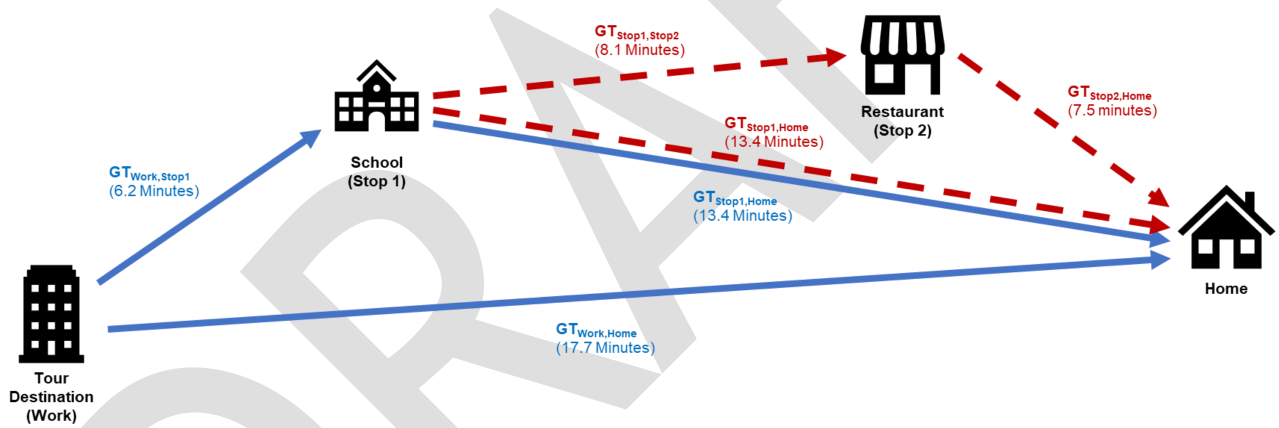
The generalized time of diversion can be thought of as the extra disutility on the path from the stop origin, *si*, to the tour origin, *TI*, caused by making a stop located in specific zone. Figure graphically illustrates this concept for the inbound half of a home-based work tour with a stop for a class at a school and a second stop to eat at a restaurant. For the first stop at the school, the generalized time of diversion would be:

6.2 minutes + 13.4 minutes − 17.7 minutes = 1.9 minutes

For the second stop at the restaurant, the generalized time of diversion would be:

8.1 minutes + 7.5 minutes – 13.4 minutes = 2.2 minutes

Figure 4.49 Generalized Time of Diversion Illustration



Source: Cambridge Systematics

Generalized Time for Proximity to an End of a Trip

The generalized time for proximity to an end of a trip is the minimum of $GT_{si,sj|P,M}$ and $GT_{sj,TI|P,M}$. This variable applies only for motorized modes: drive alone, shared ride 2, shared ride 3+, walk to transit, and drive to transit[55]. In effect, this variable increases the likelihood of an intermediate stop being made at a location near one of the ends of half-tour made by a motorized mode rather than at a location nearer the middle of the half-tour. This variable might have an indirect impact on trip mode choice by increasing the likelihood of changing a trip mode from the chosen tour mode, such as from drive alone for the tour to shared ride 2 for the trip from the last stop on the half tour or transit-drive access to walk on the trip from the last stop on an outbound tour to the tour destination.

[55] Intermediate stops on school bus trips are precluded.

Stop Location Zonal Variables

Mixed Use Density is applied for all stop purposes is defined as:

$$MixedUseDensity = \left[\frac{(RetailDensity + RestaurantDensity) \times ResidentialDensity}{max[0.001, (ResidentialDensity + RetailDensity + RestaurantDensity)]}\right]$$

Where: *RetailDensity* is the number of retail employees within 0.5 miles of the centroid of the stop destination zone divided by 1000
RestaurantDensity is the number of restaurant employees within 0.5 miles of the centroid of the stop destination zone divided by 1000
ResidentialDensity is the number of households within 0.5 miles of the virtual centroid of the stop destination zone based on households divided by 1000

Total Retail Employment Density-Shop is applied only when the stop purpose is shop and is defined as the number of retail employees within 0.5 miles of the centroid of the destination zone divided by 1000.

Total Employment Density-Other is applied for personal business and social/recreation stop purposes and is defined as the total number of employees within 0.5 miles of centroid of the destination zone divided by 1000.

Total Household Density-Other is applied for personal business and social/recreation stop purposes and is defined as the total number of households within 0.5 miles of the virtual centroid of the destination zone based on households divided by 1000.

Stop Point Location Monte Carlo

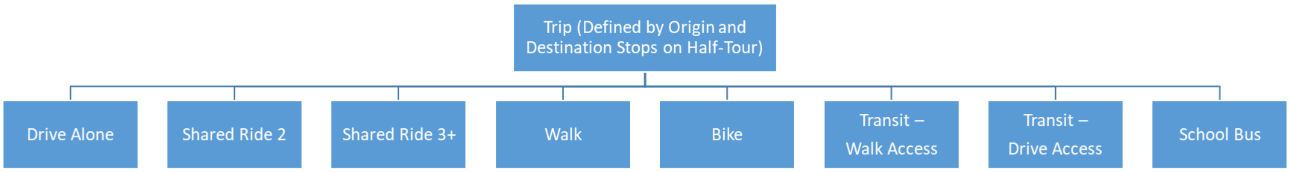
The intermediate stop location choice model is used to forecast a TAZ for each stop made by each person on an outbound or inbound half-tour. Each household and employment establishment within a TAZ has also been assigned to a point location (see ***Section 2.3.2***). Since stops may be made to either households or establishments, the intermediate stop location choice point location Monte Carlo uses a simple random selection process to select an actual household or establishment and its point location from the set of all households and establishments within the TAZ chosen for each stop.

4.2.18 Trip Mode Choice

Model Structure

The trip mode choice model determines the trip mode for all trips including trips defined by half-tours with no stops. The tour mode was determined previously by the tour mode choice model (see ***Section 4.2.13***); this knowledge is used in combination with time of day skim data, person and household data, zonal data, tour and intermediate stop purpose choices, and intermediate stop sequencing choices to find the trip modes used between intermediate stops on tours. A single multinomial logit model (***Figure 4.50***) has been estimated to be used for all tour and trip purposes, with some purpose specific variables used to develop different utilities based on different tour and trip purpose combinations.

Figure 4.50 Trip Mode Choice Model Structure



Source: Cambridge Systematics.

The mode choice alternatives available for the model vary by tour purpose in which the trip is made:

- Home-based work: drive alone, shared ride 2, shared ride 3+, walk, bike, walk to transit, drive to transit
- Home-based school: drive alone, shared ride 2, shared ride 3+, walk, bike, walk to transit, drive to transit, school bus
- Home-based escort: drive alone, shared ride 2, shared ride 3+, walk
- Home-based other (includes personal business, shop, meal, and social/recreation): drive alone, shared ride 2, shared ride 3+, walk, bike, walk to transit, drive to transit
- Work-based sub-tour: drive alone, shared ride 2, shared ride 3+, walk, bike, walk to transit

The modes available for each trip are based on the mode for the tour of which the trip is part. For example, suppose a person is on their outbound half-tour and their tour mode is shared ride 2. If the person is the passenger, the trip mode might be shared ride 2 to the first stop in the half-tour or, after the person has been dropped off at an intermediate stop, he or she might take bike or walk to their next stop or tour destination. Likewise, if the person is the driver, the trip mode might be shared ride 2 to the first stop in the half-tour and, after the passenger has been dropped off at an intermediate stop, he or she might continue driving alone, or also take bike or walk to their next stop or tour destination. Note that trip modes higher in the mode hierarchy are not available since, by caveat, they would have been the tour mode if they are used on the tour (e.g. the passenger in the example would not have transferred to drive to transit after being dropped off since such a transfer would have implied that their tour mode was drive to transit).

Trip mode availability by tour mode is shown in ***Table 4.25***. The table also shows the percentages of observations in the model estimation data set for each tour mode-trip mode combination.

Table 4.25 Trip Mode Availability and Observed Use Percentage by Tour Mode

Tour Mode[2]	Trip Mode[1,2]								Total
	Drive to Transit	Walk to Transit	School Bus	Shared Ride 3+	Shared Ride 2	Drive Alone	Bike	Walk	
Drive to Transit	70.1%	4.5%	0.0%	2.4%	9.3%	11.0%	0.1%	2.7%	100.0%
Walk to Transit		72.1%	0.1%	3.4%	7.6%	1.1%	1.4%	14.3%	100.0%
School Bus			70.7%	14.4%	12.5%	0.5%	0.3%	1.7%	100.0%
Shared Ride 3+				69.4%	17.7%	11.5%	0.1%	1.4%	100.0%
Shared Ride 2					74.4%	24.2%	0.1%	1.2%	100.0%

Drive Alone						99.5%	0.0%	0.5%	100.0%
Bike							98.5%	1.5%	100.0%
Walk								100.0%	100.0%

Source: Cambridge Systematics summaries of unexpanded FRTC data used for model estimation.

Notes: [1] Shaded cells mean trip mode is not available for the tour mode.

[2] Tour modes are shown in hierarchical order with drive to transit the highest and walk the lowest. Thus, a traveler using a lower level mode in the hierarchy on a tour, such as drive alone, will never transfer to a trip mode higher in the hierarchy, such as shared ride 2, since, by definition, such a transfer implies that the tour mode would have been shared ride 2 with one of the trips on the tour being made by drive alone.

Several additional trip mode decision rules listed below are used to determine the availability of modes for specific trips in each half-tour. The following list describes the composit decision rules regarding whether a specific mode is available for a trip.

Walk

1) Walk time is less than 120 minutes

Bike

1) Tour mode is not a lower priority mode (i.e. walk for the bike mode)
2) Bike time is less than 120 minutes
3) Tour purpose is not equal to home-based escort
4) Tour mode is not equal to drive to transit
5) Tour mode is not equal to drive alone

Drive Alone

1) Tour mode is not a lower priority mode (i.e. walk or bike for the drive alone mode)
2) Age is greater than or equal to 16
3) Number of cars in the household is greater than zero

Shared Ride 2

1) Tour mode is not a lower priority mode (i.e. walk, bike, or drive alone for the shared ride 2 mode)

Shared Ride 3+

1) Tour mode is not a lower priority mode (i.e. walk, bike, drive alone, or shared ride 2 for the shared ride 3+ mode)

School Bus

1) Tour mode is not a lower priority mode (i.e. walk, bike, drive alone, shared ride 2, or shared ride 3+ for the school bus mode)
2) Tour purpose is home-based school

Walk to Transit

1) Tour mode is not a lower priority mode (i.e. walk, bike, drive alone, shared ride 2, shared ride 3+, or school bus for the walk to transit mode)
2) Tour purpose is not equal to home-based escort
3) Walk to transit time is valid

Drive to Transit

1) Tour mode is drive to transit (all other modes are lower priority modes)
2) Tour purpose is not equal to home-based escort
3) Tour purpose is not equal to work-based sub-tour
4) Drive to transit time is valid
5) Person age is greater than or equal to five years old

Utility Function

The general form of the utility equation for the trip mode choice model for a trip between a stop in TAZ_i and a stop TAZ_j is:

$$
\begin{aligned}
U_{m,i-j|M} = {} & K_m + C_{GT} \times GT_{i-j,m|TP} + \sum_{h=1}^{H} \left(CH_{h|m} \times DH_h\right) + \sum_{p=1}^{P} \left(CP_{p|m} \times DP_p\right) + \sum_{lu=1}^{L} \left(CLU_{lu|m} \times LU_{lu}\right) \\
& + \sum_{ptm=1}^{PTM} \left(CTM_{ptm|m} \times DTM_{ptm|m}\right) + \sum_{ptp=1}^{PTP} \left(CTP_{ptp|m} \times DTP_{ptp}\right) + \sum_{et=1}^{ET} \left(CET_{et|m} \times DET_{et}\right) \\
& + \sum_{seq=1}^{SEQ} \left(CETS_{seq|m} \times DETS_{seq}\right)
\end{aligned}
$$

Where:

$U_{m,i\text{-}j|M}$ is the utility of trip mode *m* for a trip between TAZ *i* and TAZ *j* on a tour using tour mode *M*

K_m is a constant for trip mode *m*

C_{GT} is the coefficient of generalized time

$GT_{i\text{-}j,m|TP}$ is the generalized time from TAZ *i* to TAZ *j* using trip mode *m* based on parent tour purpose *PT*

$CH_{h|m}$ is the coefficient for a traveler from a household with characteristic *h* using trip mode *m*

DH_h is a dummy variable that takes the value of 1 for a traveler from a household with characteristic *h* and 0 otherwise

$CP_{p|m}$ is the coefficient for a traveler with characteristic *p* using trip mode *m*

DP_p is a dummy variable that takes the value of 1 for a traveler with characteristic *p* and 0 otherwise

$CLU_{l|m}$ is the coefficient for a land use variable *lu* occurring in trip origin TAZ *i* or trip destination TAZ *j* for a trip using mode *m*

LU_{lu} is a variable for land use *lu*; the variable may be for the trip origin TAZ or the trip destination TAZ, as appropriate

$CTM_{ptm|m}$ is the coefficient for a trip being part of a tour using tour mode *ptm* for a trip using trip mode *m*

$DTM_{ptm|m}$ is a dummy variable that takes the value of 1 if the trip mode *m* is the same as tour mode *M* and 0 otherwise

$CTP_{ptp|m}$ is the coefficient for a trip being part of a parent tour for tour purpose *ptp* for a trip using trip mode *m*

DTP_{ptp} is a dummy variable that takes the value of 1 if the trip is part of a parent tour (*TP*) for purpose *ptp* and 0 otherwise

$CET_{et|m}$ is the coefficient for a trip being an escort trip with characteristic *et* using trip mode *m*

DET_{et} is a dummy variable that takes the value of 1 if the trip is an escort trip with characteristic *et* and 0 otherwise

$CETS_{seq|m}$ is the coefficient for an escort trip being part of a sequence of escort trips with the escort trip being considered has a characteristic *seq* using trip mode *m*

$DETS_{seq}$ is a dummy variable that takes the value of 1 if the trip is an escort trip in a sequence of escort trips with the escort trip being considered having the characteristic *seq* and 0 otherwise

Variables

Table 4.26 identifies the variables used in the trip mode choice model for each trip mode. Explanations of the variables follow the table; ***Appendix F.18*** lists the estimated and final model coefficients.

Table 4.26 Trip Mode Choice Variables

	Trip Mode							
Variable	**Drive Alone**	**Shared Ride 2**	**Shared Ride 3+**	**Walk**	**Bike**	**Walk to Transit**	**Drive to transit**	**School Bus**
Constant		x	x	x	x	x	x	x
Generalized time[1]	x	x	x	x	x	x	x	x
Household Variables								
One person household		x	x					
Two person household			x					
Household cars greater than zero but less than number of <u>drivers</u>	x							
Household cars greater than zero but less than number of <u>workers</u>				x				
No car in household		x	x	x			x	
Number of non-working adults in household		x	x					
Number of pre-driving age students (5-15 year old child) in household		x	x					
Lower income	x					x	x	
Modest income	x					x		
Upper income		x	x					x
Top income		x	x			x	x	x
Missing income[2]	x	x	x			x	x	
Person Variables								
Male		x	x		x			
Age under 35				x				
Pre-school child (0-4 year old child)				x		x		
Pre-driving age student (5-15 year old child)						x	x	

Variable	Trip Mode							
	Drive Alone	**Shared Ride 2**	**Shared Ride 3+**	**Walk**	**Bike**	**Walk to Transit**	**Drive to transit**	**School Bus**
Driving age student (child aged 16+)						x	x	
University student					x	x	x	
Land Use Variables								
Origin intersection density				x	x	x		x
Destination intersection density				x				
Origin intersection density-inbound half-tour							x	
Destination retail density-outbound half-tour				x	x	x	x	
Destination retail density-inbound half-tour				x		x	x	
Parent Tour Mode Choice Variables								
Same as tour mode	x	x	x	x	x	x	x	x
Same as tour mode-only outbound trip	x	x	x	x	x	x	x	x
Same as tour mode-only inbound trip	x	x	x	x	x	x	x	x
Same as tour mode-first outbound trip	x	x	x	x	x	x	x	x
Same as tour mode-first inbound trip	x	x	x	x	x	x	x	x
Same as tour mode-last outbound trip	x	x	x	x	x	x	x	x
Same as tour mode-last inbound trip	x	x	x	x	x	x	x	x
Shared ride 2 tour	x				x			
Shared ride 3+ tour	x	x			x			
Walk to transit tour	x		x		x			
Drive to transit tour		x				x		
School bus tour		x	x					
Parent Tour Purpose Variables								
Work tour	x			x	x			
School tour		x	x	x	x			
Escort tour	x	x	x					
Shop tour		x	x					
Meal tour		x	x					
Social/recreation tour		x	x					
Work-based sub-tour	x							
Non-closed tour		x	x	x	x			
Escort Destination Variables								
Home to escort trip	x	x	x					
Home to escort trip-AM peak period		x	x					

Variable	Trip Mode							
	Drive Alone	Shared Ride 2	Shared Ride 3+	Walk	Bike	Walk to Transit	Drive to transit	School Bus
Home to escort trip-Midday period		x	x					
Home to escort trip-PM peak period		x	x					
Home to escort trip-Evening period		x	x					
Other to escort trip			x					
Escort Trip Sequencing Variables								
Previous mode drive alone and previous purpose escort		x	x					
Previous mode drive alone and previous purpose escort – AM peak		x	x					
Previous mode shared ride 2 and previous purpose escort	x		x					
Previous mode shared ride 2 and previous purpose escort – AM peak	x							
Previous mode shared ride 2 and previous purpose escort – PM peak	x							
Previous mode shared ride 3+ and previous purpose escort	x	x						
Previous mode shared ride 3+ and previous purpose escort – AM peak	x	x						
Previous mode shared ride 3+ and previous purpose escort – PM peak	x	x						
Sampling Bias Variables[2]								
FREX oversample						x	x	
Transit oversample						x	x	

Source: Cambridge Systematics

Notes: [1] The same generalized time coefficient is used for all trip modes. However, the calculation of generalized time varies by trip mode based on the tour purpose within which the trip is being made and the associated tour mode choice model coefficients estimated for the same mode.

[2] Variable used for model estimation only; not used in model application.

Generalized Time

A single level of service variable, generalized time, is used for each mode for trips between stops. The time of day used to determine the generalized time has been determined by the trip time of day model simulation (see ***Section** Error! Reference source not found.*) implemented earlier in the StateFocus modeling sequence. Generalized time for each mode is defined as the "level of service utility" for the mode divided by the in-vehicle time coefficient for the mode, resulting in the variable being expressed as minutes. The level of service utility for each modal alternative for each interchange for the trip mode choice model is obtained from the tour mode choice model.

The generalized times consider only the level of service variables for the modes considered (see ***Table 4.19***) and divide the resulting utilities from the variables and their associated model coefficients by the appropriate mode specific coefficient of auto in-vehicle travel time. Generalized time coefficients are based on the purpose of the parent tour within which the trip is being made.

A trip serving an escort stop on a tour provides a good example to illustrate the calculation and variation of generalized time since escort stops are valid for only home-based work tours, home-based school tours, home-based escort tours, and work-based sub-tours (see ***Table 4.22***). Since home-based escort tours allow only drive alone, shared ride 2, shared ride 3+, and walk as available trip modes, the tour mode will be assumed to be shared ride 3+, the mode highest in the mode hierarchy. Finally, suppose that the traveler is from a modest income household, and the cost and travel time components for the trip interchange are:

- Distance: 1.2 miles
- Auto Cost: $0.33 (=1.2 miles at $0.2776 per mile, in 2010 dollars)
- Auto In-vehicle time: 4.2 minutes
- Auto Terminal time: 3.0 minutes
- Walk time: 24.0 minutes (=1.2 miles at 20 minutes per mile)
- Bike Time: 9.0 minutes (=1.2 miles at 7.5 minutes per mile)

Table 4.27 shows the tour mode choice model coefficients used to calculate the generalized times for the different trip modes, the resulting utilities of the trips based on the assumptions outlined above, and, finally, the resulting generalized times for the available trip modes.

Table 4.27 Trip Generalized Time Examples

	Parent Tour Purpose			
Trip Mode Generalized Time Components	**Home-Based Work**	**Home-Based School**	**Home-Based Escort**	**Work-Based Sub-tour**
Coefficient of:				
Cofficient of Cost (Modest Income)	-0.0311	-0.1219	-0.2222	-0.2042
Coeffcient of Auto In-Vehicle Time	-0.0068	-0.0093	-0.0105	-0.0255
Coeffcient of AutoTerminal Time	-0.0270	-0.0320	-0.0420	-0.0436
Walk Time	-0.0270	-0.0320	-0.0420	-0.0436
Bike Time	-0.0204	-0.0374	n/a[1]	-0.0603
Utility of:				
Drive Alone	-0.1198	-0.1760	-0.2440	-0.3058
Shared Ride 2	-0.1198	-0.1760	-0.2440	-0.3058
Shared Ride 3+	-0.1198	-0.1760	-0.2440	-0.3058
Walk	-0.6482	-0.7690	-1.0073	-1.0459
Bike	-0.1836	-0.3362	n/a[1]	-0.5426
Generalized Time (in Minutes):				
Drive Alone	17.7	18.8	23.3	12.0

Shared Ride 2	17.7	18.8	23.3	12.0
Shared Ride 3+	17.7	18.8	23.3	12.0
Walk	96.0	82.3	96.0	41.0
Bike	27.2	36.0	n/a[1]	21.3

Source: Cambridge Systematics

Notes: [1] The bike mode is not available if the parent tour is home-based escort.

Household Variables

These variables include the following household information for each traveler:

- **One person household** – this variable is 1 if the traveler is the only member of his household and 0 otherwise
- **Two person household** – this variable is 1 if the traveler's household has two members (i.e. <u>not</u> two or more) and 0 otherwise
- **Household cars greater than zero but less than number of drivers** – this variable is 1 if the traveler's household has more cars than the number of drivers and 0 otherwise
- **Household cars greater than zero but less than number of workers** – this variable is 1 if the traveler's household has more cars than the number of workers and 0 otherwise
- **No car in household** – this variable is 1 if the traveler's household does not have any cars and 0 if the household has one or more cars
- **Number of non-working adults in household** – this variable is the number of members in the traveler's household who are 18 or older and are non-workers
- **Number of pre-driving age students (5-15 year old child) in household** – this variable is the number of members in the traveler's household who are greater than 4 years old and less than 16 years old
- **Income Group Variables** – these variables take on values of 0 or 1 depending on the income group of the traveler's household. The five standard income groups identified in ***Section 3.1.1*** are used based on the income assigned to the household by the population synthesis (see ***Section 2.2***). In model estimation, the household income level was not reported for some households, so coefficients for "missing household income" were also estimated. In model application, all households will have an income group assigned.

Person Variables

These variables include the following information for each traveler:

- **Male** – this variable is 1 if the traveler is a male and 0 otherwise
- **Age under 35** – this variable is 1 if the traveler is under the age of 35 and 0 otherwise

- **Pre-school child (0-4 year old child)** – this variable is 1 if the traveler is under 5 years of age (i.e. person type 8) and 0 otherwise
- **Pre-driving age student (5-15 year old child)** – this variable is 1 if the traveler is a student greater than 4 years old and less than 16 years old (i.e. person type 7), and 0 otherwise
- **Driving age student (child aged 16+)** – this variable is 1 if the traveler is a high school student age 16 or older (i.e. person type 6) and 0 otherwise
- **University student** – this variable is 1 if the traveler is a university student (i.e. person type 5) and 0 otherwise

Land Use Variables

These variables describe the density of development near the origins or destinations of the trip:

- ***Origin or Destination Intersection Density*** variables are intersection densities at the trip origin or the trip destination zones. The variables may be applied for both outbound and inbound half-tours (i.e. **Origin intersection density** and **Destination intersection density**) or for only the inbound half-tour (i.e. **Origin intersection density-inbound half-tour**). The intersection density variables are input zonal level variables determined exogenously to the StateFocus modeling process using GIS information. Intersections may be of three types:
  - *4-way intersections* are normal intersections, signalized or unsignalized, formed by two or more intersecting roadways,
  - *3-way intersections* are formed by two intersecting roadways where one of the roadways does not extend beyond the intersection (“T-intersections”), and
  - *1-way intersections* are not truly intersections but are formed by nodes on a single roadway.

  Intersection density is calculated as follows:

$$IntersectionDensity = \frac{(4\text{–}\,way\ intersections + 0.5 \times 3\text{–}\,way\ intersections - 1\text{–}\,way\ intersections)}{1000}$$

  Where: *4-way intersections* is the number of 4-way intersections within 0.5 miles of the virtual centroid of the zone based on households
  3-way intersections is the number of 3-way intersections within 0.5 miles of the centroid of the zone
  1-way intersections is the number of 1-way intersections within 0.5 miles of the virtual centroid of the zone based on households.

- **Destination retail density-outbound half-tour** is the number of retail employees within 0.5 miles of the centroid of the destination zone of the trip divided by 1000 for those trips occuring on the outbound half-tour of the parent tour

- **Destination retail density-inbound half-tour** is the number of retail employees within 0.5 miles of the centroid of the destination zone of the trip divided by 1000 for those trips occuring on the inbound half-tour of the parent tour

Parent Tour Mode Choice Variables

These variables compare the mode option being considered for the trip with the tour mode chosen in the tour mode main choice model (see ***Section 4.2.13***):

- **Same as tour mode** – this variable is 1 if the mode being evaluated for the trip is the same as tour mode and 0 otherwise; it is applied for all trips in either direction of the half-tour
- **Same as tour mode-only outbound trip** – this variable is 1 if the trip mode is the same as the tour mode and the trip is the only trip on the half-tour from home to the primary destination (i.e. there are no intermediate stops), and zero otherwise
- **Same as tour mode-only inbound trip** – this variable is 1 if the trip mode is the same as the tour mode and the trip is the only trip on the half-tour from the primary destination to home (i.e. there are no intermediate stops), and zero otherwise
- **Same as tour mode-first outbound trip** – this variable is 1 if the trip mode is the same as the tour mode and the trip is the first of two or more trips on the half-tour from home to the primary destination, and zero otherwise
- **Same as tour mode-first inbound trip** – this variable is 1 if the trip mode is the same as the tour mode and the trip is the first of two or more trips on the half-tour from the primary destination to home, and zero otherwise
- **Same as tour mode-last outbound trip** – this variable is 1 if the trip mode is the same as the tour mode and the trip is the last of two or more trips on the half-tour from home to the primary destination, and zero otherwise
- **Same as tour mode-last inbound trip** – this variable is 1 if the trip mode is the same as the tour mode and the trip is the last of two or more trips on the half-tour from the primary destination to home, and zero otherwise
- **Shared ride 2 tour** – this variable is 1 if the tour mode is shared ride 2 and 0 otherwise; the variable may be used for only selected trip modes being considered
- **Shared ride 3+ tour** – this variable is 1 if the tour mode is shared ride 3+ and 0 otherwise; the variable may be used for only selected trip modes being considered
- **Walk to transit tour** – this variable is 1 if the tour mode is walk to transit and 0 otherwise; the variable may be used for only selected trip modes being considered
- **Drive to transit tour** – this variable is 1 if the tour mode is drive to transit and 0 otherwise; the variable may be used for only selected trip modes being considered

- **School bus tour** – this variable is 1 if the tour mode is school bus and 0 otherwise; the variable may be used for only selected trip modes being considered

Parent Tour Purpose Variables

These variables are based on the tour purpose in which the trip is being made. With the exception of "Non-closed tour," these variables are mutually exclusive. For example, a parent tour must be either home-based work or home-based meal – it cannot be both. However, a parent tour may be both a home-based work tour and a non-closed tour.

- **Work tour** – this variable is 1 if the tour purpose is home-based work and 0 otherwise
- **School tour** – this variable is 1 if the tour purpose is home-based school and 0 otherwise
- **Escort tour** – this variable is 1 if the tour purpose is home-based escort and 0 otherwise
- **Shop tour** – this variable is 1 if the tour purpose is home-based shop and 0 otherwise
- **Meal tour** – this variable is 1 if the tour purpose is home-based meal and 0 otherwise
- **Social/recreation tour** – this variable is 1 if the tour purpose is home-based social/recreation and 0 otherwise
- **Work-based sub-tour** – this variable is 1 if the tour purpose is work-based sub-tour and 0 otherwise
- **Non-closed tour** – this variable is 1 if the tour is a non-closed tour and 0 otherwise

Escort Destination Variables

These variables are applicable only when the stop purpose at the trip destination is escort. The variables are directional – e.g. a home to escort variable and it's related model coefficient are not applied for an escort to home trip. The variables may be time of day specific based on the time of day at the trip origin:

- AM peak period: 6:00 AM-8:59 AM
- Midday period: 9:00 AM-2:59 PM
- PM peak period: 3:00 PM-7:00 PM
- Evening period: 7:00 PM-10:59 PM

The escort trip variables are as follows:

- **Home to escort trip** – this variable is 1 if the trip origin is home and the activity at the destination end is escort and 0 otherwise
- **Home to escort trip-AM peak period** – this variable is 1 if the trip origin is home and the activity at the destination end is escort and the trip takes place in the AM peak period, and 0 otherwise

- **Home to escort trip-Midday period** – this variable is 1 if the trip origin is home and the activity at the destination end is escort and the trip takes place in the midday period, and 0 otherwise

- **Home to escort trip-PM peak period** – this variable is 1 if the trip origin is home and the activity at the destination end is escort and the trip takes place in the PM peak period, and 0 otherwise

- **Home to escort trip-Evening period** – this variable is 1 if the trip origin is home and the activity at the destination end is escort and the trip takes place in the evening period, and 0 otherwise

- **Other to escort trip** – this variable is 1 if the activity at the trip origin is for any purpose other than home or escort, and the activity at the destination end is escort, and 0 otherwise

Escort Trip Sequencing Variables

These variables are based on the the trip mode used for the previous trip when the previous stop purpose was escort. For example, suppose that on an outbound half-tour for a home-based work tour purpose, the person leaves home, makes an escort stop to drop a child at school, and continues on to their work location. The first trip is a home to escort trip made by the shared ride 2 mode. In this case, there is no previous mode or purpose. For the second trip from escort to work, the previous mode is shared ride 2 and the previous stop is escort, so the appropriate variables would be set to 1. The times of day used for the escort trip sequencing variables are the same as those used for ***Escort Destination Variables***.

- **Previous mode drive alone and previous purpose escort** – this variable is 1 if the purpose at the previous stop (at the origin of the current trip) is escort and the mode used to get to the previous stop was drive alone, and 0 otherwise

- **Previous mode drive alone and previous purpose escort – AM peak** – this variable is 1 if the purpose at the previous stop (at the origin of the current trip) is escort, the mode used to get to the previous stop was drive alone, and the current trip takes place in the AM peak period, and 0 otherwise

- **Previous mode shared ride 2 and previous purpose escort** – this variable is 1 if the purpose at the previous stop (at the origin of the current trip) is escort and the mode used to get to the previous stop was shared ride 2, and 0 otherwise

- **Previous mode shared ride 2 and previous purpose escort – AM peak** – this variable is 1 if the purpose at the previous stop (at the origin of the current trip) is escort, the mode used to get to the previous stop was shared ride 2, and the current trip takes place in the AM peak period, and 0 otherwise

- **Previous mode shared ride 2 and previous purpose escort – PM peak** – this variable is 1 if the purpose at the previous stop (at the origin of the current trip) is escort, the mode used to get to the previous stop was shared ride 2, and the current trip takes place in the PM peak period, and 0 otherwise

- **Previous mode shared ride 3+ and previous purpose escort** – this variable is 1 if the purpose at the previous stop (at the origin of the current trip) is escort and the mode used to get to the previous stop was shared ride 2, and 0 otherwise

- **Previous mode shared ride 3+ and previous purpose escort – AM peak** – this variable is 1 if the purpose at the previous stop (at the origin of the current trip) is escort, the mode used to get to the previous stop was shared ride 3+, and the current trip takes place in the AM peak period, and 0 otherwise

- **Previous mode shared ride 3+ and previous purpose escort – PM peak** – this variable is 1 if the purpose at the previous stop (at the origin of the current trip) is escort, the mode used to get to the previous stop was shared ride 3+, and the current trip takes place in the PM peak period, and 0 otherwise

Sampling Bias Variables

The FRTC data used for model estimation included two intercept oversamples: one for households of travelers using the Front Range Express (FREX) between Colorado Springs and Denver and one for households of travelers using park-and-ride lots in Denver. Since mode choice observations from the two oversamples were based on non-random sampling, 0/1 variables were used to identify households from each of the oversamples and coefficients were estimated for those households in order to remove some of the bias introduced by the non-random sampling. The variables and associated model coefficients are not used in model application.

4.2.19 Trip Time of Day Choice

Model Structure

The trip level time of day choice model is a multinomial logit model that predicts the arrival time for stops made on the outbound half-tour from the tour origin (home for home-based tour purposes or work for work-based sub-tours) and the departure time for stops made on the inbound half-tour from the primary tour activity location. While the purpose of each intermediate stop is included as a variable in the model, a single multinomial logit model for trip time of day choice is used in StateFocus. There are 24 potential alternatives in the model representing one-hour time periods starting at 3:00 AM–3:59 AM:

1. 3:00 AM – 3:59 AM
2. 4:00 AM – 1:59 AM

….

23. 1:00 AM – 1:59 AM
24. 2:00 AM – 2:59 AM

The time period alternatives available for each stop are constrained by the time window for the primary activity as determined by the tour time of day choice model (see ***Section 4.2.14***) as well as the half-tour on which the stop occurs. For example, if the primary tour activity occurs between the 8:00-8:59 AM and 5:00-5:59 PM time periods, intermediate stops on the outbound half-tour may take place between the 3:00-3:59 AM and 8:00-8:59 AM time periods and stops on the inbound half-tour may take place between the 5:00-5:59 PM and 2:00-2:59 AM time periods, assuming there are no other tours made during the day that constrain the available time periods.

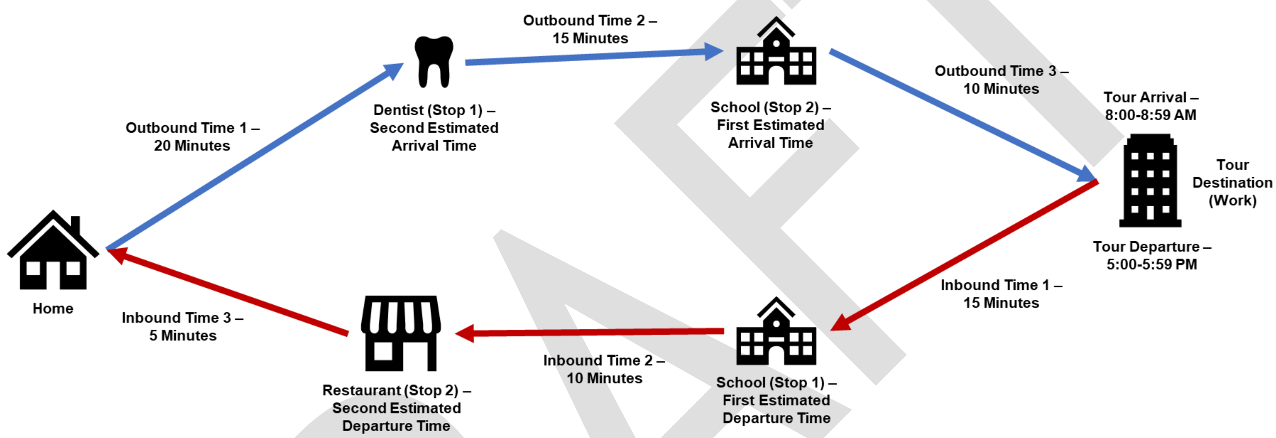
The modeling of stop times is dependent on the half-tour on which the stop occurs:

- On the outbound half-tour, the arrival times for stops are simulated backwards in time, from the primary destination toward the origin of the tour (i.e. from the latest stop on the outbound half-tour to the earliest).

- On the inbound half-tour, the departure times for stops are simulated forward in time from the primary destination toward the tour origin (i.e. from the earliest stop on the inbound half-tour to the latest).

As an example, consider a parent making a home-based work tour with two intermediate escort stops on the outbound half-tour to take a child to a dentist appointment and then to school and one intermediate escort stop on the inbound half-tour to pick the child up from school and then participate in a meal stop at a restaurant for dinner as shown in ***Figure 4.51***. Further, assume that the parent's arrival time at work was simulated to be the 8:00-8:59 AM time period and their departure time was the 5:00-5:59 PM time period. Since the parent was serving escort stops on their work tour, further assume that tour and trip modes are auto (of varying occupancies).

Figure 4.51 Trip Time of Day Estimation Order Example



Source: Cambridge Systematics.

On the outbound half-tour, the following process is used to simulate stop arrival times since the stops are simulated backwards in time:

- The departure time period from Stop 2 (escort stop at the school) is the arrival time at the tour destination (work) minus "Outbound Time 3."[56] Since Time 3 is 10 minutes, the departure time from Stop 2 could be in the 8:00-8:59 AM time period. The arrival time period for Stop 2 is then simulated within the constrained time window, 3:00-3:59 AM to 8:00-8:59 AM. Suppose the arrival time period for the escort stop at the school is simulated to be the same as the parent's arrival time at work, 8:00-8:59 AM. The activity duration for the stop can be inferred (roughly, given the one-hour time periods) as the difference between the arrival and departure times, or zero hours.

- Likewise, the departure time from Stop 1 (escort stop at the dentist) is the simulated arrival time for Stop 2 (8:00-8:59 AM) minus "Outbound Time 2." Since Time 2 is 15 minutes, the departure time from Stop 1 could still be in the 8:00-8:59 AM time period and the arrival time at Stop 1 would continue to be simulated within the constrained time window, 3:00-3:59 AM to 8:00-8:59 AM. Suppose the arrival time

[56] Travel times are known from the network skims since all stop locations (from the trip destination choice model) and modes (from the trip mode choice model) are known from previously applied models.

period for the escort stop at the dentist is simulated to be the 7:00-7:59 AM time period. The rough activity duration for the escort stop at the dentist would be estimated as one hour.

- Finally, the departure time period from home is simulated as the simulated arrival time at Stop 1 minus "Outbound Time 1." Since Time 1 is 20 minutes, the departure time from home would still be in the 7:00-7:59 AM time period.

On the inbound half-tour, the process is reversed to simulate the stop departure times since the stops are simulated forward in time:

- The arrival time period at Stop 1 (escort stop at the school) is the departure time from the tour destination (work) plus "Inbound Time 1." Since Time 1 is 15 minutes, the arrival time at Stop 1 could be in the 5:00-5:59 PM time period. The departure time period from Stop 1 is then simulated within the constrained time window, 5:00-5:59 AM to 2:00-2:59 AM. Suppose the departure time period for the escort stop at the school is simulated to be the 6:00-6:59 PM time period. The activity duration for the stop would be inferred (roughly, given the one-hour time periods) as the difference between the arrival and departure times, or one hour.

- Likewise, the arrival time from Stop 2 (meal stop at a restaurant) is the simulated departure time from Stop 1 (6:00-6:59 PM) plus "Inbound Time 2." Since Time 2 is 10 minutes, the arrival time from Stop 2 could still be in the 6:00-6:59 PM time period and the departure time from Stop 2 would be simulated within the constrained time window, 6:00-6:59 PM to 2:00-2:59 AM. Suppose the departure time period for the meal stop is simulated to be the 7:00-7:59 PM time period. The rough activity duration for the meal stop would be estimated as one hour.

- Finally, the arrival time period at home is simulated as the simulated departure time from Stop 2 plus "Inbound Time 3." Since Inbound Time 3 is 5 minutes, the arrival time period at home would still be in the 7:00-7:59 PM time period.

Utility Function

The general form of the utility equation for the trip mode choice model for a trip between a stop in TAZ_i and a stop TAZ_j is:

$$
\begin{aligned}
U_{tt,i-j|m,TP,adt} = {} & C_{GT|m} \times GT_{i-j,tm|adt} + \sum_{dir=1}^{2} (CAPD_{dir} \times DAPD_{dir}) + (CTRW \times DTRW) + (CSRAW \times DSRAW) \\
& + AltHrs \\
& \times \left[\sum_{p=1}^{P} (CP_p \times DP_p) + \sum_{sp=1}^{6} (CSP_{sp} \times DSP_{sp}) + \sum_{TP=1}^{4} (CTP_{TP,dir} \times DTP_{TP,dir}) \right. \\
& \left. + \sum_{Alt=1}^{24} (KDUR_{Alt} \times DDUR_{Alt}) \right] + \sum_{tod=1}^{24} (KAP_{tod} \times DAP_{tod|OB}) + \sum_{tod=1}^{24} (KDP_{tod} \times DDP_{tod|IB})
\end{aligned}
$$

Where: $U_{tt,i\text{-}j|m,TP,adt}$ is the utility of trip time of day *tt* for a trip between TAZ *i* and TAZ *j* on a trip using trip mode *m* on a tour for purpose *TP* and arriving at or departing from a previous stop depending on the direction of the half-tour at time period *adt*

C_{GT} is the coefficient of generalized time for trip mode *m*

$GT_{i\text{-}j,m\|adt}$	is the generalized time from TAZ *i* to TAZ *j* using trip mode *m* for trip arrival/departure from previous stop depending on half-tour direction *adt*
$CAPD_{dir}$	is the coefficient for the departure or arrival period half-tour direction *dir* (outbound or inbound) being partially used for another stop
$DAPD_{dir}$	is a dummy variable that takes the value of 1 if there is another stop in the departure or arrival period for time of day alternative being considered on the half-tour direction *dir* and 0 otherwise
CTRW	is the coefficient for the total remaining tours divided by the total remaining window
DTRW	is the total remaining tours divided by the total remaining window
CSRAW	is the coefficient for the remaining stops on the half-tour divided by the adjacent window
DSRAW	is the remaining stops on the half-tour divided by the adjacent window
AltHrs	is the number of hours between the arrival time at the stop and the departure time from the stop; the calculation of this variable varies by direction of the half-tour and the alternative being considered for the arrival or departure time from the stop
CP_p	is the stop duration shift coefficient for a traveler with characteristic *p*
DP_p	is a dummy variable that takes the value of 1 for a traveler with characteristic *p* and 0 otherwise
CSP_{sp}	is the trip duration shift coefficient for stop purpose *sp*
DSP_{sp}	is a dummy variable that takes the value of 1 for if the traveler is making a stop for stop purpose *sp* and 0 otherwise
$CTP_{TP,dir}$	is the trip duration shift coefficient for tour purpose *TP* for outbound or inbound half-tour *dir*
$DTP_{TP,dir}$	is a dummy variable that takes the value of 1 for if the traveler on the outbound or inbound half-tour *dir* for a tour purpose *TP* and 0 otherwise
$KDUR_{Alt}$	is the constant for the stop duration for the alternative being considered is *Alt* hours
$DDUR_{Alt}$	is a dummy variable that takes the value of 1 if the stop duration for the alternative being considered (*AltHrs)* equals *Alt* hours and 0 otherwise
KAP_{tod}	is the constant for arrival time for the stop being in time period *tod*
$DAP_{tod\|OB}$	is a dummy variable that takes the value of 1 if the arrival time for the stop in the outbound half-tour (*OB*) is in time period *tod* and 0 otherwise
KDP_{tod}	is the constant for departure time for the stop being in time period *tod*
$DDP_{tod\|IB}$	is a dummy variable that takes the value of 1 if the departure time from the stop in the inbound half-tour (*IB*) is in time period *tod* and 0 otherwise

Variables

Generalized Time

As in the tour time of day model (see ***Section 4.2.14***), the generalized time for auto and transit modes for the period is based on the network travel times for the ten highway level of service periods (see ***Table 2.1***) and four transit level of service periods (see ***Table 2.2***), multiplied by the relevant level of service coefficients from the tour mode choice models, and then divided by the auto travel time coefficient to convert back to units of minutes. The generalized time variables are calculated in the same manner as described for tour time of day (see ***Section 4.2.14***, ***Generalized Time Variables***). Note, however, for trip time of day choice, these variables are not applied for walk, bike, or school bus tours.

The model uses the generalized time from the last known previously modeled stop time period to the stop being modeled using the chosen trip mode from the trip mode choice model (see ***Section 4.2.18***). Thus, if the tour mode is walk to transit but the mode for a trip segment on the tour is auto shared ride 2, the generalized auto travel time rather than the generalized transit travel time would be used between the stops. Travel times between stops are modeled as described in this section under ***Model Structure***.

Duration Shift Variables

Duration shift variables affect the amount of time spent at the stop activity based on the time of day alternative being considered for the arrival at or departure from the stop. As described under ***Model Structure***, the arrival time at the stop or the departure time from the stop is fixed depending on the direction of the half-tour and the stop being considered and the departure time from the stop or arrival time at the stop is the alternative being modeled. The duration shift variables are interacted with traveler characteristics, stop purposes, and tour purposes as well as constants for different stop durations as described below:

- **Person Characteristics**[57]
  - **Child age 0-4** is 1 if person is pre-school aged child (person type 8) and 0 otherwise
  - **Child age 5-15** is 1 if person is a pre-driving aged child (person type 7) and 0 otherwise
  - **Driving age student** is 1 if person is a 16+ aged K-12 student (person type 6) and 0 otherwise
  - **University student** is 1 if person is a 16+ aged university student (person type 5) and 0 otherwise
  - **Other non-worker** is 1 if the person is a non-worker age 18-65 (person type 4) and 0 otherwise
  - **Retirement age non-worker** is 1 if the person is a non-worker age 65+ (person type 3) and 0 otherwise
- **Stop Purpose**
  - **School stop** is 1 if the stop is an school stop and 0 otherwise
  - **Escort stop** is 1 if the stop is an escort stop and 0 otherwise
  - **Personal business stop** is 1 if the stop is an personal business stop and 0 otherwise
  - **Shop stop** is 1 if the stop is a shop stop and 0 otherwise
  - **Meal stop** is 1 if the stop is a meal stop and 0 otherwise
  - **Social/recreation stop** is 1 if the stop is a social/recreation stop and 0 otherwise
- **Tour Purpose**
  - **Work tour outbound** is 1 if the stop is on the outbound half-tour of a home-based work tour and 0 otherwise
  - **Work tour inbound** is 1 if the stop is on the inbound half-tour of a home-based work tour and 0 otherwise

[57] Person characteristics are defined by person types as described in ***Section 3.1.2***.

- **Non-work tour inbound** is 1 if the stop is on the inbound half-tour of a home-based tour for any non-work purpose and 0 otherwise
- **Work-based sub-tour** is 1 if the stop is on a work-based sub-tour and 0 otherwise

- **Duration Constants**
  - **Duration x:00-x:59 hours** ia 1 if the resulting stop duration (stop departure hour minus stop arrival hour) for trip time of day being considered is in the range x:00-x:59 where x varies between 0 and 24, and 0 otherwise

Other Variables

- **Arrival period partially used** is1 if the arrival period on an outbound half-tour is also the (known) departure period for the stop or another tour ends in the arrival period and 0 otherwise
- **Departure period partially used** is1 if the departure period on an inbound half tour is also the (known) arrival period for the stop or another tour begins in the departure period and 0 otherwise
- **Remaining tours/total remaining window** is the remaining number of tours to be scheduled in the day after scheduling the stops in the current tour divided by the sum of the durations of all empty windows in the day before the period starts and after the period ends. Empty windows are those not used for activities already simulated in the current tour or for activities and travel in any previously simulated tours. This variable is evaluated separately for each alternative as if the person has chosen that alternative time of day being considered.
- **Remaining stops on half-tour/adjacent window** is the remaining number of tours to be scheduled in the day after scheduling the stops on the current tour divided by the duration of the adjacent time window. The adjacent window is the window before (earlier in the day) the most recently simulated activity on the outbound tour or after (later in the day) the most recently simulated activity on the inbound tour). This variable is evaluated separately for each alternative as if the person has chosen that alternative time of day being considered.

Arrival and Departure Time Constants

Arrival and departure constants are calibrated for each of the 24 one-hour time slots during the travel day.[58] Constants may be positive or negative with positive constants encouraging the use of a time slot and negative constants discoursing the use of a time slot. In addition, constants are calibrated for each of the 24 possible tour durations (00:00-00:59 hours to 23:00-23:59 hours) with positive constants producing more tours for the one-hour duration being considered and negative constants producing fewer tours for the one-hour duration.

[58] "Before" the travel day begins and "after" the travel day ends constants comparable to those used for non-closed tour time of day choice (see ***Adjustments for Non-Closed Tours***, and ***Arrival Constants, Departure Constants, and Duration Constants*** in ***Section 4.2.14***) are not required for stop time of day since the first or last stop of the day modeled will be during the travel day.

4.3 Simulating Choices

4.3.1 "Reproducible" Random Seed Generation

StateFocus produces a "reproducible" random number. Computer generated random numbers are not truly random but, rather, are based on an input random seed. Whenever the same seed is used, the same sequence of random numbers will be produced. As discussed in the following section, the production of random numbers is crucial for the determination of choices based on the various choice models. Some control over the random numbers is useful. For example, if households are added in Grand Junction, auto ownership choices for residents of Denver would not be expected to change.

The reproducible random seed used to generate the random numbers are based on two components: a user specified input parameter and a decision key based on the type of decision being made. The decision keys are based on a combination of information about the household identifier, person identifier within the household, the tour identifier for the tour being made by the person, and the trip identifier for the trip being made within the tour being made. For example, a person identifier would be a combination of the household identifier and the person within the household. The model components and decision keys are shown in ***Table 4.28***.

Table 4.28 Decision Keys for Reproducible Random Seed Generation

Model Component	Decision Key Basis
Regular / No Regular Workplace Choice	Household + Person
Regular Workplace Location Choice	Household + Person
Home-Schooled / Not Home-Schooled Choice	Household + Person
Regular School Location Choice	Household + Person
Autos Available Choice	Household
Daily Activity Pattern Choice	Household + Person
Exact Number of Tours Choice	Household + Person
Work Tour Destination Type Choice	Household + Person
Work-Based Sub-Tour Generation Choice	Household + Person + Tour
Tour Time of Day Simulation	Not Applicable – Not a Choice Model
Tour Primary Destination Choice	Household + Person + Tour
Tour Priority Assignment	Not Applicable – Not a Choice Model
Tour Main Mode Choice	Household + Person + Tour
Tour Time of Day Choice	Household + Person + Tour
Intermediate Stop Generation Choice	Household + Person + Tour
Trip Time of Day Simulation	Not Applicable – Not a Choice Model
Intermediate Stop Location Choice	Household + Person + Tour + Trip
Trip Mode Choice	Household + Person + Tour + Trip
Trip Time of Day Choice	Household + Person + Tour + Trip

Source: Cambridge Systematics

4.3.2 Determining a Choice Based on Estimated Choice Probabilities and Random Number Generation

When results from disaggregate choice models are applied to aggregate populations, the choice probabilities are, typically, assumed to be proportions to be applied to the group population. For example, if the choice probabilities from an autos available model for modest income, three person households in a zone were 0.1 for no autos, 0.2 for one auto, 0.4 for two autos, 0.2 for three autos, and 0.1 for four or more autos, the probabilities can be assumed to be percentages of the households in each of those autos available groups in the zone.

With a simulation model like StateFocus where choices for every household and person in the Colorado are modeled, a proportional allocation does not fit well with the overall logic of modeling individual choices. It does not make sense to say that 10 percent of an individual modest income, three person household will have no autos, 20 percent of the individual household will have one auto, and so on, especially when the number of autos available to that household is used in subsequent choices such as tour mode choice.

An alternative to proportional assignment would be to assign the choice with the highest choice probability; in the auto availability example, two autos available had the highest choice probability and would be selected as the choice for the household. The problem with such an approach is that it produces lumpy results. While overall accessibility is considered in the autos available choice model, there may be little or no variation of the variable among modest income, three person households within a specific zone. As a result, all of the modest income, three person households in the zone would be two auto households.

The procedure used in StateFocus uses the reproducible random seeds for each choice "unit" (household, person, tour, or trip) to generate a random number in the range 0 to 1. The random numbers are used to identify the selected choice using the following procedure:

- The cumulative probability of the alternative choices are determined for the individual choice unit. In effect, this becomes a number line from 0 to 1 where each alternative choice covers a portion of the number line.

- The alternative in the range on the number line "covering" the random number is the chosen alternative.

For example, ***Table 4.29*** shows an example of choice probabilities and cumulative choice probabilities generated for the autos available example. The width of the columns in ***Table 4.29*** are in proportion to the choice probabilities. If the reproducible random seed for the household produced a random number of 0.732, three autos would be the selected choice since the random number fell in the cumulative probability range for three autos.

Table 4.29 Example Choice Probabilities from Autos Available Model

	0 Autos	1 Auto	2 Autos	3 Autos	4+ Autos
Probability	0.1	0.2	0.4	0.2	0.1
Cumulative Probability	0.0–0.1	0.1–0.3	0.3–0.7	0.7–0.9	0.9–1.0

Source: Cambridge Systematics

4.4 Creating Time of Day Trip Tables for Trip Assignment

Time of day trip tables in origin to destination format are created for traffic and transit assignment. Vehicle trip tables are created for traffic assignment and person trip tables are created for transit assignment. The ten times of day for traffic assignment are the same as those defined in ***Table 2.1*** and the four time of day trip tables for transit assignment are the same as those defined in ***Table 2.2***. Although trips are modeled for the non-motorized (walk and bike) and school bus modes, assignment trip tables for them are not built since they are not assigned to networks.[59] The results of trip based models for truck trips, internal-external, external-internal, external-external, and visitor trips are added to the trips resulting from the choice models at this point in the modeling process (see ***Sections 2.4.1***, ***2.4.2***, and ***2.4.4***). In addition, trips to and from DIA modeled using the choice models are replaced with trips from the DIA trip based model (see ***Section 2.4.3***).

4.4.1 Creating 10-Period Time of Day Trip Tables for Traffic Assignment

Ten time of day auto trip tables are built from the auto person trips modeled for each individual in the state for use in the traffic assignment process (see ***Table 2.1*** for the ten time of day definitions). The trips are allocated to each of the tables based on whether the stops defining the trip are on the outbound leg of a tour or the return (inbound) leg. Trips occurring on the outbound leg are assigned to a trip table based on the arrival time at the stop location while trips occurring on the inbound leg are assigned to a trip table based on the departure time from the previous stop location. ***Table 4.30*** provides an example for a person who makes a home-based work tour with one stop on the outbound leg and two stops on the inbound leg.

Table 4.30 Example Allocation of Trips to Time of Day Trip Tables for Traffic Assignment

Tour Leg	From	Departure Time	To	Arrival Time	Trip Assigned to Time of Day Trip Table
Outbound	Home	–	Coffee Shop	**7:00-7:59 AM**	AM2
	Coffee Shop	7:00-7:59 AM	Work	**8:00-8:59 AM**	AM3
Inbound	Work	**4:00-4:59 PM**	Dry Cleaners	5:00-5:59 PM	PM1
	Dry Cleaners	**5:00-5:59 PM**	Restaurant	5:00-5:59 PM	PM2
	Restaurant	**7:00-7:59 PM**	Home	–	OP4

Source: Cambridge Systematics
Note: **Bold time periods** identify period used for allocating trip to time of day trip table.

Separate time of day trip tables are created for drive alone, share ride 2, and shared ride 3+ vehicle trips. Each person trip using shared ride 2 is divided by two before adding to the shared ride 2 time of day trip table (to convert from person trips to vehicle trips) and each person using shared ride 3+ is divided by an assumed average auto occupancy of 3.2 before adding to the shared ride 3+ time of day trip table (also to convert to vehicle trips).

[59] Obviously, it would be very easy to develop the procedures to construct the trip tables if the assignment of walk, bike, or school bus trips is desired.

Several of the traffic assignment time periods start or end at the half-hour while the trip time of day choice model determines stop arrival and departure times on an hourly basis. Trips are allocated to the half-hour periods using the percentages shown in ***Table 4.31***.

Table 4.31 Factors for Allocating Hourly Trip Time of Day Choice Trips to Trip Tables Starting or Ending on a Half-Hour

Auto Assignment Time Period	Trip Table Time Period	Trip Time of Day Choice Time Period	Proportion of Trips Assigned to Trip Table
Early Morning Peak (AM1)	6:30 AM – 6:59 AM	6:00 AM – 6:59 AM	66.3%
Late Night (OP1)	11:00 PM – 6:29 AM	6:00 AM – 6:59 AM	33.7%
Morning Off-Peak (OP2)	9:00 AM – 11:29 AM	11:00 AM – 11:59 AM	44.0%
Midday Off-Peak (OP3)	11:30 AM – 2:59 PM	11:00 AM – 11:59 AM	56.0%

Source: Cambridge Systematics analysis of FRTC data

4.4.2 Creating 4-Period Time of Day Trip Tables for Transit Assignment

Four time of day transit trip tables are built for the transit assignment process from the transit person trips modeled for each individual in the state (see ***Table 2.2*** for the four time of day definitions). The transit trip tables are built in origin to destination format (as opposed to many travel models that assign transit trips in production to attraction format). As with the development of auto trip tables, transit trips to be included in each of the tables are determined based on whether the stops defining the trip are on the outbound leg of a tour or the return (inbound) leg; trips occurring on the outbound leg are based on the arrival time at the stop location while trips occurring on the inbound leg are based on the departure time from the previous stop location.

Separate transit trip tables are built for walk to transit and drive to transit. As noted above, transit trips are assigned directionally from origin to destination. For the drive to transit trips, drive to transit auto trip tables are written out for the drive from the home to the park and ride lot on the outbound leg or the drive from the park and ride lot to the home for the inbound leg. These auto access and egress auto trip tables are combined with the auto vehicle trip tables described in ***Section 4.4.1***.

Two of the transit assignment time periods start or end at the half-hour while the trip time of day choice model determines stop arrival and departure times on an hourly basis. Trips are allocated to the half-hour periods using the percentages shown in ***Table 4.32***.

Table 4.32 Factors for Allocating Hourly Trip Time of Day Choice Trips to Trip Tables Starting or Ending on a Half-Hour

Transit Assignment Time Period	Trip Table Time Period	Trip Time of Day Choice Time Period	Proportion of Trips Assigned to Trip Table
Morning (AM)	6:30 AM – 6:59 AM	6:00 AM – 6:59 AM	66.3%
Evening-Late (EL)	11:00 PM – 6:29 AM	6:00 AM – 6:59 AM	33.7%

Source: Cambridge Systematics analysis of FRTC data

Appendix A. Highway Network Data

The highway network information in this appendix is generally more volatile than parameters noted in the main report in that the data may change by alternative.

Table A.1 Highway Network Metadata

Highway Link Field_Name	Internal Data Storage Type	Input Field Width	Input Number of Decimal Places	Description
ID	Integer (4 bytes)	10	0	Link ID (Links indexed on this variable)
Dir	Integer (2 bytes)	2	0	Direction code (see TransCAD)
Length	Real (8 bytes)	10	2	Link length in miles
TagLinkID	Integer (4 bytes)	10	0	
DIST	Real (8 bytes)	15	2	
TYPE	Integer (4 bytes)	10	0	
FACILITY TYPE	Integer (4 bytes)	8	0	
LANE	Integer (4 bytes)	10	0	
LaneAB	Integer (4 bytes)	10	0	
LaneBA	Integer (4 bytes)	10	0	
TOLL	Integer (4 bytes)	10	0	
USE	Integer (4 bytes)	10	0	
TollCost	Real (8 bytes)	15	2	
TollCost_HOV	Real (8 bytes)	15	2	
TollCost_Pk	Real (8 bytes)	15	2	
TollCost_OP	Real (8 bytes)	15	2	
TollCost_HOV2_Pk	Real (8 bytes)	15	2	
TollCost_HOV2_OP	Real (8 bytes)	15	2	
TollCost_HOV3p_Pk	Real (8 bytes)	15	2	
TollCost_HOV3p_OP	Real (8 bytes)	15	2	
override_FFSpeed	Integer (4 bytes)	10	0	
override_CapPerLane	Integer (4 bytes)	10	0	
override_PenaltyMinutes	Integer (4 bytes)	10	0	
T_SPEED	Real (8 bytes)	15	2	
AM_AB_SPEED	Real (8 bytes)	15	2	
AM_BA_SPEED	Real (8 bytes)	15	2	
MD_AB_SPEED	Real (8 bytes)	15	2	
MD_BA_SPEED	Real (8 bytes)	15	2	
PM_AB_SPEED	Real (8 bytes)	15	2	
PM_BA_SPEED	Real (8 bytes)	15	2	

Highway Link Field_Name	Internal Data Storage Type	Input Field Width	Input Number of Decimal Places	Description
EL_AB_SPEED	Real (8 bytes)	15	2	
EL_BA_SPEED	Real (8 bytes)	15	2	
AM1_AB_SPEED	Real (8 bytes)	15	2	
AM1_BA_SPEED	Real (8 bytes)	15	2	
AM2_AB_SPEED	Real (8 bytes)	15	2	
AM2_BA_SPEED	Real (8 bytes)	15	2	
AM3_AB_SPEED	Real (8 bytes)	15	2	
AM3_BA_SPEED	Real (8 bytes)	15	2	
PM1_AB_SPEED	Real (8 bytes)	15	2	
PM1_BA_SPEED	Real (8 bytes)	15	2	
PM2_AB_SPEED	Real (8 bytes)	15	2	
PM2_BA_SPEED	Real (8 bytes)	15	2	
PM3_AB_SPEED	Real (8 bytes)	15	2	
PM3_BA_SPEED	Real (8 bytes)	15	2	
OP1_AB_SPEED	Real (8 bytes)	15	2	
OP1_BA_SPEED	Real (8 bytes)	15	2	
OP2_AB_SPEED	Real (8 bytes)	15	2	
OP2_BA_SPEED	Real (8 bytes)	15	2	
OP3_AB_SPEED	Real (8 bytes)	15	2	
OP3_BA_SPEED	Real (8 bytes)	15	2	
OP4_AB_SPEED	Real (8 bytes)	15	2	
OP4_BA_SPEED	Real (8 bytes)	15	2	
Walk_Mode	Integer (2 bytes)	4	0	
Walk_Time	Real (8 bytes)	15	2	
Turn_Prohibited	Character	16	0	
CherryCreekLinks	Integer (4 bytes)	10	0	
Route_Name	Character	32	0	
Route	Character	16	0	
Road Type	Character	16	0	
RtdName	Character	16	0	
MPOLinks	Character	16	0	
MPO	Character	16	0	
PreMergeID	Integer (4 bytes)	10	0	
Screenline_State	Integer (4 bytes)	10	0	
ScreenlineName_State	Character	25	0	
VAL_COUNT	Integer (4 bytes)	10	0	

Highway Link Field_Name	Internal Data Storage Type	Input Field Width	Input Number of Decimal Places	Description
ValCount_10	Integer (4 bytes)	10	0	
ValCount_15	Integer (4 bytes)	10	0	
Speed Limits	Real (8 bytes)	10	2	
Sp_Lim_Check	Character	10	0	
SubRegionID	Integer (4 bytes)	8	0	
transfer_val15	Integer (4 bytes)	8	0	
transfer_val10	Integer (4 bytes)	8	0	

Source: Colorado Department of Transportation.

A.1 Highway Network Data Lookup Tables

The data in the lookup tables below are posted to the highway network based on other network characteristics. The data may be changed for individual links for special cases or the data in the tables may be changed to globally affect all links with the lookup characteristics for the changed cell.

Table A.2 Default Peak Period Congested Speeds for Highway Path-Building

Facility Type	Posted Speed Limit (MPH)	Area Type				
		(1) CBD	(2) Fringe	(3) Urban	(4) Suburban	(5) Rural
(1) Freeway	25	47.50	39.55	43.84	52.25	54.15
	30	47.50	39.55	43.84	52.25	54.15
	35	47.50	39.55	43.84	52.25	54.15
	40	47.50	39.55	43.84	52.25	54.15
	45	47.50	39.55	43.84	52.25	54.15
	50	47.50	39.55	43.84	52.25	54.15
	55	47.50	39.55	43.84	52.25	54.15
	60	51.30	39.55	43.84	55.48	57.00
	65	52.25	39.55	43.84	55.48	61.75
	70	55.94	39.55	43.84	55.48	66.50
	75	55.94	39.55	43.84	55.48	71.25
	Missing	55.94	39.55	43.84	55.48	71.25
(2) Major Regional Arterial	25	32.30	25.71	35.60	38.95	42.75
	30	32.30	25.71	35.60	38.95	42.75
	35	32.30	25.71	35.60	38.95	42.75
	40	34.20	25.71	35.60	39.96	44.65
	45	35.15	25.71	35.60	39.96	45.60
	50	35.15	25.71	35.60	39.96	48.45
	55	35.15	25.71	35.60	39.96	50.35
	60	38.00	25.71	35.60	39.96	50.35
	65	40.85	25.71	35.60	39.96	54.73
	70	40.85	25.71	35.60	39.96	54.73
	75	40.85	25.71	35.60	39.96	54.73
	Missing	42.75	25.71	35.60	39.96	54.73
(3) Principal Arterial	25	15.97	21.38	23.32	29.78	33.25
	30	15.97	21.38	23.32	29.78	33.25
	35	15.97	21.38	23.32	29.78	35.15
	40	15.97	21.38	23.32	29.78	38.95
	45	15.97	21.38	23.32	29.78	39.90

Facility Type	Posted Speed Limit (MPH)	Area Type				
		(1) CBD	(2) Fringe	(3) Urban	(4) Suburban	(5) Rural
(3) Principal Arterial	50	15.97	21.38	23.32	29.78	42.75
	55	15.97	21.38	23.32	29.78	49.40
	60	15.97	21.38	23.32	29.78	49.40
	65	15.97	21.38	23.32	29.78	49.40
	70	15.97	21.38	23.32	29.78	49.40
	75	15.97	21.38	23.32	29.78	49.40
	Missing	15.97	21.38	23.32	29.78	51.13
Minor Arterial	25	14.80	18.30	23.07	28.50	31.35
	30	14.80	18.30	23.07	28.50	31.35
	35	14.80	18.30	23.07	28.97	33.25
	40	14.80	18.30	23.07	28.97	38.00
	45	14.80	18.30	23.07	28.97	38.00
	50	14.80	18.30	23.07	28.97	40.64
	55	14.80	18.30	23.07	28.97	40.64
	60	14.80	18.30	23.07	28.97	40.64
	65	14.80	18.30	23.07	28.97	40.64
	70	14.80	18.30	23.07	28.97	40.64
	75	14.80	18.30	23.07	28.97	40.64
	Missing	14.80	18.30	23.07	28.97	40.64
(5) Collector	25	14.65	19.95	18.87	23.73	23.75
	30	14.65	19.95	18.87	23.73	28.50
	35	14.65	20.91	18.87	23.73	30.72
	40	14.65	20.91	18.87	23.73	30.72
	45	14.65	20.91	18.87	23.73	30.72
	50	14.65	20.91	18.87	23.73	30.72
	55	14.65	20.91	18.87	23.73	30.72
	60	14.65	20.91	18.87	23.73	30.72
	65	14.65	20.91	18.87	23.73	30.72
	70	14.65	20.91	18.87	23.73	30.72
	75	14.65	20.91	18.87	23.73	30.72
	Missing	14.65	19.00	18.87	23.73	30.72
(6) Ramp	25	28.15	23.98	26.17	30.24	29.64
	30	28.15	23.98	26.17	30.24	29.64
	35	28.15	23.98	26.17	30.24	29.64
	40	28.15	23.98	26.17	30.24	29.64
	45	28.15	23.98	26.17	30.24	29.64

Facility Type	Posted Speed Limit (MPH)	Area Type				
		(1) CBD	(2) Fringe	(3) Urban	(4) Suburban	(5) Rural
(6) Ramp	50	28.15	23.98	26.17	30.24	29.64
	55	28.15	23.98	26.17	30.24	29.64
	60	28.15	23.98	26.17	30.24	29.64
	65	28.15	23.98	26.17	30.24	29.64
	70	28.15	23.98	26.17	30.24	29.64
	75	28.15	23.98	26.17	30.24	29.64
	Missing	28.15	23.98	26.17	30.24	29.64
(7) Future Use	25	42.75	25.71	35.60	39.96	54.73
	30	42.75	25.71	35.60	39.96	54.73
	35	42.75	25.71	35.60	39.96	54.73
	40	42.75	25.71	35.60	39.96	54.73
	45	42.75	25.71	35.60	39.96	54.73
	50	42.75	25.71	35.60	39.96	54.73
	55	42.75	25.71	35.60	39.96	54.73
	60	42.75	25.71	35.60	39.96	54.73
	65	42.75	25.71	35.60	39.96	54.73
	70	42.75	25.71	35.60	39.96	54.73
	75	42.75	25.71	35.60	39.96	54.73
	Missing	42.75	25.71	35.60	39.96	54.73
(8) Centroid Connector	25	11.00	13.00	16.00	20.00	28.00
	30	11.00	13.00	16.00	20.00	28.00
	35	11.00	13.00	16.00	20.00	28.00
	40	11.00	13.00	16.00	20.00	28.00
	45	11.00	13.00	16.00	20.00	28.00
	50	11.00	13.00	16.00	20.00	28.00
	55	11.00	13.00	16.00	20.00	28.00
	60	11.00	13.00	16.00	20.00	28.00
	65	11.00	13.00	16.00	20.00	28.00
	70	11.00	13.00	16.00	20.00	28.00
	75	11.00	13.00	16.00	20.00	28.00
	Missing	11.00	13.00	16.00	20.00	28.00
(10) Future Use	–	–	–	–	–	–

Source: Cambridge Systematics

Table A.3 Default Off-Peak Period Congested Speeds for Highway Path-Building

Facility Type	Posted Speed Limit (MPH)	Area Type				
		(1) CBD	(2) Fringe	(3) Urban	(4) Suburban	(5) Rural
(1) Freeway	25	47.50	52.25	52.25	52.25	54.15
	30	47.50	52.25	52.25	52.25	54.15
	35	47.50	52.25	52.25	52.25	54.15
	40	47.50	52.25	52.25	52.25	54.15
	45	47.50	52.25	52.25	52.25	54.15
	50	47.50	52.25	52.25	52.25	54.15
	55	47.50	52.25	52.25	52.25	54.15
	60	51.30	56.05	56.05	57.00	57.00
	65	52.25	56.36	58.90	59.85	61.75
	70	56.05	56.36	61.75	64.60	66.50
	75	57.00	56.36	62.58	71.25	71.25
	Missing	57.91	56.36	60.80	62.70	71.25
(2) Major Regional Arterial	25	32.30	35.15	38.95	38.95	42.75
	30	32.30	35.15	38.95	38.95	42.75
	35	32.30	35.15	38.95	38.95	42.75
	40	34.20	36.82	40.85	40.85	44.65
	45	35.15	36.82	41.80	41.80	45.60
	50	35.15	36.82	41.80	44.65	48.45
	55	35.15	36.82	41.80	46.55	50.35
	60	38.00	36.82	45.60	46.55	50.35
	65	40.85	36.82	48.37	48.84	55.10
	70	40.85	36.82	48.37	48.84	55.10
	75	40.85	36.82	48.37	48.84	55.10
	Missing	42.75	36.82	48.37	48.45	56.50
(3) Principal Arterial	25	19.58	26.64	30.40	33.25	33.25
	30	19.58	26.64	30.40	33.25	33.25
	35	19.58	26.64	31.20	35.15	35.15
	40	19.58	26.64	31.20	35.15	38.95
	45	19.58	26.64	31.20	35.15	39.90
	50	19.58	26.64	31.20	36.34	42.75

Facility Type	Posted Speed Limit (MPH)	Area Type				
		(1) CBD	(2) Fringe	(3) Urban	(4) Suburban	(5) Rural
(3) Principal Arterial	55	19.58	26.64	31.20	36.34	49.40
	60	19.58	26.64	31.20	36.34	49.40
	65	19.58	26.64	31.20	36.34	49.40
	70	19.58	26.64	31.20	36.34	49.40
	75	19.58	26.64	31.20	36.34	49.40
	Missing	19.58	24.70	31.20	36.34	56.64
Minor Arterial	25	18.54	22.79	26.60	28.50	31.35
	30	18.54	22.79	26.60	28.50	31.35
	35	18.54	22.79	27.90	30.40	33.25
	40	18.54	22.79	27.90	32.30	38.00
	45	18.54	22.79	27.90	33.25	38.00
	50	18.54	22.79	27.90	33.69	40.85
	55	18.54	22.79	27.90	33.69	42.45
	60	18.54	22.79	27.90	33.69	42.45
	65	18.54	22.79	27.90	33.69	42.45
	70	18.54	22.79	27.90	33.69	42.45
	75	18.54	22.79	27.90	33.69	42.45
	Missing	18.54	22.79	27.90	33.25	42.45
(5) Collector	25	15.36	19.95	19.00	23.75	23.75
	30	15.36	19.95	19.80	23.75	28.50
	35	15.36	20.26	19.80	25.49	31.35
	40	15.36	20.26	19.80	25.49	31.35
	45	15.36	20.26	19.80	25.49	31.35
	50	15.36	20.26	19.80	25.49	31.35
	55	15.36	20.26	19.80	25.49	31.35
	60	15.36	20.26	19.80	25.49	31.35
	65	15.36	20.26	19.80	25.49	31.35
	70	15.36	20.26	19.80	25.49	31.35
	75	15.36	20.26	19.80	25.49	31.35
	Missing	15.36	19.00	19.80	23.75	33.83
(6) Ramp	25	37.05	32.21	33.78	36.16	37.05
	30	37.05	32.21	33.78	36.16	37.05
	35	37.05	32.21	33.78	36.16	37.05
	40	37.05	32.21	33.78	36.16	37.05
	45	37.05	32.21	33.78	36.16	37.05

Facility Type	Posted Speed Limit (MPH)	Area Type				
		(1) CBD	(2) Fringe	(3) Urban	(4) Suburban	(5) Rural
(6) Ramp	50	37.05	32.21	33.78	36.16	37.05
	55	37.05	32.21	33.78	36.16	37.05
	60	37.05	32.21	33.78	36.16	37.05
	65	37.05	32.21	33.78	36.16	37.05
	70	37.05	32.21	33.78	36.16	37.05
	75	37.05	32.21	33.78	36.16	37.05
	Missing	37.05	32.21	33.78	36.16	37.05
(7) Future Use	25	42.75	36.82	48.37	48.45	56.50
	30	42.75	36.82	48.37	48.45	56.50
	35	42.75	36.82	48.37	48.45	56.50
	40	42.75	36.82	48.37	48.45	56.50
	45	42.75	36.82	48.37	48.45	56.50
	50	42.75	36.82	48.37	48.45	56.50
	55	42.75	36.82	48.37	48.45	56.50
	60	42.75	36.82	48.37	48.45	56.50
	65	42.75	36.82	48.37	48.45	56.50
	70	42.75	36.82	48.37	48.45	56.50
	75	42.75	36.82	48.37	48.45	56.50
	Missing	42.75	36.82	48.37	48.45	56.50
(8) Centroid Connector	25	11.00	13.00	16.00	20.00	28.00
	30	11.00	13.00	16.00	20.00	28.00
	35	11.00	13.00	16.00	20.00	28.00
	40	11.00	13.00	16.00	20.00	28.00
	45	11.00	13.00	16.00	20.00	28.00
	50	11.00	13.00	16.00	20.00	28.00
	55	11.00	13.00	16.00	20.00	28.00
	60	11.00	13.00	16.00	20.00	28.00
	65	11.00	13.00	16.00	20.00	28.00
	70	11.00	13.00	16.00	20.00	28.00
	75	11.00	13.00	16.00	20.00	28.00
	Missing	11.00	13.00	16.00	20.00	28.00
(10) Future Use	–	–	–	–	–	–

Source: Cambridge Systematics

Table A.4 Link Capacities in Vehicles per Lane per Hour

Facility Type	(1) CBD		(2) Fringe		(3) Urban		(4) Suburban		(5) Rural	
	1 Lane	2+ Lanes	1 Lane	2+ Lanes	1 Lane	2+ Lanes	1 Lane	2+ Lanes	1 Lane	2+ Lanes
(1) Freeway	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
(2) Major Regional Arterial	800	800	1000	1000	1250	1250	1250	1350	1250	1400
(3) Principal Arterial	550	600	800	850	900	950	900	950	1000	1100
(4) Minor Arterial	400	450	500	550	550	600	700	750	750	800
(5) Collector	350	400	400	450	450	500	500	550	550	600
(6) Ramp	700	700	900	900	1100	1100	1100	1100	1100	1100
(7) Not used in StateFocus	*800*	*800*	*1000*	*1000*	*1250*	*1250*	*1250*	*1350*	*1250*	*1400*
(8) Centroid Connector	99999	99999	99999	99999	99999	99999	99999	99999	99999	99999
(10) Not used in StateFocus	*2000*	*2000*	*2000*	*2000*	*2000*	*2000*	*2000*	*2000*	*2000*	*2000*

Source: DRCOG, *Integrated Regional Model – Model Refresh Project, Chapter 8: Highway Skimming and Assignment Documentation*, December 2004 with updates for StateFocus for Facility Types 7 and 10.

Table A.5 BPR Parameters

Facility Type	(1) CBD		(2) Fringe		(3) Urban		(4) Suburban		(5) Rural	
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
(1) Freeway	0.70	5.5	0.70	5.5	0.40	7.5	0.40	7.5	0.40	5.0
(2) Major Regional Arterial	0.10	7.5	0.10	7.5	0.25	7.5	0.25	7.5	0.40	5.0
(3) Principal Arterial	0.20	5.0	0.30	5.0	0.40	5.5	0.40	5.5	0.40	5.0
(4) Minor Arterial	0.20	5.0	0.30	5.0	0.40	5.5	0.40	5.5	0.40	5.0
(5) Collector	0.20	5.0	0.30	5.0	0.40	5.5	0.40	5.5	0.40	5.0
(6) Ramp	0.15	4.0	0.15	4.0	0.15	4.0	0.15	4.0	0.15	4.0
(7) Not used in StateFocus	*0.10*	*7.5*	*0.10*	*7.5*	*0.25*	*7.5*	*0.25*	*7.5*	*0.40*	*5.0*
(8) Centroid Connector	0.00	1.001	0.00	1.001	0.00	1.001	0.00	1.001	0.00	1.001
(10) Not used in StateFocus	*0.70*	*5.5*	*0.70*	*5.5*	*0.40*	*7.5*	*0.40*	*7.5*	*0.40*	*5.0*

Source: DRCOG, *Integrated Regional Model – Model Refresh Project, Chapter 8: Highway Skimming and Assignment Documentation*, December 2004 with updates for StateFocus for Facility Types 7 and 10.

Table A.6 Free-Flow Speeds for Traffic Assignments

Facility Type	Posted Speed Limit (MPH)	Area Type				
		(1) CBD	(2) Fringe	(3) Urban	(4) Suburban	(5) Rural
(1) Freeway	25	50	55	55	55	57
	30	50	55	55	55	57
	35	50	55	55	55	57
	40	50	55	55	55	57
	45	50	55	55	55	57
	50	50	55	55	55	57
	55	50	55	55	55	57
	60	54	59	59	60	60
	65	55	61	62	63	65
	70	59	65	65	68	70
	75	60	66	66	75	75
	Missing	62	62	64	66	75
(2) Major Regional Arterial	25	34	37	41	41	45
	30	34	37	41	41	45
	35	34	37	41	41	45
	40	36	39	43	43	47
	45	37	40	44	44	48
	50	37	40	44	47	51
	55	37	40	44	49	53
	60	40	44	48	49	53
	65	43	47	51	58	58
	70	43	47	51	58	58
	75	43	47	51	58	58
	Missing	45	45	51	51	61
(3) Principal Arterial	25	28	31	32	35	35
	30	28	31	32	35	35
	35	30	33	34	37	37
	40	32	35	36	37	41
	45	34	37	37	37	42
	50	36	39	42	42	45

Facility Type	Posted Speed Limit (MPH)	Area Type				
		(1) CBD	(2) Fringe	(3) Urban	(4) Suburban	(5) Rural
(3) Principal Arterial	55	38	41	42	47	52
	60	38	42	42	47	52
	65	38	42	42	47	52
	70	38	42	42	47	52
	75	38	42	42	47	52
	Missing	26	26	36	42	61
Minor Arterial	25	23	25	28	30	33
	30	23	25	28	30	33
	35	25	27	30	32	35
	40	27	30	33	34	40
	45	29	32	35	35	40
	50	32	35	38	39	43
	55	33	36	40	45	48
	60	33	36	40	45	48
	65	33	36	40	45	48
	70	33	36	40	45	48
	75	33	36	40	45	48
	Missing	26	26	31	35	47
(5) Collector	25	18	21	20	25	25
	30	18	21	25	25	30
	35	20	25	30	30	33
	40	20	25	30	30	33
	45	20	25	30	30	33
	50	20	25	30	30	33
	55	20	25	30	30	33
	60	20	25	30	30	33
	65	20	25	30	30	33
	70	20	25	30	30	33
	75	20	25	30	30	33
	Missing	20	20	22	25	36
(6) Ramp	25	39	39	39	39	39
	30	39	39	39	39	39
	35	39	39	39	39	39
	40	39	39	39	39	39
	45	39	39	39	39	39

Facility Type	Posted Speed Limit (MPH)	Area Type				
		(1) CBD	(2) Fringe	(3) Urban	(4) Suburban	(5) Rural
(6) Ramp	50	39	39	39	39	39
	55	39	39	39	39	39
	60	39	39	39	39	39
	65	39	39	39	39	39
	70	39	39	39	39	39
	75	39	39	39	39	39
	Missing	39	39	39	39	39
(7) Future Use	25	45	45	51	51	61
	30	45	45	51	51	61
	35	45	45	51	51	61
	40	45	45	51	51	61
	45	45	45	51	51	61
	50	45	45	51	51	61
	55	45	45	51	51	61
	60	45	45	51	51	61
	65	45	45	51	51	61
	70	45	45	51	51	61
	75	45	45	51	51	61
	Missing	45	45	51	51	61
(8) Centroid Connector	25	11	13	16	20	28
	30	11	13	16	20	28
	35	11	13	16	20	28
	40	11	13	16	20	28
	45	11	13	16	20	28
	50	11	13	16	20	28
	55	11	13	16	20	28
	60	11	13	16	20	28
	65	11	13	16	20	28
	70	11	13	16	20	28
	75	11	13	16	20	28
	Missing	11	13	16	20	28
(10) Future Use	–	–	–	–	–	–

Source: Cambridge Systematics

Appendix B. Transit Network Data Dictionary

Table B.1 Transit Route System Metadata

Highway Link Field_Name	Internal Data Storage Type	Input Field Width	Input Number of Decimal Places	Description
Route_ID	Integer	4	0	Route ID (routes indexed on this variable)
Route_Name	Character	32	0	Route name (routes indexed on this variable)
Route	Character	16	0	Route name without pattern or direction qualifiers, for reporting statistics for a "family" of routes
SYSTEM	Character	25	0	Transit System name
Direction	Character	16	0	Code for the direction a route travels, such as EB or NB. Loop routes may be indicated by CW for clockwise or CC for counter-clockwise
MODE	Integer	4	0	Mode ID code corresponding to the entry in the Modes.bin table
Service_Type	Character	32	0	Optional text description of the service type
Equipment_Type	Character	32	0	Optional text description of the vehicles typically assigned to this route, such as 40-foot transit bus or light rail vehicle
AM_Peak_Hdwy	Real Number	8	2	AM peak period headway in minutes
Off_Peak_Hdwy	Real Number	8	2	Off-peak period headway in minutes
PM_Peak_Hdwy	Real Number	8	2	PM peak period headway in minutes
Early_Late_Hdwy	Real Number	8	2	Early/late period headway in minutes
MPO	Character	16	0	MPO name where route operates

Source: Colorado Department of Transportation.

Appendix C. Zonal Data Dictionary

Data Item	Input or Derived	Definition
ZONE ID		Unique identifier for the zone (6440 Zones State TAZ System)
Area		Zonal area (units of square miles)
ACREAGE		Zonal acreage (units of acres)
County_ID		State County ID (Co FIPS)
County		County Name
MPO		MPO name
MPOZone_ID		MPO zone ID (from MPOs Model TAZ system)
Area Type		values 1 to 5
HH Pop_		Total household population, not including population in group quarters
Low Inc_ HH		Number of households low-income
Med_ Inc_ HH		Number of households medium-income
High Inc_ HH		Number of households high-income
TOT HH		Total households
GQ_POP		Total population in group quarters
Avg HH Size		Average household size(HH Pop/TOT HH)
TotalEmp_QCEW_3		Total Number of Employees in the Zone (3 categories)
Retail_QCEW_3		Number of Production and Retail Employees in the Zone (3 categories)
Service_QCEW_3		Number of Service Employees in the Zone (3 categories)
Production_QCEW_3		Number of Production and Distribution Employees in the Zone (3 categories)
SquareHalfSideLength		Square root of the area of the zone divided by two; This never changes unless your zone system changes. If it does re-calculate it as SQRT(AREA)/2
ZoneCentroid_Long		Zone centroid longitude
ZoneCentroid_Lat		Zone centroid latitude
Education_QCEW_6		Number of Education Employees in the Zone (6 categories)
Entertainment_QCEW_6		Number of Entertainment Employees in the Zone (6 categories)
Production_QCEW_6		Number of Production Employees in the Zone (6 categories)
Restaurant_QCEW_6		Number of Restaurant Employees in the Zone (6 categories)
Retail_QCEW_6		Number of Retail Employees in the Zone (6 categories)
Service_QCEW_6		Number of Service Employees in the Zone (6 categories)
TotalEmp_QCEW_6		Total Number of Employees in the Zone (6 categories)
District		DRCOG Districts
DIAtime		Pseudo travel time used for distribution trips to DIA(DRCOG area)
PkgCost_LI		Daily Parking Cost for Lower Income (1996 $)

PkgCost_MI		Daily Parking cost for med income (1996 $)
PkgCost_HI		Daily parking cost for high income (1996 $)
PkgCost_Short		Short Term Parking Cost (2 hours)
1-Way_ZoneTot		Number of 1-Way intersections in the Zone
3-Way_ ZoneTot		Number of 3-Way intersections in the Zone
4-Way_ZoneTot		Number of 4-Way intersections in the Zone
TotalIntersections_ZoneTot		Total number of intersections in the Zone
NumTransitStops		Total number of Transit Stops in the Zone
TransitStops_Regular		Number of Regular Stops in the Zone
TransitStops_Premier		Number of Premier Stops in the Zone
TransitStops_Rail		Number of Rail Stops in the Zone
Schools_Pre-K		Number of students enrolled in Pre-schools and kindergartens in the zone
Schools_K-8		Number of students enrolled in Kindergarten to 8th grade schools in the zone
Schools_9-12		Number of students enrolled in 9th to 12th grade schools in the zone
Schools_CollegeUniv		Number of students enrolled in universities and colleges in the zone
Schools_Total		Total Number of students in the zone
HousingVirCent_Longitude		Housing Virtual Centroid Longitude
HousingVirCent_Latitude		Housing Virtual Centroid Latitude
HHVirtHHBuffer		Number of Households located within 0.5 mi household virtual centroid buffer
HHCentroid1wayIntr		Number of 1-Way intersections located within 0.5 mi household virtual centroid buffer
HHCentroid3wayIntr		Number of 3-Way intersections located within 0.5 mi household virtual centroid buffer
HHCentroid4wayIntr		Number of 4-Way intersections located within 0.5 mi household virtual centroid buffer
IntrDensHHBuffer(4-way intersections + 0.5* 3-way intersections – 1-way intersections)		
RetailDensHHCentroid		Number of Retail Employees in 0.5 mile buffer around the zone household centroid
RestaurantDensHHCentroid		Number of Restaurant Employees in 0.5 mile buffer around the zone household centroid
ServDensHHCentroid		Number of Service Employees in 0.5 mile buffer around the zone household centroid
EmpVirCent_Longitude		Employment Virtual Centroid Longitude
EmpVirCent_Latitude		Employment Virtual Centroid Latitude
EmpDensEmpCentroid		Number of Employees in 0.5 mile buffer around zone employment centroid
EdDensEmpCentroid		Number of Education Employees in 0.5 mile buffer around zone employment centroid

EntDensEmpCentroid		Number of Entertainment Employees in 0.5 mile buffer around zone employment centroid
ProdDensEmpCentroid		Number of Production Employees in 0.5 mile buffer around zone employment centroid
ServDensEmpCentroid		Number of Service Employees in 0.5 mile buffer around zone employee centroid
RetailDensEmpCentroid		Number of Retail Employees in 0.5 mile buffer around zone employment centroid
RestaurantDensEmpCentroid		Number of Restaurant Employees in 0.5 mile buffer around zone employment centroid
EmpCentroid1wayIntr		Number of 1-Way intersections located within 0.5 mi employment virtual centroid buffer
EmpCentroid3wayIntr		Number of 3-Way intersections located within 0.5 mi employment virtual centroid buffer
EmpCentroid4wayIntr		Number of 4-Way intersections located within 0.5 mi employment virtual centroid buffer
IntrDensEmpBuffer(4-way intersections + 0.5* 3-way intersections – 1-way intersections)		
HHVirEmpBuffer		Number of Households located within the 0.5 mi employment virtual centroid buffer

Appendix D. Population Synthesis and Establishment Data

D.1 Household Data

Table D.1 Population Synthesis Household Data[1]

Variable Name	Description	Continuous or Categorical	Definition
Synthetic Household Identification and Geographic Location Data[2]			
houseid	Unique household ID	Continuous	This variable is a combination of "geo" and "unique_id_in_geo". For example, If "geo" is 1 and "unique_id_in_geo" is 1, houseid is "00010001"
countyid	County code	Continuous	Same as "COUNTY_ID" in "DTD_taz6400.shp"
tract[3]	Census Tract code	Continuous	Geographic area codes from US Census
block[3]	Census Block Group code	Continuous	Geographic area codes from US Census
tract_block[3]	Combination of Census Tract + Block group codes	Continuous	
geo	Traffic Analysis Zone	Continuous	Same as "ZONE_ID" in "DTD_taz6400.shp"
unique_id_in_geo	Unique household ID assigned by PopGen2	Continuous	Starts at 1 and increases sequentially to h, where h is the total number of synthetic households generated within the TAZ
Entity	"household" or "groupquarter"	Categorical	household groupquarter
PUMA00	PUMA00 area code	Continuous	Public use microdata area code based on Census 2000 definition
County and TAZ Level Control Marginals[4]			
hhldrage[5]	Householder age (County marginal)	Categorical	1 = 18-24 2 = 25-44 3 = 45-64 4 = 65 & Over
hhldrtype[5]	Householder type (County marginal)	Categorical	1 = One adult with no children 2 = One adult with children 3 = More than one adult with no children 4 = More than one adult with children

Variable Name	Description	Continuous or Categorical	Definition
hhldsize[5]	Household size (County marginal)	Categorical	1 = 1 Person 2 = 2 Persons 3 = 3 Persons 4 = 4 Persons 5 = 5 Persons 6 = 6 Persons 7 = 7 or More Persons
groupquarter	Group quarter (TAZ marginal)	Categorical	0 = No 1 = Yes
tazinc[5]	Household income in three categories (TAZ marginal)[6]	Categorical	1 = Low 2 = Medium 3 = High
Output Generated or Appended from PUMS Data or by PopGen2[7]			
SERIALNO[8]	Housing unit/GQ person serial number from PUMS data	Continuous	13-digit identifier
NP	Number of persons in housing unit	Continuous	Ranges from 1 to 20
TEN[5]	Tenure	Categorical	0 = N/A (GQ or vacant) 1 = Owned with mortgage or loan (include home equity loans) 2 = Owned free and clear 3 = Rented 4 = Occupied without payment of rent
VEH[5,9]	Household vehicle ownership	Categorical	0 = 0 or GQ 1 = 1 vehicle 2 = 2 vehicles 3 = 3 vehicles 4 = 4 vehicles 5 = 5 vehicles 6 = 6 or more vehicles
HINCP[5,10]	Household income (2010 $)	Continuous	Ranges from -$59,999 to $99,999,999; PUMS reports HINCP in 2012 dollars – PopGen2 converts to 2010
NOC[5]	Number of own children in the household	Continuous	Ranges from 0 to 19
Nwrkr[5]	Number of workers in the household	Continuous	
Num_Children_0_to_4[5]	Number of children aged 0-4	Continuous	
Num_Children_5_to_15[5]	Number of children aged 5-15	Continuous	
Num_Members_18_plus[5]	Number of household members aged 18+	Continuous	
No_Emp[5]	Number of non-working adults (18+) in household	Continuous	
Num_Persons_16_ plus[5]	Number of drivers in household (or, number aged 16+)	Continuous	

Variable Name	Description	Continuous or Categorical	Definition
Num_PartTimeWorker[5]	Number of part-time workers in household	Continuous	
Num_Children_16Plus[5]	Number of age 16+ children in household	Continuous	
Num_People_75Plus[5]	Number of age 75+ persons in household	Continuous	
Num_Univ_Students[5]	Number of university students in household	Continuous	
Childpresence[11]	Presence of own children	Categorical	1 = Yes 2 = No
hhisp	Hispanic origin of householder	Categorical	1 = Yes 2 = No
hhldinc[12]	Household income (2010 $)	Categorical	1 = $0 - $14,999 2 = $15,000 - $24,999 3 = $25,000 - $34,999 4 = $35,000 - $44,999 5 = $45,000 - $59,999 6 = $60,000 - $99,999 7 = $100,000 - $149,999 8 = $150,000 or more
hhown[13]	Home ownership status	Categorical	1 = Own 2 = Rent
hhrace	Householder race	Categorical	1 = White 2 = Black or African American 3 = American Indian and Alaska Native 4 = Asian 5 = Native Hawaiian and Other Pacific Islander 6 = Some Other Race 7 = Two or More Races
Hhveh[9,14]	Household vehicle ownership	Categorical	0 = 0 Vehicles 1 = 1 Vehicle 2 = 2 Vehicles 3 = 3 Vehicles 4 = 4 or More Vehicles
workers[15]	Number of workers in the household	Categorical	1 = No Workers 2 = 1 Worker 3 = 2 Workers 4 = 3 or More Workers

Source: Arizona State University

Notes: [1] The household file is output as a comma separated variable (CSV) file with the variable names listed in order on the first record of the file. The order of the variables shown in the table has been changed to place the variables into logical groupings.

[2] ***Synthetic Household Identification and Geographic Location Data*** variables are used as inputs (e.g. geographic information) or generated by PopGen2 to identify the synthesized household.

[3] As CDOT's TAZ boundaries do not perfectly align with those of Census Tract and Block Group, the following approach was developed to append Census Tract and Block Group codes to the synthetic population data:

1. In ArcGIS, the "DTD_taz6400.shp"polygon shape file was converted to a (centroid) point shape file,
2. The centroid point features were overlaid on Block Group polygon features (the Block Group shape file includes both Census Tract and Block Group in the attribute table),
3. All TAZs that fall in each Block Group were identified and a geographical correspondence table was generated,
4. Census Tract and Block Group codes were added to the synthetic population data using TAZ ("ZONE_ID") as the key.

As the TAZ boundaries do not align perfectly with the Census Tract or Block Group boundaries, users must be cautious when conducting comparative analysis of synthetic population at the level of Census Tract or Block Group.

[4] ***County and TAZ Level Control Marginals*** are from the PUMS data sample for the synthesized household but are selected in the population synthesis process to match input county and TAZ level marginal distributions.

[5] Zeros are entered for these variables for group quarters “households.”

[6] Income values are categorized differently by MPO. See ***Section 2.2.3***, ***TAZ Level Marginals*** for details and ***Table 2.8*** for income ranges.

[7] ***Output Generated or Appended from PUMS Data or by PopGen2*** variables are either generated during the population synthesis process by or appended after the population synthesis process. Variables listed in capital letters are taken from the 2008-2012 ACS PUMS data for the synthesized household. Variables in upper and lower case letters are generated during the population synthesis process.

[8] SERIALNO is a unique identifier from the PUMS data used to generate the synthesized household. This identifier can be used as the key to add household level variables from 2008-2012 ACS PUMS household data to the synthetic population data.

[9] While household vehicle ownership is posted from the PUMS data, it is not used for StateFocus modeling. Rather, StateFocus includes an Autos Available Choice model component (see ***Section 4.2.5***) that considers a number of socioeconomic and accessibility factors in forecasting the number of autos owned by a household.

[10] HINCP is the household income in 2010 dollars from the PUMS data used to generate the synthesized household. Synthetic households are randomly generated (selected) from the 2008-2012 ACS PUMS data so that the number of households in synthesized population for each TAZ match the input income group marginals for the TAZ (see Tazinc). Since the HINCP variable is continuous, it can used to determine the hhldinc group variable and can be used in the modeling process to define alternative income groupings. Negative incomes (indicating a net loss of income for the household) in the PUMS data are included in the lowest income group.

[11] “2” (presence of own children is no) is entered for this variable for group quarters “households.”

[12] “1” ($0 - $14,999) is entered for this variable for group quarters “households.”

[13] Blanks are entered for this variable for group quarters “households.”

[14] Zeros are entered for this variable for group quarters “households.”

[15] A 1 (no workers) is entered for this variable for group quarters “households.”

D.2 Person Data

Table D.2 Population Synthesis Person Data[1]

Variable Name	Description	Continuous or Categorical	Definition
Synthetic Household and Person Identification and Geographic Location Data[2]			
houseid	Unique household ID	Continuous	This variable is a combination of "geo" and "unique_id_in_geo". For example, If "geo" is 1 and "unique_id_in_geo" is 1, houseid is "00010001"
countyid	County code	Continuous	Same as "COUNTY_ID" in "DTD_taz6400.shp"
tract[3]	Census Tract code	Continuous	Geographic area codes from US Census
block[3]	Census Block Group code	Continuous	Geographic area codes from US Census
tract_block[3]	Combination of Census Tract + Block group codes	Continuous	
geo	Traffic Analysis Zone	Continuous	Same as "ZONE_ID" in "DTD_taz6400.shp"
unique_id_in_geo	Unique household ID assigned by PopGen2	Continuous	Starts at 1 and increases sequentially to h, where h is the total number of synthetic households generated within the TAZ. This identifies the household of which the person is a member.
pid	Person ID in the household.	Continuous	Person id in the household. Note that a unique person identifier in the population synthesis data is a combination of "houseid" & "pid."
PUMA00	PUMA00 area code - Public use microdata area code based on Census 2000 definition	Continuous	Public use microdata area code based on Census 2000 definition
County and TAZ Level Control Marginals[4]			
age	Person age (County marginal)	Categorical	*1 = Less than 5 years* *2 = 5 - 14 years* *3 = 15 - 24 years* *4 = 25 - 34 years* *5 = 35 - 44 years* *6 = 45 - 54 years* *7 = 55 - 64 years* *8 = 65 - 74 years* *9 = 75 - 84 years* *10 = 85 years or older*
gender	Person gender (County marginal)	Categorical	1 = Male 2 = Female
employment[5]	Employment status (County marginal)	Categorical	1 = Employed 2 = Unemployed 3 = Not in Labor Force (age 15 or more) 4 = Child (under age 15)

Variable Name	Description	Continuous or Categorical	Definition
entity	Indicates whether the person belongs to a household or a groupquarter (TAZ marginals)	Categorical	household groupquarter
Output Generated or Appended from PUMS Data or by PopGen2[6]			
RACE	Person race	Categorical	1 = White 2 = Black or African American 3 = American Indian and Alaska Native 4 = Asian 5 = Native Hawaiian and Other Pacific Islander 6 = Some Other Race 7 = Two or More Races
occp	Occupation	Categorical	1 = Unemployed or Not Applicable 2 = Management, Business, Science, and Arts 3 = Service 4 = Sales and Office 5 = Natural Resources, Construction, and Maintenance 6 = Production, Transportation, and Material Moving 7 = Active Military Personnel
educ	Educational attainment	Categorical	1 = Not (Not Yet) a High School Graduate 2 = High School Graduate 3 = Some College, No Degree 4 = Associate's Degree 5 = Bachelor's Degree 6 = Graduate or Professional Degree
hisp	Hispanic origin	Categorical	1 = Yes 2 = No
SERIALNO[7]	Housing unit/GQ person serial number (This can be used as the 'key' variable to add household level variables from 2008-2012 ACS PUMS data to the synthetic population data)	Continuous	13-digit number
AGEP	Person age	Continuous	0 (under 1 year) to 99
SCH	School enrollment	Categorical	0 = N/A (Less than 3 years old) 1 = No, has not attended in the last 3 months 2 = Yes, public school or public college 3 = Yes, private school, private college, or home school
SCHG	Grade level attending	Categorical	0 = N/A (not attending school) 1 = Nursery school/preschool 2 = Kindergarten

Variable Name	Description	Continuous or Categorical	Definition
			3 = Grade 1 4 = Grade 2 5 = Grade 3 6 = Grade 4 7 = Grade 5 8 = Grade 6 9 = Grade 7 10 = Grade 8 11 = Grade 9 12 = Grade 10 13 = Grade 11 14 = Grade 12 15 = College undergraduate years (freshman to senior) 16 = Post-bachelor's degree graduate or professional school
SCHL	Educational attainment	Categorical	0 = N/A (less than 3 years old) 1 = No schooling completed 2 = Nursery school, preschool 3 = Kindergarten 4 = Grade 1 5 = Grade 2 6 = Grade 3 7 = Grade 4 8 = Grade 5 9 = Grade 6 10 = Grade 7 11 = Grade 8 12 = Grade 9 13 = Grade 10 14 = Grade 11 15 = 12th grade - no diploma 16 = Regular high school diploma 17 = GED or alternative credential 18 = Some college, but less than 1 year 19 = 1 or more years of college credit, no degree 20 = Associate's degree 12 = Bachelor's degree 22 = Master's degree 23 = Professional degree beyond a bachelor's degree 24 = Doctorate degree
WKHP	Usual hours worked per week past 12 months	Continuous	Range of 00 (did not work) to 98; 99 is 99 or more usual hours
NAICSP	Industry code based on 2007 NAICS codes	Categorical	Same as INDP in PUMS ACS data, -99 if NA.

Variable Name	Description	Continuous or Categorical	Definition
OCCP10	Occupation recode for data years 2010 and 2011 based on 2010 OCC codes	Categorical	Same as PUMS ACS data.
RAC1P	Recoded detailed race code	Categorical	1 = White alone 2 = Black or African American alone 3 = American Indian alone 4 = Alaska Native alone 5 = American Indian and Alaska Native tribes specified; or American .Indian or Alaska Native, not specified and no other races 6 = Asian alone 7 = Native Hawaiian and Other Pacific Islander alone 8 = Some Other Race alone 9 = Two or More Races alone
FHISP	Detailed Hispanic origin allocation flag	Categorical	0 = No 1 = Yes
Emp_Category	Employment Category	Categorical	-99 = NA 0 = Service 1 = Education 2 = Retail 3 = Restaurant 4 = Production 5 = Entertainment

Source: Arizona State University

Notes: [1] The person file is output as a comma separated variable (CSV) file with the variable names listed in order on the first record of the file. The order of the variables shown in the table has been changed to place the variables into logical groupings.

[2] ***Synthetic Household and Person Identification and Geographic Location Data*** variables are used as inputs (e.g. geographic information) or generated by PopGen2 to identify the synthesized household and person within the household.

[3] As CDOT's TAZ boundaries do not perfectly align with those of Census Tract and Block Group, the following approach was developed to append Census Tract and Block Group codes to the synthetic population data:

1. In ArcGIS, the "DTD_taz6400.shp"polygon shape file was converted to a (centroid) point shape file,
2. The centroid point features were overlaid on Block Group polygon features (the Block Group shape file includes both Census Tract and Block Group in the attribute table),
3. All TAZs that fall in each Block Group were identified and a geographical correspondence table was generated,
4. Census Tract and Block Group codes were added to the synthetic population data using TAZ ("ZONE_ID") as the key.

As the TAZ boundaries do not align perfectly with the Census Tract or Block Group boundaries, users must be cautious when conducting comparative analysis of synthetic population at the level of Census Tract or Block Group.

4 ***County and TAZ Level Control Marginals*** are from the PUMS data sample for the synthesized household but are selected in the population synthesis process to match input county and TAZ level marginal distributions.

5 The input marginal distributions for employment.that are matched by PopGen2 are only for population in the workforce (values 1, 2, or 3).

6 ***Output Generated or Appended from PUMS Data or by PopGen2*** variables are either generated during the population synthesis process by or appended after the population synthesis process. Variables listed in capital letters are taken from the 2008-2012 ACS PUMS data for the synthesized household. Variables in upper and lower case letters are generated during the population synthesis process.

7 SERIALNO is a unique identifier from the PUMS data used to generate the synthesized household. The combination of "SERIALNO" & "pid" can be used as the 'key' variable to add person level variables from 2008-2012 ACS PUMS person data to the synthetic population data when “pid” is matched to “SPORDER” in the PUMS data.

D.3 Establishment Data

[To be developed.]

Appendix E. Logsum Coefficients and Variables

E.1 Disaggregate Tour Main Mode Choice Logsums

Disaggregate tour main mode choice logsums are used in several model components applied prior to tour main mode choice. In order to efficiently apply the StateFocus activity-based models, simplifications such as the estimation of the logsums for only one or two time periods or the use of sample average data from the FRTC are used. The disaggregate logsums used prior to tour main mode choice are listed below along with the simplifications used as input.

Note that all model coefficients are the same as estimated and documented for the tour main mode choice models in ***Appendix F***. Only those variables that are based on a choice made as part of the activity-based model application are shown in the following sections; constants and variables used for logsums that are based on input zonal data or PopGen2 data are not shown.

E.1.1 Home-Based Work – Disaggregate Logsum Simplifications

Table E.1 shows the home-based work main mode choice model coefficients along with sample average values and skims used for model components that occur prior to an actual choice for the variable value or skim having been made. For example, home-based work purpose fully disaggregate main mode choice logsums are used for the following model components:

- regular / no regular workplace
- workplace location
- autos available
- daily activity pattern
- exact number of tours
- work tour destination type choice
- tour primary destination choice (for home-based work tours made to non-regular work locations)

The time of day of travel is not simulated until the step preceding tour primary destination choice. Thus, the actual simulated time of day skim data will be used only for the tour primary destination choice for home-based work tours made to non-regular work locations; time of day skim data from selected example time periods will be used for the other model components requiring fully disaggregate main mode choice logsums. However, after the autos available choice model is run, all variables related to the numbers of autos available to a household can be defined for each person and used in their logsums.

In ***Table E.1***, the sample average values or skims used for model components up to the model component where actual choices are made or simulated are shown. After the model component where the choice for a person is made, the actual choice information for person will be used.

Table E.1 Home-Based Work – Coefficients and Variable Values Used in Disaggregate Logsums[1]

Variable	Coefficient	Sample Average Value to Use OR Skim Time Period to Use Until Choice Information Available	Model Component Where Choice is Made or Assigned (Subsequent Components Can Use Actual Choice Information)
Cost (2010$), Lower Income	-0.03114	AM2 Highway / AM Transit	Simulated Time Period
Cost (2010$), Modest Income	-0.03114	AM2 Highway / AM Transit	Simulated Time Period
Cost (2010$), Middle Income	-0.02145	AM2 Highway / AM Transit	Simulated Time Period
Cost (2010$), Upper Income	-0.02145	AM2 Highway / AM Transit	Simulated Time Period
Cost (2010$), Top Income	-0.00715	AM2 Highway / AM Transit	Simulated Time Period
Auto In-Vehicle Time (minutes)	-0.00675	AM2 Highway / AM Transit	Simulated Time Period
Rail In-Vehicle Time (minutes)	-0.00473	AM2 Highway / AM Transit	Simulated Time Period
Transit Non-Rail In-Vehicle Time (minutes)	-0.00675	AM2 Highway / AM Transit	Simulated Time Period
Transit Walk Access/Egress Time (minutes)	-0.02701	AM2 Highway / AM Transit	Simulated Time Period
Transit Drive Access/Egress Time (minutes)	-0.00675	AM2 Highway / AM Transit	Simulated Time Period
Transit Initial Wait Time (minutes)	-0.01218	AM2 Highway / AM Transit	Simulated Time Period
Transit Transfer Wait Time (minutes)	-0.01218	AM2 Highway / AM Transit	Simulated Time Period
Walk Time (minutes)	-0.02701	AM2 Highway / AM Transit	Simulated Time Period
Bike Time (minutes)	-0.02040	AM2 Highway / AM Transit	Simulated Time Period
Auto Terminal Time (minutes)	-0.02701	AM2 Highway / AM Transit	Simulated Time Period
Local Bus IVT / O-D Distance	-0.14584	AM2 Highway / AM Transit	Simulated Time Period
DT_to_DA_Ratio_OverHalf	-2.07577	AM2 Highway / AM Transit	Simulated Time Period
NonClosedTour: SR2	0.06290	= 0; Drops Out of Tour Mode Choice Logsum Calculation Since Closed Tour is Assumed	Daily Activity Pattern
NonClosedTour: SR3+	0.47600		Daily Activity Pattern
NonClosedTour: NonMotor	-0.08620		Daily Activity Pattern
NonClosedTour: WT	-0.44420		Daily Activity Pattern
NonClosedTour: DT	1.06620		Daily Activity Pattern
NoCars: SR2	4.50000	= 0; Drops Out of Logsum Calculation Since At Least One Auto / Driver is Assumed	Autos Available
NoCars: SR3+	5.07580		Autos Available
NoCars: Walk	5.89467		Autos Available
NoCars: Bike	6.01260		Autos Available
NoCars: WT	6.96560		Autos Available
NoCars: DT	2.00000		Autos Available
CarsButLessThanWorkers: SR2	1.63920		Autos Available
CarsButLessThanWorkers: SR3+	1.23950		Autos Available
CarsButLessThanWorkers: NonMotor	3.21530		Autos Available
CarsButLessThanWorkers: WT	2.10561		Autos Available
CarsButLessThanWorkers: DT	0.75533		Autos Available

CarsForWorkersButNotAllDrivers: SR	0.21659		Autos Available
CarsForWorkersButNotAllDrivers: NonMotor	0.64890		Autos Available
CarsForWorkersButNotAllDrivers: WT	1.48541		Autos Available
CarsForWorkersButNotAllDrivers: DT	0.50553		Autos Available
ArriveDestInAMPeak: Auto	-0.21718		Simulated Time Period
DepartDestInPMPeak: Auto	-0.24314		Simulated Time Period
EscortStopFlagByToursRemain: SR	3.50462		Intermediate Stop Generation
OtherStopFlagByToursRemain: DA	0.62337		Intermediate Stop Generation
OtherStopFlagByToursRemain: SR	0.80671		Intermediate Stop Generation
DestRetailDensity: Transit	0.33416	Information is Available for All Destinations for Regular/No Regular Workplace	Regular Workplace Location or Tour Primary Destination for Non-Regular Workplace
O & D Mixed Use Density: Walk	0.26579		
O & D Mixed Use Density: Bike	0.25359		
Dest Intersection Density: Transit	5.29367	Information is Available for All Destinations for Regular/No Regular Workplace	Regular Workplace Location or Tour Primary Destination for Non-Regular Workplace
O & D Intersection Density: Walk	3.92850		
O & D Intersection Density: Bike	1.14981		

Source: Cambridge Systematics

Note: [1] Only those variables that are based on a choice made as part of the activity-based model application are shown in the table; other constants and variables used for logsums that are based on input zonal data or PopGen2 data are shown in ***Appendix F***.

E.1.2 Home-Based School Disaggregate Logsum Simplifications

Table E.2 shows the home-based school main mode choice model coefficients along with sample average values and skims used for model components that occur prior to an actual choice for the variable value or skim have been made. For example, home-based school purpose fully disaggregate main mode choice logsums are used for the following model components:

- regular school location
- daily activity pattern
- exact number of tours

The time of day of travel is not simulated until the step preceding tour primary destination choice. Thus, the actual simulated time of day skim data are not available for any of the above three model components and, as a result, time of day skim data from selected example time periods will be used for those model components. However, after the autos available choice model is run, all variables related to the numbers of autos available to a household can be defined for each person and used in their logsums for daily activity pattern and exact number of tours choice models.

Table E.2 Home-Based School – Coefficients and Variable Values Used in Disaggregate Logsums[1]

Variable	Coefficient	Sample Average Value to Use OR Skim Time Period to Use Until Choice Information Available	Model Component Where Choice is Made or Assigned (Subsequent Components Can Use Actual Choice Information)
Cost (2010$), Lower Income	-0.16758	AM2 Highway / AM Transit	Simulated Time Period
Cost (2010$), Modest Income	-0.12191	AM2 Highway / AM Transit	Simulated Time Period
Cost (2010$), Middle Income	-0.07283	AM2 Highway / AM Transit	Simulated Time Period
Cost (2010$), Upper Income	-0.02573	AM2 Highway / AM Transit	Simulated Time Period
Cost (2010$), Top Income	-0.00934	AM2 Highway / AM Transit	Simulated Time Period
Auto In-Vehicle Time (minutes)	-0.00934	AM2 Highway / AM Transit	Simulated Time Period
Rail In-Vehicle Time (minutes)	-0.00654	AM2 Highway / AM Transit	Simulated Time Period
Transit Non-Rail In-Vehicle Time (minutes)	-0.00934	AM2 Highway / AM Transit	Simulated Time Period
Transit Walk Access/Egress Time (minutes)	-0.03204	AM2 Highway / AM Transit	Simulated Time Period
Transit Drive Access/Egress Time (minutes)	-0.00934	AM2 Highway / AM Transit	Simulated Time Period
Transit Initial Wait Time (minutes)	-0.03735	AM2 Highway / AM Transit	Simulated Time Period
Transit Transfer Wait Time (minutes)	-0.03735	AM2 Highway / AM Transit	Simulated Time Period
Walk Time (minutes)	-0.03204	AM2 Highway / AM Transit	Simulated Time Period
Bike Time (minutes)	-0.03735	AM2 Highway / AM Transit	Simulated Time Period
Auto Terminal Time (minutes)	-0.03204	AM2 Highway / AM Transit	Simulated Time Period
Local Bus IVT / O-D Distance	-0.00307	AM2 Highway / AM Transit	Simulated Time Period
DT_to_DA_Ratio_OverHalf	-1.44099	AM2 Highway / AM Transit	Simulated Time Period
NoCars: Walk	5.67560	= 0; Drops Out of Logsum Calculation Since At Least One Auto / Driver is Assumed	Autos Available
NoCars: Bike	2.81526		Autos Available
NoCars: WT	2.95686		Autos Available
CarsButLessThanWorkers: Walk	1.98020		Autos Available
CarsButLessThanWorkers: Bike	1.98020		Autos Available
CarsButLessThanWorkers: WT	0.95329		Autos Available
CarsForWorkersButNotAllDrivers: Walk	0.38754		Autos Available
CarsForWorkersButNotAllDrivers: Bike	0.38754		Autos Available
CarsForWorkersButNotAllDrivers: WT	0.95329		Autos Available
EscortStopFlagByToursRemain: DA	-1.67716		Intermediate Stop Generation
EscortStopFlagByToursRemain: SR2	1.36429		Intermediate Stop Generation
EscortStopFlagByToursRemain: SR3+	1.36429		Intermediate Stop Generation
OtherStopFlagByToursRemain: SR2	0.56992		Intermediate Stop Generation
OtherStopFlagByToursRemain: SR3+	0.56992		Intermediate Stop Generation
Orig Intersection Density: WT	5.42567		Regular School Location
Dest Intersection Density: WT	5.42567		

Dest Intersection Density: DT	5.42567	Information is Available for All Destinations for Regular School Location Choice	
O & D Intersection Density: SBus	-8.98672		
O & D Intersection Density: SBus	-8.98672		
Distance (exp(-○)): SBus	3.25735	AM2 Highway	Simulated Time Period
Distance (exp(-○/2)): SBus	-9.91386	AM2 Highway	Simulated Time Period
Distance (exp(-○/4)): SBus	6.70396	AM2 Highway	Simulated Time Period

Source: Cambridge Systematics
Note: [1] Only those variables that are based on a choice made as part of the activity-based model application are shown in the table; other constants and variables used for logsums that are based on input zonal data or PopGen2 data are shown in ***Appendix F***.

E.1.3 Home-Based Escort Disaggregate Logsum Simplifications

Table E.3 shows the home-based escort main mode choice model coefficients along with sample average values used for tour primary destination choice model component. Since the disaggregate home-based escort main mode choice logsums are used only for the tour primary destination choice model, time period specific skims will be used based on the time periods assigned in the time of day simulation model component.

Table E.3 Home-Based Escort – Coefficients and Variable Values Used in Disaggregate Logsums[1]

Variable	Coefficient	Sample Average Value to Use OR Skim Time Period to Use Until Choice Information Available	Model Component Where Choice is Made or Assigned (Subsequent Components Can Use Actual Choice Information)
EscortStopFlagByToursRemain: SR2	1.15396		Intermediate Stop Generation
EscortStopFlagByToursRemain: SR3+	1.15396		Intermediate Stop Generation
OtherStopFlagByToursRemain: SR2	1.57977		Intermediate Stop Generation
OtherStopFlagByToursRemain: SR3+	1.57977		Intermediate Stop Generation

Source: Cambridge Systematics
Note: [1] Only those variables that are based on a choice made as part of the activity-based model application are shown in the table; other constants and variables used for logsums that are based on input zonal data or PopGen2 data are shown in ***Appendix F***.

E.1.4 Home-Based Other

Table E.4 shows the home-based other main mode choice model coefficients along with sample average values used for tour primary destination choice model component. Since the disaggregate home-based other main mode choice logsums are used only for the tour primary destination choice model, time period specific skims will be used based on the time periods assigned in the time of day simulation model component.

Table E.4 Home-Based Other – Coefficients and Variable Values Used in Disaggregate Logsums[1]

Variable	Coefficient	Sample Average Value to Use OR Skim Time Period to Use Until Choice Information Available	Model Component Where Choice is Made or Assigned (Subsequent Components Can Use Actual Choice Information)
EscortStopFlagByToursRemain: SR2	0.05728		
EscortStopFlagByToursRemain: SR3+	0.05728		
OtherStopFlagByToursRemain: SR2	0.09140		
OtherStopFlagByToursRemain: SR3+	0.09140		
DestRetailDensity: WT	0.32293	Information is Available for All Destinations	Tour Primary Destination
DestRetailDensity: DT	0.32293		
O & D Mixed Use Density: Walk (Orig)	0.36990		
O & D Mixed Use Density: Walk (Dest)	0.36990		
O & D Mixed Use Density: Bike (Orig)	0.36990		
O & D Mixed Use Density: Bike (Dest)	0.36990		
Dest Intersection Density: WT	12.58830		
Dest Intersection Density: DT	12.58830		
O & D Intersection Density: Walk (Orig)	3.90290		
O & D Intersection Density: Walk (Dest)	3.90290		

Source: Cambridge Systematics

Note: [1] Only those variables that are based on a choice made as part of the activity-based model application are shown in the table; other constants and variables used for logsums that are based on input zonal data or PopGen2 data are shown in ***Appendix F***.

E.1.5 Work-Based Sub-Tour

Table E.5 shows the work-based sub-tour main mode choice model coefficients along with sample average values used for tour primary destination choice model component. Since the disaggregate work-based sub-tour main mode choice logsums are used only for the tour primary destination choice model, time period specific skims will be used based on the time periods assigned in the time of day simulation model component.

Table E.5 Work-Based Sub-Tour – Coefficients and Variable Values Used in Disaggregate Logsums[1]

Variable	Coefficient	Sample Average Value to Use OR Skim Time Period to Use Until Choice Information Available	Model Component Where Choice is Made or Assigned (Subsequent Components Can Use Actual Choice Information)
O & D Intersection Density: Walk (Orig)	5.65680	Information is Available for All Destinations	Tour Primary Destination
O & D Intersection Density: Walk (Dest)	6.78820		
Used_DA_to_work: DA	3.96417		Tour Main Mode
Used_DA_to_work: SR2	2.01981		Tour Main Mode
Used_DA_to_work: SR3+	0.90738		Tour Main Mode
Used_SR_to_work: DA	2.87846		Tour Main Mode
Used_SR_to_work: SR2	2.07000		Tour Main Mode
Used_SR_to_work: SR3+	0.95155		Tour Main Mode
Used_Transit_to_work: WT	0.84951		Tour Main Mode

Source: Cambridge Systematics

Note: [1] Only those variables that are based on a choice made as part of the activity-based model application are shown in the table; other constants and variables used for logsums that are based on input zonal data or PopGen2 data are shown in ***Appendix F***.

E.2 Aggregate Accessibility Logsums

There are two components for aggregate accessibility logsums: mode choice logsums for individual interchanges and destination choice logsums aggregated over all possible destinations. Aggregate accessibility logsums used in the daily activity pattern and exact number of tours model components are applied prior to tour destination choice and tour main mode choice. In order to efficiently apply the StateFocus activity-based models, simplifications such as the estimation of the logsums for only one time period and the use of sample average data from the FRTC are used. The aggregate accessibility logsums are calculated for the following five tour purposes:

- Home-based serve passenger
- Home-based personal business
- Home-based shopping
- Home-based meal
- Home-based social/recreation

The daily activity pattern choice model also uses an aggregate accessibility logsum for the non-closed work tour purpose. This variable is simply the average of the aggregate accessibility logsums for the escort, personal business, shop, meal, and social-recreational tour purposes.

Note that all tour mode choice model coefficients are the same as estimated and documented in ***Appendix F***. Only those variables that are based on a choice made as part of the activity-based model application along with the source of data for the variables or assumed variable values are shown in the following sections; constants and variables used for logsums that are based on input zonal data or PopGen2 data are not shown. Information specific to the home-based escort and home-based other mode choice models are shown.

E.2.1 Home-Based Escort Aggregate Tour Mode Choice Logsum Simplifications

Table E.6 shows the home-based escort main mode choice model coefficients along with sample average values used and skims time periods used for the aggregate logsums used in the daily activity pattern and exact number of tours model components.

Table E.6 Home-Based Escort – Coefficients and Variable Values Used in Aggregate Logsums[1]

Variable	Coefficient	Sample Average Value OR Skim Time Period Used[2]
Cost (2010$), Lower Income	-0.26497	OP3 for highway skims/MD for transit skims
Cost (2010$), Modest Income	-0.22222	OP3 for highway skims/MD for transit skims
Cost (2010$), Middle Income	-0.17746	OP3 for highway skims/MD for transit skims
Cost (2010$), Upper Income	-0.17746	OP3 for highway skims/MD for transit skims
Cost (2010$), Top Income	-0.05915	OP3 for highway skims/MD for transit skims
Auto In-Vehicle Time (minutes)	-0.01049	OP3 for highway skims/MD for transit skims
Walk Time (minutes)	-0.04197	OP3 for highway skims/MD for transit skims
Auto Terminal Time (minutes)	-0.04197	OP3 for highway skims/MD for transit skims
EscortStopFlagByToursRemain: SR	1.15396	
EscortStopFlagByToursRemain: SR	1.15396	
OtherStopFlagByToursRemain: SR	1.57977	
OtherStopFlagByToursRemain: SR	1.57977	

Source: Cambridge Systematics

Note: 1 Only those variables that are based on a choice made as part of the activity-based model application are shown in the table; other constants and variables used for logsums that are based on input zonal data or PopGen2 data are shown in ***Appendix F***.

2 Since the aggregate logsums are used only in the daily activity pattern and exact number of tours model components, information regarding the “Model Component Where Choice is Made or Assigned (Subsequent Components Can Use Actual Choice Information)” is moot.

E.2.2 Home-Based Other Aggregate Tour Mode Choice Logsum Simplifications

Table E.7 shows the home-based other main mode choice model coefficients along with sample average values used and skims time periods used for the aggregate logsums used in the daily activity pattern and exact number of tours model components. The home-based other tour mode choice logsums use common parameters for most variables with constant adjustments based on 0/1 dummy variables for meal, shopping, and social-recreation tour purposes. Thus, four unique aggregate logsums can be estimated since home-based personal business logsums are defined by the base.

The daily activity pattern choice model also uses an aggregate accessibility logsum for the non-closed work tour purpose. That logsum variable is represented by the average of the aggregate accessibility logsums for the escort, personal business, shop, meal, and social-recreational tour purposes.

Table E.7 Home-Based Other – Coefficients and Variable Values Used in Disaggregate Logsums[1]

Variable	Coefficient	Sample Average Value OR Skim Time Period Used[2]
Cost (2010$), Lower Income	-0.05538	OP3 for highway skims/MD for transit skims
Cost (2010$), Modest Income	-0.03911	OP3 for highway skims/MD for transit skims
Cost (2010$), Middle Income	-0.03911	OP3 for highway skims/MD for transit skims
Cost (2010$), Upper Income	-0.03394	OP3 for highway skims/MD for transit skims
Cost (2010$), Top Income	-0.01435	OP3 for highway skims/MD for transit skims
Auto In-Vehicle Time (minutes)	-0.00897	OP3 for highway skims/MD for transit skims
Rail In-Vehicle Time (minutes)	-0.00628	OP3 for highway skims/MD for transit skims
Transit Non-Rail In-Vehicle Time (minutes)	-0.00897	OP3 for highway skims/MD for transit skims
Transit Walk Access/Egress Time (minutes)	-0.03586	OP3 for highway skims/MD for transit skims
Transit Drive Access/Egress Time (minutes)	-0.00897	OP3 for highway skims/MD for transit skims
Transit Initial Wait Time (minutes)	-0.01345	OP3 for highway skims/MD for transit skims
Transit Transfer Wait Time (minutes)	-0.01345	OP3 for highway skims/MD for transit skims
Walk Time (minutes)	-0.03586	OP3 for highway skims/MD for transit skims
Bike Time (minutes)	-0.02542	OP3 for highway skims/MD for transit skims
Auto Terminal Time (minutes)	-0.03586	OP3 for highway skims/MD for transit skims
Local Bus IVT / O-D Distance	0.00000	OP3 for highway skims/MD for transit skims
DT_to_DA_Ratio_OverHalf	-0.58196	OP3 for highway skims/MD for transit skims
NonClosedTour: Walk	-2.15320	= 0; Drops Out of Tour Mode Choice Logsum Calculation Since Closed Tour is Assumed
NonClosedTour: Bike	-2.15320	
NonClosedTour: WT	-0.80000	
NonClosedTour: DT	0.68390	
OnePersonHH: SR2	-0.63455	
OnePersonHH: SR3+	-1.15606	
TwoPersonHH: SR3+	-0.79734	
AgeUnder20: Walk	-0.86380	
AgeUnder20: Bike	-1.76900	
AgeOver50: Walk	-0.05970	
AgeOver50: Bike	-1.23647	
University Student: WT	0.40247	
University Student: DT	0.40247	
High School Student: WT	1.51811	
High School Student: DT	1.51811	

Female: SR2	0.03668	
Female: SR3+	0.03668	
Female: Bike	-0.87490	
ArriveDestInAMPeak: Auto	-0.36676	= 0; midday travel assumed
ArriveDestInAMPeak: Auto	-0.36676	
ArriveDestInAMPeak: Auto	-0.36676	
DepartDestInPMPeak: Auto	0.10970	
DepartDestInPMPeak: Auto	0.10970	
DepartDestInPMPeak: Auto	0.10970	
EscortStopFlagByToursRemain: SR	0.05728	
EscortStopFlagByToursRemain: SR	0.05728	
OtherStopFlagByToursRemain: SR	0.09140	
OtherStopFlagByToursRemain: SR	0.09140	
MealTour: DA	-1.18130	= 1 if meal tour logsum, else 0
MealTour: SR2	1.75000	= 1 if meal tour logsum, else 0
MealTour: SR3+	3.05620	= 1 if meal tour logsum, else 0
ShoppingTour: Transit	0.20000	= 1 if shopping tour logsum, else 0
ShoppingTour: Transit	-1.50000	= 1 if shopping tour logsum, else 0
SocialRecTour: SR2	-0.15440	= 1 if social-recreation tour logsum, else 0
SocialRecTour: SR3+	2.10000	= 1 if social-recreation tour logsum, else 0
SocialRecTour: Walk	1.10000	= 1 if social-recreation tour logsum, else 0
SocialRecTour: Bike	0.15000	= 1 if social-recreation tour logsum, else 0

Source: Cambridge Systematics

Note: [1] Only those variables that are based on a choice made as part of the activity-based model application are shown in the table; other constants and variables used for logsums that are based on input zonal data or PopGen2 data are shown in ***Appendix F***.

[2] Since the aggregate logsums are used only in the daily activity pattern and exact number of tours model components, information regarding the “Model Component Where Choice is Made or Assigned (Subsequent Components Can Use Actual Choice Information)” is moot.

Appendix F. Model Coefficients and Calibrated Constants

F.1 Regular/No Regular Workplace Choice

Regular/no regular workplace choice model variables, StateFocus C# parameter names, estimated model coefficients and t-statistics, and final calibrated parameters based on the 2015 model calibration/validation are shown in ***Table F.1***, below.

Table F.1 Regular/No Regular Workplace Choice Coefficients

Variable[1]	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Person Variables				
Person Type				
Part-time worker (PType=2)	[HaveRegularWorkplace].[Part-time worker]	0.598	1.9	-0.600
Retired (PType=3)	[HaveRegularWorkplace].[Retired]	-6.035	-34.6	-3.633
Other non-worker (PType=4)	[HaveRegularWorkplace].[Other non-worker]	-6.400	-47.0	-4.015
University student (PType=5)	[HaveRegularWorkplace].[University student]	-5.544	-29.7	-2.200
Student age 16+ (PType=6)	[HaveRegularWorkplace].[Student age 16+]	-5.233	-23.0	-1.966
Age				
Age 66+	[HaveRegularWorkplace].[Age 66+]	-0.272	-2.1	-0.272
Educational Attainment				
High school graduate	[HaveRegularWorkplace].[High School Grad]	1.183	7.1	No Change
Some college	[HaveRegularWorkplace].[Some College]	1.597	9.7	No Change
Associate, technical degree	[HaveRegularWorkplace].[Associate Degree]	1.579	8.8	No Change
Bachelor's degree	[HaveRegularWorkplace].[Bachelor Degree]	1.975	12.0	No Change
Graduate degree	[HaveRegularWorkplace].[Graduate Degree]	2.319	13.9	No Change
Other, don't know[2]	*Used for Model Estimation Only*	*0.721*	*1.6*	–
Other				
Student (Undefined)[2]	*Used for Model Estimation Only*	*1.188*	*12.5*	–
Household Characteristics				
Household Income Level[3]				
Lower income	[HaveRegularWorkplace].[IncomeSegment]	-0.279	-3.4	No Change
Modest income	[HaveRegularWorkplace].[IncomeSegment]	-0.136	-2.1	No Change
Upper income	[HaveRegularWorkplace].[IncomeSegment]	0.081	1.3	No Change
Top income	[HaveRegularWorkplace].[IncomeSegment]	0.081	1.3	No Change
Missing income[2]	*Used for Model Estimation Only*	*0.074*	*0.3*	–

Variable[1]	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Household Composition				
Only adult in household	[HaveRegularWorkplace].[Only adult in HH]	0.179	2.5	No Change
Person / Household Characteristics				
Male with child(ren) age 0-15	[HaveRegularWorkplace].[Male Adult with Children age 0-15 in Household]	0.129	1.1	No Change
Female with no children	[HaveRegularWorkplace].[Female Adult with No Children in Household]	0.404	6.9	No Change
Female with child(ren) age 0-4[4]	[HaveRegularWorkplace].[Female Adult with Children age 0-4 in Household]	-0.726	-5.7	No Change
Female with child(ren) age 0-15[4]	[HaveRegularWorkplace].[Female Adult with Children age 0-15 in Household]	0.939	9.7	No Change
Nesting Coefficients				
Accessibility Logsum	[HaveRegularWorkplace].[Accessibility logsum]	0.051	1.5	No Change
Alternative Specific Constants				
Have Regular Workplace	[HaveRegularWorkplace].[ASC]	2.918	11.9	0.200
Model Estimation Statistics				
Number of Observations	23,604			
Log-likelihood at Convergence	-5,563.1			
Log-likelihood at Constants	n/a			
Log-likelihood at Null Parameters	n/a			
Rho-squared w.r.t. Constants	0.613			
Rho-squared w.r.t. Null Parameters	0.660			

Source: Cambridge Systematics

Notes:
1 The coefficients for all variables are for the choice to have a regular workplace. The alternative in the binary choice is not having a regular workplace. All variables, with the exception of the accessibility logsum, are 0/1 variables with the variable taking the value of 1 if the person has the characteristic and 0 otherwise.
2 Variable used for model estimation purposes only and is not used in model application.
3 The StateFocus Code Parameter Names for income related variables are input as a six element array as follows: [Less than $30K, $30K-$40K, $40K-$60K, $60K-$100K, $100K-$150K, $150K or more]. The six elements correspond to the following income groups: [Lower income, Modest Income, Modest Income (modest income coefficient is repeated), Middle Income, Upper Income, Top Income].
4 These two variables are additive (i.e. they are not mutually exclusive):
Female with 1 or more children age 0-4 = -0.726 + 0.939 (since the child is both under the age of 5 and under the age of 16)
Female with 1 or more 0-4 children and 1 or more 5-15 children = -0.726 + 0.939
Female with 1 or more children aged 5-15 = 0.939

F.2 Regular Workplace Location Choice

The regular workplace location choice model variables, StateFocus C# parameter names, estimated model coefficients and t-statistics, and final calibrated parameters based on the 2015 model calibration/validation are shown in ***Table F.2***, below.

Table F.2 Regular Workplace Location Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Size Variables				
Beta Logsum Multiplier[1]				
Destination Area Type 1	[RegularWorkLocation].[OutofHome].[Beta].[DestinationAreaTypeSegment]	0.6958	-40.41	0.975
Destination Area Type 2		0.6958	-40.41	1.050
Destination Area Type 3		0.6958	-40.41	1.050
Destination Area Type 4		0.6958	-40.41	1.070
Destination Area Type 5		0.6958	-40.41	1.170
Person with "Lower" Education[2]				
Service Employment	[RegularWorkLocation].[OutofHome].[ServEmp_LowEd]	0.0000	Base	No Change
Educational Employment	[RegularWorkLocation].[OutofHome].[EdEmp_LowEd]	0.0386	0.30	No Change
Retail Employment	[RegularWorkLocation].[OutofHome].[RetEmp_LowEd]	0.8695	9.67	No Change
Restaurant Employment	[RegularWorkLocation].[OutofHome].[RestEmp_LowEd]	0.1191	0.63	No Change
Production Employment	[RegularWorkLocation].[OutofHome].[ProdEmp_LowEd]	0.6365	7.83	No Change
Entertainment Employment	[RegularWorkLocation].[OutofHome].[EntEmp_LowEd]	0.2447	0.99	No Change
Person with "Higher" Education[2]				
Service Employment	[RegularWorkLocation].[OutofHome].[ServEmp_HighEd]	0.0000	Base	No Change
Educational Employment	[RegularWorkLocation].[OutofHome].[EdEmp_HighEd]	0.0949	1.22	No Change
Retail Employment	[RegularWorkLocation].[OutofHome].[RetEmp_HighEd]	-15.0000	Fixed	No Change
Restaurant Employment	[RegularWorkLocation].[OutofHome].[RestEmp_HighEd]	-1.1980	-6.11	No Change
Production Employment	[RegularWorkLocation].[OutofHome].[ProdEmp_HighEd]	-0.9861	-9.65	No Change
Entertainment Employment	[RegularWorkLocation].[OutofHome].[EntEmp_HighEd]	-15.0000	Fixed	No Change
Work at home size dummy	*Used for model estimation only*	*0.0000*	*Fixed*	–

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Non-Size Variables				
Work at home constant	[RegularWorkLocation].[AtHome].[Constant]	-16.8800	-36.64	-20.000
Work at home – person aged 35 to 44	[RegularWorkLocation].[AtHome].[Age3544]	2.4780	2.94	No Change
Work at home – person aged 45 or older	[RegularWorkLocation].[AtHome].[AgeO45]	3.8510	7.01	3.500
Work at home – person is a part-time worker	[RegularWorkLocation].[AtHome].[PTWrkr]	9.4370	17.06	8.200
Work at home – female with no children under 5	[RegularWorkLocation].[AtHome].[Fem_NoChU5]	-2.1200	-3.97	No Change
Work at home – female; number of children under 5	[RegularWorkLocation].[AtHome].[Fem_h0005]	0.9386	1.18	No Change
One-way distance in miles from home to work zone[3]	[RegularWorkLocation].[OutofHome].[Dist].[OriginAreaTypeSegment]	-0.4884	-10.23	-0.5128
2-mile distance threshold[3] (Damping factor = 1.0)[4]	[RegularWorkLocation].[OutofHome].[Dist_2].[OriginAreaTypeSegment]	0.4404	9.63	0.4677
Natural log of 1+distance[3]				
Origin Area Type 1	[RegularWorkLocation].[OutofHome].[LogOnePlusOneWayDist].[OriginAreaTypeSegment]	-0.9186	-20.54	No Change
Origin Area Type 2		-0.9186	-20.54	No Change
Origin Area Type 3		-0.9186	-20.54	No Change
Origin Area Type 4		-0.9186	-20.54	No Change
Origin Area Type 5		-0.9186	-20.54	-0.5000
Mode Choice Logsum	[RegularWorkLocation].[OutofHome].[Mode Logsum]	0.7742	7.55	No Change
Nesting Coefficient	[RegularWorkLocation].[Theta]	0.1000	Fixed	No Change
Work zone is at Denver International Airport	[RegularWorkLocation].[OutofHome].[DIADummy]	1.2800	9.96	No Change
Added Calibration Variables				
CBD destination	[RegularWorkLocation].[OutofHome].[CBD Dummy]	–	–	0.3000
Home County to Work County				
Boulder to Larimer	[RegularWorkLocation].[OutofHome].[Home].[Boulder].[Work].[Larimer]	–	–	-1.000
Boulder to Weld	[RegularWorkLocation].[OutofHome].[Home].[Boulder].[Work].[Weld]	–	–	0.500
Delta to Gunnison	[RegularWorkLocation].[OutofHome].[Home].[Delta].[Work].[Gunnison]	–	–	2.850
Eagle to Pitkin	[RegularWorkLocation].[OutofHome].[Home].[Eagle].[Work].[Pitkin]	–	–	3.200
El Paso to Arapahoe	[RegularWorkLocation].[OutofHome].[Home].[ElPaso].[Work].[Arapahoe]	–	–	0.750
El Paso to Fremont	[RegularWorkLocation].[OutofHome].[Home].[ElPaso].[Work].[Fremont]	–	–	2.000

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
El Paso to Pueblo	[RegularWorkLocation].[OutofHome].[Home].[ElPaso].[Work].[Pueblo]	–	–	0.750
Garfield to Eagle	[RegularWorkLocation].[OutofHome].[Home].[Garfield].[Work].[Eagle]	–	–	2.000
Garfield to Pitkin	[RegularWorkLocation].[OutofHome].[Home].[Garfield].[Work].[Pitkin]	–	–	3.600
Gunnison to Garfield	[RegularWorkLocation].[OutofHome].[Home].[Gunnison].[Work].[Garfield]	–	–	2.000
Gunnison to Pitkin	[RegularWorkLocation].[OutofHome].[Home].[Gunnison].[Work].[Pitkin]	–	–	1.500
Lake to Eagle	[RegularWorkLocation].[OutofHome].[Home].[Lake].[Work].[Eagle]	–	–	2.500
Lake to Summit	[RegularWorkLocation].[OutofHome].[Home].[Lake].[Work].[Summit]	–	–	2.100
Larimer to Adams	[RegularWorkLocation].[OutofHome].[Home].[Larimer].[Work].[Adams]	–	–	-1.000
Larimer to Arapahoe	[RegularWorkLocation].[OutofHome].[Home].[Larimer].[Work].[Arapahoe]	–	–	-1.000
Larimer to Boulder	[RegularWorkLocation].[OutofHome].[Home].[Larimer].[Work].[Boulder]	–	–	-0.500
Larimer to Denver	[RegularWorkLocation].[OutofHome].[Home].[Larimer].[Work].[Denver]	–	–	-1.250
Larimer to Jefferson	[RegularWorkLocation].[OutofHome].[Home].[Larimer].[Work].[Jefferson]	–	–	-1.500
Mesa to Garfield	[RegularWorkLocation].[OutofHome].[Home].[Mesa].[Work].[Garfield]	–	–	4.000
Moffat to Routt	[RegularWorkLocation].[OutofHome].[Home].[Moffat].[Work].[Routt]	–	–	3.000
Montrose to Delta	[RegularWorkLocation].[OutofHome].[Home].[Montrose].[Work].[Delta]	–	–	-0.450
Montrose to Mesa	[RegularWorkLocation].[OutofHome].[Home].[Montrose].[Work].[Mesa]	–	–	2.000
Montrose to San Miguel	[RegularWorkLocation].[OutofHome].[Home].[Montrose].[Work].[SanMiguel]	–	–	4.500
Pitkin to Eagle	[RegularWorkLocation].[OutofHome].[Home].[Pitkin].[Work].[Eagle]	–	–	-1.250
Pitkin to Garfield	[RegularWorkLocation].[OutofHome].[Home].[Pitkin].[Work].[Garfield]	–	–	-0.750
Pueblo to El Paso	[RegularWorkLocation].[OutofHome].[Home].[Pueblo].[Work].[ElPaso]	–	–	0.550
Pueblo to Fremont	[RegularWorkLocation].[OutofHome].[Home].[Pueblo].[Work].[Fremont]	–	–	1.000
Summit to Jefferson	[RegularWorkLocation].[OutofHome].[Home].[Summit].[Work].[Jefferson]	–	–	-1.750
Weld to Adams	[RegularWorkLocation].[OutofHome].[Home].[Weld].[Work].[Adams]	–	–	-0.650

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Weld to Arapahoe	[RegularWorkLocation].[OutofHome].[Home].[Weld].[Work].[Arapahoe]	–	–	-1.000
Weld to Broomfield	[RegularWorkLocation].[OutofHome].[Home].[Weld].[Work].[Broomfield]	–	–	-0.500
Weld to Denver	[RegularWorkLocation].[OutofHome].[Home].[Weld].[Work].[Denver]	–	–	-1.000
Weld to Jefferson	[RegularWorkLocation].[OutofHome].[Home].[Weld].[Work].[Jefferson]	–	–	-0.750
Model Estimation Statistics				
Number of Observations	16,479			
Log-likelihood at Convergence	-89,242.02			
Log-likelihood at Constants	n/a			
Log-likelihood at Null Parameters	-116,971.13			
Rho-squared w.r.t. Constants	n/a			
Rho-squared w.r.t. Null Parameters	0.237			

Source: Cambridge Systematics

Notes:

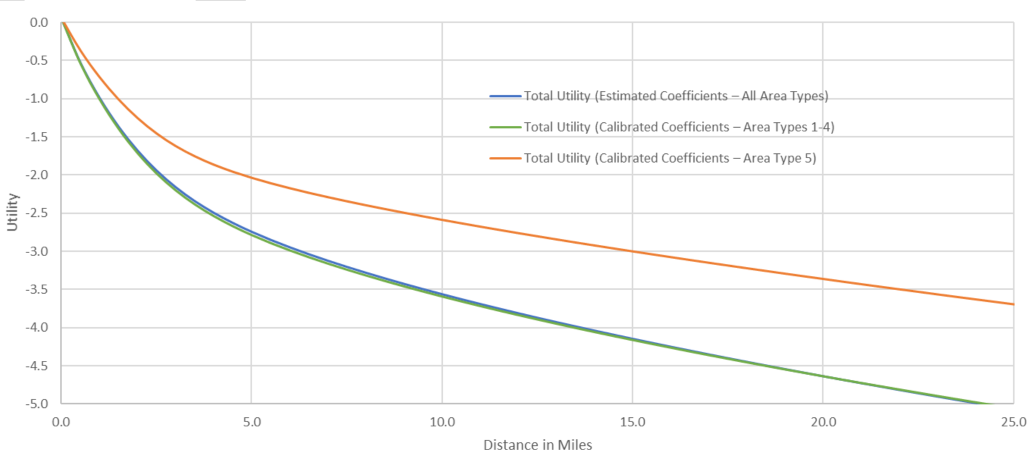
[1] The original model estimation did not stratify the size variable logsum multipliers by destination area type. The stratified variables are entered into a five element array, with the element number corresponding to the area type.

[2] Two educational levels are considered:
- Lower education level = persons without a bachelor's or graduate degree
- Higher education level = Persons with a bachelor's or graduate degree.

[3] The original model estimation did not stratify the distance variables by origin area type. The stratified variables are entered into a five element array, with the element number corresponding to the area type.

[4] This smoothed stepwise linear function (see ***Section 4.1.3***) is used along with the linear distance and the ln(1+distance) functions to modify the impact of the mode choice logsum on regular work location choice. ***Figure F.1*** shows the composite utilities from the smoothed stepwise linear function combined with linear distance and the ln(1+distance) functions for the range 0-25 miles.

Figure F.1 Estimated and Calibrated Utilities Resulting from Distance-Based Functions



Source: Cambridge Systematics.

F.3 Home-Schooled/Not Home-Schooled Choice

Home-schooled/not home-schooled choice model variables, StateFocus C# parameter names, estimated model coefficients and t-statistics, and final calibrated parameters based on the 2015 model calibration/validation are shown in ***Table F.3***, below.

Table F.3 Home-Schooled/Not Home-Schooled Choice Coefficients

Variable[1]	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Person Variables				
Person Type				
Full-time worker	[HomeSchool].[Full-time worker]	2.2950	9.39	1.7829
Part-time worker[2]	[HomeSchool].[Part-time worker]	-99.0000	Constrained	0.8705
Non-worker age 65 or older	[HomeSchool].[Retired]	-0.9504	-0.92	-0.5989
Other non-worker	[HomeSchool].[Other non-worker]	1.2470	5.13	0.4877
University student	[HomeSchool].[University Student]	-0.1207	-0.38	0.1097
Driving age student	[HomeSchool].[Student age 16+]	-0.0819	-0.30	-0.5902
Pre-driving age student[3]	[HomeSchool].[Student age 5-15]	0.0635	0.31	-0.3778
Other				
Part-time adult student[4]	[HomeSchool].[Adult part-time student]	0.6010	4.09	No Change
Household Characteristics				
Household Income Level[5]				
Lower income	[HomeSchool].[IncomeSegment]	–	–	-1.2375
Modest income	[HomeSchool].[IncomeSegment]	–	–	0.0852
Middle income	[HomeSchool].[IncomeSegment]	–	–	-0.0390
Upper income	[HomeSchool].[IncomeSegment]	-0.4461	-3.68	-0.6113
Top income	[HomeSchool].[IncomeSegment]	-0.7020	-4.21	-0.2499
Missing income[6]	*Used for Model Estimation Only*	-0.0521	-0.25	–
Person / Household Characteristics				
Child student in household with at least one non-working adult × (number of children 15 or younger) × (number of children 15 or younger)	[HomeSchool].[Child with 1pNWA * (Number of Children) ^2]	0.0985	12.26	No Change
Adult in household with at least one non-working adult × (number of children 15 or younger) × (number of children 15 or younger)	[HomeSchool].[Adult with 1pNWA * (Number of Children) ^2]	0.0911	4.19	No Change
Alternative Specific Constants				
Home-schooled	[HomeSchool].[ASC]	-3.2010	-15.88	-2.8245

Variable[1]	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Model Estimation Statistics				
Number of Observations	7405			
Log-likelihood at Convergence	-1706.67			
Log-likelihood at Constants	n/a			
Log-likelihood at Null Parameters	-5132.75			
Rho-squared w.r.t. Constants	n/a			
Rho-squared w.r.t. Null Parameters	0.667			

Source: Cambridge Systematics

Notes:
[1] The coefficients for all variables are for the choice to be home-schooled. The alternative in the binary choice is not having a regular workplace. All variables, with the exception of the accessibility logsum, are 0/1 variables with the variable taking the value of 1 if the person has the characteristic and 0 otherwise.
[2] The FRTC estimation data did not contain any observations of part-time workers (person type 2) who were also students. Thus, the parameter for this person-type was undefined.
[3] Excluding pre-school children.
[4] Any adult (person types: full-time worker, part-time worker, non-work age 65+, other non-worker, or university student) who is listed as a part-time student.
[5] The StateFocus Code Parameter Names for income related variables are input as a six element array as follows: [Less than $30K, $30K-$40K, $40K-$60K, $60K-$100K, $100K-$150K, $150K or more]. The six elements correspond to the following income groups: [Lower income, Modest Income, Modest Income (modest income coefficient is repeated), Middle Income, Upper Income, Top Income].
[6] Variable used for model estimation purposes only and is not used in model application.

F.4 Regular School Location Choice

The regular school location choice model variables, StateFocus C# parameter names, estimated model coefficients and t-statistics, and final calibrated parameters based on the 2015 model calibration/validation are shown in ***Table F.4***, below.

Table F.4 Regular School Location Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Size Variables				
Beta Logsum Multiplier				
Pre-school	[SchoolLocation].[PreSchool].[Beta]	0.9051	-5.30	1.0000
K-8	[SchoolLocation].[K8School].[Beta]	0.9051	-5.30	1.0000
High School	[SchoolLocation].[HighSchool].[Beta]	0.9051	-5.30	1.0000
College/University	[SchoolLocation].[University].[Beta]	0.9051	-5.30	1.0000
Enrollment in Destination Zone				
Pre-school	[SchoolLocation].[PreSchool].[Zone_PrekEnrollment]	0.0000	Constrained	No change
K-8	[SchoolLocation].[K8School].[Zone_K8Enrollment]	0.0000	Constrained	No change
High School	[SchoolLocation].[HighSchool].[GenericHighSchoolEnrollment]	0.0000	Constrained	No change
College/University	*Not used in model application*	–	–	–
Educational Employment in Destination Zone				
Pre-school	[SchoolLocation].[PreSchool].[Zone_EdEmployees]	-2.4490	-2.50	-100
K-8	[SchoolLocation].[K8School].[Zone_EdEmployees]	-2.4260	-5.50	-100
High School	[SchoolLocation].[HighSchool].[Zone_EducationEmployees]	-1.0930	-2.42	-100
College/University	[SchoolLocation].[University].[Zone_EdEmployees]	-10.0000	Constrained	-100
Non-Size Variables				
Pre-School Students				
One-way distance from home to school zone in miles	[SchoolLocation].[PreSchool].[PWDist]	0.7329	1.20	0.6329
1-mile distance threshold (Damping factor = 2.0)[1]	[SchoolLocation].[PreSchool].[PWDist_1]	-0.7817	-1.33	No change
Natural log of 1+distance	[SchoolLocation].[PreSchool].[Log_Dist]	-1.8150	-5.19	No change
Mode Choice Logsum	[SchoolLocation].[PreSchool].[DisaggregateModeChoiceLogsum]	0.8797	13.14	No change
Older sibling attends school in the same zone	[SchoolLocation].[PreSchool].[OldSibSchZone]	3.359	48.90	No change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
K-8 Students				
One-way distance from home to school zone in miles	[SchoolLocation].[K8School].[PWDist]	-0.9859	-4.92	No change
1-mile distance threshold (Damping factor = 2.0)[1]	[SchoolLocation].[K8School].[PWDist_1]	0.8803	4.68	No change
Natural log of 1+distance	[SchoolLocation].[K8School].[Log_Dist]	-1.6970	-12.04	No change
Mode Choice Logsum	[SchoolLocation].[K8School].[DisaggregateModeChoiceLogsum]	0.8797	13.14	No change
Older sibling attends school in the same zone	[SchoolLocation].[K8School].[OldSibSchZone]	3.359	48.90	No change
Destination zone is in the same school district as the home zone	[SchoolLocation].[K8School].[SchoolDistrictZone]	0.9547	18.90	0.4774
High School Students				
One-way distance from home to school zone in miles	[SchoolLocation].[HighSchool].[PWDist]	-0.6349	-8.93	No change
3-mile distance threshold (Damping factor = 1.0)[1]	[SchoolLocation].[HighSchool].[PWDist_3]	0.3144	3.42	0.3644
10-mile distance threshold (Damping factor = 1.0)[1]	[SchoolLocation].[HighSchool].[PWDist_10]	0.0986	2.26	No change
Mode Choice Logsum	[SchoolLocation].[HighSchool].[DisaggregateModeChoiceLogsum]	0.8797	13.14	No change
Older sibling attends school in the same zone	[SchoolLocation].[HighSchool].[OldSibSchZone]	4.475	14.12	No change
Destination zone is in the same school district as the home zone	[SchoolLocation].[HighSchool].[SchoolDistrictZone]	0.9547	18.90	0.4774
College/University Students				
One-way distance from home to school zone in miles	[SchoolLocation].[University].[PWDist]	-2.1080	-3.65	-2.7080
1-mile distance threshold (Damping factor = 2.0)[1,2]	[SchoolLocation].[University].[PWDist]	-2.1080	-3.65	-2.7080
7-mile distance threshold (Damping factor = 1.0)[1]	[SchoolLocation].[University].[PWDist_7]	-0.0493	-9.98	-0.0743
Mode Choice Logsum	[SchoolLocation].[University].[DisaggregateModeChoiceLogsum]	0.8797	13.14	No change

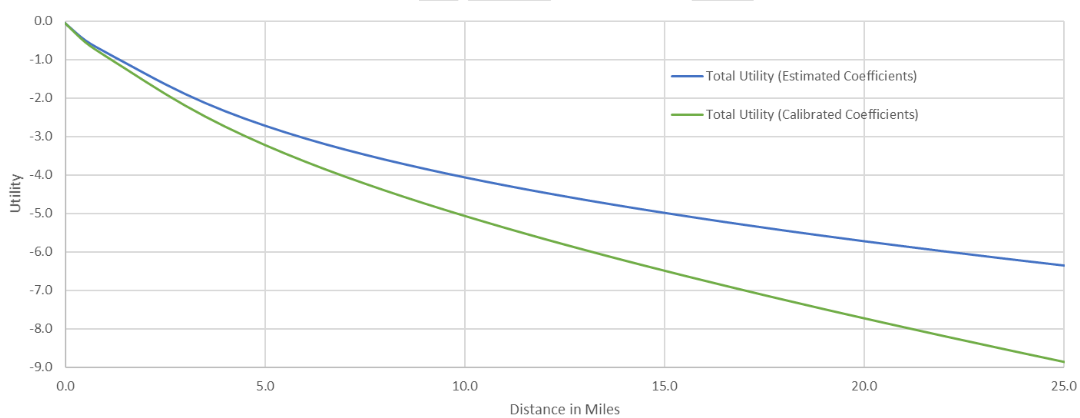
Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Model Estimation Statistics				
Number of Observations	5,067			
Log-likelihood at Convergence	-13,012.31			
Log-likelihood at Constants	n/a			
Log-likelihood at Null Parameters	-36,028.54			
Rho-squared w.r.t. Constants	n/a			
Rho-squared w.r.t. Null Parameters	0.639			

Source: Cambridge Systematics

Notes: [1] This variable is used in the smoothed stepwise linear function (see ***Section 4.1.3***) along with the linear function for distance and/or the ln(1+distance) function to create a composite distance-based utlity. ***Figure F.2*** through ***Figure F.5*** show the composite utilities from the smoothed stepwise linear function combined with the results from the linear distance and the ln(1+distance) functions for the range 0-25 miles for pre-school, kindergarten through 8th grade, high school, and college/university regular school location choice models.

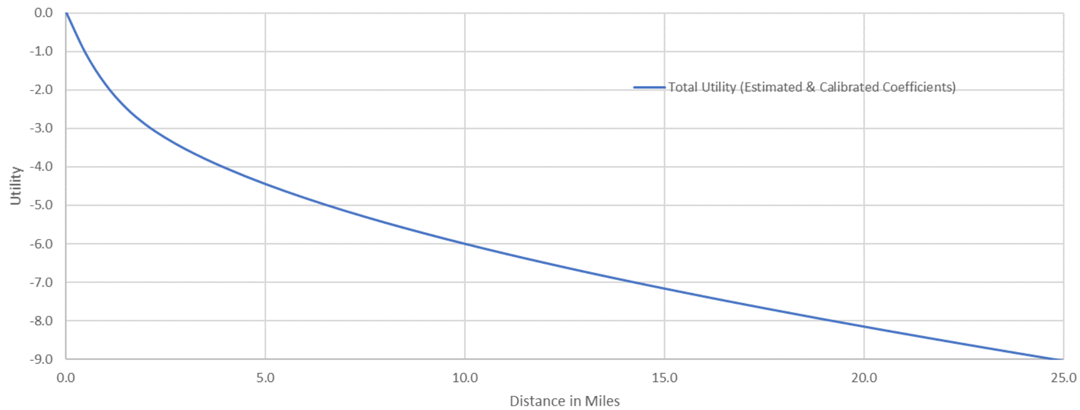
[2] The negative of the smoothed stepwise linear function is used for this variable.

Figure F.2 Estimated and Calibrated Pre-School Utilities Resulting from Distance-Based Functions



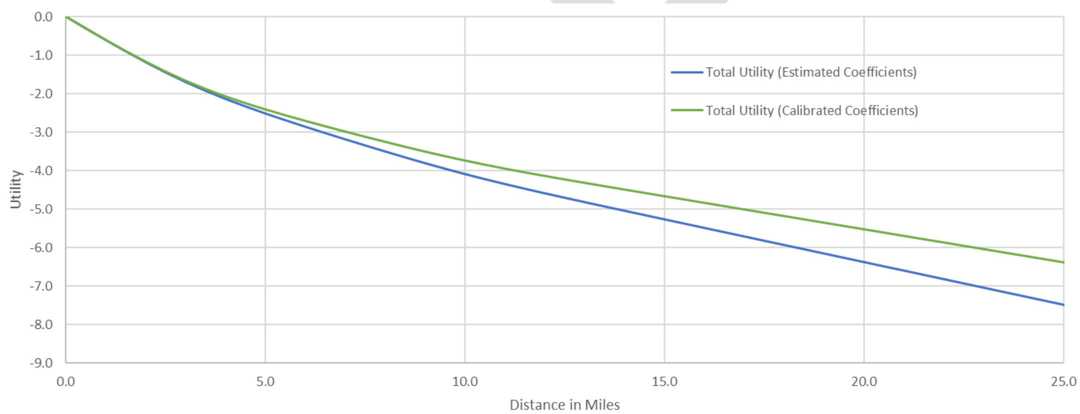
Source: Cambridge Systematics.

Figure F.3 Estimated and Calibrated Kindergarten-8th Grade Utilities Resulting from Distance-Based Functions



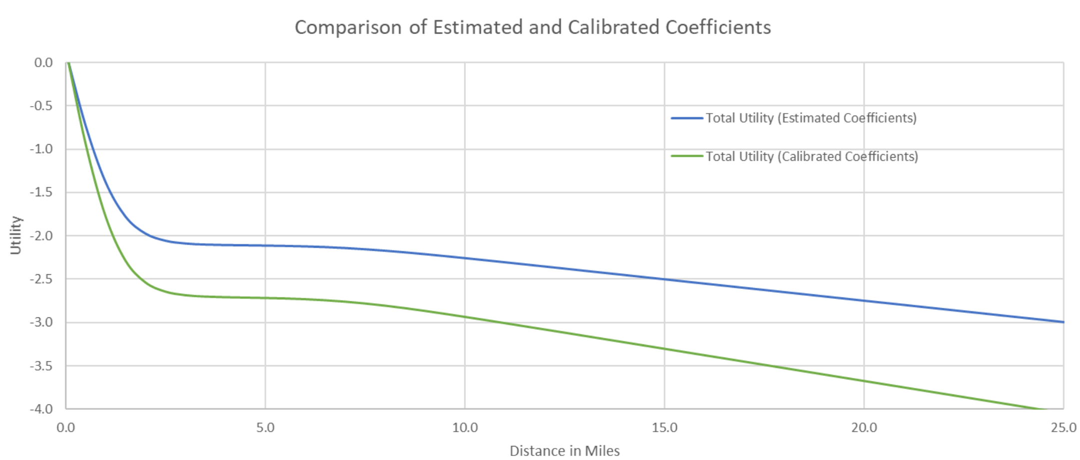
Source: Cambridge Systematics.

Figure F.4 Estimated and Calibrated High School Utilities Resulting from Distance-Based Functions



Source: Cambridge Systematics.

Figure F.5 Estimated and Calibrated College & University Utilities Resulting from Distance-Based Functions



Source: Cambridge Systematics.

F.5 Autos Available Choice

The autos available choice model variables, StateFocus C# parameter names, estimated model coefficients and t-statistics, and final calibrated parameters based on the 2015 model calibration/validation are shown in ***Table F.5***, below.

Table F.5 Autos Available Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Household Variables				
Zero Auto Household Alternative				
Low income[1]	[Auto Availability].[0cars].[IncomeSegment]	2.9570	11.35	3.692
Modest income[1]	[Auto Availability].[0cars].[IncomeSegment]	1.1520	4.19	1.3045
Middle income[1]	[Auto Availability].[0cars].[IncomeSegment]	–	–	-0.7355
Upper income[1]	[Auto Availability].[0cars].[IncomeSegment]	-0.7749	-1.22	No Change
Top income[1]	[Auto Availability].[0cars].[IncomeSegment]			-0.5943
Missing Income[2]		*1.2510*	*1.26*	–
1 driver in household	[Auto Availability].[0cars].[Driver1]	-6.1190	-21.51	-6.2940
2 drivers in household	[Auto Availability].[0cars].[Driver2]			-7.1931
3 drivers in household	[Auto Availability].[0cars].[Driver3]	-8.2720	-23.33	-9.2988
4+ drivers in household	[Auto Availability].[0cars].[Driver4P]			-6.8353
Adults age 75 or older per driver	[Auto Availability].[0cars].[ElderPrDrvr]	-0.3487	-1.47	No Change
Children under 5 per driver	[Auto Availability].[0cars].[ChUnd5PrDrvr]	-0.8086	-1.41	No Change
At least as many autos as workers[3]	[Auto Availability].[0cars].[CarsGtWorkers]	0.6662	8.44	No Change
One Auto Household Alternative				
Low income[1]	[Auto Availability].[1car].[IncomeSegment]	1.0110	10.69	0.8291
Modest income[1]	[Auto Availability].[1car].[IncomeSegment]	0.4055	5.25	-0.0201
Middle income[1]	[Auto Availability].[1car].[IncomeSegment]	–	–	-0.8708
Upper income[1]	[Auto Availability].[1car].[IncomeSegment]	-0.3591	-3.30	-1.1172
Top income[1]	[Auto Availability].[1car].[IncomeSegment]	-0.3942	-2.76	-1.3059
Missing Income[2]	*Not used in model application*	*-0.2557*	*-0.76*	–
2 drivers in household	[Auto Availability].[1car].[Driver2]	-3.1870	-20.63	-2.5035
3 drivers in household	[Auto Availability].[1car].[Driver3]	-4.7810	-14.13	-2.4160
4+ drivers in household	[Auto Availability].[1car].[Driver4P]	-5.7580	-5.67	-3.2330
Adults age 75 or older per driver	[Auto Availability].[1car].[ElderPrDrvr]	0.3370	3.89	No Change
Children under 5 per driver	[Auto Availability].[1car].[ChUnd5PrDrvr]	-0.5759	-3.73	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
At least as many autos as workers[2]	[Auto Availability].[1car]. [CarsGtWorkers]	0.6662	8.44	No Change
Two Autos Household Alternative				
1 driver in household	[Auto Availability].[2cars].[Driver1]	-0.0040	-0.04	-0.3553
3 drivers in household	[Auto Availability].[2cars].[Driver3]	-1.8220	-11.67	-1.3314
4+ drivers in household	[Auto Availability].[2cars].[Driver4P]	-3.1110	-10.31	-1.6902
At least as many autos as workers[2]	[Auto Availability].[2cars].[CarsGtWorkers]	0.6662	8.44	No Change
Three Autos Household Alternative				
Low income[1]	[Auto Availability].[3cars].[IncomeSegment]	-0.3445	-2.63	0.1969
Modest income[1]	[Auto Availability].[3cars].[IncomeSegment]	-0.1482	-1.95	0.2831
Middle income[1]	[Auto Availability].[3cars].[IncomeSegment]	–	–	0.3727
Upper income[1]	[Auto Availability].[3cars].[IncomeSegment]	0.1301	1.86	0.3566
Top income[1]	[Auto Availability].[3cars].[IncomeSegment]	0.3798	4.60	0.7204
Missing Income[2]	*Not used in model application*	*-0.5080*	*-1.38*	–
1 driver in household	[Auto Availability].[3cars].[Driver1]	-1.4880	-12.23	-2.1002
2 drivers in household	[Auto Availability].[3cars].[Driver2]	-0.2903	-3.91	-0.5943
4+ drivers in household	[Auto Availability].[3cars].[Driver4P]	-2.1940	-10.37	-1.7668
Children under 5 per driver	[Auto Availability].[3cars].[ChUnd5PrDrvr]	-0.5649	-4.45	No Change
At least as many autos as workers[2]	[Auto Availability].[3cars].[CarsGtWorkers]	0.6662	8.44	No Change
Four or More Autos Household Alternative				
Low income[1]	[Auto Availability].[4Pcars].[IncomeSegment]	-0.3047	-1.62	0.2142
Modest income[1]	[Auto Availability].[4Pcars].[IncomeSegment]	-0.2200	-1.97	-0.0191
Middle income[1]	[Auto Availability].[4Pcars].[IncomeSegment]	–	–	0.2157
Upper income[1]	[Auto Availability].[4Pcars].[IncomeSegment]	0.3595	3.79	0.2877
Top income[1]	[Auto Availability].[4Pcars].[IncomeSegment]	0.6348	5.82	0.7105
Missing Income[2]	*Not used in model application*	*0.3136*	*0.65*	–
1 driver in household	[Auto Availability].[4Pcars].[Driver1]	-2.0570	-13.55	-2.5147
2 drivers in household	[Auto Availability].[4Pcars].[Driver2]	-1.2540	-13.45	-1.3298
3 drivers in household	[Auto Availability].[4Pcars].[Driver3]	0.1050	0.93	0.5221
Part-time workers per driver	[Auto Availability].[4Pcars].[PTWrkPrDrvr]	-0.2534	-1.76	No Change
Adults age 75 or older per driver	[Auto Availability].[4Pcars].[ElderPrDrvr]	-0.7991	-3.73	No Change
Children age 16 or older per driver	[Auto Availability].[4Pcars].[DrAgeChPrDr]	-0.4767	-0.85	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Children under 5 per driver	[Auto Availability].[4Pcars].[ChUnd5PrDrvr]	-1.1110	-4.99	No Change
At least as many autos as workers[2]	[Auto Availability].[4Pcars].[CarsGtWorkers]	0.6662	8.44	No Change
Zonal Variables				
Log (1+Service Employment Density)				
Autos < Drivers[4]	[Auto Availability].[*****].[LNServDens_ FewCars]	0.3326	12.36	No Change
Autos ≥ Drivers[4]	[Auto Availability].[*****].[LNServDens_ EqualCars]	0.1513	11.58	No Change
No autos (applicable only to zero auto household alternative)	[Auto Availability].[0cars].[LNServDens]	0.1366	3.65	No Change
Transit Stop Distance Variable				
Autos < Drivers[4]	[Auto Availability].[*****].[AmtTransLsHMi_ FewCars]	1.8080	4.37	No Change
Autos ≥ Drivers[4]	[Auto Availability].[*****].[AmtTransLsHMi_ EqualCars]	0.2743	1.21	No Change
Home-Based Work Mode Choice Logsum Variables				
Sum of Differences Between 0 Autos Logsums and 1 Auto / Driver Logsums Across All Full-Time Workers with a Regular Workplace				
Low & modest income[1,4]	[Auto Availability].[*****].[SumWrkLogsum_ FTWrkrGtCars_ IncomeSegment]	-0.1063	-3.10	No Change
Middle income[1,4]	[Auto Availability].[*****].[SumWrkLogsum_ FTWrkrGtCars_ IncomeSegment]	-0.0427	-1.62	No Change
Model Estimation Statistics				
Number of Observations	12,385			
Log-likelihood at Convergence	-11,406.28			
Log-likelihood at Constants	n/a			
Log-likelihood at Null Parameters	-19,932.89			
Rho-squared w.r.t. Constants	n/a			
Rho-squared w.r.t. Null Parameters	0.428			

Source: Cambridge Systematics and CDOT

Notes: [1] The StateFocus Code Parameter Names for income related variables are input as a six element array as follows: [Less than $30K, $30K-$40K, $40K-$60K, $60K-$100K, $100K-$150K, $150K or more]. The six elements correspond to the following income groups: [Lower income, Modest Income, Modest Income (modest income coefficient is repeated), Middle Income, Upper Income, Top Income].

[2] Variable used for model estimation purposes only and is not used in model application.

[3] This coefficient is common among all autos available alternatives.

[4] These coefficients are common among all autos available alternatives. The "[*****]" in the StateFocus Code Parameter Name is [0cars], [1car], [2cars], [3cars], or [4Pcars], as appropriate.

F.6 Daily Activity Pattern Choice

The daily activity pattern choice model utility function is shown below (see ***Section 4.2.6*** for full documentation).

$$\left\{\sum_{t=1}^{9}\sum_{s=1}^{7}\left[(TI_t \times BPtk_t) + (SI_s \times BPsk_s) + TI_t \times \left(\sum_{pc=1}^{PC}(BPphc_{pc|t} \times PHC_{pc}) + \sum_{i=1}^{n}(BPls_t \times LS_{i|t})\right)\right.\right.$$
$$\left.\left.+ SI_{s|s\neq t} \times \left(\sum_{pc=1}^{PC}(BPphc_{pc|s} \times PHC_{pc}) + \sum_{i=1}^{n}(BPls_s \times LS_{i|s})\right)\right]\right\}$$
$$+ \left[ln(NT) \times \left(\sum_{pc=1}^{PC}(BTphc_{pc} \times PHC_{pc}) + (BTls_i \times HAALS_i)\right)\right]$$
$$+ \left[ln(NS) \times \left(\sum_{pc=1}^{PC}(BSphc_{pc} \times PHC_{pc}) + (BSls_i \times HAALS_i)\right)\right] + \sum_{t=1}^{9}\sum_{t2=t+1}^{9}(TI_t \times TI_{t2} \times X_{t,t2})$$
$$+ \sum_{s=1}^{7}\sum_{s2=s+1}^{7}(SI_s \times SI_{s2} \times Y_{s,s2}) + \sum_{t=1}^{9}\sum_{s=1}^{7}(TI_t \times SI_s \times Z_{t,s}) + C_{NT,NS}$$

Where:

U_{DAP}	is the utility of a specific Daily Activity Pattern comprising 1+ tours for specific purpose(s) combined with 0 or 1+ stops for specific purpose(s)
t & $t2$	are indices that range from 1 to 9 for the different purposes representing work, school, escort, personal business, shop, meal, social/recreation, non-closed work, and non-closed other
s & $s2$	are indices that range from 1 to 7 for the different purposes representing work, school, escort, personal business, shop, meal, social/recreation (note that non-closed purposes apply only to tours)
TI_t	is 1 if there are 1+ tours in the alternative for purpose *t* and 0 otherwise
SI_s	is 1 if there are 1+ stops in the alternative for purpose *s* and 0 otherwise
$BPtk_t$	is a purpose-specific constant related to making 1+ tours for a specific purpose *t*
$BPsk_s$	is a purpose-specific constant related to making 1+ stops for a specific purpose *s*
pc	is an index for person characteristics or characteristics of the household in which the person is a member (e.g. person type, household income); *pc* ranges from 1 to PC characteristics
$BPphc_{pc\|\bullet}$	is a purpose-specific array of coefficients based on person characteristics or characteristics of the household in which the person is a member to making 1+ tours or 1+ stops for a specific purpose ● (where ● refers to either tour purpose *t* or stop purpose *s*) provided the stop purpose is not the same as the tour purpose (the coefficients are applied only once for stops and tours of same purpose as indicated by the conditional index $SI_{s\|s\neq t}$)
PHC_{pc}	is 1 if the person has the person characteristic or is a member of a household with the specified household characteristic and 0 otherwise
$BPls_\bullet$	is an array of coefficients based on the mode choice logsum for the person's work tour to their regular work location or school tour to their regular school location or, for other purposes, the aggregate accessibility logsum associated with the home zone of the person for a specific purpose ● (where ● refers to either tour purpose *t* or stop purpose *s*), again provided the stop purpose is not the same as the tour purpose (the coefficients are applied only once for stops and tours of same purpose as indicated by the conditional index $SI_{s\|s\neq t}$)
$LS_{i\|\bullet}$	is the mode choice logsum for the person's work tour to their regular work location or school tour to their regular school location or, for other purposes, the aggregate accessibility logsum associated with the home zone, *i*, of the person for a specific purpose ●, where ● is either tour purpose *t* or stop purpose *s*

NT	is the minimum of the sum of TI_t across the 9 tour purposes and 3; (1 ≤ NT ≤ 3)
$BTphc_{pc}$	is an array of coefficients based on person characteristics or characteristics of the household in which the person is a member related, *pc,* related to making more tours; since the sum of the coefficients are multiplied by ln(count of tours), this component does not become active unless there are two or more tour purposes in the daily activity pattern
$BTls_i$	is a coefficient for additional tours based on the home average aggregate accessibility logsum, $HAALS_i$, associated with the home zone, *i,* of the person
$HAALS_i$	is the home average accessibility logsum for zone *i*; $HAALS_i$ is the average across aggregate accessibility logsums for the escort, personal business, shop, meal, and social/recreation tour purposes (i.e. the aggregate accessibility logsums are summed and divided by 5)
NS	is the maximum of 1 and the minimum of the sum of SI_s across the 7 stop purposes and 4; (1 ≤ NS ≤ 4)
$BSphc_{pc}$	is an array of coefficients based on person characteristics or characteristics of the household in which the person is a member related, *pc,* related to making more stops; since the sum of the coefficients are multiplied by ln(count of stops), this component does not become active unless there are two or more stop purposes in the daily activity pattern
$BSls_i$	is a coefficient for stops based on the home average aggregate accessibility logsum, $HAALS_i$, associated with the home zone, *i,* of the person
$BX_{t,t2}$	is a matrix of coefficients for making tours for BOTH of a given pair of tour purposes, *t* and *t2*. Only a half-matrix is estimated, with the diagonal constrained to 0.
$BY_{s,s2}$	is a matrix of coefficients for making stops for BOTH of a given pair of stop purposes, *s* and *s2*. Only a half-matrix is estimated, with the diagonal constrained to 0.
$BZ_{t,s}$	is a matrix of coefficients for making a stop, *s*, of a given purpose in combination with a tour, *t*, of a given purpose. Here, a nearly full matrix can be estimated, as all stop purposes and tour purposes can occur together in the same pattern.
$C_{NT,NS}$	is a set of constants related to making tours for exactly NT different purposes and stops for exactly NS different purposes

The parameters and constants for each of the sets are documented in the following sections.

F.6.1 BPtk & BPsk – Purpose-Specific Constants for Making 1+ Tours and 1+ Stops

Purpose-specific tours, StateFocus C# parameter names, estimated model constants and t-statistics, and final calibrated parameters based on the 2015 model calibration/validation are shown in ***Table F.6***, below.

F.6.2 Table F.6 BPtk & BPsk – Purpose-Specific Constants for Making 1+ Tours and 1+ Stops

Tour Purpose[1]	StateFocus Code Parameter Name	Estimated Constant	(t-Statistic)	Calibrated Constant
BPtk – 1+ Tour Constants				
Work Tour	[DAP].[BP].[Work].[Constant-Tour]	1.1343	10.38	2.2980
School Tour	[DAP].[BP].[School].[Constant-Tour]	-1.2833	-6.62	0.2927
Escort Tour	[DAP].[BP].[Escort].[Constant-Tour]	-4.4015	-29.22	-3.0650
Personal Business Tour	[DAP].[BP].[PersonalBusiness].[Constant-Tour]	-3.0878	-30.64	-2.1188
Shop Tour	[DAP].[BP].[Shop].[Constant-Tour]	-3.2492	-32.27	-2.2113
Meal Tour	[DAP].[BP].[Meal].[Constant-Tour]	-3.8917	-35.09	-3.1305
Social Recreation Tour	[DAP].[BP].[SocialRecreational].[Constant-Tour]	-2.4488	-25.10	-1.6715
Work Non-Closed Tour	[DAP].[BP].[WorkNCT].[Constant-Tour]	-2.1741	-5.60	-3.1343

Tour Purpose[1]	StateFocus Code Parameter Name	Estimated Constant	(t-Statistic)	Calibrated Constant
Other Non-Closed Tour	[DAP].[BP].[OtherNCT].[Constant-Tour]	-3.9461	-18.58	No Change
BPsk – 1+ Stop Constants				
Work Stop	[DAP].[BP].[Work].[Constant-Stop]	0.7279	2.83	0.8007
School Stop	[DAP].[BP].[School].[Constant-Stop]	0.0000	–	No Change
Escort Stop	[DAP].[BP].[Escort].[Constant-Stop]	-2.3028	-10.26	-2.3502
Personal Business Stop	[DAP].[BP].[PersonalBusiness].[Constant-Stop]	0.4616	2.49	0.2631
Shop Stop	[DAP].[BP].[Shop].[Constant-Stop]	0.4986	2.69	0.2844
Meal Stop	[DAP].[BP].[Meal].[Constant-Stop]	-0.4092	-2.19	-0.6416
Social Recreation Stop	[DAP].[BP].[SocialRecreational].[Constant-Stop]	-0.0587	-0.35	-0.0921

Source: Cambridge Systematics

Notes: [1] In the DRCOG Focus model code, *BPtk* and *BPsk* were included in the *BP* array which stood for "purposes." The original DRCOG Focus utility equation was rewritten to identify constants (*BPtk* and *BPsk*), person/household characteristics (*BPphc*), and mode choice logsum and accessibility variables (*BPls*) associated with the different purposes. However, to maintain C# code consistency, all of the variables are included in the group of coefficients starting with: "[DAP].[BP]."

F.6.3 BPphc – Purpose-Specific Coefficients by Person Characteristics for Making 1+ Tours or 1+ Stops

Array PX is stratified by person characteristic. The coefficients shown in ***Table F.7*** are applied for each tour purpose and/or stop purpose alternative for each person based on whether or not they have the characteristic with the exception that the coefficients are applied only once if the stop purpose is the same as the tour purpose. The person characteristic by tour/stop purpose, StateFocus C# parameter names, estimated model constants and t-statistics, and final calibrated parameters based on the 2015 model calibration/validation are shown in ***Table F.7***, below.

Table F.7 BPphc – Purpose-Specific Coefficients by Person Characteristics for Making 1+ Tours or 1+ Stops

Tour / Stop Purpose[1]	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
1+ Work Tours or Stops				
Person Type				
Part-time worker	[DAP].[BP].[Work].[Part-time worker]	-1.0228	-18.13	-1.2274
Non-worker age 65+	[DAP].[BP].[Work].[Retired]	-2.6072	-22.56	-2.8858
Other non-worker	[DAP].[BP].[Work].[Other non-worker]	-2.1382	-26.13	-2.1382
University student	[DAP].[BP].[Work].[University student]	-1.5619	-10.03	-1.3578
Student age 16+	[DAP].[BP].[Work].[Student age 16+]	-2.4906	-13.97	-2.2595
Student age 5-15	[DAP].[BP].[Work].[Student age 5-15]	-20.0000	Fixed	No Change
Child age 0-4	[DAP].[BP].[Work].[Child age 0-4]	-20.0000	Fixed	No Change

Tour / Stop Purpose[1]	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Age				
Adult aged 51-65	[DAP].[BP].[Work].[Age 51-65]	-0.2026	-3.82	No Change
Adult aged 66+	[DAP].[BP].[Work].[Age 66+]	-0.3072	-3.34	No Change
Household Composition				
Adult female, 1+ children aged 0-4	[DAP].[BP].[Work].[Female / age 0-4/IsAdult]	-0.2785	-3.04	No Change
Other Person/Household Characteristics				
Autos per adult	[DAP].[BP].[Work].[Cars per adult in HH]	0.0750	1.78	-0.0250
Only worker	[DAP].[BP].[Work].[Only worker in HH]	-0.0355	-0.65	No Change
Works at home	[DAP].[BP].[Work].[Work at home]	-2.4582	-43.47	No Change
No regular workplace[2]	[DAP].[BP].[Work].[No Regular Workplace]	-5.0258	-28.72	No Change
1+ School Tours or Stops				
Person Type				
Non-worker age 65+	[DAP].[BP].[School].[Retired]	0.6504	1.91	No Change
Other non-worker	[DAP].[BP].[School].[Other non-worker]	0.7985	4.27	3.8328
University student	[DAP].[BP].[School].[University student]	1.0345	4.04	0.6621
Student age 16+	[DAP].[BP].[School].[Student age 16+]	2.6434	13.33	No Change
Student age 5-15	[DAP].[BP].[School].[Student age 5-15]	2.9423	16.10	No Change
Child age 0-4	[DAP].[BP].[School].[Child age 0-4]	1.4571	7.58	5.2456
Age				
Adult aged 18-25	[DAP].[BP].[School].[Age 18-25]	0.3394	1.52	No Change
Household Income[3]				
Upper income	[DAP].[BP].[School].[IncomeSegment]	0.1845	2.70	3.3390
Top income	[DAP].[BP].[School].[IncomeSegment]	0.1845	2.70	3.3390
Missing income[4]	*Used for Model Estimation Only*	*1.3997*	*2.89*	–
Household Composition				
Adult female, 1+ children aged 0-4[5]	[DAP].[BP].[School].[Female / age 0-4/IsAdult]	–	–	-0.6671
Adult female, 1+ children aged 0-15[5]	[DAP].[BP].[School].[Female / age 5-15/IsAdult]	-0.6671	-4.19	No Change
Other Person/Household Characteristics				
Works at home	[DAP].[BP].[school].[Work at home]	-1.0975	-3.59	No Change
Not a student	[DAP].[BP].[School].[Non Student]	-20.0000	Fixed	No Change
Home-schooled	[DAP].[BP].[School].[Home Schooled]	-20.0000	Fixed	No Change
1+ Escort Tours or Stops				
Person Type				
Non-worker age 65+	[DAP].[BP].[Escort].[Retired]	-0.3155	-2.57	No Change
Other non-worker	[DAP].[BP].[Escort].[Other non-worker]	-0.1812	-2.51	No Change

Tour / Stop Purpose[1]	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
University student	[DAP].[BP].[Escort].[University student]	-0.6118	-3.48	-1.5827
Student age 16+	[DAP].[BP].[Escort].[Student age 16+]	0.3462	2.30	No Change
Student age 5-15	[DAP].[BP].[Escort].[Student age 5-15]	1.0854	10.27	No Change
Child age 0-4	[DAP].[BP].[Escort].[Child age 0-4]	1.3957	14.71	No Change
Age				
Adult aged 51-65	[DAP].[BP].[Escort].[Age 51-65]	-0.3001	-5.09	No Change
Adult aged 66+	[DAP].[BP].[Escort].[Age 66+]	-0.3352	-2.90	No Change
Household Income[3]				
Upper income	[DAP].[BP].[Escort].[IncomeSegment]	0.1379	3.82	No Change
Top income	[DAP].[BP].[Escort].[IncomeSegment]	0.1379	3.82	No Change
Missing income[4]	*Used for Model Estimation Only*	*0.1840*	*0.69*	–
Household Composition				
Adult female, no children	[DAP].[BP].[Escort].[Female / none/IsAdult]	0.2583	4.24	No Change
Adult female, 1+ children aged 0-4[5]	[DAP].[BP].[Escort].[Female / age 0-4/IsAdult]	–	–	2.4608
Adult female, 1+ children aged 0-15[5]	[DAP].[BP].[Escort].[Female / age 5-15/IsAdult]	2.4608	36.39	No Change
Adult male, 1+ children aged 0-4[5]	[DAP].[BP].[Escort].[Male / age 0-4/IsAdult]	–	–	2.0694
Adult male, 1+ children aged 0-15[5]	[DAP].[BP].[Escort].[Male / age 5-15/IsAdult]	2.0694	27.15	No Change
Other Person/Household Characteristics				
Autos per adult	[DAP].[BP].[Escort].[Cars per adult in HH]	-0.0966	-2.44	No Change
Only worker	[DAP].[BP].[Escort].[Only worker in HH]	-0.4336	-7.27	No Change
Works at home	[DAP].[BP].[Escort].[Work at home]	0.1324	2.02	No Change
1+ Personal Business Tours or Stops				
Person Type				
Part-time worker	[DAP].[BP].[PersonalBusiness].[Part-time worker]	0.1840	3.88	No Change
Non-worker age 65+	[DAP].[BP].[PersonalBusiness].[Retired]	0.2556	3.79	No Change
Other non-worker	[DAP].[BP].[PersonalBusiness].[Other non-worker]	0.2298	3.68	0.1103
University student	[DAP].[BP].[PersonalBusiness].[University student]	0.3393	2.30	No Change
Student age 16+	[DAP].[BP].[PersonalBusiness].[Student age 16+]	-0.2248	-1.88	No Change
Age				
Adult aged 18-25	[DAP].[BP].[PersonalBusiness].[Age 18-25]	0.1665	1.48	No Change

Tour / Stop Purpose[1]	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Household Composition				
Adult female, no children	[DAP].[BP].[PersonalBusiness].[Female / none/ IsAdult]	0.1121	3.22	No Change
Adult male, 1+ children aged 0-4[5]	[DAP].[BP].[PersonalBusiness].[Male / age 0-4/ IsAdult]	–	–	-0.1013
Adult male, 1+ children aged 0-15[5]	[DAP].[BP].[PersonalBusiness].[Male / age 5-15/ IsAdult]	-0.1013	-1.65	No Change
Other Person/Household Characteristics				
Autos per (worker + 1)	[DAP].[BP].[PersonalBusiness].[Cars per worker+1 in HH]	0.0820	3.11	No Change
Only adult	[DAP].[BP].[PersonalBusiness].[Only adult in HH]	0.1246	2.31	No Change
Only worker	[DAP].[BP].[PersonalBusiness].[Only worker in HH]	-0.0958	-1.97	No Change
Works at home	[DAP].[BP].[PersonalBusiness].[Work at home]	0.1831	3.63	No Change
1+ Shop Tours or Stops				
Person Type				
Part-time worker	[DAP].[BP].[Shop].[Part-time worker]	0.2929	6.01	No Change
Non-worker age 65+	[DAP].[BP].[Shop].[Retired]	0.3240	3.86	No Change
Other non-worker	[DAP].[BP].[Shop].[Other non-worker]	0.3722	6.01	0.1787
Student age 16+	[DAP].[BP].[Shop].[Student age 16+]	-0.5682	-4.21	No Change
Age				
Adult aged 51-65	[DAP].[BP].[Shop].[Age 51-65]	-0.0844	-1.82	No Change
Adult aged 66+	[DAP].[BP].[Shop].[Age 66+]	-0.1537	-1.92	No Change
Household Composition				
Adult female, no children	[DAP].[BP].[Shop].[Female / none/IsAdult]	0.2511	6.93	No Change
Adult female, 1+ children aged 0-4[5]	[DAP].[BP].[Shop].[Female / age 0-4/IsAdult]	0.1004	1.35	No Change
Adult male, 1+ children aged 0-4[5]	[DAP].[BP].[Shop].[Male / age 0-4/IsAdult]	-0.2036	-2.75	-0.0667
Adult male, 1+ children aged 0-15[5]	[DAP].[BP].[Shop].[Male / age 5-15/IsAdult]	0.1369	1.35	No Change
Other Person/Household Characteristics				
Autos per (worker + 1)	[DAP].[BP].[Shop].[Cars per worker+1 in HH]	0.0284	1.06	No Change
Only adult	[DAP].[BP].[Shop].[Only adult in HH]	0.0887	1.77	No Change
Works at home	[DAP].[BP].[Shop].[Work at home]	0.0993	1.91	No Change

Tour / Stop Purpose[1]	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
1+ Meal Tours or Stops				
Person Type				
Non-worker age 65+	[DAP].[BP].[Meal].[Retired]	0.2451	3.84	No Change
Student age 16+	[DAP].[BP].[Meal].[Student age 16+]	-0.1556	-1.10	No Change
Student age 5-15	[DAP].[BP].[Meal].[Student age 5-15]	-0.1875	-1.81	No Change
Child age 0-4	[DAP].[BP].[Meal].[Child age 0-4]	-0.3601	-3.61	No Change
Household Income[3]				
Lower income	[DAP].[BP].[Meal].[IncomeSegment]	-0.4017	-5.40	No Change
Modest income	[DAP].[BP].[Meal].[IncomeSegment]	-0.1676	-3.46	No Change
Upper income	[DAP].[BP].[Meal].[IncomeSegment]	0.1130	2.53	No Change
Top income	[DAP].[BP].[Meal].[IncomeSegment]	0.1391	2.61	No Change
Missing income[4]	*Used for Model Estimation Only*	*0.0841*	*0.38*	–
Household Composition				
Adult female, 1+ children aged 0-4[5]	[DAP].[BP].[Meal].[Female / age 0-4/IsAdult]	–	–	-0.4335
Adult female, 1+ children aged 0-15[5]	[DAP].[BP].[Meal].[Female / age 5-15/IsAdult]	-0.4335	-7.22	No Change
Other Person/Household Characteristics				
Autos per (worker + 1)	[DAP].[BP].[Meal].[Cars per worker+1 in HH]	0.0719	2.43	No Change
Works at home	[DAP].[BP].[Meal].[Work at home]	0.1779	2.99	No Change
1+ Social Recreation Tours or Stops				
Person Type				
Part-time worker	[DAP].[BP].[SocialRecreational].[Part-time worker]	0.1138	2.13	No Change
Non-worker age 65+	[DAP].[BP].[SocialRecreational].[Retired]	0.1886	2.19	No Change
Other non-worker	[DAP].[BP].[SocialRecreational].[Other non-worker]	0.1701	2.87	0.0817
University student	[DAP].[BP].[SocialRecreational].[University student]	0.3938	2.64	0.7718
Student age 16+	[DAP].[BP].[SocialRecreational].[Student age 16+]	0.2747	2.67	0.5384
Student age 5-15	[DAP].[BP].[SocialRecreational].[Student age 5-15]	0.8992	13.81	No Change
Child age 0-4	[DAP].[BP].[SocialRecreational].[Child age 0-4]	0.4056	5.78	0.1460
Age				
Adult aged 18-25	[DAP].[BP].[SocialRecreational].[Age 18-25]	0.4101	3.81	No Change
Adult aged 26-35				
Adult aged 51-65	[DAP].[BP].[SocialRecreational].[Age 51-65]	-0.2174	-4.82	No Change
Adult aged 66+	[DAP].[BP].[SocialRecreational].[Age 66+]	-0.1619	-2.01	No Change

Tour / Stop Purpose[1]	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Household Income[3]				
Lower income	[DAP].[BP].[SocialRecreational].[IncomeSegment]	-0.5434	-9.13	No Change
Modest income	[DAP].[BP].[SocialRecreational].[IncomeSegment]	-0.2695	-7.06	No Change
Missing income[4]	*Used for Model Estimation Only*	*-0.1908*	*-0.95*	–
Household Composition				
Adult female, no children	[DAP].[BP].[SocialRecreational].[Female / none/ IsAdult]	0.1310	3.34	No Change
Adult female, 1+ children aged 0-4[5]	[DAP].[BP].[SocialRecreational].[Female / age 0-4/IsAdult]	–	–	0.1690
Adult female, 1+ children aged 0-15[5]	[DAP].[BP].[SocialRecreational].[Female / age 5-15/IsAdult]	0.1690	3.05	No Change
Adult male, 1+ children aged 0-4[5]	[DAP].[BP].[SocialRecreational].[Male / age 0-4/ IsAdult]	–	–	0.0718
Adult male, 1+ children aged 0-15[5]	[DAP].[BP].[SocialRecreational].[Male / age 5-15/ IsAdult]	0.0718	1.18	No Change
Other Person/Household Characteristics				
Only adult	[DAP].[BP].[SocialRecreational].[Only adult in HH]	0.1061	2.16	No Change
Works at home	[DAP].[BP].[SocialRecreational].[Work at home]	0.1219	2.35	No Change
1+ Non-Closed Work Tours				
Person Type				
Part-time worker	[DAP].[BP].[WorkNCT].[Part-time worker]	-0.7848	-4.52	-0.7065
Non-worker age 65+	[DAP].[BP].[WorkNCT].[Retired]	-3.0452	-7.42	No Change
Other non-worker	[DAP].[BP].[WorkNCT].[Other non-worker]	-1.5103	-2.90	No Change
University student	[DAP].[BP].[WorkNCT].[University student]	-0.5954	-1.07	No Change
Student age 16+	[DAP].[BP].[WorkNCT].[Student age 16+]	-0.8395	-1.52	No Change
Student age 5-15	[DAP].[BP].[WorkNCT].[Student age 5-15]	-20.0000	Fixed	No Change
Child age 0-4	[DAP].[BP].[WorkNCT].[Child age 0-4]	-20.0000	Fixed	No Change
Age				
Adult aged 18-25	[DAP].[BP].[WorkNCT].[Age 18-25]	1.2046	4.88	No Change
Adult aged 26-35	[DAP].[BP].[WorkNCT].[Age 26-35]	0.5281	2.96	No Change
Adult aged 51-65	[DAP].[BP].[WorkNCT].[Age 51-65]	-0.2135	-1.43	No Change
Adult aged 66+	[DAP].[BP].[WorkNCT].[Age 66+]	-0.7519	-2.58	No Change
Household Composition				
Adult female, no children	[DAP].[BP].[WorkNCT].[Female / none/IsAdult]	-0.4723	-3.30	No Change
Adult female, 1+ children aged 0-4[5]	[DAP].[BP].[WorkNCT].[Female / age 0-4/IsAdult]	–	–	-0.6311
Adult female, 1+ children aged 0-15[5]	[DAP].[BP].[WorkNCT].[Female / age 5-15/IsAdult]	-0.6311	-2.86	No Change

Tour / Stop Purpose[1]	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Other Person/Household Characteristics				
Autos per adult	[DAP].[BP].[WorkNCT].[Cars per adult in HH]	0.2186	2.09	No Change
Only adult	[DAP].[BP].[WorkNCT].[Only adult in HH]	-0.3037	-1.44	No Change
Only worker	[DAP].[BP].[WorkNCT].[Only worker in HH]	0.2856	1.96	No Change
Works at home	[DAP].[BP].[WorkNCT].[Work at home]	-1.6641	-7.95	No Change
No regular workplace[2]	[DAP].[BP].[WorkNCT].[No regular workplace]	-1.5133	-3.84	No Change
1+ Non-Closed Other Tours				
Person Type				
Non-worker age 65+	[DAP].[BP].[OtherNCT].[Retired]	-0.2450	-0.81	No Change
Other non-worker	[DAP].[BP].[OtherNCT].[Other non-worker]	-0.6468	-4.05	No Change
University student	[DAP].[BP].[OtherNCT].[University student]	0.3686	1.31	No Change
Student age 16+	[DAP].[BP].[OtherNCT].[Student age 16+]	1.1816	4.63	No Change
Student age 5-15	[DAP].[BP].[OtherNCT].[Student age 5-15]	1.2890	6.53	No Change
Child age 0-4	[DAP].[BP].[OtherNCT].[Child age 0-4]	-0.6470	-2.56	No Change
Age				
Adult aged 18-25	[DAP].[BP].[OtherNCT].[Age 18-25]	1.4381	6.48	No Change
Adult aged 26-35	[DAP].[BP].[OtherNCT].[Age 26-35]	0.4154	2.08	No Change
Adult aged 51-65	[DAP].[BP].[OtherNCT].[Age 51-65]	-0.4670	-2.84	No Change
Adult aged 66+	[DAP].[BP].[OtherNCT].[Age 66+]	-1.3340	-4.22	No Change
Household Income[3]				
Lower income	[DAP].[BP].[OtherNCT].[IncomeSegment]	–	–	0.5660
Top income	[DAP].[BP].[OtherNCT].[IncomeSegment]	0.2940	2.33	No Change
Missing income[4]	*Used for Model Estimation Only*	*0.5662*	*0.95*	–
Household Composition				
Adult female, 1+ children aged 0-4[5]	[DAP].[BP].[OtherNCT].[Female / age 0-4/IsAdult]	–	–	-0.4180
Adult female, 1+ children aged 0-15[5]	[DAP].[BP].[OtherNCT].[Female / age 5-15/ IsAdult]	-0.4180	-2.24	No Change
Adult male, 1+ children aged 0-4[5]	[DAP].[BP].[OtherNCT].[Male / age 0-4/IsAdult]	–	–	-0.5392
Adult male, 1+ children aged 0-15[5]	[DAP].[BP].[OtherNCT].[Male / age 5-15/IsAdult]	-0.5392	-2.51	No Change
Other Person/Household Characteristics				
Autos per adult	[DAP].[BP].[OtherNCT].[Cars per adult in HH]	0.0872	1.02	No Change
Works at home	[DAP].[BP].[OtherNCT].[Work at home]	-0.4142	-2.24	No Change

Source: Cambridge Systematics

Notes: [1] In the DRCOG Focus model code, *BPtk* and *BPsk* were included in the *BP* array which stood for "purposes." The original DRCOG Focus utility equation was rewritten to identify constants (*BPtk* and *BPsk*), person/household characteristics (*BPphc*), and mode choice logsum and accessibility variables (*BPls*) associated with the different purposes. However, to maintain C# code consistency, all of the variables are included in the group of coefficients starting with: "[DAP].[BP]."

[2] If the person works at home, the "No regular workplace" coefficient is not applied.
[3] The StateFocus Code Parameter Names for income related variables are input as a six element array as follows: [Less than $30K, $30K-$40K, $40K-$60K, $60K-$100K, $100K-$150K, $150K or more]. The six elements correspond to the following income groups: [Lower income, Modest Income, Modest Income (modest income coefficient is repeated), Middle Income, Upper Income, Top Income].
[4] Variable used for model estimation purposes only and is not used in model application.
[5] The original model estimation used "…children aged 0-4" and "…children aged 0-15". In the application and calibration, the variables were split so they didn't overlap. However, the splitting of the ranges didn't affect the effective meaning of the variables since they simply check for the presence of one or more children in the age range. The final calibrated coefficients without overlap produce the same results as the initially estimated coefficients with overlap.

F.6.4 BPls – Purpose-Specific Coefficients by Mode Choice Logsum and Aggregate Accessibility Logsum for Making 1+ Tours or 1+ Stops

BPls is a set of coefficients applied to the mode choice logsum and aggregate accessibility logsum data associated with the home zone of the person for a specific purpose. The coefficients shown in ***Table F.8*** are applied for each tour purpose and/or stop purpose alternative for each person based on whether or not they have the characteristic with the exception that the coefficients are applied only once if the stop purpose is the same as the tour purpose. The variable by tour/stop purpose, StateFocus C# parameter names, estimated model constants and t-statistics, and final calibrated parameters based on the 2015 model calibration/ validation are shown in ***Table F.8***, below.

Table F.8 BPls – Purpose-Specific Coefficients by Mode Choice Logsum and Aggregate Accessibility Logsum Data for Making 1+ Tours or 1+ Stops

Tour / Stop Purpose[1]	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
1+ Work Tours or Stops				
Mode Choice Logsum[2]	[DAP].[BP].[Work].[MC logsum]	0.2989	4.65	No Change
1+ School Tours or Stops				
Mode Choice Logsum[2]	[DAP].[BP].[School].[MC logsum]	0.1055	3.54	No Change
1+ Escort Tours or Stops				
Aggregate Accessibility Logsum	[DAP].[BP].[Escort].[Accessibility logsum]	0.0781	3.87	No Change
1+ Personal Business Tours or Stops[3]				
1+ Shop Tours or Stops				
Aggregate Accessibility Logsum	[DAP].[BP].[Shop].[Accessibility logsum]	0.0446	2.92	No Change
1+ Meal Tours or Stops				
Aggregate Accessibility Logsum	[DAP].[BP].[Meal].[Accessibility logsum]	0.0398	2.17	No Change
Home Retail Employment Density	[DAP].[BP].[Meal].[Home retail emp density]	0.2000	4.52	No Change

Tour / Stop Purpose[1]	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
1+ Social Recreation Tours or Stops[3]				
1+ Non-Closed Work Tours				
Aggregate Accessibility Logsum[4]	[DAP].[BP].[WorkNCT].[Accessibility logsum]	-0.1292	-1.77	No Change
1+ Non-Closed Other Tours[3]				

Source: Cambridge Systematics

Notes:

[1] In the DRCOG Focus model code, *BPtk* and *BPsk* were included in the *BP* array which stood for "purposes." The original DRCOG Focus utility equation was rewritten to identify constants (*BPtk* and *BPsk*), person/household characteristics (*BPphc*), and mode choice logsum and accessibility variables (*BPls*) associated with the different purposes. However, to maintain C# code consistency, all of the variables are included in the group of coefficients starting with: "[DAP].[BP]."

[2] If the person works at home, the "Mode Choice Logsum" coefficient is not applied.

[3] No mode choice logsum, aggregate accessibility logsum, or zonal variables were significant for the tour/stop purpose.

[4] In order to simplify the model application, the aggregate accessibility for non-closed work tours is the average of the aggregate accessibilities for escort, personal business, shop, meal, and social-recreation.

F.6.5 BTphc, BSphc, BTls, & BSls – Coefficients by Person Characteristic and by Home Average Accessibility Logsum for Making More Than 1 Tour Purpose or More Than 1 Stop Purpose

BTphc and *BSphc* are sets of coefficients applied based on person characteristics that affect the likelihood of making tours for more than one tour purpose or stops for more than one stop purpose. *BTphc* is applied for tours and *BSphc* is applied for stops. Likewise, *BTls* and *BSls* are sets of coefficients applied based on the home average accessibility logsum with *BTls* applied for additional tour purposes and *BSls* applied for additional tour purposes. Since the sum of the coefficients are multiplied by ln(count of tours), this component does not become active unless there are two or more tour purposes or two or more stop purposes in the daily activity pattern.

The coefficients shown in ***Table F.9*** are applied based on the tour and/or stop purpose patterns for an alternative. They are not purpose specific. Thus, the same coefficients would be applied for daily activity patterns of 1+ work tours / 1+ shop tours and 1+ escort tours / 1+ social recreation tours since there are two tour purposes in each; the exact number of tours model is used to determine the actual numbers of work tours and shop tours, or escort tours and social recreation tours. The variable by set (*BTphc*, *BSphc*, *BTls*, & *BSls*), StateFocus C# parameter names, estimated model constants and t-statistics, and final calibrated parameters based on the 2015 model calibration/validation are shown in ***Table F.9***, below.

Table F.9 BTphc, BSphc, BTls, & BSls – Coefficients by Person Characteristic and by Aggregate Accessibility Logsum for Making More Than 1 Tour Purpose or More Than 1 Stop Purpose

Tour / Stop Purpose	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
BTphc – 1+ Tour Purposes by Person Characteristic				
Person Type				
Part-time worker	[DAP].[BT].[Part-time worker]	0.7083	8.04	No Change
Non-worker age 65+	[DAP].[BT].[Retired]	0.4180	2.91	No Change
Other non-worker	[DAP].[BT].[Other non-worker]	0.4532	4.78	No Change
University student	[DAP].[BT].[University student]	0.5737	2.35	No Change
Student age 5-15	[DAP].[BT].[Student age 5-15]	-0.5719	-5.15	No Change
Age				
Adult aged 18-25	[DAP].[BT].[Age 18-25]	-0.9967	-7.08	No Change
Adult aged 51-65	[DAP].[BT].[Age 51-65]	0.2015	2.89	No Change
Adult aged 66+	[DAP].[BT].[Age 66+]	0.1725	1.41	No Change
Household Income[1]				
Lowest income	[DAP].[BT].[IncomeSegment]	-0.3992	-5.66	No Change
Modest income	[DAP].[BT].[IncomeSegment]	-0.1321	-2.56	No Change
Missing income[2]	*Used for Model Estimation Only*	*-0.1416*	*-0.53*	–
Household Composition				
Adult female, no children	[DAP].[BT].[Female / none/IsAdult]	-0.4139	-7.00	No Change
Adult female, 1+ children aged 0-4[3]	[DAP].[BT].[Female / age 0-4/IsAdult]	-0.8304	-7.03	-0.5647
Adult female, 1+ children aged 0-15[3]	[DAP].[BT].[Female / age 5-15/IsAdult]	0.2657	2.71	No Change
Adult male, 1+ children aged 0-4[3]	[DAP].[BT].[Male / age 0-4/IsAdult]	-0.6734	-5.12	-0.4735
Adult male, 1+ children aged 0-15[3]	[DAP].[BT].[Male / age 5-15/IsAdult]	0.1999	1.88	0.1999
Other Person/Household Characteristics				
Autos per adult	[DAP].[BT].[Cars per adult in HH]	0.0887	2.02	No Change
Only worker	[DAP].[BT].[Only worker in HH]	0.0934	1.21	No Change
BSphc – 1+ Stop Purposes by Person Characteristic				
Person Type				
Other non-worker	[DAP].[BS].[Other non-worker]	0.0518	0.77	No Change
Student age 16+	[DAP].[BS].[Student age 16+]	0.5101	3.31	No Change
Student age 5-15	[DAP].[BS].[Student age 5-15]	-0.2692	-3.53	No Change

Tour / Stop Purpose	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Age				
Adult aged 18-25	[DAP].[BS].[Age 18-25]	-0.3630	-3.92	No Change
Adult aged 51-65	[DAP].[BS].[Age 51-65]	0.2807	6.50	No Change
Adult aged 66+	[DAP].[BS].[Age 66+]	0.1750	2.74	No Change
Household Income[1]				
Lowest income	[DAP].[BS].[IncomeSegment]	-0.1351	-2.51	No Change
Missing income[2]	*Used for Model Estimation Only*	*-0.0830*	*-0.44*	–
Household Composition				
Adult male, 1+ children aged 0-4[3]	[DAP].[BS].[Male / age 0-4/IsAdult]	–	–	-0.2956
Adult male, 1+ children aged 0-15[3]	[DAP].[BS].[Male / age 5-15/IsAdult]	-0.2956	-4.51	No Change
Other Person/Household Characteristics				
Autos per adult	[DAP].[BS].[Cars per adult in HH]	0.0808	2.63	No Change
Only adult	[DAP].[BS].[Only adult in HH]	0.3419	5.90	No Change
BTls – 1+ Tour Purposes by Person Characteristic[4]				
Home Average Accessibility Logsum	[DAP].[BT].[Home Aggregate Accessibility]	0.2902	11.07	No Change
BSls – 1+ Stop Purposes by Person Characteristic[4]				
Home Average Accessibility Logsum	[DAP].[BS].[Home Aggregate Accessibility]	-0.1605	-7.05	No Change

Source: Cambridge Systematics

Notes:

[1] The StateFocus Code Parameter Names for income related variables are input as a six element array as follows: [Less than $30K, $30K-$40K, $40K-$60K, $60K-$100K, $100K-$150K, $150K or more]. The six elements correspond to the following income groups: [Lower income, Modest Income, Modest Income (modest income coefficient is repeated), Middle Income, Upper Income, Top Income].

[2] Variable used for model estimation purposes only and is not used in model application.

[3] The original model estimation used "…children aged 0-4" and "…children aged 0-15". In the application and calibration, the variables were split so they didn't overlap. However, the splitting of the ranges didn't affect the effective meaning of the variables since they simply check for the presence of one or more children in the age range. The final calibrated coefficients without overlap produce the same results as the initially estimated coefficients with overlap.

[4] In the DRCOG Focus model code, *BTphc* and *BSphc* were included in the *BT* and *BS* arrays which stood for tours and stops" The original DRCOG Focus utility equation was rewritten to identify person characteristics (*BTphc* and *BSphc*), and mode choice logsum and accessibility variables (*BTls* and *BSls*) associated with the making of multiple tour or stop purposes. However, to maintain C# code consistency, all of the variables are included in the groups of coefficients starting with: "[DAP].[BT]" and "[DAP].[BS]."

F.6.6 X, Y, & Z – Coefficients for Tour-Tour Purpose, Stop-Stop Purpose, and Tour-Stop Purpose Combinations

Many of the 2,146 daily activity pattern alternatives include combinations of two tour purposes, two stop purposes, and/or a tour and stop purpose:

- The X matrix (***Table F.10***) provides additional coefficients (constants) added to the utility equation for each combination of two different tour purposes; only a half-matrix is estimated, with the diagonal constrained to 0.
- The Y matrix (***Table F.11***) provides additional coefficients (constants) added to the utility equation for each combination of two different stop purposes; only a half-matrix is estimated, with the diagonal constrained to 0.
- The Z matrix (***Table F.12***) provides additional coefficients (constants) added to the utility equation for each combination of a tour and a stop purpose. A nearly full matrix can be estimated, as all stop purposes and tour purposes can occur together in the same pattern.

Purpose combinations, StateFocus C# parameter names, estimated model constants and t-statistics, and final calibrated parameters based on the 2015 model calibration/validation are shown in ***Table F.10*** through ***Table F.12*** below.

Table F.10 X – Coefficients by Tour Purpose Combination

Tour + Tour Purpose Combination	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Work + School	[DAP].[Xpq].[Tour+Tour].[Work+School]	-1.0075	-6.97	-1.4018
Work + Escort	[DAP].[Xpq].[Tour+Tour].[Work+Escort]	-1.0806	-15.21	-1.4473
Work + Personal Business	[DAP].[Xpq].[Tour+Tour].[Work+PersonalBusiness]	-0.9254	-14.11	-1.2194
Work + Shop	[DAP].[Xpq].[Tour+Tour].[Work+Shop]	-0.6988	-10.78	-0.9209
Work + Meal	[DAP].[Xpq].[Tour+Tour].[Work+Meal]	-0.0590	-0.82	-0.0778
Work + Social Recreation	[DAP].[Xpq].[Tour+Tour].[Work+SocialRecreational]	-0.3340	-5.83	-0.4401
Work + Work Non-Closed Tour	[DAP].[Xpq].[Tour+Tour].[WorkNCT+Work]	-3.4048	-15.57	-0.5648
Work + Other Non-Closed Tour	[DAP].[Xpq].[Tour+Tour].[OtherNCT+Work]	-1.6490	-9.66	-0.2735
School + Escort	[DAP].[Xpq].[Tour+Tour].[School+Escort]	-0.9901	-11.00	-1.5830
School + Personal Business	[DAP].[Xpq].[Tour+Tour].[School+PersonalBusiness]	-0.8746	-9.40	-1.5365
School + Shop	[DAP].[Xpq].[Tour+Tour].[School+Shop]	-0.7347	-7.64	-1.2909
School + Meal	[DAP].[Xpq].[Tour+Tour].[School+Meal]	-0.1756	-1.47	-0.3086
School + Social Recreation	[DAP].[Xpq].[Tour+Tour].[School+SocialRecreational]	-0.2733	-4.03	-0.4802
School + Other Non-Closed Tour	[DAP].[Xpq].[Tour+Tour].[OtherNCT+School]	-2.0685	-12.15	-0.4343

Tour + Tour Purpose Combination	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Escort + Personal Business	[DAP].[Xpq].[Tour+Tour].[Escort+ PersonalBusiness]	0.4669	6.49	0.0883
Escort + Shop	[DAP].[Xpq].[Tour+Tour].[Escort+Shop]	0.3813	5.14	0.0721
Escort + Meal	[DAP].[Xpq].[Tour+Tour].[Escort+Meal]	0.3873	3.99	0.0733
Escort + Social Recreation	[DAP].[Xpq].[Tour+Tour].[Escort+ SocialRecreational]	0.2760	4.19	-0.0522
Escort + Work Non-Closed Tour	[DAP].[Xpq].[Tour+Tour].[WorkNCT+Escort]	-0.4464	-1.67	-0.0750
Escort + Other Non-Closed Tour	[DAP].[Xpq].[Tour+Tour].[OtherNCT+Escort]	0.0085	0.04	0.0323
Personal Business + Shop	[DAP].[Xpq].[Tour+Tour].[PersonalBusiness+ Shop]	0.3365	5.11	0.1745
Personal Business + Meal	[DAP].[Xpq].[Tour+Tour].[PersonalBusiness+ Meal]	0.5995	7.66	0.3108
Personal Business + Social Recreation	[DAP].[Xpq].[Tour+Tour].[PersonalBusiness+ SocialRecreational]	0.1490	2.40	0.0773
Personal Business + Work Non-Closed Tour	[DAP].[Xpq].[Tour+Tour].[WorkNCT+ PersonalBusiness]	-0.3569	-1.42	-0.0926
Personal Business + Other Non-Closed Tour	[DAP].[Xpq].[Tour+Tour].[OtherNCT+ PersonalBusiness]	-0.6612	-2.79	-0.1714
Shop + Meal	[DAP].[Xpq].[Tour+Tour].[Shop+Meal]	0.1517	1.71	0.0638
Shop + Social Recreation	[DAP].[Xpq].[Tour+Tour].[Shop+ SocialRecreational]	0.2006	3.22	0.0842
Shop + Work Non-Closed Tour	[DAP].[Xpq].[Tour+Tour].[WorkNCT+Shop]	-0.6226	-2.06	-0.1614
Shop + Other Non-Closed Tour	[DAP].[Xpq].[Tour+Tour].[OtherNCT+Shop]	-0.7004	-2.74	-0.1816
Meal + Work Non-Closed Tour	[DAP].[Xpq].[Tour+Tour].[WorkNCT+Meal]	-0.4367	-1.12	-0.1132
Meal + Other Non-Closed Tour	[DAP].[Xpq].[Tour+Tour].[OtherNCT+Meal]	-0.4528	-1.32	-0.1174
Social Recreation + Work Non-Closed Tour	[DAP].[Xpq].[Tour+Tour].[WorkNCT+ SocialRecreational]	-1.1170	-3.71	-0.2895
Social Recreation + Other Non-Closed Tour	[DAP].[Xpq].[Tour+Tour].[OtherNCT+ SocialRecreational]	-0.8942	-4.26	-0.2318

Source: Cambridge Systematics

Table F.11 Y – Coefficients by Stop Purpose Combination

Stop + Stop Purpose Combination	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Work + Escort	[DAP].[Ypq].[Stop+Stop].[Work+Escort]	-0.5384	-5.78	-0.2692
Work + Personal Business	[DAP].[Ypq].[Stop+Stop].[Work+ PersonalBusiness]	-0.2387	-2.96	-0.1193
Work + Shop	[DAP].[Ypq].[Stop+Stop].[Work+Shop]	-0.4716	-5.55	-0.2358
Work + Meal	[DAP].[Ypq].[Stop+Stop].[Work+Meal]	0.2313	2.72	0.3469
Work + Social Recreation	[DAP].[Ypq].[Stop+Stop].[Work+ SocialRecreational]	-0.6022	-6.00	-0.3011
School + Escort	[DAP].[Ypq].[Stop+Stop].[School+Escort]	-0.6684	-3.45	-0.6684
School + Personal Business	[DAP].[Ypq].[Stop+Stop].[School+ PersonalBusiness]	-0.0766	-0.49	-0.0766
School + Shop	[DAP].[Ypq].[Stop+Stop].[School+Shop]	-0.6829	-3.26	-0.6829
School + Meal	[DAP].[Ypq].[Stop+Stop].[School+Meal]	0.8931	5.65	0.8931
School + Social Recreation	[DAP].[Ypq].[Stop+Stop].[School+ SocialRecreational]	0.1834	1.21	0.1834
Escort + Personal Business	[DAP].[Ypq].[Stop+Stop].[Escort+ PersonalBusiness]	-0.3242	-4.54	-0.3242
Escort + Shop	[DAP].[Ypq].[Stop+Stop].[Escort+Shop]	-0.3826	-5.18	-0.3826
Escort + Meal	[DAP].[Ypq].[Stop+Stop].[Escort+Meal]	-0.2038	-2.52	-0.2038
Escort + Social Recreation	[DAP].[Ypq].[Stop+Stop].[Escort+ SocialRecreational]	-0.2002	-2.62	-0.2002
Personal Business + Shop	[DAP].[Ypq].[Stop+Stop].[PersonalBusiness+ Shop]	-0.0282	-0.44	-0.0282
Personal Business + Meal	[DAP].[Ypq].[Stop+Stop].[PersonalBusiness+ Meal]	-0.1564	-2.29	-0.1564
Personal Business + Social Recreation	[DAP].[Ypq].[Stop+Stop].[PersonalBusiness+ SocialRecreational]	-0.4787	-6.82	-0.4787
Shop + Meal	[DAP].[Ypq].[Stop+Stop].[Shop+Meal]	-0.2733	-3.93	-0.2733
Shop + Social Recreation	[DAP].[Ypq].[Stop+Stop].[Shop+ SocialRecreational]	-0.5408	-7.59	-0.5408

Source: Cambridge Systematics

Table F.12 Z – Coefficients by Tour-Stop Purpose Combination

Tour + Stop Purpose Combination[1]	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Work + Work	[DAP].[Zpq].[Tour+Stop].[Work+Work]	-0.6556	-3.41	-1.2431
Work + School	[DAP].[Zpq].[Tour+Stop].[Work+School]	-0.4139	-1.59	-0.8253
Work + Escort	[DAP].[Zpq].[Tour+Stop].[Work+Escort]	1.2045	15.73	0.5304
Work + Personal Business	[DAP].[Zpq].[Tour+Stop].[Work+ PersonalBusiness]	-0.0924	-1.62	-0.2690

Tour + Stop Purpose Combination[1]	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Work + Shop	[DAP].[Zpq].[Tour+Stop].[Work+Shop]	-0.2888	-4.95	-0.6087
Work + Meal	[DAP].[Zpq].[Tour+Stop].[Work+Meal]	0.0492	0.66	-0.0784
School + School	[DAP].[Zpq].[Tour+Stop].[School+School]	-1.5291	-7.34	-2.2387
School + Escort	[DAP].[Zpq].[Tour+Stop].[School+Escort]	1.1974	12.91	0.7855
School + Personal Business	[DAP].[Zpq].[Tour+Stop].[School+ PersonalBusiness]	-0.4477	-6.09	-0.6554
School + Shop	[DAP].[Zpq].[Tour+Stop].[School+Shop]	-0.8439	-10.61	-1.2354
School + Meal	[DAP].[Zpq].[Tour+Stop].[School+Meal]	-0.4362	-4.04	-0.6387
Escort + Escort	[DAP].[Zpq].[Tour+Stop].[Escort+Escort]	3.2417	22.94	-0.3857
Escort + Personal Business	[DAP].[Zpq].[Tour+Stop].[Escort+ PersonalBusiness]	0.3354	5.88	0.8249
Escort + Shop	[DAP].[Zpq].[Tour+Stop].[Escort+Shop]	0.3299	5.67	-0.0653
Escort + Meal	[DAP].[Zpq].[Tour+Stop].[Escort+Meal]	0.4068	5.63	-0.2031
Personal Business + Escort	[DAP].[Zpq].[Tour+Stop].[PersonalBusiness+ Escort]	-0.4273	-4.73	-0.5404
Personal Business + Personal Business	[DAP].[Zpq].[Tour+Stop].[PersonalBusiness+ PersonalBusiness]	0.7482	11.12	0.5728
Personal Business + Shop	[DAP].[Zpq].[Tour+Stop].[PersonalBusiness+ Shop]	-0.0723	-1.25	-0.0915
Personal Business + Meal	[DAP].[Zpq].[Tour+Stop].[PersonalBusiness+ Meal]	-0.2251	-2.94	-0.2846
Shop + Escort	[DAP].[Zpq].[Tour+Stop].[Shop+Escort]	-0.5104	-5.50	-0.6453
Shop + Personal Business	[DAP].[Zpq].[Tour+Stop].[Shop+ PersonalBusiness]	0.3351	5.99	0.2565
Shop + Shop	[DAP].[Zpq].[Tour+Stop].[Shop+Shop]	0.6954	9.59	0.5324
Shop + Meal	[DAP].[Zpq].[Tour+Stop].[Shop+Meal]	-0.3922	-4.96	-0.4959
Meal + Escort	[DAP].[Zpq].[Tour+Stop].[Meal+Escort]	-0.3463	-3.18	-0.4380
Meal + Personal Business	[DAP].[Zpq].[Tour+Stop].[Meal+ PersonalBusiness]	0.1584	2.42	0.1213
Meal + Shop	[DAP].[Zpq].[Tour+Stop].[Meal+Shop]	0.3016	4.59	0.2310
Meal + Meal	[DAP].[Zpq].[Tour+Stop].[Meal+Meal]	-0.2188	-1.97	-0.2767
Social Recreation + Escort	[DAP].[Zpq].[Tour+Stop].[SocialRecreational+ Escort]	-0.4870	-6.84	-0.6158
Social Recreation + Personal Business	[DAP].[Zpq].[Tour+Stop].[SocialRecreational+ PersonalBusiness]	-0.0327	-0.63	-0.0413
Social Recreation + Shop	[DAP].[Zpq].[Tour+Stop].[SocialRecreational+ Shop]	0.0226	0.43	0.0174
Social Recreation + Meal	[DAP].[Zpq].[Tour+Stop].[SocialRecreational+ Meal]	0.0696	1.07	0.0532
Work Non-Closed Tour + Escort	[DAP].[Zpq].[Tour+Stop].[WorkNCT+Escort]	0.0949	0.36	0.0897
Work Non-Closed Tour + Personal Business	[DAP].[Zpq].[Tour+Stop].[WorkNCT+ PersonalBusiness]	0.0376	0.24	0.0338

Tour + Stop Purpose Combination[1]	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Work Non-Closed Tour + Shop	[DAP].[Zpq].[Tour+Stop].[WorkNCT+Shop]	-0.5556	-3.01	-0.6111
Work Non-Closed Tour + Meal	[DAP].[Zpq].[Tour+Stop].[WorkNCT+Meal]	-0.2189	-0.99	-0.2408
Other Non-Closed Tour + Escort	[DAP].[Zpq].[Tour+Stop].[OtherNCT+Escort]	0.1818	0.98	0.1718
Other Non-Closed Tour + Personal Business	[DAP].[Zpq].[Tour+Stop].[OtherNCT+ PersonalBusiness]	0.3507	3.11	0.3156
Other Non-Closed Tour + Shop	[DAP].[Zpq].[Tour+Stop].[OtherNCT+Shop]	-0.2420	-1.85	-0.2662
Other Non-Closed Tour + Meal	[DAP].[Zpq].[Tour+Stop].[OtherNCT+Meal]	0.6181	4.48	0.5563

Source: Cambridge Systematics

Notes: [1] The first purpose listed is the tour purpose and the second purpose is the stop purpose.

F.6.7 CNT,NS – Coefficients by Number of Tour Purposes and Number of Stop Purposes in the Daily Activity Pattern Alternative

$C_{NT,NS}$ is a set of coefficients applied based on the number of tour purposes and stop purposes included in the daily activity pattern alternative. The number of purpose and number of stop combinations, StateFocus C# parameter names, estimated model constants and t-statistics, and final calibrated parameters based on the 2015 model calibration/validation are shown in ***Table F.13***.

Table F.13 $C_{NT,NS}$ – Coefficients by Number of Tour Purposes and Number of Stop Purposes in the Daily Activity Pattern Alternative

Number of Tours / Number of Stops Combinations	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
1 tour purpose + 1 stop purpose	[DAP].[c(nt,ns)].[1tourpurpose+ 1stoppurpose]	-2.1638	-12.25	-2.2720
1 tour purpose + 2 stop purposes	[DAP].[c(nt,ns)].[1tourpurpose+ 2stoppurposes]	-3.4532	-11.53	-3.4532
1 tour purpose + 3+stop purposes	[DAP].[c(nt,ns)].[1tourpurpose+ 3+stoppurposes]	-4.1414	-10.65	-4.1414
2 tour purposes + 1 stop purpose	[DAP].[c(nt,ns)].[2tourpurposes+ 1stoppurpose]	-1.7707	-9.84	-1.7707
2 tour purposes + 2 stop purposes	[DAP].[c(nt,ns)].[2tourpurposes+ 2stoppurposes]	-2.9695	-9.76	-2.9695
2 tour purposes + 3 stop purposes	[DAP].[c(nt,ns)].[2tourpurposes+ 3stoppurposes]	-3.1743	-8.22	-3.1743
3 tour purposes + 1 stop purpose	[DAP].[c(nt,ns)].[3tourpurposes+ 1stoppurpose]	-1.6653	-8.41	-1.6653
3 tour purposes + 2 stop purposes	[DAP].[c(nt,ns)].[3tourpurposes+ 2stoppurposes]	-2.8796	-8.80	-2.8796

Source: Cambridge Systematics

F.6.8 Model Estimation Statistics

The daily activity pattern choice model estimation statistics are shown in ***Table F.14***.

Table F.14 Daily Activity Pattern Choice Model Estimation Statistics

Item	Model Estimation Statistics
Number of Observations	29,388
Log-likelihood at Convergence	-114,856
Log-likelihood at Constants	n/a
Log-likelihood at Null Parameters	n/a
Rho-squared w.r.t. Constants	0.490
Rho-squared w.r.t. Null Parameters	0.159

Source: Cambridge Systematics

F.7 Exact Number of Tours Choice

The exact number of tours choice model variables, StateFocus C# parameter names, estimated model constants and t-statistics, and final calibrated parameters based on the 2015 model calibration/validation are shown by tour purpose in ***Sections F.7.1*** through ***F.7.7***. Each section lists the active variables for the purpose under consideration based on the model utility function is shown below (see ***Section 4.2.7*** for full documentation). The base alternative for each purpose, make one tour, has 0.0 utility. The utility function for making two or more tours for each tour purpose is as follows:

$$U_{N|t} = \sum_{pc=1}^{PC} \left(BX_{pc|t} \times PHC_{pc}\right) + L_{N|t} \times Logsum_t + \sum_{z=1}^{7} \left(BYt_{z|t} \times OTN_{z \neq t}\right)$$
$$+ \sum_{z=1}^{7} \left(BYs_{z|t} \times OS_z\right) + \sum_{i=1}^{3} \left(BYcs_{i|t} \times OSN_i\right) + C_{N|t}$$

Where:

- $U_{N|t}$ is the utility of making *N* tours for the day for the given tour purpose *t*; *N* includes the final six alternatives shown in ***Figure 4.11*** and *t* includes the seven tour purposes: work, school, escort, personal business, shop, meal, and social/recreation
- *t* is an index indicating which of the seven different tour purposes is being processed
- *pc* is an index that ranges from 1 to PC for the different person/household characteristics
- $BX_{pc|t}$ is a purpose-specific array of coefficients based on person characteristics or characteristics of the household in which the person is a member related, *pc,* to making 2+ tours for a specific purpose *t*
- PHC_{pc} is a 0/1 array indicating whether the person possesses the indicated person/household characteristic or providing a continuous variable associated with the person or household
- $L_{N|t}$ is an array of coefficients based on the person's mode choice logsum associated with the tour interchange for work and school tours (since the regular workplace or school is known) or the person's aggregate accessibility logsum for other tour purposes
- $Logsum_t$ is the mode choice logsum or aggregate accessibility logsum, as appropriate, associated with the home zone of the person for a specific purpose *t*
- $BYt_{z|t}$ is an array of coefficients based on each of the seven tour purposes for tour purpose *t*
- $OTN_{z \neq t}$ is an array indicating the numbers of tours for purpose *z* made during the day[60]
- $BYs_{z|t}$ is an array of coefficients based each of the seven stop purposes for tour purpose, *t*
- OS_z is a 0/1 array indicating whether the daily activity pattern for a person includes 0 or 1+ stops for purpose *z*
- $BYcs_{i|t}$ is a three element array of coefficients for the number of stop purposes included in the daily activity pattern for the person for tour purpose *t*; the three coefficients relate to making 2+ closed tours or one non-traditional closed tour for each tour purpose
- OSN_i is a three element array with the following information based on the person's daily activity pattern: total number of stop purposes, total number of non-work and non-school stop purposes, and total number of stop purposes (repeated variable used with the coefficient for making one non-traditional closed tour)
- $C_{N|t}$ is a set of constants related to making one of the final six number of tours/tour combinations shown in ***Figure 4.11*** for purpose *t*

[60] The exact number of tours choice model is applied in priority order of tour purposes: work, school, escort, personal business, shop, meal, and social recreation. When higher priority tour purposes are processed, only the existence of 0 or 1+ tours for lower level purposes is known from the results of the daily activity pattern model and are represented in the exact number of tour choice model as a 0 or 1. As subsequent tour purposes are modeled, the modeled numbers of tours for higher level purposes are known and represented in the exact number of tour choice model for the purpose being processed.

F.7.1 Exact Number of Tours Choice Coefficients – Work Tours

The exact number of tours choice model evaluates the tour purposes in priority order with work tours being the highest priority.

Table F.15 Exact Number of Tours Choice Coefficients – Work Tours

Variable	StateFocus Code Parameter Name	Estimated Constant	(t-Statistic)	Calibrated Constant
Array BX – Associated Person & Household Characteristics (PHC$_{pc}$)				
Person Type				
For Making 2+ Tours				
Part-time worker	[ExactNumberTours].[BX].[Work].[Part-time worker]	0.2583	2.90	0.6509
Other non-worker	[ExactNumberTours].[BX].[Work].[Other non-worker]	1.0304	8.12	1.7954
University student	[ExactNumberTours].[BX].[Work].[University student]	-1.4967	-2.01	-1.6464
For Making 1 Non-Traditional Closed Tour				
Full-time worker	[ExactNumberTours].[BX].[Work].[Full-time worker 1 NT closed]	2.2895	2.24	No Change
Part-time worker	[ExactNumberTours].[BX].[Work].[Part-time worker 1 NT closed]	1.3135	1.21	No Change
Adult Age Group				
For Making 2+ Tours				
Adult, age 18-25	[ExactNumberTours].[BX].[Work].[Age 18-25]	-0.2038	-0.88	No Change
Adult, age 66+	[ExactNumberTours].[BX].[Work].[Age 66+]	0.2516	2.16	1.5098
For Making 1 Non-Traditional Closed Tour				
Adult, age 18-25	[ExactNumberTours].[BX].[Work].[Age 18-25 1 NT closed]	0.4753	0.74	No Change
Adult, age 51-65	[ExactNumberTours].[BX].[Work].[Age 51-65 1 NT closed]	-0.6111	-2.02	No Change
Adult, age 66+	[ExactNumberTours].[BX].[Work].[Age 66+ 1 NT closed]	-0.6111	-2.02	No Change
Adult Gender/Children				
For Making 2+ Tours				
Adult female with child age 0-4	[ExactNumberTours].[BX].[Work].[Female / age 0-4/IsAdult]	-0.3880	-2.22	No Change
Household Composition				
For Making 2+ Tours				
Only worker in household	[ExactNumberTours].[BX].[Work].[Only worker in HH]	-0.3083	-3.66	No Change

Variable	StateFocus Code Parameter Name	Estimated Constant	(t-Statistic)	Calibrated Constant
Household Income[1]				
For Making 2+ Tours				
Lower income	[ExactNumberTours].[BX].[Work].[Income Segment]	0.0629	0.42	No Change
Modest income	[ExactNumberTours].[BX].[Work].[Income Segment]	0.0582	0.61	No Change
Upper income	[ExactNumberTours].[BX].[Work].[Income Segment]	-0.2539	-2.69	No Change
Top income	[ExactNumberTours].[BX].[Work].[Income Segment]	-0.6052	-5.01	No Change
Missing Income[2]	*Used for Model Estimation Only*	*-0.3376*	*-0.71*	–
For Making 1 Non-Traditional Closed Tour				
Lower income	[ExactNumberTours].[BX].[Work].[Income Segment 1 NT closed]	0.9552	2.29	No Change
Upper income	[ExactNumberTours].[BX].[Work].[Income Segment 1 NT closed]	-0.3825	-1.00	No Change
Top income	[ExactNumberTours].[BX].[Work].[Income Segment 1 NT closed]	-1.2172	-1.66	No Change
Other				
For Making 2+ Tours				
Autos per adult	[ExactNumberTours].[BX].[Work].[Cars per adult in HH]	0.0948	1.43	No Change
Work at home	[ExactNumberTours].[BX].[Work].[Work at home]	1.2623	9.05	No Change
No regular workplace[3]	[ExactNumberTours].[L].[Work].[No regular workplace - 2+ tours]	-1.5228	-1.48	No Change
For Making 1 Non-Traditional Closed Tour				
Work at home	[ExactNumberTours].[BX].[Work].[Work at home 1 NT closed]	-0.7359	-1.00	No Change
No regular workplace[3]	[ExactNumberTours].[L].[Work].[No regular workplace - 1 NT closed]	-20.0000	Fixed	No Change
L (Associated with Logsum Data)				
Mode Choice Logsum				
To regular work location – 2 Tours	[ExactNumberTours].[L].[Work].[MC logsum to work - 2 tours]	0.3940	7.23	No Change
To regular work location – 3 Tours	[ExactNumberTours].[L].[Work].[MC logsum to work - 3 tours]	0.4763	2.91	No Change
Array BYt – Number of Tours by Purpose (Associated with OTN)				
Other tours in day (0/1+ or counted)[3]				
For Making 2+ Tours				
Escort tours	[ExactNumberTours].[BY].[Work].[Escort tours]	0.2269	3.74	No Change
Personal business tours	[ExactNumberTours].[BY].[Work].[Personal Business tours]	0.2269	3.74	No Change

Variable	StateFocus Code Parameter Name	Estimated Constant	(t-Statistic)	Calibrated Constant
Shop tours	[ExactNumberTours].[BY].[Work].[Shop tours]	0.2269	3.74	No Change
Meal tours	[ExactNumberTours].[BY].[Work].[Meal tours]	0.2269	3.74	No Change
Social/recreation tours	[ExactNumberTours].[BY].[Work].[Social Recreational tours]	0.2269	3.74	No Change
Arrays BYs and BYcs – Stops by Purpose and Number of Stops (Associated with OS and OSN)				
Other stops in day (0/1+)				
For Making 2+ Tours				
Meal stops	[ExactNumberTours].[BY].[Work].[Meal stops]	-0.5064	-4.13	No Change
Count of stop purposes				
For Making 2+ Tours				
Total non-work and non-school stop purposes	[ExactNumberTours].[BY].[Work].[Non-Wrk Sch stop purps - 2+ tours]	0.2546	6.30	No Change
For Making 1 Non-Traditional Closed Tour				
Total stop purposes	[ExactNumberTours].[BY].[Work].[Total Stop purps - 1 NT closed]	-0.8154	-3.92	No Change
Array C – Constants				
2 tours	[ExactNumberTours].[Constant].[Work].[2 tours]	-2.7351	-24.81	-3.2916
3 tours	[ExactNumberTours].[Constant].[Work].[3 tours]	-5.0831	-31.73	-5.6203
1 tour with 1 being non-traditional closed	[ExactNumberTours].[Constant].[Work].[1 Tour & 1 NT closed]	-8.6704	-7.79	No Change
2 tours with 1 being non-traditional closed	[ExactNumberTours].[Constant].[Work].[2 Tours & 1 NT closed]	-3.9371	-3.80	No Change
3 tours with 1 being non-traditional closed	[ExactNumberTours].[Constant].[Work].[3 Tours & 1 NT closed]	-4.2496	-3.60	No Change
Model Estimation Statistics				
Number of Observations	11,323			
Log-likelihood at Convergence	-3,621.5			
Log-likelihood at Constants	n/a			
Log-likelihood at Null Parameters	n/a			
Rho-squared w.r.t. Constants	0.049			
Rho-squared w.r.t. Null Parameters	0.821			

Source: Cambridge Systematics

Notes: [1] The StateFocus Code Parameter Names for income related variables are input as a six element array as follows: [Less than $30K, $30K-$40K, $40K-$60K, $60K-$100K, $100K-$150K, $150K or more]. The six elements correspond to the following income groups: [Lower income, Modest Income, Modest Income (modest income coefficient is repeated), Middle Income, Upper Income, Top Income].

[2] Variable used for model estimation purposes only and is not used in model application.

[3] 0 means there is a regular work location and 1 means there is no regular work location for the person.
[4] The exact number of tours choice model is applied in priority order of tour purposes: work, school, escort, personal business, shop, meal, and social recreation. When higher priority tour purposes are processed, only the existence of 0 or 1+ tours for lower level purposes is known from the results of the daily activity pattern model and are represented in the exact number of tour choice model as a 0 or 1. As subsequent tour purposes are modeled, the modeled numbers of tours for higher level purposes are known and represented in the exact number of tour choice model for the purpose being processed.

F.7.2 Exact Number of Tours Choice Coefficients – School Tours

The exact number of tours choice model evaluates the tour purposes in priority order with school tours being the second highest priority. Some variables used in the school exact number of tours choice model are obtained from the results of the exact number of tours choice models for higher level purposes.

Table F.16 Exact Number of Tours Choice Coefficients – School Tours

Variable	StateFocus Code Parameter Name	Estimated Constant	(t-Statistic)	Calibrated Constant
Array BX – Associated Person & Household Characteristics (PHC_{pc})				
Person Type				
For Making 2+ Tours				
Other non-worker	[ExactNumberTours].[BX].[School].[Other non-worker]	0.4206	0.70	1.0094
University student	[ExactNumberTours].[BX].[School].[University student]	1.7345	2.05	No Change
Student age 16+	[ExactNumberTours].[BX].[School].[Student age 16+]	1.6073	2.39	No Change
Student age 5-15	[ExactNumberTours].[BX].[School].[Student age 5-15]	0.3156	0.49	No Change
Child age 0-4	[ExactNumberTours].[BX].[School].[Child age 0-4]	0.3535	0.51	No Change
Adult Age Group				
For Making 2+ Tours				
Adult, age 18-25	[ExactNumberTours].[BX].[School].[Age 18-25]	-0.9101	-1.35	No Change
Adult, age 66+	[ExactNumberTours].[BX].[School].[Age 66+]	1.2842	2.54	1.5411
Adult Gender/Children				
For Making 2+ Tours				
Adult female with child age 0-4	[ExactNumberTours].[BX].[School].[Female / age 0-4/IsAdult]	-2.0000	Fixed	No Change
Household Income[1]				
For Making 2+ Tours				
Lower income	[ExactNumberTours].[BX].[School].[Income Segment]	-0.7771	-2.11	No Change

Variable	StateFocus Code Parameter Name	Estimated Constant	(t-Statistic)	Calibrated Constant
Other				
For Making 2+ Tours				
Autos per (workers + 1)	[ExactNumberTours].[BX].[School].[Cars per worker in HH]	0.2837	2.44	No Change
L (Associated with Logsum Data)				
Mode Choice Logsum				
To regular school location – 2+ Tours	[ExactNumberTours].[L].[School].[MC logsum to school - 2+ tours]	0.5029	3.37	No Change
Array BYt – Number of Tours by Purpose (Associated with OTN)				
Other tours in day (0/1+ or counted)[2]				
For Making 2+ Tours				
Shop tours	[ExactNumberTours].[BY].[School].[Shop tours]	-0.9430	-1.82	No Change
Social/recreation tours	[ExactNumberTours].[BY].[School].[Social Recreational tours]	-0.5884	-2.61	No Change
Arrays BYs and BYcs – Stops by Purpose and Number of Stops (Associated with OS and OSN)				
Count of stop purposes				
For Making 2+ Tours				
Total non-work and non-school stop purposes	[ExactNumberTours].[BY].[School].[Non-Wrk Sch stop purps - 2+ tours]	0.3166	4.09	No Change
Array C – Constants				
2 tours	[ExactNumberTours].[Constant].[School].[2 tours]	-3.8308	-5.89	-4.1661
3 tours	[ExactNumberTours].[Constant].[School].[3 tours]	-6.6936	-9.51	No Change
Model Estimation Statistics				
Number of Observations	5,187			
Log-likelihood at Convergence	-972.4			
Rho-squared w.r.t. Constants	0.055			
Rho-squared w.r.t. Null Parameters	0.829			

Source: Cambridge Systematics

Notes:
1. The StateFocus Code Parameter Names for income related variables are input as a six element array as follows: [Less than $30K, $30K-$40K, $40K-$60K, $60K-$100K, $100K-$150K, $150K or more]. The six elements correspond to the following income groups: [Lower income, Modest Income, Modest Income (modest income coefficient is repeated), Middle Income, Upper Income, Top Income].
2. The exact number of tours choice model is applied in priority order of tour purposes: work, school, escort, personal business, shop, meal, and social recreation. When higher priority tour purposes are processed, only the existence of 0 or 1+ tours for lower level purposes is known from the results of the daily activity pattern model and are represented in the exact number of tour choice model as a 0 or 1. As subsequent tour purposes are modeled, the modeled numbers of tours for higher level purposes are known and represented in the exact number of tour choice model for the purpose being processed.

F.7.3 Exact Number of Tours Choice Coefficients – Escort Tours

The exact number of tours choice model evaluates the tour purposes in priority order with escort tours being the third highest priority. Some variables used in the escort exact number of tours choice model are obtained from the results of the exact number of tours choice models for higher level purposes.

Table F.17 Exact Number of Tours Choice Coefficients – Escort Tours

Variable	StateFocus Code Parameter Name	Estimated Constant	(t-Statistic)	Calibrated Constant
Array BX – Associated Person & Household Characteristics (PHC$_{pc}$)				
Person Type				
For Making 2+ Tours				
Part-time worker	[ExactNumberTours].[BX].[Escort].[Part-time worker]	0.5173	4.09	0.7242
Other non-worker	[ExactNumberTours].[BX].[Escort].[Other non-worker]	0.5620	4.90	0.5058
Student age 16+	[ExactNumberTours].[BX].[Escort].[Student age 16+]	-1.8752	-1.80	-2.8073
Student age 5-15	[ExactNumberTours].[BX].[Escort].[Student age 5-15]	-0.9383	-3.02	No Change
Child age 0-4	[ExactNumberTours].[BX].[Escort].[Child age 0-4]	0.6558	3.23	No Change
Adult Age Group				
For Making 2+ Tours				
Adult, age 18-25	[ExactNumberTours].[BX].[Escort].[Age 18-25]	-0.4946	-1.93	No Change
Adult, age 26-35	[ExactNumberTours].[BX].[Escort].[Age 26-35]	-0.1480	-1.07	No Change
Adult, age 51-65	[ExactNumberTours].[BX].[Escort].[Age 51-65]	-0.2312	-1.87	No Change
Adult, age 66+	[ExactNumberTours].[BX].[Escort].[Age 66+]	-0.1942	-1.09	-1.1649
Adult Gender/Children				
For Making 2+ Tours				
Adult male with child age 0-15[1]	[ExactNumberTours].[BX].[Escort].[Male / age 0-4/IsAdult] [ExactNumberTours].[BX].[Escort].[Male / age 5-15/IsAdult]	0.7988	4.79	No Change
Adult female-no children	[ExactNumberTours].[BX].[Escort].[Female / none/IsAdult]	-0.2252	-1.41	No Change
Adult female with child age 0-15[1]	[ExactNumberTours].[BX].[Escort].[Female / age 0-4/IsAdult] [ExactNumberTours].[BX].[Escort].[Female / age 5-15/IsAdult]	0.8187	5.20	No Change

Variable	StateFocus Code Parameter Name	Estimated Constant	(t-Statistic)	Calibrated Constant
L (Associated with Logsum Data)				
Aggregate Accessibility Logsum				
By non-work & non-school purpose – 2 Tours	[ExactNumberTours].[L].[Escort].[Accessibility logsum-2 tours]	0.1027	2.13	No Change
By non-work & non-school purpose – 3+ Tours	[ExactNumberTours].[L].[Escort].[Accessibility logsum-3+ tours]	0.2219	2.63	No Change
Array BYt – Number of Tours by Purpose (Associated with OTN)				
Other tours in day (0/1+ or counted)[2]				
For Making 2+ Tours				
Work tours	[ExactNumberTours].[BY].[Escort].[Work tours]	-0.8674	-9.17	No Change
School tours	[ExactNumberTours].[BY].[Escort].[School tours]	-0.9449	-4.27	-1.2283
Personal business tours	[ExactNumberTours].[BY].[Escort].[PersonalBusiness tours]	-0.2459	-3.58	No Change
Shop tours	[ExactNumberTours].[BY].[Escort].[Shop tours]	-0.2459	-3.58	No Change
Meal tours	[ExactNumberTours].[BY].[Escort].[Meal tours]	-0.2459	-3.58	No Change
Social/recreation tours	[ExactNumberTours].[BY].[Escort].[SocialRecreational tours]	-0.2459	-3.58	No Change
Arrays BYs and BYcs – Stops by Purpose and Number of Stops (Associated with OS and OSN)				
Count of stop purposes				
For Making 2+ Tours				
Total stop purposes	[ExactNumberTours].[BY].[Escort].[Total Stop Purps - 2+ tours]	-0.1876	-5.08	No Change
Array C – Constants				
2 tours	[ExactNumberTours].[Constant].[Escort].[2 tours]	-1.1748	-4.21	-0.8573
3 tours	[ExactNumberTours].[Constant].[Escort].[3 tours]	-3.4075	-8.03	-2.5258
4 tours	[ExactNumberTours].[Constant].[Escort].[4 tours]	-4.1240	-9.55	-3.7470
Model Estimation Statistics				
Number of Observations	3,183			
Log-likelihood at Convergence	-2,618.0			
Log-likelihood at Constants	n/a			
Log-likelihood at Null Parameters	n/a			
Rho-squared w.r.t. Constants	0.085			
Rho-squared w.r.t. Null Parameters	0.407			

Source: Cambridge Systematics

Notes: [1] The original model estimation used "…children aged 0-4" and "…children aged 0-15". In the application and calibration, the variables were split so they didn't overlap. However, the splitting of the ranges didn't affect the effective meaning of the variables since they simply check for the presence of one or more children in the age range. The final calibrated coefficients without overlap produce the same results as the initially estimated coefficients with overlap.

[2] The exact number of tours choice model is applied in priority order of tour purposes: work, school, escort, personal business, shop, meal, and social recreation. When higher priority tour purposes are processed, only the existence of 0 or 1+ tours for lower level purposes is known from the results of the daily activity pattern model and are represented in the exact number of tour choice model as a 0 or 1. As subsequent tour purposes are modeled, the modeled numbers of tours for higher level purposes are known and represented in the exact number of tour choice model for the purpose being processed.

F.7.4 Exact Number of Tours Choice Coefficients – Personal Business Tours

The exact number of tours choice model evaluates the tour purposes in priority order with personal business tours being the fourth highest priority. Some variables used in the personal business exact number of tours choice model are obtained from the results of the exact number of tours choice models for higher level purposes.

Table F.18 Exact Number of Tours Choice Coefficients – Personal Business Tours

Variable	StateFocus Code Parameter Name	Estimated Constant	(t-Statistic)	Calibrated Constant
Array BX – Associated Person & Household Characteristics (PHC_{pc})				
Person Type				
For Making 2+ Tours				
Student age 16+	[ExactNumberTours].[BX].[PersonalBusiness].[Student age 16+]	0.5980	1.20	1.2055
Student age 5-15	[ExactNumberTours].[BX].[PersonalBusiness].[Student age 5-15]	-1.1248	-2.23	No Change
Child age 0-4	[ExactNumberTours].[BX].[PersonalBusiness].[Child age 0-4]	-0.8077	-2.29	No Change
For Making 1 Non-Traditional Closed Tour				
Student age 16+	[ExactNumberTours].[BX].[PersonalBusiness].[Student age 16+ 1 NT closed]	2.0793	1.86	No Change
Student age 5-15	[ExactNumberTours].[BX].[PersonalBusiness].[Student age 5-15 1 NT closed]	1.7733	1.58	No Change
Child age 0-4	[ExactNumberTours].[BX].[PersonalBusiness].[Child age 0-4 1 NT closed]	-3.0000	Fixed	No Change
Adult Age Group				
For Making 2+ Tours				
Adult, age 18-25	[ExactNumberTours].[BX].[PersonalBusiness].[Age 18-25]	-0.6058	-1.41	No Change
Adult, age 26-35	[ExactNumberTours].[BX].[PersonalBusiness].[Age 26-35]	-0.3590	-1.17	No Change

Variable	StateFocus Code Parameter Name	Estimated Constant	(t-Statistic)	Calibrated Constant
Adult Gender/Children				
For Making 2+ Tours				
Adult female with child age 0-4	[ExactNumberTours].[BX].[PersonalBusiness].[Female / age 0-4/IsAdult]	-0.4377	-1.26	No Change
Household Composition				
For Making 2+ Tours				
Only adult in household	[ExactNumberTours].[BX].[PersonalBusiness].[Only adult in HH]	0.3366	2.18	No Change
Household Income[1]				
For Making 2+ Tours				
Lower income	[ExactNumberTours].[BX].[PersonalBusiness].[IncomeSegment]	-0.6959	-3.36	No Change
Missing Income[2]	*Used for Model Estimation Only*	*-0.7556*	*-0.73*	–
Other				
For Making 2+ Tours				
Work at home	[ExactNumberTours].[BX].[PersonalBusiness].[Work at home]	-0.2481	-1.35	No Change
L (Associated with Logsum Data)				
Aggregate Accessibility Logsum				
By non-work & non-school purpose – 2 Tours	[ExactNumberTours].[L].[PersonalBusiness].[Accessibility logsum-2 tours]	0.1122	0.80	No Change
By non-work & non-school purpose – 3+ Tours	ExactNumberTours].[L].[PersonalBusiness].[Accessibility logsum-3+ tours]	0.1122	0.80	No Change
Array BYt – Number of Tours by Purpose (Associated with OTN)				
Other tours in day (0/1+ or counted)[3]				
For Making 2+ Tours				
Work tours	[ExactNumberTours].[BY].[PersonalBusiness].[Work tours]	-0.7079	-3.92	No Change
School tours	[ExactNumberTours].[BY].[PersonalBusiness].[School tours]	-1.0694	-2.11	No Change
Arrays BYs and BYcs – Stops by Purpose and Number of Stops (Associated with OS and OSN)				
Other stops in day (0/1+)				
For Making 2+ Tours				
Personal business stops	[ExactNumberTours].[BY].[PersonalBusiness].[PersonalBusiness stops]	0.3737	2.32	No Change
Count of stop purposes				
For Making 2+ Tours				
Total stop purposes	[ExactNumberTours].[BY].[PersonalBusiness].[Total Stop Purps - 2+ tours]	-0.1548	-1.77	No Change

Variable	StateFocus Code Parameter Name	Estimated Constant	(t-Statistic)	Calibrated Constant
For Making 1 Non-Traditional Closed Tour				
Total stop purposes	[ExactNumberTours].[BY].[PersonalBusiness].[Total Stop Purps - 1 NT closed]	0.7989	2.47	No Change
Array C – Constants				
2 tours	[ExactNumberTours].[Constant].[Personal Business].[2 tours]	-2.8044	-2.82	-2.0912
3 tours	[ExactNumberTours].[Constant].[Personal Business].[3 tours]	-5.1542	-5.10	No Change
1 tour with 1 being non-traditional closed	[ExactNumberTours].[Constant].[Personal Business].[1 Tour & 1 NT closed]	-8.2027	-9.68	No Change
2 tours with 1 being non-traditional closed	[ExactNumberTours].[Constant].[Personal Business].[2 Tours & 1 NT closed]	-5.4902	-7.27	No Change
3 tours with 1 being non-traditional closed	[ExactNumberTours].[Constant].[Personal Business].[3 Tours & 1 NT closed]	-3.8336	-4.15	No Change
Model Estimation Statistics				
Number of Observations	3377			
Log-likelihood at Convergence	-1214.22			
Log-likelihood at Constants	n/a			
Log-likelihood at Null Parameters	n/a			
Rho-squared w.r.t. Constants	0.034			
Rho-squared w.r.t. Null Parameters	0.799			

Source: Cambridge Systematics

Notes:
[1] The StateFocus Code Parameter Names for income related variables are input as a six element array as follows: [Less than $30K, $30K-$40K, $40K-$60K, $60K-$100K, $100K-$150K, $150K or more]. The six elements correspond to the following income groups: [Lower income, Modest Income, Modest Income (modest income coefficient is repeated), Middle Income, Upper Income, Top Income].
[2] Variable used for model estimation purposes only and is not used in model application.
[3] The exact number of tours choice model is applied in priority order of tour purposes: work, school, escort, personal business, shop, meal, and social recreation. When higher priority tour purposes are processed, only the existence of 0 or 1+ tours for lower level purposes is known from the results of the daily activity pattern model and are represented in the exact number of tour choice model as a 0 or 1. As subsequent tour purposes are modeled, the modeled numbers of tours for higher level purposes are known and represented in the exact number of tour choice model for the purpose being processed.

F.7.5 Exact Number of Tours Choice Coefficients – Shop Tours

The exact number of tours choice model evaluates the tour purposes in priority order with shop tours being the fifth highest priority. Some variables used in the shop exact number of tours choice model are obtained from the results of the exact number of tours choice models for higher level purposes.

Table F.19 Exact Number of Tours Choice Coefficients – Shop Tours

Variable	StateFocus Code Parameter Name	Estimated Constant	(t-Statistic)	Calibrated Constant
Array BX – Associated Person & Household Characteristics (PHC_{pc})				
Person Type				
For Making 2+ Tours				
Part-time worker	[ExactNumberTours].[BX].[Shop].[Part-time worker]	0.4251	2.18	0.3443
Student age 5-15	[ExactNumberTours].[BX].[Shop].[Student age 5-15]	-2.3186	-2.25	No Change
Child age 0-4	[ExactNumberTours].[BX].[Shop].[Child age 0-4]	-0.3420	-0.90	No Change
Adult Age Group				
For Making 2+ Tours				
Adult, age 18-25	[ExactNumberTours].[BX].[Shop].[Age 18-25]	-0.5828	-0.97	No Change
Adult Gender/Children				
For Making 2+ Tours				
Adult female with child age 0-4	[ExactNumberTours].[BX].[Shop].[Female / age 0-4/IsAdult]	-0.4769	-1.27	No Change
Household Composition				
For Making 2+ Tours				
Only adult in household	[ExactNumberTours].[BX].[Shop].[Only adult in HH]	-0.4494	-2.05	No Change
Other				
For Making 2+ Tours				
Home retail employment density[1]	[ExactNumberTours].[BX].[Shop].[Retail Emp density]	-0.4184	-1.51	No Change
Autos per adult	[ExactNumberTours].[BX].[Shop].[Cars per adult in HH]	0.2236	1.76	No Change
L (Associated with Logsum Data)				
Aggregate Accessibility Logsum				
By non-work & non-school purpose – 2 Tours	[ExactNumberTours].[L].[Shop].[Accessibility logsum-2 tours]	0.3115	2.88	No Change
By non-work & non-school purpose – 3+ Tours	[ExactNumberTours].[L].[Shop].[Accessibility logsum-3+ tours]	0.6752	1.47	No Change
Array BYt – Number of Tours by Purpose (Associated with OTN)				
Other tours in day (0/1+ or counted)[2]				
For Making 2+ Tours				
Work tours	[ExactNumberTours].[BY].[Shop].[Work tours]	-0.8774	-3.69	No Change
School tours	[ExactNumberTours].[BY].[Shop].[School tours]	-0.6260	-1.05	No Change
Meal tours	[ExactNumberTours].[BY].[Shop].[Meal tours]	-0.5634	-1.51	No Change

Variable	StateFocus Code Parameter Name	Estimated Constant	(t-Statistic)	Calibrated Constant
Arrays BYs and BYcs – Stops by Purpose and Number of Stops (Associated with OS and OSN)				
Other stops in day (0/1+)				
For Making 2+ Tours				
Work stops	[ExactNumberTours].[BY].[Shop].[Work stops]	-0.9642	-0.93	No Change
School stops	[ExactNumberTours].[BY].[Shop].[School stops]	-0.9642	-0.93	No Change
Count of stop purposes				
For Making 2+ Tours				
Total non-work and non-school stop purposes	[ExactNumberTours].[BY].[Shop].[Non-Wrk Sch stop purps - 2+ tours]	0.1441	1.76	No Change
Array C – Constants				
2 tours	[ExactNumberTours].[Constant].[Shop].[2 tours]	-3.2880	-13.21	-2.5690
3 tours	[ExactNumberTours].[Constant].[Shop].[3 tours]	-6.4319	-8.11	No Change
Model Estimation Statistics				
Number of Observations	3,226			
Log-likelihood at Convergence	-731.9			
Log-likelihood at Constants	n/a			
Log-likelihood at Null Parameters	n/a			
Rho-squared w.r.t. Constants	0.042			
Rho-squared w.r.t. Null Parameters	0.793			

Source: Cambridge Systematics

Notes: [1] $Home\ retail\ employment\ density = \frac{RetailDensHHCentroid}{1000}$, where *RetailDensHHCentroid* is the number of retail employees in 0.5 mile buffer around the zone household virtual centroid (see ***Section 2.3.4*** and ***Appendix C***).

[2] The exact number of tours choice model is applied in priority order of tour purposes: work, school, escort, personal business, shop, meal, and social recreation. When higher priority tour purposes are processed, only the existence of 0 or 1+ tours for lower level purposes is known from the results of the daily activity pattern model and are represented in the exact number of tour choice model as a 0 or 1. As subsequent tour purposes are modeled, the modeled numbers of tours for higher level purposes are known and represented in the exact number of tour choice model for the purpose being processed.

F.7.6 Exact Number of Tours Choice Coefficients – Meal Tours

The exact number of tours choice model evaluates the tour purposes in priority order with meal tours being the sixth highest priority. Some variables used in the meal exact number of tours choice model are obtained from the results of the exact number of tours choice models for higher level purposes.

Table F.20 Exact Number of Tours Choice Coefficients – Meal Tours

Variable	StateFocus Code Parameter Name	Estimated Constant	(t-Statistic)	Calibrated Constant
Array BX – Associated Person & Household Characteristics (PHC$_{pc}$)				
Person Type				
For Making 2+ Tours				
Part-time worker	[ExactNumberTours].[BX].[Meal].[Part-time worker]	-1.3419	-2.17	No Change
University student	[ExactNumberTours].[BX].[Meal].[University student]	-2.0000	Fixed	No Change
Student age 16+	[ExactNumberTours].[BX].[Meal].[Student age 16+]	-2.0000	Fixed	No Change
Student age 5-15	[ExactNumberTours].[BX].[Meal].[Student age 5-15]	-2.0000	Fixed	No Change
Child age 0-4	[ExactNumberTours].[BX].[Meal].[Child age 0-4]	-2.0000	Fixed	No Change
Adult Gender/Children				
For Making 2+ Tours				
Adult female-no children	[ExactNumberTours].[BX].[Meal].[Female / none/IsAdult]	-0.3781	-1.31	No Change
Adult female with child age 0-15[1]	[ExactNumberTours].[BX].[Meal].[Female / age 0-4/IsAdult] [ExactNumberTours].[BX].[Meal].[Female / age 5-15/IsAdult]	-0.9979	-1.51	No Change
Household Income[2]				
For Making 2+ Tours				
Top income	[ExactNumberTours].[BX].[Meal].[Income Segment]	0.4703	1.28	No Change
Other				
For Making 2+ Tours				
Autos per adult	[ExactNumberTours].[BX].[Meal].[Cars per adult in HH]	0.2493	1.18	No Change
Work at home	[ExactNumberTours].[BX].[Meal].[Work at home]	0.4978	1.46	No Change
L (Associated with Logsum Data)				
Aggregate Accessibility Logsum				
By non-work & non-school purpose – 2 Tours	[ExactNumberTours].[L].[Meal].[Accessibility logsum-2 tours]	0.3380	2.00	No Change
Array BYt – Number of Tours by Purpose (Associated with OTN)				
Other tours in day (0/1+ or counted)[3]				
For Making 2+ Tours				
Work tours	[ExactNumberTours].[BY].[Meal].[Work tours]	-0.9925	-2.53	No Change
Escort tours	[ExactNumberTours].[BY].[Meal].[Escort tours]	0.4576	1.72	No Change

Variable	StateFocus Code Parameter Name	Estimated Constant	(t-Statistic)	Calibrated Constant
Personal business tours	[ExactNumberTours].[BY].[Meal].[Personal Business tours]	0.4163	1.71	No Change
Shop tours	[ExactNumberTours].[BY].[Meal].[Shop tours]	-0.3245	-0.83	No Change
Social/recreation tours	[ExactNumberTours].[BY].[Meal].[Meal tours]	-0.9022	-2.02	No Change
Arrays BYs and BYcs – Stops by Purpose and Number of Stops (Associated with OS and OSN)				
Other stops in day (0/1+)				
For Making 2+ Tours				
Work stops	[ExactNumberTours].[BY].[Meal].[Work stops]	-1.1684	-1.54	No Change
School stops	[ExactNumberTours].[BY].[Meal].[School stops]	-1.1684	-1.54	No Change
Escort stops	[ExactNumberTours].[BY].[Meal].[Escort stops]	-1.1684	-1.54	No Change
Personal business stops	[ExactNumberTours].[BY].[Meal].[Personal Business stops]	0.6562	2.42	No Change
Shop stops	[ExactNumberTours].[BY].[Meal].[Shop stops]	0.2703	0.98	No Change
Array C – Constants				
2 tours	[ExactNumberTours].[Constant].[Meal].[2 tours]	-4.0795	-7.53	-3.4871
Model Estimation Statistics				
Number of Observations	1,767			
Log-likelihood at Convergence	-234.4			
Log-likelihood at Constants	n/a			
Log-likelihood at Null Parameters	n/a			
Rho-squared w.r.t. Constants	0.127			
Rho-squared w.r.t. Null Parameters	0.809			

Source: Cambridge Systematics

Notes:

[1] The original model estimation used "…children aged 0-4" and "…children aged 0-15". In the application and calibration, the variables were split so they didn't overlap. However, the splitting of the ranges didn't affect the effective meaning of the variables since they simply check for the presence of one or more children in the age range. The final calibrated coefficients without overlap produce the same results as the initially estimated coefficients with overlap.

[2] The StateFocus Code Parameter Names for income related variables are input as a six element array as follows: [Less than $30K, $30K-$40K, $40K-$60K, $60K-$100K, $100K-$150K, $150K or more]. The six elements correspond to the following income groups: [Lower income, Modest Income, Modest Income (modest income coefficient is repeated), Middle Income, Upper Income, Top Income].

[3] The exact number of tours choice model is applied in priority order of tour purposes: work, school, escort, personal business, shop, meal, and social recreation. When higher priority tour purposes are processed, only the existence of 0 or 1+ tours for lower level purposes is known from the results of the daily activity pattern model and are represented in the exact number of tour choice model as a 0 or 1. As subsequent tour purposes are modeled, the modeled numbers of tours for higher level purposes are known and represented in the exact number of tour choice model for the purpose being processed.

F.7.7 Exact Number of Tours Choice Coefficients – Social/Recreation Tours

The exact number of tours choice model evaluates the tour purposes in priority order with social/recreation tours being the seventh highest priority. Some variables used in the social/recreation exact number of tours choice model are obtained from the results of the exact number of tours choice models for higher level purposes.

Table F.21 Exact Number of Tours Choice Coefficients – Social/Recreation Tours

Variable	StateFocus Code Parameter Name	Estimated Constant	(t-Statistic)	Calibrated Constant
Array BX – Associated Person & Household Characteristics (PHC_{pc})				
Person Type				
For Making 2+ Tours				
Part-time worker	[ExactNumberTours].[BX].[SocialRecreational].[Part-time worker]	0.6256	3.85	1.3023
Non-worker age 65+	[ExactNumberTours].[BX].[SocialRecreational].[Retired]	0.7904	3.12	2.1517
Other non-worker	[ExactNumberTours].[BX].[SocialRecreational].[Other non-worker]	0.5426	3.74	1.1192
University student	[ExactNumberTours].[BX].[SocialRecreational].[University student]	-1.0412	-1.35	-0.5998
For Making 1 Non-Traditional Closed Tour				
Full-time worker	[ExactNumberTours].[BX].[SocialRecreational].[Full-time worker 1 NT closed]	1.3498	2.08	No Change
Student age 16+	[ExactNumberTours].[BX].[SocialRecreational].[Student age 16+ 1 NT closed]	1.2955	1.14	No Change
Child age 0-4	[ExactNumberTours].[BX].[SocialRecreational].[Child age 0-4 1 NT closed]	-3.0000	Fixed	No Change
Adult Age Group				
For Making 2+ Tours				
Adult, age 18-25	[ExactNumberTours].[BX].[SocialRecreational].[Age 18-25]	0.3190	1.07	No Change
Adult, age 66+	[ExactNumberTours].[BX].[SocialRecreational].[Age 66+]	-0.2467	-1.11	No Change
For Making 1 Non-Traditional Closed Tour				
Adult, age 51-65	[ExactNumberTours].[BX].[SocialRecreational].[Age 51-65 1 NT closed]	-1.4286	-2.01	No Change
Adult, age 66+	[ExactNumberTours].[BX].[SocialRecreational].[Age 66+ 1 NT closed]	-1.4286	-2.01	No Change
Adult Gender/Children				
For Making 2+ Tours				
Adult male with child age 0-15[1]	[ExactNumberTours].[BX].[SocialRecreational].[Male / age 0-4/IsAdult] [ExactNumberTours].[BX].[SocialRecreational].[Male / age 5-15/IsAdult]	-1.7030	-1.57	No Change

Variable	StateFocus Code Parameter Name	Estimated Constant	(t-Statistic)	Calibrated Constant
Adult female with child age 0-15[1]	[ExactNumberTours].[BX].[SocialRecreational].[Female / age 0-4/IsAdult] [ExactNumberTours].[BX].[SocialRecreational].[Female / age 5-15/IsAdult]	-1.7030	-1.57	No Change
For Making 1 Non-Traditional Closed Tour				
Adult male with child age 0-15	[ExactNumberTours].[BX].[SocialRecreational].[Male / age 0-15/IsAdult 1 NT closed]	-1.8278	-1.69	No Change
Adult female with child age 0-15	[ExactNumberTours].[BX].[SocialRecreational].[Female / age 0-15/IsAdult 1 NT closed]	-1.8278	-1.69	No Change
Household Composition				
For Making 2+ Tours				
Only adult in household	[ExactNumberTours].[BX].[SocialRecreational].[Only adult in HH]	0.1927	1.29	No Change
Household Income[2]				
For Making 2+ Tours				
Lower income	[ExactNumberTours].[BX].[SocialRecreational].[IncomeSegment]	-0.8591	-3.76	No Change
Modest income	[ExactNumberTours].[BX].[SocialRecreational].[IncomeSegment]	-0.5041	-3.77	No Change
Missing Income[3]	*Used for Model Estimation Only*	*-0.1808*	*-0.29*	–
Other				
For Making 2+ Tours				
Autos per (workers + 1)	[ExactNumberTours].[BX].[SocialRecreational].[Cars per worker in HH]	0.1165	1.59	No Change
L (Associated with Logsum Data)				
Aggregate Accessibility Logsum				
By non-work & non-school purpose – 2 Tours	[ExactNumberTours].[L].[SocialRecreational].[Accessibility logsum-2 tours]	0.1156	0.86	No Change
By non-work & non-school purpose – 3+ Tours	[ExactNumberTours].[L].[SocialRecreational].[Accessibility logsum-3+ tours]	0.1156	0.86	No Change
Array BYt – Number of Tours by Purpose (Associated with OTN)				
Other tours in day (0/1+ or counted)[4]				
For Making 2+ Tours				
Work tours	[ExactNumberTours].[BY].[SocialRecreational].[Work tours]	-0.5640	-4.22	No Change
School tours	[ExactNumberTours].[BY].[SocialRecreational].[School tours]	-0.9172	-4.34	No Change
Escort tours	[ExactNumberTours].[BY].[SocialRecreational].[Escort tours]	-0.2019	-2.81	No Change
Personal business tours	[ExactNumberTours].[BY].[SocialRecreational].[PersonalBusiness tours]	-0.2019	-2.81	No Change
Shop tours	[ExactNumberTours].[BY].[SocialRecreational].[Shop tours]	-0.2019	-2.81	No Change

Variable	StateFocus Code Parameter Name	Estimated Constant	(t-Statistic)	Calibrated Constant
Meal tours	[ExactNumberTours].[BY].[SocialRecreational].[Meal tours]	-0.2019	-2.81	No Change
Arrays BYs and BYcs – Stops by Purpose and Number of Stops (Associated with OS and OSN)				
Other stops in day (0/1+)				
For Making 2+ Tours				
Work stops	[ExactNumberTours].[BY].[SocialRecreational].[Work stops]	-0.8606	-1.84	No Change
School stops	[ExactNumberTours].[BY].[SocialRecreational].[School stops]	-0.8606	-1.84	No Change
Escort stops	[ExactNumberTours].[BY].[SocialRecreational].[Escort stops]	-0.4676	-1.81	No Change
Social/recreation stops	[ExactNumberTours].[BY].[SocialRecreational].[SocialRecreational stops]	0.2825	1.94	No Change
Count of stop purposes				
For Making 2+ Tours				
Total non-work and non-school stop purposes	[ExactNumberTours].[BY].[SocialRecreational].[Non-Wrk Sch stop purps - 2+ tours]	0.1649	2.68	No Change
For Making 1 Non-Traditional Closed Tour				
Total stop purposes	[ExactNumberTours].[BY].[SocialRecreational].[Total Stop Purps - 1 NT closed]	0.5171	1.77	No Change
Array C – Constants				
2 tours	[ExactNumberTours].[Constant].[Social Recreational].[2 tours]	-3.3457	-3.37	-1.6645
3 tours	[ExactNumberTours].[Constant].[Social Recreational].[3 tours]	-5.7211	-5.71	-4.5769
1 tour with 1 being non-traditional closed	[ExactNumberTours].[Constant].[Social Recreational].[1 Tour & 1 NT closed]	-6.9264	-9.87	No Change
2 tours with 1 being non-traditional closed	[ExactNumberTours].[Constant].[Social Recreational].[2 Tours & 1 NT closed]	-4.7605	-6.26	No Change
3 tours with 1 being non-traditional closed	[ExactNumberTours].[Constant].[Social Recreational].[3 Tours & 1 NT closed]	-3.7624	-3.25	No Change
Model Estimation Statistics				
Number of Observations	5,092			
Log-likelihood at Convergence	-1,722.1			
Log-likelihood at Constants	n/a			
Log-likelihood at Null Parameters	n/a			
Rho-squared w.r.t. Constants	0.055			
Rho-squared w.r.t. Null Parameters	0.811			

Source: Cambridge Systematics

Notes:

[1] The original model estimation used "…children aged 0-4" and "…children aged 0-15". In the application and calibration, the variables were split so they didn't overlap. However, the splitting of the ranges didn't affect the effective meaning of the variables since they simply check for the presence of one or more children in the age range. The final calibrated coefficients without overlap produce the same results as the initially estimated coefficients with overlap.

[2] The StateFocus Code Parameter Names for income related variables are input as a six element array as follows: [Less than $30K, $30K-$40K, $40K-$60K, $60K-$100K, $100K-$150K, $150K or more]. The six elements correspond to the following income groups: [Lower income, Modest Income, Modest Income (modest income coefficient is repeated), Middle Income, Upper Income, Top Income].

[3] Variable used for model estimation purposes only and is not used in model application.

[4] The exact number of tours choice model is applied in priority order of tour purposes: work, school, escort, personal business, shop, meal, and social recreation. When higher priority tour purposes are processed, only the existence of 0 or 1+ tours for lower level purposes is known from the results of the daily activity pattern model and are represented in the exact number of tour choice model as a 0 or 1. As subsequent tour purposes are modeled, the modeled numbers of tours for higher level purposes are known and represented in the exact number of tour choice model for the purpose being processed.

F.8 Work Tour Destination Type Choice

The work tour destination type choice model variables, StateFocus C# parameter names, estimated model coefficients and t-statistics, and final calibrated parameters based on the 2015 model calibration/validation are shown in ***Table F.22***, below.

Table F.22 Work Tour Destination Type Choice

Variable / Coefficient	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Usual workplace constant	[Work Tour Type].[Usual].[Constant]	1.1054	23.11	2.7500
Mode choice logsum	[Work Tour Type].[Usual].[ModeLogsum]	0.1093	9.31	No Change
Distance[1]	[Work Tour Type].[Usual].[Distance]	-0.1103	-7.19	-0.0794
Ln(Distance)[1]	[Work Tour Type].[Usual].[Distance_Log]	0.1568	10.36	0.3952
Total Employment – Low Income – Full-time Worker[2]	[Work Tour Type].[Usual].[TotalEmp_FTW].[IncomeSegment]	0.0638	7.34	0.0201
Total Employment – Medium Income – Full-time Worker[2]	[Work Tour Type].[Usual].[TotalEmp_FTW].[IncomeSegment]	0.0589	10.44	0.0766
Total Employment – High Income – Full-time Worker[2]	[Work Tour Type].[Usual].[TotalEmp_FTW].[IncomeSegment]	0.0421	5.91	0.1294
Work at Home Dummy	[Work Tour Type].[Usual].[WorkAtHome]	-3.9884	-17.50	No Change
Student Dummy[3]	[Work Tour Type].[Usual].[Student]	0.1595	1.51	0.2871
First of Multiple Work Tours Dummy	[Work Tour Type].[Usual].[FirstWorkTour]	-0.4343	-7.58	-1.9513
Subsequent of Multiple Work Tours Dummy	[Work Tour Type].[Usual].[NotFirstWorkTour]	-0.3118	-2.30	2.3350
Not Primary Tour Dummy[4]	[Work Tour Type].[Usual].[NotPrimaryTour]	-0.4475	-3.48	-0.2000
Model Estimation Statistics				
Number of Observations	11,819			
Log-likelihood at Convergence	-3,590.60			
Rho-squared w.r.t. Constants	0.340			
Rho-squared w.r.t. Null Parameters	0.581			

Source: Cambridge Systematics

Notes: [1] Distance is the maximum of the total tour roadway distance from home to regular workplace to home in miles and 0.01 (to prevent taking the natural log of zero). The distances are based on the late night (OP1) skims to provide uncongested travel distances.

[2] Income level is a special, 3-level, income grouping for the work tour destination type choice model (see ***Section 3.1.1***).

[3] Student is a variable derived from the PopGen2 data as follows:

1 = Primary or secondary school student three years of age or older,

2 = Post-secondary school student, and

3 = Not a student.

[4] The first work tour is the primary tour unless the person is also a Student, in which case the school tour is considered the primary tour.

F.9 Work-Based Sub-Tour Generation Choice

The work-based sub-tour generation choice model variables, StateFocus C# parameter names, estimated model coefficients and t-statistics, and final calibrated parameters based on the 2015 model calibration/ validation are shown in ***Table F.23***, below.

Table F.23 Work-Based Sub-Tour Generation Choice

Variable / Coefficient	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Work Sub-Tour				
Constant	[Workbased Subtour].[Work].[Constant]	-0.3881	-6.59	No Change
Single person household	[Workbased Subtour].[Work].[One Person Household]	-0.3558	-2.27	No Change
School Sub-Tour				
Constant	[Workbased Subtour].[School].[Constant]	-3.6529	-5.10	-2.5570
Escort Sub-Tour				
Constant	[Workbased Subtour].[Escort].[Constant]	-3.8099	-17.23	-2.1716
Over 50 years old	[Workbased Subtour].[Escort].[Age 50+]	1.4070	4.62	No Change
Personal Business Sub-Tour				
Constant	[Workbased Subtour].[Personal Business].[Constant]	-2.7965	-16.40	-2.5169
30 years old or younger	[Workbased Subtour].[Personal Business].[Age 0-30]	0.7856	3.11	No Change
Full-time worker	[Workbased Subtour].[Personal Business].[Full-time Worker]	1.0577	5.86	No Change
Shop Sub-Tour				
Constant	[Workbased Subtour].[Shop].[Constant]	-3.0301	-14.72	-2.8089
Full-time worker	[Workbased Subtour].[Shop].[Full-time Worker]	1.0276	4.61	No Change
Meal Sub-Tour				
Constant	[Workbased Subtour].[Meal].[Constant]	-1.4479	-9.75	-1.1583
Full-time worker	[Workbased Subtour].[Meal].[Full-time Worker]	1.0579	6.89	No Change
Adult female with children under 18 in household	[Workbased Subtour].[Meal].[Adult Female with Children under 18 in Household]	-0.3513	-2.07	No Change
Restaurant density	[Workbased Subtour].[Meal].[Restaurant Density]	0.0922	2.76	No Change
Social/Recreation Sub-Tour				
Constant	[Workbased Subtour].[SocialRecreational].[Constant]	-2.6471	-12.59	-2.9118
Full-time worker	[Workbased Subtour].[SocialRecreational].[Full-time Worker]	0.6662	3.06	No Change
Residential density	[Workbased Subtour].[SocialRecreational].[Residential Density]	0.1093	2.90	No Change

Variable / Coefficient	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
"Quit"				
30 years old or younger	[Workbased Subtour].[Quit].[Age 0-30]	0.2592	1.88	No Change
Low income household	[Workbased Subtour].[Quit].[Income Less than 30K]	0.3981	4.79	No Change
Ln(total home-based tours)	[Workbased Subtour].[Quit].[Number of Home-based Tours]	0.2655	4.39	No Change
2 or more work tours	[Workbased Subtour].[Quit].[Two Plus Tours]	0.8268	7.81	No Change
Cycle Through Work-Based Sub-Tour Generation Choice Model				
Second cycle	[Workbased Subtour].[Quit].[Second Subtour]	1.4292	16.18	No Change
Third cycle	[Workbased Subtour].[Quit].[Third Subtour]	1.3410	6.94	0.8717
Fourth cycle	[Workbased Subtour].[Quit].[Forth Subtour]	2.3178	3.82	No Change
Model Estimation Statistics				
Number of Observations	14,376			
Log-likelihood at Convergence	-4,508.76			
Log-likelihood at Constants	n/a			
Log-likelihood at Null Parameters	n/a			
Rho-squared w.r.t. Constants	0.071			
Rho-squared w.r.t. Null Parameters	0.481			

Source: Cambridge Systematics

Notes: [1] Income level is a special, 3-level, income grouping for the work tour destination type choice model (see ***Section 3.1.1***).

F.10 Tour Time of Day Simulation

Table F.24 summarizes the proportions of tours by arrival time and departure time from the primary tour destination from the expanded FRTC survey data. The data shown in ***Table F.24*** are used with a Monte Carlo simulation process to assign preliminary estimates of arrival and departure times to all tours before the application of the tour primary destination choice, tour main mode choice, and tour time of day choice StateFocus model components. The preliminary times of day are used to select the time of day auto and transit skim data used for tour primary destination choice and tour main mode choice.

Table F.25 shows proportions of non-closed tours by actual arrival and departure times at the primary destinations. By definition, non-closed tours are at the primary tour destination either at the start of the travel day (3:00 AM) and depart that location during the day or arrive at the tour destination during the day and depart after the end of the travel day (2:59 AM). ***Table F.25*** aggregates the non-closed tour proportions to show departure times for those tours starting the day at the non-home location and the arrival times at the non-home location for those non-closed tours ending the day away from home.

Table F.24 Observed Tour Destination Arrival and Departure Time Proportions by Tour Purpose

Sequence Number	Tour Destination Arrival Time	Tour Destination Departure Time	Work-Regular Work Location	Work-Other Work Location	School	Escort	Personal Business	Shop	Meal	Social / Recreation	Work-Based Sub-Tour	Non-Closed Work[1]	Non-Closed Non-Work[1]
1	3:00 AM–3:59 AM	3:00 AM–3:59 AM	–	–	–	0.00025	–	–	–	–	–	–	–
2	3:00 AM–3:59 AM	4:00 AM–4:59 AM	–	0.00057	–	–	–	0.00029	–	–	–	0.00026	–
3	3:00 AM–3:59 AM	5:00 AM–5:59 AM	0.00004	–	–	–	–	–	–	0.00043	–	0.00232	0.00004
4	3:00 AM–3:59 AM	6:00 AM–6:59 AM	–	0.00074	–	–	–	–	–	–	–	0.00117	0.00027
5	3:00 AM–3:59 AM	7:00 AM–7:59 AM	–	–	–	–	–	–	–	–	–	0.00461	0.00070
6	3:00 AM–3:59 AM	8:00 AM–8:59 AM	0.00034	–	–	–	–	–	–	–	–	0.00385	0.00049
7	3:00 AM–3:59 AM	9:00 AM–9:59 AM	–	–	–	–	–	–	–	–	–	0.00098	0.00031
8	3:00 AM–3:59 AM	10:00 AM–10:59 AM	0.00011	–	–	–	–	–	–	–	–	0.00063	0.00100
9	3:00 AM–3:59 AM	11:00 AM–11:59 AM	0.00025	–	–	–	–	–	–	–	–	0.00279	0.00042
10	3:00 AM–3:59 AM	12:00 PM–12:59 PM	0.00033	–	–	–	–	–	–	–	–	0.00099	0.00034
11	3:00 AM–3:59 AM	1:00 PM–1:59 PM	0.00089	–	–	–	–	–	–	–	–	0.00078	0.00037
12	3:00 AM–3:59 AM	2:00 PM–2:59 PM	0.00027	0.00095	–	–	–	–	–	–	–	0.00165	0.00060
13	3:00 AM–3:59 AM	3:00 PM–3:59 PM	0.00036	–	–	–	–	–	–	–	–	0.00175	0.00035
14	3:00 AM–3:59 AM	4:00 PM–4:59 PM	0.00074	–	–	–	–	–	–	–	–	0.00180	0.00097
15	3:00 AM–3:59 AM	5:00 PM–5:59 PM	–	–	–	–	–	–	–	–	–	0.00180	0.00132
16	3:00 AM–3:59 AM	6:00 PM–6:59 PM	–	–	–	–	–	–	–	–	–	0.00329	0.00086
17	3:00 AM–3:59 AM	7:00 PM–7:59 PM	–	–	–	–	–	–	–	–	–	0.00161	0.00165
18	3:00 AM–3:59 AM	8:00 PM–8:59 PM	–	–	–	–	–	–	–	–	–	0.00327	0.00078
19	3:00 AM–3:59 AM	9:00 PM–9:59 PM	–	–	–	–	–	–	–	–	–	0.00156	0.00100
20	3:00 AM–3:59 AM	10:00 PM–10:59 PM	–	–	–	–	–	–	–	–	–	0.00775	0.00091
21	3:00 AM–3:59 AM	11:00 PM–11:59 PM	–	–	–	–	–	–	–	–	–	0.00177	0.00018
22	3:00 AM–3:59 AM	12:00 AM–12:59 AM	–	–	–	–	–	–	–	–	–	0.00054	0.00007
23	3:00 AM–3:59 AM	1:00 AM–1:59 AM	–	–	–	–	–	–	–	–	–	0.00012	–
24	3:00 AM–3:59 AM	2:00 AM–2:59 AM	–	–	–	–	–	–	–	–	–	0.00073	0.00008
25	4:00 AM–4:59 AM	4:00 AM–4:59 AM	0.00103	–	–	0.00025	–	–	–	–	–	0.00023	–
26	4:00 AM–4:59 AM	5:00 AM–5:59 AM	–	0.00020	–	0.00034	–	–	–	0.00045	–	0.00216	0.00009
27	4:00 AM–4:59 AM	6:00 AM–6:59 AM	0.00005	–	0.00028	–	–	–	–	0.00175	–	0.00146	0.00054
28	4:00 AM–4:59 AM	7:00 AM–7:59 AM	0.00005	–	–	–	–	–	–	0.00023	–	0.00509	0.00143
29	4:00 AM–4:59 AM	8:00 AM–8:59 AM	0.00042	–	–	–	–	–	–	0.00002	–	0.00395	0.00099

Sequence Number	Tour Destination Arrival Time	Tour Destination Departure Time	Work-Regular Work Location	Work-Other Work Location	School	Escort	Personal Business	Shop	Meal	Social / Recreation	Work-Based Sub-Tour	Non-Closed Work[1]	Non-Closed Non-Work[1]
30	4:00 AM–4:59 AM	9:00 AM–9:59 AM	0.00034	–	–	–	–	–	–	–	–	0.00117	0.00062
31	4:00 AM–4:59 AM	10:00 AM–10:59 AM	0.00018	–	–	–	–	–	–	–	–	0.00061	0.00203
32	4:00 AM–4:59 AM	11:00 AM–11:59 AM	0.00053	–	–	–	–	–	–	0.00007	–	0.00255	0.00085
33	4:00 AM–4:59 AM	12:00 PM–12:59 PM	0.00162	–	–	–	–	–	–	–	–	0.00095	0.00069
34	4:00 AM–4:59 AM	1:00 PM–1:59 PM	0.00265	0.00096	–	–	–	–	–	–	–	0.00087	0.00076
35	4:00 AM–4:59 AM	2:00 PM–2:59 PM	0.00181	–	–	–	–	–	–	–	–	0.00163	0.00122
36	4:00 AM–4:59 AM	3:00 PM–3:59 PM	0.00150	–	–	–	–	–	–	–	–	0.00206	0.00071
37	4:00 AM–4:59 AM	4:00 PM–4:59 PM	0.00073	–	–	–	–	–	–	–	–	0.00184	0.00197
38	4:00 AM–4:59 AM	5:00 PM–5:59 PM	0.00067	0.00032	–	–	–	–	–	–	–	0.00214	0.00268
39	4:00 AM–4:59 AM	6:00 PM–6:59 PM	0.00043	–	–	–	–	–	–	–	–	0.00318	0.00173
40	4:00 AM–4:59 AM	7:00 PM–7:59 PM	–	0.00040	–	–	–	–	–	–	–	0.00146	0.00335
41	4:00 AM–4:59 AM	8:00 PM–8:59 PM	–	–	–	–	–	–	–	–	–	0.00299	0.00159
42	4:00 AM–4:59 AM	9:00 PM–9:59 PM	–	–	–	–	–	–	–	–	–	0.00139	0.00203
43	4:00 AM–4:59 AM	10:00 PM–10:59 PM	–	–	–	–	–	–	–	–	–	0.00683	0.00184
44	4:00 AM–4:59 AM	11:00 PM–11:59 PM	–	–	–	–	–	–	–	–	–	0.00155	0.00037
45	4:00 AM–4:59 AM	12:00 AM–12:59 AM	–	–	–	–	–	–	–	–	–	0.00047	0.00014
46	4:00 AM–4:59 AM	1:00 AM–1:59 AM	–	–	–	–	–	–	–	–	–	0.00016	–
47	4:00 AM–4:59 AM	2:00 AM–2:59 AM	–	–	–	–	–	–	–	–	–	0.00064	0.00017
48	5:00 AM–5:59 AM	5:00 AM–5:59 AM	0.00016	–	–	0.00419	0.00151	–	–	0.00073	–	0.00125	0.00005
49	5:00 AM–5:59 AM	6:00 AM–6:59 AM	0.00028	0.00081	–	0.00123	0.00038	0.00044	0.00008	0.00728	–	0.00450	0.00063
50	5:00 AM–5:59 AM	7:00 AM–7:59 AM	0.00016	0.00048	–	–	–	–	–	0.00335	–	0.01189	0.00110
51	5:00 AM–5:59 AM	8:00 AM–8:59 AM	0.00053	–	–	–	–	–	–	0.00028	–	0.00726	0.00081
52	5:00 AM–5:59 AM	9:00 AM–9:59 AM	0.00079	–	–	–	–	–	–	–	–	0.00331	0.00073
53	5:00 AM–5:59 AM	10:00 AM–10:59 AM	0.00080	–	–	–	0.00050	–	–	–	–	0.00087	0.00164
54	5:00 AM–5:59 AM	11:00 AM–11:59 AM	0.00068	–	–	–	0.00079	–	–	–	–	0.00246	0.00072
55	5:00 AM–5:59 AM	12:00 PM–12:59 PM	0.00152	–	0.00009	–	–	–	–	–	–	0.00127	0.00065
56	5:00 AM–5:59 AM	1:00 PM–1:59 PM	0.00129	–	0.00010	–	–	–	–	–	–	0.00209	0.00051
57	5:00 AM–5:59 AM	2:00 PM–2:59 PM	0.01131	0.00114	–	–	–	–	–	–	–	0.00255	0.00085
58	5:00 AM–5:59 AM	3:00 PM–3:59 PM	0.00827	0.00286	–	–	–	–	–	–	–	0.00565	0.00047
59	5:00 AM–5:59 AM	4:00 PM–4:59 PM	0.00638	0.00085	0.00011	–	–	–	–	–	–	0.00334	0.00117

Sequence Number	Tour Destination Arrival Time	Tour Destination Departure Time	Work-Regular Work Location	Work-Other Work Location	School	Escort	Personal Business	Shop	Meal	Social / Recre-ation	Work-Based Sub-Tour	Non-Closed Work[1]	Non-Closed Non-Work[1]
60	5:00 AM–5:59 AM	5:00 PM–5:59 PM	0.00361	0.00157	0.00021	–	–	–	–	–	–	0.00597	0.00164
61	5:00 AM–5:59 AM	6:00 PM–6:59 PM	0.00412	–	0.00011	–	–	–	–	–	–	0.00448	0.00101
62	5:00 AM–5:59 AM	7:00 PM–7:59 PM	0.00093	–	–	–	–	–	–	0.00011	–	0.00135	0.00195
63	5:00 AM–5:59 AM	8:00 PM–8:59 PM	0.00004	–	0.00006	–	–	–	–	–	–	0.00302	0.00089
64	5:00 AM–5:59 AM	9:00 PM–9:59 PM	0.00052	–	–	–	–	–	–	–	–	0.00109	0.00112
65	5:00 AM–5:59 AM	10:00 PM–10:59 PM	–	–	–	–	–	–	–	–	–	0.00470	0.00107
66	5:00 AM–5:59 AM	11:00 PM–11:59 PM	–	–	–	–	–	–	–	–	–	0.00105	0.00025
67	5:00 AM–5:59 AM	12:00 AM–12:59 AM	–	–	–	–	–	–	–	–	–	0.00029	0.00008
68	5:00 AM–5:59 AM	1:00 AM–1:59 AM	–	–	–	–	–	–	–	–	–	0.00057	–
69	5:00 AM–5:59 AM	2:00 AM–2:59 AM	–	–	–	–	–	–	–	–	–	0.00039	0.00009
70	6:00 AM–6:59 AM	6:00 AM–6:59 AM	0.00070	0.00030	0.00012	0.01574	0.00020	0.00024	0.00124	0.00173	0.00079	0.00195	0.00197
71	6:00 AM–6:59 AM	7:00 AM–7:59 AM	0.00264	0.00121	0.00089	0.00296	0.00174	0.00342	0.00194	0.00641	0.00736	0.01246	0.00706
72	6:00 AM–6:59 AM	8:00 AM–8:59 AM	0.00154	0.00610	0.00027	–	–	–	0.00132	0.00327	–	0.00906	0.00521
73	6:00 AM–6:59 AM	9:00 AM–9:59 AM	0.00239	0.00146	–	–	0.00020	–	0.00054	0.00034	0.00017	0.00304	0.00456
74	6:00 AM–6:59 AM	10:00 AM–10:59 AM	0.00051	0.00120	0.00064	–	–	–	–	–	–	0.00132	0.01052
75	6:00 AM–6:59 AM	11:00 AM–11:59 AM	0.00418	0.00359	0.00089	–	0.00097	0.00012	–	–	–	0.00515	0.00461
76	6:00 AM–6:59 AM	12:00 PM–12:59 PM	0.00206	0.00056	0.00177	–	–	–	–	0.00153	–	0.00202	0.00410
77	6:00 AM–6:59 AM	1:00 PM–1:59 PM	0.00417	0.00252	0.00080	–	–	–	–	0.00006	–	0.00214	0.00332
78	6:00 AM–6:59 AM	2:00 PM–2:59 PM	0.00951	0.00065	0.01071	–	–	–	–	–	–	0.00360	0.00553
79	6:00 AM–6:59 AM	3:00 PM–3:59 PM	0.04156	0.01089	0.00873	–	0.00076	–	–	–	–	0.00530	0.00309
80	6:00 AM–6:59 AM	4:00 PM–4:59 PM	0.03194	0.00606	0.00707	–	0.00056	–	–	0.00012	–	0.00421	0.00767
81	6:00 AM–6:59 AM	5:00 PM–5:59 PM	0.01447	0.00393	0.00496	–	0.00014	–	–	0.00063	–	0.00554	0.01074
82	6:00 AM–6:59 AM	6:00 PM–6:59 PM	0.00690	0.00217	0.00088	–	–	–	–	–	–	0.00687	0.00667
83	6:00 AM–6:59 AM	7:00 PM–7:59 PM	0.00519	–	0.00008	–	0.00017	–	–	–	–	0.00293	0.01285
84	6:00 AM–6:59 AM	8:00 PM–8:59 PM	0.00167	–	0.00018	–	–	–	–	0.00026	–	0.00610	0.00591
85	6:00 AM–6:59 AM	9:00 PM–9:59 PM	0.00028	–	–	–	–	–	–	–	–	0.00274	0.00741
86	6:00 AM–6:59 AM	10:00 PM–10:59 PM	0.00007	–	–	–	–	–	–	–	–	0.01323	0.00703
87	6:00 AM–6:59 AM	11:00 PM–11:59 PM	–	–	0.00021	–	–	–	–	–	–	0.00300	0.00165
88	6:00 AM–6:59 AM	12:00 AM–12:59 AM	–	–	–	–	–	–	–	–	–	0.00091	0.00050
89	6:00 AM–6:59 AM	1:00 AM–1:59 AM	–	–	–	–	–	–	–	–	–	0.00046	–

Sequence Number	Tour Destination Arrival Time	Tour Destination Departure Time	Work-Regular Work Location	Work-Other Work Location	School	Escort	Personal Business	Shop	Meal	Social / Recre-ation	Work-Based Sub-Tour	Non-Closed Work[1]	Non-Closed Non-Work[1]
90	6:00 AM–6:59 AM	2:00 AM–2:59 AM	–	–	–	–	–	–	–	–	–	0.00123	0.00062
91	7:00 AM–7:59 AM	7:00 AM–7:59 AM	0.00414	0.00891	0.00125	0.13197	0.00402	0.00393	0.00139	0.00411	0.02053	0.01872	0.00497
92	7:00 AM–7:59 AM	8:00 AM–8:59 AM	0.00180	0.01351	0.00242	0.01880	0.00932	0.00372	0.00748	0.01022	0.00247	0.02597	0.00773
93	7:00 AM–7:59 AM	9:00 AM–9:59 AM	0.00219	0.02288	0.00320	0.00103	0.00466	0.00013	0.00290	0.00806	0.00044	0.00952	0.00825
94	7:00 AM–7:59 AM	10:00 AM–10:59 AM	0.00315	0.00393	0.00765	–	0.00552	0.00048	0.00173	0.00135	0.00042	0.00361	0.01541
95	7:00 AM–7:59 AM	11:00 AM–11:59 AM	0.00496	0.00665	0.01236	–	0.00099	–	–	0.00111	–	0.01325	0.00697
96	7:00 AM–7:59 AM	12:00 PM–12:59 PM	0.00860	0.01006	0.01288	–	0.00412	–	–	0.00032	0.00056	0.00548	0.00664
97	7:00 AM–7:59 AM	1:00 PM–1:59 PM	0.00906	0.00294	0.01329	–	0.00015	–	–	0.00077	–	0.00649	0.00417
98	7:00 AM–7:59 AM	2:00 PM–2:59 PM	0.01281	0.00448	0.14744	–	0.00020	–	–	0.00017	0.00055	0.01002	0.00717
99	7:00 AM–7:59 AM	3:00 PM–3:59 PM	0.04154	0.01781	0.16643	0.00008	0.00222	–	–	0.00191	0.00043	0.01649	0.00386
100	7:00 AM–7:59 AM	4:00 PM–4:59 PM	0.09066	0.02412	0.04219	–	0.00280	–	–	0.00159	0.00019	0.01203	0.00828
101	7:00 AM–7:59 AM	5:00 PM–5:59 PM	0.07103	0.00456	0.02959	–	0.00113	–	–	0.00072	–	0.01727	0.01206
102	7:00 AM–7:59 AM	6:00 PM–6:59 PM	0.02047	0.00340	0.00827	0.00021	0.00209	–	–	–	–	0.01876	0.00707
103	7:00 AM–7:59 AM	7:00 PM–7:59 PM	0.00551	0.00136	0.00214	–	–	–	–	0.00019	–	0.00750	0.01357
104	7:00 AM–7:59 AM	8:00 PM–8:59 PM	0.00263	0.00032	0.00052	–	–	–	–	–	–	0.01578	0.00596
105	7:00 AM–7:59 AM	9:00 PM–9:59 PM	0.00151	–	0.00009	–	–	–	–	0.00021	–	0.00685	0.00722
106	7:00 AM–7:59 AM	10:00 PM–10:59 PM	0.00053	–	0.00035	–	–	–	–	–	–	0.03255	0.00735
107	7:00 AM–7:59 AM	11:00 PM–11:59 PM	0.00008	–	–	–	–	–	–	–	–	0.00737	0.00211
108	7:00 AM–7:59 AM	12:00 AM–12:59 AM	–	–	–	–	–	–	–	–	–	0.00220	0.00048
109	7:00 AM–7:59 AM	1:00 AM–1:59 AM	–	–	–	–	–	–	–	–	–	0.00151	–
110	7:00 AM–7:59 AM	2:00 AM–2:59 AM	–	–	–	–	–	–	–	–	–	0.00298	0.00060
111	8:00 AM–8:59 AM	8:00 AM–8:59 AM	0.00381	0.02085	0.00207	0.12194	0.01420	0.00755	0.00307	0.00465	0.01135	0.00863	0.00297
112	8:00 AM–8:59 AM	9:00 AM–9:59 AM	0.00359	0.02693	0.00232	0.02276	0.03041	0.00878	0.01269	0.01119	0.01827	0.00682	0.00608
113	8:00 AM–8:59 AM	10:00 AM–10:59 AM	0.00418	0.01989	0.00546	0.00012	0.01211	0.00297	0.00837	0.01528	0.00842	0.00229	0.01188
114	8:00 AM–8:59 AM	11:00 AM–11:59 AM	0.00777	0.02048	0.02008	–	0.00972	0.00007	0.00038	0.00794	0.00576	0.00785	0.00533
115	8:00 AM–8:59 AM	12:00 PM–12:59 PM	0.00978	0.01010	0.01098	0.00021	0.00296	–	–	0.00203	0.00502	0.00344	0.00501
116	8:00 AM–8:59 AM	1:00 PM–1:59 PM	0.00616	0.01411	0.00668	0.00005	0.00066	0.00014	0.00011	0.00173	0.00085	0.00452	0.00334
117	8:00 AM–8:59 AM	2:00 PM–2:59 PM	0.01025	0.00513	0.02595	–	0.00472	–	–	0.00237	0.00416	0.00646	0.00570
118	8:00 AM–8:59 AM	3:00 PM–3:59 PM	0.02001	0.00637	0.17661	–	0.00115	–	–	0.00157	0.00140	0.01176	0.00309
119	8:00 AM–8:59 AM	4:00 PM–4:59 PM	0.04852	0.01088	0.03557	–	0.00434	–	–	0.00131	0.00091	0.00797	0.00691

Sequence Number	Tour Destination Arrival Time	Tour Destination Departure Time	Work-Regular Work Location	Work-Other Work Location	School	Escort	Personal Business	Shop	Meal	Social / Recre-ation	Work-Based Sub-Tour	Non-Closed Work[1]	Non-Closed Non-Work[1]
120	8:00 AM–8:59 AM	5:00 PM–5:59 PM	0.08258	0.01735	0.02094	–	0.00274	–	–	0.00076	–	0.01235	0.00996
121	8:00 AM–8:59 AM	6:00 PM–6:59 PM	0.02568	0.00881	0.00560	–	0.00056	–	–	0.00143	–	0.01188	0.00593
122	8:00 AM–8:59 AM	7:00 PM–7:59 PM	0.00506	0.00071	0.00046	–	–	–	–	–	–	0.00441	0.01141
123	8:00 AM–8:59 AM	8:00 PM–8:59 PM	0.00225	0.00088	0.00009	–	–	–	–	0.00014	–	0.00942	0.00508
124	8:00 AM–8:59 AM	9:00 PM–9:59 PM	0.00096	–	0.00046	–	–	–	–	0.00053	–	0.00392	0.00622
125	8:00 AM–8:59 AM	10:00 PM–10:59 PM	0.00048	–	–	–	–	–	–	0.00076	–	0.01826	0.00619
126	8:00 AM–8:59 AM	11:00 PM–11:59 PM	–	–	–	–	–	–	–	–	–	0.00412	0.00168
127	8:00 AM–8:59 AM	12:00 AM–12:59 AM	–	–	–	–	–	–	–	–	–	0.00121	0.00042
128	8:00 AM–8:59 AM	1:00 AM–1:59 AM	–	–	–	–	–	–	–	–	–	0.00112	–
129	8:00 AM–8:59 AM	2:00 AM–2:59 AM	–	–	0.00007	–	–	–	–	–	–	0.00165	0.00052
130	9:00 AM–9:59 AM	9:00 AM–9:59 AM	0.00207	0.02010	0.00135	0.04080	0.02102	0.01282	0.00497	0.00573	0.02217	0.00118	0.00264
131	9:00 AM–9:59 AM	10:00 AM–10:59 AM	0.00308	0.02761	0.00212	0.00313	0.05010	0.03107	0.01127	0.02652	0.02195	0.00098	0.01229
132	9:00 AM–9:59 AM	11:00 AM–11:59 AM	0.00539	0.02017	0.00866	0.00013	0.02294	0.00386	0.00422	0.02421	0.01568	0.00376	0.00537
133	9:00 AM–9:59 AM	12:00 PM–12:59 PM	0.00432	0.02328	0.00474	0.00184	0.00946	0.00194	0.00270	0.00800	0.00315	0.00150	0.00477
134	9:00 AM–9:59 AM	1:00 PM–1:59 PM	0.00488	0.00910	0.00240	–	0.00031	0.00021	–	0.00400	0.00307	0.00164	0.00390
135	9:00 AM–9:59 AM	2:00 PM–2:59 PM	0.00595	0.01088	0.00688	–	0.00139	–	–	0.00258	0.00095	0.00269	0.00648
136	9:00 AM–9:59 AM	3:00 PM–3:59 PM	0.00951	0.00922	0.01778	–	0.00221	0.00116	–	0.00454	0.00058	0.00409	0.00363
137	9:00 AM–9:59 AM	4:00 PM–4:59 PM	0.01587	0.00734	0.01244	–	0.00311	–	–	0.00136	0.00075	0.00317	0.00903
138	9:00 AM–9:59 AM	5:00 PM–5:59 PM	0.02294	0.00945	0.00705	–	0.00077	–	–	0.00057	–	0.00428	0.01264
139	9:00 AM–9:59 AM	6:00 PM–6:59 PM	0.01439	0.00475	0.00061	–	–	–	–	0.00029	0.00035	0.00510	0.00786
140	9:00 AM–9:59 AM	7:00 PM–7:59 PM	0.00382	0.00061	0.00044	–	–	–	–	–	–	0.00214	0.01515
141	9:00 AM–9:59 AM	8:00 PM–8:59 PM	0.00126	–	0.00101	–	–	–	–	0.00018	–	0.00446	0.00697
142	9:00 AM–9:59 AM	9:00 PM–9:59 PM	0.00073	–	–	–	–	–	–	0.00011	–	0.00199	0.00875
143	9:00 AM–9:59 AM	10:00 PM–10:59 PM	0.00024	–	–	–	–	–	–	–	–	0.00955	0.00829
144	9:00 AM–9:59 AM	11:00 PM–11:59 PM	0.00017	–	–	–	–	–	–	–	–	0.00217	0.00194
145	9:00 AM–9:59 AM	12:00 AM–12:59 AM	–	–	–	–	–	–	–	–	–	0.00065	0.00060
146	9:00 AM–9:59 AM	1:00 AM–1:59 AM	–	–	–	–	–	–	–	–	–	0.00036	–
147	9:00 AM–9:59 AM	2:00 AM–2:59 AM	0.00010	–	–	–	–	–	–	–	–	0.00088	0.00073
148	10:00 AM–10:59 AM	10:00 AM–10:59 AM	0.00125	0.02312	0.00096	0.01796	0.02806	0.03996	0.00280	0.00697	0.03046	0.00014	0.01187
149	10:00 AM–10:59 AM	11:00 AM–11:59 AM	0.00203	0.01677	0.00072	0.00728	0.07188	0.06337	0.01079	0.02372	0.03053	0.00090	0.01067

Sequence Number	Tour Destination Arrival Time	Tour Destination Departure Time	Work-Regular Work Location	Work-Other Work Location	School	Escort	Personal Business	Shop	Meal	Social / Recre-ation	Work-Based Sub-Tour	Non-Closed Work[1]	Non-Closed Non-Work[1]
150	10:00 AM–10:59 AM	12:00 PM–12:59 PM	0.00149	0.01312	0.00298	0.00020	0.01532	0.01479	0.00500	0.01036	0.00981	0.00043	0.01007
151	10:00 AM–10:59 AM	1:00 PM–1:59 PM	0.00109	0.00471	0.00274	–	0.00763	0.00209	0.00265	0.00564	0.00476	0.00063	0.00661
152	10:00 AM–10:59 AM	2:00 PM–2:59 PM	0.00280	0.00406	0.00431	–	0.00267	0.00017	0.00168	0.00427	0.00118	0.00083	0.01129
153	10:00 AM–10:59 AM	3:00 PM–3:59 PM	0.00307	0.00375	0.00336	–	0.00099	–	–	0.00197	0.00037	0.00168	0.00612
154	10:00 AM–10:59 AM	4:00 PM–4:59 PM	0.00282	0.00702	0.00137	–	0.00162	–	–	0.00455	–	0.00105	0.01354
155	10:00 AM–10:59 AM	5:00 PM–5:59 PM	0.00372	0.00533	0.00112	–	–	–	–	0.00029	–	0.00177	0.01955
156	10:00 AM–10:59 AM	6:00 PM–6:59 PM	0.00417	0.00044	0.00010	–	–	–	–	–	–	0.00149	0.01160
157	10:00 AM–10:59 AM	7:00 PM–7:59 PM	0.00453	–	0.00084	–	–	–	–	–	–	0.00050	0.02230
158	10:00 AM–10:59 AM	8:00 PM–8:59 PM	0.00218	–	–	–	–	–	–	–	–	0.00109	0.00990
159	10:00 AM–10:59 AM	9:00 PM–9:59 PM	0.00089	–	–	–	–	–	–	–	–	0.00042	0.01208
160	10:00 AM–10:59 AM	10:00 PM–10:59 PM	0.00029	–	0.00033	–	–	–	–	–	–	0.00191	0.01210
161	10:00 AM–10:59 AM	11:00 PM–11:59 PM	0.00074	–	–	–	–	–	–	–	–	0.00043	0.00334
162	10:00 AM–10:59 AM	12:00 AM–12:59 AM	0.00001	–	–	–	–	–	–	–	–	0.00012	0.00081
163	10:00 AM–10:59 AM	1:00 AM–1:59 AM	0.00045	–	–	–	–	–	–	–	–	0.00017	–
164	10:00 AM–10:59 AM	2:00 AM–2:59 AM	–	–	–	–	–	–	–	–	–	0.00017	0.00100
165	11:00 AM–11:59 AM	11:00 AM–11:59 AM	0.00174	0.02905	0.00043	0.04033	0.02631	0.02478	0.00603	0.00627	0.06026	0.00115	0.00239
166	11:00 AM–11:59 AM	12:00 PM–12:59 PM	0.00282	0.01895	0.00277	0.00604	0.04160	0.05868	0.05013	0.01546	0.12348	0.00130	0.00446
167	11:00 AM–11:59 AM	1:00 PM–1:59 PM	0.00098	0.01001	0.00115	–	0.00795	0.01057	0.04548	0.01490	0.03001	0.00234	0.00304
168	11:00 AM–11:59 AM	2:00 PM–2:59 PM	0.00221	0.00460	0.00705	–	0.00245	0.00242	0.00488	0.00492	0.00344	0.00269	0.00517
169	11:00 AM–11:59 AM	3:00 PM–3:59 PM	0.00369	0.00281	0.00323	–	0.00148	0.00049	0.00018	0.00456	0.00084	0.00641	0.00282
170	11:00 AM–11:59 AM	4:00 PM–4:59 PM	0.00181	0.00031	0.00528	–	0.00035	0.00071	–	0.00084	0.00049	0.00360	0.00638
171	11:00 AM–11:59 AM	5:00 PM–5:59 PM	0.00316	0.00298	0.00025	–	0.00028	0.00019	–	0.00176	–	0.00678	0.00915
172	11:00 AM–11:59 AM	6:00 PM–6:59 PM	0.00138	0.00186	–	–	0.00040	–	–	–	–	0.00463	0.00548
173	11:00 AM–11:59 AM	7:00 PM–7:59 PM	0.00499	0.00107	–	–	–	0.00097	–	0.00091	–	0.00125	0.01054
174	11:00 AM–11:59 AM	8:00 PM–8:59 PM	0.00187	–	–	–	–	–	–	0.00090	–	0.00287	0.00471
175	11:00 AM–11:59 AM	9:00 PM–9:59 PM	0.00089	–	0.00021	–	0.00063	–	–	–	–	0.00095	0.00579
176	11:00 AM–11:59 AM	10:00 PM–10:59 PM	0.00023	–	0.00035	–	–	–	–	–	–	0.00383	0.00573
177	11:00 AM–11:59 AM	11:00 PM–11:59 PM	0.00036	–	–	–	–	–	–	–	–	0.00084	0.00153
178	11:00 AM–11:59 AM	12:00 AM–12:59 AM	–	–	–	–	–	–	–	–	–	0.00022	0.00039
179	11:00 AM–11:59 AM	1:00 AM–1:59 AM	–	–	–	–	–	–	–	–	–	0.00066	–

Sequence Number	Tour Destination Arrival Time	Tour Destination Departure Time	Work-Regular Work Location	Work-Other Work Location	School	Escort	Personal Business	Shop	Meal	Social / Recre-ation	Work-Based Sub-Tour	Non-Closed Work[1]	Non-Closed Non-Work[1]
180	11:00 AM–11:59 AM	2:00 AM–2:59 AM	–	–	–	–	–	–	–	–	–	0.00030	0.00048
181	12:00 PM–12:59 PM	12:00 PM–12:59 PM	0.00099	0.00910	0.00098	0.03672	0.02615	0.02254	0.01065	0.00191	0.12749	0.00032	0.00205
182	12:00 PM–12:59 PM	1:00 PM–1:59 PM	0.00120	0.01293	0.00042	0.00570	0.02818	0.04290	0.07897	0.01174	0.10403	0.00096	0.00300
183	12:00 PM–12:59 PM	2:00 PM–2:59 PM	0.00100	0.01126	0.00349	–	0.01528	0.00416	0.01437	0.00926	0.01572	0.00124	0.00505
184	12:00 PM–12:59 PM	3:00 PM–3:59 PM	0.00401	0.00494	0.01270	0.00016	0.00562	0.00058	0.00511	0.00648	0.00169	0.00257	0.00278
185	12:00 PM–12:59 PM	4:00 PM–4:59 PM	0.00720	0.00216	0.00342	–	0.00287	0.00047	–	0.00370	0.00068	0.00158	0.00656
186	12:00 PM–12:59 PM	5:00 PM–5:59 PM	0.00520	0.00024	0.00043	–	0.00037	–	–	0.00289	0.00028	0.00271	0.00931
187	12:00 PM–12:59 PM	6:00 PM–6:59 PM	0.00155	0.00157	0.00069	–	0.00039	–	–	0.00059	–	0.00221	0.00567
188	12:00 PM–12:59 PM	7:00 PM–7:59 PM	0.00083	–	0.00010	–	–	–	–	0.00013	–	0.00072	0.01092
189	12:00 PM–12:59 PM	8:00 PM–8:59 PM	0.00279	–	–	–	–	–	–	–	–	0.00158	0.00495
190	12:00 PM–12:59 PM	9:00 PM–9:59 PM	0.00165	0.00029	–	–	0.00119	0.00024	–	0.00022	–	0.00061	0.00613
191	12:00 PM–12:59 PM	10:00 PM–10:59 PM	0.00078	–	–	–	–	–	–	–	–	0.00270	0.00595
192	12:00 PM–12:59 PM	11:00 PM–11:59 PM	0.00091	–	–	–	–	–	–	–	–	0.00061	0.00150
193	12:00 PM–12:59 PM	12:00 AM–12:59 AM	–	–	–	–	–	–	–	–	–	0.00017	0.00042
194	12:00 PM–12:59 PM	1:00 AM–1:59 AM	–	–	–	–	–	–	–	–	–	0.00026	–
195	12:00 PM–12:59 PM	2:00 AM–2:59 AM	–	–	–	–	–	–	–	–	–	0.00023	0.00051
196	1:00 PM–1:59 PM	1:00 PM–1:59 PM	0.00193	0.01940	0.00094	0.02226	0.03813	0.03038	0.00816	0.00231	0.07040	0.00056	0.00082
197	1:00 PM–1:59 PM	2:00 PM–2:59 PM	0.00210	0.01695	0.00194	0.00720	0.04024	0.05436	0.04936	0.01447	0.03094	0.00175	0.00287
198	1:00 PM–1:59 PM	3:00 PM–3:59 PM	0.00255	0.01300	0.00198	–	0.01529	0.01133	0.00911	0.00817	0.00632	0.00284	0.00150
199	1:00 PM–1:59 PM	4:00 PM–4:59 PM	0.00447	0.00336	0.00228	–	0.00399	0.00038	0.00045	0.00564	0.00506	0.00210	0.00288
200	1:00 PM–1:59 PM	5:00 PM–5:59 PM	0.00799	0.00257	0.00141	0.00011	0.00074	0.00079	–	0.00177	0.00148	0.00298	0.00434
201	1:00 PM–1:59 PM	6:00 PM–6:59 PM	0.00204	0.00055	0.00134	–	0.00007	–	–	0.00083	0.00369	0.00329	0.00242
202	1:00 PM–1:59 PM	7:00 PM–7:59 PM	0.00117	–	–	–	–	–	–	0.00092	–	0.00133	0.00463
203	1:00 PM–1:59 PM	8:00 PM–8:59 PM	0.00112	0.00011	–	–	–	–	–	0.00039	–	0.00279	0.00195
204	1:00 PM–1:59 PM	9:00 PM–9:59 PM	0.00116	0.00074	–	–	0.00018	–	–	0.00009	–	0.00122	0.00227
205	1:00 PM–1:59 PM	10:00 PM–10:59 PM	0.00556	0.00055	0.00025	–	0.00013	–	–	0.00022	–	0.00579	0.00248
206	1:00 PM–1:59 PM	11:00 PM–11:59 PM	0.00091	–	–	–	–	–	–	0.00085	–	0.00131	0.00084
207	1:00 PM–1:59 PM	12:00 AM–12:59 AM	0.00014	–	–	–	–	–	–	–	–	0.00039	0.00015
208	1:00 PM–1:59 PM	1:00 AM–1:59 AM	0.00028	0.00143	–	–	–	–	–	–	–	0.00026	–
209	1:00 PM–1:59 PM	2:00 AM–2:59 AM	–	–	–	–	–	–	–	–	–	0.00053	0.00019

Sequence Number	Tour Destination Arrival Time	Tour Destination Departure Time	Work-Regular Work Location	Work-Other Work Location	School	Escort	Personal Business	Shop	Meal	Social / Recre-ation	Work-Based Sub-Tour	Non-Closed Work[1]	Non-Closed Non-Work[1]
210	2:00 PM–2:59 PM	2:00 PM–2:59 PM	0.00178	0.01840	0.00340	0.06835	0.02189	0.03175	0.00726	0.00268	0.03930	0.00118	0.00250
211	2:00 PM–2:59 PM	3:00 PM–3:59 PM	0.00270	0.01567	0.00225	0.04583	0.03474	0.04591	0.01759	0.01548	0.02415	0.00462	0.00264
212	2:00 PM–2:59 PM	4:00 PM–4:59 PM	0.00212	0.00582	0.00234	0.00084	0.01052	0.00754	0.00279	0.00868	0.00674	0.00298	0.00525
213	2:00 PM–2:59 PM	5:00 PM–5:59 PM	0.00334	0.01177	0.00108	–	0.00575	0.00089	–	0.00459	–	0.00486	0.00782
214	2:00 PM–2:59 PM	6:00 PM–6:59 PM	0.00340	0.00195	0.00005	0.00006	0.00080	0.00103	0.00015	0.00111	0.00157	0.00429	0.00443
215	2:00 PM–2:59 PM	7:00 PM–7:59 PM	0.00128	–	0.00079	–	0.00041	0.00031	–	0.00242	–	0.00150	0.00849
216	2:00 PM–2:59 PM	8:00 PM–8:59 PM	0.00137	0.00735	–	0.00009	0.00032	–	–	0.00096	–	0.00324	0.00362
217	2:00 PM–2:59 PM	9:00 PM–9:59 PM	0.00089	0.00120	–	–	–	–	–	0.00033	–	0.00130	0.00428
218	2:00 PM–2:59 PM	10:00 PM–10:59 PM	0.00213	0.00023	–	–	–	–	–	–	–	0.00594	0.00457
219	2:00 PM–2:59 PM	11:00 PM–11:59 PM	0.00453	–	–	–	–	–	–	0.00060	–	0.00134	0.00146
220	2:00 PM–2:59 PM	12:00 AM–12:59 AM	0.00091	–	–	–	–	–	–	–	–	0.00039	0.00029
221	2:00 PM–2:59 PM	1:00 AM–1:59 AM	0.00041	–	–	–	–	–	–	–	–	0.00045	–
222	2:00 PM–2:59 PM	2:00 AM–2:59 AM	0.00004	–	–	–	–	–	–	–	–	0.00053	0.00035
223	3:00 PM–3:59 PM	3:00 PM–3:59 PM	0.00560	0.01954	0.00276	0.12842	0.03092	0.02520	0.00376	0.00476	0.02581	0.00356	0.00069
224	3:00 PM–3:59 PM	4:00 PM–4:59 PM	0.00175	0.02492	0.00247	0.01778	0.03604	0.05471	0.00642	0.02239	0.00883	0.00545	0.00263
225	3:00 PM–3:59 PM	5:00 PM–5:59 PM	0.00270	0.00783	0.00204	0.00010	0.00600	0.00744	0.00741	0.00716	0.00216	0.00744	0.00397
226	3:00 PM–3:59 PM	6:00 PM–6:59 PM	0.00234	0.00099	0.00068	–	0.00320	0.00056	0.00093	0.00808	0.00219	0.00874	0.00221
227	3:00 PM–3:59 PM	7:00 PM–7:59 PM	0.00163	0.00087	–	–	0.00015	0.00014	0.00048	0.00229	–	0.00364	0.00423
228	3:00 PM–3:59 PM	8:00 PM–8:59 PM	0.00179	0.00207	0.00018	–	0.00020	–	0.00024	0.00355	–	0.00760	0.00177
229	3:00 PM–3:59 PM	9:00 PM–9:59 PM	0.00187	0.00071	0.00008	–	–	–	–	0.00361	–	0.00337	0.00206
230	3:00 PM–3:59 PM	10:00 PM–10:59 PM	0.00165	–	–	–	–	–	–	0.00021	–	0.01618	0.00226
231	3:00 PM–3:59 PM	11:00 PM–11:59 PM	0.00125	–	–	–	–	–	–	0.00032	–	0.00367	0.00077
232	3:00 PM–3:59 PM	12:00 AM–12:59 AM	0.00394	0.00144	–	–	–	–	–	0.00011	–	0.00110	0.00014
233	3:00 PM–3:59 PM	1:00 AM–1:59 AM	0.00034	–	–	–	–	–	–	–	–	0.00063	–
234	3:00 PM–3:59 PM	2:00 AM–2:59 AM	0.00015	–	–	–	–	–	–	–	–	0.00149	0.00017
235	4:00 PM–4:59 PM	4:00 PM–4:59 PM	0.00135	0.01213	0.00150	0.05989	0.03415	0.03295	0.00523	0.00850	0.02532	0.00184	0.00197
236	4:00 PM–4:59 PM	5:00 PM–5:59 PM	0.00096	0.01120	0.00169	0.00811	0.02436	0.03944	0.01845	0.03846	0.00286	0.00573	0.00644
237	4:00 PM–4:59 PM	6:00 PM–6:59 PM	0.00072	0.00329	0.00109	0.00031	0.00416	0.00484	0.01158	0.02223	0.00220	0.00547	0.00315
238	4:00 PM–4:59 PM	7:00 PM–7:59 PM	0.00084	0.00352	0.00033	0.00009	0.00086	0.00126	0.00306	0.01041	–	0.00202	0.00599
239	4:00 PM–4:59 PM	8:00 PM–8:59 PM	0.00177	0.01385	0.00076	–	–	–	–	0.00319	–	0.00432	0.00219

Sequence Number	Tour Destination Arrival Time	Tour Destination Departure Time	Work-Regular Work Location	Work-Other Work Location	School	Escort	Personal Business	Shop	Meal	Social / Recre-ation	Work-Based Sub-Tour	Non-Closed Work[1]	Non-Closed Non-Work[1]
240	4:00 PM–4:59 PM	9:00 PM–9:59 PM	0.00326	0.00493	0.00186	–	0.00026	–	–	0.00325	–	0.00179	0.00223
241	4:00 PM–4:59 PM	10:00 PM–10:59 PM	0.00387	0.00076	0.00055	–	–	–	0.00204	0.00087	–	0.00833	0.00312
242	4:00 PM–4:59 PM	11:00 PM–11:59 PM	0.00154	–	–	–	0.00023	–	–	–	–	0.00188	0.00150
243	4:00 PM–4:59 PM	12:00 AM–12:59 AM	0.00026	–	–	–	0.00030	–	–	–	–	0.00055	0.00014
244	4:00 PM–4:59 PM	1:00 AM–1:59 AM	–	–	–	–	–	–	–	–	–	0.00052	–
245	4:00 PM–4:59 PM	2:00 AM–2:59 AM	0.00024	–	–	–	–	–	–	0.00052	–	0.00075	0.00017
246	5:00 PM–5:59 PM	5:00 PM–5:59 PM	0.00182	0.00736	0.00184	0.04422	0.02911	0.04038	0.01173	0.00890	0.00386	0.00389	0.00512
247	5:00 PM–5:59 PM	6:00 PM–6:59 PM	0.00130	0.00976	0.00114	0.00747	0.01784	0.04088	0.06404	0.04898	0.00388	0.00921	0.00525
248	5:00 PM–5:59 PM	7:00 PM–7:59 PM	0.00130	0.01249	0.00391	–	0.00764	0.01003	0.03473	0.03474	0.00707	0.00385	0.00999
249	5:00 PM–5:59 PM	8:00 PM–8:59 PM	0.00111	0.00496	0.00665	0.00175	0.00462	–	0.01089	0.01790	0.00067	0.00804	0.00385
250	5:00 PM–5:59 PM	9:00 PM–9:59 PM	0.00495	0.00163	0.00494	–	0.00018	–	0.00466	0.01046	0.00160	0.00357	0.00415
251	5:00 PM–5:59 PM	10:00 PM–10:59 PM	0.00114	0.00133	0.00221	–	0.00013	–	0.00101	0.00242	–	0.01717	0.00526
252	5:00 PM–5:59 PM	11:00 PM–11:59 PM	0.00044	–	–	–	–	–	–	0.00166	–	0.00389	0.00225
253	5:00 PM–5:59 PM	12:00 AM–12:59 AM	0.00055	–	–	–	–	–	–	0.00039	–	0.00117	0.00027
254	5:00 PM–5:59 PM	1:00 AM–1:59 AM	0.00099	–	–	–	–	–	–	–	–	0.00066	–
255	5:00 PM–5:59 PM	2:00 AM–2:59 AM	0.00007	–	–	–	–	–	–	–	–	0.00159	0.00033
256	6:00 PM–6:59 PM	6:00 PM–6:59 PM	0.00068	0.00380	0.00058	0.03985	0.02034	0.02839	0.01775	0.00577	0.00268	0.00385	0.00125
257	6:00 PM–6:59 PM	7:00 PM–7:59 PM	0.00069	0.00607	0.00249	0.00406	0.01973	0.03177	0.12958	0.05017	0.00588	0.00257	0.00474
258	6:00 PM–6:59 PM	8:00 PM–8:59 PM	0.00154	0.01049	0.00406	0.00037	0.01136	0.00857	0.06948	0.06863	0.00060	0.00562	0.00168
259	6:00 PM–6:59 PM	9:00 PM–9:59 PM	0.00151	0.01009	0.00313	–	0.00378	0.00005	0.02082	0.03363	0.00303	0.00219	0.00164
260	6:00 PM–6:59 PM	10:00 PM–10:59 PM	0.00114	0.00307	0.00014	0.00040	0.00100	–	0.00168	0.01184	–	0.00983	0.00245
261	6:00 PM–6:59 PM	11:00 PM–11:59 PM	0.00075	0.00112	–	–	–	–	–	0.00479	–	0.00221	0.00126
262	6:00 PM–6:59 PM	12:00 AM–12:59 AM	0.00018	0.00026	–	–	–	–	–	–	–	0.00063	0.00010
263	6:00 PM–6:59 PM	1:00 AM–1:59 AM	0.00004	–	–	–	0.00037	–	–	0.00011	–	0.00087	–
264	6:00 PM–6:59 PM	2:00 AM–2:59 AM	0.00022	–	–	–	–	–	–	–	–	0.00086	0.00012
265	7:00 PM–7:59 PM	7:00 PM–7:59 PM	0.00028	0.00454	0.00010	0.02360	0.01635	0.02981	0.01562	0.00654	0.00239	0.00034	0.00449
266	7:00 PM–7:59 PM	8:00 PM–8:59 PM	0.00109	0.00550	0.00102	0.00279	0.00789	0.02970	0.06002	0.03319	0.00074	0.00156	0.00315
267	7:00 PM–7:59 PM	9:00 PM–9:59 PM	0.00074	0.00108	0.00053	0.00045	0.00405	0.00084	0.04460	0.04006	–	0.00050	0.00306
268	7:00 PM–7:59 PM	10:00 PM–10:59 PM	0.00016	0.00431	0.00015	–	–	0.00083	0.00513	0.01908	–	0.00198	0.00464
269	7:00 PM–7:59 PM	11:00 PM–11:59 PM	0.00003	0.00072	–	–	0.00012	–	0.00187	0.00617	–	0.00043	0.00242

Sequence Number	Tour Destination Arrival Time	Tour Destination Departure Time	Work-Regular Work Location	Work-Other Work Location	School	Escort	Personal Business	Shop	Meal	Social / Recre-ation	Work-Based Sub-Tour	Non-Closed Work[1]	Non-Closed Non-Work[1]
270	7:00 PM–7:59 PM	12:00 AM–12:59 AM	0.00029	–	0.00041	–	–	–	–	0.00069	–	0.00011	0.00019
271	7:00 PM–7:59 PM	1:00 AM–1:59 AM	–	–	–	–	–	–	–	0.00016	–	0.00038	–
272	7:00 PM–7:59 PM	2:00 AM–2:59 AM	–	–	–	–	–	–	–	0.00049	–	0.00015	0.00023
273	8:00 PM–8:59 PM	8:00 PM–8:59 PM	0.00013	0.00091	–	0.01242	0.00578	0.02186	0.00630	0.00388	0.00225	0.00178	0.00049
274	8:00 PM–8:59 PM	9:00 PM–9:59 PM	0.00048	0.00032	–	0.00371	0.00214	0.00864	0.01865	0.00550	–	0.00121	0.00078
275	8:00 PM–8:59 PM	10:00 PM–10:59 PM	0.00030	0.00111	–	0.00020	–	0.00096	0.00354	0.00531	–	0.00497	0.00159
276	8:00 PM–8:59 PM	11:00 PM–11:59 PM	–	0.00037	0.00080	–	–	–	0.00024	0.00486	–	0.00110	0.00103
277	8:00 PM–8:59 PM	12:00 AM–12:59 AM	0.00011	–	–	–	–	–	–	0.00313	–	0.00030	0.00004
278	8:00 PM–8:59 PM	1:00 AM–1:59 AM	–	–	–	–	–	–	–	0.00059	–	0.00078	–
279	8:00 PM–8:59 PM	2:00 AM–2:59 AM	–	–	–	–	–	–	–	–	–	0.00040	0.00005
280	9:00 PM–9:59 PM	9:00 PM–9:59 PM	0.00005	0.00159	–	0.00760	0.00318	0.01154	0.00362	0.00188	0.00093	0.00017	0.00020
281	9:00 PM–9:59 PM	10:00 PM–10:59 PM	–	0.00158	–	0.00047	0.00019	0.00822	0.00228	0.00531	0.00037	0.00120	0.00150
282	9:00 PM–9:59 PM	11:00 PM–11:59 PM	0.00050	–	–	–	–	0.00034	0.00185	0.00485	–	0.00026	0.00121
283	9:00 PM–9:59 PM	12:00 AM–12:59 AM	0.00006	0.00108	–	0.00010	–	–	0.00482	0.00185	–	0.00006	0.00001
284	9:00 PM–9:59 PM	1:00 AM–1:59 AM	0.00005	–	–	–	–	–	–	0.00234	–	0.00036	–
285	9:00 PM–9:59 PM	2:00 AM–2:59 AM	0.00004	–	–	–	–	–	–	0.00024	–	0.00008	0.00002
286	10:00 PM–10:59 PM	10:00 PM–10:59 PM	–	–	–	0.00310	0.00013	0.00088	0.00080	0.00026	0.00078	0.00176	0.00119
287	10:00 PM–10:59 PM	11:00 PM–11:59 PM	–	–	–	0.00135	–	0.00142	–	0.00439	–	0.00072	0.00130
288	10:00 PM–10:59 PM	12:00 AM–12:59 AM	0.00012	–	–	–	–	–	–	0.00023	–	0.00012	0.00009
289	10:00 PM–10:59 PM	1:00 AM–1:59 AM	–	0.00016	–	–	–	–	–	0.00035	–	0.00173	–
290	10:00 PM–10:59 PM	2:00 AM–2:59 AM	–	0.00027	–	–	–	–	–	0.00072	–	0.00017	0.00011
291	11:00 PM–11:59 PM	11:00 PM–11:59 PM	0.00005	–	–	0.00111	–	0.00014	0.00467	0.00011	–	0.00007	0.00021
292	11:00 PM–11:59 PM	12:00 AM–12:59 AM	0.00005	–	–	0.00022	–	–	–	0.00016	–	0.00002	0.00008
293	11:00 PM–11:59 PM	1:00 AM–1:59 AM	–	–	–	–	–	–	–	–	–	0.00039	–
294	11:00 PM–11:59 PM	2:00 AM–2:59 AM	0.00018	–	–	–	–	–	–	0.00010	–	0.00003	0.00010
295	12:00 AM–12:59 AM	12:00 AM–12:59 AM	–	–	–	0.00100	–	–	–	–	–	–	–
296	12:00 AM–12:59 AM	1:00 AM–1:59 AM	–	–	–	–	–	–	–	–	–	0.00012	–
297	12:00 AM–12:59 AM	2:00 AM–2:59 AM	–	–	–	–	0.00028	–	–	–	–	–	–
298	1:00 AM–1:59 AM	1:00 AM–1:59 AM	–	–	–	0.00189	–	0.00014	–	–	–	0.00003	–
299	1:00 AM–1:59 AM	2:00 AM–2:59 AM	–	–	–	–	–	–	–	–	–	0.00016	–

Sequence Number	Tour Destination Arrival Time	Tour Destination Departure Time	Work-Regular Work Location	Work-Other Work Location	School	Escort	Personal Business	Shop	Meal	Social / Recre-ation	Work-Based Sub-Tour	Non-Closed Work[1]	Non-Closed Non-Work[1]
300	2:00 AM–2:59 AM	2:00 AM–2:59 AM	–	–	–	–	–	–	–	–	–	–	–
	Sum of Probabilities		**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**

Source: Cambridge Systematics.

Notes: [1] Proportions of non-closed tours by actual departure and arrival times at the primary destinations are shown for non-closed tours. By definition, non-closed tours are at the primary tour destination either at the start of the travel day (3:00 AM) and depart that location during the day or arrive at the tour destination during the day and depart after the end of the travel day (2:59 AM).

Table F.25 Observed Tour Departure and Arrival Times for Non-Closed Tours

Time of Day of Departure or Arrival	Proportion Departing Primary Destination for Non-Closed Tours Starting the Day at the Non-Home Location		Proportion Arriving at Primary Destination for Non-Closed Tours Ending the Day at the Non-Home Location	
	Work Tours	Non-Work Tours	Work Tours	Non-Work Tours
3:00 AM–3:59 AM	0.00000	0.00000	0.04600	0.01274
4:00 AM–4:59 AM	0.00049	0.00000	0.04539	0.02579
5:00 AM–5:59 AM	0.00572	0.00019	0.06935	0.01742
6:00 AM–6:59 AM	0.00909	0.00341	0.09325	0.11101
7:00 AM–7:59 AM	0.05277	0.01525	0.23434	0.12987
8:00 AM–8:59 AM	0.05872	0.01820	0.12810	0.09774
9:00 AM–9:59 AM	0.02602	0.02319	0.05059	0.11104
10:00 AM–10:59 AM	0.01045	0.06665	0.01373	0.16285
11:00 AM–11:59 AM	0.03986	0.03733	0.03983	0.06806
12:00 PM–12:59 PM	0.01770	0.03878	0.01846	0.06479
1:00 PM–1:59 PM	0.02303	0.02984	0.02713	0.02733
2:00 PM–2:59 PM	0.03629	0.05442	0.03262	0.04569
3:00 PM–3:59 PM	0.06878	0.03175	0.06288	0.02091
4:00 PM–4:59 PM	0.05295	0.07521	0.03321	0.02688
5:00 PM–5:59 PM	0.08552	0.11673	0.05304	0.03644
6:00 PM–6:59 PM	0.09674	0.07260	0.02863	0.01326
7:00 PM–7:59 PM	0.03910	0.14625	0.00545	0.01819
8:00 PM–8:59 PM	0.08555	0.06542	0.01054	0.00398
9:00 PM–9:59 PM	0.03684	0.07841	0.00212	0.00294
10:00 PM–10:59 PM	0.17446	0.08551	0.00450	0.00269

Time of Day of Departure or Arrival	Proportion Departing Primary Destination for Non-Closed Tours Starting the Day at the Non-Home Location		Proportion Arriving at Primary Destination for Non-Closed Tours Ending the Day at the Non-Home Location	
	Work Tours	Non-Work Tours	Work Tours	Non-Work Tours
11:00 PM–11:59 PM	0.03976	0.02882	0.00052	0.00039
12:00 AM–12:59 AM	0.01165	0.00540	0.00012	0.00000
1:00 AM–1:59 AM	0.01257	0.00000	0.00019	0.00000
2:00 AM–2:59 AM	0.01595	0.00665	0.00000	0.00000

Source: Cambridge Systematics.

F.11 Tour Primary Location Choice

The tour primary location choice model variables, StateFocus C# parameter names, estimated model constants and t-statistics, and final calibrated parameters based on the 2015 model calibration/validation are shown by tour purpose in Sections ***F.11.1*** through ***F.11.7***. Each section lists the active variables for the purpose under consideration based on the model utility function is shown below (see ***Section 4.2.11*** for full documentation).

$$U_{j|p} = \left\{\theta_p \times Ln\left[\sum_{x=1}^{X} exp\left(SC_{x|p}\right) \times SV_{x|p}\right]\right\} + \sum_{y=1}^{Y}\left(CIX_{y|p} \times DIX_{y,p|j}\right) + \sum_{z=1}^{Z}\left(CZ_{z|p} \times DZ_{j|z,p}\right)$$

Where: $U_{j|p}$ is the utility of a destination location in TAZ j for tour purpose p given an origin location of TAZ i

Θ_p is the multiplier for the logsum of the quantitative (size) variables

$SC_{x|p}$ are the coefficients applied to the size variables that are applicable for tour purpose p

$SV_{x|p}$ are the size variables that are applicable for tour purpose p

$CIX_{y|p}$ are coefficients for interchange variables, y, for tour purpose p

$DIX_{y|p}$ are interchange specific values between origin TAZ i and destination TAZ j for interchange variable, y, for tour purpose p

$CZ_{z|p}$ are coefficients for tour destination zone variables, z, for tour purpose p

$DZ_{z|p}$ are destination specific values for destination TAZ j for destination zone variable, z, for tour purpose p

F.11.1 Home-Based Work (for Tours to Non-Regular Work Locations)

Table F.26 Home-Based Work Tour Primary Location Choice Coefficients

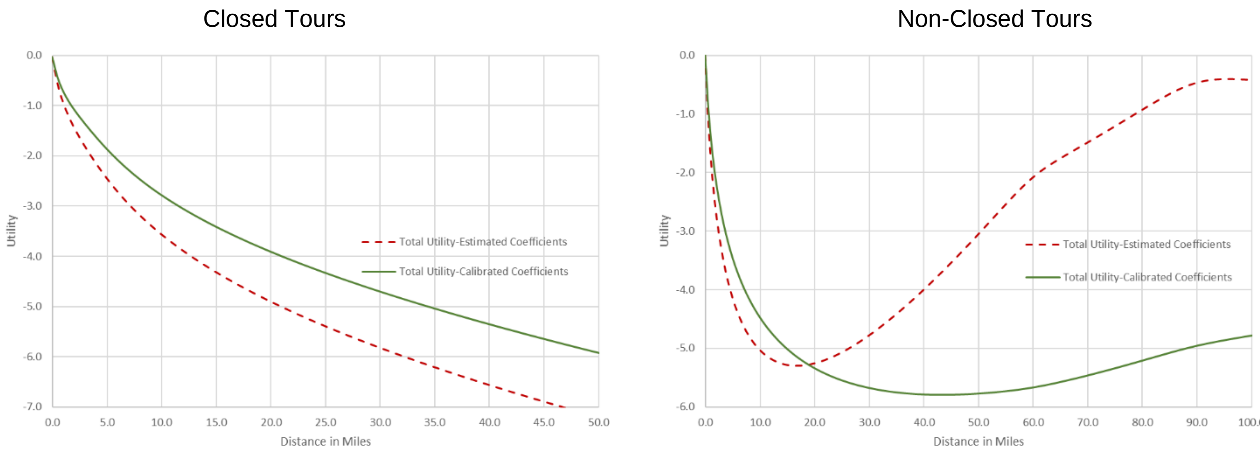
Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Quantitative (Size) Variables				
Size Logsum Multiplier (Θ)	[Tour Primary Destination].[Work].[LSM]	0.7960	-7.25	No Change
Households	[Tour Primary Destination].[Work].[Number of households in zone]	0.0000	Fixed	No Change
Production Employment	[Tour Primary Destination].[Work].[Production employment in zone]	0.9905	3.49	No Change
Service Employment	[Tour Primary Destination].[Work].[Service employment in zone]	2.3020	9.23	No Change
Education Employment	[Tour Primary Destination].[Work].[Education employment in zone]	1.1860	3.20	No Change
Retail Employment	[Tour Primary Destination].[Work].[Retail employment in zone]	1.3280	3.76	No Change
Restaurant Employment	[Tour Primary Destination].[Work].[Restaurant employment in zone]	2.3130	7.80	No Change
Entertainment Employment	[Tour Primary Destination].[Work].[Entertainment employment in zone]	0.4541	0.40	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Interchange Related Variables–Closed Tours				
Distance (Miles)	[Tour Primary Destination].[Work].[Distance]	0.2815	2.06	No Change
Ln(Distance+1)	[Tour Primary Destination].[Work].[ln (Distance)]	-1.6270	-15.91	-1.3000
Smoothed Stepwise Linear Distance Functions (Miles)[1]				
2-Mile Distance Threshold (Damping Factor = 1.0)	[Tour Primary Destination].[Work].[Distance_2_CT]	-0.3101	-2.31	No Change
Interchange Related Variables–Non-Closed Tours				
Distance (Miles)	[Tour Primary Destination].[Work].[Distance_NCT]	0.1547	13.94	0.0464
Ln(Distance+1)	[Tour Primary Destination].[Work].[ln (Distance) NCT]	-2.7440	-12.39	-2.0580
Smoothed Stepwise Linear Distance Functions (Miles)[1]				
60-Mile Distance Threshold (Damping Factor = 0.5)	[Tour Primary Destination].[Work].[Distance_60_NCT]	-0.0620	-5.48	0.0062
90-Mile Distance Threshold (Damping Factor = 0.3333)	[Tour Primary Destination].[Work].[Distance_90_NCT]	-0.0739	-12.45	-0.0170
Other Interchange Related Variables–Non-Closed and Closed Tours				
Mode Choice Logsum	[Tour Primary Destination].[Work].[Mode choice logsum]	1.0000	Fixed	No Change
Intrazonal Tour	[Tour Primary Destination].[Work].[Intrazonal dummy]	0.5152	2.78	-1.5000
Tour Destination Zone Variables				
CBD	[Tour Primary Destination].[Work].[CBD dummy]	-0.5878	-4.04	-0.7935
CBD Fringe	[Tour Primary Destination].[Work].[CBD_Fringe dummy]	-0.2763	-3.36	-0.2210
Rural	[Tour Primary Destination].[Work].[Rural dummy]	1.1020	14.92	No Change
Model Estimation Statistics				
Number of Observations	2,017			
Log-likelihood at Convergence	-13,849.28			
Log-likelihood at Constants	n/a			
Log-likelihood at Null Parameters	-16,626.96			
Rho-squared w.r.t. Constants	n/a			
Rho-squared w.r.t. Null Parameters	0.167			

Source: Cambridge Systematics.

Notes: [1] The smoothed stepwise linear distance functions (see ***Section 4.1.3***) are used in conjunction with distance and ln(distance+1) functions to modify the impact of the mode choice logsum on primary location choice. ***Figure F.6*** below shows the net contributions of the estimated and calibrated smoothed stepwise linear distance functions combined with the distance and ln(distance+1) for closed and non-closed tours.

Figure F.6 Utility Contributions of Distance, Smoothed Stepwise Distance, and Ln(Distance+1) on Home-Based Work Primary Location Choice



Source: Cambridge Systematics.

F.11.2 Home-Based Escort

Table F.27 Home-Based Escort Tour Primary Location Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Quantitative (Size) Variables				
Size Logsum Multiplier (Θ)	[Tour Primary Destination].[Escort].[LSM]	0.3651	-23.83	No Change
Households	[Tour Primary Destination].[Escort].[Number of households in zone]	0.0000	Fixed	No Change
Production Employment	[Tour Primary Destination].[Escort].[Production employment in zone]	-248.9000	0.00	No Change
Service Employment	[Tour Primary Destination].[Escort].[Service employment in zone]	-5.6470	-2.88	No Change
Education Employment	[Tour Primary Destination].[Escort].[Education employment in zone]	1.6090	3.38	No Change
Retail Employment	[Tour Primary Destination].[Escort].[Retail employment in zone]	-4.1840	-2.56	No Change
Restaurant Employment	[Tour Primary Destination].[Escort].[Restaurant employment in zone]	1.9430	8.47	No Change
Pre-school Enrollment	[Tour Primary Destination].[Escort].[Pre-K school enrollment]	-158.5000	0.00	No Change
K-8 Enrollment	[Tour Primary Destination].[Escort].[K-8 school enrollment]	0.1508	0.35	No Change
High School Enrollment	[Tour Primary Destination].[Escort].[High school enrollment]	-1.5610	-2.02	No Change
College/University Enrollment	[Tour Primary Destination].[Escort].[University enrollment]	-1.1540	-1.75	No Change

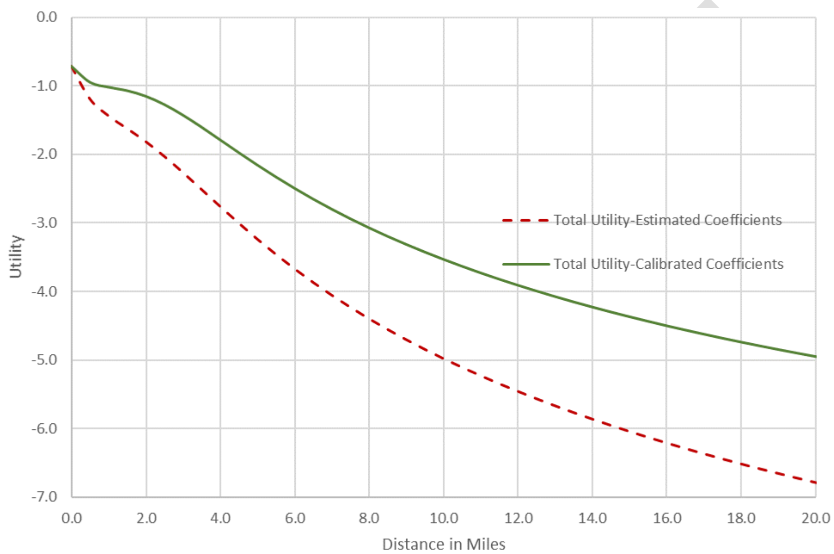
Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Pre-school Enrollment-Lower & Modest Income[1]	[Tour Primary Destination].[Escort].[Pre-K school enrollment IncomeSegment]	-5.0000	Fixed	No Change
K-8 Enrollment-Lower & Modest Income[1]	[Tour Primary Destination].[Escort].[K-8 school enrollment IncomeSegment]	0.2817	0.35	No Change
High School Enrollment-Lower & Modest Income[1]	[Tour Primary Destination].[Escort].[High school enrollment IncomeSegment]	1.9780	4.35	No Change
College/University Enrollment-Lower & Modest Income[1]	[Tour Primary Destination].[Escort].[Post IncomeSegment]	-5.0000	Fixed	No Change
Interchange Related Variables				
Distance (Miles)	[Tour Primary Destination].[Escort].[Distance]	2.2910	1768.07	No Change
Ln(Distance+1)	[Tour Primary Destination].[Escort].[ln (Distance)]	-3.1050	-106.50	-2.5013
Smoothed Stepwise Linear Distance Functions (Miles)				
1-Mile Distance Threshold (Damping Factor = 1.0)[2]	[Tour Primary Destination].[Escort].[Distance_1]	-2.2710	-2962.27	No Change
Other Interchange Related Variables				
Mode Choice Logsum	[Tour Primary Destination].[Escort].[Mode choice logsum]	1.0000	Fixed	No Change
Intrazonal Tour	[Tour Primary Destination].[Escort].[Intrazonal dummy]	0.0589	0.79	-3.0000
Tour Destination Zone Variables				
CBD	[Tour Primary Destination].[Escort].[CBD dummy]	-0.9360	-4.55	-0.5850
CBD Fringe	[Tour Primary Destination].[Escort].[CBD_Fringe dummy]	-0.2777	-3.08	-0.6249
DIA	[Tour Primary Destination].[Escort].[DIA]	5.0460	37.86	No Change
Regular Work Location for Any Household Member	[Tour Primary Destination].[Escort].[AnyHHMemberUsualWorkZone]	2.2230	25.22	No Change
Regular School Location for Any Household Member	[Tour Primary Destination].[Escort].[AnyHHMemberUsualSchoolZone]	4.6920	101.14	No Change
Model Estimation Statistics				
Number of Observations	4,692			
Log-likelihood at Convergence	-16,237.23			
Log-likelihood at Constants	n/a			
Log-likelihood at Null Parameters	-38,221.99			
Rho-squared w.r.t. Constants	n/a			
Rho-squared w.r.t. Null Parameters	0.575			

Source: Cambridge Systematics.

Notes: [1] The StateFocus Code Parameter Names for income related variables are input as a six element array as follows: [Less than $30K, $30K-$40K, $40K-$60K, $60K-$100K, $100K-$150K, $150K or more]. The six elements correspond to the following income groups: [Lower Income, Modest Income, Modest Income (modest income coefficient is repeated), Middle Income, Upper Income, Top Income].

2 The smoothed stepwise linear distance functions (see ***Section 4.1.3***) are used in conjunction with distance and ln(distance+1) functions to modify the impact of the mode choice logsum on primary location choice. ***Figure F.7*** below shows the net contributions of the estimated and calibrated smoothed stepwise linear distance functions combined with the distance and ln(distance+1) functions for closed and non-closed tours.

Figure F.7 Utility Contributions of Distance, Smoothed Stepwise Distance, and Ln(Distance+1) on Home-Based Escort Primary Location Choice



Source: Cambridge Systematics.

F.11.3 Home-Based Personal Business

Table F.28 Home-Based Personal Business Tour Primary Location Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Quantitative (Size) Variables				
Size Logsum Multiplier (Θ)	[Tour Primary Destination].[Personal business].[LSM]	0.6688	-16.76	No Change
Households	[Tour Primary Destination].[Personal business].[Number of households in zone]	0.0000	Fixed	No Change
Service Employment	[Tour Primary Destination].[Personal business].[Service employment in zone]	3.0700	10.64	No Change
Education Employment	[Tour Primary Destination].[Personal business].[Education employment in zone]	2.9660	9.38	No Change
Retail Employment[1]	[Tour Primary Destination].[Personal business].[Retail employment in zone].[SizeSumIncomeSegment]	2.4950	7.52	No Change
Restaurant Employment	[Tour Primary Destination].[Personal business].[Restaurant employment in zone]	3.4170	11.01	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Interchange Related Variables–Closed Tours				
Distance (Miles)	[Tour Primary Destination].[Personal business].[Distance]	-0.8626	-13.35	No Change
Smoothed Stepwise Linear Distance Functions (Miles)				
2-Mile Distance Threshold (Damping Factor = 1.0)^2	[Tour Primary Destination].[Personal business].[Distance_2_CT]	0.4996	6.53	No Change
10-Mile Distance Threshold (Damping Factor = 0.5)^2	[Tour Primary Destination].[Personal business].[Distance_10_CT]	0.2115	6.86	No Change
20-Mile Distance Threshold (Damping Factor = 0.3333)^2	[Tour Primary Destination].[Personal business].[Distance_20_CT]	0.0291	1.07	0.0400
40-Mile Distance Threshold (Damping Factor = 0.25)^2	[Tour Primary Destination].[Personal business].[Distance_40_CT]	0.1634	9.62	0.1362
80-Mile Distance Threshold (Damping Factor = 0.2)^2	[Tour Primary Destination].[Personal business].[Distance_80_CT]	-0.0859	-9.04	No Change
Interchange Related Variables–Non-Closed Tours				
Distance (Miles)	[Tour Primary Destination].[Personal business].[Distance_NCT]	-1.7730	-6.74	No Change
Smoothed Stepwise Linear Distance Functions (Miles)				
2-Mile Distance Threshold (Damping Factor = 1.0)^2	[Tour Primary Destination].[Personal business].[Distance_2_NCT]	1.7270	6.39	1.7443
40-Mile Distance Threshold (Damping Factor = 0.5)^2	[Tour Primary Destination].[Personal business].[Distance_40_NCT]	0.1558	4.49	0.0180
60-Mile Distance Threshold (Damping Factor = 0.3333)^2	[Tour Primary Destination].[Personal business].[Distance_60_NCT]	-0.0609	-2.36	0.0550
100-Mile Distance Threshold (Damping Factor = 0.25)^2	[Tour Primary Destination].[Personal business].[Distance_100_NCT]	-0.0219	-3.28	-0.0100
Other Interchange Related Variables–Closed & Non-Closed Tours				
Mode Choice Logsum	[Tour Primary Destination].[Personal business].[Mode choice logsum]	1.0000	Fixed	No Change
Intrazonal Tour	[Tour Primary Destination].[Personal business].[Intrazonal dummy]	0.3875	3.64	-0.4000
Tour Destination Zone Variables				
CBD	[Tour Primary Destination].[Personal business].[CBD dummy]	-1.1000	-8.06	-0.5500
DIA–Closed Tours	[Tour Primary Destination].[Personal business].[DIA_CT]	1.1200	3.09	No Change
DIA–Non-Closed Tours	[Tour Primary Destination].[Personal business].[DIA_NCT]	4.5560	26.21	2.5560
Mixed Use	[Tour Primary Destination].[Personal business].[Destination mixed use density]	0.0004284	4.08	No Change

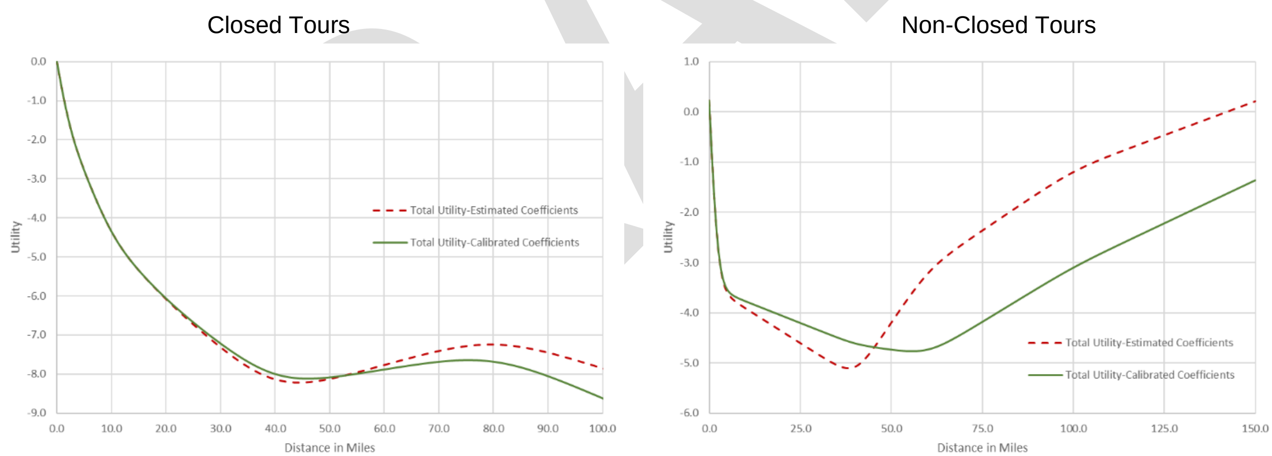
Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Model Estimation Statistics				
Number of Observations	3,743			
Log-likelihood at Convergence	-24,006.24			
Log-likelihood at Constants	n/a			
Log-likelihood at Null Parameters	-30,584.49			
Rho-squared w.r.t. Constants	n/a			
Rho-squared w.r.t. Null Parameters	0.215			

Source: Cambridge Systematics.

Notes: [1] This variable is stratified to use three groupings in the C# code: [Less than $30K, $30K-$100K, $100K or more]. However, no stratification by income group was performed; all three cells have the same coefficient.

[2] The smoothed stepwise linear distance functions (see ***Section 4.1.3***) are used in conjunction with distance function to modify the impact of the mode choice logsum on primary location choice. ***Figure F.8*** below shows the net contributions of the estimated and calibrated smoothed stepwise linear distance functions combined with the distance function for closed and non-closed tours.

Figure F.8 Utility Contributions of Distance, Smoothed Stepwise Distance, and Ln(Distance+1) on Home-Based Personal Business Primary Location Choice



Source: Cambridge Systematics.

F.11.4 Home-Based Shop

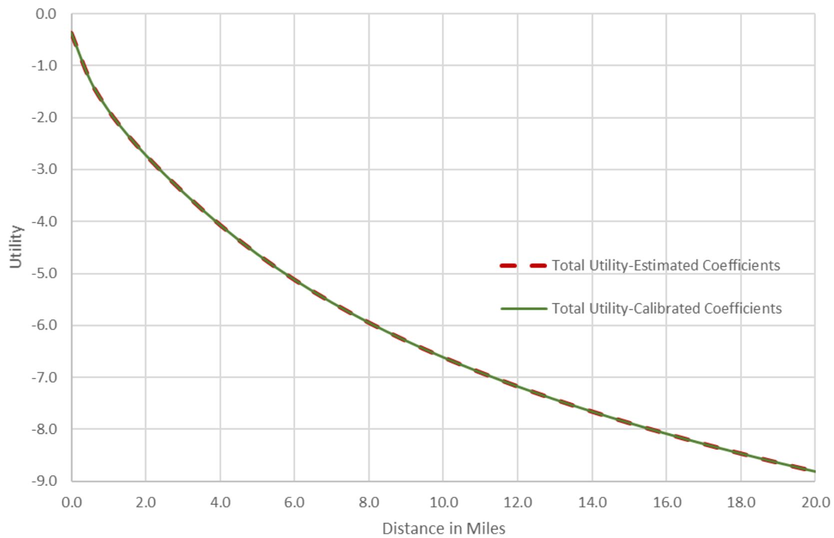
Table F.29 Home-Based Shop Tour Primary Location Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Quantitative (Size) Variables				
Size Logsum Multiplier (Θ)	[Tour Primary Destination].[Shop].[LSM]	1.0000	≦ 1.0	No Change
Households	[Tour Primary Destination].[Shop].[Number of households in zone]	0.0000	Fixed	No Change
Retail Employment	[Tour Primary Destination].[Shop].[Retail employment in zone]	3.9940	42.53	No Change
Restaurant Employment	[Tour Primary Destination].[Shop].[Restaurant employment in zone]	1.6910	5.88	No Change
Interchange Related Variables				
Distance (Miles)	[Tour Primary Destination].[Shop].[Distance]	1.1930	7.56	No Change
Ln(Distance+1)	[Tour Primary Destination].[Shop].[ln (Distance)]	-3.2110	-32.88	No Change
Smoothed Stepwise Linear Distance Functions (Miles)				
1-Mile Distance Threshold (Damping Factor = 1.0)[1]	[Tour Primary Destination].[Shop].[Distance_1]	-1.2050	-7.86	No Change
Other Interchange Related Variables				
Mode Choice Logsum	[Tour Primary Destination].[Shop].[Mode choice logsum]	1.0000	Fixed	No Change
Intrazonal Tour	[Tour Primary Destination].[Shop].[Intrazonal dummy]	-0.4289	-4.21	No Change
Tour Destination Zone Variables				
CBD	[Tour Primary Destination].[Shop].[CBD dummy]	-2.7990	-7.97	No Change
CBD Fringe	[Tour Primary Destination].[Shop].[CBD_Fringe dummy]	-0.2831	-4.18	-0.1416
Model Estimation Statistics				
Number of Observations	3,398			
Log-likelihood at Convergence	-15,366.43			
Log-likelihood at Constants	n/a			
Log-likelihood at Null Parameters	-27,402.35			
Rho-squared w.r.t. Constants	n/a			
Rho-squared w.r.t. Null Parameters	0.439			

Source: Cambridge Systematics.

Notes: [1] The smoothed stepwise linear distance functions (see ***Section 4.1.3***) are used in conjunction with distance function to modify the impact of the mode choice logsum on primary location choice. ***Figure F.9*** below shows the net contributions of the estimated and calibrated smoothed stepwise linear distance functions combined with the distance function for closed and non-closed tours.

Figure F.9 Utility Contributions of Distance, Smoothed Stepwise Distance, and Ln(Distance+1) on Home-Based Shop Primary Location Choice



Source: Cambridge Systematics.

F.11.5 Home-Based Meal

Table F.30 Home-Based Meal Tour Primary Location Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Quantitative (Size) Variables				
Size Logsum Multiplier (Θ)	[Tour Primary Destination].[Meal].[LSM]	0.7695	-8.53	No Change
Households	[Tour Primary Destination].[Meal].[Number of households in zone]	0.0000	Fixed	No Change
Retail Employment	[Tour Primary Destination].[Meal].[Retail employment in zone]	3.1280	12.93	No Change
Restaurant Employment[1]	[Tour Primary Destination].[Meal].[Restaurant employment in zone].[SizeSumIncomeSegment]	4.3270	20.47	No Change
Interchange Related Variables				
Distance (Miles)	[Tour Primary Destination].[Meal].[Distance]	0.8063	6.14	No Change
Ln(Distance+1)	[Tour Primary Destination].[Meal].[ln (Distance)]	-2.9750	-22.62	-2.3000
Smoothed Stepwise Linear Distance Functions (Miles)				
2-Mile Distance Threshold (Damping Factor = 1.0)[2]	[Tour Primary Destination].[Meal].[Distance_2]	-0.8194	-6.51	No Change
Other Interchange Related Variables				
Mode Choice Logsum	[Tour Primary Destination].[Meal].[Mode choice logsum]	1.0000	Fixed	No Change

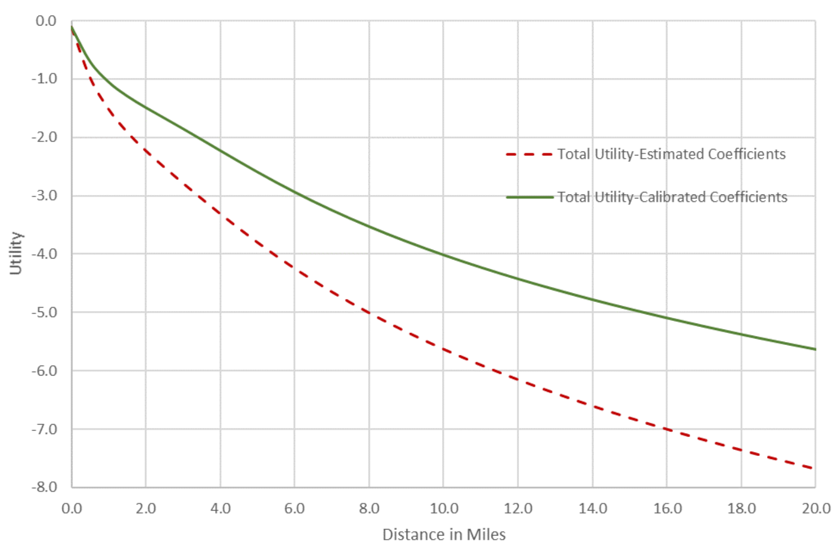
Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Intrazonal Tour	[Tour Primary Destination].[Meal].[Intrazonal dummy]	-0.8805	-4.93	-2.5000
Tour Destination Zone Variables				
CBD	[Tour Primary Destination].[Meal].[CBD dummy]	-0.8501	-4.38	-0.5441
CBD Fringe	[Tour Primary Destination].[Meal].[CBD_Fringe dummy]	-0.0847	-1.03	0.2226
Model Estimation Statistics				
Number of Observations	1,827			
Log-likelihood at Convergence	-9,551.45			
Log-likelihood at Constants	n/a			
Log-likelihood at Null Parameters	-15,009.08			
Rho-squared w.r.t. Constants	n/a			
Rho-squared w.r.t. Null Parameters	0.364			

Source: Cambridge Systematics.

Notes: [1] This variable is stratified to use three groupings in the C# code: [Less than $30K, $30K-$100K, $100K or more]. However, no stratification by income group was performed; all three cells have the same coefficient.

[2] The smoothed stepwise linear distance functions (see ***Section 4.1.3***) are used in conjunction with distance function to modify the impact of the mode choice logsum on primary location choice. ***Figure F.10*** below shows the net contributions of the estimated and calibrated smoothed stepwise linear distance functions combined with the distance function for closed and non-closed tours.

Figure F.10 Utility Contributions of Distance, Smoothed Stepwise Distance, and Ln(Distance+1) on Home-Based Meal Primary Location Choice



Source: Cambridge Systematics.

F.11.6 Home-Based Social/Recreation

Table F.31 Home-Based Social/Recreation Tour Primary Location Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Quantitative (Size) Variables				
Size Logsum Multiplier (Θ)	[Tour Primary Destination].[Social recreation].[LSM]	0.6525	-19.24	No Change
Households	[Tour Primary Destination].[Social recreation].[Number of households in zone]	0.0000	Fixed	No Change
Service Employment	[Tour Primary Destination].[Social recreation].[Service employment in zone]	-0.9781	-6.41	No Change
Retail Employment	[Tour Primary Destination].[Social recreation].[Retail employment in zone]	-2.7820	-3.48	No Change
Restaurant Employment	[Tour Primary Destination].[Social recreation].[Restaurant employment in zone]	1.3370	13.93	No Change
Entertainment Employment[1]	[Tour Primary Destination].[Social recreation].[Entertainment employment in zone].[SizeSumIncomeSegment]	2.7790	27.87	No Change
Ski Area Acres	[Tour Primary Destination].[Social recreation].[Ski acres in zone]	1.1940	6.36	No Change
Interchange Related Variables–Closed Tours				
Distance (Miles)	[Tour Primary Destination].[Social recreation].[Distance]	-0.6846	-12.36	No Change
Smoothed Stepwise Linear Distance Functions (Miles)				
2-Mile Distance Threshold (Damping Factor = 1.0)[2]	[Tour Primary Destination].[Social recreation].[Distance_2_CT]	0.3649	5.52	No Change
10-Mile Distance Threshold (Damping Factor = 0.5)[2]	[Tour Primary Destination].[Social recreation].[Distance_10_CT]	0.2090	7.81	No Change
20-Mile Distance Threshold (Damping Factor = 0.3333)[2]	[Tour Primary Destination].[Social recreation].[Distance_20_CT]	0.0516	2.37	0.0300
40-Mile Distance Threshold (Damping Factor = 0.25)[2]	[Tour Primary Destination].[Social recreation].[Distance_40_CT]	0.1167	9.86	0.0400
80-Mile Distance Threshold (Damping Factor = 0.2)[2]	[Tour Primary Destination].[Social recreation].[Distance_80_CT]	-0.1007	-11.89	-0.0504
120-Mile Distance Threshold (Damping Factor = 0.2)[2]	[Tour Primary Destination].[Social recreation].[Distance_120_CT]	0.0229	2.39	0.0143

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Interchange Related Variables–Non-Closed Tours				
Distance (Miles)	[Tour Primary Destination].[Social recreation].[Distance_NCT]	-0.9606	-4.53	No Change
Smoothed Stepwise Linear Distance Functions (Miles)				
2-Mile Distance Threshold (Damping Factor = 1.0)[2]	[Tour Primary Destination].[Social recreation].[Distance_2_NCT]	0.8832	4.09	No Change
40-Mile Distance Threshold (Damping Factor = 0.3333)[2]	[Tour Primary Destination].[Social recreation].[Distance_40_NCT]	0.3097	14.55	0.2100
60-Mile Distance Threshold (Damping Factor = 0.25)[2]	[Tour Primary Destination].[Social recreation].[Distance_60_NCT]	-0.2181	-15.37	-0.0981
150-Mile Distance Threshold (Damping Factor = 0.2)[2]	[Tour Primary Destination].[Social recreation].[Distance_150_NCT]	0.0032	2.11	-0.0290
Other Interchange Related Variables–Closed Tours				
Intrazonal Tour	[Tour Primary Destination].[Social recreation].[Intrazonal_CT]	0.3147	3.89	0.5000
Intraregional Tour[3]	[Tour Primary Destination].[Social recreation].[Intraregional_CT]	0.2405	2.10	No Change
Other Interchange Related Variables–Non-Closed Tours				
Intrazonal Tour	[Tour Primary Destination].[Social recreation].[Intrazonal_NCT]	1.6260	4.61	1.0630
Intraregional Tour[3]	[Tour Primary Destination].[Social recreation].[Intraregional_NCT]	-0.7938	-4.90	No Change
Other Interchange Related Variables–Closed & Non-Closed Tours				
Mode Choice Logsum	[Tour Primary Destination].[Social recreation].[Mode choice logsum]	1.0000	Fixed	No Change
Tour Destination Zone Variables–Closed Tours				
DIA[4,5]	[Tour Primary Destination].[Social recreation].[DIA_CT].[IncomeSegment]	2.4820	9.66	No Change
DIA–Lower Income[4,5]	[Tour Primary Destination].[Social recreation].[DIA_CT].[IncomeSegment]	-15.0000	Fixed	No Change
DIA–Lower-Modest Income[4,5]	[Tour Primary Destination].[Social recreation].[DIA_CT].[IncomeSegment]	-1.1380	-1.83	No Change
Mountains[4,6,9]	[Tour Primary Destination].[Social recrea tion].[Mountains_CT].[IncomeSegment]	1.9920	23.10	No Change
Mountains–Lower Income[4,6,9]	[Tour Primary Destination].[Social recrea tion].[Mountains_CT].[IncomeSegment]	-1.6880	-5.26	No Change
Mountains–Modest Income[4,6,9]	[Tour Primary Destination].[Social recrea tion].[Mountains_CT].[IncomeSegment]	-0.2442	-1.48	No Change
Tour Destination Zone Variables–Non-Closed Tours				
DIA[4,7]	[Tour Primary Destination].[Social recreation].[DIA_NCT].[IncomeSegment]	3.5180	17.36	No Change
DIA–Lower Income[4,7]	[Tour Primary Destination].[Social recreation].[DIA_NCT].[IncomeSegment]	-10.0000	Fixed	No Change
DIA–Lower-Modest Income[4,7]	[Tour Primary Destination].[Social recreation].[DIA_NCT].[IncomeSegment]	-1.0660	-1.92	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Mountains[4,8,9]	[Tour Primary Destination].[Social recrea tion].[Mountains_NCT].[IncomeSegment]	2.5480	37.61	6.548
Mountains–Lower Income[4,8,9]	[Tour Primary Destination].[Social recrea tion].[Mountains_NCT].[IncomeSegment]	-1.0370	-5.16	No Change
Mountains–Modest Income[4,8,9]	[Tour Primary Destination].[Social recrea tion].[Mountains_NCT].[IncomeSegment]	-1.0950	-7.01	No Change
Tour Destination Zone Variables–Closed & Non-Closed Tours				
CBD	[Tour Primary Destination].[Social recreation].[CBD dummy]	-1.1530	-7.18	-0.5391
CBD Fringe	[Tour Primary Destination].[Social recreation].[CBD_Fringe dummy]	-0.3662	-5.67	No Change
Mixed Use	[Tour Primary Destination].[Social recrea tion].[Destination mixed use density]	0.0003203	2.84	No Change
Model Estimation Statistics				
Number of Observations	6,563			
Log-likelihood at Convergence	-44,135.62			
Log-likelihood at Constants	n/a			
Log-likelihood at Null Parameters	-54,920.61			
Rho-squared w.r.t. Constants	0.196			
Rho-squared w.r.t. Null Parameters	0.196			

Source: Cambridge Systematics.

Notes:

1 This variable is stratified to use three groupings in the C# code for consistency with the original DRCOG Focus code: [Less than $30K, $30K-$100K, $100K or more]. However, no stratification by income group was performed; all three cells have the same coefficient.

2 The smoothed stepwise linear distance functions (see ***Section 4.1.3***) are used in conjunction with distance function to modify the impact of the mode choice logsum on primary location choice. ***Figure F.11*** below shows the net contributions of the estimated and calibrated smoothed stepwise linear distance functions combined with the distance function for closed and non-closed tours.

3 Due to a C# coding error, the eight regions defined in ***Section 4.2.11***, ***Interchange Related Variables***, were never input from the zonal file. This caused the zonal values for regions to all take on their default value of zero so that intraregional determination (origin region = destination region) was always true, resulting in the intraregional tour coefficient to always be applied. In effect, it became a constant value for all interchanges and meaningless to the tour location choice.

4 The three DRCOG Focus income groupings noted in Note #1 were used rather than the standard five StateFocus groupings. The "less than $30K" DRCOG grouping matched the StateFocus "Lower Income" grouping, but the "$30K-$100K" grouping covered the "Modest Income" and "Middle Income" StateFocus groupings (see ***Section 3.1.1***).

5 In the C# code, the coefficients by income group are summed as appropriate for application. The resulting values for the three "IncomeSegments" are: -13.656,1.344,2.482.

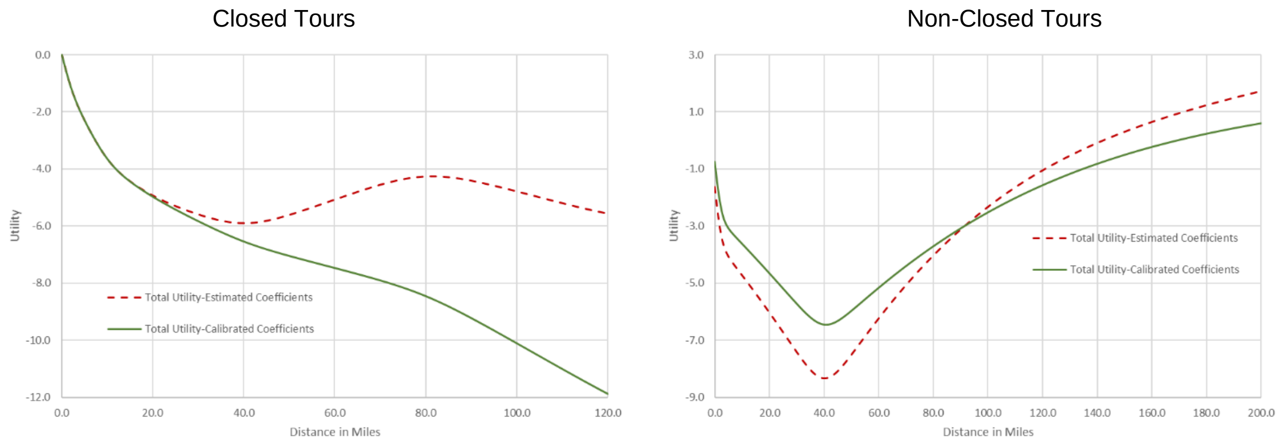
6 In the C# code, the coefficients by income group are summed as appropriate for application. The resulting values for the three "IncomeSegments" are: 0.304,1.7478,1.992.

7 In the C# code, the coefficients by income group are summed as appropriate for application. The resulting values for the three "IncomeSegments" are: -7.548,2.452,3.518.

8 In the C# code, the coefficients by income group are summed as appropriate for application. The resulting values for the three "IncomeSegments" are: 5.511,5.453,6.548.

9 Due to a C# coding error, "Mountain" zones defined in ***Section 4.2.11***, ***Tour Destination Zone Variables***, were never input from the zonal file. This caused the zonal values mountain zones to all take on their default value of zero so that the mountain related coefficients were never applied.

Figure F.11 Utility Contributions of Distance and Smoothed Stepwise Distance on Home-Based Social/Recreation Primary Location Choice



Source: Cambridge Systematics.

F.11.7 Work-Based Sub-Tour

Table F.32 Work-Based Sub-Tour Primary Location Choice Coefficients

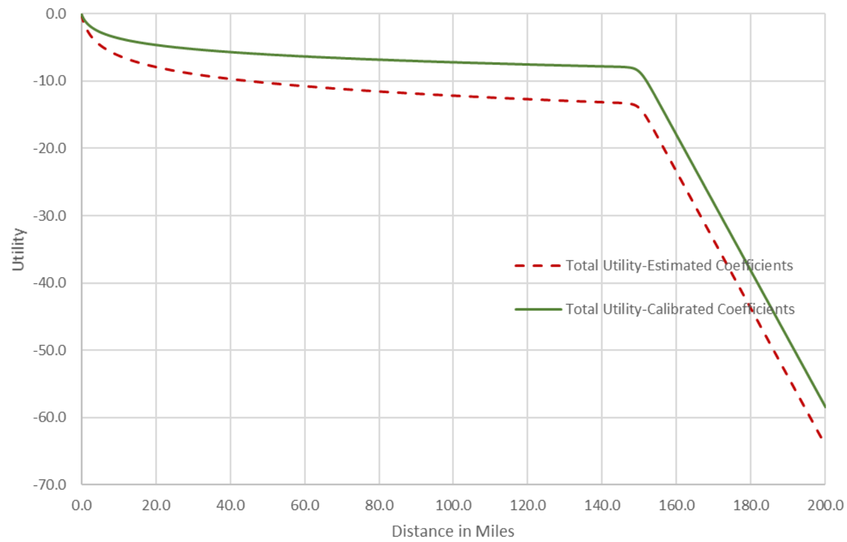
Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Quantitative (Size) Variables				
Size Logsum Multiplier (Θ)	[Tour Primary Destination].[Work based subtour].[LSM]	0.7206	-8.45	No Change
Households	[Tour Primary Destination].[Work based subtour].[Number of households in zone]	0.0000	Fixed	No Change
Production Employment	[Tour Primary Destination].[Work based subtour].[Production employment in zone]	-0.8726	-1.75	No Change
Service Employment	[Tour Primary Destination].[Work based subtour].[Service employment in zone]	0.5484	2.15	No Change
Education Employment	[Tour Primary Destination].[Work based subtour].[Education employment in zone]	1.1600	3.34	No Change
Retail Employment	[Tour Primary Destination].[Work based subtour].[Retail employment in zone]	2.1230	8.02	No Change
Restaurant Employment	[Tour Primary Destination].[Work based subtour].[Restaurant employment in zone]	2.7710	11.31	No Change
Entertainment Employment	[Tour Primary Destination].[Work based subtour].[Entertainment employment in zone]	2.1700	6.13	No Change
Interchange Related Variables				
Distance (Miles)	[Tour Primary Destination].[Work based subtour].[Distance]	0.00901	0.07	No Change
Ln(Distance+1)	[Tour Primary Destination].[Work based subtour].[ln (Distance)]	-2.5750	-18.86	-1.5000

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Smoothed Stepwise Linear Distance Functions (Miles)				
2-Mile Distance Threshold (Damping Factor = 1.0)[1]	[Tour Primary Destination].[Work based subtour].[Distance_2]	-0.01185	-0.09	No Change
150-Mile Distance Threshold (Damping Factor = 1.0)[1]	[Tour Primary Destination].[Work based subtour].[Distance_150]	-1.0000	Fixed	No Change
Other Interchange Related Variables				
Mode Choice Logsum	[Tour Primary Destination].[Work based subtour].[Mode choice logsum]	1.0000	Fixed	No Change
Intrazonal Tour	[Tour Primary Destination].[Work based subtour].[Intrazonal dummy]	-0.3256	-2.75	-3.0000
Tour Destination Zone Variables				
CBD	[Tour Primary Destination].[Work based subtour].[CBD dummy]	-0.3436	-2.56	No Change
CBD Fringe	[Tour Primary Destination].[Work based subtour].[CBD_Fringe dummy]	-0.1154	-1.44	0.2000
Rural	[Tour Primary Destination].[Work based subtour].[Rural dummy]	1.2500	9.61	No Change
Model Estimation Statistics				
Number of Observations	1,595			
Log-likelihood at Convergence	-8,495.54			
Log-likelihood at Constants	n/a			
Log-likelihood at Null Parameters	-13,108.18			
Rho-squared w.r.t. Constants	n/a			
Rho-squared w.r.t. Null Parameters	0.352			

Source: Cambridge Systematics.

Notes: [1] The smoothed stepwise linear distance functions (see ***Section 4.1.3***) are used in conjunction with distance function to modify the impact of the mode choice logsum on primary location choice. ***Figure F.12*** below shows the net contributions of the estimated and calibrated smoothed stepwise linear distance functions combined with the distance function for closed and non-closed tours.

Figure F.12 Utility Contributions of Distance, Smoothed Stepwise Distance, and Ln(Distance+1) on Work-Based Sub-Tour Primary Location Choice



Source: Cambridge Systematics.

F.12 Tour Priority Assignment

Tour priority assignment is a rule-based rather than a choice-based model. There are no estimated or calibrated parameters for this step. See ***Section 4.2.12*** for details.

F.13 Tour Main Mode Choice

Tour main mode choice model variables, StateFocus C# parameter names, estimated model coefficients and t-statistics, final calibrated parameters based on the 2015 model calibration/validation are shown by tour purpose in the following sections. Definitions of the variables are shown in ***Section 4.2.13***.

F.13.1 Home-Based Work

Table F.33 Home-Based Work Tour Main Mode Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Level of Service				
Travel Cost (Specified in 2010$)[1]				
Cost, Lower Income	[GeneralizedTime].[Work].[CostBy].[IncomeSegment]	-0.03114	≦Cost, Modest Income	No Change
Cost, Modest Income	[GeneralizedTime].[Work].[CostBy].[IncomeSegment]	-0.03114	-3.340	No Change
Cost, Middle Income	[GeneralizedTime].[Work].[CostBy].[IncomeSegment]	-0.02145	≦Cost, Upper Income	No Change
Cost, Upper Income	[GeneralizedTime].[Work].[CostBy].[IncomeSegment]	-0.02145	≧Cost, Top Income × 3.0	No Change
Cost, Top Income	[GeneralizedTime].[Work].[CostBy].[IncomeSegment]	-0.00715	-3.270	No Change
Cost, Missing Income[2]	*Used for Model Estimation Only*	*-0.01571*	*-0.343*	–
Travel Time (Specified in Minutes)				
Auto In-Vehicle Time	[GeneralizedTime].[Work].[InVehicleTime]	-0.00675	-17.100	No Change
Auto Terminal Time	[GeneralizedTime].[Work].[Auto].[WorkAutoTerminalTime]	-0.02701	= Walk Time	No Change
Transit Rail In-Vehicle Time	[GeneralizedTime].[Work].[Transit].[InVehicleTimeRail]	-0.00473	=Auto In-Vehicle Time × 0.7	No Change
Transit Non-Rail In-Vehicle Time	[GeneralizedTime].[Work].[InVehicleTime]	-0.00675	=Auto In-Vehicle Time	No Change
Transit Walk Time	[GeneralizedTime].[Work].[Transit].[WalkTransitAccEgrTime]	-0.02701	=Walk Time	No Change
Transit Drive Time	[GeneralizedTime].[Work].[Transit].[DriveTransitAccEgrTime]	-0.00675	=Auto In-Vehicle Time	No Change
Transit Initial Wait Time	[GeneralizedTime].[Work].[Transit].[TransitInitWaitTime]	-0.01218	-3.650	No Change
Transit Transfer Wait Time	[GeneralizedTime].[Work].[Transit].[TransitTransferWaitTime]	-0.01218	=Transit First Wait Time	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Walk Time	[GeneralizedTime].[Work].[Walk].[WalkTime]	-0.02701	≧Auto In-Vehicle Time × 4.0	No Change
Bike Time	[GeneralizedTime].[Work].[Bike].[BikeTime]	-0.02040	-12.200	No Change
Travel Time Related				
Local Bus In-Vehicle Time (minutes) / O-D Distance (miles)	[GeneralizedTime].[Work].[Transit].[TransitIVTODDist]	-0.14584	-4.800	No Change
Transit Drive Access Time / Drive Alone Time Ratio Amount Exceeding 0.5	[GeneralizedTime].[Work].[DriveToTransit].[DriveAccessFractionMr50Pcnt]	-2.07577	-7.810	No Change
Traveler and Household Characteristics				
Income Group[1]				
Lower Income: Shared Ride 2	[Tour Mode Choice].[Work].[SharedRide2].[IncomeSegment]	0.18893	2.460	No Change
Lower Income: Shared Ride 3+	[Tour Mode Choice].[Work].[SharedRide3P].[IncomeSegment]			
Lower Income: Bike	[Tour Mode Choice].[Work].[Bike].[IncomeSegment]	-1.32240	-3.800	No Change
Modest Income: Shared Ride 2	[Tour Mode Choice].[Work].[SharedRide2].[IncomeSegment]	0.08153	1.730	No Change
Modest Income: Shared Ride 3+	[Tour Mode Choice].[Work].[SharedRide3P].[IncomeSegment]			
Modest Income: Bike	[Tour Mode Choice].[Work].[Bike].[IncomeSegment]	-0.74022	-3.610	No Change
Top Income: Drive Alone	[Tour Mode Choice].[Work].[DriveAlone].[IncomeSegment]	0.39241	3.210	No Change
Top Income: Shared Ride 2	[Tour Mode Choice].[Work].[SharedRide2].[IncomeSegment]	0.38895	3.070	No Change
Top Income: Shared Ride 3+	[Tour Mode Choice].[Work].[SharedRide3P].[IncomeSegment]			
Missing Income: Shared Ride[2]	*Used for Model Estimation Only*	*0.15653*	*0.693*	–
Missing Income: Drive to Transit[2]	*Used for Model Estimation Only*	*-0.35073*	*-0.474*	–
Automobile Ownership				
No Cars: Shared Ride 2	[Tour Mode Choice].[Work].[SharedRide2].[NoCarHH]	2.88896	4.350	4.5000
No Cars: Shared Ride 3+	[Tour Mode Choice].[Work].[SharedRide3P].[NoCarHH]			5.0758
No Cars: Walk	[Tour Mode Choice].[Work].[Walk].[NoCarHH]	5.89467	8.560	No Change
No Cars: Bike	[Tour Mode Choice].[Work].[Bike].[NoCarHH]			6.0126

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
No Cars: Walk to Transit	[Tour Mode Choice].[Work].[WalkToTransit].[NoCarHH]	6.96560	10.700	No Change
No Cars: Drive to Transit	[Tour Mode Choice].[Work].[DriveToTransit].[NoCarHH]	3.40942	3.960	2.0000
Cars But Less Than Workers: Shared Ride 2	[Tour Mode Choice].[Work].[SharedRide2].[HHCLWrs]	0.79454	6.860	1.6392
Cars But Less Than Workers: Shared Ride 3+	[Tour Mode Choice].[Work].[SharedRide3P].[HHCLWrs]			1.2395
Cars But Less Than Workers: Walk	[Tour Mode Choice].[Work].[Walk].[HHCLWrs]	1.86069	11.200	3.2153
Cars But Less Than Workers: Bike	[Tour Mode Choice].[Work].[Bike].[HHCLWrs]			
Cars But Less Than Workers: Walk to Transit	[Tour Mode Choice].[Work].[WalkToTransit].[HHCLWrs]	2.10561	10.100	No Change
Cars But Less Than Workers: Drive to Transit	[Tour Mode Choice].[Work].[DriveToTransit].[HHCLWrs]	0.75533	2.480	No Change
Cars For Workers But Not All Drivers: Shared Ride 2	[Tour Mode Choice].[Work].[SharedRide2].[HHCMrLsA]	0.21659	3.380	No Change
Cars For Workers But Not All Drivers: Shared Ride 3+	[Tour Mode Choice].[Work].[SharedRide3P].[HHCMrLsA]			
Cars For Workers But Not All Drivers: Walk	[Tour Mode Choice].[Work].[Walk].[HHCMrLsA]	0.64890	3.220	No Change
Cars For Workers But Not All Drivers: Bike	[Tour Mode Choice].[Work].[Bike].[HHCMrLsA]			
Cars For Workers But Not All Drivers: Walk to Transit	[Tour Mode Choice].[Work].[WalkToTransit].[HHCMrLsA]	1.48541	7.030	No Change
Cars For Workers But Not All Drivers: Drive to Transit	[Tour Mode Choice].[Work].[DriveToTransit].[HHCMrLsA]	0.50553	1.870	No Change
Household Size				
One Person Household: Shared Ride 2	[Tour Mode Choice].[Work].[SharedRide2].[HH1P]	-0.84857	-6.390	No Change
One Person Household: Shared Ride 3+	[Tour Mode Choice].[Work].[SharedRide3P].[HH1P]	-1.47971	-6.490	No Change
Two Person Household: Shared Ride 3+	[Tour Mode Choice].[Work].[SharedRide3P].[HH2P]	-0.82031	-7.100	No Change
Traveler Age				
Age Over 50: Walk	[Tour Mode Choice].[Work].[Walk].[AgeO50]	-0.36137	-2.150	No Change
Gender				
Female: Shared Ride 2	[Tour Mode Choice].[Work].[SharedRide2].[Female]	0.33346	6.420	0.6336
Female: Shared Ride 3+	[Tour Mode Choice].[Work].[SharedRide3P].[Female]			1.7167
Female: Bike	[Tour Mode Choice].[Work].[Bike].[Female]	-1.08430	-7.010	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Geographic				
Land Use				
Destination Retail Density: Walk to Transit	[Tour Mode Choice].[Work].[WalkToTransit].[RetDensEmpCentDiv1000DecisionMaker]	0.33416	8.340	No Change
Destination Retail Density: Drive to Transit	[Tour Mode hoice].[Work].[DriveToTransit].[RetDensEmpCentDiv1000DecisionMaker]			
Origin & Destination Mixed Use Density: Walk	[Tour Mode Choice].[Work].[Walk].[MixedUseDensityOrig]	0.26579	3.600	No Change
	[Tour Mode Choice].[Work].[Walk].[MixedUseDensityDest]			
Origin & Destination Mixed Use Density: Bike	[Tour Mode Choice].[Work].[Bike].[MixedUseDensityOrig]	0.25359	3.200	No Change
	[Tour Mode Choice].[Work].[Bike].[MixedUseDensityDest]			
Origin Intersection Density: Walk to Transit	[Tour Mode Choice].[Work].[WalkToTransit].[IntrDensHHBufferDiv1000]	7.52482	3.620	No Change
Destination Intersection Density: Walk to Transit	[Tour Mode Choice].[Work].[WalkToTransit].[IntrDensEmpBufferDiv1000DecisionMaker]	5.29367	3.020	No Change
Destination Intersection Density: Drive to Transit	[Tour Mode Choice].[Work].[DriveToTransit].[IntrDensEmpBufferDiv1000DecisionMaker]			
Origin & Destination Intersection Density: Walk	[Tour Mode Choice].[Work].[Walk].[IntrDensHHBufferDiv1000]	3.92850	2.590	No Change
	[Tour Mode Choice].[Work].[Walk].[IntrDensEmpBufferDiv1000DecisionMaker]			
Origin & Destination Intersection Density: Bike	[Tour Mode Choice].[Work].[Bike].[IntrDensHHBufferDiv1000]	1.14981	0.777	No Change
	[Tour Mode Choice].[Work].[Bike].[IntrDensEmpBufferDiv1000DecisionMaker]			
MPO Specific Constants				
DRCOG: Walk	[Tour Mode Choice].[Work].[Walk].[ConstantDRCOG]	0.53194	2.830	No Change
DRCOG: Walk to Transit	[Tour Mode Choice].[Work].[WalkToTransit].[ConstantDRCOG]	0.42362	1.680	No Change
DRCOG: Drive to Transit	[Tour Mode Choice].[Work].[DriveToTransit].[ConstantDRCOG]	0.76190	2.570	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Tour Level				
Non-Closed Tour Indicator				
Non-Closed Tour: Shared Ride 2	[Tour Mode Choice].[Work].[SharedRide2].[NonClosedTour]	-0.13584	-1.050	0.0629
Non-Closed Tour: Shared Ride 3+	[Tour Mode Choice].[Work].[SharedRide3P].[NonClosedTour]	-0.44656	-2.160	0.476
Non-Closed Tour: Walk	[Tour Mode Choice].[Work].[Walk].[NonClosedTour]	0.21554	0.445	-0.0862
Non-Closed Tour: Bike	[Tour Mode Choice].[Work].[Bike].[NonClosedTour]			
Non-Closed Tour: Walk to Transit	[Tour Mode Choice].[Work].[WalktoTransit].[NonClosedTour]	-0.71071	-1.140	-0.4442
Non-Closed Tour: Drive to Transit	[Tour Mode Choice].[Work].[DrivetoTransit].[NonClosedTour]			1.0662
Schedule and Day Pattern				
Arrive Destination In AM Peak: Drive Alone	[Tour Mode Choice].[Work].[DriveAlone].[ArriveAMPeak]	-0.21718	-2.470	No Change
Arrive Destination In AM Peak: Shared Ride 2	[Tour Mode Choice].[Work].[SharedRide2].[ArriveAMPeak]			
Arrive Destination In AM Peak: Shared Ride 3+	[Tour Mode Choice].[Work].[SharedRide3P].[ArriveAMPeak]			
Depart Destination In PM Peak: Drive Alone	[Tour Mode Choice].[Work].[DriveAlone].[LeavePMPeak]	-0.24314	-2.860	No Change
Depart Destination In PM Peak: Shared Ride 2	[Tour Mode Choice].[Work].[SharedRide2].[LeavePMPeak]			
Depart Destination In PM Peak: Share Ride 3+	[Tour Mode Choice].[Work].[SharedRide3P].[LeavePMPeak]			
Escort Stop Flag By Tours Remain: Shared Ride 2	[Tour Mode Choice].[Work].[SharedRide2].[EscortStopsDivTours]	3.50462	8.630	No Change
Escort Stop Flag By Tours Remain: Shared Ride 3+	[Tour Mode Choice].[Work].[SharedRide3P].[EscortStopsDivTours]			
Other Stop Flag By Tours Remain: DA	[Tour Mode Choice].[Work].[DriveAlone].[OtherStopsDivTours]	0.62337	5.200	No Change
Other Stop Flag By Tours Remain: Shared Ride 2	[Tour Mode Choice].[Work].[SharedRide2].[OtherStopsDivTours]	0.80671	6.460	No Change
Other Stop Flag By Tours Remain: Shared Ride 3+	[Tour Mode Choice].[Work].[SharedRide3P].[OtherStopsDivTours]			
Sampling Bias				
FREX: Walk to Transit[1]	*Used for Model Estimation Only*	*1.27666*	*1.570*	–
FREX: Drive to Transit[1]	*Used for Model Estimation Only*	*4.02870*	*11.000*	–

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Other Non-Random: Walk[1]	*Used for Model Estimation Only*	*0.52362*	*0.843*	–
Other Non-Random: Walk to Transit[1]	*Used for Model Estimation Only*	*1.20117*	*4.240*	–
Other Non-Random: Drive to Transit[1]	*Used for Model Estimation Only*	*1.86224*	*7.810*	–
Nesting Coefficients				
Logsum Auto	[Tour Mode Choice].[Work].[NestParamAuto]	0.53044	-7.280	No Change
Alternative Specific Constants				
Shared Ride 2	[Tour Mode Choice].[Work].[SharedRide2].[Constant]	-1.50599	-8.030	-3.5405
Shared Ride 3+	[Tour Mode Choice].[Work].[SharedRide3P].[Constant]	-1.68030	-8.000	-5.1453
Walk	[Tour Mode Choice].[Work].[Walk].[Constant]	-1.55325	-7.480	-1.2219
Bike	[Tour Mode Choice].[Work].[Bike].[Constant]	-2.38267	-13.000	-1.8162
Walk to Transit	[Tour Mode Choice].[Work].[WalkToTransit].[Constant]	-3.49079	-10.800	-2.5000
Drive to Transit	[Tour Mode Choice].[Work].[DriveToTransit].[Constant]	-3.58301	-10.400	No Change
Model Estimation Statistics				
Number of Observations	12,494			
Log-likelihood at Convergence	-8,482.72			
Log-likelihood at Constants	-12,789.83			
Log-likelihood at Null Parameters	-22,887.08			
Rho-squared w.r.t. Constants	0.337			
Rho-squared w.r.t Null Parameters	0.629			

Source: Cambridge Systematics

Notes:
1 The StateFocus Code Parameter Names for income related variables are input as a six element array as follows: [Less than $30K, $30K-$40K, $40K-$60K, $60K-$100K, $100K-$150K, $150K or more]. The six elements correspond to the following income groups: [Low Income, Modest Income, Modest Income (modest income coefficient is repeated), Middle Income, Upper Income, Top Income].
2 Variable used for model estimation purposes only and is not used in model application.

F.13.2 Home-Based School

Table F.34 Home-Based School Tour Main Mode Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Level of Service				
Travel Cost (Specified in 2010$)[1]				
Cost, Lower Income	[GeneralizedTime].[School].[CostBy].[IncomeSegment]	-0.16758	-3.040	No Change
Cost, Modest Income	[GeneralizedTime].[School].[CostBy].[IncomeSegment]	-0.12191	-3.240	No Change
Cost, Middle Income	[GeneralizedTime].[School].[CostBy].[IncomeSegment]	-0.07283	-2.610	No Change
Cost, Upper Income	[GeneralizedTime].[School].[CostBy].[IncomeSegment]	-0.02573	-0.984	No Change
Cost, Top Income	[GeneralizedTime].[School].[CostBy].[IncomeSegment]	-0.00934	≦ Auto In-Vehicle Time	No Change
Cost, Missing Income[2]	*Used for Model Estimation Only*	*-0.04156*	*-0.265*	–
Travel Time (Specified in Minutes)				
Auto In-Vehicle Time	[GeneralizedTime].[School].[InVehicleTime]	-0.00934	-8.750	No Change
Auto Terminal Time	[GeneralizedTime].[School].[Auto].[AutoTerminalTime]	-0.03204	= Walk Time	No Change
Transit Rail In-Vehicle Time	[GeneralizedTime].[School].[Transit].[InVehicleTimeRail]	-0.00654	= Auto In-Vehicle Time × 0.7	No Change
Transit Non-Rail In-Vehicle Time	[GeneralizedTime].[School].[InVehicleTime]	-0.00934	= Auto In-Vehicle Time	No Change
Transit Walk Time	[GeneralizedTime].[School].[Transit].[WalkTransitAccEgrTime]	-0.03204	= Walk Time	No Change
Transit Drive Time	[GeneralizedTime].[School].[Transit].[DriveTransitAccEgrTime]	-0.00934	= Auto In-Vehicle Time	No Change
Transit Initial Wait Time	[GeneralizedTime].[School].[Transit].[TransitInitWaitTime]	-0.03735	≧ Auto In-Vehicle Time × 4.0	No Change
Transit Transfer Wait Time	[GeneralizedTime].[School].[Transit].[TransitTransferWaitTime]	-0.03735	= Transit First Wait Time	No Change
Walk Time	[GeneralizedTime].[School].[Walk].[WalkTime]	-0.03204	-17.000	No Change
Bike Time	[GeneralizedTime].[School].[Bike].[BikeTime]	-0.03735	≧ Auto In-Vehicle Time × 4.0	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Travel Time Related				
Local Bus In-Vehicle Time (minutes) / Origin-Destination Distance (miles)	[GeneralizedTime].[School].[Transit].[TransitIVTODDist]	-0.00307	-0.072	No Change
Transit Drive Access Time / Drive Alone Time Ratio Amount Exceeding 0.5	[GeneralizedTime].[School].[DriveToTransit].[DriveAccessFractionMr50Pcnt]	-1.44099	-3.560	No Change
Distance Related				
Distance (exp(-School Bus Distance)): School Bus	[Tour Mode Choice].[School].[SchoolBus].[DistanceExp]	3.25735	7.750	No Change
Distance (exp(-School Bus Distance/2)): School Bus	[Tour Mode Choice].[School].[SchoolBus].[DistanceExp2]	-9.91386	-18.100	No Change
Distance (exp(-School Bus Distance/4)): School Bus	[Tour Mode Choice].[School].[SchoolBus].[DistanceExp4]	6.70396	20.000	No Change
Traveler and Household Characteristics				
Automobile Ownership				
No Cars: Walk	[Tour Mode Choice].[School].[Walk].[NoCarHH]	2.81526	5.990	5.6756
No Cars: Bike	[Tour Mode Choice].[School].[Bike].[NoCarHH]			No Change
No Cars: Walk to Transit	[Tour Mode Choice].[School].[WalkToTransit].[NoCarHH]	2.95686	5.390	No Change
Cars But Less Than Workers: Walk	[Tour Mode Choice].[School].[Walk].[HHCLWrs]	1.17870	4.710	1.9802
Cars But Less Than Workers: Bike	[Tour Mode Choice].[School].[Bike].[HHCLWrs]			
Cars But Less Than Workers: Walk to Transit	[Tour Mode Choice].[School].[WalkToTransit].[HHCLWrs]	0.95329	3.800	No Change
Cars For Workers But Not All Drivers: Walk	[Tour Mode Choice].[School].[Walk].[HHCMrLsA]	0.38754	1.900	No Change
Cars For Workers But Not All Drivers: Bike	[Tour Mode Choice].[School].[Bike].[HHCMrLsA]			
Cars For Workers But Not All Drivers: Walk to Transit	[Tour Mode Choice].[School].[WalkToTransit].[HHCMrLsA]	0.95329	≦ Cars But Less Than Workers, Walk to Transit	No Change
Household Size				
One Person Household: Shared Ride 2	[Tour Mode Choice].[School].[SharedRide2].[HH1P]	-0.29141	-0.350	No Change
One Person Household: Shared Ride 3+	[Tour Mode Choice].[School].[SharedRide3P].[HH1P]	-1.94889	-1.800	No Change
Two Person Household: Shared Ride 2	[Tour Mode Choice].[School].[SharedRide2].[HH2P]	0.56978	3.450	No Change
Two Person Household: Shared Ride 3+	[Tour Mode Choice].[School].[SharedRide3P].[HH2P]	-1.65091	-6.570	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Traveler Age				
Pre-School Aged: Walk	[Tour Mode Choice].[School].[Walk].[PrSchStu]	-1.45261	-4.220	No Change
Pre-School Aged: Bike	[Tour Mode Choice].[School].[Bike].[PrSchStu]	-1.54351	-2.130	No Change
Pre-School Aged: Walk to Transit	[Tour Mode Choice].[School].[WalkToTransit].[PrSchStu]	-2.02729	-1.960	No Change
Pre-School Aged: Drive to Transit	[Tour Mode Choice].[School].[DriveToTransit].[PrSchStu]	-2.02729	-1.960	No Change
Pre-School Aged: School Bus	[Tour Mode Choice].[School].[SchoolBus].[PrSchStu]	-2.87280	-9.250	No Change
High School Student: Drive Alone	[Tour Mode Choice].[School].[DriveAlone].[HSStuAge16P]	-0.55521	-3.280	No Change
High School Student: Bike	[Tour Mode Choice].[School].[Bike].[HSStuAge16P]	0.48654	1.820	No Change
High School Student: Walk to Transit	[Tour Mode Choice].[School].[WalkToTransit].[HSStuAge16P]	2.09855	7.940	No Change
High School Student: Drive to Transit	[Tour Mode Choice].[School].[DriveToTransit].[HSStuAge16P]	2.09855	7.940	No Change
High School Student: School Bus	[Tour Mode Choice].[School].[SchoolBus].[HSStuAge16P]	-0.41441	-4.640	No Change
University Student: Bike	[Tour Mode Choice].[School].[Bike].[UniStu]	3.34172	8.400	No Change
University Student: Walk to Transit	[Tour Mode Choice].[School].[WalkToTransit].[UniStu]	3.71729	11.200	No Change
University Student: Drive to Transit	[Tour Mode Choice].[School].[DriveToTransit].[UniStu]	3.71729	11.200	No Change
University Student: School Bus	[Tour Mode Choice].[School].[SchoolBus].[UniStu]	-10.00000	fixed value	No Change
University Student: Drive Alone (DRCOG)	[Tour Mode Choice].[School].[DriveAlone].[UniStu]	0.61533	2.200	No Change
University Student: Drive Alone (Not DRCOG)	[Tour Mode Choice].[School].[DriveAlone].[UniStuNotDRCOG]	1.44196	5.180	0.8266
Other Adult: Walk	[Tour Mode Choice].[School].[Walk].[OtherAdult]	1.29405	3.000	No Change
Other Adult: Walk to Transit	[Tour Mode Choice].[School].[WalkToTransit].[OtherAdult]	2.23777	5.470	No Change
Other Adult: Drive to Transit	[Tour Mode Choice].[School].[DriveToTransit].[OtherAdult]	2.23777	5.470	No Change
Any Adult: School Bus	[Tour Mode Choice].[School].[SchoolBus].[Adult]	-10.00000	fixed value	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Geographic				
Land Use				
Rural Origin: Shared Ride 2	[Tour Mode Choice].[School].[SharedRide2].[RuralAreaType]	-0.64173	-6.400	No Change
Rural Origin: Shared Ride 3+	[Tour Mode Choice].[School].[SharedRide3P].[RuralAreaType]	-0.64173	-6.400	No Change
Rural Origin: Walk	[Tour Mode Choice].[School].[Walk].[RuralAreaType]	-2.11289	-3.970	No Change
Rural Origin: Bike	[Tour Mode Choice].[School].[Bike].[RuralAreaType]	-1.79594	-1.770	No Change
Origin Intersection Density: Walk to Transit	[Tour Mode Choice].[School].[WalkToTransit].[IntrDensHHBufferDiv1000]	5.42567	2.780	No Change
Destination Intersection Density: Walk to Transit	[Tour Mode Choice].[School].[WalkToTransit].[IntrDensEmpBufferDiv1000DecisionMaker]	5.42567	= Walk to Transit, Origin Intersection Density	No Change
Destination Intersection Density: Drive to Transit	[Tour Mode Choice].[School].[DriveToTransit].[IntrDensEmpBufferDiv1000DecisionMaker]	5.42567	= Walk to Transit, Origin Intersection Density	No Change
Origin & Destination Intersection Density: School Bus	[Tour Mode Choice].[School].[SchoolBus].[IntrDensHHBufferDiv1000Orig]	-8.98672	-9.630	No Change
Origin & Destination Intersection Density: School Bus	[Tour Mode Choice].[School].[SchoolBus].[IntrDensHHBufferDiv1000Dest]	-8.98672	-9.630	No Change
Schedule and Day Pattern				
Escort Stop Flag By Tours Remain: Drive Alone	[Tour Mode Choice].[School].[DriveAlone].[EscortStopsDivTours]	-1.67716	-3.660	No Change
Escort Stop Flag By Tours Remain: Shared Ride 2	[Tour Mode Choice].[School].[SharedRide2].[EscortStopsDivTours]	1.36429	9.270	No Change
Escort Stop Flag By Tours Remain: Shared Ride 3+	[Tour Mode Choice].[School].[SharedRide3P].[EscortStopsDivTours]			
Other Stop Flag By Tours Remain: Shared Ride 2	[Tour Mode Choice].[School].[SharedRide2].[OtherStopsDivTours]	0.56992	6.660	No Change
Other Stop Flag By Tours Remain: Shared Ride 3+	[Tour Mode Choice].[School].[SharedRide3P].[OtherStopsDivTours]			
Sampling Bias				
FREX: Walk to Transit[1]	*Used for Model Estimation Only*	*0.36481*	*0.283*	–
FREX: Drive to Transit[1]	*Used for Model Estimation Only*	*1.77395*	*1.760*	–

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
OtherNonRandom: Walk[1]	*Used for Model Estimation Only*			
OtherNonRandom: Walk to Transit[1]	*Used for Model Estimation Only*	*0.66382*	*1.480*	–
OtherNonRandom: Drive to Transit[1]	*Used for Model Estimation Only*	*1.93382*	*3.890*	–
Nesting Coefficients				
Logsum Non-Motorized	[Tour Mode Choice].[School].[NestParamNonMotorized]	1.00000	≦ 1.0	No Change
Logsum Transit	[Tour Mode Choice].[School].[NestParamTransit]	1.00000	≦ 1.0	No Change
Logsum Auto	[Tour Mode Choice].[School].[NestParamAuto]	1.00000	≦ 1.0	No Change
Alternative Specific Constants				
Shared Ride 2	[Tour Mode Choice].[School].[SharedRide2].[Constant]	-1.54907	-9.990	-1.4409
Shared Ride 3+	[Tour Mode Choice].[School].[SharedRide3P].[Constant]	-0.69765	-4.530	-0.6024
Walk	[Tour Mode Choice].[School].[Walk].[Constant]	-0.27638	-1.550	-0.4151
Bike	[Tour Mode Choice].[School].[Bike].[Constant]	-3.04157	-13.800	No Change
Walk to Transit	[Tour Mode Choice].[School].[WalkToTransit].[Constant]	-2.74677	-6.920	-1.9379
Drive to Transit	[Tour Mode Choice].[School].[DriveToTransit].[Constant]	-3.54199	-9.230	-3.0000
School Bus	[Tour Mode Choice].[School].[SchoolBus].[Constant]	-1.70813	-9.260	-2.0580
Model Estimation Statistics				
Number of Observations	5,361			
Log-likelihood at Convergence	-6334.40			
Log-likelihood at Constants	-7,759.35			
Log-likelihood at Null Parameters	-9926.76			
Rho-squared w.r.t. Constants	0.184			
Rho-squared w.r.t. Null Parameters	0.362			

Source: Cambridge Systematics

Notes: [1] The StateFocus Code Parameter Names for income related variables are input as a six element array as follows: [Less than $30K, $30K-$40K, $40K-$60K, $60K-$100K, $100K-$150K, $150K or more]. The six elements correspond to the following income groups: [Low Income, Modest Income, Modest Income (modest income coefficient is repeated), Middle Income, Upper Income, Top Income].

[2] Variable used for model estimation purposes only and is not used in model application.

F.13.3 Home-Based Escort

Table F.35 Home-Based Escort Tour Main Mode Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Level of Service				
Travel Cost (Specified in 2010$)[1]				
Cost, Lower Income	[GeneralizedTime].[Escort].[CostBy].[IncomeSegment]	-0.26497	-2.090	No Change
Cost, Modest Income	[GeneralizedTime].[Escort].[CostBy].[IncomeSegment]	-0.22222	-2.520	No Change
Cost, Middle Income	[GeneralizedTime].[Escort].[CostBy].[IncomeSegment]	-0.17746	≦ Cost, Upper Income	No Change
Cost, Upper Income	[GeneralizedTime].[Escort].[CostBy].[IncomeSegment]	-0.17746	≧ Cost, Top Income × 3.0	No Change
Cost, Top Income	[GeneralizedTime].[Escort].[CostBy].[IncomeSegment]	-0.05915	-2.860	No Change
Cost, Missing Income[2]	*Used for Model Estimation Only*	*-0.91144*	*-0.318*	–
Travel Time (Specified in Minutes)				
Auto In-Vehicle Time	[GeneralizedTime].[Escort].[InVehicleTime]	-0.01049	-12.300	No Change
Auto Terminal Time	[GeneralizedTime].[Escort].[Auto].[AutoTerminalTime]	-0.04197	= Walk Time	No Change
Walk Time	[GeneralizedTime].[Escort].[Walk].[WalkTime]	-0.04197	≧ Auto In-Vehicle Time × 4.0	No Change
Traveler and Household Characteristics				
Automobile Ownership				
No Cars: Walk	[Tour Mode Choice].[Escort].[Walk].[NoCarHH]	3.85113	3.160	6.0656
Other Parameters				
Number of Full-time Workers in the Household: Shared Ride 3+	[Tour Mode Choice].[Escort].[SharedRide3P].[hworkers]	-0.13527	-2.640	-0.5887
Number of Part-time Workers in the Household: Shared Ride 3+	[Tour Mode Choice].[Escort].[SharedRide3P].[hworkersPT]	-0.06257	-1.140	No Change
Number of Children Under 5 in the Household: Shared Ride 3+	[Tour Mode Choice].[Escort].[SharedRide3P].[h0005]	1.18895	21.000	2.5682
Number of Children Age 5 to 15 in the Household: Shared Ride 3+	[Tour Mode Choice].[Escort].[SharedRide3P].[NumHH5to15]	0.55850	17.200	1.5080

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Schedule and Day Pattern				
Escort Stop Flag By Tours Remain: Shared Ride 2	[Tour Mode Choice].[Escort].[SharedRide2].[EscortStopsDivTours]	1.15396	3.140	No Change
Escort Stop Flag By Tours Remain: Shared Ride 3+	[Tour Mode Choice].[Escort].[SharedRide3P].[EscortStopsDivTours]			
Other Stop Flag By Tours Remain: Shared Ride 2	[Tour Mode Choice].[Escort].[SharedRide2].[OtherStopsDivTours]	1.57977	5.210	No Change
Other Stop Flag By Tours Remain: Shared Ride 3+	[Tour Mode Choice].[Escort].[SharedRide3P].[OtherStopsDivTours]			
Alternative Specific Constants				
Shared Ride 3+	[Tour Mode Choice].[Escort].[SharedRide3P].[Constant]	-0.94489	-11.700	-2.2660
Walk	[Tour Mode Choice].[Escort].[Walk].[Constant]	0.49194	3.720	-0.1150
Model Estimation Statistics				
Number of Observations	4,615			
Log-likelihood at Convergence	-3157.25			
Log-likelihood at Constants	-4778.76			
Log-likelihood at Null Parameters	-5039.28			
Rho-squared w.r.t. Constants	0.339			
Rho-squared w.r.t. Null Parameters	0.373			

Source: Cambridge Systematics

Notes: [1] The StateFocus Code Parameter Names for income related variables are input as a six element array as follows: [Less than $30K, $30K-$40K, $40K-$60K, $60K-$100K, $100K-$150K, $150K or more]. The six elements correspond to the following income groups: [Low Income, Modest Income, Modest Income (modest income coefficient is repeated), Middle Income, Upper Income, Top Income].

[2] Variable used for model estimation purposes only and is not used in model application.

F.13.4 Home-Based Other

Table F.36 Home-Based Other Tour Main Mode Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Level of Service				
Travel Cost (Specified in 2010$)[1]				
Cost, Lower Income	[GeneralizedTime].[Other].[CostBy].[IncomeSegment]	-0.05538	-3.100	No Change
Cost, Modest Income	[GeneralizedTime].[Other].[CostBy].[IncomeSegment]	-0.03911	≦ Cost, Middle Income	No Change
Cost, Middle Income	[GeneralizedTime].[Other].[CostBy].[IncomeSegment]	-0.03911	-3.210	No Change
Cost, Upper Income	[GeneralizedTime].[Other].[CostBy].[IncomeSegment]	-0.03394	-2.990	No Change
Cost, Top Income	[GeneralizedTime].[Other].[CostBy].[IncomeSegment]	-0.01435	-1.680	No Change
Cost, Missing Income[2]	*Used for Model Estimation Only*	*-0.04470*	*-1.010*	–
Travel Time (Specified in Minutes)				
Auto In-Vehicle Time	[GeneralizedTime].[Other].[InVehicleTime]	-0.00897	-25.800	No Change
Auto Terminal Time	[GeneralizedTime].[Other].[Auto].[AutoTerminalTime]	-0.03586	= Walk Time	No Change
Transit Rail In-Vehicle Time	[GeneralizedTime].[Other].[Transit].[InVehicleTimeRail]	-0.00628	= Auto In-Vehicle Time × 0.7	No Change
Transit Non-Rail In-Vehicle Time	[GeneralizedTime].[Other].[InVehicleTime]	-0.00897	-25.800	No Change
Transit Walk Time	[GeneralizedTime].[Other].[Transit].[WalkTransitAccEgrTime]	-0.03586	= Walk Time	No Change
Transit Drive Time	[GeneralizedTime].[Other].[Transit].[DriveTransitAccEgrTime]	-0.00897	= Auto In-Vehicle Time	No Change
Transit Initial Wait Time	[GeneralizedTime].[Other].[Transit].[TransitInitWaitTime]	-0.01345	≦ Auto In-Vehicle Time × 1.5	No Change
Transit Transfer Wait Time	[GeneralizedTime].[Other].[Transit].[TransitTransferWaitTime]	-0.01345	= Transit First Wait Time	No Change
Walk Time	[GeneralizedTime].[Other].[Walk].[WalkTime]	-0.03586	≧ Auto In-Vehicle Time × 4.0	No Change
Bike Time	[GeneralizedTime].[Other].[Bike].[BikeTime]	-0.02542	-8.950	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Travel Time Related				
Transit Drive Access Time / Drive Alone Time Ratio Amount Exceeding 0.5	[GeneralizedTime].[Other].[DriveToTransit] . [DriveAccessFractionMr50Pcnt]	-0.58196	-2.240	No Change
Traveler and Household Characteristics				
Income Group[1]				
Lower Income: Shared Ride 2	[Tour Mode Choice].[Other].[SharedRide2]. [IncomeSegment]	0.08849	2.260	No Change
Lower Income: Shared Ride 3+	[Tour Mode Choice].[Other]. [SharedRide3P].[IncomeSegment]	0.08849	2.260	No Change
Lower Income: Walk to Transit	[Tour Mode Choice].[Other]. [WalkToTransit].[IncomeSegment]	1.13978	5.030	No Change
Upper Income: Shared Ride 2	[Tour Mode Choice].[Other]. [SharedRide2].[IncomeSegment]	-0.06918	-2.610	No Change
Upper Income: Shared Ride 3+	[Tour Mode Choice].[Other]. [SharedRide3P].[IncomeSegment]	-0.06918	-2.610	No Change
Upper Income: Walk	[Tour Mode Choice].[Other].[Walk]. [IncomeSegment]	0.24442	2.260	No Change
Upper Income: Bike	[Tour Mode Choice].[Other].[Bike]. [IncomeSegment]	0.24442	2.260	No Change
Top Income: Shared Ride 2	[Tour Mode Choice].[Other]. [SharedRide2].[IncomeSegment]	-0.06957	-2.310	No Change
Top Income: Shared Ride 3+	[Tour Mode Choice].[Other]. [SharedRide3P].[IncomeSegment]	-0.06957	-2.310	No Change
Top Income: Walk	[Tour Mode Choice].[Other].[Walk]. [IncomeSegment]	-0.29080	-1.950	No Change
Top Income: Bike	[Tour Mode Choice].[Other].[Bike]. [IncomeSegment]	-0.29080	-1.950	No Change
Missing Income: Shared Ride[2]	*Used for Model Estimation Only*	*0.10704*	*1.120*	–
Missing Income: Walk to Transit[2]	*Used for Model Estimation Only*	*1.10000*	*1.450*	–
Missing Income: Non-Motorized[2]	*Used for Model Estimation Only*	*0.56143*	*1.190*	–
Automobile Ownership				
No Cars: Drive Alone	[Tour Mode Choice].[Other]. [DriveAlone].[NoCarHH]	-1.47472	-3.320	-2.5695
No Cars: Walk	[Tour Mode Choice].[Other].[Walk]. [NoCarHH]	2.22403	7.960	2.1128
No Cars: Bike	[Tour Mode Choice].[Other].[Bike]. [NoCarHH]	2.22403	---	4.3154
No Cars: Walk to Transit	[Tour Mode Choice].[Other]. [WalkToTransit].[NoCarHH]	3.81590	12.800	4.5791
Cars But Less Than Drivers: Drive Alone	[Tour Mode Choice].[Other]. [DriveAlone].[HHCLDrvs]	-0.18036	-3.310	-4.6462

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Cars But Less Than Drivers: Walk	[Tour Mode Choice].[Other].[Walk].[HHCLWrs]	0.45115	4.000	No Change
Cars But Less Than Drivers: Bike	[Tour Mode Choice].[Other].[Bike].[HHCLWrs]	0.45115	4.000	No Change
Cars But Less Than Drivers: Walk to Transit	[Tour Mode Choice].[Other].[WalkToTransit].[HHCLDrvs]	1.15841	5.500	2.2000
Cars But Less Than Workers: Walk	[Tour Mode Choice].[Other].[Walk].[HHCLWrs]	0.45115	4.000	No Change
Cars But Less Than Workers: Bike	[Tour Mode Choice].[Other].[Bike].[HHCLWrs]	0.45115	4.000	No Change
Household Size				
One Person Household: Shared Ride 2	[Tour Mode Choice].[Other].[SharedRide2].[HH1P]	-0.63455	-3.630	No Change
One Person Household: Shared Ride 3+	[Tour Mode Choice].[Other].[SharedRide3P].[HH1P]	-1.15606	-3.600	No Change
Two Person Household: Shared Ride 3+	[Tour Mode Choice].[Other].[SharedRide3P].[HH2P]	-0.79734	-3.580	No Change
Traveler Age				
Age Under 20: Walk	[Tour Mode Choice].[Other].[Walk].[UndAge20]	-0.13708	-0.946	-0.8638
Age Under 20: Bike	[Tour Mode Choice].[Other].[Bike].[UndAge20]	-0.54597	-2.410	-1.7690
Age Over 50: Walk	[Tour Mode Choice].[Other].[Walk].[AgeO50]	-0.46642	-4.060	-0.0597
Age Over 50: Bike	[Tour Mode Choice].[Other].[Bike].[AgeO50]	-1.23647	-6.620	No Change
Educational Status				
High School Student: Walk to Transit	[Tour Mode Choice].[Other].[WalkToTransit].[HSStuAge16P]	1.51811	4.390	No Change
High School Student: Drive to Transit	[Tour Mode Choice].[Other].[DriveToTransit].[HSStuAge16P]	1.51811	4.390	No Change
University Student: Walk to Transit	[Tour Mode Choice].[Other].[WalkToTransit].[UniStu]	0.40247	0.850	No Change
University Student: Drive to Transit	[Tour Mode Choice].[Other].[DriveToTransit].[UniStu]	0.40247	0.850	No Change
Gender				
Female: Shared Ride 2	[Tour Mode Choice].[Other].[SharedRide2].[Female]	0.03668	2.150	No Change
Female: Shared Ride 3+	[Tour Mode Choice].[Other].[SharedRide3P].[Female]	0.03668	2.150	No Change
Female: Bike	[Tour Mode Choice].[Other].[Bike].[Female]	-0.72906	-4.340	-0.8749

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Geographic				
Land Use				
Destination Retail Density: Walk to Transit	[Tour Mode Choice].[Other].[WalkToTransit].[DestRetDensity]	0.32293	5.620	No Change
Destination Retail Density: Drive to Transit	[Tour Mode Choice].[Other].[DriveToTransit].[DestRetDensity]	0.32293	5.620	No Change
Origin & Destination Mixed Use Density: Walk	[Tour Mode Choice].[Other].[Walk].[MixedUseDensityOrig]	0.14679	2.930	0.3699
Origin & Destination Mixed Use Density: Walk	[Tour Mode Choice].[Other].[Walk].[MixedUseDensityDest]	0.14679	2.930	0.3699
Origin & Destination Mixed Use Density: Bike	[Tour Mode Choice].[Other].[Bike].[MixedUseDensityOrig]	0.14679	2.930	No Change
Origin & Destination Mixed Use Density: Bike	[Tour Mode Choice].[Other].[Bike].[MixedUseDensityDest]	0.14679	2.930	No Change
Origin Intersection Density: Walk to Transit	[Tour Mode Choice].[Other].[WalkToTransit].[OrigIntDensity]	-0.52064	-0.176	0.0000
Destination Intersection Density: Walk to Transit	[Tour Mode Choice].[Other].[WalkToTransit].[DestIntDensity]	12.58830	4.540	No Change
Destination Intersection Density: Drive to Transit	[Tour Mode Choice].[Other].[DriveToTransit].[DestIntDensity]	12.58830	4.540	No Change
Origin & Destination Intersection Density: Walk	[Tour Mode Choice].[Other].[Walk].[IntrDensHHBufferDiv1000Orig]	2.95673	3.650	3.9029
Origin & Destination Intersection Density: Walk	[Tour Mode Choice].[Other].[Walk].[IntrDensEmpBufferDiv1000Dest]	2.95673	3.650	3.9029
Tour Level				
Non-Closed Tour Indicator				
Non-Closed Tour: Walk	[Tour Mode Choice].[Other].[Walk].[NonClosedTour]	-2.15320	-3.980	No Change
Non-Closed Tour: Bike	[Tour Mode Choice].[Other].[Bike].[NonClosedTour]	-2.15320	-3.980	No Change
Non-Closed Tour: Walk to Transit	[Tour Mode Choice].[Other].[WalktoTransit].[NonClosedTour]	1.42484	3.220	-0.8000
Non-Closed Tour: Drive to Transit	[Tour Mode Choice].[Other].[DrivetoTransit].[NonClosedTour]	1.42484	3.220	0.6839
Tour Purpose				
Meal Tour: Drive Alone	[Tour Mode Choice].[Other].[DriveAlone].[MealTour]	-0.31251	-1.920	-1.1813
Meal Tour: Shared Ride 2	[Tour Mode Choice].[Other].[SharedRide2].[MealTour]	0.19443	1.320	1.7500
Meal Tour: Shared Ride 3+	[Tour Mode Choice].[Other].[SharedRide3P].[MealTour]	0.45200	2.420	3.0562
Shopping Tour: Walk to Transit	[Tour Mode Choice].[Other].[WalkToTransit].[ShopTour]	-0.67110	-3.040	0.2000

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Shopping Tour: Drive to Transit	[Tour Mode Choice].[Other]. [DriveToTransit].[ShopTour]	-0.67110	-3.040	-1.5000
Social/recreation Tour: Shared Ride 2	[Tour Mode Choice].[Other].[SharedRide2]. [SocialRecreationTour]	0.09048	3.090	-0.1544
Social/recreation Tour: Shared Ride 3	[Tour Mode Choice].[Other]. [SharedRide3P]. [SocialRecreationTour]	0.30603	3.520	2.1000
Social/recreation Tour: Walk	[Tour Mode Choice].[Other].[Walk]. [SocialRecreationTour]	0.84858	8.120	1.1000
Social/recreation Tour: Bike	[Tour Mode Choice].[Other].[Bike]. [SocialRecreationTour]	0.72742	4.290	0.1500
Schedule and Day Pattern				
Arrive Destination In AM Peak: Drive Alone	[Tour Mode Choice].[Other].[DriveAlone]. [ArriveAMPeak]	-0.36676	-3.030	No Change
Arrive Destination In AM Peak: Share Ride 2	[Tour Mode Choice].[Other]. [SharedRide2].[ArriveAMPeak]	-0.36676	-3.030	No Change
Arrive Destination In AM Peak: Share Ride 3+	[Tour Mode Choice].[Other]. [SharedRide3P].[ArriveAMPeak]	-0.36676	-3.030	No Change
Depart Destination In PM Peak: Drive Alone	[Tour Mode Choice].[Other].[DriveAlone]. [LeavePMPeak]	0.10970	3.160	No Change
Depart Destination In PM Peak: Shared Ride 2	[Tour Mode Choice].[Other].[SharedRide2]. [LeavePMPeak]	0.10970	3.160	No Change
Depart Destination In PM Peak: Shared Ride 3+	[Tour Mode Choice].[Other]. [SharedRide3P].[LeavePMPeak]	0.10970	3.160	No Change
Escort Stop Flag By Tours Remain: Shared Ride 2	[Tour Mode Choice].[Other].[SharedRide2]. [EscortStopsDivTours]	0.05728	1.650	No Change
Escort Stop Flag By Tours Remain: Shared Ride 3+	[Tour Mode Choice].[Other].[SharedRide3P]. [EscortStopsDivTours]	0.05728	1.650	No Change
Other Stop Flag By Tours Remain: Shared Ride 2	[Tour Mode Choice].[Other].[SharedRide2]. [OtherStopsDivTours]	0.09140	3.130	No Change
Other Stop Flag By Tours Remain: Shared Ride 3+	[Tour Mode Choice].[Other]. [SharedRide3P]. [OtherStopsDivTours]	0.09140	3.130	No Change
Sampling Bias				
FREX: Walk to Transit[1]	*Used for Model Estimation Only*	*2.27499*	*2.360*	–
FREX: Drive to Transit[1]	*Used for Model Estimation Only*	*2.27499*	*= Walk to Transit, FREX*	–
Other Non-Random: Walk[1]	*Used for Model Estimation Only*	*0.69710*	*2.330*	–
Other Non-Random: Bike[1]	*Used for Model Estimation Only*	*0.74190*	*1.810*	–
Other Non-Random: Walk to Transit[1]	*Used for Model Estimation Only*	*1.52811*	*4.660*	–
Other Non-Random: Drive to Transit[1]	*Used for Model Estimation Only*	*1.00980*	*1.340*	–

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Nesting Coefficients				
Logsum Auto	[Tour Mode Choice].[Other].[NestParamAuto]	0.33540	-7.120	No Change
Alternative Specific Constants				
Shared Ride 2	[Tour Mode Choice].[Other].[SharedRide2].[Constant]	-0.34887	-3.510	-4.5959
Shared Ride 3+	[Tour Mode Choice].[Other].[SharedRide3P].[Constant]	-0.45327	-3.510	-6.3828
Walk	[Tour Mode Choice].[Other].[Walk].[Constant]	-0.69369	-4.660	-2.5579
Bike	[Tour Mode Choice].[Other].[Bike].[Constant]	-3.03050	-14.800	-5.2000
Walk to Transit	[Tour Mode Choice].[Other].[WalkToTransit].[Constant]	-4.68700	-18.100	-7.8000
Drive to Transit	[Tour Mode Choice].[Other].[DriveToTransit].[Constant]	-5.08560	-17.700	-8.5000
Model Estimation Statistics				
Number of Observations	14,891			
Log-likelihood at Convergence	-13,875.49			
Log-likelihood at Constants	-17,800.26			
Log-likelihood at Null Parameters	-25,506.10			
Rho-squared w.r.t. Constants	0.220			
Rho-squared w.r.t. Null Parameters	0.456			

Source: Cambridge Systematics

Notes: [1] The StateFocus Code Parameter Names for income related variables are input as a six element array as follows: [Less than $30K, $30K-$40K, $40K-$60K, $60K-$100K, $100K-$150K, $150K or more]. The six elements correspond to the following income groups: [Low Income, Modest Income, Modest Income (modest income coefficient is repeated), Middle Income, Upper Income, Top Income].

[2] Variable used for model estimation purposes only and is not used in model application.

F.13.5 Work-Based Sub-Tour

Table F.37 Work-Based Sub-Tour Main Mode Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Level of Service				
Travel Cost (Specified in 2010$)[1]				
Cost, Lower Income	[GeneralizedTime].[WorkBasedSubTour].[CostBy].[IncomeSegment]	-0.20424	≦ Cost, Modest Income	No Change
Cost, Modest Income	[GeneralizedTime].[WorkBasedSubTour].[CostBy].[IncomeSegment]	-0.20424	≦ Cost, Mid-Income	No Change
Cost, Middle Income	[GeneralizedTime].[WorkBasedSubTour].[CostBy].[IncomeSegment]	-0.20424	≦ Cost, Upper Income	No Change
Cost, Upper Income	[GeneralizedTime].[WorkBasedSubTour].[CostBy].[IncomeSegment]	-0.20424	≦ Cost, Top Income	No Change
Cost, Top Income	[GeneralizedTime].[WorkBasedSubTour].[CostBy].[IncomeSegment]	-0.20424	-8.070	No Change
Cost, Missing Income[2]	*Used for Model Estimation Only*	*0.51776*	*0.792*	–
Travel Time (Specified in Minutes)				
Auto In-Vehicle Time	[GeneralizedTime].[WorkBasedSubTour].[InVehicleTime]	-0.02549	-3.560	No Change
Auto Terminal Time	[GeneralizedTime].[WorkBasedSubTour].[Auto].[AutoTerminalTime]	-0.04358	= Walk Time	No Change
Transit Rail In-Vehicle Time	[GeneralizedTime].[WorkBasedSubTour].[Transit].[InVehicleTimeRail]	-0.01785	= Auto In-Vehicle Time × 0.7	No Change
Transit Non-Rail In-Vehicle Time	[GeneralizedTime].[WorkBasedSubTour].[InVehicleTime]	-0.02549	-3.560	No Change
Transit Walk Time	[GeneralizedTime].[WorkBasedSubTour].[Transit]. [WalkTransitAccEgrTime]	-0.04358	= Walk Time	No Change
Transit Drive Time	[GeneralizedTime].[WorkBasedSubTour].[Transit]. [DriveTransitAccEgrTime]	-0.02549	= Auto In-Vehicle Time	No Change
Transit Initial Wait Time	[GeneralizedTime].[WorkBasedSubTour].[Transit].[TransitInitWaitTime]	-0.10197	≧ Auto In-Vehicle Time × 4.0	No Change
Transit Transfer Wait Time	[GeneralizedTime].[WorkBasedSubTour].[Transit]. [TransitTransferWaitTime]	-0.10197	= Transit First Wait Time	No Change
Walk Time	[GeneralizedTime].[WorkBasedSubTour].[Walk].[WalkTime]	-0.04358	-11.800	No Change
Bike Time	[GeneralizedTime].[WorkBasedSubTour].[Bike].[BikeTime]	-0.06029	-3.320	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Travel Time Related				
Total Travel Time, Lower Income	[GeneralizedTime].[WorkBasedSubTour].[DriveToTransit].[TotalTravelTimeIncLs30K]	-0.07767	-1.380	No Change
Traveler and Household Characteristics				
Income Group[1]				
Lower Income: Walk to Transit	[Tour Mode Choice].[WorkBasedSubTour].[WalkToTransit].[IncomeSegment]	-2.00000	fixed value	No Change
Modest Income: Walk to Transit	[Tour Mode Choice].[WorkBasedSubTour].[WalkToTransit].[IncomeSegment]	-2.00000	fixed value	No Change
Geographic				
Land Use				
Origin & Destination Intersection Density: Walk	[Tour Mode Choice].[WorkBasedSubTour].[Walk]. [IntrDensHHBufferDiv1000Orig]	4.71397	3.120	5.6568
Origin & Destination Intersection Density: Walk	[Tour Mode Choice].[WorkBasedSubTour].[Walk].[IntrDensEmpBufferDiv1000Dest]	4.71397	3.120	6.7882
Tour Level				
Tour Purpose				
Meal Tour: Shared Ride 2	[Tour Mode Choice].[WorkBasedSubTour].[SharedRide2].[MealTour]	1.01537	6.400	No Change
Meal Tour: Shared Ride 3+	[Tour Mode Choice].[WorkBasedSubTour].[SharedRide3P].[MealTour]	1.76545	8.710	No Change
Meal Tour: Walk	[Tour Mode Choice].[WorkBasedSubTour].[Walk].[MealTour]	1.30752	6.090	No Change
Shopping Tour: Shared Ride 2	[Tour Mode Choice].[WorkBasedSubTour].[SharedRide2].[ShopTour]	-0.94140	-2.600	No Change
Shopping Tour: Shared Ride 3+	[Tour Mode Choice].[WorkBasedSubTour].[SharedRide3P].[ShopTour]	-2.22606	-2.180	No Change
Used Drive Alone to Work: Drive Alone	[Tour Mode Choice].[WorkBasedSubTour].[DriveAlone].[UsedDAToWork]	3.96417	7.920	No Change
Used Drive Alone to Work: Shared Ride 2	[Tour Mode Choice].[WorkBasedSubTour].[SharedRide2].[UsedDAToWork]	2.01981	4.070	No Change
Used Drive Alone to Work: Shared Ride 3+	[Tour Mode Choice].[WorkBasedSubTour].[SharedRide3P].[UsedDAToWork]	0.90738	1.920	No Change
Used Shared Ride to Work: Drive Alone	[Tour Mode Choice].[WorkBasedSubTour].[DriveAlone].[UsedSRToWork]	2.87846	5.520	No Change
Used Shared Ride to Work: Shared Ride 2	[Tour Mode Choice].[WorkBasedSubTour].[SharedRide2].[UsedSRToWork]	2.07000	3.990	No Change
Used Shared Ride to Work: Shared Ride 3+	[Tour Mode Choice].[WorkBasedSubTour].[SharedRide3P].[UsedSRToWork]	0.95155	1.900	No Change
Used Transit to Work: Walk to Transit	[Tour Mode Choice].[WorkBasedSubTour].[WalkToTransit].[UsedTRToWork]	0.84951	1.700	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Sampling Bias				
Other Non-Random: Walk[1]	*Used for Model Estimation Only*	*1.03734*	*1.580*	–
Other Non-Random: Walk to Transit[1]	*Used for Model Estimation Only*	*1.71963*	*1.790*	–
Nesting Coefficients				
Logsum Non-Motorized	[Tour Mode Choice].[WorkBasedSubTour].[NestParamNonMotorized]	1.00000	≦ 1.0	No Change
Logsum Auto	[Tour Mode Choice].[WorkBasedSubTour].[NestParamAuto]	1.00000	≦ 1.0	No Change
Alternative Specific Constants				
Shared Ride 2	[Tour Mode Choice].[WorkBasedSubTour].[SharedRide2].[Constant]	-0.18200	-0.353	0.0741
Shared Ride 3+	[Tour Mode Choice].[WorkBasedSubTour].[SharedRide3P].[Constant]	-0.19289	-0.381	0.2138
Walk	[Tour Mode Choice].[WorkBasedSubTour].[Walk].[Constant]	3.03253	5.570	3.1844
Bike	[Tour Mode Choice].[WorkBasedSubTour].[Bike].[Constant]	0.02742	0.043	No Change
Walk to Transit	[Tour Mode Choice].[WorkBasedSubTour].[WalkToTransit].[Constant]	1.79795	2.820	-0.4046
Model Estimation Statistics				
Number of Observations	1,666			
Log-likelihood at Convergence	-1,365.28			
Log-likelihood at Constants	-2,110.25			
Log-likelihood at Null Parameters	-2,873.67			
Rho-squared w.r.t. Constants	0.353			
Rho-squared w.r.t. Null Parameters	0.525			

Source: Cambridge Systematics

Notes: [1] The StateFocus Code Parameter Names for income related variables are input as a six element array as follows: [Less than $30K, $30K-$40K, $40K-$60K, $60K-$100K, $100K-$150K, $150K or more]. The six elements correspond to the following income groups: [Low Income, Modest Income, Modest Income (modest income coefficient is repeated), Middle Income, Upper Income, Top Income].

[2] Variable used for model estimation purposes only and is not used in model application.

F.14 Tour Time of Day Choice

Tour time of day choice model variables, StateFocus C# parameter names, estimated model coefficients and t-statistics, final calibrated parameters based on the 2015 model calibration/validation are shown by tour purpose in the following sections. Definitions of the variables are shown in ***Section 4.2.14***.

For model estimation, there were only a few non-closed home-based school tours, so the home-based school tour time of day model was estimated considering only the closed tours. Besides the 98 non-closed home-based school tours removed from the estimation sample, 179 observations with incomplete information were also removed. The final sample sizes for estimation are shown in ***Table F.38***:

Table F.38 Sample Sizes for Tour Time of Day Choice Estimation

Model	Closed Tours		Non-Closed Tours		Total Tours	
	Number	Percent	Number	Percent	Number	Percent
Home-based work	12,349	96.8%	412	3.2%	12,761	100.0%
Home-based school	5,456	100.0%	0	0.0%	5,456	100.0%
Home-based social/recreation	6,242	95.1%	321	4.9%	6,563	100.0%
Home-based other	13,322	98.4%	218	1.6%	13,540	100.0%
Work-based sub-tour	1,659	100.0%	0	0.0%	1,659	100.0%

Source: Arizona State University analysis of FRTC data.

Arrival and departure hours and durations for non-closed tours were treated differently from other types of tours for the model estimation:

- The arrival hour for "before" is 1:00 AM
- The departure hour for "after" is 28 (or, in effect 4:00 AM of the following day)
- For duration, three hours were added to the total of time reported in the data. For example, if an individual started an activity in the 7:00 PM-7:59 PM time period, and continued the activity past the end of the surveyed travel day (2:59 AM) the duration was set as 12:00 hours (9+3). Similarly, if an individual was already performing the activity at 3:00 AM and departed during the 6:00 AM-6:59 AM, the duration is 8:00 hours (5+3).

F.14.1 Home-Based Work

Table F.39 Home-Based Work Tour Time of Day Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Person Type Shift Effects				
Full-time worker – Duration	[Tour Time of Day].[Home based work].[Full-time worker - Duration shift]	-0.782	-4.28	0.450
Full-time worker – Duration < 9 hours	[Tour Time of Day].[Home based work].[Full-time worker – Duration < 9 hrs]	–	–	-1.4685

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Part-time worker – Arrival	[Tour Time of Day].[Home based work]. [Part-time worker-Arrival shift]	0.067	3.27	No Change
Part-time worker – Duration	[Tour Time of Day].[Home based work]. [Part-time worker-Duration shift]	-0.205	-3.11	0.050
Other non-worker – Arrival	[Tour Time of Day].[Home based work]. [Other non-worker -Arrival shift]	-0.058	-2.18	-0.100
Other non-worker – Duration	[Tour Time of Day].[Home based work]. [Other non-worker -Duration shift]	-0.240	-5.21	-0.500
University student – Arrival	[Tour Time of Day].[Home based work]. [University student -Arrival shift]	0.405	5.91	No Change
University student – Duration	[Tour Time of Day].[Home based work]. [University student-Duration shift]	0.476	2.67	No Change
Driving Age Student – Arrival	[Tour Time of Day].[Home based work]. [K12 student 16+ -Arrival shift]	0.631	2.27	0.800
Driving Age Student – Duration	[Tour Time of Day].[Home based work]. [K12 student 16+ -Duration shift]	0.595	2.54	0.720
Income Group Shift Effects (Incomes in 2010 $)				
Income <$25,000 – Arrival	[Tour Time of Day].[Home based work]. [Income <$25K - Arrival shift]	0.289	2.17	0.024
Income <$25,000 – Duration	[Tour Time of Day].[Home based work]. [Income <$25K - Duration shift]	-0.034	-1.06	No Change
Income ≥ $75,000 – Arrival	[Tour Time of Day].[Home based work]. [Income >$75K - Arrival shift]	-0.001	-0.98	-0.050
Income ≥ $75,000 – Duration	[Tour Time of Day].[Home based work]. [Income >$75K - Duration shift]	0.032	1.82	No Change
Day Pattern Variables				
Escort stops in day – Arrival	[Tour Time of Day].[Home based work]. [Escort stops in day - Arrival shift]	-0.003	-1.23	No Change
Escort stops in day – Duration	[Tour Time of Day].[Home based work]. [Escort stops in day - Duration shift]	0.237	2.75	0.145
Higher Priority of 2+ different tours – Arrival	[Tour Time of Day].[Home based work]. [Higher of 2+ different tours - Arrival shift]	1.389	3.22	0.000
Higher Priority of 2+ different tours – Duration	[Tour Time of Day].[Home based work]. [Higher of 2+ different tours - Duration shift]	2.680	2.16	0.000
Higher Priority of 2+ different tours – Duration < 8 hours	[Tour Time of Day].[Home based work]. [Higher of 2+ different tours - Duration< 8 hrs]	–	–	-0.5765
Higher Priority of 2+ work tours – Duration < 8 hours	[Tour Time of Day].[Home based work]. [Higher of 2+ work tours- Duration<8 hrs]	–	–	1.558
Lower Priority of 2+ work tours – Arrival	[Tour Time of Day].[Home based work]. [Lower of 2+ work tours - Arrival shift]	0.690	4.58	No Change
Lower Priority of 2+ work tours – Duration	[Tour Time of Day].[Home based work]. [Lower of 2+ work tours - Duration shift]	0.302	2.11	0.000
Lower Priority of 2+ work tours – Duration < 8 hours	[Tour Time of Day].[Home based work]. [Lower of 2+ work tours- Duration<8 hrs]	–	–	1.500

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Number of stop purposes/ multiple tours – Arrival	[Tour Time of Day].[Home based work]. [# stop purposes/multiple tours - Arrival shift]	-0.083	-1.31	No Change
Number of stop purposes/multiple tours – Duration	[Tour Time of Day].[Home based work]. [# stop purposes/multiple tours - Duration shift]	-0.142	-7.36	-0.384
Number of stop purposes/only tour – Arrival	[Tour Time of Day].[Home based work]. [# stop purposes/only tour - Arrival shift]	-0.025	-2.79	No Change
Number of stop purposes/only tour – Duration	[Tour Time of Day].[Home based work]. [# stop purposes/only tour - Duration shift]	-0.231	-2.32	-0.3049
Number of sub-tours in tour – Arrival	[Tour Time of Day].[Home based work]. [# subtours in tour - Arrival shift]	-0.347	-4.21	-0.0739
Number of sub-tours in tour – Duration	[Tour Time of Day].[Home based work]. [# subtours in tour - Duration shift]	0.170	2.41	No Change
Only tour of day – Arrival	[Tour Time of Day].[Home based work]. [Only tour in day - Arrival shift]	0.125	1.97	-0.200
Only tour of day – Duration	[Tour Time of Day].[Home based work]. [Only tour in day - Duration shift]	0.190	2.05	0.100
Generalized Time Variable (Minutes)				
Auto, Full-time worker	[Tour Time of Day].[Home based work]. [Auto generalized time (min)- Full-time worker]	-0.006	Constrained	No Change
Auto, Part-time worker	[Tour Time of Day].[Home based work]. [Auto generalized time (min)- Part-time worker]	-0.051	-1.87	No Change
Transit, Transit Tours	[Tour Time of Day].[Home based work]. [Transit generalized time (min)- Transit tours]	-0.006	Constrained	No Change
Schedule Pressure Effects				
Empty window before 1st tour	[Tour Time of Day].[Home based work]. [Empty window remaining before- 1st tour]	0.167	2.10	No Change
Empty window after 1st tour	[Tour Time of Day].[Home based work]. [Empty window remaining after - 1st tour]	-0.529	-2.31	No Change
Empty window before 2nd + tour	[Tour Time of Day].[Home based work]. [Empty window remaining before- 2nd+ tour]	0.0731	1.66	No Change
Empty window after 2nd + tour	[Tour Time of Day].[Home based work]. [Empty window remaining after - 2nd+ tour]	0.008	0.65	No Change
Remaining tours/ total window	[Tour Time of Day].[Home based work]. [Remaining tours/total remaining window]	-15.231	-6.30	-24.770
Remaining tours/maximum window	[Tour Time of Day].[Home based work]. [Remaining tours/maximum remaining window]	-5.750	-5.88	No Change
Arrival period partially used	[Tour Time of Day].[Home based work]. [Arrival period partially used]	-3.117	-4.32	No Change
Departure period partially used	[Tour Time of Day].[Home based work]. [Departure period partially used]	-3.789	-3.20	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Arrival Constants[1]				
Before	[Tour Time of Day].[Home based work].[Arrival Before]	-3.061	-4.21	-6.000
Arrival – 00:00-00:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	-10.000	Constrained	-15.000
Arrival – 01:00-01:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	-10.000	Constrained	-15.000
Arrival – 02:00-02:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	-10.000	Constrained	-15.000
Arrival – 03:00-03:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	-10.000	Constrained	-13.000
Arrival – 04:00-04:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	-10.000	Constrained	-2.000
Arrival – 05:00-05:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	-10.000	Constrained	-1.500
Arrival – 06:00-06:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	-1.654	-20.31	0.000
Arrival – 07:00-07:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	0.010	0.78	0.300
Arrival – 08:00-08:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	0.000	Base	No Change
Arrival – 09:00-09:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	-1.571	-17.32	-1.000
Arrival – 10:00-10:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	-2.678	-12.31	-2.000
Arrival – 11:00-11:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	-2.678	-12.31	No Change
Arrival – 12:00-12:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	-2.678	-12.31	No Change
Arrival – 13:00-13:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	-2.896	-10.22	-2.678
Arrival – 14:00-14:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	-2.896	-10.22	-3.500
Arrival – 15:00-15:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	-2.896	-10.22	-4.000
Arrival – 16:00-16:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	-2.028	-7.10	-5.000
Arrival – 17:00-17:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	-2.028	-7.10	-7.000
Arrival – 18:00-18:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	-2.028	-7.10	-10.000
Arrival – 19:00-19:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	-7.190	-21.26	-10.000
Arrival – 20:00-20:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	-7.190	-21.26	-10.000

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Arrival – 21:00-21:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	-7.190	-21.26	-10.000
Arrival – 22:00-22:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	-7.190	-21.26	-10.000
Arrival – 23:00-23:59	[Tour Time of Day].[Home based work].[ArrivalTimeConstants]	-10.000	Constrained	No Change
Departure Constants[2]				
Departure – 00:00-00:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-10.000	Constrained	No Change
Departure – 01:00-01:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-10.000	Constrained	No Change
Departure – 02:00-02:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-10.000	Constrained	No Change
Departure – 03:00-03:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-10.000	Constrained	No Change
Departure – 04:00-04:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-10.000	Constrained	No Change
Departure – 05:00-05:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-10.000	Constrained	No Change
Departure – 06:00-06:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-1.637	-7.36	-5.000
Departure – 07:00-07:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-1.637	-7.36	No Change
Departure – 08:00-08:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-1.637	-7.36	No Change
Departure – 09:00-09:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-1.637	-7.36	No Change
Departure – 10:00-10:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-1.321	-11.95	No Change
Departure – 11:00-11:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-1.321	-11.95	No Change
Departure – 12:00-12:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-1.321	-11.95	-0.568
Departure – 13:00-13:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-1.321	-11.95	-0.568
Departure – 14:00-14:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-0.568	-0.23	No Change
Departure – 15:00-15:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	0.000	Base	No Change
Departure – 16:00-16:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-0.104	-2.16	-0.200
Departure – 17:00-17:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-0.503	-7.60	-0.500
Departure – 18:00-18:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-2.268	-10.07	-1.500

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Departure – 19:00-19:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-2.875	-20.26	-2.400
Departure – 20:00-20:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-2.875	-20.26	-3.000
Departure – 21:00-21:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-4.266	-14.24	No Change
Departure – 22:00-22:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-4.266	-14.24	-6.000
Departure – 23:00-23:59	[Tour Time of Day].[Home based work].[DepartureTimeConstants]	-10.000	Constrained	No Change
After	[Tour Time of Day].[Home based work].[Departure After]	-5.321	-7.43	-8.000
***Duration*[3]**				
Duration – 00:00-00:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	-0.784	-5.72	-0.900
Duration – 01:00-01:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	-0.784	-5.72	-0.300
Duration – 02:00-02:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	-0.784	-5.72	-0.100
Duration – 03:00-03:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	-0.433	-8.27	0.200
Duration – 04:00-04:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	-0.433	-8.27	0.100
Duration – 05:00-05:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	0.000	Base	No Change
Duration – 06:00-06:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	0.000	Base	-0.700
Duration – 07:00-07:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	-0.371	-4.52	-0.900
Duration – 08:00-08:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	-0.371	-4.52	-0.900
Duration – 09:00-09:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	-1.011	-5.22	-0.900
Duration – 10:00-10:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	-1.874	-4.32	-1.800
Duration – 11:00-11:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	-3.104	-5.00	No Change
Duration – 12:00-12:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	-4.620	-9.32	No Change
Duration – 13:00-13:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	-4.620	-9.32	No Change
Duration – 14:00-14:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	-4.278	-5.38	-6.000
Duration – 15:00-15:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	-4.278	-5.38	-6.000

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Duration – 16:00-16:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	-4.278	-5.38	-6.000
Duration – 17:00-17:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	-4.278	-5.38	-6.000
Duration – 18:00-18:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	-8.326	-1.51	No Change
Duration – 19:00-19:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	-8.326	-1.51	No Change
Duration – 20:00-20:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	-8.326	-1.51	No Change
Duration – 21:00-21:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	-8.326	-1.51	No Change
Duration – 22:00-22:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	-8.326	-1.51	No Change
Duration – 23:00-23:59 Hours	[Tour Time of Day].[Home based work].[DurationConstants]	-8.326	-1.51	No Change
Model Estimation Statistics				
Number of Observations	12,761			
Log-likelihood (β)	-39,779.43			
Rho-squared (0)	0.423			

Source: Cambridge Systematics

Notes: [1] Arrival constants (Arrival – HH:00-HH:59) are input as a 24 cell array. Variables with common coefficients and t-scores were estimated as grouped variables. Calibrated coefficients for parts of the grouped cells might vary.

[2] Departure constants (Departure – HH:00-HH:59) are input as a 24 cell array. Variables with common coefficients and t-scores were estimated as grouped variables. Calibrated coefficients for parts of the grouped cells might vary.

[3] Duration constants (Duration – HH:00-HH:59 Hours) are input as a 24 cell array. Variables with common coefficients and t-scores were estimated as grouped variables. Calibrated coefficients for parts of the grouped cells might vary.

F.14.2 Home-Based School

Table F.40 Home-Based School Tour Time of Day Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Person Type Shift Effects				
University student – Arrival	[Tour Time of Day].[Home based school].[University-Arrival Shift]	0.451	13.45	0.100
University student – Duration	[Tour Time of Day].[Home based school].[University-Duration Shift]	-0.165	-5.31	No Change
Driving Age Student – Arrival	[Tour Time of Day].[Home based school].[Driving Age Kid Arrival Shift]	-0.242	-6.66	No Change
Driving Age Student – Duration	[Tour Time of Day].[Home based school].[Driving Age Kid Duration Shift]	-0.064	-3.00	0.200

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Pre-school Child – Arrival	[Tour Time of Day].[Home based school]. [Preschool Age Arrival Shift]	0.196	5.36	-0.010
Pre-school Child – Duration	[Tour Time of Day].[Home based school]. [Preschool Age Duration Shift]	-0.106	-3.87	-0.050
Day Pattern Variables				
Any Escort Tour in Day – Arrival	[Tour Time of Day].[Home based school]. [Any Escort Tour in Day- Arrival Shift]	0.007	0.12	No Change
Any Escort Tour in Day – Duration	[Tour Time of Day].[Home based school]. [Any Escort Tours in Day- Duration Shift]	-0.125	-3.75	No Change
Higher Priority of 2+ different tours – Arrival	[Tour Time of Day].[Home based school]. [Higher of 2+ Different Tours- arrival shift]	0.172	4.36	No Change
Higher Priority of 2+ different tours – Duration	[Tour Time of Day].[Home based school]. [Higher of 2+ Different Tours- duration shift]	0.595	19.43	0.000
Higher Priority of 2+ different tours – Duration < 6 hours	[Tour Time of Day].[Home based school]. [Higher of 2+ Different Tours-Duration< 6 hours]	–	–	-0.250
Higher Priority of 2+ school tours – Arrival	[Tour Time of Day].[Home based school]. [Higher of Two School Tours- arrival shift]	-0.206	-3.56	No Change
Higher Priority of 2+ school tours – Duration	[Tour Time of Day].[Home based school]. [Higher of Two School Tours- duration shift]	0.166	4.52	0.000
Higher Priority of 2+ school tours – Duration < 6 hours	[Tour Time of Day].[Home based school]. [Higher of 2+ School Tours-Duration< 6 hours]	–	–	0.166
Lower Priority of 2+ different tours – Arrival	[Tour Time of Day].[Home based school]. [Lower of 2+ Different Tours- arrival shift]	1.100	24.36	0.100
Lower Priority of 2+ different tours - Duration	[Tour Time of Day].[Home based school]. [Lower of 2+ Different Tours- duration shift]	0.287	6.42	0.000
Lower Priority of 2+ different tours – Duration < 6 hours	[Tour Time of Day].[Home based school]. [Lower of2+Different Tours-Duration< 6 hours]	–	–	-0.390
Lower Priority of 2+ school tours – Arrival	[Tour Time of Day].[Home based school]. [Lower of Two School Tours- arrival shift]	1.100	24.36	0.640
Lower Priority of 2+ school tours - Duration	[Tour Time of Day].[Home based school]. [Lower of Two School Tours-duration shift]	0.324	7.11	0.520
Number of stop purposes/multiple tours – Arrival	[Tour Time of Day].[Home based school]. [# stop purposes/multiple tours - Arrival shift]	0.129	1.48	-0.100
Number of stop purposes/multiple tours – Duration	[Tour Time of Day].[Home based school]. [# stop purposes/multiple tours - Duration shift]	-0.173	-3.11	-0.080
Number of stop purposes/only tour – Arrival	[Tour Time of Day].[Home based school]. [# stop purposes/only tour - Arrival shift]	-0.102	-1.27	No Change
Number of stop purposes/only tour – Duration	[Tour Time of Day].[Home based school]. [# stop purposes/only tour - Duration shift]	-0.276	-2.37	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Only tour of day – Arrival	[Tour Time of Day].[Home based school]. [Only Tour in the Day Arrival Shift]	0.261	6.22	No Change
Only tour of day – Duration	[Tour Time of Day].[Home based school]. [Only Tour in the Day Duration Shift]	0.831	27.17	No Change
Generalized Time Variable (Minutes)				
Auto, University Students	[Tour Time of Day].[Home based school]. [Auto Generalized Cost- University Student]	-0.060	Constrained	No Change
Transit, Transit Tours	[Tour Time of Day].[Home based school]. [Transit Generalized Cost- Transit Tours]	-0.010	Constrained	No Change
Schedule Pressure Effects				
Empty window before 1st tour	[Tour Time of Day].[Home based school]. [Empty window remaining before- 1st tour]	0.652	2.17	No Change
Empty window after 1st tour	[Tour Time of Day].[Home based school]. [Empty window remaining after - 1st tour]	-0.193	-1.98	No Change
Empty window before 2nd + tour	[Tour Time of Day].[Home based school]. [Empty window remaining before- 2nd+ tour]	0.493	1.07	No Change
Empty window after 2nd + tour	[Tour Time of Day].[Home based school]. [Empty window remaining after - 2nd+ tour]	0.659	1.56	No Change
Remaining tours/ total window	[Tour Time of Day].[Home based school]. [Remaining tours/total remaining window]	-10.268	-3.90	No Change
Arrival period partially used	[Tour Time of Day].[Home based school]. [Departure Period Partially Used]	-1.980	-2.55	No Change
Departure period partially used	[Tour Time of Day].[Home based school]. [Empty window remaining before- 1st tour]	-2.322	-1.99	No Change
Arrival Constants[1]				
Arrival – 00:00-00:59	[Tour Time of Day].[Home based school]. [ArrivalTimeConstants]	-10.000	Constrained	No Change
Arrival – 01:00-01:59	[Tour Time of Day].[Home based school]. [ArrivalTimeConstants]	-10.000	Constrained	No Change
Arrival – 02:00-02:59	[Tour Time of Day].[Home based school]. [ArrivalTimeConstants]	-10.000	Constrained	No Change
Arrival – 03:00-03:59	[Tour Time of Day].[Home based school]. [ArrivalTimeConstants]	-10.000	Constrained	No Change
Arrival – 04:00-04:59	[Tour Time of Day].[Home based school]. [ArrivalTimeConstants]	-10.000	Constrained	No Change
Arrival – 05:00-05:59	[Tour Time of Day].[Home based school]. [ArrivalTimeConstants]	-10.000	Constrained	No Change
Arrival – 06:00-06:59	[Tour Time of Day].[Home based school]. [ArrivalTimeConstants]	-2.740	-26.19	-2.000
Arrival – 07:00-07:59	[Tour Time of Day].[Home based school]. [ArrivalTimeConstants]	0.036	-0.65	0.800
Arrival – 08:00-08:59	[Tour Time of Day].[Home based school]. [ArrivalTimeConstants]	0.000	Base	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Arrival – 09:00-09:59	[Tour Time of Day].[Home based school].[ArrivalTimeConstants]	-1.520	-20.12	-1.600
Arrival – 10:00-10:59	[Tour Time of Day].[Home based school].[ArrivalTimeConstants]	-2.081	-16.78	-4.300
Arrival – 11:00-11:59	[Tour Time of Day].[Home based school].[ArrivalTimeConstants]	-2.081	-16.78	-4.300
Arrival – 12:00-12:59	[Tour Time of Day].[Home based school].[ArrivalTimeConstants]	-2.081	-16.78	-4.300
Arrival – 13:00-13:59	[Tour Time of Day].[Home based school].[ArrivalTimeConstants]	-2.870	-12.70	-7.250
Arrival – 14:00-14:59	[Tour Time of Day].[Home based school].[ArrivalTimeConstants]	-2.870	-12.70	-7.250
Arrival – 15:00-15:59	[Tour Time of Day].[Home based school].[ArrivalTimeConstants]	-2.870	-12.70	-7.250
Arrival – 16:00-16:59	[Tour Time of Day].[Home based school].[ArrivalTimeConstants]	-2.188	-7.09	-7.740
Arrival – 17:00-17:59	[Tour Time of Day].[Home based school].[ArrivalTimeConstants]	-2.188	-7.09	-7.740
Arrival – 18:00-18:59	[Tour Time of Day].[Home based school].[ArrivalTimeConstants]	-2.188	-7.09	-7.740
Arrival – 19:00-19:59	[Tour Time of Day].[Home based school].[ArrivalTimeConstants]	-6.190	-11.29	-10.000
Arrival – 20:00-20:59	[Tour Time of Day].[Home based school].[ArrivalTimeConstants]	-6.190	-11.29	-10.000
Arrival – 21:00-21:59	[Tour Time of Day].[Home based school].[ArrivalTimeConstants]	-6.190	-11.29	-10.000
Arrival – 22:00-22:59	[Tour Time of Day].[Home based school].[ArrivalTimeConstants]	-6.190	-11.29	-10.000
Arrival – 23:00-23:59	[Tour Time of Day].[Home based school].[ArrivalTimeConstants]	-10.000	Constrained	No Change
Departure Constants[2]				
Departure – 00:00-00:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	-10.000	Constrained	No Change
Departure – 01:00-01:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	-10.000	Constrained	No Change
Departure – 02:00-02:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	-10.000	Constrained	No Change
Departure – 03:00-03:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	-10.000	Constrained	No Change
Departure – 04:00-04:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	-10.000	Constrained	No Change
Departure – 05:00-05:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	-10.000	Constrained	No Change
Departure – 06:00-06:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	-1.723	-8.22	-0.040

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Departure – 07:00-07:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	-1.723	-8.22	-0.040
Departure – 08:00-08:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	-1.723	-8.22	-0.040
Departure – 09:00-09:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	-1.723	-8.22	-0.040
Departure – 10:00-10:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	-1.243	-17.23	1.320
Departure – 11:00-11:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	-1.243	-17.23	1.320
Departure – 12:00-12:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	-1.243	-17.23	1.320
Departure – 13:00-13:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	-1.243	-17.23	1.670
Departure – 14:00-14:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	-0.783	-9.47	1.670
Departure – 15:00-15:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	0.000	Base	1.670
Departure – 16:00-16:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	0.000	Base	No Change
Departure – 17:00-17:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	-0.485	-7.64	-0.220
Departure – 18:00-18:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	-2.150	-18.01	-1.450
Departure – 19:00-19:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	-2.900	-21.10	-2.360
Departure – 20:00-20:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	-2.900	-21.10	-2.360
Departure – 21:00-21:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	-4.340	-19.56	-3.690
Departure – 22:00-22:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	-4.340	-19.56	-3.690
Departure – 23:00-23:59	[Tour Time of Day].[Home based school].[DepartureTimeConstants]	-10.000	Constrained	No Change
Duration[3]				
Duration – 00:00-00:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	-1.104	-3.27	-2.000
Duration – 01:00-01:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	-1.104	-3.27	-1.000
Duration – 02:00-02:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	-1.104	-3.27	-0.200
Duration – 03:00-03:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	-0.624	-9.47	0.200
Duration – 04:00-04:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	-0.624	-9.47	-0.200

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Duration – 05:00-05:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	0.000	Base	-0.300
Duration – 06:00-06:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	0.000	Base	No Change
Duration – 07:00-07:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	-0.397	-4.20	0.900
Duration – 08:00-08:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	-0.397	-4.20	0.400
Duration – 09:00-09:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	-1.125	-7.36	-0.500
Duration – 10:00-10:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	-1.894	-6.97	-1.300
Duration – 11:00-11:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	-3.267	-9.70	-3.000
Duration – 12:00-12:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	-4.608	-11.19	No Change
Duration – 13:00-13:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	-4.608	-11.19	No Change
Duration – 14:00-14:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	-4.519	-8.75	No Change
Duration – 15:00-15:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	-4.519	-8.75	No Change
Duration – 16:00-16:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	-4.519	-8.75	No Change
Duration – 17:00-17:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	-4.519	-8.75	No Change
Duration – 18:00-18:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	-8.285	-1.20	-10.000
Duration – 19:00-19:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	-8.285	-1.20	-10.000
Duration – 20:00-20:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	-8.285	-1.20	-10.000
Duration – 21:00-21:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	-8.285	-1.20	-10.000
Duration – 22:00-22:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	-8.285	-1.20	-10.000
Duration – 23:00-23:59 Hours	[Tour Time of Day].[Home based school].[DurationConstants]	-8.285	-1.20	-10.000
Model Estimation Statistics				
Number of Observations	5,456			
Log-likelihood (β)	-17094.28			
Rho-squared (0)	0.453			

Source: Cambridge Systematics

Notes: [1] Arrival constants (Arrival – HH:00-HH:59) are input as a 24 cell array. Variables with common coefficients and t-scores were estimated as grouped variables. Calibrated coefficients for parts of the grouped cells might vary.

[2] Departure constants (Departure – HH:00-HH:59) are input as a 24 cell array. Variables with common coefficients and t-scores were estimated as grouped variables. Calibrated coefficients for parts of the grouped cells might vary.

[3] Duration constants (Duration – HH:00-HH:59 Hours) are input as a 24 cell array. Variables with common coefficients and t-scores were estimated as grouped variables. Calibrated coefficients for parts of the grouped cells might vary.

F.14.3 Home-Based Social/Recreation

Table F.41 Home-Based Social/Recreation Tour Time of Day Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Person Type Shift Effects				
Full-time worker – Arrival	[Tour Time of Day].[Home Based SocRec].[Full-time worker-Arrival shift]	0.261	2.05	0.100
Full-time worker – Duration	[Tour Time of Day].[Home Based SocRec].[Full-time worker - Duration shift]	-0.289	-2.17	-0.289
Part-time worker – Arrival	[Tour Time of Day].[Home Based SocRec].[Part-time worker-Arrival shift]	-0.068	-8.34	0.050
Part-time worker – Duration	[Tour Time of Day].[Home Based SocRec].[Part-time worker-Duration shift]	-0.127	-3.78	-0.127
Other non-worker – Arrival	[Tour Time of Day].[Home Based SocRec].[Other non-worker -Arrival shift]	-0.078	-3.23	-0.078
Other non-worker – Duration	[Tour Time of Day].[Home Based SocRec].[Other non-worker -Duration shift]	-0.168	-6.13	-0.168
University student – Arrival	[Tour Time of Day].[Home Based SocRec].[University student -Arrival shift]	0.201	6.02	0.201
University student – Duration	[Tour Time of Day].[Home Based SocRec].[University student-Duration shift]	0.221	3.61	0.334
Pre-school Child – Arrival	[Tour Time of Day].[Home Based SocRec].[Child Age 5-15 - Arrival shift]	0.078	2.81	No Change
Pre-school Child – Duration	[Tour Time of Day].[Home Based SocRec].[Child Age 5-15- Duration shift]	0.163	2.22	-0.300
Income Group Shift Effects (Incomes in 2010 $)				
Income <$25,000 – Arrival	[Tour Time of Day].[Home Based SocRec].[Income <$25K - Arrival shift]	-0.031	-1.60	0.000
Income <$25,000 – Duration	[Tour Time of Day].[Home Based SocRec].[Income <$25K - Duration shift]	-0.023	-1.52	-0.023
Income ≥ $75,000 – Arrival	[Tour Time of Day].[Home Based SocRec].[Income >$75K - Arrival shift]	0.104	1.99	0.104
Income ≥ $75,000 – Duration	[Tour Time of Day].[Home Based SocRec].[Income >$75K - Duration shift]	0.359	2.76	0.000

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Day Pattern Variables				
Escort stops in day – Arrival	[Tour Time of Day].[Home Based SocRec].[Escort stops in day - Arrival shift]	-0.017	-1.79	-0.017
Escort stops in day – Duration	[Tour Time of Day].[Home Based SocRec].[Escort stops in day - Duration shift]	0.128	2.64	0.128
Higher Priority of 2+ different tours – Duration	[Tour Time of Day].[Home Based SocRec].[Higher of 2+ different tours - Duration shift]	0.763	2.78	0.100
Higher Priority of 2+ same tours – Arrival	[Tour Time of Day].[Home Based SocRec].[Higher of 2+ same tours - Arrival shift]	-0.672	-3.79	-0.200
Higher Priority of 2+ same tours – Duration	[Tour Time of Day].[Home Based SocRec].[Higher of 2+ same tours - Duration shift]	-0.570	-2.18	-0.570
Lower Priority of 2+ same tours – Arrival	[Tour Time of Day].[Home Based SocRec].[Lower of 2+ same tours - Arrival shift]	0.037	1.29	0.037
Lower Priority of 2+ same tours – Duration	[Tour Time of Day].[Home Based SocRec].[Lower of 2+ same tours - Duration shift]	-0.568	-3.27	-0.568
Number of stop purposes/ multiple tours – Arrival	[Tour Time of Day].[Home Based SocRec].[# stop purposes/multiple tours - Arrival shift]	0.106	2.24	0.106
Number of stop purposes/ multiple tours – Duration	[Tour Time of Day].[Home Based SocRec].[# stop purposes/multiple tours - Duration shift]	-0.272	-3.36	0.020
Number of stop purposes/only tour – Arrival	[Tour Time of Day].[Home Based SocRec].[# stop purposes/only tour - Arrival shift]	0.056	2.81	0.056
Number of stop purposes/only tour – Duration	[Tour Time of Day].[Home Based SocRec].[# stop purposes/only tour - Duration shift]	-0.220	-3.76	-0.180
Only tour of day – Arrival	[Tour Time of Day].[Home Based SocRec].[Only tour in day - Arrival shift]	-0.028	-2.07	-0.150
Only tour of day – Duration	[Tour Time of Day].[Home Based SocRec].[Only tour in day - Duration shift]	-0.176	-2.17	-0.170
Generalized Time Variable (Minutes)				
Auto	[Tour Time of Day].[Home Based SocRec].[Auto generalized time (min)]	-0.006	Constrained	-0.006
Transit	[Tour Time of Day].[Home Based SocRec].[Transit generalized time (min)]	-0.006	Constrained	-0.006
Schedule Pressure Effects				
Empty window before 1st tour	[Tour Time of Day].[Home Based SocRec].[Empty window remaining before- 1st tour]	-0.267	-2.24	-0.267
Empty window after 1st tour	[Tour Time of Day].[Home Based SocRec].[Empty window remaining after - 1st tour]	-0.289	-2.89	-0.289
Empty window before 2nd + tour	[Tour Time of Day].[Home Based SocRec].[Empty window remaining before- 2nd+ tour]	0.063	2.07	0.063
Empty window after 2nd + tour	[Tour Time of Day].[Home Based SocRec].[Empty window remaining after - 2nd+ tour]	0.071	1.76	0.071

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Remaining tours/maximum window	[Tour Time of Day].[Home Based SocRec].[Remaining tours/maximum remaining window]	-7.276	-11.23	-7.276
Arrival period partially used	[Tour Time of Day].[Home Based SocRec].[Arrival period partially used]	-2.002	-6.42	-2.002
Departure period partially used	[Tour Time of Day].[Home Based SocRec].[Departure period partially used]	-2.276	-3.32	-2.276
Arrival Constants[1]				
Before	[Tour Time of Day].[Home Based SocRec].[Arrival Before]	-3.421	-3.20	-7.500
Arrival – 00:00-00:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-2.167	-2.72	-15.000
Arrival – 01:00-01:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-2.167	-2.72	-15.000
Arrival – 02:00-02:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-2.167	-2.72	-15.000
Arrival – 03:00-03:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-10.000	Constrained	No Change
Arrival – 04:00-04:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-2.789	-6.73	No Change
Arrival – 05:00-05:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-2.789	-6.73	-1.000
Arrival – 06:00-06:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-2.561	-21.25	-1.000
Arrival – 07:00-07:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-2.221	-4.55	-0.200
Arrival – 08:00-08:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-1.601	-3.22	0.200
Arrival – 09:00-09:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-1.500	-16.32	0.400
Arrival – 10:00-10:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-2.224	-11.99	0.200
Arrival – 11:00-11:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-2.224	-11.99	0.200
Arrival – 12:00-12:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-2.224	-11.99	-0.100
Arrival – 13:00-13:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-0.024	-1.26	-0.100
Arrival – 14:00-14:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-0.024	-1.26	-0.100
Arrival – 15:00-15:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-0.024	-1.26	-0.200
Arrival – 16:00-16:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-0.767	-7.10	-0.100
Arrival – 17:00-17:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-0.767	-7.10	0.100

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Arrival – 18:00-18:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	0.000	Base	No Change
Arrival – 19:00-19:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-0.672	-2.17	-1.000
Arrival – 20:00-20:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-2.065	-2.61	-3.000
Arrival – 21:00-21:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-2.167	-2.72	-3.500
Arrival – 22:00-22:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-2.167	-2.72	-8.000
Arrival – 23:00-23:59	[Tour Time of Day].[Home Based SocRec].[ArrivalTimeConstants]	-2.167	-2.72	-10.000
***Departure Constants*[2]**				
Departure – 00:00-00:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	-1.763	-5.67	No Change
Departure – 01:00-01:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	-1.763	-5.67	No Change
Departure – 02:00-02:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	-1.763	-5.67	No Change
Departure – 03:00-03:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	-1.628	-3.27	No Change
Departure – 04:00-04:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	-1.628	-3.27	-5.000
Departure – 05:00-05:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	-1.628	-3.27	-4.000
Departure – 06:00-06:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	-1.033	-7.24	-3.000
Departure – 07:00-07:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	-1.033	-7.24	-2.000
Departure – 08:00-08:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	-1.033	-7.24	-1.628
Departure – 09:00-09:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	-1.033	-7.24	No Change
Departure – 10:00-10:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	-0.368	-9.86	No Change
Departure – 11:00-11:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	-0.368	-9.86	No Change
Departure – 12:00-12:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	-0.368	-9.86	-0.500
Departure – 13:00-13:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	-0.368	-9.86	-0.500
Departure – 14:00-14:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	-0.571	-10.20	No Change
Departure – 15:00-15:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	-0.508	-2.42	-0.400

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Departure – 16:00-16:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	-0.508	-2.42	-0.300
Departure – 17:00-17:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	-0.499	-4.57	-0.300
Departure – 18:00-18:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	-0.321	-6.11	-0.300
Departure – 19:00-19:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	0.000	Base	-0.300
Departure – 20:00-20:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	0.000	Base	No Change
Departure – 21:00-21:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	0.000	Base	-0.100
Departure – 22:00-22:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	-1.056	-12.17	-0.200
Departure – 23:00-23:59	[Tour Time of Day].[Home Based SocRec].[DepartureTimeConstants]	-1.763	-5.67	-0.300
After	[Tour Time of Day].[Home Based SocRec].[Departure After]	-1.764	-2.64	No Change
Duration[3]				
Duration – 00:00-00:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	0.000	Base	-2.100
Duration – 01:00-01:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	0.000	Base	No Change
Duration – 02:00-02:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	-0.298	-2.75	0.200
Duration – 03:00-03:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	-0.823	-9.23	-0.300
Duration – 04:00-04:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	-0.823	-9.23	-0.700
Duration – 05:00-05:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	-0.402	-3.10	-1.000
Duration – 06:00-06:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	-0.402	-3.10	-1.200
Duration – 07:00-07:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	-0.896	-2.98	-3.500
Duration – 08:00-08:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	-0.896	-2.98	-6.000
Duration – 09:00-09:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	-1.348	-5.34	-7.500
Duration – 10:00-10:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	-2.411	-6.68	-7.500
Duration – 11:00-11:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	-3.927	-4.56	-7.500
Duration – 12:00-12:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	-4.885	-9.86	-7.500

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Duration – 13:00-13:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	-4.885	-9.86	-8.000
Duration – 14:00-14:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	-5.003	-11.24	-8.000
Duration – 15:00-15:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	-5.003	-11.24	-10.000
Duration – 16:00-16:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	-5.003	-11.24	-10.000
Duration – 17:00-17:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	-5.003	-11.24	-10.000
Duration – 18:00-18:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	-8.832	-2.11	-10.000
Duration – 19:00-19:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	-8.832	-2.11	-10.000
Duration – 20:00-20:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	-8.832	-2.11	-10.000
Duration – 21:00-21:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	-8.832	-2.11	-10.000
Duration – 22:00-22:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	-8.832	-2.11	-10.000
Duration – 23:00-23:59 Hours	[Tour Time of Day].[Home Based SocRec].[DurationConstants]	-8.832	-2.11	-10.000
Model Estimation Statistics				
Number of Observations	6,563			
Log-likelihood (β)	-19,020.34			
Rho-squared (0)	0.418			

Source: Cambridge Systematics

Notes:
[1] Arrival constants (Arrival – HH:00-HH:59) are input as a 24 cell array. Variables with common coefficients and t-scores were estimated as grouped variables. Calibrated coefficients for parts of the grouped cells might vary.
[2] Departure constants (Departure – HH:00-HH:59) are input as a 24 cell array. Variables with common coefficients and t-scores were estimated as grouped variables. Calibrated coefficients for parts of the grouped cells might vary.
[3] Duration constants (Duration – HH:00-HH:59 Hours) are input as a 24 cell array. Variables with common coefficients and t-scores were estimated as grouped variables. Calibrated coefficients for parts of the grouped cells might vary.

F.14.4 Home-Based Other

Table F.42 Home-Based Other Tour Time of Day Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Person Type Shift Effects				
Full-time worker – Arrival	[Tour Time of Day].[Home based other].[Full_Time_Worker_Arrival_Shift]	0.283	2.16	-0.020
Full-time worker – Duration	[Tour Time of Day].[Home based other].[Full_Time_Worker_Duration_Shift]	-0.293	-2.16	-0.200
Part-time worker – Arrival	[Tour Time of Day].[Home based other].[Part_Time_Worker_Arrival_Shift]	-0.070	-4.32	No Change
Part-time worker – Duration	[Tour Time of Day].[Home based other].[Part_Time_Worker_Duration_Shift]	-0.178	-4.30	No Change
Other non-worker – Arrival	[Tour Time of Day].[Home based other].[Other_Non_Worker_Arrival_Shift]	-0.098	-3.82	-0.300
Other non-worker – Duration	[Tour Time of Day].[Home based other].[Other_Non_Worker_Duration_Shift]	-0.318	-6.17	No Change
University student – Arrival	[Tour Time of Day].[Home based other].[University_Student_Arrival_Shift]	0.291	6.01	0.050
University student – Duration	[Tour Time of Day].[Home based other].[University_Student_Duration_Shift]	0.272	3.65	0.113
Pre-driving Age Student – Arrival	[Tour Time of Day].[Home based other].[Child_Age_5_15_Arrival_Shift]	0.097	3.21	No Change
Pre-driving Age Student – Duration	[Tour Time of Day].[Home based other].[Child_Age_5_15_Duration_Shift]	0.131	2.10	No Change
Income Group Shift Effects (Incomes in 2010 $)				
Income <$25,000 – Arrival	[Tour Time of Day].[Home based other].[Income <$25K - Arrival shift]	-0.121	-1.74	0.050
Income <$25,000 – Duration	[Tour Time of Day].[Home based other].[Income <$25K - Duration shift]	-0.069	-1.70	No Change
Income ≥ $75,000 – Arrival	[Tour Time of Day].[Home based other].[Income >$75K - Arrival shift]	0.167	2.12	0.010
Income ≥ $75,000 – Duration	[Tour Time of Day].[Home based other].[Income >$75K - Duration shift]	0.398	2.70	0.010
Day Pattern Variables				
Escort stops in day – Arrival	[Tour Time of Day].[Home based other].[Escort_Stops_In_Day_Arrival_Shift]	-0.045	-2.11	No Change
Escort stops in day – Duration	[Tour Time of Day].[Home based other].[Escort_Stops_In_Day_ Duration_Shift]	0.156	2.53	No Change
Escort tour – Arrival	[Tour Time of Day].[Home based other].[Escort_Tour_Arrival_Shift]	-0.129	-3.41	No Change
Escort tour – Duration	[Tour Time of Day].[Home based other].[Escort_Tour_Duration_Shift]	-0.083	-2.26	-2.000
Higher Priority of 2+ different tours – Duration	[Tour Time of Day].[Home based other].[Higher_Of_2P_Different_Tours_ Duration_Shift]	0.639	2.87	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Higher of 2+ same tours – Arrival	[Tour Time of Day].[Home based other].[Higher_Of_2P_Same_Tours_ Arrival_Shift]	-0.672	-4.21	No Change
Higher Priority of 2+ same tours – Duration	[Tour Time of Day].[Home based other].[Higher_Of_2P_Same_Tours_ Duration_Shift]	-0.589	-2.11	-0.081
Lower Priority of 2+ same tours – Arrival	[Tour Time of Day].[Home based other].[Lower_Of_2P_Same_Tours_ Arrival_Shift]	0.035	1.86	-0.066
Lower Priority of 2+ same tours – Duration	[Tour Time of Day].[Home based other].[Lower_Of_2P_Same_Tours_ Duration_Shift]	-0.431	-3.32	No Change
Meal tour – Arrival	[Tour Time of Day].[Home based other].[Shopping_Tour_Arrival_Shift]	0.048	2.08	No Change
Meal tour - Duration	[Tour Time of Day].[Home based other].[Shopping_Tour_Duration_Shift]	0.873	1.98	-0.250
Number of stop purposes/multiple tours – Arrival	[Tour Time of Day].[Home based other].[Num_Stop_Purposes_Multiple_ Tour_ Arrival_Shift]	0.121	3.21	No Change
Number of stop purposes/multiple tours – Duration	[Tour Time of Day].[Home based other].[Num_Stop_Purposes_Multiple_ Tour_ Duration_Shift]	-0.245	-3.42	-0.100
Number of stop purposes/only tour – Arrival	[Tour Time of Day].[Home based other].[Num_Stop_Purposes_Only_Tour_ Arrival_Shift]	0.073	2.80	No Change
Number of stop purposes/only tour – Duration	[Tour Time of Day].[Home based other].[Num_Stop_Purposes_Only_Tour_ Duration_Shift]	-0.250	-4.91	-0.134
Only tour of day – Arrival	[Tour Time of Day].[Home based other].[Only_Tour_Of_The_Day_ Arrival_Shift]	-0.058	-2.31	No Change
Only tour of day – Duration	[Tour Time of Day].[Home based other].[Only_Tour_Of_The_Day_ Duration_Shift]	-0.178	-2.79	-0.300
Shopping tour – Arrival	[Tour Time of Day].[Home based other].[Shopping_Tour_Arrival_Shift]	0.048	2.08	No Change
Shopping tour – Duration	[Tour Time of Day].[Home based other].[Shopping_Tour_Duration_Shift]	0.873	1.98	-0.250
Generalized Time Variable (Minutes)				
Auto, Escort Tours	[Tour Time of Day].[Home based other].[Auto_Generalized_Cost_Min_ Escort_Tour]	-0.006	Constrained	No Change
Auto, Meal Tours	[Tour Time of Day].[Home based other].[Auto_Generalized_Cost_Min_ Meal_Tour]	-0.006	Constrained	No Change
Auto, Personal Business Tours	[Tour Time of Day].[Home based other].[Auto_Generalized_Cost_Min_ Personal_Business_Tour]	-0.006	Constrained	No Change
Auto, Shop Tours	[Tour Time of Day].[Home based other].[Auto_Generalized_Cost_Min_ Shop_Tour]	-0.006	Constrained	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Auto, Social/Recreation Tours	[Tour Time of Day].[Home based other].[Auto_Generalized_Cost_Min_Soc_Rec_Tour]	-0.006	Constrained	No Change
Transit, Transit Tours	[Tour Time of Day].[Home based other].[Transit_Generalized_Cost_Transit_Tours]	-0.006	Constrained	No Change
Schedule Pressure Effects				
Empty window before 1st tour	[Tour Time of Day].[Home based other].[Empty_Window_Remaining_Before_1St_Tour]	-0.223	-2.01	No Change
Empty window after 1st tour	[Tour Time of Day].[Home based other].[Empty_Window_Remaining_After_1St_Tour]	-0.221	-2.67	No Change
Empty window before 2nd + tour	[Tour Time of Day].[Home based other].[Empty_Window_Remaining_Before_2Ndp_Tour]	0.034	2.12	No Change
Empty window after 2nd + tour	[Tour Time of Day].[Home based other].[Empty_Window_Remaining_After_2Ndp_Tour]	0.067	1.86	No Change
Remaining tours/maximum window	[Tour Time of Day].[Home based other].[Remaining_Tours_Div_Max_Remaining_Window]	-6.736	-8.27	No Change
Arrival period partially used	[Tour Time of Day].[Home based other].[Arrival_Period_Partially_Used]	-1.983	-6.32	No Change
Departure period partially used	[Tour Time of Day].[Home based other].[Departure_Period_Partially_Used]	-2.321	-3.98	-2.320
Arrival Constants[1]				
Before	[Tour Time of Day].[Home based other].[Arrival Before]	-6.100	-8.40	-8.000
Arrival – 00:00-00:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	-1.638	-3.19	-10.000
Arrival – 01:00-01:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	-1.638	-3.19	-10.000
Arrival – 02:00-02:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	-1.638	-3.19	-10.000
Arrival – 03:00-03:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	-1.638	-3.19	-10.000
Arrival – 04:00-04:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	-1.638	-3.19	-10.000
Arrival – 05:00-05:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	-1.638	-3.19	-2.000
Arrival – 06:00-06:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	-1.638	-3.19	-2.000
Arrival – 07:00-07:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	-0.387	-2.34	-0.650
Arrival – 08:00-08:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	-0.275	-3.55	0.100

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Arrival – 09:00-09:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	-0.478	-3.73	0.100
Arrival – 10:00-10:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	-0.286	-4.42	0.300
Arrival – 11:00-11:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	-0.109	-3.58	0.300
Arrival – 12:00-12:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	-0.084	-4.31	0.100
Arrival – 13:00-13:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	-0.101	-5.87	0.100
Arrival – 14:00-14:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	-0.163	-3.23	0.100
Arrival – 15:00-15:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	0.000	Base	No Change
Arrival – 16:00-16:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	0.000	Base	-0.800
Arrival – 17:00-17:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	-0.391	-3.51	-1.200
Arrival – 18:00-18:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	-0.529	-3.31	-1.500
Arrival – 19:00-19:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	-0.627	-2.09	-2.300
Arrival – 20:00-20:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	-1.081	-4.21	-3.000
Arrival – 21:00-21:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	-1.371	-6.89	-5.000
Arrival – 22:00-22:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	-1.371	-6.89	-10.000
Arrival – 23:00-23:59	[Tour Time of Day].[Home based other].[ArrivalTimeConstants]	-1.638	-3.19	-10.000
Departure Constants[2]				
Departure – 00:00-00:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	-1.838	-3.71	-10.000
Departure – 01:00-01:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	-1.838	-3.71	-10.000
Departure – 02:00-02:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	-1.838	-3.71	-10.000
Departure – 03:00-03:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	-1.838	-3.71	-10.000
Departure – 04:00-04:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	-1.838	-3.71	-10.000
Departure – 05:00-05:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	-1.838	-3.71	-10.000
Departure – 06:00-06:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	-1.838	-3.71	-10.000

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Departure – 07:00-07:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	-0.568	-2.42	No Change
Departure – 08:00-08:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	-0.478	-3.21	No Change
Departure – 09:00-09:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	-0.738	-3.20	No Change
Departure – 10:00-10:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	-0.645	-4.81	No Change
Departure – 11:00-11:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	-0.239	-3.17	No Change
Departure – 12:00-12:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	-0.201	-4.52	No Change
Departure – 13:00-13:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	-0.198	-6.37	No Change
Departure – 14:00-14:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	-0.224	-3.85	-0.198
Departure – 15:00-15:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	0.000	Base	No Change
Departure – 16:00-16:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	0.000	Base	-0.479
Departure – 17:00-17:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	-0.479	-3.49	No Change
Departure – 18:00-18:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	-0.780	-3.21	No Change
Departure – 19:00-19:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	-0.981	-2.11	No Change
Departure – 20:00-20:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	-1.206	-3.21	No Change
Departure – 21:00-21:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	-1.849	-6.74	No Change
Departure – 22:00-22:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	-1.849	-6.74	No Change
Departure – 23:00-23:59	[Tour Time of Day].[Home based other].[DepartureTimeConstants]	-1.838	-3.71	-10.000
After	[Tour Time of Day].[Home based other].[Departure After]	-5.927	-2.49	-8.000
***Duration*[3]**				
Duration – 00:00-00:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	0.000	Base	No Change
Duration – 01:00-01:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-0.157	-3.22	0.850
Duration – 02:00-02:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-0.304	-3.57	-0.204
Duration – 03:00-03:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-0.786	-9.06	-0.686

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Duration – 04:00-04:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-0.786	-9.06	-1.000
Duration – 05:00-05:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-0.411	-4.13	-1.000
Duration – 06:00-06:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-0.411	-4.13	-1.000
Duration – 07:00-07:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-0.627	-4.06	-1.000
Duration – 08:00-08:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-0.627	-4.06	-1.000
Duration – 09:00-09:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-1.808	-2.65	No Change
Duration – 10:00-10:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-2.463	-6.97	No Change
Duration – 11:00-11:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-4.162	-5.34	No Change
Duration – 12:00-12:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-5.265	-9.64	No Change
Duration – 13:00-13:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-5.265	-9.64	No Change
Duration – 14:00-14:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-5.783	-11.03	No Change
Duration – 15:00-15:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-5.783	-11.03	No Change
Duration – 16:00-16:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-5.783	-11.03	No Change
Duration – 17:00-17:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-5.783	-11.03	No Change
Duration – 18:00-18:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-8.952	-2.69	No Change
Duration – 19:00-19:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-8.952	-2.69	No Change
Duration – 20:00-20:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-8.952	-2.69	No Change
Duration – 21:00-21:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-8.952	-2.69	No Change
Duration – 22:00-22:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-8.952	-2.69	No Change
Duration – 23:00-23:59 Hours	[Tour Time of Day].[Home based other].[DurationConstants]	-8.952	-2.69	No Change
Model Estimation Statistics				
Number of Observations	13,540			
Log-likelihood (β)	-43,703.93			
Rho-squared (0)	0.407			

Source: Cambridge Systematics

Notes: [1] Arrival constants (Arrival – HH:00-HH:59) are input as a 24 cell array. Variables with common coefficients and t-scores were estimated as grouped variables. Calibrated coefficients for parts of the grouped cells might vary.

[2] Departure constants (Departure – HH:00-HH:59) are input as a 24 cell array. Variables with common coefficients and t-scores were estimated as grouped variables. Calibrated coefficients for parts of the grouped cells might vary.

[3] Duration constants (Duration – HH:00-HH:59 Hours) are input as a 24 cell array. Variables with common coefficients and t-scores were estimated as grouped variables. Calibrated coefficients for parts of the grouped cells might vary.

F.14.5 Work-Based Sub-Tour

Table F.43 Work-Based Sub-Tour Time of Day Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Sub-Tour Purpose Shift Effects				
Escort – Arrival	[Tour Time of Day].[Work based subtour].[Escort tour - Arrival shift]	0.050	0.74	-0.300
Escort - Duration	[Tour Time of Day].[Work based subtour].[Escort tour - Duration shift]	-1.960	-5.04	-3.500
Meal – Arrival	[Tour Time of Day].[Work based subtour].[Meal tour - Arrival shift]	0.085	3.18	No Change
Meal – Duration	[Tour Time of Day].[Work based subtour].[Meal tour - Duration shift]	-0.660	-12.29	No Change
Shop – Arrival	[Tour Time of Day].[Work based subtour].[Shopping tour - Arrival shift]	0.091	2.39	No Change
Shop - Duration	[Tour Time of Day].[Work based subtour].[Shopping tour - Duration shift]	-1.082	-8.88	-1.222
Social / Recreation – Arrival	[Tour Time of Day].[Work based subtour].[Social/recreation tour - Arrival shift]	0.188	4.74	No Change
Social / Recreation – Duration	[Tour Time of Day].[Work based subtour].[Social/recreation tour - Duration shift]	-0.089	-1.20	0.200
Any Escort in Day – Arrival	[Tour Time of Day].[Work based subtour].[Any escort in day - Arrival shift]	0.032	0.78	-0.222
Any Escort in Day – Duration	[Tour Time of Day].[Work based subtour].[Any Escort in day - Duration shift]	-0.114	-1.11	-0.182
Arrival period partially used	[Tour Time of Day].[Work based subtour].[Arrival period partially used]	-1.384	-5.21	No Change
Departure period partially used	[Tour Time of Day].[Work based subtour].[Departure period partially used]	1.983	2.06	2.702
Number of stop purposes/ only tour – Arrival	[Tour Time of Day].[Work based subtour].[# stop purposes/only tour - Arrival shift]	0.172	2.35	0.097
Number of stop purposes/ only tour – Duration	[Tour Time of Day].[Work based subtour].[# stop purposes/only tour - Duration shift]	-0.328	-1.46	-0.265
Number of stop purposes/ multiples tour – Arrival	[Tour Time of Day].[Work based subtour].[# stop purposes/multiple tour - Arrival shift]	0.099	2.03	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Number of stop purposes/ multiples tour – Duration	[Tour Time of Day].[Work based subtour]. [# stop purposes/multiple tour - Duration shift]	-0.206	-3.79	No Change
Generalized Time Variable (Minutes)				
Auto	[Tour Time of Day].[Work based subtour]. [Generalized cost- Auto]	-0.095	Constrained	No Change
Transit	[Tour Time of Day].[Work based subtour]. [Generalized cost- Transit]	-0.095	Constrained	No Change
Arrival Constants[1]				
Arrival – 00:00-00:59	[Tour Time of Day].Work based subtour]. [ArrivalTimeConstants]	-10.000	Constrained	-15.000
Arrival – 01:00-01:59	[Tour Time of Day].Work based subtour]. [ArrivalTimeConstants]	-10.000	Constrained	-15.000
Arrival – 02:00-02:59	[Tour Time of Day].Work based subtour]. [ArrivalTimeConstants]	-10.000	Constrained	-15.000
Arrival – 03:00-03:59	[Tour Time of Day].Work based subtour]. [ArrivalTimeConstants]	-10.000	Constrained	-15.000
Arrival – 04:00-04:59	[Tour Time of Day].Work based subtour]. [ArrivalTimeConstants]	-10.000	Constrained	-15.000
Arrival – 05:00-05:59	[Tour Time of Day].Work based subtour]. [ArrivalTimeConstants]	-10.000	Constrained	-15.000
Arrival – 06:00-06:59	[Tour Time of Day].Work based subtour]. [ArrivalTimeConstants]	-3.140	-5.31	0.000
Arrival – 07:00-07:59	[Tour Time of Day].Work based subtour]. [ArrivalTimeConstants]	-0.903	-4.09	2.200
Arrival – 08:00-08:59	[Tour Time of Day].Work based subtour]. [ArrivalTimeConstants]	0.000	Base	2.600
Arrival – 09:00-09:59	[Tour Time of Day].Work based subtour]. [ArrivalTimeConstants]	0.341	2.20	1.800
Arrival – 10:00-10:59	[Tour Time of Day].Work based subtour]. [ArrivalTimeConstants]	1.420	9.39	1.300
Arrival – 11:00-11:59	[Tour Time of Day].Work based subtour]. [ArrivalTimeConstants]	1.420	9.39	1.900
Arrival – 12:00-12:59	[Tour Time of Day].Work based subtour]. [ArrivalTimeConstants]	1.420	9.39	1.900
Arrival – 13:00-13:59	[Tour Time of Day].Work based subtour]. [ArrivalTimeConstants]	0.869	4.75	1.400
Arrival – 14:00-14:59	[Tour Time of Day].Work based subtour]. [ArrivalTimeConstants]	0.869	4.75	1.200
Arrival – 15:00-15:59	[Tour Time of Day].Work based subtour]. [ArrivalTimeConstants]	0.869	4.75	1.000
Arrival – 16:00-16:59	[Tour Time of Day].Work based subtour]. [ArrivalTimeConstants]	0.755	2.59	0.200
Arrival – 17:00-17:59	[Tour Time of Day].Work based subtour]. [ArrivalTimeConstants]	0.755	2.59	-1.300

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Arrival – 18:00-18:59	[Tour Time of Day].Work based subtour].[ArrivalTimeConstants]	0.755	2.59	-1.300
Arrival – 19:00-19:59	[Tour Time of Day].Work based subtour].[ArrivalTimeConstants]	-0.343	-0.68	-2.343
Arrival – 20:00-20:59	[Tour Time of Day].Work based subtour].[ArrivalTimeConstants]	-0.343	-0.68	-2.343
Arrival – 21:00-21:59	[Tour Time of Day].Work based subtour].[ArrivalTimeConstants]	-0.343	-0.68	-2.343
Arrival – 22:00-22:59	[Tour Time of Day].Work based subtour].[ArrivalTimeConstants]	-0.343	-0.68	-2.343
Arrival – 23:00-23:59	[Tour Time of Day].Work based subtour].[ArrivalTimeConstants]	-10.000	Constrained	-15.000
***Departure Constants*[2]**				
Departure – 00:00-00:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	-10.000	Constrained	No Change
Departure – 01:00-01:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	-10.000	Constrained	No Change
Departure – 02:00-02:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	-10.000	Constrained	No Change
Departure – 03:00-03:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	-10.000	Constrained	No Change
Departure – 04:00-04:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	-10.000	Constrained	No Change
Departure – 05:00-05:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	-10.000	Constrained	No Change
Departure – 06:00-06:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	1.203	5.02	-2.000
Departure – 07:00-07:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	1.203	5.02	-2.000
Departure – 08:00-08:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	1.203	5.02	-2.000
Departure – 09:00-09:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	1.203	5.02	-0.500
Departure – 10:00-10:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	1.321	7.48	0.500
Departure – 11:00-11:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	1.321	7.48	No Change
Departure – 12:00-12:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	1.321	7.48	2.000
Departure – 13:00-13:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	1.028	6.75	1.500
Departure – 14:00-14:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	1.028	6.75	1.000
Departure – 15:00-15:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	1.028	6.75	0.500

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Departure – 16:00-16:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	0.000	Base	No Change
Departure – 17:00-17:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	-1.070	-4.49	No Change
Departure – 18:00-18:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	-1.170	-4.63	No Change
Departure – 19:00-19:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	-1.449	-5.22	No Change
Departure – 20:00-20:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	-1.449	-5.22	No Change
Departure – 21:00-21:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	-2.200	-4.71	-6.000
Departure – 22:00-22:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	-2.200	-4.71	-6.000
Departure – 23:00-23:59	[Tour Time of Day].Work based subtour].[DepartureTimeConstants]	-10.000	Constrained	No Change
***Duration*[3]**				
Duration – 00:00-00:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	0.000	Base	No Change
Duration – 01:00-01:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-0.885	-3.45	0.980
Duration – 02:00-02:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-1.535	-5.22	0.550
Duration – 03:00-03:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-2.100	-10.50	0.350
Duration – 04:00-04:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-2.100	-10.50	-0.450
Duration – 05:00-05:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-2.350	-6.26	-1.300
Duration – 06:00-06:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-2.350	-6.26	-1.300
Duration – 07:00-07:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-1.670	-3.62	-0.750
Duration – 08:00-08:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-1.670	-3.62	-0.750
Duration – 09:00-09:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-7.420	-0.52	-0.875
Duration – 10:00-10:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-6.900	-0.48	-5.000
Duration – 11:00-11:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-6.360	-0.44	-6.000
Duration – 12:00-12:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-5.770	-0.40	-10.000
Duration – 13:00-13:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-5.770	-0.40	-10.000

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Duration – 14:00-14:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-3.480	-0.24	-10.000
Duration – 15:00-15:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-3.480	-0.24	-10.000
Duration – 16:00-16:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-3.480	-0.24	-10.000
Duration – 17:00-17:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-3.480	-0.24	-10.000
Duration – 18:00-18:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-0.009	0.00	-10.000
Duration – 19:00-19:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-0.009	0.00	-10.000
Duration – 20:00-20:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-0.009	0.00	-10.000
Duration – 21:00-21:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-0.009	0.00	-10.000
Duration – 22:00-22:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-0.009	0.00	-10.000
Duration – 23:00-23:59 Hours	[Tour Time of Day].Work based subtour].[DurationConstants]	-0.009	0.00	-10.000
Model Estimation Statistics				
Number of Observations	1,659			
Log-likelihood (β)	-5,682.221			
Rho-squared (0)	0.400			

Source: Cambridge Systematics

Notes:

[1] Arrival constants (Arrival – HH:00-HH:59) are input as a 24 cell array. Variables with common coefficients and t-scores were estimated as grouped variables. Calibrated coefficients for parts of the grouped cells might vary.

[2] Departure constants (Departure – HH:00-HH:59) are input as a 24 cell array. Variables with common coefficients and t-scores were estimated as grouped variables. Calibrated coefficients for parts of the grouped cells might vary.

[3] Duration constants (Duration – HH:00-HH:59 Hours) are input as a 24 cell array. Variables with common coefficients and t-scores were estimated as grouped variables. Calibrated coefficients for parts of the grouped cells might vary.

F.15 Intermediate Stop Generation Choice

The intermediate stop generation choice model variables, StateFocus C# parameter names, estimated model coefficients and t-statistics, and final calibrated parameters based on the 2015 model calibration/validation are shown in the ***Sections F.15.1*** through ***F.15.8***. The variables and coefficients for each of the stop purposes shown in ***Sections F.15.1*** through ***F.15.7*** and for the "quit" purpose shown in ***Section F.15.8*** are used for each iteration through the intermediate stop generation choice model for each half-tour made during the day. Up to six iterations of the intermediate stop generation choice model may be run for each half-tour. Note, however, that the daily activity pattern choice model limits the number of different stop purposes (but not the number of stops) to four. Thus, multiple stops for the same purpose must be made for the number of stops on any half-tour to exceed six.

Definitions of the variables are shown in ***Section 4.2.15***. Only those variables used for a stop purpose are shown in the tables associated with the individual stop purposes.

F.15.1 Coefficients for Home-Based Work Stops

Table F.44 Home-Based Work Intermediate Stop Generation Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Daily Activity Pattern/Tour/Stop				
Work-Based Sub-Tour	[Stop Generation].[Work].[work based subtour]	1.2290	5.05	-0.4284
Non-Closed Tour	[Stop Generation].[Work].[nonclosed tour]	2.3300	6.68	1.8873
Non-Traditional Closed Tour	[Stop Generation].[Work].[alt closed tour]	-10.0000	0.00	No change
Home-Based Work Tour	[Stop Generation].[Work].[home based work tour]	-0.0131	-0.05	0.2000
Outbound Half-Tour	[Stop Generation].[Work].[outbound half tour]	-3.6330	-28.19	-4.0950
Number of Remaining Tours	[Stop Generation].[Work].[tours remaining in day]	-0.0802	-1.35	No Change
Available Time Window	[Stop Generation].[Work].[time window available]	0.0908	9.53	No Change
Natural Log of Half-TourDistance (Miles)	[Stop Generation].[Work].[ln tour distance]	0.1242	4.35	No Change
Half-Tour In Time Period 7:00 AM-9:00 AM	[Stop Generation].[Work].[period 7 am to 9 am]	-0.0663	-0.55	No Change
Half-Tour In Time Period 9:00 AM-11:00 AM	[Stop Generation].[Work].[period 9 am to 11 am]	0.5208	5.75	No Change
Half-Tour In Time Period 3:00 PM-5:00 PM	[Stop Generation].[Work].[period 3 pm to 5 pm]	-0.3358	-2.89	No Change
Half-Tour In Time Period 5:00 PM-7:00 PM	[Stop Generation].[Work].[period 5 pm to 7 pm]	-0.6726	-4.13	No Change
Half-Tour In Time Period 7:00 PM-10:00 PM	[Stop Generation].[Work].[period 7 pm to 10 pm]	-1.2610	-3.60	No Change
Half-Tour In Time Period 10:00 PM-7:00 AM	[Stop Generation].[Work].[period 10 pm to 7 am]	-1.0760	-3.15	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Tour Mode is Drive Alone	[Stop Generation].[Work].[drive alone tour]	0.3736	1.76	0.7322
Tour Mode is Shared Ride 2	[Stop Generation].[Work].[shared ride 2 tour]	0.6533	2.96	0.7513
Tour Mode is Shared Ride 3+	[Stop Generation].[Work].[shared ride 3+tour]	0.3219	1.32	0.3702
Stop for Same Purpose on Previous Tour	[Stop Generation].[Work].[stop for same purpose-prior tours]	-1.7480	-12.08	No Change
Stop for Same Purpose Earlier on This Tour	[Stop Generation].[Work].[stop for same purpose-same tour]	-1.4160	-17.37	No Change
No Stops[1]	–	*-50000*	–	–

Source: Cambridge Systematics

Notes: [1] No Stops is not actually an input coefficient but, rather, is embedded in the C# code so that if this stop purpose is <u>not</u> forecast by the daily activity pattern model for the person, it is excluded from consideration.

F.15.2 Coefficients for Home-Based School Stops

Table F.45 Home-Based School Intermediate Stop Generation Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Daily Activity Pattern/Tour/Stop				
Non-Closed Tour	[Stop Generation].[School].[nonclosed tour]	4.7430	14.58	No Change
Non-Traditional Closed Tour	[Stop Generation].[School].[alt closed tour]	6.2640	4.51	No Change
Home-Based Work Tour	[Stop Generation].[School].[home based work tour]	3.5760	13.22	4.5000
Home-Based School Tour	[Stop Generation].[School].[home based school tour]	1.9100	10.20	5.5000
Outbound Half-Tour	[Stop Generation].[School].[outbound half tour]	-2.0230	-9.70	-2.6704
Number of Remaining Tours	[Stop Generation].[School].[tours remaining in day]	-0.5084	-3.34	No Change
Natural Log of Half-TourDistance (Miles)	[Stop Generation].[School].[In tour distance]	0.0235	0.42	No Change
Half-Tour In Time Period 7:00 AM-9:00 AM	[Stop Generation].[School].[period 7 am to 9 am]	-0.8377	-3.74	No Change
Half-Tour In Time Period 9:00 AM-11:00 AM	[Stop Generation].[School].[period 9 am to 11 am]	-0.2538	-1.17	No Change
Half-Tour In Time Period 3:00 PM-5:00 PM	[Stop Generation].[School].[period 3 pm to 5 pm]	0.1564	0.69	No Change
Half-Tour In Time Period 5:00 PM-7:00 PM	[Stop Generation].[School].[period 5 pm to 7 pm]	-0.6352	-1.97	No Change
Half-Tour In Time Period 7:00 PM-10:00 PM	[Stop Generation].[School].[period 7 pm to 10 pm]	-3.1910	-4.49	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Half-Tour In Time Period 10:00 PM-7:00 AM	[Stop Generation].[School].[period 10 pm to 7 am]	-1.9800	-3.84	No Change
Stop for Same Purpose on Previous Tour	[Stop Generation].[School].[stop for same purpose-prior tours]	-3.2760	-4.38	No Change
Stop for Same Purpose Earlier on This Tour	[Stop Generation].[School].[stop for same purpose-same tour]	-4.8100	-19.53	No Change
First Simulated Stop	[Stop Generation].[School].[first simulated]	-1.6190	-9.27	No Change
No Stops[1]	–	*-50000*	–	–

Source: Cambridge Systematics

Notes: [1] No Stops is not actually an input coefficient but, rather, is embedded in the C# code so that if this stop purpose is not forecast by the daily activity pattern model for the person, it is excluded from consideration.

F.15.3 Coefficients for Home-Based Escort Stops

Table F.46 Home-Based Escort Intermediate Stop Generation Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Person/Household Characteristics				
Female with Child Age 0-15	[Stop Generation].[Escort].[female/children]	0.0412	0.99	0.2223
Daily Activity Pattern/Tour/Stop				
Work-Based Sub-Tour	[Stop Generation].[Escort].[work based subtour]	0.4560	1.39	-1.1358
Non-Closed Tour	[Stop Generation].[Escort].[nonclosed tour]	2.3340	11.10	No Change
Non-Traditional Closed Tour	[Stop Generation].[Escort].[alt closed tour]	-0.5733	-0.26	No Change
Home-Based Work Tour	[Stop Generation].[Escort].[home based work tour]	1.7020	12.72	1.0893
Home-Based School Tour	[Stop Generation].[Escort].[home based school tour]	0.9273	7.62	No Change
Home-Based Escort Tour	[Stop Generation].[Escort].[home based escort tour]	0.0062	0.05	6.0000
Outbound Half-Tour	[Stop Generation].[Escort].[outbound half tour]	-2.1590	-35.31	-2.3749
Number of Remaining Tours	[Stop Generation].[Escort].[tours remaining in day]	-0.3599	-13.44	No Change
Natural Log of Half-TourDistance (Miles)	[Stop Generation].[Escort].[ln tour distance]	0.1162	6.79	No Change
Half-Tour In Time Period 7:00 AM-9:00 AM	[Stop Generation].[Escort].[period 7 am to 9 am]	0.4105	6.19	No Change
Half-Tour In Time Period 9:00 AM-11:00 AM	[Stop Generation].[Escort].[period 9 am to 11 am]	0.1693	1.94	No Change
Half-Tour In Time Period 3:00 PM-5:00 PM	[Stop Generation].[Escort].[period 3 pm to 5 pm]	0.0030	0.05	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Half-Tour In Time Period 5:00 PM-7:00 PM	[Stop Generation].[Escort].[period 5 pm to 7 pm]	-0.3003	-3.69	No Change
Half-Tour In Time Period 7:00 PM-10:00 PM	[Stop Generation].[Escort].[period 7 pm to 10 pm]	-1.0590	-6.80	No Change
Half-Tour In Time Period 10:00 PM-7:00 AM	[Stop Generation].[Escort].[period 10 pm to 7 am]	-0.2498	-1.89	No Change
Tour Mode is Drive Alone	[Stop Generation].[Escort].[drive alone tour]	-4.4210	-10.84	0.5000
Tour Mode is Shared Ride 2	[Stop Generation].[Escort].[shared ride 2 tour]	0.2354	2.00	1.3000
Tour Mode is Shared Ride 3+	[Stop Generation].[Escort].[shared ride 3+tour]	0.8527	7.55	1.6800
Stop for Same Purpose on Previous Tour	[Stop Generation].[Escort].[stop for same purpose-prior tours]	-1.7000	-20.58	-1.0180
Stop for Same Purpose Earlier on This Tour	[Stop Generation].[Escort].[stop for same purpose-same tour]	-2.5620	-47.93	-0.5000
First Simulated Stop	[Stop Generation].[Escort].[first simulated]			
No Stops[1]	–	*-50000*	–	–

Source: Cambridge Systematics

Notes: [1] No Stops is not actually an input coefficient but, rather, is embedded in the C# code so that if this stop purpose is not forecast by the daily activity pattern model for the person, it is excluded from consideration.

F.15.4 Coefficients for Home-Based Personal Business Stops

Table F.47 Home-Based Personal Business Intermediate Stop Generation Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Person/Household Characteristics				
Single Person Household	[Stop Generation].[Personal Business].[single person household]	0.1326	2.80	No Change
Daily Activity Pattern/Tour/Stop				
Work-Based Sub-Tour	[Stop Generation].[Personal Business].[work based subtour]	0.3082	2.76	No Change
Non-Closed Tour	[Stop Generation].[Personal Business].[nonclosed tour]	0.9321	7.27	-0.200
Non-Traditional Closed Tour	[Stop Generation].[Personal Business].[alt closed tour]	0.8231	2.17	No Change
Home-Based Work Tour	[Stop Generation].[Personal Business].[home based work tour]	0.3824	6.34	0.6883
Home-Based School Tour	[Stop Generation].[Personal Business].[home based school tour]	0.2563	3.69	0.9153

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Home-Based Escort Tour	[Stop Generation].[Personal Business].[home based escort tour]	0.3283	4.90	No Change
Home-Based Personal Business Tour	[Stop Generation].[Personal Business].[home based personal business tour]	0.4556	6.81	0.8298
Home-Based Shop Tour	[Stop Generation].[Personal Business].[home based shop tour]	0.5184	7.37	0.7776
Home-Based Meal Tour	[Stop Generation].[Personal Business].[home based meal tour]	0.6271	6.86	0.9916
Home-Based Social/Recreation Tour	[Stop Generation].[Personal Business].[home based social/recreation tour]	0.4398	5.88	0.3299
Outbound Half-Tour	[Stop Generation].[Personal Business].[outbound half tour]	-1.0920	-28.41	-1.5725
Number of Remaining Tours	[Stop Generation].[Personal Business].[tours remaining in day]	-0.2943	-12.55	No Change
Available Time Window	[Stop Generation].[Personal Business].[time window available]	0.0637	18.07	No Change
Natural Log of Half-TourDistance (Miles)	[Stop Generation].[Personal Business].[ln tour distance]	0.1129	9.65	No Change
Half-Tour In Time Period 7:00 AM-9:00 AM	[Stop Generation].[Personal Business].[period 7 am to 9 am]	-0.7456	-13.44	No Change
Half-Tour In Time Period 9:00 AM-11:00 AM	[Stop Generation].[Personal Business].[period 9 am to 11 am]	-0.0740	-1.53	No Change
Half-Tour In Time Period 3:00 PM-5:00 PM	[Stop Generation].[Personal Business].[period 3 pm to 5 pm]	-0.2275	-5.17	No Change
Half-Tour In Time Period 5:00 PM-7:00 PM	[Stop Generation].[Personal Business].[period 5 pm to 7 pm]	-0.6051	-10.66	No Change
Half-Tour In Time Period 7:00 PM-10:00 PM	[Stop Generation].[Personal Business].[period 7 pm to 10 pm]	-1.0580	-13.57	No Change
Half-Tour In Time Period 10:00 PM-7:00 AM	[Stop Generation].[Personal Business].[period 10 pm to 7 am]	-1.7270	-12.42	No Change
Stop for Same Purpose on Previous Tour	[Stop Generation].[Personal Business].[stop for same purpose-prior tours]	-2.1960	-36.70	No Change
Stop for Same Purpose Earlier on This Tour	[Stop Generation].[Personal Business].[stop for same purpose-same tour]	-1.8310	-47.79	No Change
No Stops[1]	–	*-50000*	–	–

Source: Cambridge Systematics

Notes: [1] No Stops is not actually an input coefficient but, rather, is embedded in the C# code so that if this stop purpose is not forecast by the daily activity pattern model for the person, it is excluded from consideration.

F.15.5 Coefficients for Home-Based Shop Stops

Table F.48 Home-Based Shop Intermediate Stop Generation Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Person/Household Characteristics				
Other Non-Worker (18-65)	[Stop Generation].[Shop].[non-worker age 18-65]	-0.0154	-0.37	No Change
Daily Activity Pattern/Tour/Stop				
Work-Based Sub-Tour	[Stop Generation].[Shop].[work based subtour]	0.2211	1.33	No Change
Non-Closed Tour	[Stop Generation].[Shop].[nonclosed tour]	0.6563	3.83	0.4594
Non-Traditional Closed Tour	[Stop Generation].[Shop].[alt closed tour]	-0.8271	-1.79	No Change
Home-Based Work Tour	[Stop Generation].[Shop].[home based work tour]	-0.0851	-0.86	1.0495
Home-Based School Tour	[Stop Generation].[Shop].[home based school tour]	-0.3328	-3.08	0.8405
Home-Based Escort Tour	[Stop Generation].[Shop].[home based escort tour]	-0.3297	-3.02	1.1527
Home-Based Personal Business Tour	[Stop Generation].[Shop].[home based personal business tour]	-0.1968	-1.83	No Change
Home-Based Shop Tour	[Stop Generation].[Shop].[home based shop tour]	0.4177	3.99	No Change
Home-Based Meal Tour	[Stop Generation].[Shop].[home based meal tour]	0.2340	1.90	No Change
Home-Based Social/Recreation Tour	[Stop Generation].[Shop].[home based social/recreation tour]	0.2514	2.33	No Change
Outbound Half-Tour	[Stop Generation].[Shop].[outbound half tour]	-1.6240	-37.79	-2.1278
Number of Remaining Tours	[Stop Generation].[Shop].[tours remaining in day]	-0.1843	-6.41	No Change
Available Time Window	[Stop Generation].[Shop].[time window available]	0.0803	19.09	No Change
Natural Log of Half-TourDistance (Miles)	[Stop Generation].[Shop].[ln tour distance]	0.1252	9.19	No Change
Half-Tour In Time Period 7:00 AM-9:00 AM	[Stop Generation].[Shop].[period 7 am to 9 am]	-1.1580	-15.82	No Change
Half-Tour In Time Period 9:00 AM-11:00 AM	[Stop Generation].[Shop].[period 9 am to 11 am]	-0.3642	-6.53	No Change
Half-Tour In Time Period 3:00 PM-5:00 PM	[Stop Generation].[Shop].[period 3 pm to 5 pm]	-0.1584	-3.29	No Change
Half-Tour In Time Period 5:00 PM-7:00 PM	[Stop Generation].[Shop].[period 5 pm to 7 pm]	-0.3515	-5.91	No Change
Half-Tour In Time Period 7:00 PM-10:00 PM	[Stop Generation].[Shop].[period 7 pm to 10 pm]	-0.6502	-8.16	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Half-Tour In Time Period 10:00 PM-7:00 AM	[Stop Generation].[Shop].[period 10 pm to 7 am]	-1.5820	-10.29	No Change
Tour Mode is Drive Alone	[Stop Generation].[Shop].[drive alone tour]	0.3524	4.28	0.4581
Tour Mode is Shared Ride 2	[Stop Generation].[Shop].[shared ride 2 tour]	0.4670	5.55	No Change
Tour Mode is Shared Ride 3+	[Stop Generation].[Shop].[shared ride 3+tour]	0.4694	5.47	0.2000
Stop for Same Purpose on Previous Tour	[Stop Generation].[Shop].[stop for same purpose-prior tours]	-2.7360	-36.68	No Change
Stop for Same Purpose Earlier on This Tour	[Stop Generation].[Shop].[stop for same purpose-same tour]	-2.0910	-47.70	No Change
No Stops[1]	–	*-50000*	–	–

Source: Cambridge Systematics

Notes: [1] No Stops is not actually an input coefficient but, rather, is embedded in the C# code so that if this stop purpose is not forecast by the daily activity pattern model for the person, it is excluded from consideration.

F.15.6 Coefficients for Home-Based Meal Stops

Table F.49 Home-Based Meal Intermediate Stop Generation Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Person/Household Characteristics				
Pre-School Child (0-4)	[Stop Generation].[Meal].[child age 0-4]	-0.4864	-3.48	No Change
Pre-Driving Age Child (5-15)	[Stop Generation].[Meal].[child age 5-15]	-0.2988	-2.92	No Change
Daily Activity Pattern/Tour/Stop				
Work-Based Sub-Tour	[Stop Generation].[Meal].[work based subtour]	1.1830	6.32	0.2800
Non-Closed Tour	[Stop Generation].[Meal].[nonclosed tour]	2.1960	11.66	No Change
Non-Traditional Closed Tour	[Stop Generation].[Meal].[alt closed tour]	0.0753	0.10	No Change
Home-Based Work Tour	[Stop Generation].[Meal].[home based work tour]	0.4649	4.05	No Change
Home-Based School Tour	[Stop Generation].[Meal].[home based school tour]	0.4447	3.27	0.7747
Home-Based Escort Tour	[Stop Generation].[Meal].[home based escort tour]	0.3206	2.34	3.0468
Home-Based Personal Business Tour	[Stop Generation].[Meal].[home based personal business tour]	0.1122	0.77	No Change
Home-Based Shop Tour	[Stop Generation].[Meal].[home based shop tour]	0.6279	4.28	No Change
Home-Based Meal Tour	[Stop Generation].[Meal].[home based meal tour]	-0.4089	-1.56	-2.9388

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Home-Based Social/Recreation Tour	[Stop Generation].[Meal].[home based social/recreation tour]	0.5604	4.03	0.6164
Outbound Half-Tour	[Stop Generation].[Meal].[outbound half tour]	-1.8600	-27.48	-2.0460
Number of Remaining Tours	[Stop Generation].[Meal].[tours remaining in day]	-0.6395	-12.31	No Change
Available Time Window	[Stop Generation].[Meal].[time window available]	0.0797	11.88	No Change
Natural Log of Half-TourDistance (Miles)	[Stop Generation].[Meal].[ln tour distance]	0.1533	7.21	No Change
Half-Tour In Time Period 7:00 AM-9:00 AM	[Stop Generation].[Meal].[period 7 am to 9 am]	-0.9261	-8.60	No Change
Half-Tour In Time Period 9:00 AM-11:00 AM	[Stop Generation].[Meal].[period 9 am to 11 am]	-0.4849	-5.01	No Change
Half-Tour In Time Period 3:00 PM-5:00 PM	[Stop Generation].[Meal].[period 3 pm to 5 pm]	-0.7116	-7.90	No Change
Half-Tour In Time Period 5:00 PM-7:00 PM	[Stop Generation].[Meal].[period 5 pm to 7 pm]	-0.5267	-5.69	No Change
Half-Tour In Time Period 7:00 PM-10:00 PM	[Stop Generation].[Meal].[period 7 pm to 10 pm]	-0.4328	-4.02	No Change
Half-Tour In Time Period 10:00 PM-7:00 AM	[Stop Generation].[Meal].[period 10 pm to 7 am]	-1.1350	-5.23	No Change
Tour Mode is Shared Ride 2	[Stop Generation].[Meal].[shared ride 2 tour]	0.3156	4.25	0.5909
Tour Mode is Shared Ride 3+	[Stop Generation].[Meal].[shared ride 3+tour]	0.3628	4.38	0.9403
Stop for Same Purpose on Previous Tour	[Stop Generation].[Meal].[stop for same purpose-prior tours]	-3.2010	-20.74	No Change
Stop for Same Purpose Earlier on This Tour	[Stop Generation].[Meal].[stop for same purpose-same tour]	-3.9780	-35.86	No Change
No Stops[1]	–	*-50000*	–	–

Source: Cambridge Systematics

Notes: [1] No Stops is not actually an input coefficient but, rather, is embedded in the C# code so that if this stop purpose is not forecast by the daily activity pattern model for the person, it is excluded from consideration.

F.15.7 Coefficients for Home-Based Social/Recreation Stops

Table F.50 Home-Based Social/Recreation Intermediate Stop Generation Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Daily Activity Pattern/Tour/Stop				
Work-Based Sub-Tour	[Stop Generation].[SocialRecreation].[work based subtour]	-1.9940	-7.89	No Change
Non-Closed Tour	[Stop Generation]. [SocialRecreation]. [nonclosed tour]	0.2584	1.84	0.3101
Non-Traditional Closed Tour	[Stop Generation]. [SocialRecreation]. [alt closed tour]	-0.1960	-0.50	No Change
Home-Based Work Tour	[Stop Generation]. [SocialRecreation]. [home based work tour]	-0.6564	-7.57	No Change
Home-Based School Tour	[Stop Generation]. [SocialRecreation]. [home based school tour]	-0.2373	-2.65	-0.2848
Home-Based Escort Tour	[Stop Generation]. [SocialRecreation]. [home based escort tour]	-0.4950	-4.94	1.3514
Home-Based Personal Business Tour	[Stop Generation]. [SocialRecreation]. [home based personal business tour]	-1.0680	-8.57	-1.6918
Home-Based Shop Tour	[Stop Generation]. [SocialRecreation]. [home based shop tour]	-0.7207	-5.93	-1.1417
Home-Based Meal Tour	[Stop Generation]. [SocialRecreation]. [home based meal tour]	-0.8296	-5.95	No Change
Home-Based Social/Recreation Tour	[Stop Generation]. [SocialRecreation]. [home based social/recreation tour]	-0.3480	-3.38	-0.5513
Outbound Half-Tour	[Stop Generation]. [SocialRecreation]. [outbound half tour]	-1.1300	-22.33	-1.4238
Number of Remaining Tours	[Stop Generation]. [SocialRecreation]. [tours remaining in day]	-0.3671	-10.10	No Change
Available Time Window	[Stop Generation]. [SocialRecreation]. [time window available]	0.0905	18.47	No Change
Natural Log of Half-TourDistance (Miles)	[Stop Generation]. [SocialRecreation]. [ln tour distance]	0.1291	8.35	No Change
Half-Tour In Time Period 7:00 AM-9:00 AM	[Stop Generation]. [SocialRecreation]. [period 7 am to 9 am]	-0.8236	-10.46	No Change
Half-Tour In Time Period 9:00 AM-11:00 AM	[Stop Generation]. [SocialRecreation]. [period 9 am to 11 am]	-0.0638	-0.83	No Change
Half-Tour In Time Period 3:00 PM-5:00 PM	[Stop Generation]. [SocialRecreation]. [period 3 pm to 5 pm]	0.0915	1.49	No Change
Half-Tour In Time Period 5:00 PM-7:00 PM	[Stop Generation]. [SocialRecreation]. [period 5 pm to 7 pm]	0.1641	2.25	No Change
Half-Tour In Time Period 7:00 PM-10:00 PM	[Stop Generation]. [SocialRecreation]. [period 7 pm to 10 pm]	0.1470	1.72	No Change
Half-Tour In Time Period 10:00 PM-7:00 AM	[Stop Generation]. [SocialRecreation]. [period 10 pm to 7 am]	-0.1595	-1.36	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Tour Mode is Shared Ride 2	[Stop Generation]. [SocialRecreation]. [shared ride 2 tour]	0.2350	3.97	No Change
Tour Mode is Shared Ride 3+	[Stop Generation]. [SocialRecreation]. [shared ride 3+tour]	0.4485	7.94	0.3000
Stop for Same Purpose on Previous Tour	[Stop Generation]. [SocialRecreation]. [stop for same purpose-prior tours]	-2.5680	-27.07	No Change
Stop for Same Purpose Earlier on This Tour	[Stop Generation]. [SocialRecreation]. [stop for same purpose-same tour]	-2.1830	-39.48	No Change
No Stops[1]	–	*-50000*	–	–

Source: Cambridge Systematics

Notes: [1] No Stops is not actually an input coefficient but, rather, is embedded in the C# code so that if this stop purpose is not forecast by the daily activity pattern model for the person, it is excluded from consideration.

F.15.8 Coefficients for "Quit" Option

Table F.51 "Quit" Option Intermediate Stop Generation Choice Coefficients by Iteration

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Home-Based Work Tour With a Sub-Tour	[Stop Generation].[Quit].[work tour with subtour]	0.2512	4.45	No Change
Secondary Tour	[Stop Generation].[Quit].[secondary tour]	-0.1882	-6.71	No Change
Outbound Half-Tour – Iteration 2	[Stop Generation].[Quit].[if the second stop on the outbound tour is being modeled]	-0.3004	-7.48	No Change
Outbound Half-Tour – Iteration 3	[Stop Generation].[Quit].[if the third stop on the outbound tour is being modeled]	-0.6350	-9.96	No Change
Outbound Half-Tour – Iteration 4	[Stop Generation].[Quit].[if the fourth stop on the outbound tour is being modeled]	-0.5572	-5.65	No Change
Outbound Half-Tour – Iteration 5	[Stop Generation].[Quit].[if the fifth stop on the outbound tour is being modeled]	-0.1710	-1.07	No Change
Outbound Half-Tour – Iteration 6	[Stop Generation].[Quit].[if the sixth stop on the outbound tour is being modeled]	-1.7590	-6.36	No Change
Inbound Half-Tour – Iteration 2	[Stop Generation].[Quit].[if the second stop on the inbound tour is being modeled]	0.3861	11.99	No Change
Inbound Half-Tour – Iteration 3	[Stop Generation].[Quit].[if the third stop on the inbound tour is being modeled]	0.3451	8.10	No Change
Inbound Half-Tour – Iteration 4	[Stop Generation].[Quit].[if the fourth stop on the inbound tour is being modeled]	0.2315	3.89	No Change
Inbound Half-Tour – Iteration 5	[Stop Generation].[Quit].[if the fifth stop on the inbound tour is being modeled]	0.5090	6.27	No Change
Inbound Half-Tour – Iteration 6	[Stop Generation].[Quit].[if the sixth stop on the inbound tour is being modeled]	0.0430	0.35	No Change

Source: Cambridge Systematics

F.15.9 Model Estimation Statistics

The daily activity pattern choice model estimation statistics are shown in ***Table F.52***.

Table F.52 Intermediate Stop Generation Choice Model Estimation Statistics

Item	Model Estimation Statistics
Number of Observations	107,308
Log-likelihood at Convergence	-43,265.74
Log-likelihood at Constants	n/a
Log-likelihood at Null Parameters	-62,170.33
Rho-squared w.r.t. Constants	n/a
Rho-squared w.r.t. Null Parameters	0.304

Source: Cambridge Systematics

F.16 Stop Time of Day Simulation

Table F.24 summarizes the proportions of stops by arrival time and ***Table F.54*** summarizes the proportions by departure time from the stop locations from the expanded FRTC survey data. The data shown in ***Table F.24*** and ***Table F.54*** are used with a Monte Carlo simulation process to assign preliminary estimates of arrival and departure times to all stops before the application of the intermediate stop location choice, trip main mode choice, and trip time of day choice StateFocus model components. The preliminary times of day are used to select the time of day auto and transit skim data used for intermediate stop location choice and trip main mode choice.

Table F.53 Percent of Stops by Stop Arrival Time by Stop Purpose

Time of Day	Work	School	Escort	Personal Business	Shop	Meal	Social/ Recreation
3:00 AM–3:59 AM	0.31%	0.00%	0.04%	0.00%	0.01%	0.00%	0.07%
4:00 AM–4:59 AM	0.83%	0.01%	0.12%	0.04%	0.02%	0.01%	0.24%
5:00 AM–5:59 AM	2.76%	0.13%	0.68%	0.33%	0.16%	0.21%	0.82%
6:00 AM–6:59 AM	7.48%	5.71%	3.30%	0.82%	0.41%	0.69%	1.48%
7:00 AM–7:59 AM	13.16%	23.26%	17.18%	3.57%	1.05%	1.96%	2.62%
8:00 AM–8:59 AM	8.47%	12.33%	12.04%	5.54%	2.01%	2.07%	3.46%
9:00 AM–9:59 AM	4.59%	2.39%	4.03%	7.19%	3.97%	1.93%	4.63%
10:00 AM–10:59 AM	3.22%	1.78%	1.99%	8.86%	9.00%	2.66%	4.96%
11:00 AM–11:59 AM	4.13%	3.38%	4.15%	10.09%	8.95%	10.39%	5.58%
12:00 PM–12:59 PM	4.37%	2.82%	3.90%	9.97%	8.99%	14.70%	4.26%
1:00 PM–1:59 PM	4.48%	2.01%	2.81%	8.89%	9.87%	11.24%	4.41%
2:00 PM–2:59 PM	5.29%	10.99%	8.66%	8.33%	9.11%	5.38%	4.15%
3:00 PM–3:59 PM	8.39%	19.92%	15.76%	9.29%	9.46%	3.25%	5.87%
4:00 PM–4:59 PM	10.72%	6.38%	8.45%	9.00%	9.27%	4.76%	8.67%
5:00 PM–5:59 PM	10.50%	4.70%	6.52%	6.94%	9.48%	7.57%	10.89%
6:00 PM–6:59 PM	4.52%	1.59%	4.21%	4.98%	7.09%	11.61%	12.64%
7:00 PM–7:59 PM	2.06%	0.80%	2.45%	3.01%	5.21%	9.63%	8.65%
8:00 PM–8:59 PM	1.54%	0.81%	1.65%	1.57%	3.44%	6.73%	6.98%
9:00 PM–9:59 PM	1.17%	0.63%	1.16%	1.16%	1.63%	3.74%	5.29%
10:00 PM–10:59 PM	0.98%	0.25%	0.48%	0.26%	0.60%	0.84%	2.27%
11:00 PM–11:59 PM	0.54%	0.09%	0.18%	0.10%	0.21%	0.44%	1.28%
12:00 AM–12:59 AM	0.29%	0.02%	0.14%	0.02%	0.01%	0.16%	0.40%
1:00 AM–1:59 AM	0.12%	0.00%	0.08%	0.03%	0.01%	0.00%	0.19%
2:00 AM–2:59 AM	0.06%	0.00%	0.02%	0.01%	0.02%	0.05%	0.17%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Source: Cambridge Systematics.

Table F.54 Percent of Stops by Stop Departure Time by Stop Purpose

Time of Day	Work	School	Escort	Personal Business	Shop	Meal	Social/ Recreation
3:00 AM–3:59 AM	0.31%	0.00%	0.04%	0.00%	0.01%	0.00%	0.07%
4:00 AM–4:59 AM	0.83%	0.01%	0.12%	0.04%	0.02%	0.01%	0.24%
5:00 AM–5:59 AM	2.76%	0.13%	0.68%	0.33%	0.16%	0.21%	0.82%
6:00 AM–6:59 AM	7.48%	5.71%	3.30%	0.82%	0.41%	0.69%	1.48%
7:00 AM–7:59 AM	13.16%	23.26%	17.18%	3.57%	1.05%	1.96%	2.62%
8:00 AM–8:59 AM	8.47%	12.33%	12.04%	5.54%	2.01%	2.07%	3.46%
9:00 AM–9:59 AM	4.59%	2.39%	4.03%	7.19%	3.97%	1.93%	4.63%
10:00 AM–10:59 AM	3.22%	1.78%	1.99%	8.86%	9.00%	2.66%	4.96%
11:00 AM–11:59 AM	4.13%	3.38%	4.15%	10.09%	8.95%	10.39%	5.58%
12:00 PM–12:59 PM	4.37%	2.82%	3.90%	9.97%	8.99%	14.70%	4.26%
1:00 PM–1:59 PM	4.48%	2.01%	2.81%	8.89%	9.87%	11.24%	4.41%
2:00 PM–2:59 PM	5.29%	10.99%	8.66%	8.33%	9.11%	5.38%	4.15%
3:00 PM–3:59 PM	8.39%	19.92%	15.76%	9.29%	9.46%	3.25%	5.87%
4:00 PM–4:59 PM	10.72%	6.38%	8.45%	9.00%	9.27%	4.76%	8.67%
5:00 PM–5:59 PM	10.50%	4.70%	6.52%	6.94%	9.48%	7.57%	10.89%
6:00 PM–6:59 PM	4.52%	1.59%	4.21%	4.98%	7.09%	11.61%	12.64%
7:00 PM–7:59 PM	2.06%	0.80%	2.45%	3.01%	5.21%	9.63%	8.65%
8:00 PM–8:59 PM	1.54%	0.81%	1.65%	1.57%	3.44%	6.73%	6.98%
9:00 PM–9:59 PM	1.17%	0.63%	1.16%	1.16%	1.63%	3.74%	5.29%
10:00 PM–10:59 PM	0.98%	0.25%	0.48%	0.26%	0.60%	0.84%	2.27%
11:00 PM–11:59 PM	0.54%	0.09%	0.18%	0.10%	0.21%	0.44%	1.28%
12:00 AM–12:59 AM	0.29%	0.02%	0.14%	0.02%	0.01%	0.16%	0.40%
1:00 AM–1:59 AM	0.12%	0.00%	0.08%	0.03%	0.01%	0.00%	0.19%
2:00 AM–2:59 AM	0.06%	0.00%	0.02%	0.01%	0.02%	0.05%	0.17%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Source: Cambridge Systematics.

F.17 Intermediate Stop Location Choice

The intermediate stop location choice model variables, StateFocus C# parameter names, estimated model constants and t-statistics, and final calibrated parameters based on the 2015 model calibration/validation are shown below. Even though only one general utility function has been estimated, different variables may be used depending on the stop purpose being considered. See ***Section 4.2.17*** for documentation of the model and variables.

Table F.55 Intermediate Stop Location Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Quantitative (Size) Variables				
Size Logsum Multiplier (Θ)	[Stop Location].[****].[LnSizeSum][1]	0.5674	-78.43	No Change
Work Stops				
Total Households	[Stop Location].[SizeSum].[Work].[Number of households in the zone]	-1.8240	-10.67	No Change
School Stops				
Base Size	[Stop Location].[SizeSum].[School].[BaseSize].[EnrollmentByStudentTypeDummy]	0.0000[2]	Fixed	No Change
Education Employment	[Stop Location].[SizeSum].[School].[Education employment in the zone]	6.9790	31.30	No Change
Escort Stops				
Education Employment	[Stop Location].[SizeSum].[Escort].[Education employment in the zone]	9.5330	98.13	No Change
Personal Business Stops				
Total Households-Other	[Stop Location].[SizeSum].[PersonalBusiness].[Number of households in the zone]	-2.7150	-15.81	No Change
Meal				
Retail Employment	[Stop Location].[SizeSum].[Meal].[Retail employment in the zone]	-1.4120	-9.81	No Change
Social Recreation				
Total Households	[Stop Location].[SizeSum].[SocialRecreational].[Number of households in the zone]	-2.7150	-15.81	No Change
Interchange Related Variables–Closed Tours				
Generalized Time of Diversion	[Stop Location].[****].[Generalized time][1]	-0.02831	-34.10	No Change
Generalized Time for Proximity to an End of a Trip	[Stop Location].[****].[Generalized time Proximity to End Motorized][1]	-0.1092	-71.68	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Tour Destination Zone Variables				
Mixed Use Density	[Stop Location].[****].[Destination mixed use density][1]	0.3472	20.78	No Change
Total Employment Density-Other[3]	[Stop Location].[PersonalBusiness].[Total employment density] [Stop Location].[SocialRecreational].[Total employment density]	-0.01513	-8.67	No Change
Total Household Density-Other[3]	[Stop Location].[PersonalBusiness].[Total households density] [Stop Location].[SocialRecreational].[Total households density]	0.0563	5.76	No Change
Total Retail Employment Density-Shop	[Stop Location].[Shop].[Retail employment density]	0.1922	12.98	No Change
Model Estimation Statistics				
Number of Observations	26,504			
Log-likelihood at Convergence	-140,107.38			
Log-likelihood at Constants	n/a			
Log-likelihood at Null Parameters	-223,665.71			
Rho-squared w.r.t. Constants	n/a			
Rho-squared w.r.t. Null Parameters	0.374			

Source: Cambridge Systematics.

Notes: [1] The same model coefficient is used for all stop purposes. The "[****]" is replaced with [Work], [School], [Escort], [Personal Business], [Shop], [Meal], or [SocialRecreational] as appropriate for the stop purpose being considered.

[2] The base size coefficient is exponentiated in the Quantitative (Size) component of the utility function; exp(0.0) = 1, resulting in the size variable being multiplied by 1.

[3] The same model coefficient is used for [Personal Business] and [SocialRecreational].

F.18 Trip Main Mode Choice

The intermediate stop location choice model variables, StateFocus C# parameter names, estimated model constants and t-statistics, and final calibrated parameters based on the 2015 model calibration/validation are shown below. A single multinomial logit model (***Figure 4.50***) has been estimated to be used for trips, with some tour mode and tour purpose specific variables for specific trip modes. For this reason, ***Table F.56*** presents the model C# parameters, estimated model constants and t-statistics, and final calibrated parameters in a different format than used in previous appendices so that the variation of the various model coefficients across alternative trip modes can be seen. When a coefficient spans multiple trip modes, that means that the same coefficient was estimated for each trip mode.

See ***Section 4.2.18*** for documentation of the model and variables.

Table F.56 Trip Mode Choice Coefficients

	Trip Mode							
Variable	**Drive Alone**	**Shared Ride 2**	**Shared Ride 3+**	**Walk**	**Bike**	**Walk to Transit**	**Drive to transit**	**School Bus**
Constant[1]	[Trip Mode Choice].[*xxxx*].[Constant]							
Estimated Coefficients	–	-0.2957	0.1552	-0.0207	-1.4926	-1.6464	0.1454	-1.0750
t-statistic	–	-2.74	1.33	-0.14	-5.47	-7.04	0.58	-5.61
Calibrated Coefficients	–	0.7480	2.5650	-0.1000	0.5000	0.6105	5.0000	3.5000
Generalized time[1,2]	[Trip Mode Choice].[*xxxx*].[Generalized time]							
Estimated Coefficients	-0.0073							
t-statistic	-29.58							
Calibrated Coefficients	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
Household Variables								
One person household[1]	[Trip Mode Choice].[*xxxx*].[1 person HH]							
Estimated Coefficients	–	-0.8591	-0.9829	–	–	–	–	–
t-statistic	–	-12.67	-9.18	–	–	–	–	–
Calibrated Coefficients	–	No Change	No Change	–	–	–	–	–
Two person household[1]	[Trip Mode Choice].[*xxxx*].[2 person HH]							
Estimated Coefficients	–	–	-0.4779	–	–	–	–	–
t-statistic	–	–	-3.51	–	–	–	–	–
Calibrated Coefficients	–	–	No Change	–	–	–	–	–
Household cars greater than zero but less than number of drivers[1]	[Trip Mode Choice].[*xxxx*].[HH cars >0, <drivers]							
Estimated Coefficients	-0.2411	–	–	–	–	–	–	–
t-statistic	-6.16	–	–	–	–	–	–	–
Calibrated Coefficients	No Change	–	–	–	–	–	–	–

Variable	Trip Mode							
	Drive Alone	Shared Ride 2	Shared Ride 3+	Walk	Bike	Walk to Transit	Drive to transit	School Bus
Household cars greater than zero but less than number of workers[1]	[Trip Mode Choice].[*xxxx*].[HH cars >0, <workers]							
Estimated Coefficients	–	–	–	0.4920	–	–	–	–
t-statistic	–	–	–	3.72	–	–	–	–
Calibrated Coefficients	–	–	–	No Change	–	–	–	–
No car in household[1]	[Trip Mode Choice].[*xxxx*].[No car in HH]							
Estimated Coefficients	–	-0.5919		0.8285	–	–	-1.6739	–
t-statistic	–	-2.83		4.11	–	–	-2.76	–
Calibrated Coefficients	–	-0.2072	No Change	–	–		–	
Number of non-working adults in household[1]	[Trip Mode Choice].[*xxxx*].[Household nonworking adults]							
Estimated Coefficients	–	0.1525		–	–	–	–	–
t-statistic	–	7.74		–	–	–	–	–
Calibrated Coefficients	–	No Change	No Change	–	–	–	–	
Number of pre-driving age students (5-15 year old child) in household[1]	[Trip Mode Choice].[*xxxx*].[Household members age 5-15]							
Estimated Coefficients	–	-0.2285		–	–	–	–	–
t-statistic	–	-15.50		–	–	–	–	–
Calibrated Coefficients	–	No Change	No Change	–	–	–	–	
Lower income[1,3]	[Trip Mode Choice].[*xxxx*].[Income Segment]							
Estimated Coefficients	-0.1967	–	–	–	–	0.3371	-0.4907	–
t-statistic	-3.20	–	–	–	–	1.58	-1.26	–
Calibrated Coefficients	No Change	–	–	–	–	No Change	No Change	–
Modest income[1,3]	[Trip Mode Choice].[*xxxx*].[Income Segment]							
Estimated Coefficients	-0.1142	–	–	–	–	0.2332	–	–
t-statistic	-2.78	–	–	–	–	1.14	–	–
Calibrated Coefficients	No Change	–	–	–	–	No Change	–	–
Upper income[1,3]	[Trip Mode Choice].[*xxxx*].[Income Segment]							
Estimated Coefficients	–	-0.1122		–	–	–	–	-0.2904
t-statistic	–	-3.09		–	–	–	–	-2.43
Calibrated Coefficients	–	No Change	No Change	–	–	–	–	No Change
Top income[1,3]	[Trip Mode Choice].[*xxxx*].[Income Segment]							
Estimated Coefficients	–	-0.1900		–	–	-0.6842	0.2844	-0.2603
t-statistic	–	-4.29		–	–	-3.91	0.81	-1.71
Calibrated Coefficients	–	No Change	No Change	–	–	No Change	No Change	No Change

Variable	Trip Mode							
	Drive Alone	Shared Ride 2	Shared Ride 3+	Walk	Bike	Walk to Transit	Drive to transit	School Bus
Missing income[1,3,4]	–							
Estimated Coefficients	-0.9389	-0.7346		–	–	-0.7967	-0.6189	–
t-statistic	-2.78	-2.24		–	–	-1.39	-0.67	–
Calibrated Coefficients	–	–	–	–	–	–	–	–
Person Variables								
Male[1]	[Trip Mode Choice].[*xxxx*].[Male]							
Estimated Coefficients	–	-0.0606		–	0.3145	–	–	–
t-statistic	–	-2.16		–	1.71	–	–	–
Calibrated Coefficients	–	No Change	No Change	–	–	–	–	–
Age under 35[1]	[Trip Mode Choice].[*xxxx*].[Age under 35]							
Estimated Coefficients	–	–	–	0.3893	–	–	–	–
t-statistic	–	–	–	3.88	–	–	–	–
Calibrated Coefficients	–	–	–	No Change	–	–	–	–
Pre-school child (0-4 year old child)[1]	[Trip Mode Choice].[*xxxx*].[Child under 5]							
Estimated Coefficients	–	–	–	-0.4515	–	-1.0911	–	–
t-statistic	–	–	–	-2.61	–	-1.56	–	–
Calibrated Coefficients	–	–	–	No Change	–	No Change	–	–
Pre-driving age student (5-15 year old child)[1]	[Trip Mode Choice].[*xxxx*].[Child 5-15]							
Estimated Coefficients	–	–	–	–	–	-1.8325	-3.1540	–
t-statistic	–	–	–	–	–	-7.75	-6.07	–
Calibrated Coefficients	–	–	–	–	–	-0.5000	No Change	–
Driving age student (child aged 16+)[1]	[Trip Mode Choice].[*xxxx*].[Child 16+]							
Estimated Coefficients	–	–	–	–	–	-1.1354	-2.0382	–
t-statistic	–	–	–	–	–	-4.03	-3.09	–
Calibrated Coefficients	–	–	–	–	–	-0.5000	No Change	–
University student[1]	[Trip Mode Choice].[*xxxx*].[University Student]							
Estimated Coefficients	–	–	–	–	0.6810	-0.4859	-0.8952	–
t-statistic	–	–	–	–	1.59	-2.17	-2.77	–
Calibrated Coefficients	–	–	–	–	No Change	0.5000	1.5000	–
Land Use Variables								
Origin intersection density[1]	[Trip Mode Choice].[*xxxx*].[Origin intersection density]							
Estimated Coefficients	–	–	–	3.3613	4.6464	5.4080	–	-4.6201
t-statistic	–	–	–	5.44	1.67	2.97	–	-2.29
Calibrated Coefficients	–	–	–	No Change	No Change	No Change	–	No Change

Variable	Trip Mode							
	Drive Alone	Shared Ride 2	Shared Ride 3+	Walk	Bike	Walk to Transit	Drive to transit	School Bus
Destination intersection density[1]	[Trip Mode Choice].[*xxxx*].[Destination intersection density]							
Estimated Coefficients	–	–	–	3.3613	–	–	–	–
t-statistic	–	–	–	5.44	–	–	–	–
Calibrated Coefficients	–	–	–	No Change	–	–	–	–
Origin intersection density-inbound half-tour[1]	[Trip Mode Choice].[*xxxx*].[Origin intersection density HT2]							
Estimated Coefficients	–	–	–	–	–	–	21.4128	–
t-statistic	–	–	–	–	–	–	7.69	–
Calibrated Coefficients	–	–	–	–	–	–	No Change	–
Destination retail density-outbound half-tour[1]	[Trip Mode Choice].[*xxxx*].[Destination retail density HT1]							
Estimated Coefficients	–	–	–	0.0860	0.1059	0.0927	0.2725	–
t-statistic	–	–	–	3.42	1.98	2.62	4.52	–
Calibrated Coefficients	–	–	–	No Change	No Change	No Change	No Change	–
Destination retail density-inbound half-tour[1]	[Trip Mode Choice].[*xxxx*].[Destination retail density HT2]							
Estimated Coefficients	–	–	–	0.1455	–	0.0431	-0.3965	–
t-statistic	–	–	–	6.53	–	1.21	-4.01	–
Calibrated Coefficients	–	–	–	No Change	–	No Change	No Change	–
Parent Tour Mode Choice Variables								
Same as tour mode[1]	[Trip Mode Choice].[*xxxx*].[Same as tour mode]							
Estimated Coefficients	3.5438							
t-statistic	28.54							
Calibrated Coefficients	0.4000	No Change	No Change	No Change	No Change	No Change	No Change	No Change
Same as tour mode-only outbound trip[1]	[Trip Mode Choice].[*xxxx*].[Same as tour mode - only outbound trip]							
Estimated Coefficients	0.6024							
t-statistic	15.44							
Calibrated Coefficients	No Change	No Change	No Change	No Change	1.5300	No Change	No Change	No Change
Same as tour mode-only inbound trip[1]	[Trip Mode Choice].[*xxxx*].[Same as tour mode - only return trip]							
Estimated Coefficients	0.7375							
t-statistic	18.03							
Calibrated Coefficients	No Change	No Change	No Change	No Change	1.6000	No Change	No Change	No Change
Same as tour mode-first outbound trip[1]	[Trip Mode Choice].[*xxxx*].[Same as tour mode - first outbound trip]							
Estimated Coefficients	0.1154							-2.6916
t-statistic	2.16							-5.57
Calibrated Coefficients	No Change	No Change	No Change	No Change	0.2730	No Change	No Change	0.2730

Variable	Trip Mode							
	Drive Alone	Shared Ride 2	Shared Ride 3+	Walk	Bike	Walk to Transit	Drive to transit	School Bus
Same as tour mode-first inbound trip[1]	[Trip Mode Choice].[*xxxx*].[Same as tour mode - first return trip]							
Estimated Coefficients	0.0783							–
t-statistic	1.84							–
Calibrated Coefficients	No Change	No Change	No Change	No Change	0.1050	No Change	No Change	–
Same as tour mode-last outbound trip[1]	[Trip Mode Choice].[*xxxx*].[Same as tour mode - last outbound trip]							
Estimated Coefficients	0.1385							–
t-statistic	2.67							–
Calibrated Coefficients	No Change	No Change	No Change	No Change	0.231	No Change	No Change	–
Same as tour mode-last inbound trip[1]	[Trip Mode Choice].[*xxxx*].[Same as tour mode - last return trip]							
Estimated Coefficients	0.1413							-3.0347
t-statistic	3.28							-11.85
Calibrated Coefficients	No Change	No Change	No Change	No Change	0.127	No Change	No Change	0.127
Shared ride 2 tour[1]	[Trip Mode Choice].[*xxxx*].[Shared ride 2 tour]							
Estimated Coefficients	1.3085	–	–	–	-1.8926	–	–	–
t-statistic	8.50	–	–	–	-6.89	–	–	–
Calibrated Coefficients	-2.0000	–	–	–	0.2500	–	–	–
Shared ride 3+ tour[1]	[Trip Mode Choice].[*xxxx*].[Shared ride 3 + tour]							
Estimated Coefficients	0.9807	2.7224	–	–	-2.5360	–	–	–
t-statistic	6.61	20.17	–	–	-7.77	–	–	–
Calibrated Coefficients	-1.5000	-0.1800	–	–	1.0000	–	–	–
Walk to transit tour[1]	[Trip Mode Choice].[*xxxx*].[Walk to transit tour]							
Estimated Coefficients	-3.6517	–	-1.0892	–	-2.5604	–	–	–
t-statistic	-13.80	–	-6.19	–	-7.60	–	–	–
Calibrated Coefficients	No Change	-1.3800	-4.6000	–	-4.2200	–	–	–
Drive to transit tour[1]	[Trip Mode Choice].[*xxxx*].[Drive to transit tour]							
Estimated Coefficients	–	1.9935	–	–	–	3.2129	–	–
t-statistic	–	12.97	–	–	–	13.73	–	–
Calibrated Coefficients	-0.2500	0.6500	-0.6000	–	–	No Change	–	–
School bus tour[1]	[Trip Mode Choice].[*xxxx*].[School bus tour]							
Estimated Coefficients	–	3.2980	3.0120	–	–	–	–	–
t-statistic	–	18.57	16.66	–	–	–	–	–
Calibrated Coefficients	–	1.3000	-1.6000	–	–	–	–	–

Variable	Trip Mode: Drive Alone	Shared Ride 2	Shared Ride 3+	Walk	Bike	Walk to Transit	Drive to transit	School Bus
Parent Tour Purpose Variables[5]								
Work tour[1]	[Trip Mode Choice].[*xxxx*].[Work tour]							
Estimated Coefficients	2.2441	–	–	0.7888	2.2314	–	–	–
t-statistic	34.47	–	–	7.58	8.11	–	–	–
Calibrated Coefficients	1.4663	–	–	0.1016	No Change	–	–	–
School tour[1]	[Trip Mode Choice].[*xxxx*].[School tour]							
Estimated Coefficients	–	-1.1342		0.1205	0.3004	–	–	–
t-statistic	–	-12.87		0.95	1.13	–	–	–
Calibrated Coefficients	–	-0.9799	No Change	-0.2000	–	–	–	–
Escort tour[1]	[Trip Mode Choice].[*xxxx*].[Escort tour]							
Estimated Coefficients	2.2410	0.3921		–	–	–	–	–
t-statistic	12.06	2.10		–	–	–	–	–
Calibrated Coefficients	No Change	1.8576	2.8224	–	–	–	–	–
Shop tour[1]	[Trip Mode Choice].[*xxxx*].[Shop tour]							
Estimated Coefficients	–	1.0499		–	–	–	–	–
t-statistic	–	9.68		–	–	–	–	–
Calibrated Coefficients	–	0.8175	1.3500	–	–	–	–	–
Meal tour[1]	[Trip Mode Choice].[*xxxx*].[Meal tour]							
Estimated Coefficients	–	1.0171		–	–	–	–	–
t-statistic	–	8.66		–	–	–	–	–
Calibrated Coefficients	–	0.3158	0.6456	–	–	–	–	–
Social/recreation tour[1]	[Trip Mode Choice].[*xxxx*].[Socialrecreational tour]							
Estimated Coefficients	–	0.1519		–	–	–	–	–
t-statistic	–	1.96		–	–	–	–	–
Calibrated Coefficients	–	No Change	0.5702	–	–	–	–	–
Work-based sub-tour[1]	[Trip Mode Choice].[*xxxx*].[Work based subtour]							
Estimated Coefficients	0.3766	–	–	–	–	–	–	–
t-statistic	3.52	–	–	–	–	–	–	–
Calibrated Coefficients	0.5435	–	–	–	–	–	–	–
Non-closed tour[1]	[Trip Mode Choice].[*xxxx*].[Non-closed tour]							
Estimated Coefficients	–	-0.8403	-0.7177	-2.1470	-2.5560	–	–	–
t-statistic	–	-6.72	-4.86	-9.15	-3.15	–	–	–
Calibrated Coefficients	–	1.8540	2.6400	No Change	No Change	–	–	–

	Trip Mode							
Variable	**Drive Alone**	**Shared Ride 2**	**Shared Ride 3+**	**Walk**	**Bike**	**Walk to Transit**	**Drive to transit**	**School Bus**
Escort Destination Variables								
Home to escort trip[1]	[Trip Mode Choice].[*xxxx*].[Home to escort trip]							
Estimated Coefficients	2.6172	3.3089	2.0681	–	–	–	–	–
t-statistic	4.80	5.08	2.42	–	–	–	–	–
Calibrated Coefficients	No Change	No Change	No Change	–	–	–	–	–
Home to escort trip-AM peak period[1]	[Trip Mode Choice].[*xxxx*].[Home to escort trip-am peak period]							
Estimated Coefficients	–	1.8051	4.0462	–	–	–	–	–
t-statistic	–	4.81	6.00	–	–	–	–	–
Calibrated Coefficients	–	No Change	No Change	–	–	–	–	–
Home to escort trip-Midday period[1]	[Trip Mode Choice].[*xxxx*].[Home to escort trip-midday period]							
Estimated Coefficients	–	-0.8937	-0.8300	–	–	–	–	–
t-statistic	–	-2.45	-1.25	–	–	–	–	–
Calibrated Coefficients	–	No Change	No Change	–	–	–	–	–
Home to escort trip-PM peak period[1]	[Trip Mode Choice].[*xxxx*].[Home to escort trip-pm peak period]							
Estimated Coefficients	–	-1.4250	-1.1687	–	–	–	–	–
t-statistic	–	-3.91	-1.76	–	–	–	–	–
Calibrated Coefficients	–	No Change	No Change	–	–	–	–	–
Home to escort trip-Evening period[1]	[Trip Mode Choice].[*xxxx*].[Home to escort trip-evening period]							
Estimated Coefficients	–	-1.9805	-1.2893	–	–	–	–	–
t-statistic	–	-5.03	-1.84	–	–	–	–	–
Calibrated Coefficients	–	No Change	No Change	–	–	–	–	–
Other to escort trip[1]	[Trip Mode Choice].[*xxxx*].[Other to escort trip]							
Estimated Coefficients	–	–	-0.6301	–	–	–	–	–
t-statistic	–	–	-10.23	–	–	–	–	–
Calibrated Coefficients	–	–	No Change	–	–	–	–	–
Escort Trip Sequencing Variables								
Previous mode drive alone and previous purpose escort[1]	[Trip Mode Choice].[*xxxx*].[Prv Mode DA Prv Purp Esc]							
Estimated Coefficients	–	5.2722	3.9971	–	–	–	–	–
t-statistic	–	14.78	10.95	–	–	–	–	–
Calibrated Coefficients	–	No Change	No Change	–	–	–	–	–

Variable	Trip Mode							
	Drive Alone	Shared Ride 2	Shared Ride 3+	Walk	Bike	Walk to Transit	Drive to transit	School Bus
Previous mode drive alone and previous purpose escort – AM peak[1]	[Trip Mode Choice].[*xxxx*].[Prv Mode DA Prv Purp Esc AMPk]							
Estimated Coefficients	–	-1.3857	-1.2737	–	–	–	–	–
t-statistic	–	-2.01	-1.75	–	–	–	–	–
Calibrated Coefficients	–	No Change	No Change	–	–	–	–	–
Previous mode shared ride 2 and previous purpose escort[1]	[Trip Mode Choice].[*xxxx*].[Prv Mode SR2 Prv Purp Esc]							
Estimated Coefficients	3.0603	–	3.6329	–	–	–	–	–
t-statistic	22.27	–	24.14	–	–	–	–	–
Calibrated Coefficients	No Change	–	No Change	–	–	–	–	–
Previous mode shared ride 2 and previous purpose escort – AM peak[1]	[Trip Mode Choice].[*xxxx*].[Prv Mode SR2 Prv Purp Esc AMPk]							
Estimated Coefficients	2.1429	–	–	–	–	–	–	–
t-statistic	11.14	–	–	–	–	–	–	–
Calibrated Coefficients	No Change	–	–	–	–	–	–	–
Previous mode shared ride 2 and previous purpose escort – PM peak[1]	[Trip Mode Choice].[*xxxx*].[Prv Mode SR2 Prv Purp Esc PMPk]							
Estimated Coefficients	-0.4745	–	–	–	–	–	–	–
t-statistic	-2.74	–	–	–	–	–	–	–
Calibrated Coefficients	No Change	–	–	–	–	–	–	–
Previous mode shared ride 3+ and previous purpose escort[1]	[Trip Mode Choice].[*xxxx*].[Prv Mode SR3 Prv Purp Esc]							
Estimated Coefficients	0.3559	1.5227	–	–	–	–	–	–
t-statistic	2.90	18.62	–	–	–	–	–	–
Calibrated Coefficients	No Change	No Change	–	–	–	–	–	–
Previous mode shared ride 3+ and previous purpose escort – AM peak[1]	[Trip Mode Choice].[*xxxx*].[Prv Mode SR3 Prv Purp Esc AMPk]							
Estimated Coefficients	1.2367	0.6024	–	–	–	–	–	–
t-statistic	8.55	5.62	–	–	–	–	–	–
Calibrated Coefficients	No Change	No Change	–	–	–	–	–	–
Previous mode shared ride 3+ and previous purpose escort – PM peak[1]	[Trip Mode Choice].[*xxxx*].[Prv Mode SR3 Prv Purp Esc PMPk]							
Estimated Coefficients	-1.1574	-0.9103	–	–	–	–	–	–
t-statistic	-6.36	-8.21	–	–	–	–	–	–
Calibrated Coefficients	No Change	No Change	–	–	–	–	–	–

Variable	Trip Mode							
	Drive Alone	Shared Ride 2	Shared Ride 3+	Walk	Bike	Walk to Transit	Drive to transit	School Bus
***Sampling Bias Variables*[2]**								
FREX oversample	*Used for Model Estimation Only*							
Estimated Coefficients	–	–	–	–	–	0.7792	1.9729	–
t-statistic	–	–	–	–	–	1.58	4.15	–
Calibrated Coefficients	–	–	–	–	–	–	–	–
Transit oversample	*Used for Model Estimation Only*							
Estimated Coefficients	–	–	–	–	–	-0.1803	0.0860	–
t-statistic	–	–	–	–	–	-1.34	0.34	–
Calibrated Coefficients	–	–	–	–	–	–	–	–
Model Estimation Statistics								
Number of Observations	77,174							
Log-likelihood at Convergence	-30736.43							
Log-likelihood at Constants	-44,519.49							
Log-likelihood at Null Parameters	–							
Rho-squared w.r.t. Constants	0.310							
Rho-squared w.r.t. Null Parameters	–							

Source: Cambridge Systematics

Notes:

[1] C# variable names are consistent across modes with the exception that "[*xxxx*]" is trip mode specific as follows:

[Drive alone]
[Shared ride 2]
[Shared ride 3+]
[Walk]
[Bike]
[Walk to transit]
[Drive to transit]
[School bus]

[2] The same generalized time coefficient is used for all trip modes. However, the calculation of generalized time varies by trip mode based on the tour purpose within which the trip is being made and the associated tour mode choice model coefficients estimated for the same mode.

[3] The StateFocus Code Parameter Names for income related variables are input as a six element array as follows: [Less than $30K, $30K-$40K, $40K-$60K, $60K-$100K, $100K-$150K, $150K or more]. The six elements correspond to the following income groups: [Lower income, Modest Income, Modest Income (modest income coefficient is repeated), Middle Income, Upper Income, Top Income].

[4] Variable used for model estimation purposes only and is not used in model application.

[5] With the exception of the non-closed tour variables, the tour parent mode variables are mutually exclusive. Tour purposes are single purpose only: home-based work "xor" home-based school "xor" home-based escort, etc. ("xor" means exclusive or). However, any of the tour purposes may also be non-closed tours.

F.19 Trip Time of Day Choice

Trip time of day choice model variables, StateFocus C# parameter names, estimated model coefficients and t-statistics, and final calibrated parameters based on the 2015 model calibration/validation are shown in ***Table F.57***, below. Definitions of the variables are shown in ***Section 4.2.19***.

Table F.57 Trip Time of Day Choice Coefficients

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Generalized Time Variable (Minutes)				
Auto	[Trip Time of Day].[Auto generalized time (min) in period]	-0.033	Constrained	No Change
Transit	[Trip Time of Day].[Transit generalized time (min) in period]	-0.024	Constrained	No Change
Transit tour with no transit path in time period	[Trip Time of Day].[Transit tour- No transit path in period]	-20.000	Constrained	No Change
Duration Shift Variables				
Person Characteristics				
Child age 0-4	[Trip Time of Day].[Child age 0-4 - Duration shift]	0.239	5.71	0.600
Child age 5-15	[Trip Time of Day].[Child age 5-15 - Duration shift]	0.427	12.20	0.700
Driving age student	[Trip Time of Day].[K12 student 16+ - Duration shift]	0.410	9.78	0.200
University student	[Trip Time of Day].[University student- Duration shift]	0.303	6.23	-0.200
Other non-worker	[Trip Time of Day].[Non-worker age<65 - Duration shift]	0.123	3.64	0.200
Retirement age non-worker	[Trip Time of Day].[Non-worker age 65+ - Duration shift]	0.125	5.15	-0.200
Stop Purpose				
School stop	[Trip Time of Day].[School stop - Duration shift]	0.207	3.78	No Change
Escort stop	[Trip Time of Day].[Escort stop - Duration shift]	-0.449	-10.70	No Change
Personal business stop	[Trip Time of Day].[Personal business stop - Duration shift]	-0.187	-5.49	No Change
Shop stop	[Trip Time of Day].[Shopping stop - Duration shift]	-0.300	-9.55	No Change
Meal stop	[Trip Time of Day].[Meal stop - Duration shift]	-0.111	-2.23	No Change
Social/recreation stop	[Trip Time of Day].[Social/recreation stop - Duration shift]	0.151	4.00	No Change

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Tour Purpose				
Work tour outbound	[Trip Time of Day].[Work tour outbound - Duration shift]	0.250	9.17	-0.300
Work tour inbound	[Trip Time of Day].[Work tour return - Duration shift]	-0.921	-17.56	-0.300
Non-work tour inbound	[Trip Time of Day].[Non-work tour return - Duration shift]	-1.443	-16.32	-0.900
Work-based sub-tour	[Trip Time of Day].[Work-based subtour - Duration shift]	0.628	7.88	No Change
Duration Constants[1]				
Duration – 00:00-00:59 Hours	[Trip Time of Day].[DurationConstants]	-0.799	-9.76	1.500
Duration – 01:00-01:59 Hours	[Trip Time of Day].[DurationConstants]	0.586	14.23	2.300
Duration – 02:00-02:59 Hours	[Trip Time of Day].[DurationConstants]	0.000	Constr	1.550
Duration – 03:00-03:59 Hours	[Trip Time of Day].[DurationConstants]	1.232	17.56	1.000
Duration – 04:00-04:59 Hours	[Trip Time of Day].[DurationConstants]			0.600
Duration – 05:00-05:59 Hours	[Trip Time of Day].[DurationConstants]	2.764	18.14	0.000
Duration – 06:00-06:59 Hours	[Trip Time of Day].[DurationConstants]			-0.500
Duration – 07:00-07:59 Hours	[Trip Time of Day].[DurationConstants]	3.401	17.56	-0.500
Duration – 08:00-08:59 Hours	[Trip Time of Day].[DurationConstants]			-3.000
Duration – 09:00-09:59 Hours	[Trip Time of Day].[DurationConstants]	5.086	19.76	-3.000
Duration – 10:00-10:59 Hours	[Trip Time of Day].[DurationConstants]			-5.000
Duration – 11:00-11:59 Hours	[Trip Time of Day].[DurationConstants]			-5.000
Duration – 12:00-12:59 Hours	[Trip Time of Day].[DurationConstants]	6.112	12.31	-5.000
Duration – 13:00-13:59 Hours	[Trip Time of Day].[DurationConstants]			-5.000
Duration – 14:00-14:59 Hours	[Trip Time of Day].[DurationConstants]	7.256	10.67	-10.000
Duration – 15:00-15:59 Hours	[Trip Time of Day].[DurationConstants]			-10.000
Duration – 16:00-16:59 Hours	[Trip Time of Day].[DurationConstants]			-10.000
Duration – 17:00-17:59 Hours	[Trip Time of Day].[DurationConstants]			-10.000
Duration – 18:00-18:59 Hours	[Trip Time of Day].[DurationConstants]	-10.000	Constr	-15.000
Duration – 19:00-19:59 Hours	[Trip Time of Day].[DurationConstants]			-15.000
Duration – 20:00-20:59 Hours	[Trip Time of Day].[DurationConstants]			-15.000
Duration – 21:00-21:59 Hours	[Trip Time of Day].[DurationConstants]			-15.000
Duration – 22:00-22:59 Hours	[Trip Time of Day].[DurationConstants]			-15.000
Duration – 23:00-23:59 Hours	[Trip Time of Day].[DurationConstants]			-15.000

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Other Variables				
Arrival period partially used	[Trip Time of Day].[Arrival period partially used]	1.469	8.56	No Change
Departure period partially used	[Trip Time of Day].[Departure period partially used]	-0.431	-2.94	No Change
Remaining tours/total remaining window	[Trip Time of Day].[Remaining tours/ total remaining window]	-4.119	-5.72	No Change
Remaining stops on half-tour/ adjacent window	[Trip Time of Day].[Remaining stops on half tour/adjacent window]	-8.325	-15.28	No Change
Arrival Constants[2]				
Arrival – 00:00-00:59	[Trip Time of Day].[ArrivalTimeConstants]			2.000
Arrival – 01:00-01:59	[Trip Time of Day].[ArrivalTimeConstants]	8.253	7.35	2.000
Arrival – 02:00-02:59	[Trip Time of Day].[ArrivalTimeConstants]			2.000
Arrival – 03:00-03:59	[Trip Time of Day].[ArrivalTimeConstants]			2.000
Arrival – 04:00-04:59	[Trip Time of Day].[ArrivalTimeConstants]	0.187	1.74	-1.000
Arrival – 05:00-05:59	[Trip Time of Day].[ArrivalTimeConstants]			-2.500
Arrival – 06:00-06:59	[Trip Time of Day].[ArrivalTimeConstants]	-2.221	-8.67	-4.000
Arrival – 07:00-07:59	[Trip Time of Day].[ArrivalTimeConstants]	-0.798	-8.23	-2.000
Arrival – 08:00-08:59	[Trip Time of Day].[ArrivalTimeConstants]	0.000	Constr	-1.000
Arrival – 09:00-09:59	[Trip Time of Day].[ArrivalTimeConstants]	0.402	2.97	0.000
Arrival – 10:00-10:59	[Trip Time of Day].[ArrivalTimeConstants]			2.800
Arrival – 11:00-11:59	[Trip Time of Day].[ArrivalTimeConstants]	1.632	10.43	3.200
Arrival – 12:00-12:59	[Trip Time of Day].[ArrivalTimeConstants]			2.600
Arrival – 13:00-13:59	[Trip Time of Day].[ArrivalTimeConstants]			2.000
Arrival – 14:00-14:59	[Trip Time of Day].[ArrivalTimeConstants]	3.279	11.77	2.000
Arrival – 15:00-15:59	[Trip Time of Day].[ArrivalTimeConstants]			1.500
Arrival – 16:00-16:59	[Trip Time of Day].[ArrivalTimeConstants]			0.750
Arrival – 17:00-17:59	[Trip Time of Day].[ArrivalTimeConstants]	3.981	10.22	1.000
Arrival – 18:00-18:59	[Trip Time of Day].[ArrivalTimeConstants]			2.000
Arrival – 19:00-19:59	[Trip Time of Day].[ArrivalTimeConstants]			2.000
Arrival – 20:00-20:59	[Trip Time of Day].[ArrivalTimeConstants]	4.902	8.67	2.000
Arrival – 21:00-21:59	[Trip Time of Day].[ArrivalTimeConstants]			2.000
Arrival – 22:00-22:59	[Trip Time of Day].[ArrivalTimeConstants]	8.253	7.35	2.000
Arrival – 23:00-23:59	[Trip Time of Day].[ArrivalTimeConstants]			2.000

Variable	StateFocus Code Parameter Name	Estimated Coefficient	(t-Statistic)	Calibrated Coefficient
Departure Constants[3]				
Departure – 00:00-00:59	[Trip Time of Day].[DepartureTimeConstants]	-2.689	-9.26	-1.021
Departure – 01:00-01:59	[Trip Time of Day].[DepartureTimeConstants]			-1.428
Departure – 02:00-02:59	[Trip Time of Day].[DepartureTimeConstants]			-1.428
Departure – 03:00-03:59	[Trip Time of Day].[DepartureTimeConstants]			-1.428
Departure – 04:00-04:59	[Trip Time of Day].[DepartureTimeConstants]	-1.222	-1.60	-2.689
Departure – 05:00-05:59	[Trip Time of Day].[DepartureTimeConstants]			-2.689
Departure – 06:00-06:59	[Trip Time of Day].[DepartureTimeConstants]			-2.689
Departure – 07:00-07:59	[Trip Time of Day].[DepartureTimeConstants]	-0.864	-4.24	-2.689
Departure – 08:00-08:59	[Trip Time of Day].[DepartureTimeConstants]			-1.222
Departure – 09:00-09:59	[Trip Time of Day].[DepartureTimeConstants]			1.000
Departure – 10:00-10:59	[Trip Time of Day].[DepartureTimeConstants]	-0.403	-3.31	1.800
Departure – 11:00-11:59	[Trip Time of Day].[DepartureTimeConstants]			3.500
Departure – 12:00-12:59	[Trip Time of Day].[DepartureTimeConstants]			2.700
Departure – 13:00-13:59	[Trip Time of Day].[DepartureTimeConstants]	-0.227	-4.08	1.100
Departure – 14:00-14:59	[Trip Time of Day].[DepartureTimeConstants]			0.800
Departure – 15:00-15:59	[Trip Time of Day].[DepartureTimeConstants]			0.000
Departure – 16:00-16:59	[Trip Time of Day].[DepartureTimeConstants]	0.000	Constr	-0.800
Departure – 17:00-17:59	[Trip Time of Day].[DepartureTimeConstants]	0.097	1.49	-1.700
Departure – 18:00-18:59	[Trip Time of Day].[DepartureTimeConstants]	-0.510	-5.97	-2.200
Departure – 19:00-19:59	[Trip Time of Day].[DepartureTimeConstants]	-1.021	-8.00	-2.200
Departure – 20:00-20:59	[Trip Time of Day].[DepartureTimeConstants]			-2.200
Departure – 21:00-21:59	[Trip Time of Day].[DepartureTimeConstants]	-1.428	-6.93	-1.500
Departure – 22:00-22:59	[Trip Time of Day].[DepartureTimeConstants]			-1.200
Departure – 23:00-23:59	[Trip Time of Day].[DepartureTimeConstants]			-1.021
Model Estimation Statistics				
Number of Observations	107,864			
Final Log-likelihood	-122,090.2			
Rho-squared (0)	0.446			

Source: Cambridge Systematics

Notes:
[1] Duration constants (Duration – HH:00-HH:59 Hours) are input as a 24 cell array. Variables with common coefficients and t-scores were estimated as grouped variables. Calibrated coefficients for parts of the grouped cells might vary.
[2] Arrival constants (Arrival – HH:00-HH:59) are input as a 24 cell array. Variables with common coefficients and t-scores were estimated as grouped variables. Calibrated coefficients for parts of the grouped cells might vary.
[3] Departure constants (Departure – HH:00-HH:59) are input as a 24 cell array. Variables with common coefficients and t-scores were estimated as grouped variables. Calibrated coefficients for parts of the grouped cells might vary.