SimAGENT Core Models 4

SimAGENT Activity-Based Travel Demand Analysis

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SimAGENT Activity-Based Travel-Demand Analysis: Framework, Behavioral Models, and Application Results

Table of Contents

1. Introduction

The State of California has recently embarked on an aggressive movement towards reducing greenhouse gas emissions that contribute to global climate change, promoting sustainability, and better managing vehicular travel demand. The recent California State Senate Bill 375 explicitly calls for major metropolitan areas in California to meet ambitious greenhouse gas (GHG) emission reduction targets within the next several years. Metro areas are considering a range of policies to meet the emission reduction targets including land use strategies, pricing mechanisms, managed lanes, telecommuting and flexible work hours, enhancement of transit and pedestrian/bicycle modes, and use of technology to better utilize existing capacity. The analysis of these policies, and responding to the mandates of legislative actions such as Senate Bill 375 in California, calls for the adoption of model systems that are able to accurately represent activity travel patterns in a fine-resolution time-space continuum. Moreover, these model systems are expected to provide a platform for simulating integrated land use and transportation plans that are better able to represent gains in emission control in the medium (5-10 years) and the longer term (10-25 years) horizons.

The Southern California Association of Governments (SCAG), the metropolitan planning agency for the Southern California region (includes the counties of Imperial, Los Angeles, Orange, Riverside, San Bernardino, and Ventura), is moving forward with the development of a comprehensive activity-based microsimulation model system of travel demand to enhance its ability to estimate the impacts of a range of policy measures in response to Senate Bill 375. SCAG is also required to develop a "Sustainable Community Strategy" through integration of land use and transportation planning and demonstrate its ability to meet the GHG emissions reduction targets by 2020 (8% GHG per capita per day reduction) and 2035 (13% GHG per capita per day tentatively). These are challenging targets for such a vast region, which includes a

population of approximately 18.6 million people in 2008 (expected to grow to 23 million by 2035) and offers an extremely complex multimodal and diverse planning context with multiple actors in different jurisdictions. The new activity-based microsimulation model system is developed to address exactly this diversity among persons and contexts, it is expected to be used in the 2016 Regional Transportation Plan (RTP), and is described in this paper. This model system is the outcome of the second phase of research and development as well as application of the Simulator of Activities, Greenhouse Emissions, Networks, and Travel (SimAGENT), which is tailored to the Southern California region and is compared to the four step model system used in the SCAG 2008 Regional Transportation Plan.

There are four major components in SimAGENT each of which is designed to handle specific tasks. First, PopGen is the model system used to recreate the population (household and person characteristics) of the SCAG area and is developed at Arizona State University. Second, Comprehensive Econometric Microsimulator of Socio-Economics, Land use and Transportation Systems (CEMSELTS) is the component used to give additional socio-economic and demographic attributes for each person in the synthetic population with a view to develop a rich set of input data for the activity-based microsimulation model system. Third, latest version of Comprehensive Econometric Microsimulator of Daily Activity-travel (CEMDAP III) modified and tailored for the California region, is the component used to give each person a daily schedule of activities and travel. Both CEMSELTS and CEMDAP III are developed at UT Austin and were already implemented for the DFW region in the past. Lastly, the output from CEMDAP is aggregated to the zonal level to construct OD trip tables, which are loaded onto the transportation network using TRANSIMS, and finally, the vehicle activity is translated into emissions using EMFAC which is the California region specific emissions estimation tool used for all conformity analysis.

In this chapter, we discuss the modified CEMSELTS and CEMDAP III components of SimAGENT. Specifically, the chapter is organized as follows. Section 2 discusses the implementation of CEMSELTS to generate the disaggregate household and person level inputs required for CEMDAP. Section 3 describes the econometric modeling system and the microsimulation framework embedded within the latest version of CEMDAP. Section 4 presents

the empirical validation of CEMDAP and the results of sensitivity testing undertaken using CEMDAP.

2. Modified CEMSELTS

The synthetic population that is obtained from PopGen includes a host of demographic and socio-economic attributes for each household. These attributes are those available in the sample file (regardless of whether they were used as control variables in the synthesis process). For example, one may have used household size, number of workers, and household income as household level control variables. In addition to these variables, there are a host of other household attributes that are likely to be available in the sample file, and all of them get carried over into the synthetic population. These may include such variables as vehicle ownership, number of children, housing unit type, family type, race of householder, age of householder, and ownership of home. Similarly, a host of person-level attributes are also carried over into the synthetic population file.

As mentioned earlier, the replication of sample records in the synthetic population results in the loss of a rich variance in population socio-economic characteristics. Moreover, many of the socio-economic choice phenomena are not explicitly modeled as a function of other demographic attributes, thus creating a system where long and medium term choice decisions are not sensitive to household and person demographic characteristics. To overcome these limitations and provide a rich set of socio-economic inputs for activity-based modeling, SimAGENT integrates a comprehensive econometric microsimulator of socio-economics, land-use, and transportation system (CEMSELTS). All of the variables that can be simulated by CEMSELTS are stripped away from the synthetic population generated by PopGen and replaced with simulated values from CEMSELTS. The resulting richer set of inputs is then fed to CEMDAP, the core activity-based modeling engine within SimAGENT to simulate complete daily activity-travel patterns for the population of the region.

Figure 1 presents the overall framework of CEMSELTS. The base year module of CEMSELTS is comprised of two components. The first component corresponds to a series of individual attributes including educational attainment, student status, school/college location, labor force participation, employment industry, work location, weekly work duration, and work flexibility. The second module corresponds to household level attributes of interest including household income, residential tenure, housing unit type, and household vehicle fleet characteristics. The model system may be considered a hierarchical system of submodels where the outputs of a model higher in the hierarchy serve as inputs to subsequent models later in the hierarchy. Virtually all of the models constitute econometric choice or duration models. The estimates of all the model components in CEMSELTS and lookup tables for determining education status are presented in Appendix A.

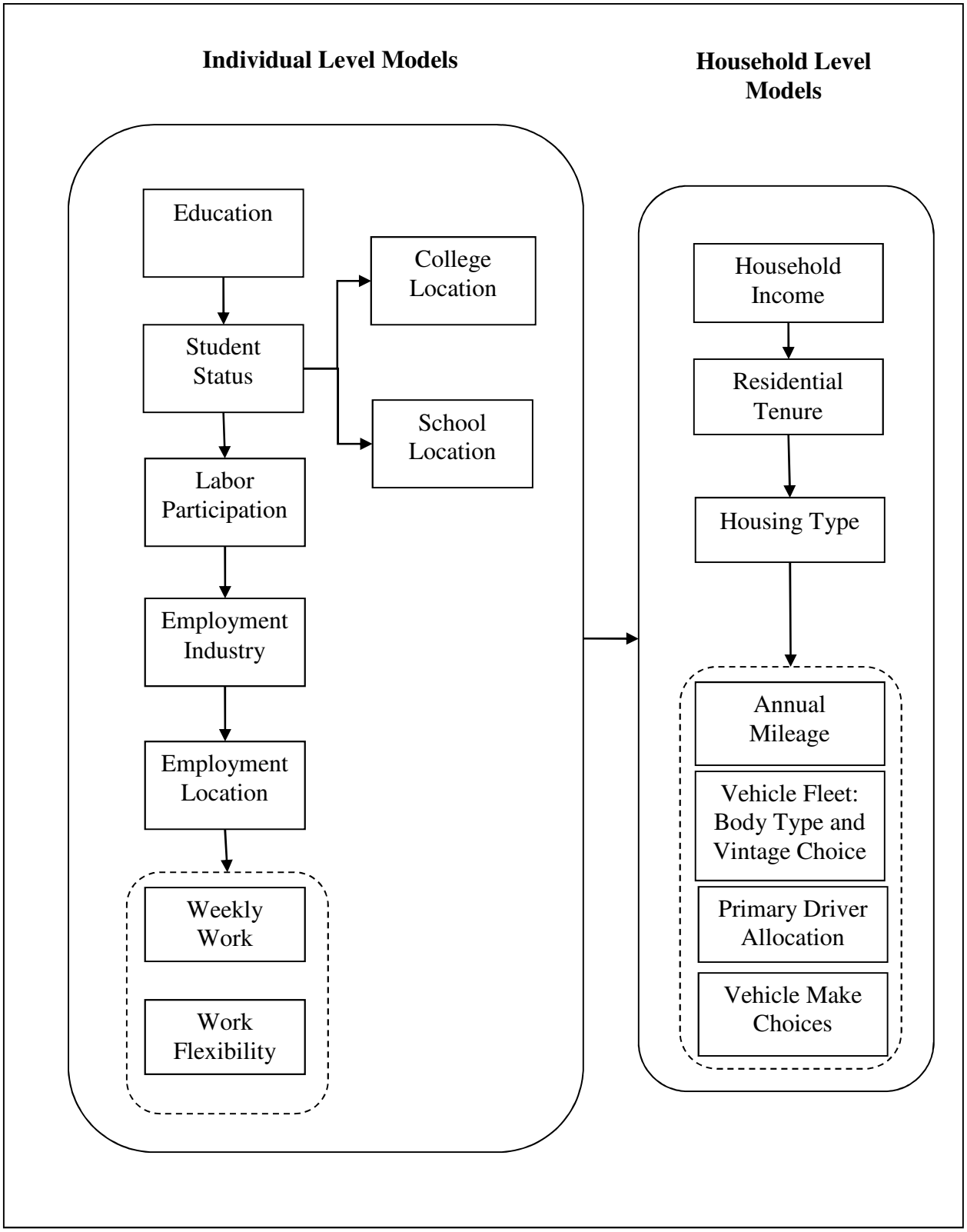


Figure 1. Basic Framework of CEMSELTS

2.1 Individual Level Models

Within the CEMSELTS model, all individuals under five years of age are assumed to not go to school (although they may go to child care facilities, such activities are modeled in CEMDAP). All individuals between 5 and 12 years of age are assumed to pursue education using a rule-based assignment to grades kindergarten through seven, based on age of the child. A rule-based probability model, constructed using look-up tables of school drop-out rates, is be used to determine the education level of individuals between 13 and 18 years of age based on such attributes as age, gender, and race. Another rule-based probability model, similarly constructed using look-up tables of educational achievement, is used within CEMSELTS to determine the education status of each individual 18 years of age or over.

Following the modeling of educational status, the school and college location of all individuals who are students are simulated. At this time, for simplicity, a simple rule-based school location model is used for individuals under the age of 18. All individuals under the age of 18 are assumed to go to school to the closest zone (to the home zone) with a school. While it is true that many students attend schools that are not within their neighborhood or assigned school district, it is difficult to model school location choice in the absence of attributes about the various schools in the region. If such data were available, then a robust school location choice model could have been estimated. For those 18 years or age or over, a multinomial logit model of college location choice is estimated and deployed in CEMSELTS. All of the zones with colleges and universities constitute the choice set for the college location model.

A binary logit model is used to determine whether an individual is participating in the labor force. This model is estimated and applied for all individuals aged 16 years and over. The employment industry is determined using a classic multinomial logit model with the following six alternatives – construction and manufacturing, trade and transportation, professional business, government, retail, and other. The work location of all workers is determined using a multinomial logit model. The universe of zones in the study region forms the choice set for this

model. Several zonal characteristics including population, fraction of retail employment, fraction of service employment, level of service variables including travel time and travel cost, and accessibility measures capturing the number of employees (in 15 different industry types) that can be reached within different travel time windows from any given zone are included as explanatory variables in the work location model. In addition, several interaction variables that account for observed heterogeneity among individuals (due to demographic attributes, such as age and gender) are included in the work location model specification.

Finally, two additional work characteristics – weekly work duration and work flexibility – are modeled. While weekly time expenditure for work may be modeled as a continuous duration variable, CEMSELTS models weekly work duration using a multinomial logit model with a view to determine whether an individual works part-time, full-time, or over-time. The three alternatives are defined as working less than 35 hours per week, between 35 and 45 hours per week, and over 45 hours per week. Work flexibility is characterized as an ordinal variable with four levels – none, low, medium, and high degrees of flexibility (as specified by respondents to travel surveys that include such information).

2.2 Household Models

CEMSELTS includes a model of household income that includes a host of employment, employment industry, and demographic variables as explanatory factors. A grouped ordered response model formulation is used for household income. The five categories in the household income model of CEMSELTS are: less than $10,000 per year, between $10,000 and $35,000 per year, between $35,000 and $50,000 per year, between $50,000 and $75,000 per year, and more than $75,000 per year. Home ownership (whether own or rent housing unit) is determined using a binary logit model that includes a series of socio-economic and demographic attributes as explanatory variables in addition to a few accessibility and built environment variables. Separate multinomial logit models are estimated and applied to the two home ownership groups (owners and renters) to determine housing unit type. The alternatives in the multinomial logit model for households that own their units are single-family detached, single-family attached, and mobile

home/trailer. The alternatives in the model for those renting their home are single-family detached, single-family attached, and apartment.

Finally, CEMSELTS includes a series of four models that collectively simulate the vehicle fleet composition for each household in the synthetic population. Unlike most models that only simulate vehicle count, the latest version of CEMSELTS is capable of simulating vehicle fleet composition with each vehicle characterized by body type, vintage, and make and model. In addition, each vehicle is assigned a primary driver from the household. This allows one to track vehicle usage later in the activity-travel simulation process, a critical step towards more accurately forecasting energy consumption and greenhouse gas emissions in response to alternative policies aimed at encouraging ownership and use of fuel efficient and clean vehicles.

We used the residential component of the 2008 California Vehicle Survey data collected by the California Energy Commission (CEC) to estimate the vehicle fleet composition and use MDCEV model. The residential component of the survey had two components - a revealed preference (RP) data component and a stated preference (SP) data component. In this analysis, we use the RP data. The RP data contained information on all vehicles currently owned by the household, including vehicle body type, vintage, vehicle year, make, annual mileage, and primary driver, in addition to detailed household and individual level demographics. The RP data was collected for a sample of households representative of the population of households in the State of California. In the vehicle fleet composition and allocation module, the total annual household mileage (including non-motorized mileage) is first determined using a log-linear regression model. However, the survey data did not collect information about the household's non-motorized mileage. So, we estimated the non-motorized mileage of each household using a deterministic rule that each individual in the household walks or bikes for half a mile daily. The total annual non-motorized mileage for a household is obtained as 0.5*365*(household size). The output of this model is used as input to the joint Multiple Discrete Continuous Extreme Value (MDCEV)-MNL model of vehicle fleet composition and primary driver allocation (Bhat and Sen, 2006, Vyas *et al.,* 2012). This model uses the total mileage as a travel budget which is allocated across the fleet of vehicles in the household. The MDCEV model formulation explicitly recognizes that

vehicle ownership is characterized by multiple discreteness, with households free to choose multiple vehicle alternatives from among those in the market place.

At this time, each alternative in the MDCEV model is defined as a combination of body type and vintage category. Nine body types are used, namely, sub-compact car, compact car, medium car, large car, sports car, medium sports utility vehicle (SUV), large SUV, van, and pick-up truck. Six different vintage categories are used, namely, new or less than one year, two to three years, four to five years, six to nine years, 10 to 12 years, and more than 12 years. The fuel type is not yet included as a dimension in the vehicle type choice model because of the very few observations of alternative fuel vehicles in virtually all vehicle data sets of travel surveys. As additional survey data about ownership of alternative fueled vehicles becomes available, the vehicle fleet composition simulation framework in CEMSELTS can be easily expanded to include consideration of fuel type. In the current version, the total number of alternatives in the MDCEV model is 55 (54 combinations of body type and vintage categories plus one non-motorized mileage alternative). A multinomial logit model formulation is used to model the primary driver of each vehicle owned by the household. The CEC data collected primary driver information for each vehicle owned by the household. The number of alternatives in this model component is equal to the number of licensed drivers in the household. This model component includes interaction terms that account for observed heterogeneity due to demographic attributes (such as gender, education, employment) that affects the allocation of drivers to vehicles.

After the vehicle type and the primary driver is simulated, the make and model of all vehicles in the fleet is determined. This is done using a multinomial logit model. The choice set for the multinomial logit model varies by body type and vintage category. There are a total of 759 make and model alternatives across all of the 54 combinations of body type and vintage categories. The model specifications include numerous variables that describe the attributes of each vehicle make and model. The model is therefore able to include several key vehicle attributes such as dimensions of the vehicle, horse power, engine capacity, type of wheel drive, curb weight, greenhouse gas rating, annual fuel cost, purchase price, and vehicle manufacturer indicator variables.

Currently, all the models in CEMSELTS except for the suite of four models which model the vehicle fleet composition and allocate each vehicle to a primary driver in the household, are implemented externally for the synthetic population using Gauss software. The log-linear vehicle mileage model, vehicle fleet MDCEV model, vehicle make MNL model, and primary driver allocation MNL model are integrated with the activity based microsimulation framework CEMDAP.

2.3 Data

The Southern California Association of Governments (SCAG) provided data regarding school drop-out rates for various ages so that a rule-based probability model of being in school could be constructed for 13 to 18 year old individuals based on age, gender, and race. The agency also provided data regarding educational attainment status for individuals 18 years or age or older. Much of this data is based on census information and is therefore representative of the trends in the population. Accessibility indicators which measure the number of employees that can be reached from any zone within various travel time windows were constructed using detailed micro-level land use data provided by SCAG (Chen *et al.*, 2011). Models of work location, work flexibility, and labor force participation at the person level, and household income at the household level, were estimated using the 2000 Post Census Regional Household Travel Survey conducted by the SCAG. Finally, the MDCEV model of vehicle fleet composition and MNL model for primary driver allocation are estimated using the residential component of the California vehicle survey data collected in 2008. The information for the vehicle make model is obtained from the Wards Automotive Year Books and Green Vehicle Guide of the US Environmental Protection Agency (Binder, 2010; EPA, 2011). This secondary data is appended to the vehicle records in the CEC dataset to facilitate vehicle make MNL model estimation. In summary, a suite of models were estimated using local survey and land use data so that the model system was customized to reflect conditions in Southern California.

2.4 Validation Results from the Application of CEMSELTS

This section presents a detailed discussion of the results obtained from the application of CEMSELTS to model socio-economic characteristics of the synthetic population for the

Southern California region. In order to validate CEMSELTS, the predictions from CEMSELTS were compared against regional socio-economic characteristics as reported in the American Community Survey (ACS) data of 2003 and the decennial census data of 2000. In Table 1, results from the person-level modules of CEMSELTS are compared against the census distributions for these two years. Note that the simulation year for CEMSELTS (and PopGen) is 2003. The model generally predicts characteristics of the population quite well. For children 3 to 17 years old, the model under-predicts the proportion of individuals in the higher grades and over-predicts the proportion of young children going to preschool through third grade. With regard to educational attainment status for adults, the model predicts a larger proportion of individuals as completing high school, whereas the census distributions show higher percentages of individuals having an education attainment less than high school completion. Nevertheless, the model reflects the general trend reasonably well. The labor force participation rate is replicated quite well. The employment distribution is also reasonably consistent with census distributions except for construction and manufacturing and retail trade where the model under-predicts the proportions, and the other category here the model appears to over-predict the proportion. Overall, percent differences are not substantial.

In Table 2, a comparison of the output of the household level modules of CEMSELTS against census distributions shows that the model, with a few exceptions, is able to replicate distributions quite well. The vehicle ownership distribution is replicated very well, except for a modest over-prediction of the proportion of households falling into the highest vehicle ownership category of four or more vehicles. The distribution of households by number of workers is predicted in a satisfactory manner, with a slight over-prediction of zero-worker households and a slight under-prediction of households with two or more workers. The income distribution is also replicated well, although there is an under-prediction of the percent of households in the highest two income brackets and an over-prediction of the percent of households in the second income bracket. Home ownership and housing unit type distributions are matched very well; however, the housing unit type for renters shows considerable discrepancy. Additional work is warranted in the estimation and calibration of a renter housing unit type model. Whereas CEMSELTS predicts that renters are equally split between single units (attached and detached) and

apartments, the census data suggests that nearly three quarters of renters are residing in apartments.

Table 3 offers a detailed look at census journey to work flow distributions in comparison to CEMSELTS predictions of work flows. These work-flows are based on the work locations simulated by CEMSELTS for all workers in the synthetic population. For each origin county in the Southern California model region, the table shows the percent of workers whose work location is within the origin county versus the percent of workers whose work location is outside the origin (home) county. About 85 percent of workers have a work location within the origin (home) county according to the census (American Community Survey data of 2003) and CEMSELTS replicates this number almost perfectly. Even when one examines individual counties, CEMSELTS does an excellent job of replicating journey to work patterns. Note that, consistent with expectations, just over 50 percent of all workers live and work in Los Angeles County – a statistic that is replicated by CEMSELTS.

Table 4 shows the journey to work flow distributions by county pair for the year 2000 (such information is available only in the decennial Census year of 2000) and compares the flow distributions against predictions provided by CEMSELTS. It is once again seen that the model is able to predict county to county work flow patterns remarkably well. The differences between the predicted distributions and the observed census distributions are very small for virtually all cells in the table. Overall, it appears that CEMSELTS is able to simulate socio-economic and work flow characteristics for the synthetic population such that the resulting synthetic population is representative of the true population in the region.

Table 1. CEMSELTS 2003 Individual Level Modules – Comparison with ACS 2003 and Census 2000

Individual Socio-demographics	Values in Percent			Values in Percent		
	ACS 2003	CEMSELTS Predicted	Difference in Percentage	Census 2000	CEMSELTS Predicted	Difference in Percentage
Enrollment of Children (3 to 17 years)						
Preschool - Grade 3	37.07	44.59	7.52	41.17	44.59	3.42
Grade 4 - Grade 8	41.64	42.16	0.52	38.76	42.16	3.40
Grade 9 - Grade 11	21.29	13.25	-8.04	20.07	13.25	-6.82
Educational Attainment (Adults)						
Less than Grade 9	11.58	2.23	-9.35	13.14	2.23	-10.91
Grade 9 - Grade 12 (no diploma)	12.05	8.28	-3.78	14.71	8.28	-6.44
Completed High School	45.70	58.48	12.78	44.00	58.48	14.48
Associate or Bachelors	22.55	22.95	0.41	20.77	22.95	2.18
Graduate Degree (Masters or Ph.D)	8.12	8.06	-0.06	7.37	8.06	0.69
Labor Participation						
Employed	59.47	59.07	-0.40	56.81	59.07	2.26
Unemployed	40.53	40.93	0.40	43.19	40.93	-2.26
Employment Industry						
Construction and Manufacturing	19.92	14.46	-5.46	20.67	14.46	-6.21
Trade and Transportation	4.94	7.32	2.38	4.86	7.32	2.46
Personal, Professional and Financial	50.63	49.42	-1.21	49.34	49.42	0.08
Public and Military	3.94	5.07	1.13	4.04	5.07	1.03
Retail Trade	15.29	10.77	-4.51	15.60	10.77	-4.83
Other	5.28	12.96	7.68	5.49	12.96	7.47

Table 2. CEMSELTS 2003 Household Level Modules – Comparison with ACS 2003 Data and Census 2000

Household Socio-demographics	Values in Percent			Values in Percent		
	ACS 2003	CEMSELTS Predicted	Difference in Percentage	Census 2000	CEMSELTS Predicted	Difference in Percentage
Number of Vehicles						
Households with no vehicles	8.29	7.27	-1.02	10.07	7.27	-2.79
Households with 1 vehicle	33.34	31.32	-2.02	34.85	31.32	-3.55
Households with 2 vehicles	37.48	34.71	-2.77	37.16	34.72	-2.44
Households with 3 vehicles	14.10	15.17	1.07	12.59	15.17	2.59
Households with 4 or more vehicles	6.79	11.52	4.74	5.33	11.52	6.19
Number of Workers						
Households with no workers	12.21	16.84	4.63	11.31	16.84	5.53
Households with 1 worker	34.23	36.80	2.58	32.98	36.80	3.82
Households with 2 or more worker	53.57	46.36	-7.21	55.71	46.36	-9.35
Household Income						
$0- $9999	8.08	8.09	0.01	8.98	8.09	-0.89
$10,000-$34,999	28.85	40.45	11.60	29.56	40.45	10.89
$35,000-$49,999	15.05	14.47	-0.58	15.24	14.48	-0.76
$50,000-$74,999	18.53	13.58	-4.95	18.89	13.58	-5.31
$75,000 and more	29.49	23.40	-6.09	27.32	23.40	-3.93
Household Tenure						
Owner	55.74	61.05	5.30	54.78	61.03	6.25
Renter	44.26	38.95	-5.30	45.22	38.97	-6.25
Household Type for Owners						
Single Unit (Attached/Detached)	88.15	93.42	5.27	54.78	61.05	6.27
Other	11.85	6.58	-5.27	45.22	38.95	-6.27
Household Type for Renters						
Single Unit (Attached/Detached)	27.87	50.49	22.62	88.32	93.42	5.10
Apartment	72.13	49.51	-22.62	11.68	6.58	-5.10

Table 3. CEMSELTS Work Flow Distribution (in Percentage) by Destination – Comparison with the ACS 2003 Data

Origin county	Within Origin County			Outside Origin County			Total		
	ACS2003 (%)	CEMSELTS 2003 (%)	Difference	ACS2003 (%)	CEMSELTS 2003 (%)	Difference	ACS2003 (%)	CEMSELTS 2003 (%)	Difference
Los Angeles	52.79	52.63	-0.16	3.86	5.29	1.43	56.65	57.92	1.26
Orange	15.61	14.28	-1.32	3.11	3.45	0.35	18.71	17.74	-0.98
Riverside	6.57	7.65	1.09	3.19	1.85	-1.35	9.76	9.50	-0.26
San Bernardino	6.88	7.58	0.70	3.18	2.60	-0.58	10.06	10.18	0.12
Ventura	3.73	3.67	-0.06	1.09	1.00	-0.09	4.82	4.67	-0.15
Total	85.57	85.81	0.24	14.43	14.19	-0.24	100.00	100.00	100.00

Table 4. CEMSELTS Work Flow Distribution (in Percent) by Destination County – Comparison with the Census 2000 Data

Origin County	Destination County													
	Imperial		Los Angeles		Orange		Riverside		San Bernardino		Ventura		Total	
	Census 2000 (%)	CEMSELTS 2003 (%)	Census 2000 (%)	CEMSELTS 2003 (%)	Census 2000 (%)	CEMSELTS 2003 (%)	Census 2000 (%)	CEMSELTS 2003 (%)	Census 2000 (%)	CEMSELTS 2003 (%)	Census 2000 (%)	CEMSELTS 2003 (%)	Census 2000 (%)	CEMSELTS 2003 (%)
Imperial	0.60	0.76	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.61	0.78
Los Angeles	0.01	0.00	53.32	52.21	2.39	3.23	0.14	0.31	0.61	1.19	0.48	0.53	56.94	57.46
Orange	0.00	0.00	2.76	2.80	16.26	14.17	0.17	0.35	0.14	0.28	0.01	0.00	19.35	17.60
Riverside	0.01	0.00	0.55	0.23	0.77	0.21	6.22	7.59	0.90	1.39	0.00	0.00	8.45	9.43
San Bernardino	0.00	0.00	1.66	1.03	0.43	0.22	0.78	1.33	6.81	7.52	0.01	0.00	9.69	10.10
Ventura	0.00	0.00	1.02	0.99	0.01	0.00	0.00	0.00	0.00	0.00	3.93	3.64	4.97	4.63
Total	0.62	0.76	59.31	57.26	19.86	17.83	7.32	9.59	8.47	10.38	4.43	4.18	100.00	100.00

3. Modified CEMDAP

In this chapter, we discuss the econometric modeling system and the microsimulation framework within the latest version of CEMDAP implemented for the Southern California region. This modified version includes several enhancements to the earlier version of CEMDAP implemented for the DFW region. Firstly, the latest version of CEMDAP has a household-level activity pattern generation model that at once predicts, for a typical weekday, the independent and joint activity participation decisions of all individuals (adults and children) in a household, for all types of households, for all combinations of individuals participating in joint activity participations, and for all disaggregate-level activity purposes. Secondly, the scheduling framework is modified significantly to accommodate the joint activity participation decisions predicted by the household level joint activity participation model. Thirdly, a suite of four models which together predict household vehicle fleet characteristics and allocate each vehicle to a primary driver are integrated with the activity-based microsimulation framework. Furthermore, we use this information later during the scheduling to assign a vehicle to every vehicular tour made during the day. Lastly, all the models in the new modeling framework (nearly 50 models) are re-estimated using travel survey data specific to the Southern California region.

The reader will note here that the design and architecture of CEMDAP is generic. In particular, CEMDAP can be applied to any metropolitan area, as long as local area models are estimated to produce the appropriate sensitivity parameters. Currently, we have estimated all the CEMDAP models using the Southern California data and the resulting specifications and parameters are embedded in CEMDAP as default specifications and parameters.

The remainder of this chapter is organized as follows. Section 3.1 describes the representation frameworks used to characterize the complete activity-travel patterns of individuals. Specifically, this section identifies all the choice elements that are predicted within CEMDAP to construct the activity-travel patterns of all household members, including both adults and children. Section 3.2 focuses on the econometric modeling system used for daily activity-travel prediction. Section 3.3 describes the data used in the empirical model estimations. Section 3.4 presents, in detail, the

microsimulation procedure implemented within CEMDAP. Section 3.5 discusses the spatial and temporal consistency checks implemented within CEMDAP to ensure that the simulation process does not result in unreasonable or impossible activity travel patterns.

3.1 Representation Frameworks

We retained the same representation framework used in the earlier version of CEMDAP. However, we present the discussion of these frameworks again in this document so that the report would serve as a stand-alone guide to any new users of CEMDAP in the future. These representation frameworks identify the complete set of attributes that are required to characterize an individual's daily activity-travel pattern. The simulation of an individual's activity-travel pattern then entails computing a predicted value for each of these attributes based on the underlying econometric models.

Broadly, the activity-travel pattern of an individual is defined as the sequence of activities and travel pursued during a day. Among all the different activities that an individual undertakes during the day, the work and school activities are undertaken under the greatest space-time constraints for most individuals. Also, participation in these activities significantly influences an individual's participation in all other activities during the day. Consequently, separate representations have been developed to characterize the daily activity-travel patterns of workers, students, non-workers, and non-students. The workers and students include adults (persons aged 16 years or older) who go to work or school and children (persons aged 15 years or younger) who go to school. The non-workers and non-students, on the other hand, include adults who neither go to work nor attend school during the day, as well as children who do not go to school during the day. For presentation ease, in the remainder of this section, we will use the term "workers" to represent workers and students and the term "non-workers" to represent non-workers and non-students. Similarly, the term "work" will be used generically to refer to either work or school as appropriate.

The representation frameworks for workers and non-workers are discussed in Sections 3.1.1 and 3.1.2, respectively. In both frameworks, the start of the day is defined as 3:00 a.m. and all individuals are assumed to be at home at this time.

3.1.1 Representation for the Activity-Travel Pattern of Workers

The daily pattern of workers is characterized by four different sub-patterns: (1) before-work pattern, which represents the activity-travel undertaken before leaving home to work; (2) commute pattern, which represents the activity-travel pursued during the home-to-work and work-to-home commutes; (3) work-based pattern, which includes all activity and travel undertaken from work; and (4) after-work pattern, which comprises the activity and travel behavior of individuals after arriving home at the end of the work-to-home commute. Within each of the before-work, work-based, and after-work patterns, there might be several tours. A tour is a circuit that begins and ends at home for the before-work and after-work patterns and is a circuit that begins and ends at work for the work-based pattern. Each of the tours, the home-to-work commute, and the work-to-home commute may include several activity stops. An activity stop is characterized by the type of activity undertaken, in addition to spatial and temporal attributes. Figure 3-1 provides a diagrammatic representation of the worker activity-travel pattern.

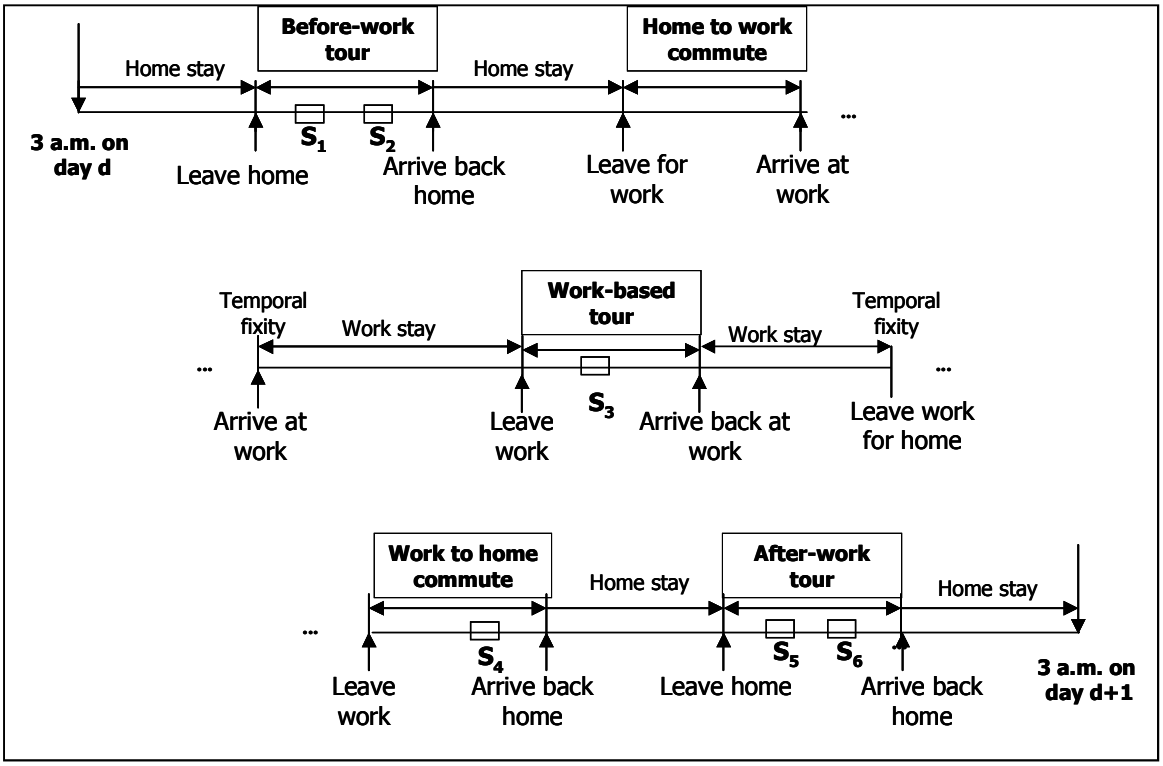


Figure 3-1 A Representation of the Activity-Travel Patterns of Workers

The characterization of the complete workday activity-travel pattern is accomplished by identifying a number of different attributes. The **primary attributes** that characterize the pattern of a worker are the start and end times of the work activity. The remaining attributes may be classified based on the level of representation that they are associated with; that is, whether they are associated with a pattern, a tour, or a stop. **Pattern-level attributes** include the travel mode, number of stops, and the duration for each of the work-to-home and home-to-work commutes, as well as the number of tours that the worker undertakes during each of the before-work, work-based, and after-work periods. **Tour-level attributes** include travel mode, number of stops, home-stay duration (or work-stay duration, in the case of the work-based tour) before the tour, and the sequence number of the tour within the before-work, work-based, and after-work periods. **Stop-level attributes** include activity type pursued, whether the activity at the stop is done alone or with other household members (and with which household members), duration of the activity stop, travel time to stop, whether the travel to the stop is undertaken alone or with

other household members (and with which household members), stop location, and the sequence of the stop in a tour or commute.

The representation described above is generic and can be used to describe any worker activity-travel pattern (i.e., any number of stops sequenced into any number of tours). Considering practical implementation constraints, certain restrictions are imposed on the maximum number of tours and the maximum number of stops in any tour in the development of CEMDAP. Specifically, in the case of adults who go to work or school, CEMDAP is designed to handle up to three tours during each of the before-work, work-based, and after-work periods and up to five stops during any tour or commute. In the case of school-going children, CEMDAP accommodates non-school activity participation of children only during the school-to-home commute and the after-school period. Further, only a single tour with one stop is supported for the after-school period.

3.1.2 Representation of the Activity-Travel Patterns of Non-Workers

In the case of non-workers, the activity-travel pattern is considered as a set of out-of-home activity episodes (stops) of different types interspersed with in-home activity stays. The chain of stops between two in-home activity episodes is referred to as a tour. The pattern is represented diagrammatically in Figure 3-2.

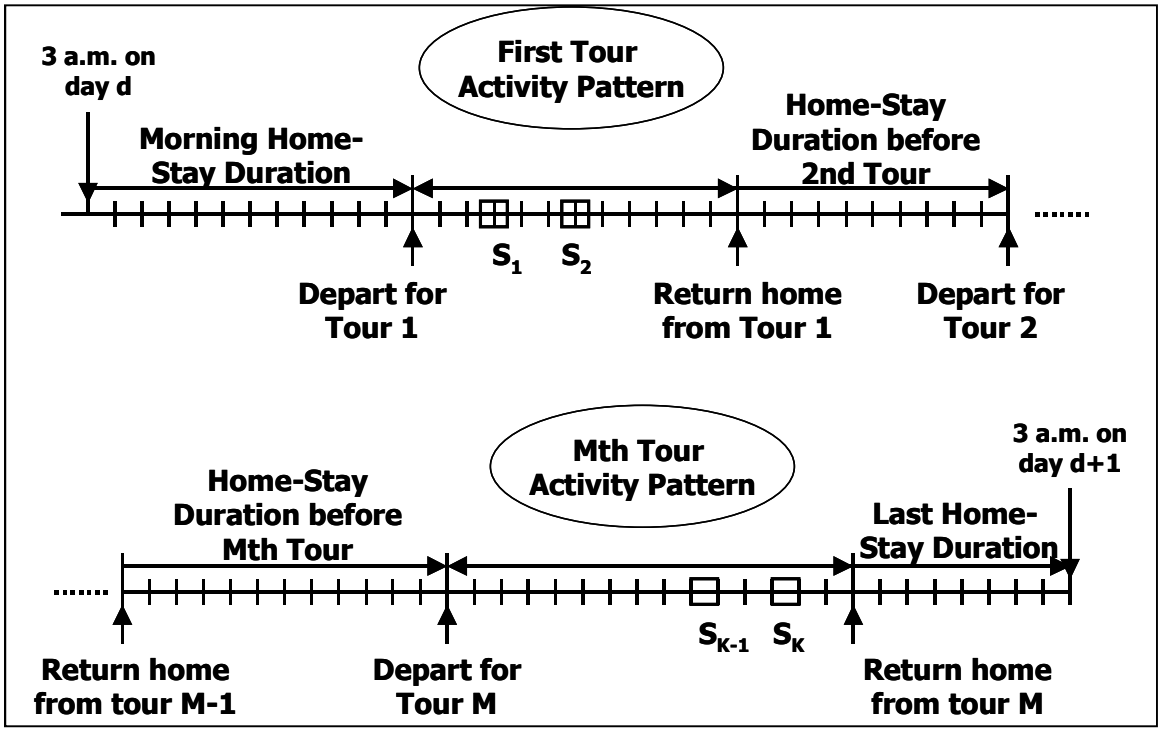


Figure 3-2 A Representation of the Activity-Travel Patterns of Non-Workers

A non-worker's daily activity-travel pattern is characterized by several attributes, which can again be classified into pattern-, tour-, and stop-level attributes. The only **pattern-level attribute** is the total number of tours that the person decides to undertake during the day. The **tour-level attributes** are the travel mode, the number of stops in the tour, the home-stay duration before the tour, and the sequence of the tour in the day. **Stop-level attributes** include activity type, whether the activity at the stop is done alone or with other household members (and with which household members), duration of the activity, travel time to stop, whether the travel to the stop is undertaken alone or with other household members (and with which household members), location, and the sequence of the stop in a tour or commute.

The representation described above is generic and can be used to describe any non-worker activity-travel pattern (i.e., any number of stops sequenced into any number of tours). Considering practical implementation constraints, certain restrictions are imposed on the maximum number of tours and the maximum number of stops in any tour. Specifically, CEMDAP is designed to handle up to a total of four tours and up to five stops during each tour.

3.2 Econometric Modeling System

This section identifies all the model components that constitute the overall modeling system implemented within CEMDAP. Each model corresponds to the determination of one or more of the attributes characterizing the activity-travel pattern of a worker or a non-worker. Together, the set of all models identified in this section, once estimated, can be used in a systematic predictive fashion to completely characterize the activity-travel patterns of all individuals in a household. (The systematic prediction procedure is described in Section 3.4.)

The overall modeling system is broadly subdivided into the following five categories: (1) the generation-allocation model system (Table 3.1), (2) the worker scheduling model system (Table 3.2), (3) the non-worker scheduling model system (Table 3.3), (4) the joint tour scheduling model system (Table 3.4), and (5) the children scheduling model system (Table 3.5). The precise econometric structure and the choice alternatives for each of the model components are also identified in Tables 3.1 through 3.5. Further, a unique identifier is associated with each model. (For example, "GA1" identifies the first model within the "generation-allocation" category, which is the decision of a child to go to school.) To facilitate easy cross-referencing, these identifiers have also been included in the figures presented in Section 3.4 (which describe the prediction procedure), as well as in Appendix B (where the estimation results for each model component are presented). The reader will also note that not all models in the tables are applicable to all households and individuals, as we discuss further in Section 3.4.

It can be observed from Tables 3.1 through 3.5 that the econometric structure for each choice dimension being modeled in CEMDAP falls under one of the eight econometric model categories: Multiple Discrete Continuous Extreme Value (MDCEV), fractional split, binary logit, multinomial logit, hazard-duration, regression, ordered probit, and spatial location choice.

Table 3.1 The Generation-Allocation Model System

General Notes: A child is an individual whose age is less than 16 years. An adult is an individual whose age is 16 years or more. In the CEMDAP architecture, all individuals in the population have to be classified into one of the following three categories: (1) student, (2) worker, and (3) non-student, non-worker. CEMDAP, in its current form, does not accept the category of "student and worker."

Model Id	Model Name	Econometric Structure	Choice Alternatives	Comments
GA1	Child's decision to go to school	Binary logit	Yes, No	Applicable only to children who are students. The determination of whether or not a child is a student is made in the CEMSELTS module (see Chapter 2).
GA2	Child's school start time (time from 3 a.m.)	Hazard-duration	Continuous time	
GA3	Child's school end time (time from school start time)	Hazard-duration	Continuous time	
GA4	Decision to go to work	Binary logit	Yes, No	Applicable only to individuals above the age of 15 and who are workers. The determination of whether or not an individual is a worker is made in the CEMSELTS module.
GA5	Work start and end times	MNL	528 discrete time period combinations	
GA6	Adult's decision to go to school	Binary logit	Yes, No	Applicable only to adults who are students, as determined in CEMSELTS
GA7	Adult's school start time (time from 3 a.m.)	Regression	Continuous time	
GA8	Adult's school end time (time from school start time)	Regression	Continuous time	
GA9	Child's travel mode to school	MNL	Driven by parent, Driven by other, School bus, Walk/bike	Applicable only to children who go to school
GA10	Child's travel mode from school	MNL	Driven by parent, Driven by other, School bus, Walk/bike	

Table 3.2 The Generation-Allocation Model System (continued)

GA11	Allocation of drop off episode to parent	Binary logit	Father, Mother	Applicable only to non-single parent household with children who go to school
GA12	Allocation of pick up episode to parent	Binary logit	Father, Mother	
GA13	Determination households with non-zero OH duration	Binary logit	Non-zero OH HH or not	
GA14	Determination of total out-of home time of a household	Fractional split Model	In-home time, out-home time, travel time	
GA15	Independent and Joint Activity participation for households of size less than or equal to five	MDCEV	9 Activity purposes	
GA16	Independent Activity participation for households of size more than five	MDCEV	9 Activity purposes	
GA17	Decision of an adult to undertake other serve-passenger activities	Binary logit	Yes, No	

Table 3.3 The Worker Scheduling Model System

Model ID	Model Name	Econometric Structure	Choice Alternative
WSCH1	Commute mode	MNL	Solo driver, Driver with passenger,
WSCH2	Number of before-work tours	Ordered probit	0 or 1
WSCH3	Number of work-based tours	Ordered probit	0, 1 or 2
WSCH4	Number of after-work tours	Ordered probit	0, 1 or 2
WSCH5	Before-work tour mode	MNL	Solo driver, Driver with passenger,
WSCH6	Work-based tour mode	MNL	Solo driver, Driver with passenger,
WSCH7	After-work tour mode	MNL	Solo driver, Driver with passenger,
WSCH8	Number of stops in a tour	Ordered probit	1,2,3,4, or 5
WSCH9	Home or work stay duration before the tour	Regression	Continuous time
WSCH10	Activity type at a stop	MNL	10 Activity purposes
WSCH11	Activity duration at stop	Regression	Continuous time
WSCH12	Travel time to a stop	Regression	Continuous time
WSCH13	Location of a stop	Spatial Location Choice	Choice alternatives based on estimated travel time

Table 3.4 The Non-Worker Scheduling Model System

Model ID	Model Name	Econometric Structure	Choice Alternatives
NWSCH1	Number of independent tours	Ordered probit	1, 2, 3, or 4
NWSCH2	Decision to undertake an independent tour before the pick-up or joint discretionary tour	Binary logit	Yes, No
NWSCH3	Decision to undertake an independent tour after the pick-up or joint discretionary tour	Binary logit	Yes, No
NWSCH4	Tour mode	MNL	Solo driver, Driver with passenger, Passenger, and Walk/bike
NWSCH5	Number of stops in a tour	Ordered probit	1, 2, 3 4, or 5
NWSCH6	Number of stops following a pick-up/drop-off stop in a tour	Ordered probit	0 or 1
NWSCH7	Home stay duration before a tour	Regression	Continuous time
NWSCH8	Activity type at stop	MNL	10 Activity purposes
NWSCH9	Activity duration at stop	Regression	Continuous time
NWSCH10	Travel time to stop	Regression	Continuous time
NWSCH11	Stop location	Spatial Location Choice	Choice alternatives based on estimated travel time

Table 3.5 The Joint Discretionary Tour Scheduling Model System

Model ID	Model Name	Econometric Structure	Choice Alternative
JASHCH1	Decision of Joint or Separate Travel	Binary Probit	Yes or No
JASHCH2	Joint Activity Start time	Regression	Continuous
JASHCH3	Joint Activity travel time to stop	Regression	Continuous
JASHCH4	Joint Activity location	Spatial Location Choice	Predetermined subset of the 4,109 zones
JASHCH5	Vehicle Used For Joint Home-Based Tour	MDCEV	Vehicle types based on body type and vintage

Table 3.6 The Children Scheduling Model System

Model ID	Model Name	Econometric Structure	Choice Alternatives
CSCH1	School to home commute time	Regression	Continuous time
CSCH2	Home to school commute time	Regression	Continuous time
CSCH3	Mode for independent discretionary tour	Binary logit	Drive by other, Walk/bike
CSCH4	Departure time from home for independent discretionary tour (time from 3 a.m.)	Regression	Continuous time
CSCH5	Activity duration at independent discretionary stop	Regression	Continuous time
CSCH6	Travel time to independent discretionary stop	Regression	Continuous time
CSCH7	Location of independent discretionary stop	Spatial Location Choice	Predetermined subset of the 4,109 zones

3.3 Data

This section discusses the data used for the estimation of all the model components identified in Section 3.2. Only the sources of the data are discussed in this report.

3.3.1 Data Sources

3.3.1.1 Primary Data Source

The data for our analysis is drawn from the 2000 Post Census Regional Household Travel Survey conducted by the South California Association of Governments (SCAG), which is the metropolitan planning organization (MPO) of the six-county Los Angeles region of California. Households were selected randomly across the study region and contacted to solicit their participation in the survey (see NuStats, 2003 for more details on the survey administration and sampling procedures). Personalized travel diaries were mailed to participant households seven to 10 days prior to the assigned travel survey weekday to aid in households' travel record-keeping. The travel information was subsequently retrieved from the households within one week of the assigned travel survey weekday. In addition to travel information (including the details of every trip that each person in the household made), the survey collected household demographic information (such as household size, number of vehicles in the household, housing tenure type, and annual household income), individual demographic information for all members in the household (including age, gender, ethnicity, educational attainment, employment status, and student status), and vehicle fleet information (including body type, fuel type, age, make, year acquired, and primary driver).

3.3.1.2 Secondary Data Sources & Construction of Accessibility Measures

In addition to the 2000 SCAG survey data set, several other secondary data sets were used to obtain residential neighborhood accessibility measures that may influence household-level activity participation behavior. All these variables were computed at the level of the residential traffic analysis zone (TAZ) of each household and considered in our model specifications. The secondary data sources included geo-coded block group and block data within the SCAG region obtained from Census website, SCAG roadway and transit network skims from SCAG, the employment data from the Census Transportation Planning Package (CTPP) and Dun & Bradstreet (D&B), and the 2000 Public-Use Microdata Samples (PUMS) from Census 2000 and the marginal distributions (population and household summary tables) from SCAG.

Two types of accessibility measures were constructed to be used in the model estimations. The first set of accessibility measures are opportunity-based indicators which measure the number of activity opportunities by twelve different industry types that can be reached within 50 minutes of Generalized Cost (GC)[1] from the home zone during the morning peak period (6am to 9am). The reader is referred to Chen *et al.*, 2011 for details. The second set of accessibility indicators correspond to Hansen type measures (Bhat and Guo, 2007), which take the following form:

$Acc_{i,\tilde{t}} = \frac{1}{N}\sum_{j=1}^{N}\left(\frac{\text{Size Measure}_{j}}{\text{Impedance}_{ij,\tilde{t}}}\right)$, where i is the index for zone, $\tilde{t}$ is the index for the time period, and N is the total number of zones in the study region (four time periods were used in our analysis: AM peak (6:30 am-9 am), midday (9 am-4 pm), PM peak (4 pm-6:30 pm), and evening (6:30 pm-6:30am)). $\text{Impedance}_{ij,\tilde{t}}$ is the composite impedance measure of travel between zones i and j at time period $\tilde{t}$ and is obtained as: $\text{Impedance}_{ij,\tilde{t}} = IVTT_{ij,\tilde{t}} + \lambda Cost_{ij,\tilde{t}}$, where $IVTT_{ij,\tilde{t}}$ and $Cost_{ij,\tilde{t}}$ are the auto travel time (in minutes) and auto travel cost (in cents), respectively, between zones i and j in time period $\tilde{t}$, and λ is the inverse of the money value of travel time. We used $\lambda == 0.0992$ in the current study, which corresponds to about \$6 per hour of implied money value of travel time. For the zonal size measure in the accessibility formulation, we considered four variables -- retail employment, retail and service employment, total employment, and population. Finally, the time period-specific accessibility measures computed as discussed above were weighted by the durations of each time period, and a composite daily accessibility measure (for each size measure) was computed for each traffic analysis zone, and appended to sample households based on the residence TAZs of households.

3.3.2 Sample Formation

The original raw survey data provide over 130,474 trip records for 40,376 persons from 16,939 households. After preliminary consistency checks, data needed for estimation of different models listed in Section 3.2 is isolated from the entire sample. For each of the models, if critical information (such as age, employment status, work location, and school location) was missing, then such records were removed from further analysis.

[1] The GC expression was obtained from the commute mode choice model (see Table B.31 in Appendix B).

The survey data obtained point information or closest cross-street intersection information for all locations (home locations, work locations, and all other activity locations) of each trip end of each individual in the survey. This was translated by SCAG to spatial coordinates, and served as the basis to determine joint activity participation decisions among household members. Specifically, the trip end information was converted to activity episode information, and each activity episode was assigned as an independent episode or a joint episode based on examining the reported activity locations of all household members. If the reported locations of activity episodes were the same across two or more household members, and the time of day of the episode start was reported within a "buffer-window" of ten minutes, the corresponding episode was designated as a joint activity episode involving the appropriate household members. The activity purpose of the episode was then determined. In some cases, one or more participating members reported the activity purpose of participation as "accompanying another individual". In such cases, the activity purpose of the participating individual who reported a purpose other than "accompanying another individual" was designated as the joint activity purpose. Finally, the durations of episodes were aggregated by purpose and participating individuals to obtain the weekday durations, and served as the dependent variables of the household level MDCEV model. Several attributes of the activity-travel patterns (such as the commutes, the tours, and the identification of the tours to which each trip and stop belongs) that are not directly reported in the surveys were derived from the overall sequence of trip records for each person.

The trip records of the persons in households without any missing information were processed to generate a trip file. In this trip file, each record corresponds to a trip that is characterized by the start and end times, the start and end locations, the activity types at the origin and the destination, and the travel mode. These characteristics of each trip are used to identify the trips that belonged to the same tour and then merge these records accordingly to form the tour file.

3.4 Microsimulation Framework

This section describes the microsimulation procedure implemented within CEMDAP for predicting the complete activity-travel patterns of all individuals in a household. This procedure is repeatedly applied to each household in the input synthetic population to completely determine

the activity-travel patterns of all individuals in the study area. The overall prediction procedure (for a household) can be subdivided into two major sequential steps: (1) the prediction of activity generation and allocation decisions and (2) the prediction of activity scheduling decisions. The first step predicts the decisions of household members to pursue various activities such as work, school, shopping- both independently and jointly during the day. This step is described in detail in Section 3.4.1. The second step predicts the sequencing of these activities, accommodating the space-time constraints imposed by work, school, and joint activities with other household members. This step is described in detail in Section 3.4.2.

3.4.1 Prediction of Activity Generation and Allocation Decisions

In the latest version of CEMDAP the emphasis is on developing an effective mechanism for micro-simulating activity participation. In the earlier version of CEMDAP, (1) adult work activity (Home-Work and Work-Home commute as well as work start and end times), and (2) child travel needs (pick-up, drop-off) are treated as two essential elements of the activity modeling framework i.e. these activities are accorded the highest priority. Accordingly, we schedule the work activity and child travel responsibilities in the schedules of individuals. Subsequently, based on the remaining available time we accommodate adult and child activity participation. As mentioned earlier, the objective of the current enhanced version of CEMDAP is to effectively accommodate joint activity participation. Towards this end, we have substantially altered the existing framework. Specifically, we added "Joint Activity Participation" as the third element (in addition to adult work activity and child travel needs) of the activity modeling framework. In the enhanced version, we model activity participation of all household members in a single framework allowing us to incorporate both individual and joint activity participation among household members simultaneously.

To do this, we employ the recently developed Multiple Discrete Continuous Extreme Value (MDCEV) model. In the MDCEV model, the choice alternatives are characterized as all possible combinations of household members for each activity purpose. For example, if there are three members in the household, the alternatives include: (1) Person 1, (2) Person 2, (3) Person 3, (4) Persons 1 and 2, (5) Persons 1 and 3, (6) Persons 2 and 3, (7) Persons 1, 2 and 3. Clearly, as the number of number of household members increases the number of combinations also increases

($2^{\wedge M}$-1 where M is the household size). However, since the usual number of members is between 2 and 3 the number of combinations still remains reasonable. The total number of alternatives in the MDCEV model is given by number of household members combinations multiplied by the number of activity purposes. A schematic of the framework is provided in Figure 3.1. The incorporation of the enhanced activity participation module within the micro-simulation framework leads to substantial changes to the framework.

The prediction of activity generation and allocation decisions comprises the following three sequential steps: (1) the generation of work and school activity participation, (2) the generation of children's travel needs and allocation of escort responsibilities to parents, and (3) the generation of independent and joint activities for personal and household needs. Each of these steps is discussed in further detail below.

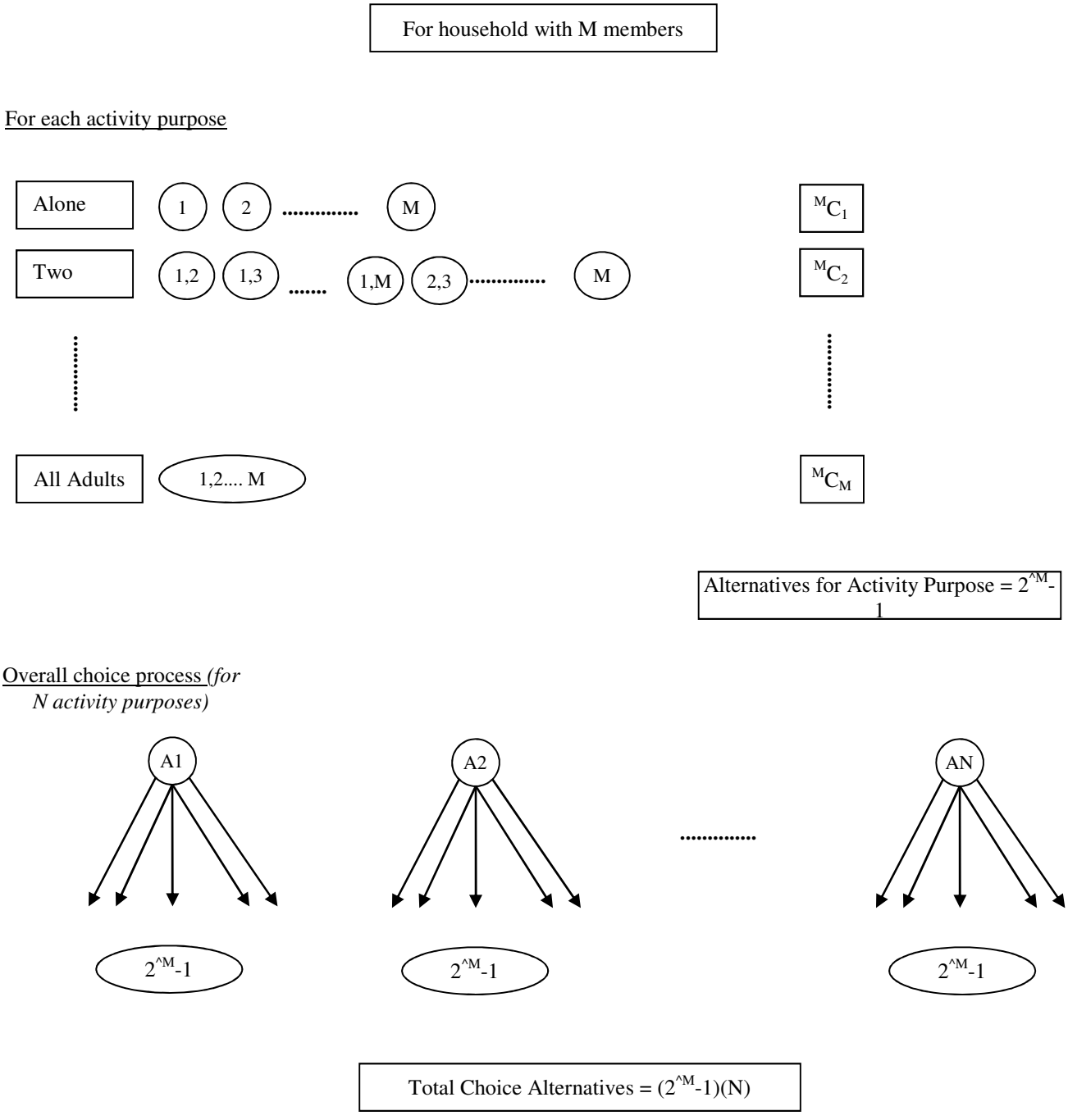


Figure 3.1 Illustration of MDCEV Framework

3.4.1.1 Generation of work and school activity participation

Decisions regarding work and school activities are predicted as the first activity generation decisions because these are pursued with significant regularity and also impose constraints on participation in all other activities during the day. This prediction step is presented schematically in **Error! Reference source not found.**.2. For each child in the household who is a student, the decision to go to school and the timing (*i.e.*, start and end times) are first determined (note that the model numbers in the figure for each component correspond to the numbering scheme employed in Table 3.1). Next, the decision of employed adults to go to work during the day and the timing of the work activity are determined. These decisions of the adults may be influenced by the need to take care of non–school-going children at home during the day, which is the reason for modeling work participation decisions subsequent to the decisions of children to go to school. The locations of the school and work are modeled and predetermined in the CEMSELTS module discussed in Chapter 2. Then, the school participation and timing decisions of each adult who is a student are determined. (Adults are exogenously classified into one of the following three categories: employed, student, or unemployed/non-student.) Adults who decide to undertake either work or school activities during the day are classified as "workers" and the other adults are classified as "non-workers." For the rest of the prediction procedure, the term "work" will be used to refer to either a work or school activity of an adult as appropriate.

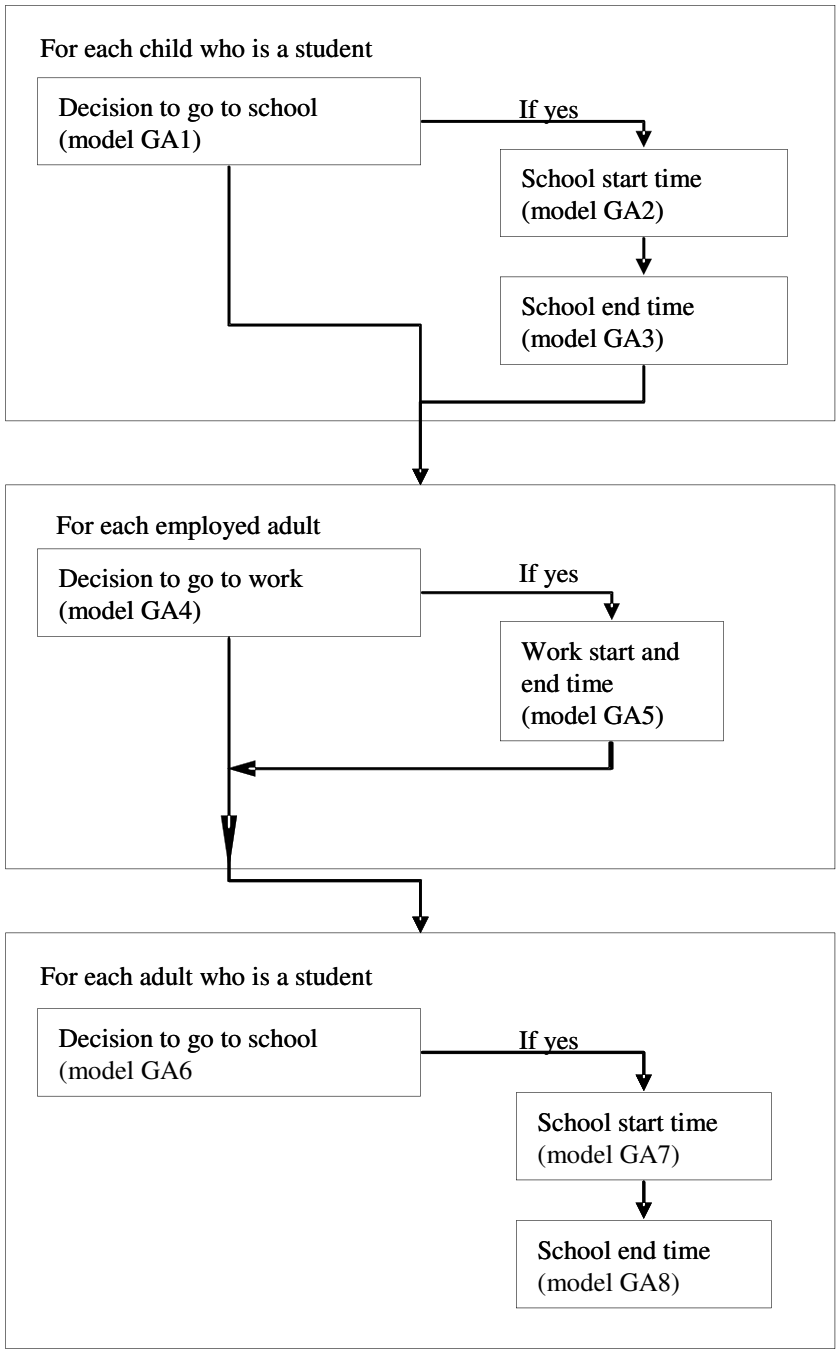


Figure 3.2 Generation of Work and School Activity Participation

3.4.1.2 Generation of children's travel needs and allocation of escort responsibilities to parents

The second major step in the prediction of the generation-allocation decisions involves the children's travel needs (**Error! Reference source not found.**). In this step, the children's travel mode to and from school are first determined. The travel mode can be one of these: drive by parent, drive by other, school bus, and walk/bike. For children driven to and from school by a parent, the escort responsibilities have to be allocated to the parents. For children in single-parent households, this allocation is trivial as there is only one parent. For children in nuclear family households (i.e., a male-female couple with children), each of the pick-up and drop-off responsibilities is allocated to either the mother or the father. The reader will note that the framework assumes that there is at most one episode each of pick-up and drop-off activities. (However, multiple children may be picked up or dropped off in a single episode.) Also, the interdependencies between children and parents are not explicitly captured in complex households (i.e., households other than those of the single-parent or nuclear-family types). Nonetheless, because single-parent and nuclear-family are the most common types of households with children, we believe that this is not a serious limitation. If any escort responsibility is allocated to a worker, then the work start and end times of this person are suitably updated to ensure feasibility of the escort activity. (Based on empirical analysis of the travel survey data, we assume that escort activities undertaken by workers are pursued during the commute.)

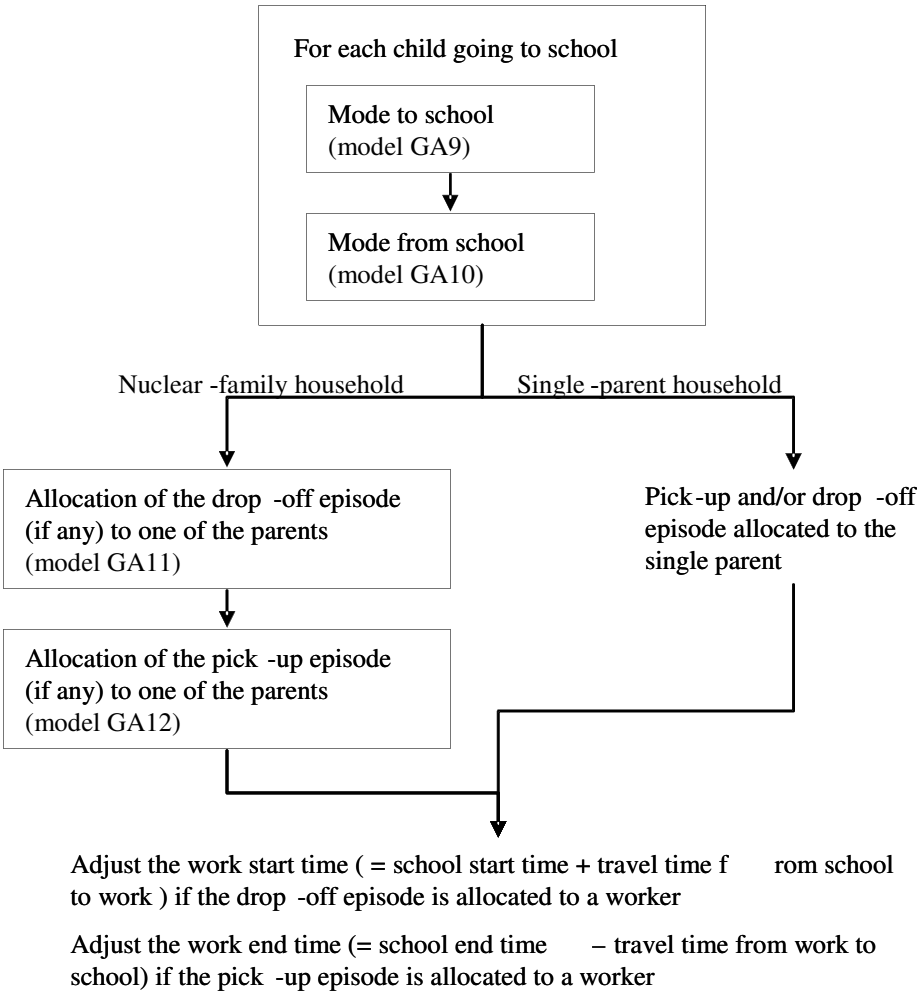


Figure 3.3 Generation and Allocation of Escort Responsibilities

3.4.1.3 Generation of independent activities for personal and household needs

The third step in the prediction of activity generation and allocation involves decisions about independent and joint activity participation (Fig 3.4). As mentioned earlier, we used the MDCEV framework to model all joint and independent activity participation decisions in the household simultaneously. All possible combinations of participating people and activity purposes form the alternative in the choice set of the MDCEV model. We do not, however, include the household-level activity alternative that corresponds to all individuals staying at home for the entire day as an alternative in the MDCEV model. This is because the duration for this alternative can be as high as $1440 \times Q$, where Q is the number of individuals in the household. This very large duration for a single alternative leads to difficulties when estimating the non-linear utility functions in the MDCEV model. Thus, we only consider those households that have

a non-zero out-of-home (OH) work participation time in the MDCEV model. This way of inclusion of households implies that each household must choose at least one alternative for participation in the MDCEV model from all the alternatives (of course, this does not preclude the possibility that specific individuals in the household will have no OH activity during the day; for instance, if all the alternatives involving individual q (q = 1, 2, …, Q) have no time allocation, it implies that individual q stays at home the entire day).

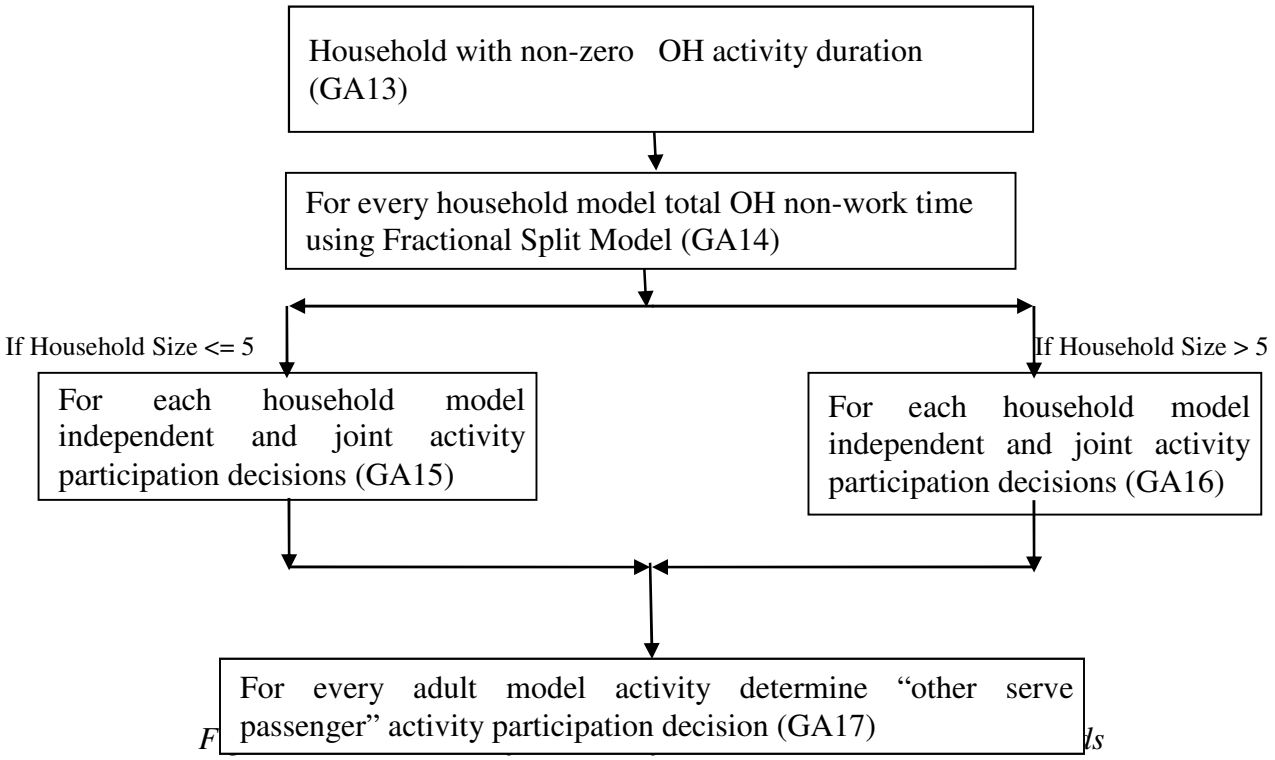
In the latest version of CEMDAP, we use a disaggregate activity purpose classification as follows: (1) shopping (grocery shopping, clothes shopping, and window shopping), (2) non-shopping maintenance (ATM and other banking, purchasing gas, quick stop for coffee/newspaper, visiting post office, paying bills, and medical/doctor visits), which we will refer to simply as "maintenance" in the rest of this report, (3) social (community meetings, political/civic event, public hearing, occasional volunteer work, church, temple and religious meeting), (4) entertainment (watching sports, going to the movies/opera, going dancing, and visiting a bar), (5) visiting friends and family, (6) active recreation (going to the gym, playing sports, biking, walking, and camping), (7) eat-out, (8) work-related, and (9) other (includes an "other" category as presented to respondents in the survey, as well as child-care and school-care activities). This classification is based on the activity purpose taxonomy used in the 2000 SCAG survey used for the current analysis. Note that we retain a "work-related" purpose as a non-work activity as opposed to a mandatory work activity, and predict the work-related time allocation of each individual in the household if the individual is employed. In this regard, work-related activity is considered as a "non-work" activity in CEMDAP. Additionally, there is an additional activity purpose- "serve passenger" in CEMDAP. These are pick-up or drop-off activities pursued by adults other than the trips for escorting children to and from school. The person(s) being served in this case may be either household members or non-members. The participation durations in this activity purpose are very low compared to other activity purposes. This very small duration for a single alternative leads to difficulties when estimating the non-linear utility functions in the MDCEV model. So, we model participation decisions in this activity purpose for each adult using a separate binary logit model subsequent to the modeling of all other participation decisions using the MDCEV model.

Of the nine purposes (after excluding the "other server passenger" activity purpose), no joint participation was observed for work-related activity (based on survey data). Thus, we allow joint activity participation in eight purposes, and only independent participation in the work-related purpose category. Also, we found that in the survey data, there are not many joint activities involving adults making pick-up during the day. Thus, we do not allow joint activity participation in any of the activity purposes involving a person making pick-up during the day. The number of individuals in the household in the survey data varied from one to nine individuals. However, households of size five or less constituted well over 97% of all households. For these households, the maximum number of alternatives is 253 (= $(2^5-1)*8+5$) (Please refer to Figure 3.1 for this calculation). The maximum number of alternatives increases significantly for households of size greater than 5. Since these households do not form a major fraction of the overall population, we do not allow joint activity participation in these households in the current version of CEMDAP. However, we still model all independent activity participation decisions in households of size greater than 5 in nine activity purposes (excluding other serve passenger activity purpose) using another MDCEV model. The maximum number of alternatives in this second MDCEV model is 81 (= 9*9).

The MDCEV model, however, needs a budget value *T*, corresponding to the total time available for OH non-work activity participation. To obtain this, we first remove the work duration of each individual q (q = 1, 2, …, Q) in the household from the total duration in a day to obtain the available non-work time (in minutes) as follows: $NWTIME_q = 1440 - WTIME_q$ (in minutes). Next, the total non-work time at the household level may be computed as $HNWTIME = \sum_{q=1}^{Q} NWTIME_q$. However, $HNWTIME$ includes travel times to OH activities as well as the in-home times (including sleep times) of individuals. So, we need to remove these times from $HNWTIME$ (note that travel times are determined only later in the scheduling phase, and are not available at the activity generation phase). We proceed by using a fractional split model for each household to split $HNWTIME$ into at-home time, travel time, and out-of-home non-work activity time (T)[2].

[2] In the SCAG survey sample used in the empirical estimation, 23.4% of households did not have any non-work activity participation at all during the weekday. Thus, we currently impose a threshold on the fraction of OH non-

Thus, the third and final step of the generation-allocation model system essentially comprises of three sub-steps. (1) The generation of total household OH activity participation duration using a fractional split model, (2) the generation of independent and joint activities for personal and household needs (excluding "other serve passenger") using the appropriate MDCEV model depending on the household size, and (3) the generation of "other serve passenger" activity participation decisions of adults.



3.4.2 Prediction of Activity Scheduling Decisions

At the end of the prediction of activity generation and allocation decisions (Section 3.4.1), the following information is available: (1) each child's decision to go to school, the school start time and end time, the modes used to travel to and from school, (2) which (if either) parent undertakes the drop-off activity, the pick-up activity, and the joint discretionary activity with the children;

work time predicted by the fractional split model such that the percentage of households with zero OH non-work time as predicted by CEMDAP matches 23.4%. In the future, we plan to estimate a simple binary choice mode to predict whether or not a household has any out-of-home (OH) non-work participation at all (across all its household members), based on household and individual characteristics (such as age of adults, presence of children, family structure, commute times, work characteristics of individuals, *etc.*) instead of imposing restrictions on the predictions of the fractional split model.

(3) each employed adult's decision to go to work, the work start time and end time, and the decision to undertake work-related activities; (4) each adult student's decision to go to school and the school start time and end time; (5) each household member's decisions as well as duration of participation in shopping, maintenance, social, entertainment, visiting friends, active recreation, eat-out, other, work related, and other serve-passenger activities –both independently and jointly with other household members.

In the next broad step of predicting activity scheduling decisions, the following sequence is adopted (see Fig 3.5): (1) determining all the attributes to be used during scheduling of the joint activities predicted by the GA model system, (2) scheduling the commutes for each worker in the household, (3) scheduling the drop-off tour for the non-worker escorting children to school, (4) scheduling the pick-up tour for the non-worker escorting children from school, (5) scheduling the commutes for school-going children, (6) scheduling the home-based joint tours of all adults in the household, (7) scheduling the independent home-based tours and work-based tours for each worker in the household, (8) scheduling the independent home-based tours for each non-worker in the household, and (9) scheduling the independent tours for each child in the household. It is important to note that not all eight steps are required for each household in the population. For example, Steps (3), (4), (5), and (9) are not necessary for households without children. Similarly, Steps (3) and (4) are not needed for a household if none of the school going children is escorted to or from school by his or her parents. Each of the eight steps is discussed in further detail here.

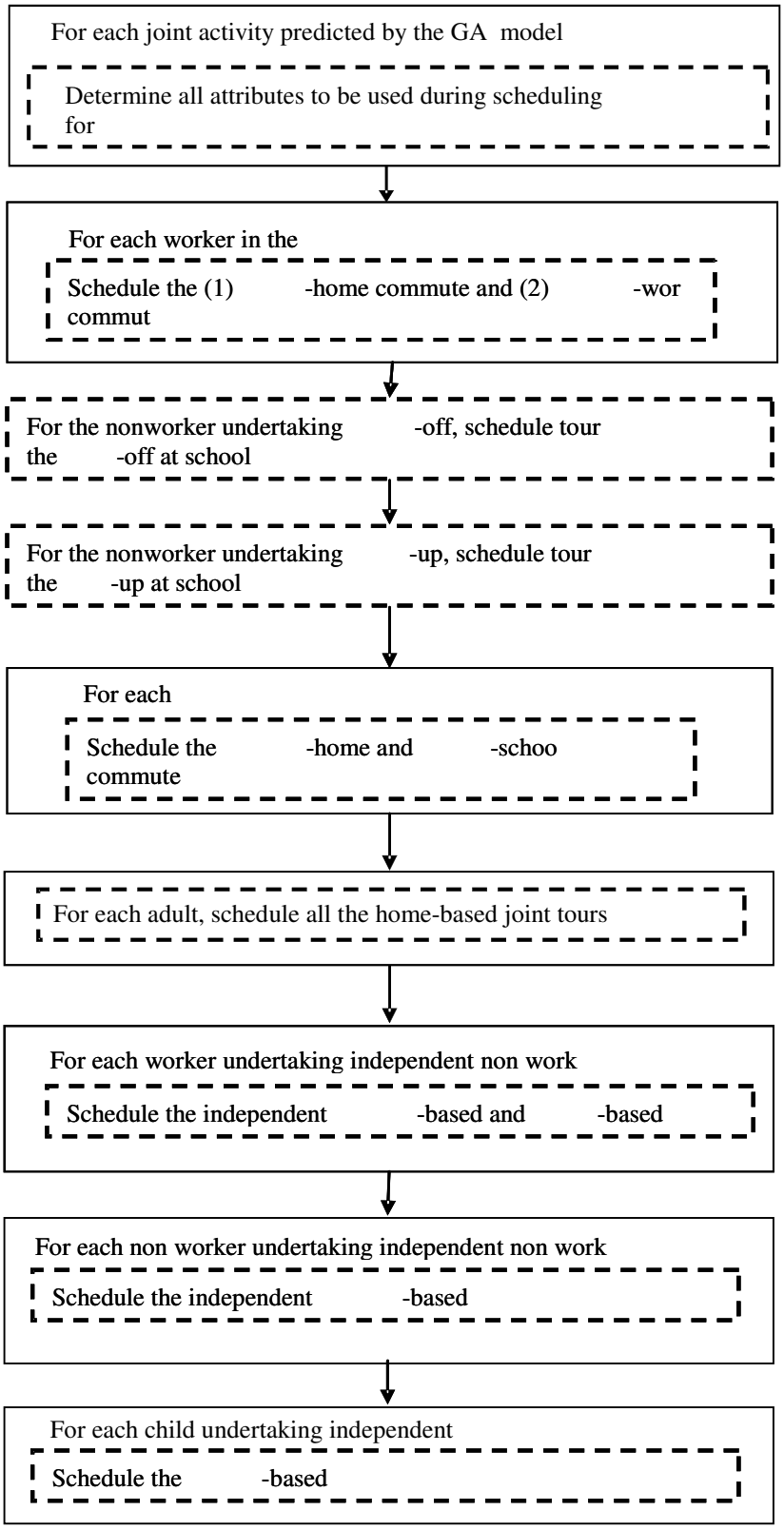


Figure 3.5 Sequence of Major Steps in the Prediction of Activity Scheduling Decisions

3.4.2.1 Scheduling all the joint activities in the household

In the travel survey data, we found that the number of episodes with the same combination of participating members (>1) and activity purpose is one in almost all cases. Thus, we schedule all the joint activities predicted by the MDCEV model in the GA model system as unique episodes. As already discussed, the MDCEV model predicts both the combination of people participating as well as the duration of participation. During activity scheduling, these household-level participations and durations are used to inform all scheduling decisions. However, we do not require the activity schedules to be perfectly consistent with the participation and duration predictions from the activity generator. For example, assume that the MDCEV model predicts the following two activities in a household with 2 people (say, A and B)- 30 minutes of independent shopping activity by A and 30 minutes (in actual time) of joint eat-out activity by A and B. The scheduler will work toward meeting the above predictions by using the predictions to constantly inform the activity-travel patterns of all individuals in the household as these patterns unfold during the course of the day, but it can so happen that individual A, because of his/her time availability constraints, participates only for 15 minutes in the independent shopping activity and 20 minutes in the joint activity.

The sequence of steps involved in the scheduling of joint activities is presented in Figure 3.6. We schedule the joint activities in the decreasing order of the duration of the participation. For every joint activity predicted by the activity generator, we determine whether all the participating people in the joint activity travel together from home or otherwise (JASCH1). Then, we determine the joint activity start time (JASCH2). There are four main assumptions that we make at this step. First, all joint activities involving workers are assumed to occur during the after work period of all the workers involved in joint activity. Second, the joint tours scheduled in the after work period of workers are assumed to be the only after-work tours that they undertake. Third, all non-workers participating in joint activities start their joint tour from home, participate in joint activity, and come back home without making any other stops. Lastly, joint activities involving adults making drop-off are scheduled after the school end time of the child whom the adult is dropping off. Consistent with these four assumptions, we use a log-linear regression model to determine the joint activity start time as the number of minutes from the *constraint time* defined as the maximum of three times- maximum work/school end time among participating

members, school start time of the child whom the adult is dropping off, if the adult making drop-off is a participating member of the joint activity, and previous joint activity start time which involves at least one of the members of the current joint activity, if any. Subsequent to this step, we model the travel time to joint activity location from home (JASCH3) which we will use later to construct alternative choice set for the joint activity location model (JASCH4). Lastly, the vehicle used for the joint activities is determined using a multinomial logit model (JASCH5). The primary vehicles of all the people involved in the joint activity form the alternate choice set for this model.

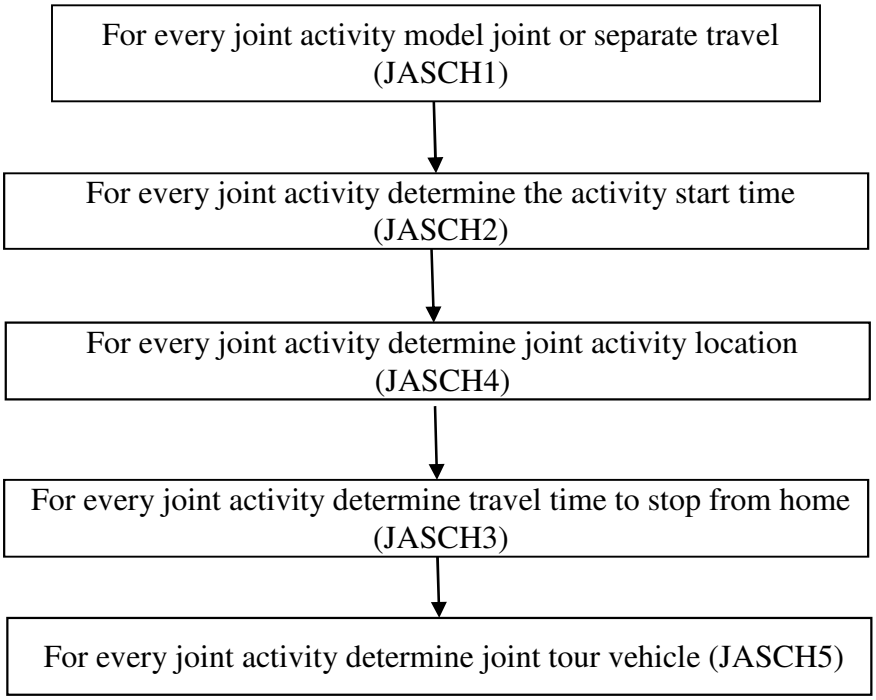


Figure 3.6 Determining All the Attributes of Joint Activity

3.4.2.2 Scheduling the commutes for each worker in the household

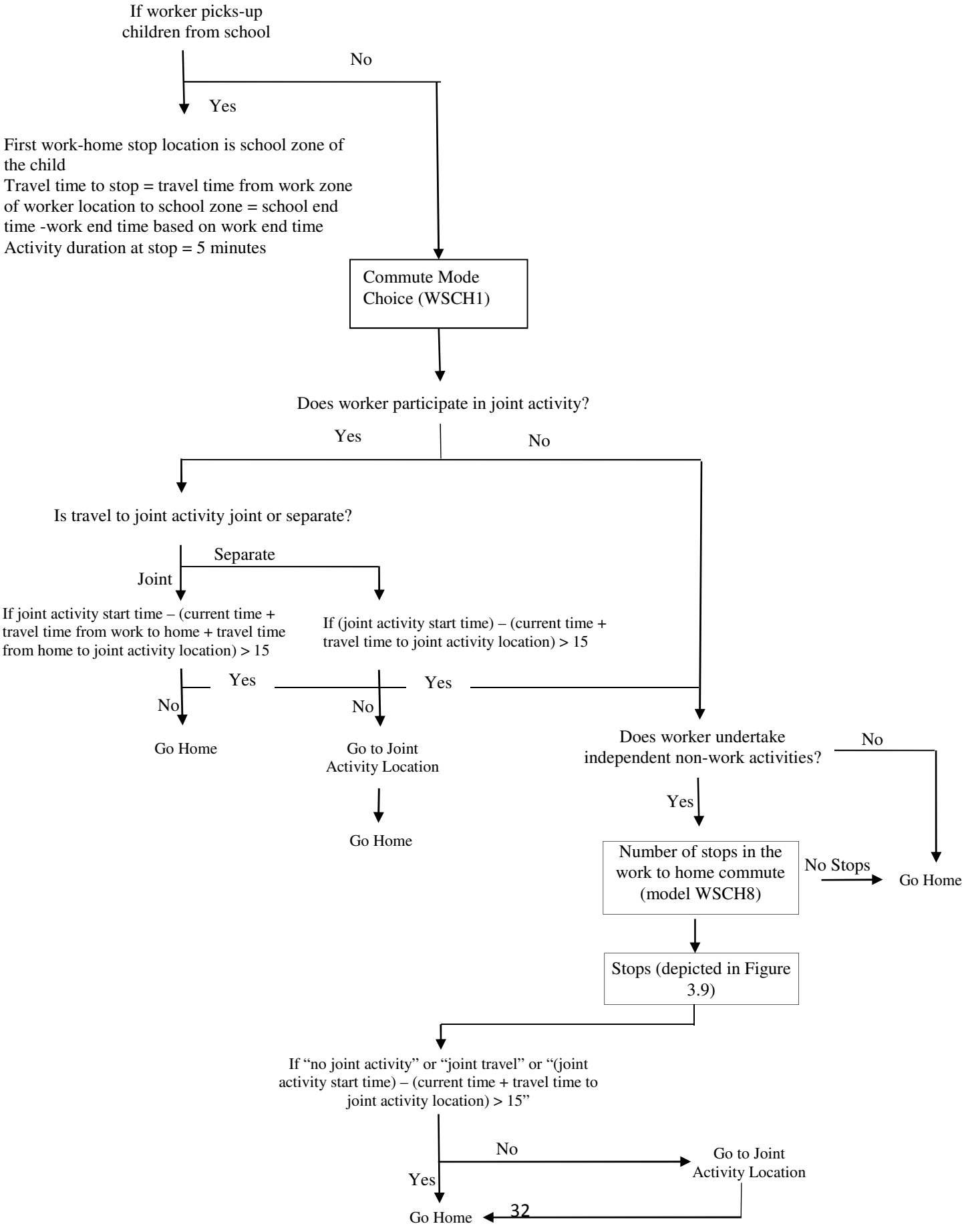
Travel undertaken to and from work is arguably the most constrained in terms of space and time (because of the rather strict need to be at the work location during a certain period of the day). Further, as already indicated, if the worker escorts children to and from school, then these pick-up and drop-off episodes are assumed to be undertaken during the commutes. Hence, the scheduling decisions relating to the commute are determined first for each worker in the household. Further based on the generation of children's travel needs and allocation of child escort responsibility to parents (Section 3.4.1.2), we already know if a given worker in the household is picking up or dropping off children. If the worker is picking up a child in the evening commute but not dropping the child in the morning commute, the evening commute mode is set to "driver with passenger" and the morning commute mode is set to "driver solo." If the worker is dropping a child in the morning commute but not picking up a child in the evening commute, the morning commute mode is set to "driver with passenger" and the evening commute mode is set to "driver solo." If the worker is both dropping off and picking up the child, both the morning and evening commute modes for the worker are set to "driver with passenger."

In the rest of this section, we discuss the prediction process for the work-to-home commute activity travel pattern and the home-to-work commute pattern. The prediction begins with the work-to-home commute pattern because there is much more activity participation in this leg of the commute than in the home-to-work commute.

<u>The work-to-home-commute</u>

If the worker is picking up children from school, then this pick-up activity is assumed to be the only stop during the work-to-home commute (see Figure 3.7). The travel times from work to school and from school to home are determined as the prevailing interzonal auto travel times between the appropriate zones and at the appropriate times of day. An activity time of 5 minutes is assigned to this pick up stop.

If the worker is not picking up children from school, the first prediction is of the travel mode (see Fig 3.7). This is accomplished using a multinomial logit model with five possible


If worker picks-up children from school
No
Yes
First work-home stop location is school zone of the child
Travel time to stop = travel time from work zone of worker location to school zone = school end time -work end time based on work end time
Activity duration at stop = 5 minutes
Commute Mode Choice (WSCH1)
Does worker participate in joint activity?
Yes
No
Is travel to joint activity joint or separate?
Joint
Separate
If joint activity start time – (current time + travel time from work to home + travel time from home to joint activity location) > 15
If (joint activity start time) – (current time + travel time to joint activity location) > 15
Yes
No
Yes
No
Go Home
Go to Joint Activity Location
Go Home
Does worker undertake independent non-work activities?
No
Yes
Number of stops in the work to home commute (model WSCH8)
No Stops
Go Home
Stops (depicted in Figure 3.9)
If "no joint activity" or "joint travel" or "(joint activity start time) – (current time + travel time to joint activity location) > 15"
No
Yes
Go to Joint Activity Location
Go Home

choice alternatives: drive solo, drive passenger, shared ride, transit, and walk/bike. Next, if the person is scheduled to participate in any joint activity, we check if there is enough time for the worker to participate in other non-work independent activities before heading either to home (if joint travel) or joint activity location (if separate travel). We currently use a buffer time of 15 minutes as indicated in the Figure 3.7 to make this decision. If the person is not scheduled to participate in any joint activities, even then we check if the worker is scheduled to participate in any non-work independent activities. Then, if the person is scheduled to participate in any independent non-work activities during the day, the next decision modeled is the number of stops made during the work-to-home commute.

If the worker does not pursue any non-work activities during the day or if the number of stops predicted by the WSCH8 model come out to be zero, then the number of work-to-home stops is set to zero. If one or more stops are predicted (the empirical modeling system allows a maximum of two stops during the commute), each of these stops is characterized, sequentially from the first to the last, in terms of the activity type at the stop, the duration of activity at the stop, the travel time to the stop, and the location of the stop. If the worker does pursue non-work activities during the day but the commute mode is transit or walk/bike, it is assumed that the worker is not making any trips during the commute. After scheduling all the stops in the work-to-home commute, the worker is made to go home: 1) if the person is scheduled to participate in a joint activity and travel jointly with other household members to the joint activity location, or 2) if he/she would reach the joint activity location more than 15 minutes earlier than the scheduled start time of the joint activity if traveling separately, or 3) if the person is not scheduled to participate in any joint activity. Otherwise, he is made to go to the joint activity location. Once all the stops are characterized, the travel time for the last leg of the work-to-home commute (i.e., the trip ending at home) is determined as the prevailing auto travel time between the location of the last activity stop and home at the departure time from the last stop.

The home-to-work commute

The home-to-work commute is characterized next (see Fig 3.8).

If the worker is pursuing drop-off of children at school, then this drop-off activity is the only stop during the home-to-work commute. The travel times from home to school and from

school to work are determined as the prevailing inter-zonal auto travel times between the appropriate zones and at the appropriate times of day. For workers not dropping off children, the scheduling of the home-to-work commute follows a procedure that is very similar to the scheduling of the work-to-home commute discussed earlier, except that there are no joint activities to schedule during the home-to-work commute.

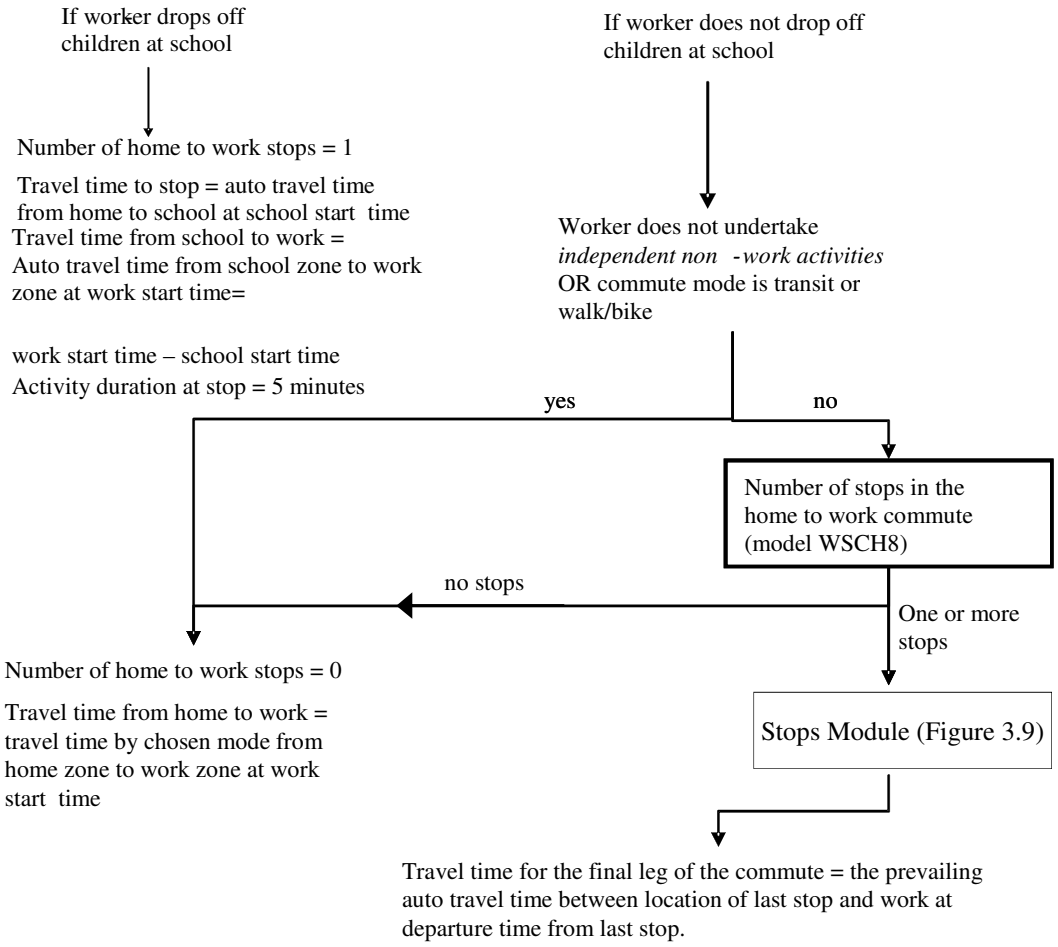


Figure 3.8 Scheduling the Home-to-Work Commute

3.4.2.3 Scheduling the drop-off tour for the non-worker escorting children to school

Among all activities and travel pursued by a non-worker, the escort of children to and from school is undertaken with perhaps the most space-time constraints. Consequently, these activities are scheduled prior to all independent activities undertaken during the day. Of the two types of

escort activities, drop-off and pick-up, the scheduling of the former is undertaken first as the drop-off activities temporally precede the pick-up activities.

Non-workers dropping off children at school are assumed to undertake this activity as the first stop of their first home-based tour for the day. The scheduling of this first tour is presented in Figure 3.10. The mode for this tour is set as "driver with passenger" and the travel time is determined as the prevailing auto travel time between the home and school zones at the school start time of the children being escorted. An activity duration of 5 minutes is assigned to the drop-off stop. After dropping off the children at school, the non-worker may choose to undertake other independent activities as part of this same tour. The number of such stops in this tour is determined next. The reader will note that this is applicable only for non-workers who have decided to undertake one or more independent non-work activities during the day. If one or more stops are predicted (the empirical modeling system allows a maximum of three additional stops in a tour containing a drop-off episode), then each of these stops are characterized, sequentially from the first to the last, in terms of the activity type at the stop, the duration of activity at the stop, the travel time to the stop, and the location of the stop. Once all the stops are characterized, the travel time for the last leg of the tour (i.e., the trip ending at home) is determined as the prevailing auto travel time between the location of the last activity stop and home at the departure time from the last stop. If the non-worker is not undertaking any activity other than the drop-off as part of this tour, then the return home time is determined as the prevailing auto travel time between the school location and home at the departure time from the drop-off episode.

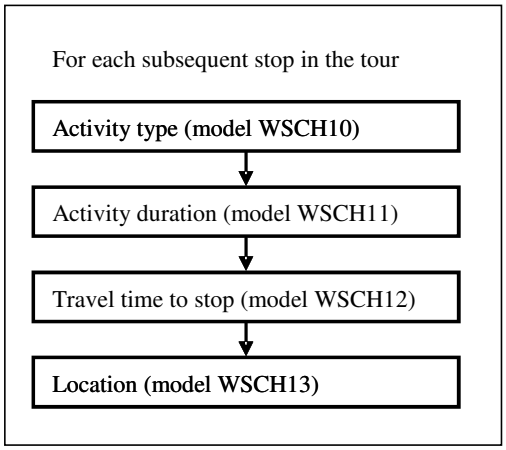


Figure 3.9 Stops Module (Workers)

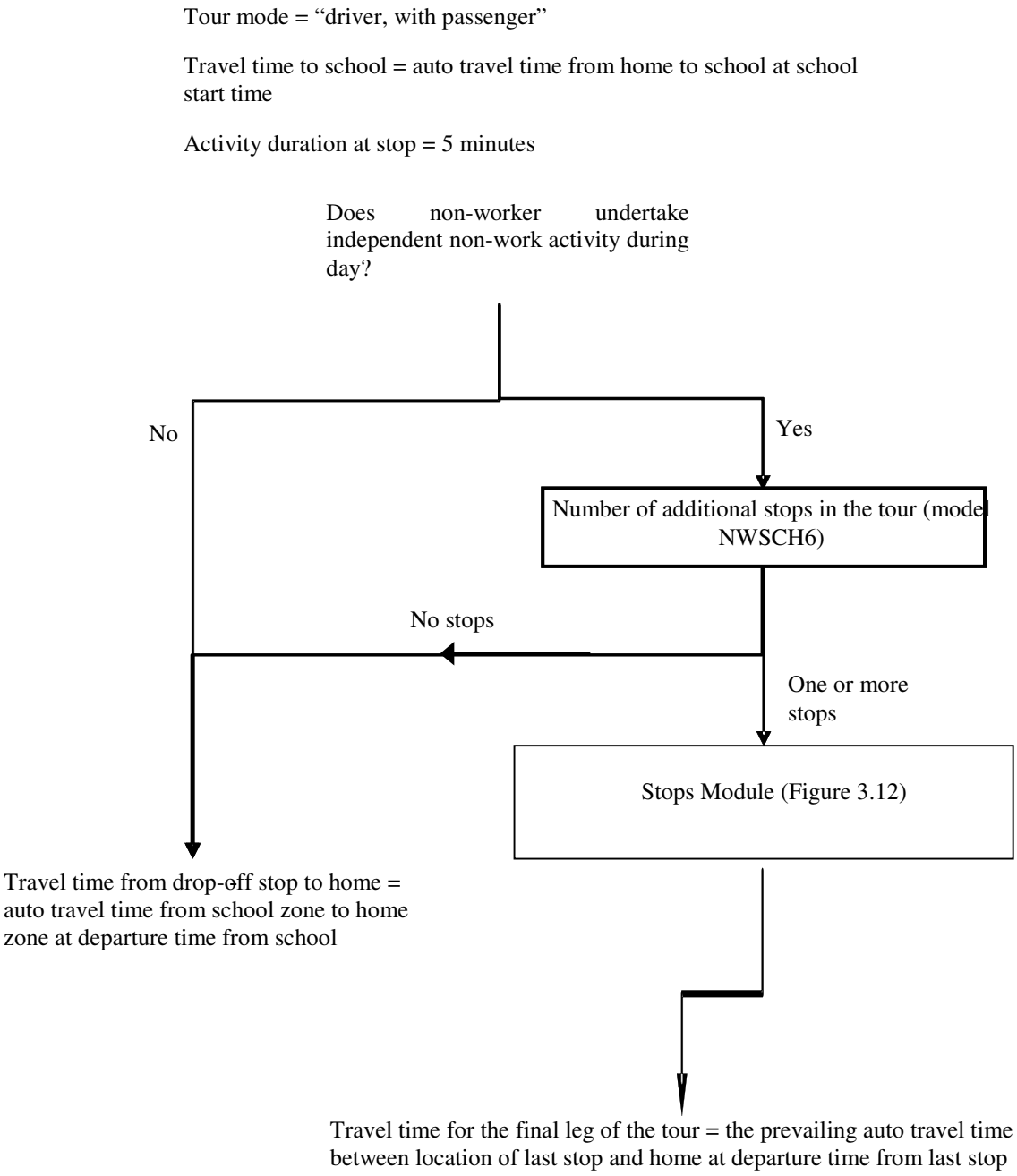


Figure 3.10 Scheduling Drop-Off Tour for Non-Worker Escorting Children to School

3.4.2.4 Scheduling the pick-up tour for the non-worker escorting children from school

Non-workers picking up children from school are assumed to be undertaking this activity as the first stop of a home-based tour. Unlike the tour containing the drop-off episode, the tour containing the pick-up episode is not necessarily the first tour of the day. In fact, it could be any (i.e., first, second, third) of the several tours made by the non-worker during the day. The overall scheduling of a tour containing the pick-up activity (Figure 3.3) is very similar to the procedure described for the scheduling of a drop-off tour. In this case, the tour is constrained by the school end time of the children being escorted as opposed to the school start time in the case of the drop-off tours.

Tour mode = driver

Travel time to school = auto travel time from home to school at school end time

Activity duration at stop = 5 minutes

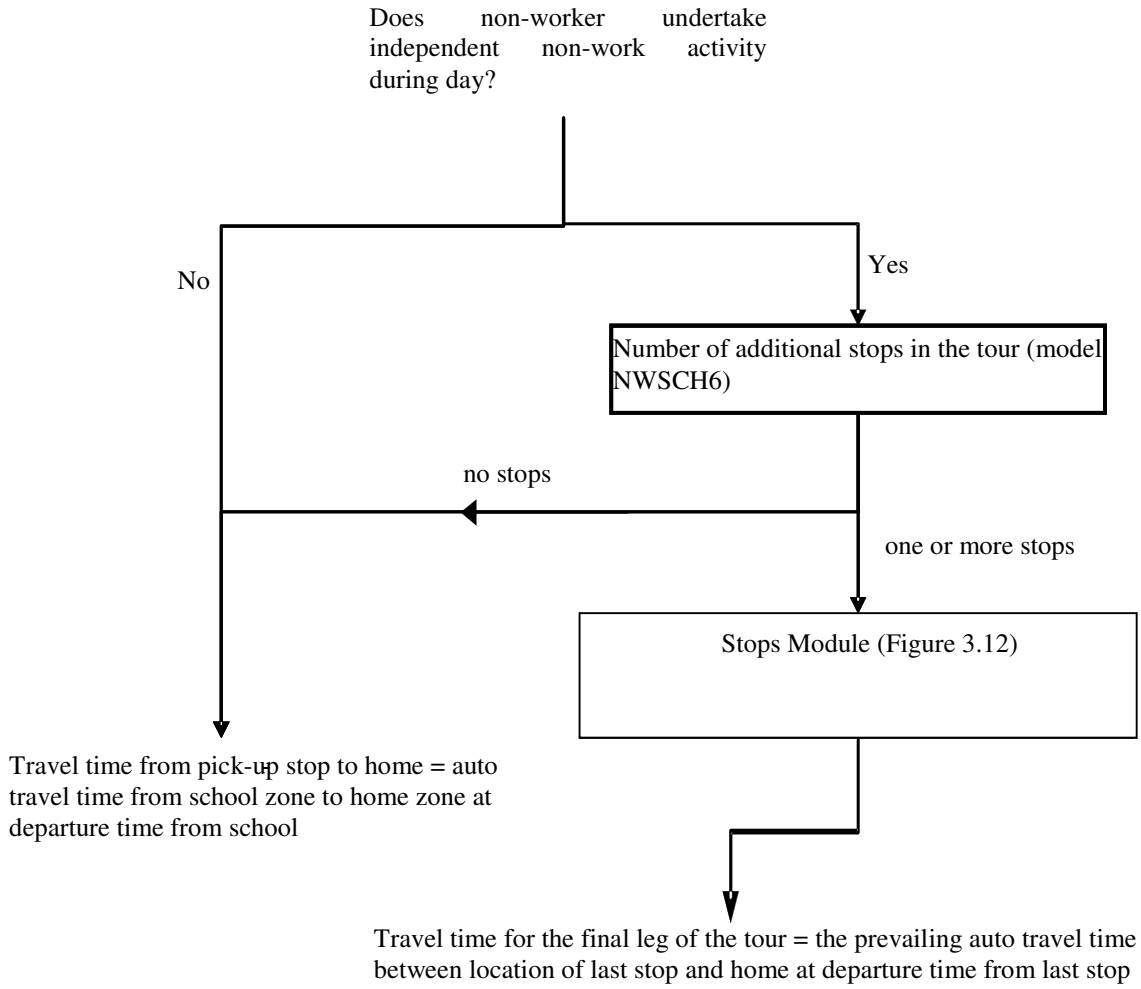


Figure 3.31 Scheduling Pick-Up Tour for the Non-Worker Escorting Children from School

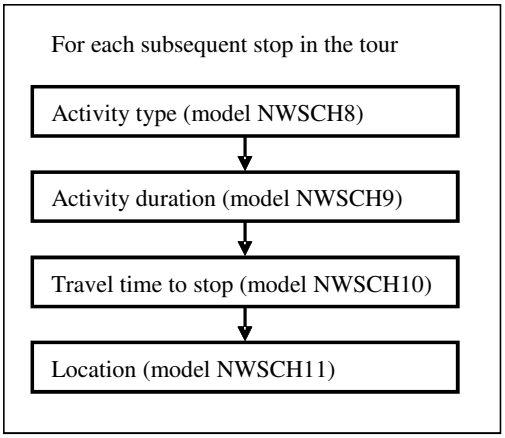


Figure 3.12 Stops Module (Non-workers)

3.4.2.5 Scheduling the commutes for school-going children

In the fourth major step of scheduling, the commute for each of the school-going children in the household is characterized (Fig. 3.13). If a child is being escorted home from school, the school-to-home commute of this child is simply obtained as the corresponding travel pattern (*i.e.*, the pattern from pick-up activity to arrival at home) of the escorting parent. If the child is not escorted, the travel time from school to home is determined using a regression model and the child is assumed not to make any stops during this commute. If a child is being escorted to school, the home-to-school commute of this child is simply obtained as the corresponding travel pattern (i.e., the pattern from departure from home to drop-off activity) of the escorting parent. If the child is not escorted, the travel time from home to school is determined using a regression model and the child is assumed not to make any stops during this commute.

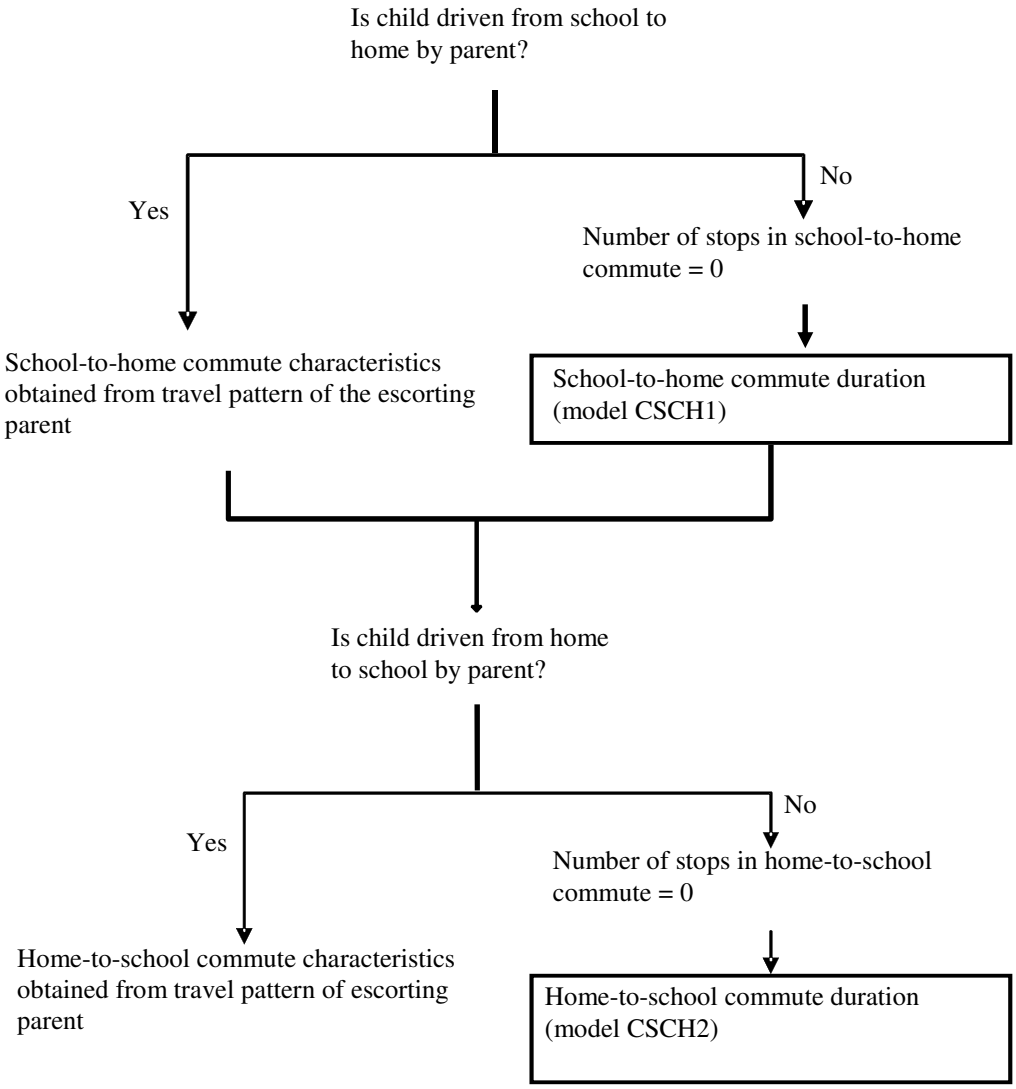


Figure 3.13 Scheduling Commutes for School-going Children

3.4.2.6 Scheduling all the home-based joint tours in the household

The next step in the scheduling procedure focuses on the home-based joint tours by all members in the household. It is important to note that all the attributes of the joint activities namely activity type, activity duration, activity start time, activity location, travel mode, and vehicle used are already determined in the first step of scheduling. In this step, we only copy these attributes appropriately to each person participating in these joint activities. If the person is a worker, then the joint activity episode involving this person is scheduled as the only stop in the only after-work tour of the worker. If this person is a non-worker, then the joint activity is pursued as the only stop in a home-based tour. This tour could be any of the several tours made by the non-

worker during the day. Moreover, in the survey data used for model estimations we did not find cases in which adults undertook both pick-up and joint activities. Hence, the adults undertaking joint activities are assumed not to escort children from school. From the standpoint of the child undertaking a joint activity, the joint activity is assumed to be undertaken after return from school.

3.4.2.7 Scheduling the independent home-based and work-based tours for each worker in the household

At this point, the scheduling of all activities that are significantly impacted by space-time constraints has been completed. The next steps in the scheduling procedure are focused on the organization of activity stops undertaken with more spatial and temporal flexibility. This seventh step (3.14 and 3.15) of the scheduling procedure is focused on the scheduling of home-based and work-based tours undertaken by workers who choose to undertake independent non-work activities during the day. For workers not undertaking joint activities, the number of after-work tours is first determined (Fig. 3.14). If the worker chooses to undertake one or more tours (up to two after-work tours are supported by the empirical modeling system), then each of these tours is characterized (sequentially from the first after-work tour) in terms of the tour mode, number of stops in the tour, and home-stay duration prior to the tour (Fig. 3.15*Figure 3.1*). The reader will note that the home-stay duration before the tour determines the time of day of departure for the tour. A maximum of five stops is supported by the empirical model system in any tour. Each of the stops in the tour is characterized (sequentially from the first to the last stop) in terms of the activity type, activity duration, travel time to the stop, and location of the stop. The attributes of all the stops in a tour are completely determined before proceeding to the subsequent tour.

As shown in Figure 3.14, once the scheduling of activities during the after-work period is complete, the decision of a worker to undertake work-based tours is determined. The empirical modeling system allows up to two tours during the work-based period. The scheduling of the tours during the work-based period follows a similar procedure to the scheduling of tours during the after-work period, which has already been discussed. Finally, after the scheduling of activities during the work-based period is complete, the worker's decision to undertake tours during the before-work period is determined (a maximum of one tour is supported). Again, the

scheduling of the tours during the before-work period follows a similar procedure to the scheduling of tours during the after-work and work-based periods. With this, the complete activity-travel pattern of all workers in the household has been generated.

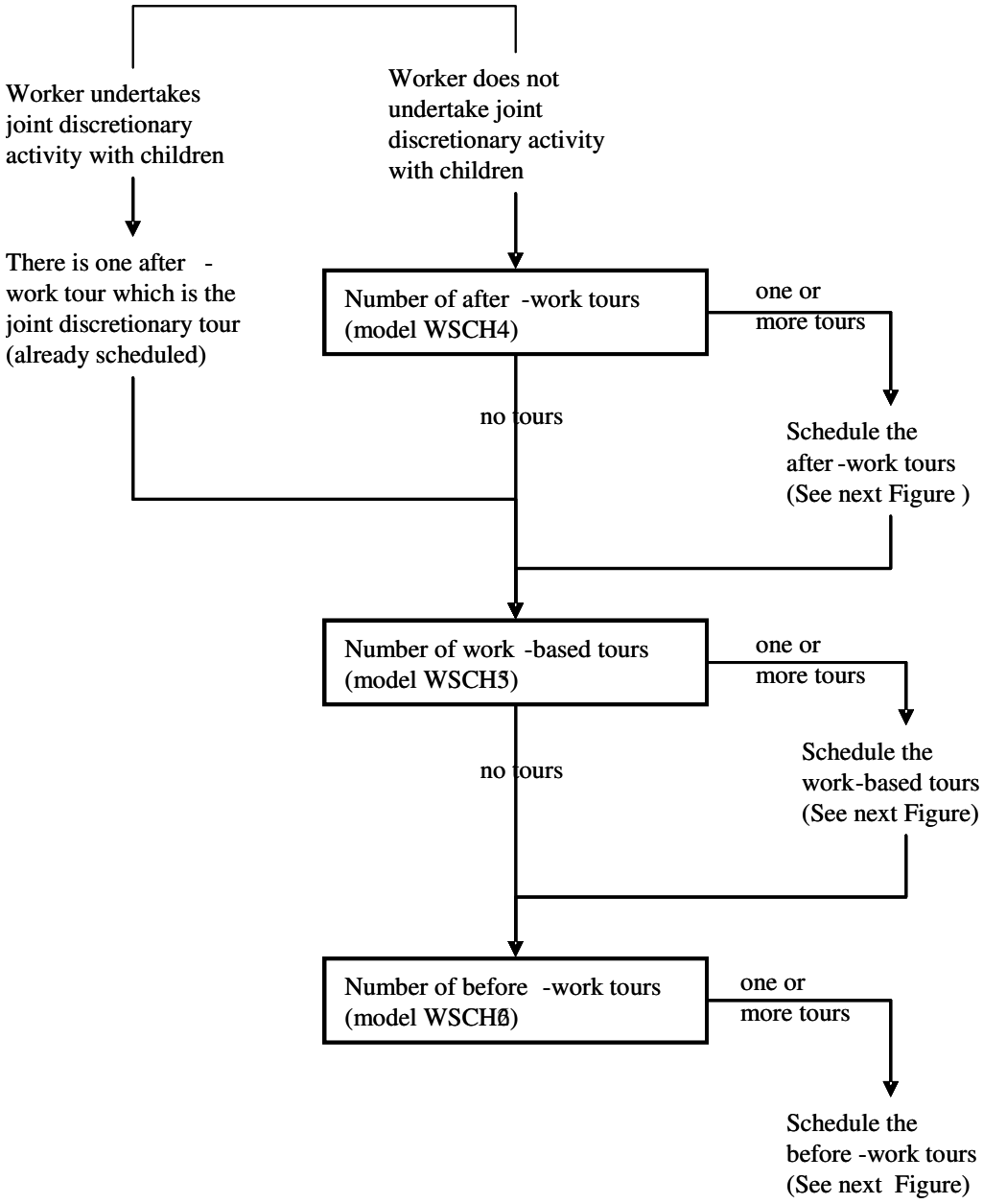


Figure 3.14 Scheduling All Independent Home-Based and Work-Based Tours for Workers

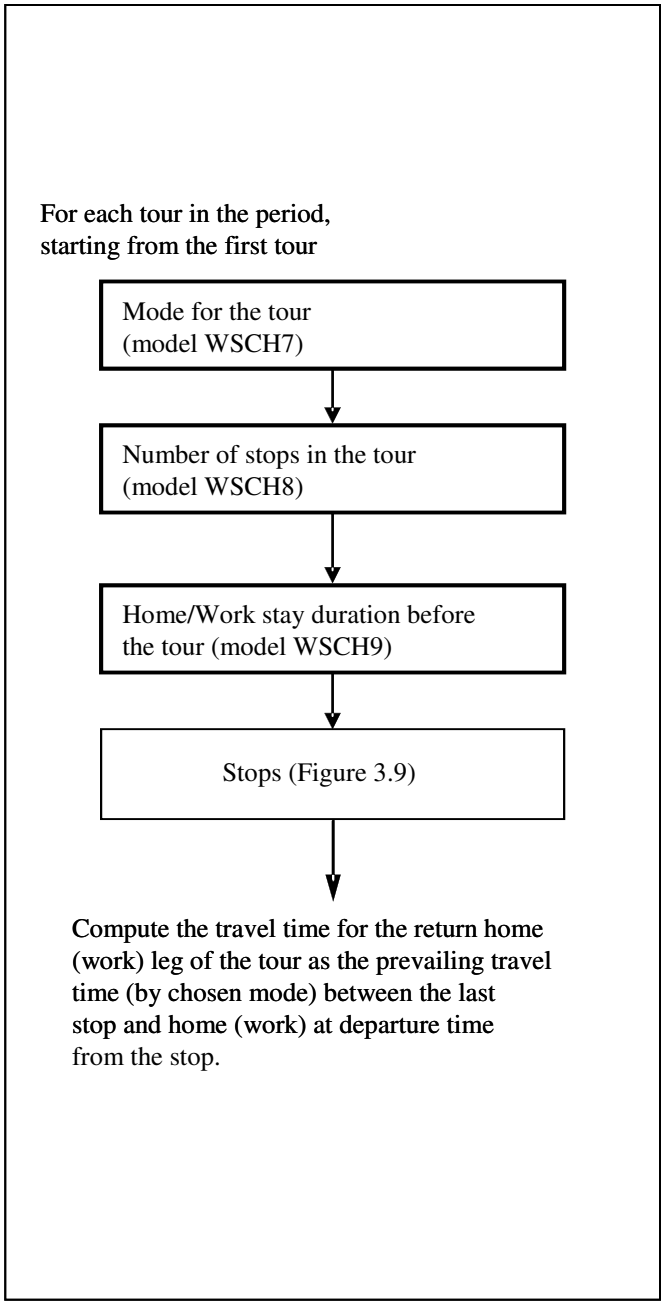


Figure 3.15 Scheduling a Single Independent Tour for Workers

3.4.2.8 Scheduling the independent home-based tours for each non-worker in the household

The penultimate step in the scheduling procedure is focused on the independent activities pursued by the non-workers in the household. If the non-worker is not pursuing pick-up or joint

activities, then the scheduling of independent activities begins with the determination of the total number of independent non-work tours to be undertaken by the individual. A maximum of four independent non-work tours is supported by the empirical modeling system. As depicted in Figure 3.16, each of these tours is characterized (sequentially from the first after-work tour) in terms of the tour mode, number of stops in the tour, and home-stay duration prior to the tour. Home-stay duration before the tour determines the departure time for the tour. A maximum of five stops is supported by the empirical model system in any tour. Each of the stops in the tour is characterized (sequentially from the first to the last stop) in terms of the activity type, activity duration, travel time to the stop, and location of the stop. The attributes of all the stops in a tour are completely determined before proceeding to the next tour.

If the non-worker is undertaking pick-up (joint) activities, then the decision of this person to undertake an independent tour before and after the pick-up (joint) tour is predicted (Figure 3.16). As already discussed, non-workers are assumed not to undertake both pickup and joint activities. This, in turn, determines the position of the pick-up (joint) tour within the overall pattern of the non-worker. For example, if a non-worker who undertakes a drop-off tour also decides to undertake an independent tour before the tour for picking up children from school, then the pick-up tour becomes the third tour in this person's overall pattern (the drop-off tour is always the first tour). Alternatively, if a non-worker who does not undertake a drop-off tour decides to undertake an independent tour before the tour for picking up children from school, then the pick-up tour becomes the second tour in this person's overall pattern. The characteristics of these tours and the stops in these tours are determined, depending on the choice to undertake a tour before and after the pick-up (joint) tour.

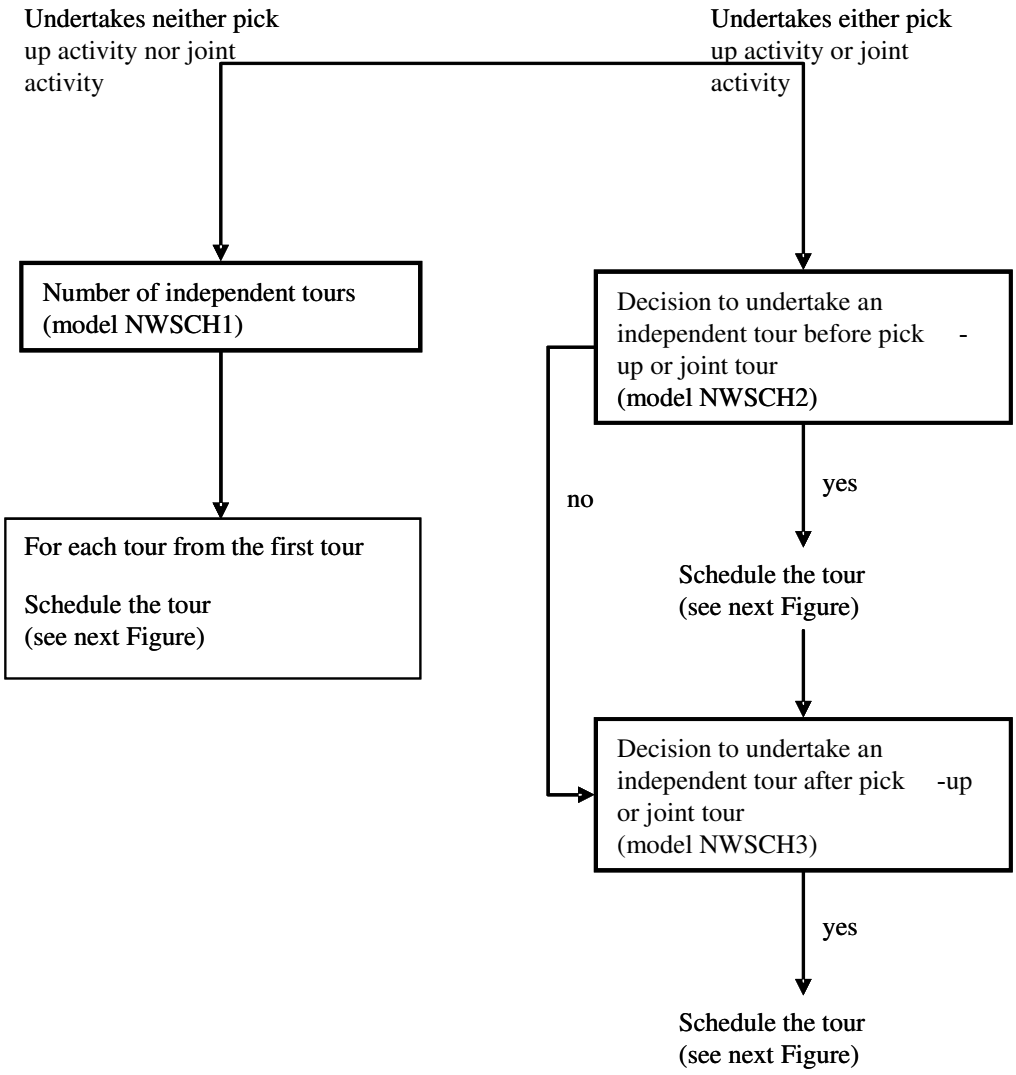


Figure 3.16 Scheduling All the Independent Home-Based Tours for Non-Workers

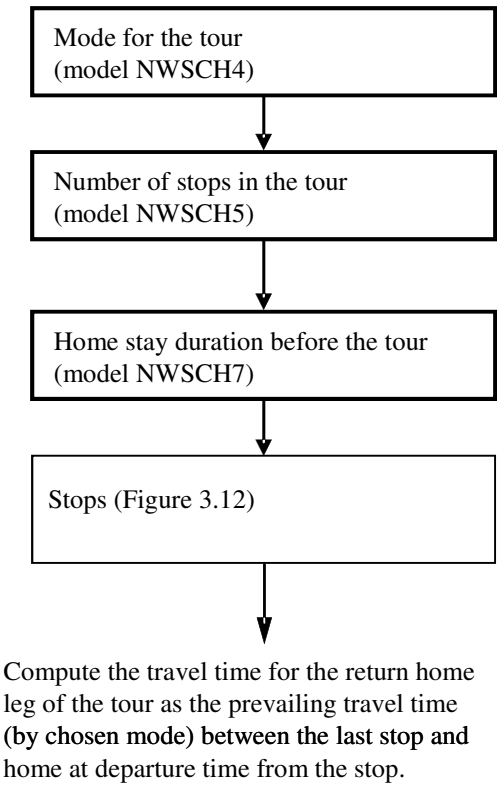


Figure 3.17 Scheduling a Single Independent Tour for Non-Workers

3.4.2.9 Scheduling the independent tours for each child in the household

In this last activity scheduling step, independent tours undertaken by the children are predicted (Figure 3.18). The characterization of the independent tour begins with the choice of the tour mode, which can be "drive by other" or "walk/bike." Next, the departure time from home for the tour is determined. If the child also goes to school, it is assumed that independent tours are undertaken after returning home from school. The characterization of the independent tour is completed by determining the activity duration at the stop, the travel time to the stop, and the location of the stop. The reader will note that there is only one stop in independent tours undertaken by children and each child undertakes at most one independent tour during the day.

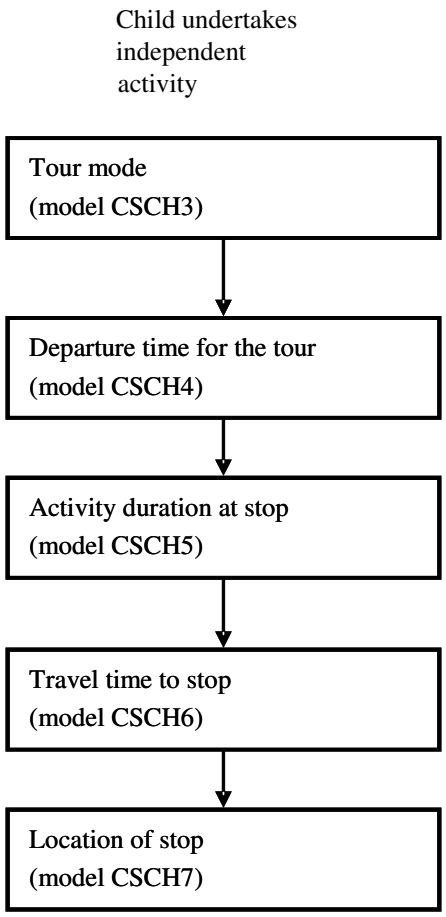


Figure 3.18 Scheduling Independent Tours for Each Child in the Household

3.5 Spatial and Temporal Consistency Checks

Several spatial and temporal consistency checks have been implemented in CEMDAP to ensure that the simulation process does not result in unreasonable or impossible activity patterns. This section describes the spatial and temporal consistency checks used in the enhanced version of CEMDAP.

3.5.1 Spatial Consistency Checks

The spatial location choices for non-work activities are determined using the spatial location choice model. Bhat *et al.* (2003) describes the mathematical procedure used to apply the spatial location choice model. The methodology employs a probabilistic choice set generation method

that uses the predicted travel time to the stop (from the previous stop location) in the determination of the candidate locations for the stop. Subsequently, a multinomial logit prediction procedure is used to predict the spatial location choice among the candidate locations in the choice set. It was found that the probabilistic choice set generation method was giving rise to unreasonably far (from the origin zone) spatial location choice predictions. Hence, a deterministic choice set generation method was developed to ensure the spatial consistency of the predicted activity-travel patterns. The deterministic choice set generation method and the subsequent spatial location choice prediction procedure are described below.

The deterministic choice set generation method also uses the predicted travel time to the stop (from the previous stop location) in the determination of the candidate locations for the stop. Subsequently, a multinomial logit prediction procedure is used to predict the spatial location choice among the candidate locations in the choice set.

The rationale behind using the predicted travel time to the stop in generating the location choice set is that the stop location to be predicted should be *within* a certain range of the predicted travel time to that stop. Hence, the location choice set for a stop consists of the zones that fall *within* a certain range of predicted travel times from the previous stop location. Half of the candidate zones selected into the location choice set have shorter travel times (from the previous stop location) than the predicted travel time, while the other half have travel times greater than or equal to the predicted travel time.

An important point to be noted here pertains to the definition of *predicted travel time* to the stop used in the context of spatial location choice. The travel time predicted by the "travel time to the stop" model is the *total expected travel time* that the person expects to travel for the next stop. As the "travel time to the stop" model was estimated using the reported travel times in the household travel survey data, the total expected travel time includes not only the in-vehicle-travel time, but also additional time such as the out-of-vehicle travel time. Hence, the out-of vehicle travel time is subtracted from the *predicted total expected travel time* to obtain the *predicted travel time* on the network for spatial location choice. This predicted travel time is used to generate the location

choice set. The steps involved in the disaggregate prediction (including the choice set generation) using the location choice model are summarized below:

1. Determine the predicted travel time by subtracting the out-of-vehicle travel time from the total expected travel time by using the following rules.
    a. If (activity type at the stop is 'other' or shopping or serve passenger and total expected travel time >20 minutes),
    predicted travel time = total expected travel time – 8 minutes
    b. If (activity type at the stop is 'other'or shopping or serve passenger and total expected travel time ≤ 20 minutes),
    predicted travel time = 0.6 X total expected travel time
    c. If (activity type at the stop none of 'other' or shopping or serve passenger and total expected travel time >24 minutes),
    predicted travel time = total expected travel time – 6 minutes
    d. If (activity type at the stop none of 'other' or shopping or serve passenger and total expected travel time >24 minutes),
    predicted travel time = 0.75 X total expected travel time.
2. If the predicted travel time is less than the intrazonal travel time from the previous stop location, then the chosen stop location is in the same zone as the previous stop location because this is the only choice alternative available. If the predicted travel time is greater than the intrazonal travel time, follow the steps below.
3. Arrange all the zonal locations in the ascending order of in-vehicle travel time from the previous stop.
4. Select the first spatial zone *Z,* whose in-vehicle travel time from the previous stop (t_z) is greater than the predicted travel time.
5. Select twenty-five zones with in-vehicle travel time (from the previous stop location) less than t_z and twenty-five zones with in-vehicle travel time greater than t_z. If twenty-five zones are not available on one or both sides of t_z, select the minimum number of zones available on both sides in order to maintain symmetry of travel times of the candidate zones in the choice set.

6. Compute the conditional probability ($P_1, P_2 \ldots P_K$) for each of the different K ($K = 50$ *or less*) candidate locations using the calibrated model parameters and the values of exogenous variables specific to the decision maker under consideration.
7. Generate a uniformly distributed random number (U) between 0 and 1.
8. The chosen alternative is determined using the computed choice probabilities and the uniform random number drawn as follows:

   If $0 <= U < P_1$, chosen alternative is A_1.

   If $P_1 <= U < P_1+P_2$, chosen alternative is A_2.

   If $P_1+P_2+..P_{J-1} <= U < P_1+P_2+..P_J$, chosen alternative is A_J.

   If $P_1+P_2+..P_{K-1} <= U < 1$, chosen alternative is A_K.

3.5.2 Temporal Consistency Checks

Most of the temporal choices (such as home-stay durations before tours, activity durations, and travel times to stops) are determined using log-linear regression models. Because the chosen duration is determined by a random draw from a normal distribution, a small (but non-zero) possibility exists that the duration determined is either very high or very low. This may lead to temporal overlapping situations in which the total predicted duration for a person exceeds 24 hours or the predicted end time of an activity falls after the predicted start time of the next activity. Rules for temporal consistency have been developed to handle cases in which the predicted duration is unreasonably high or low. Predictions on other temporal choice predictions, such as work start and end times and work durations, are also controlled using temporal checks, in order to avoid start and end times that are too early or late and durations that are too long.

The temporal checks are defined in terms of lower and upper bounds for each of the different durations that will be determined by the model system. If the predicted value of the duration falls below the lower bound, it is set to the lower bound; if it falls above the upper bound, it is set to the upper bound. The values were determined based on an empirical examination of data from the Los Angeles area and based on experience from previous cities. In most cases, the fifth-percentile value of the duration in the sample is chosen as the lower bound and the ninety-fifth-percentile value chosen as the upper bound. Most of the time bounds are defined as percentages

of available time rather than absolute values. The concept of available time is discussed below in greater detail. (Available time is a frequently updated attribute in the CEMDAP's simulation sequence). Absolute values of time bounds are avoided to reduce the likelihood of any sort of temporal overlaps.

Table 3.6 provides the definitions for available time for various temporal attributes. The available time for a worker's home stay duration before his or her first after-work tour is given by: 1440 – arrival time at home from work; that for the subsequent after-work tours is given by: 1440 – arrival time at home from the previous after-work tour. The available time for a worker's work stay duration before the first work-based tour is given by: the work-based duration, while that for his/her subsequent work-based tours is given by: work end time – arrival time at home from the previous work-based tour. The available time for a worker's home stay duration before his or her first before-work tour is given by the departure time from home for work, while that for the subsequent before-work tours is given by: departure time from home for work – arrival time at home from the previous before-work tour.

The available time for home stay duration before a non-worker's tour depends upon whether the non-worker undertakes pick-up, drop-off, or joint activities. If the non-worker does not undertake any of the above mentioned joint activities, the available time for home stay duration before his or her first tour is 1440, while that for the subsequent tours is given by: 1440 – arrival time at home from the previous tour. If the non-worker undertakes drop-off activity, the available time for home stay duration before the first tour is given by: 1440 – arrival time at home from the drop-off tour; that for subsequent tours is given by: 1440 – arrival time from the previous tour. If the non-worker undertakes either a pick-up or joint activity, the available time for home stay duration before his or her first tour before the pick-up or joint tour is given by: time from 3 a.m. until the departure for the pick-up or joint activity tour; available time for the first tour after the pick-up or joint activity tour is given by: 1440 – arrival time at home after the pick-up or joint activity tour and that for all his or her subsequent tours is given by: 1440 – arrival time from the tour before.

The available time for a worker's tour (after-work, work-based, or before-work) is given by: available time for the work or home stay duration before that tour – work or home stay duration before that tour; that for the work-home commute is given by: time from 3 a.m. until the start of the work; and that for the home-work commute is given by: 1440 – work end time. The available time for a non-worker's tour is given by: available time for the home stay duration before that tour – home stay duration before that tour.

The available time for activity duration of the first stop in a tour or commute is given by: available time for the tour or commute. Available time for any subsequent stop is given by: available time for the previous stop – activity duration for the previous stop - travel duration for the previous stop. The available time for travel for any stop is given by: available time for the activity duration – activity duration at that stop.

Tables 3.7 through 3.15 provide the temporal bounds for each of the temporal choice dimensions predicted in CEMDAP. Several observations can be made from Table 3.6 and these tables. First, the available time decreases with the hierarchy of the temporal attribute (see Table 3.6). That is, the available time for home or work stay duration is greater than the available time for the corresponding tour and the available time for a tour (a tour-level attribute) is greater than the available time for activity duration and travel duration of stops (stop-level attributes) in that tour. Second, the upper and lower bounds for home or work stay duration decrease with an increase in the number of stops or an increase in the number of tours (see Tables 3.7 and 3.8). For non-workers, earlier tours in the pattern have wider time bounds on home stay (see Table 3.8). Third, the upper and lower bounds on activity durations and travel durations decrease with the increase in the number of stops. Fourth, the temporal bounds on home or work-stay, activity duration, and travel duration are in terms of percentages of available time, whereas those of other temporal variables (work and school start and end times and durations, school-home and home-school commute durations, and departure time, activity durations, and travel durations of independent and joint discretionary tours) are in absolute time values. The bounds on work and school start and end times are to allow sufficient time for after-work tours, and before-work tours. The bounds on work and school durations restrict the durations within a reasonable range.

Table 3.7 Available Time Definitions

Available time for…	Definition (in minutes)
Home/work - stay duration for workers	
First after-work tour	1440 – arrival time at home from work
Subsequent after-work tours	1440 – arrival time at home from the previous after-work tour
First work-based tour	Work-based duration
Subsequent work-based tours	1440 – arrival time at home from the previous work-based tour
First before-work tour	Time from 3 a.m. until the departure to work
Subsequent before-work tours	1440 – arrival time at home from the previous before-work tour
Home-stay duration for non-workers	
If non-worker does not undertake pick-up, drop-off, or joint activity	
First tour	1440
Subsequent tours	1440 – arrival time from the tour before
If non-worker undertakes drop-off activity	
First tour	1440 – arrival time at home from drop-off tour
Subsequent tours	1440 – arrival time from the tour before
If non-worker undertakes pick-up/joint Activity	
First tour before pick-up/joint tour	Time from 3 a.m. until departure for pick-up/joint activity tour
First tour after pick-up/joint tour	1440 – arrival time at home after pick-up/joint activity tour
Subsequent tours	1440 – arrival time from the tour before
Tour/commute	
After-work, work-based, and before-work tours	Available time for the corresponding work/home-stay duration – work/home-stay duration
Work-home commute	Time from 3 a.m. until the start of work
Home-work commute	1440 – work end time
Non-worker tours	Available time for corresponding home-stay duration – home-stay duration
Activity duration	
First stop in a tour/commute	Available time for the tour/commute
Subsequent stops in a tour/commute	Available time for the previous stop – (activity duration + travel duration for the previous stop)
Travel duration	Available time for activity duration – activity duration

Table 3.8 Temporal Bounds on Worker Home and Work-Stay Duration (as % of available time)

	Lower Bound	Upper Bound
Before-work tours	31.58	86.96
Work-based tours		
One tour, one stop in tour	15.32	64.30
One tour, two or more stops in tour	7.17	56.76
Two or more tours, one stop in tour	11.97	64.11
Two or more tours, two or more stops in tour	7.17	59.87
After-work tours		
One tour, one stop in tour	1.47	38.55
One tour, two or more stops in tour	1.58	28.57
Two or more tours, one stop in tour	1.45	37.24
Two or more tours, two or more stops in tour	1.32	28.17

Table 3.9 Temporal Bounds on Non-Worker Home and Work-Stay Duration (as % of available time)

	Lower Bound	Upper Bound
First tour		
One stop in tour	15.28	63.54
Two stops in tour	15.28	56.25
Three or more stops in tour	13.89	50.00
Second tour		
One stop in tour	2.17	46.19
Two stops in tour	1.41	43.83
Three or more stops in tour	0.84	38.62
Third tour	1.80	37.50
Fourth tour	1.64	29.17

Table 3.10 Temporal Bounds on Worker Activity Duration (as % of available time)

	Lower Bound	Upper Bound
Stops in before-work tours	0.18	30.18
Stops in home-work commute		
One stop in commute	0.32	33.33
Two stops in commute	0.33	36.32
Stops in work-based tours		
One tour, one stop in tour	0.55	19.22
One tour, two stops in tour	0.22	15.48
Two or more tours, one stop in tour	0.79	50.00
Two or more tours, two stops in tour	0.35	32.83
Stops in work-home commute		
One stop in commute	0.18	39.15
Two stops in commute	0.30	27.43
Stops in after-work tours		
One tour, one stop in tour	0.14	18.75
One tour, two stops in tour	0.09	12.62
Two or more tours, one stop in tour	0.17	34.83
Two or more tours, two stops in tour	0.17	25.86

Table 3.11 Temporal Bounds on Non-Worker Activity Duration (as % of available time)

	Lower Bound	Upper Bound
First tour		
One stop in tour	0.09	47.40
Two stops in tour	0.14	36.04
Three stops in tour	0.15	29.53
Four or more stops in tour	0.21	25.69
Second tour		
One stop in tour	0.11	37.33
Two stops in tour	0.22	27.56
Three stops in tour	0.15	21.87
Four or more stops in tour	0.15	17.59
Third tour	0.17	30.83

Fourth tour	0.15	33.72

Table 3.12 Temporal Bounds on Worker Travel Duration (as % of available time)

	Lower Bound	Upper Bound
Stops in before-work tours	0.49	9.52
Stops in home-work commute		
One stop in commute	0.77	20
Two stops in commute	0.47	16.87
Stops in work-based tours		
One tour, one stop in tour	0.63	32.20
One tour, two stops in tour	0.36	21.14
Two or more tours, one stop in tour	0.63	32.20
Two or more tours, two stops in tour	0.36	21.14
Stops in work-home commute		
One stop in commute	0.76	19.55
Two stops in commute	0.42	12.09
Stops in after-work tours		
One tour, one stop in tour	0.21	3.21
One tour, two stops in tour	0.21	2.79
Two or more tours, one stop in tour	0.37	6.06
Two or more tours, two stops in tour	0.33	9.55

Table 3.13 Temporal Bounds on Non-Worker Travel Duration (as % of available time)

	Lower Bound	Upper Bound
First tour		
One stop in tour	0.35	9.76
Two stops in tour	0.31	9.85
Three stops in tour	0.28	9.30
Four or more stops in tour	0.28	8.76
Second tour		
One stop in tour	0.38	7.14
Two stops in tour	0.37	6.32
Three stops in tour	0.29	6.84
Four or more stops in tour	027	6.04
Third tour	0.36	6.65

Fourth tour	0.44	8.54

Table 3.14 Temporal Bounds on Work and School Start and End Times (absolute time)

	Lower Bound	Upper Bound
School (children)		
Start time (minutes from 3 a.m.)	240.0	420.0
End time (minutes from 3 a.m.)	540.0	900.0
Duration (minutes)	180.0	600.0
Work (adults)		
Start time (minutes from 3 a.m.)	210.0	660.0
End time (minutes from 3 a.m.)	660.0	1020.0
Duration (minutes)	240.0	720.0
School (adults)		
Start time (minutes from 3 a.m.)	240.0	490.0
End time (minutes from 3 a.m.)	498.8	1035.0
Duration (minutes)	120.0	600.0

Table 3.15 Temporal Bounds on Home-to-School and School-to-Home Commute Durations (absolute time in minutes)

	Lower Bound	Upper Bound
School-to-home commute duration		
Auto	5.0	45.0
School bus	10.0	60.0
Walk/bike	3.5	35.0
Home-to-school commute duration		
Auto	3.0	30.0
School bus	10.0	65.0
Walk/bike	4.0	30.0

Table 3.16 Temporal Bounds for Independent Tours Undertaken by Children (absolute time)

	Lower Bound	Upper Bound
Departure time (minutes from 3 a.m.)	255.0	990.0
Activity duration (minutes)	10.0	345.0
Travel time (minutes)	1.0	35.0

4. Validation

We used the modified CEMDAP to generate the activity travel patterns of the population in the SCAG region. In this chapter, we discuss the validation exercise undertaken to assess the ability of CEMDAP to produce predicted activity-travel patterns that are consistent, reasonable, and close to the observed patterns in the survey used for estimating all the models in CEMDAP.

Table 4.1 Average Number of Trips per Household

Type of Trips	SimAGENT	Survey	SimAGENT (85% Work Scenario)
Home Based Work	1.27	1.33	1.68
Home Based Non-work	5.13	4.90	4.94
Non-home based	2.31	2.59	2.69
Total	8.71	8.82	9.30

First, we compared the average number of trips per household by trip type in the survey data and the SimAGENT prediction. It can be seen from Table 4.1 above that the numbers match reasonably well. However, in the survey data we observed that the percentage of workers (people who go to work on the travel day) is rather low than expected (around 65%). So, we ran SimAGENT for 85% work scenario where we made 85% of the employed people go to work. Under this scenario, the average number of home-based work trips increased as expected resulting in an increase in the overall average number of trips per household across all trip types. A similar trend was observed when we further increased the percentage of workers to 90% and

95%. The reality, we believe, would be somewhere between 65% and 85%. Future data collection efforts must try to sample households appropriately for predictions close to the reality.

Table 4.2 Distribution of Number of Tours (Workers)

Number of Tours	Before Work		Work Based		After Work	
	Survey	SimAGENT	Survey	SimAGENT	Survey	SimAGENT
0	94.26	96.69	81.03	76.67	79.48	81.36
1	5.74	3.31	16.59	18.01	17.86	17.17
2	--	--	2.38	5.32	2.66	1.47

Table 4.3 Distribution of Number of Tours (Non-Workers)

Number of Tours	Survey	SimAGENT
1	58.81	55.51
2	27.53	24.79
3	9.49	12.55
4	4.17	7.15

Next, we looked at the distribution of number of tours by tour type in the survey data and SimAGENT. These results are presented in Tables 4.2 (for workers) and 4.3 (for non-workers). It can be seen from the results that the numbers in the corresponding cells match pretty closely both for workers and non-workers.

Table 4.4 Average Number of Stops by Tour Type

Average number of stops	Survey	SimAGENT
Work Based tours	1.37	1.36
Before work tours	1.41	1.34
After work tours	1.40	1.36
Work-to-home commute	0.40	0.35
Home-to-work commute	0.26	0.18
Non-worker tour	1.78	1.66

Table 4.4 presents the comparison between survey data and SimAGENT prediction of the average number of stops in different types of tours. SimAGENT performs pretty well in all tour

types except for the home-to-work commute tours. To be specific, SimAGENT seems to be under predicting the number of stops in home to work commute tours.

Table 4.5 Chaining Propensity

	Survey	SimAGENT
Worker		
Chaining Propensity	0.85	0.86
Non Worker		
Chaining Propensity	0.71	0.76

Next, we compare the chaining propensity which is a measure of the inclination to undertake more than one activity episode (or stop) in a tour. To be specific, non-commute chaining propensity for workers is defined as the ratio of the sum of the number of before-work, work-based, and after-work tours to the total number of out-of-home activity episodes undertaken in the before-work, work-based, and after-work tours, respectively. Similarly, the chaining propensity for non-workers is the ratio of the total number of tours to the total number of out-of-home activity episodes. If each tour comprises only one stop, then the chaining propensity is one. As more stops are included in each tour, the propensity falls below one. Hence, the smaller the value of the chaining propensity measure, the greater the extent of trip chaining. As we can see, SimAGENT outputs match quite well with the survey results.

Table 4.6 Tour Mode Shares

	Work-to-home		Work based		Before work		After work		Non-Worker	
	SimAGENT	Survey	SimAGENT	Survey	SimAGENT	Survey	SimAGENT	Survey	SimAGENT	Survey
Drive alone	77.7	78.2	64.2	69.3	56.5	44.0	55.0	56.2	51.9	39.8
Drive as passenger	8.9	9.8	15.9	13.8	26.2	39.1	35.3	31.7	28.8	36.7
Shared ride	8.1	6.6	6.0	6.3	4.0	2.5	3.9	5.1	12.2	14.1
Walk or bike	2.7	2.9	13.7	10.1	12.7	13.9	4.9	6.3	5.7	7.5
Transit	2.6	2.5	0.2	0.5	0.6	0.5	0.9	0.7	1.4	1.9

Lastly, we compare the tour mode shares by tour type across five modes in the survey data and SimAGENT output. It can be seen that the mode shares44 match pretty closely except for the

drive as passenger mode for the before work and non-worker tours. SimAGENT over-predicts the share of this mode in both these tour types.

Appendix A: CEMSELTS PARAMETERS

Table A-1 Drop-out rate look-up table

Male					
Age	**Hispanic**	**NH White**	**NH Black**	**NH Native**	**NH Asian**
13	0.006	0.006	0.015	0.032	0.005
14	0.013	0.005	0.030	0.033	0.008
15	0.048	0.010	0.020	0.049	0.011
16	0.049	0.016	0.054	0.058	0.011
17	0.050	0.014	0.077	0.042	0.012
18	0.056	0.028	0.070	0.056	0.016
Female					
Age	**Hispanic**	**NH White**	**NH Black**	**NH Native**	**NH Asian**
13	0.010	0.001	0.015	0.032	0.005
14	0.015	0.007	0.030	0.033	0.008
15	0.032	0.018	0.076	0.049	0.011
16	0.026	0.013	0.039	0.058	0.011
17	0.032	0.017	0.029	0.042	0.012
18	0.035	0.016	0.035	0.056	0.016

Table A-2 Educational Attainment table

Male						
Educational Attainment	**Hispanic**	**NH White**	**NH Black**	**NH Native**	**NH Asian**	**NH Other**
High School	0.790	0.523	0.701	0.713	0.419	0.579
Associate's	0.075	0.083	0.099	0.095	0.088	0.088
Bachelor's	0.093	0.242	0.137	0.111	0.329	0.212
Master's	0.038	0.132	0.056	0.054	0.140	0.107
Doctorate	0.004	0.019	0.008	0.027	0.024	0.014
Female						
Educational Attainment	**Hispanic**	**NH White**	**NH Black**	**NH Native**	**NH Asian**	**NH Other**
High School	0.787	0.590	0.681	0.734	0.437	0.606
Associate's	0.082	0.093	0.109	0.092	0.107	0.102
Bachelor's	0.089	0.214	0.142	0.115	0.352	0.202
Master's	0.039	0.095	0.063	0.048	0.096	0.078
Doctorate	0.003	0.009	0.005	0.011	0.008	0.013

Table A-3a College Location Table

Variable	Parameter	t-stat
Maximum employees of agriculture that can be reached within 10 minutes (/10^3)	-0.227	-2.26
Maximum employees of transportation that can be reached within 10 minutes (/10^3)	-0.055	-6.72
TAZ is a major college TAZ	2.177	33.87
TAZ is a minor college TAZ	1.324	22.37
Distance home to college	-0.138	-48.39
Person is Caucasian and TAZ belongs to a Caucasian dominated college TAZ	0.372	3.18
Person is Black or Caucasian and TAZ belongs to a Black and Hispanic dominated college TAZ	0.332	2.25
Person's Household Income is less than 50k and TAZ belongs to low income student TAZ	0.213	2.08
Person's Household Income is greater than 50k and TAZ belongs to high income student TAZ	0.206	1.76
Person is employed and TAZ belongs to Employed Student TAZ	0.250	2.71
Goodness of Fit Measures		
Number of Observations	2151	
Log Likelihood Function	-6385.00	
Pseudo R-squared	0.4271	

Table A-3b TAZ Lookup for College Location Model

Zones with Colleges					
101050000	221230400	240340500	265110200	300000614	500490001
101060002	221270000	240420000	270170200	300000620	500500000
101070000	222181000	240670000	270220100	403030000	500570000
101100008	222270001	240860100	270230000	403070000	500710800
101100011	222401000	246080000	270300100	403110000	500720002
101110003	222460000	246340001	270300101	403140100	500730100
101120103	222470000	248270100	280050201	403150100	500730102
101130005	223110000	250030000	290100500	404080300	500730200
101130006	224200000	250400100	292033000	404140500	500840400
101150001	226110100	253040000	300000044	404170200	500860002
101160001	226510000	254240200	300000146	404220200	500990300
101200003	226530101	254330500	300000152	404220900	501000400
101210002	226530104	254332100	300000153	404221100	501001200
211510200	226530105	254332101	300000188	404260503	501001400
211520200	226530500	254350100	300000190	404271202	501041400
212360100	226551000	255380100	300000191	404321601	501041600
213930100	227650000	255451400	300000192	404322101	501200000
218160000	229430000	255452100	300000199	404350900	600150200
219141000	229490000	257120000	300000226	404510700	600180001
219142000	229621000	257330000	300000265	404510800	600270000
219200000	230080000	257350001	300000267	404570200	600280003
219270000	240080000	257460100	300000341	404610200	600470300
220170001	240150000	257470000	300000365	500060200	600490000
220310000	240180000	257490100	300000379	500160000	600500200
220320000	240190100	257520100	300000415	500200901	600630100
220710000	240190200	260030200	300000440	500210005	600630200
220872000	240240200	260360000	300000442	500450200	600760403
221001000	240240300	265000100	300000536	500450201	600800200
221111000	240240400	265090101	300000537	500460100	--
221220400	240320000	265090200	300000565	500490000	--

Table A-3b (continued) TAZ Lookup for College Location Model

Major Education TAZ	Caucasian Education TAZ	Hispanic African American TAZ	High Income Student TAZ	Low Income Student TAZ	Employed Student TAZ
101120103	300000191	101120103	101120103	227650000	101210002
211510200	600270000	222401000	222401000	229430000	227650000
222401000	600760403	254332100	223110000	240340500	229430000
223110000	226510000	--	226551000	254332100	250030000
226510000	--	--	253040000	257460100	254332100
246340001	--	--	404350900	300000191	257470000
254332100	--	--	501041600	500450200	270300101
257460100	--	--	--	600760403	300000620
260360000	--	--	--	--	500450200
270220100	--	--	--	--	--
300000191	--	--	--	--	--
300000620	--	--	--	--	--
403070000	--	--	--	--	--
404220200	--	--	--	--	--
500450201	--	--	--	--	--
600270000	--	--	--	--	--
600760403	--	--	--	--	--
Minor Education TAZ					
101100011	226530101	240340500	265000100	300000614	500450200
101130006	226551000	248270100	270230000	403030000	500500000
101210002	227650000	250030000	270300101	404080300	500840400
212360100	229430000	253040000	300000044	404271202	501001200
213930100	230080000	255452100	300000341	404350900	501041600
219142000	240240300	257120000	300000442	404510700	600180001
220170001	240240400	257470000	300000537	500200901	600470300
222460000	--	--	--	--	--

Table A-4 Labor Participation Model

Variable	Parameter	t-stat
Constant	-1.653	-25.53
Female	-0.753	-23.11
Age		
16 - 40 years	2.852	62.91
41 - 60 years	2.514	60.86
Education Level		
High School	0.520	11.08
College, associate or bachelors	0.981	20.21
Post Graduate, Masters or PhD	1.370	21.78
Presence and age of own children		
Presence of children of age <16 years	0.288	7.02
Female with own children under 6 years	-1.048	-17.58
Ethnicity		
White	-0.170	-3.47
Hispanic	-0.184	-3.43
African American	-0.230	-2.97
Goodness of Fit Measures		
Number of Observations	26689	
Log Likelihood Function	-13504.00	
McFadden's LRI	0.2701	

Table A-5 Employment industry model

Variable	Construction and Manufacturing		Trade and Transportation		Professional Business		Government		Retail	
	Parameter	**t-stat**	**Parameter**	**t-stat**	**Parameter**	**t-stat**	**Parameter**	**t-stat**	**Parameter**	**t-stat**
Constant	-0.417	-5.88	-0.368	-2.66	1.363	20.11	-1.173	-16.98	-0.005	-0.07
Male	0.919	13.95	0.586	5.33	-0.491	-11.09	--	--	-0.172	-2.69
Female*Non-Caucasian	--	--	-0.594	-3.87	--	--	-0.106	-1.04	--	--
Age 16 to 25 years	-0.323	-3.54	-0.215	-1.93	0.341	5.02	--	--	0.665	7.66
Age 26 to 40 years	--	--	--	--	0.127	3.33	--	--	--	--
Age 41 to 65 years	--	--	--	--	--	--	--	--	-0.310	-4.78
Education Level										
High School	--	--	-0.153	-1.58	--	--	--	--	--	--
Associates	-0.378	-5.23	-0.191	-1.72	0.295	5.69	0.517	5.56	--	--
Bachelors	-0.563	-6.36	-0.561	-4.26	0.834	12.81	0.578	5.61	-0.127	-1.47
Post Graduate	-0.861	-6.89	-0.759	-4.35	1.224	14.76	0.719	5.65	-0.796	-5.54
Race										
White	--	--	-0.665	-7.56	-0.181	-3.28	--	--	--	--
Asian	--	--	-0.423	-2.33	--	--	--	--	--	--
Hispanic	0.263	4.01	--	--	-0.270	-4.16	--	--	-0.265	-3.60
African American	-0.547	-3.85	--	--	--	--	0.706	5.91	-0.421	-3.12
Goodness of Fit Measures										
Number of Observations	17136									
Log Likelihood Function	22543.00									

Table A-6 Employment location choice model

Variable	Parameter	t-stat
LN (Population / 10^4)	-0.066	-2.54
LN (Total Employment / 10^4)	0.758	18.37
Fraction of Service employment * Professional business	1.406	5.17
Fraction of retail employment	3.519	3.93
CBD	0.159	1.59
LN (Median Income /10^3)	0.179	3.88
Same Zone	3.148	24.40
Adjacent zone	0.978	6.36
Auto IVTT	-0.055	-22.97
Female*Auto IVTT	-0.013	-3.71
Grade Less than 11* Auto IVTT	-0.015	-1.82
Construction & Manufacturing * Maximum Manufacturing accessibility	0.224	2.11
Government*Maximum Armed forces accessibility	3.844	2.47
Professional Business* Maximum Art accessibility	0.459	1.68
Goodness of Fit Measures		
Number of observations	786	
Log-Likelihood Function	-4478.82	

Table A-7 Work Duration model

Variable	Work Duration: 35-45 hours		Work Duration: > 45 hours	
	Estimate	**t-stat**	**Estimate**	**t-stat**
Constant	0.465	6.18	-0.587	-5.14
Age				
16 to 40	1.082	13.88	1.351	14.17
41 to 60	1.099	14.09	1.443	15.24
Sex				
Female	-0.820	-13.26	-1.414	-24.32
Female with young kid	-0.340	-4.20	-0.577	-5.17
Hispanic	--	--	-0.437	-8.53
Education				
High School	--	--	0.229	3.02
Associate or Bachelors	--	--	0.621	8.36
Post Graduate	--	--	0.879	10.42
Industry				
Construction	0.726	8.00	0.861	8.96
Government	1.195	8.45	1.195	6.71
Transportation	0.288	2.59	0.582	4.92
Professional * Female	0.120	2.13	--	--
Government * Female	--	--	-0.358	-1.90
Government * age 41-60	--	--	-0.496	-3.05
Goodness of Fit Measures				
Number of Observations	14999			
Log Likelihood Function	-14060.00			
Mc Fadden's LRI	0.1467			

Table A-8 Work Schedule Flexibility Model

Variable	Parameter	t-stat
Threshold 1	0.054	2.41
Threshold 2	0.148	6.59
Threshold 3	0.339	15.08
Female	-0.323	-15.22
Race		
Hispanic	-0.190	-4.31
White	-0.237	-9.57
Industry		
Professional	-0.118	-5.06
Government	-0.367	-7.73
Retail	0.108	2.85
Work Duration		
less than 20 hours per week	0.589	12.23
between 20 to 40 hours per week	0.496	18.13
Education		
Bachelors or Post graduate	0.158	7.20
Goodness of Fit Measures		
Number of Observations	15261	
Log Likelihood Function	847.00	

Table A-9 Household Income Model

Variable	Parameter	t-stat
Threshold 1	0.000	--
Threshold 2	0.920	--
Threshold 3	1.250	--
Threshold 4	1.610	--
Threshold 5	2.010	--
Threshold 6	2.300	--
Threshold 7	2.710	--
Household Characteristics		
White	0.629	45.65
Hispanic	0.150	9.15
Presence of elderly individuals (age ≥ 65 years)	-0.041	-2.39
Number of individuals having high school degree	0.222	20.47
Number of individuals having college degree	0.487	46.39
Number of individuals having post graduate degree	0.708	47.43
Number of students in household	-0.034	-5.02
Employment Type Variables		
Number of people in Trade and Transportation	0.256	17.04
Number of workers in Professional business	0.304	29.50
Number of workers in Government sector	0.304	29.50
Number of workers in Retail and repair	0.191	9.81
Number of workers in construction and management	0.304	29.50
Number of workers in other business	0.256	17.04
Variance	0.702	143.69
Goodness of Fit Measures		
Number of Observations	13117	
Log Likelihood Function	-24056.58	

Table A-10 Residential Tenure Model

Variable	Parameter	t-stat
Constant	-0.334	-4.85
Large Household (size ≥ 5)	0.295	3.76
Income level		
Medium Income ($35,000 - $50,000)	0.801	13.07
Upper Middle Income ($50,00 - $74,999)	1.388	24.17
High Income ($75,000 - $150,00 or more)	2.125	33.04
Household Characteristics		
Hispanic Household	-0.456	-8.85
African American Household	-0.621	-10.52
Single Adult Household	-2.723	-24.90
Age of the Adult in Single Adult Household	0.050	24.01
Household with elderly persons	1.782	21.26
Presence of children in household (age ≤ 15)	0.286	5.65
Number of workers in household	-0.131	-4.20
Household with high education persons (at least one post grad student)	0.167	2.89
Goodness of Fit Measures		
Number of Observations	13749	
Log Likelihood Function	-7260.90	

Table A-11 Housing Type for Owners

Variable	Single-family detached		Single-family attached		Mobile home or trailer	
	Parameter	**t-stat**	**Parameter**	**t-stat**	**Parameter**	**t-stat**
Constant	--	--	-1.397	-8.42	-1.699	-8.71
Income Level						
Middle Income ($35,000-$50,000)	0.965	6.83	1.066	6.20	--	--
Upper Middle Income ($50,00 - $74,999)	1.501	10.51	1.749	10.90	--	--
High Income ($75,000 - $150,00 or more)	--	--	--	--	-2.428	-13.14
Household Characteristics						
Household size	0.126	2.59	-0.376	-5.44	--	--
Single Adult Household	-0.294	-3.22	--	--	--	--
Household with elderly persons (age ≥ 65)	-0.160	-1.52	-0.525	-4.05	--	--
Household with children (age ≤ 15)	--	--	0.228	1.64	--	--
Caucasian Household	--	--	--	--	0.612	4.81
Highest education in household is bachelors or higher	0.602	5.79	0.969	7.61	--	--
Goodness of Fit Measures						
Number of Observations	8377					
Log Likelihood Function	-4176.75					

Table A-12 Housing Type for Renters

Variable	Single-family detached		Single-family attached		Apartment	
	Parameter	**t-stat**	**Parameter**	**t-stat**	**Parameter**	**t-stat**
Constant	-1.379	-8.74	-1.626	-11.20	--	--
Household Income						
Low Income (< $35,000)	-0.144	-1.77	0.122	1.31	--	--
High Income (> $75,000)	0.220	1.97	0.348	2.59	--	--
Race of Household						
Caucasian	0.325	3.32	--	--	--	--
Asian	-0.364	-2.28	--	--	--	--
Hispanic	0.354	3.23	0.821	8.80	--	--
African American	--	--	--	--	0.170	1.76
Other Household Characteristics						
Household size	0.356	10.75	0.174	3.82	--	--
Household with elderly persons (age ≥ 65)	-0.148	-1.23	-0.260	-1.84	--	--
Household with children (age ≤ 15)	--	--	0.229	2.13	--	--
Single Adult Household	--	--	--	--	0.172	2.14
Highest education in household is bachelors or higher	-0.338	-4.35	-0.278	-3.14	--	--
Goodness of Fit Measures						
Number of Observations	5113					
Log Likelihood Function	-4835.68					

Table A-13 Estimation Results of MDCEV Component for Vehicle Holdings

Variable	Household Race								Number of Adult	
	Black		Hispanic		Asian		Caucasian			
	Param.	t-stats	Param.	t-stats	Param.	t-stats	Param.	t-stats	Param.	t-stats
Sub-compact	-1.017	-1.90	--	--	--	--	--	--	-0.266	-2.32
Compact car	--	--	--	--	--	--	-0.074	-1.19	-0.147	-1.71
mid size car	--	--	--	--	--	--	--	--	-0.263	-3.21
Large car	0.53	2.04	--	--	--	--	--	--	-0.151	-1.42
Small SUV	--	--	--	--	--	--	--	--	-0.488	-4.64
Mid Sized SUV	--	--	--	--	--	--	--	--	-0.469	-4.31
Large SUV	--	--	--	--	-0.316	-1.58	-0.187	-2.37	-0.195	-2.10
Van	--	--	--	--	-1.336	-4.16	--	--	-0.121	-1.25
Pickup	-0.888	-2.90	--	--	--	--	--	--	-0.254	-3.18
Less than 2 years	--	--	--	--	--	--	--	--	--	--
2 to 3 years	--	--	--	--	--	--	--	--	--	--
4 to 5 years	0.234	1.31	--	--	0.334	2.29	--	--	--	--
6 to 9 years	--	--	--	--	--	--	--	--	--	--
10 to 12 years	--	--	--	--	--	--	0.089	1.66	--	--
More than 12 years	--	--	--	--	--	--	0.089	1.66	--	--

Table A-13 (Continued) Estimation Results of MDCEV Component for Vehicle Holdings

Variable	Number of Male Adults		Household Income		Number of Children by age group						Number of Senior Member	
					0-4 years		5-12 years		13-15 years			
	Param.	t-stats	Param.	t-stats	Param.	t-stats	Param.	t-stats	Param.	t-stats	Param.	t-stats
Sub-compact	--	--	0.025	1.82	-0.468	-2.72	--	--	-0.373	-1.92	-0.182	-3.36
Compact car	-0.142	-2.45	--	--	-0.138	-2.03	-0.119	-1.89	--	--	--	--
mid size car	--	--	0.033	4.94	--	--	-0.201	-3.23	--	--	--	--
Large car	--	--	0.068	6.13	--	--	-0.232	-1.76	--	--	0.207	3.14
Small SUV	--	--	0.037	2.89	-0.238	-1.41	-0.219	-1.52	--	--	--	--
Mid Sized SUV	-0.085	-0.98	0.052	5.70	--	--	--	--	--	--	--	--
Large SUV	--	--	0.090	10.70	0.376	5.71	0.229	3.51	0.334	4.37	--	--
Van	--	--	--	--	0.353	4.19	0.476	6.43	0.481	5.38	--	--
Pickup	--	--	0.030	3.48	--	--	--	--	--	--	-0.097	-1.69
Less than 2 years	--	--	--	--	--	--	--	--	--	--	--	--
2 to 3 years	--	--	--	--	0.106	1.88	--	--	--	--	--	--
4 to 5 years	--	--	-0.011	-1.43	--	--	--	--	--	--	--	--
6 to 9 years	--	--	-0.031	-5.21	--	--	--	--	--	--	--	--
10 to 12 years	--	--	-0.062	-7.93	--	--	--	--	--	--	--	--
More than 12 years	--	--	-0.099	-14.27	-0.156	-2.31	--	--	--	--	--	--

Table A-13 (Continued) Estimation Results of MDCEV Component for Vehicle Holdings

Variable	Highest education level attained in household				Number of Workers		Mean distance to work calculated among workers (in miles)		Satiation Parameter*	
	Bachelor or Associate		Post graduation							
	Param.	t-stats	Param.	t-stats	Param.	t-stats	Param.	t-stats	Param.	t-stats
Sub-compact	-0.202	-1.57	--	--	--	--	--	--	0.806	4.80
Compact car	--	--	0.309	4.15	--	--	--	--	0.830	7.59
mid size car	--	--	0.146	2.01	--	--	-0.465	-2.13	0.831	7.81
Large car	-0.139	-1.32	--	--	-0.320	-4.25	--	--	0.825	5.57
Small SUV	--	--	--	--	--	--	--	--	0.737	6.64
Mid Sized SUV	--	--	--	--	0.082	1.49	--	--	0.842	6.33
Large SUV	-0.179	-1.96	-0.375	-3.43	--	--	--	--	0.806	6.75
Van	--	--	0.281	2.58	--	--	--	--	0.847	5.62
Pickup	-0.142	-1.74	-0.595	-5.54	--	--	0.469	2.00	0.793	7.42
Less than 2 years	--	--	--	--	--	--	--	--	--	--
2 to 3 years	0.072	1.08	--	--	--	--	0.598	2.67	0.836	4.11
4 to 5 years	--	--	--	--	--	--	--	--	0.830	4.10
6 to 9 years	0.113	2.08	--	--	--	--	--	--	0.826	4.31
10 to 12 years	-1.017	-1.90	--	--	--	--	--	--	0.808	4.23
More than 12 years	--	--	--	--	--	--	--	--	0.737	4.57

* The t-statistics for the satiation parameters are computed with respect to the value of 1.

Table A-13 Estimation Results of MNL Component for Primary Driver Allocation

Variable	Age						Female		Race	
	16 to 25 years		26 to 40 years		41 to 65 years				Caucasian	
	Param.	t-stat	Param.	t-stat	Param.	t-stat	Param.	t-stat	Param.	t-stat
No vehicle	--	--	--	--	--	--	--	--	--	--
Sub-compact	--	--	-0.271	-3.06	-0.294	-4.25	-0.248	-4.59	-0.274	-2.06
Compact car	--	--	-0.271	-3.06	-0.294	-4.25	-0.248	-4.59	--	--
mid size car	-0.359	-3.44	-0.26	-2.71	-0.239	-3.03	-0.249	-4.91	--	--
Large car	-0.359	-3.44	-0.26	-2.71	-0.239	-3.03	-0.614	-8.72	--	--
Small SUV	--	--	--	--	--	--	-0.614	-8.72	--	--
Mid Sized SUV	--	--	--	--	0.172	2.09	--	--	--	--
Large SUV	-0.627	-3.45	--	--	0.151	1.72	-0.231	-3.2	--	--
Van	-0.951	-4.83	-0.4	-3.37	--	--	--	--	--	--
Pickup	-0.825	-6.86	-0.215	-2.24	--	--	-1.987	-23.14	--	--
Less than 2 years	-0.468	-3.76	--	--	--	--	0.573	11.07	0.086	1.89
2 to 3 years	--	--	--	--	--	--	0.573	11.07	0.086	1.89
4 to 5 years	--	--	--	--	--	--	0.581	9.62	0.086	1.89
6 to 9 years	--	--	--	--	--	--	0.43	8.52	0.086	1.89
10 to 12 years	--	--	--	--	--	--	--	--	--	--
More than 12 years	--	--	--	--	--	--	--	--	--	--

Table A-13 (Continued) Estimation Results of MNL Component for Primary Driver Allocation

Variable	Education Level		Employment Status		Distance to work less than 10 miles	
	Bachelor or Associate		Worker			
	Param.	t-stat	Param.	t-stat	Param.	t-stat
No vehicle	--	--	--	--	--	--
Sub-compact	--	--	0.143	2.35	--	--
Compact car	--	--	0.143	2.35	--	--
mid size car	--	--	0.090	1.43	--	--
Large car	--	--	0.070	0.83	--	--
Small SUV	--	--	0.070	0.83	--	--
Mid Sized SUV	--	--	--	--	0.073	0.90
Large SUV	--	--	-0.231	-3.63	0.073	0.90
Van	--	--	-0.231	-3.63	--	--
Pickup	--	--	--	--	--	--
Less than 2 years	0.060	1.31	0.103	2.22	-0.062	-1.21
2 to 3 years	0.060	1.31	0.103	2.22	-0.062	-1.21
4 to 5 years	0.060	1.31	--	--	--	--
6 to 9 years	--	--	--	--	--	--
10 to 12 years	--	--	--	--	--	--
More than 12 years	--	--	--	--	--	--

Table A-14 Vehicle Make Model

Variable	Parameter	t-stat
Front Wheel Drive	0.317	6.96
Rear Wheel Drive	0.214	5.28
Base Wheel radius	0.016	4.82
Length	0.003	1.06
Width	0.007	1.69
Height	0.030	7.08
Annual fuel cost ($)/($10^3$)	-0.300	-4.78
Greenhouse Gas Rating	0.065	6.09
Purchase price($) / Household Income ($)	-0.383	-6.18
Length of vehicle * Household Size greater than 2	0.004	1.88
Horse Power	0.001	3.25
Engine Liters	-0.005	-2.08
Horse Power/Liters	-0.006	-5.69
Honda	1.071	28.29
Toyota	1.206	36.97
BMW	0.195	2.74
Chevrolet	0.524	13.57
Ford	0.719	20.05
Dodge	-0.192	-3.55
Nissan	-0.103	-1.81
Volkswagen	0.196	2.77

Table A-15 Annual Mileage Model

Variable	Parameter	t-stat
Constant	1.937	64.00
Household Size	0.225	11.68
Number of workers	0.128	8.45
Number of senior adults	-0.078	-4.36
Household Income ($)/1000	0.002	11.29
Number of male adults	0.028	1.24
Number of children ($\leq$ 15 years)	-0.175	-7.73
Mean distance to work (miles/100)	0.008	13.12

Appendix B.1 Generation-Allocation Model System

Table B.1.1 Child's Decision To Go to School (Model GA01)

Explanatory Variable	Param.	t-stat.
Constant	-0.719	-7.08
Highest level of education completed		
No School (Base)	--	--
Grade less than 6	1.038	11.69
Grade 7 to 12	0.979	10.06
Ethnicity		
Caucasian	0.219	2.64
Hispanic	0.363	4.38
Household Income		
Income greater than $ 100K	0.311	3.36

Table B.1.2 Child's school start time (Model GA02)

Explanatory Variable	Param.	t-stat.
Number of employed adults	-0.185	-4.58
Age	-0.133	-8.92
Highest level of education completed		
Grade less than 6	-0.526	-4.08
Grade between 7 to 12	-0.508	-2.75
Ethnicity		
African-American	-0.360	-3.13
Asian and Pacific Islander	0.178	1.14
Household Income		
Income between $25K and $100K	0.445	6.04
Income greater than $100K	0.601	5.62
Threshold parameters		
Threshold01 (0 to 260.5)	-19.643	0.90
Threshold02 (260.5 to 270.5)	-4.143	-23.39
Threshold03 (270.5 to 280.5)	-3.114	-19.06
Threshold04 (280.5 to 285.5)	-2.684	-17.06
Threshold05 (285.5 to 290.5)	-2.323	-15.30
Threshold06 (290.5 to 295.5)	-2.023	-13.74
Threshold07 (295.5 to 300.5)	-1.573	-11.20
Threshold08 (300.5 to 310.5)	-1.160	-8.52
Threshold09 (310.5 to 320.5)	-0.755	-5.57
Threshold10 (320.5 to 330.5)	-0.428	-3.05
Threshold11 (330.5 to 350.5)	0.058	0.37
Threshold12 (350.5 to 400.5)	0.619	3.14
Standard error of the heterogeneity term	0.706	8.86

Table B.1.3 Child's school end time (Model GA03)

Explanatory Variable	Param.	t-stat.
Number of workers in the household	0.192	3.90
Number of Vehicles in the household	-0.088	-2.29
Highest level of education completed		
Grade less than 6	-0.778	-8.32
Ethnicity		
Caucasian	-0.153	-2.14
African-American	0.548	4.05
Household Income		
Income greater than $100k	0.292	2.91
Threshold parameters		
Threshold01 (0 to 240.5)	-18.173	-0.13
Threshold02 (240.5 to 300.5)	-3.057	-24.56
Threshold03 (300.5 to 420.5)	-0.876	-8.77
Threshold04 (420.5 to 430.5)	0.013	0.11
Threshold05 (430.5 to 440.5)	0.325	2.38
Threshold06 (440.5 to 450.5)	0.643	4.02
Threshold07 (450.5 to 460.5)	0.917	4.97
Threshold08 (460.5 to 480.5)	1.129	5.47
Threshold09 (480.5 to 540.5)	1.485	5.98
Threshold10 (540.5 to 600.5)	2.287	6.28
Threshold11 (600.5 to 660.5)	3.563	6.01
Standard error of the heterogeneity term	0.977	9.50

Table B.1.4 Decision to go to work (Model GA04)

Explanatory Variables	Param.	t-stat.
Constant	1.290	17.72
Highest level of education completed		
Associate or Bachelor degree	0.130	2.98
Post graduate	0.250	3.99
Weekly work duration		
Between 0 and 20 hours	-1.094	-13.99
Between 20 and 40 hours	-0.266	-5.75
Work flexibility		
Medium work flexibility	-0.220	-2.81
High work flexibility	-0.610	-13.69
Number of children in the household	-0.186	-7.35
Number of workers in the household	-0.074	-2.77
Ethnicity		
African-American	-0.252	-3.12

Table B.1.5 Work start and end times (Model GA05)

Explanatory Variables	Param.	t-stat.
Arrival-time function		
$\text{Sin}(2\pi t_a/24)$	-0.072	-4.79
$\text{Sin}(4\pi t_a/24)$	-0.073	-4.71
$\text{Sin}(6\pi t_a/24)$	-0.254	-14.64
$\text{Cos}(2\pi t_a/24)$	-0.086	-4.06
$\text{Cos}(4\pi t_a/24)$	-0.052	-2.56
$\text{Cos}(6\pi t_a/24)$	-0.145	-6.38
Departure-time function		
$\text{Sin}(2\pi t_d/24)$	-0.116	-7.34
$\text{Sin}(4\pi t_d/24)$	0.035	2.03
$\text{Sin}(6\pi t_d/24)$	0.062	3.99
$\text{Cos}(2\pi t_d/24)$	-0.030	-1.53
$\text{Cos}(4\pi t_d/24)$	-0.121	-6.86
$\text{Cos}(6\pi t_d/24)$	0.122	6.46
Duration function		
Duration	16.875	7.29
Duration^2	-194.998	-10.75
Duration^3	907.059	14.77
Duration^4	-1722.461	-17.05
Duration^5	1426.281	17.97
Duration^6	-430.409	-18.09
Size Variables		
Num. of 15 min. periods in the arrival time period	0.074	19.05
Num. of 15 min. periods in the departure time period	0.026	15.94
Mother—Departure Time		
$\text{Sin}(2\pi t_d/24)$ * Mother	-0.201	-4.89
$\text{Sin}(4\pi t_d/24)$ * Mother	-0.099	-2.11
$\text{Sin}(6\pi t_d/24)$ * Mother	-0.006	-0.14
$\text{Cos}(2\pi t_d/24)$ * Mother	0.044	0.77
$\text{Cos}(4\pi t_d/24)$ * Mother	-0.139	-3.02
$\text{Cos}(6\pi t_d/24)$ * Mother	0.073	1.42

Table B.1.5 (cont.) Work start and end times (Model GA05)

Explanatory Variables	Param.	t-stat.
High work flexibility-Arrival Time		
$\text{Sin}(2\pi t_d/24)$ * High Flexibility	0.000	--
$\text{Sin}(4\pi t_d/24)$ * High Flexibility	-0.085	-1.89
$\text{Sin}(6\pi t_d/24)$ * High Flexibility	0.000	--
$\text{Cos}(2\pi t_d/24)$ * High Flexibility	0.113	2.11
$\text{Cos}(4\pi t_d/24)$ * High Flexibility	0.000	--
$\text{Cos}(6\pi t_d/24)$ * High Flexibility	0.000	--
Work duration > 40 hours/week—Arrival Time		
$\text{Sin}(2\pi t_d/24)$ * Work duration > 40 hours/week	0.000	--
$\text{Sin}(4\pi t_d/24)$ * Work duration > 40 hours/week	0.000	--
$\text{Sin}(6\pi t_d/24)$ * Work duration > 40 hours/week	0.063	2.26
$\text{Cos}(2\pi t_d/24)$ * Work duration > 40 hours/week	0.000	--
$\text{Cos}(4\pi t_d/24)$ * Work duration > 40 hours/week	0.000	--
$\text{Cos}(6\pi t_d/24)$ * Work duration > 40 hours/week	0.085	2.47
Expected Home to Work IVTT	0.018	5.97
Expected Home to Work Travel Cost	-0.333	-1.22
Expected Work to Home IVTT	0.017	4.33
Expected Home to Work IVTT * Female	-0.022	-2.64
Expected Home to Work Travel Cost * Female	-1.572	-1.50
Expected Work to Home IVTT * Female	-0.028	-2.35
Expected Work to Home Travel Cost * Female	-1.146	-1.92

Table B.1.6 Adult's decision to go to school (Model GA06)

Explanatory Variable	Param.	t-stat.
Constant	0.427	2.78
Highest level of education completed		
Grade less than 11	0.917	9.32
High School	0.224	2.32
Household Income		
Income between 25 and 100K	-0.201	-2.14
Income between 100 and 150K	-0.379	-2.42
Income Greater than 150K	-0.735	-3.42
Age	-0.037	-10.60
Total number of children at home	-0.510	-8.36
Total number of vehicles	0.052	1.52

Table B.1.7 Adult's school start time (Models GA07)

Explanatory Variable	Param.	t-stat.
Constant	5.599	219.12
Highest level of education completed		
Associate Degree	0.145	5.03
Bachelor or postgraduate	0.232	7.18
Household Income		
Income between 100K and 150 K	-0.071	-1.89
Income greater than 150K	-0.079	-1.43
Adult son or daughter in a single-parent or nuclear family household	0.102	3.76
Age	0.011	10.35
Mother	0.090	2.77

Table B.1.8 Adult's school end time (Models GA08)

Explanatory Variable	Param.	t-stat.
Constant	6.225	99.95
Highest level of education completed		
High School	-0.250	-5.40
Associate degree	-0.246	-4.79
Adult son or daughter in a single-parent or nuclear family household	-0.167	-3.19
Adult in Single Member Household	-0.242	-3.68
Age	-0.013	-7.44
Total number of vehicles	-0.051	-3.10
Mother	-0.288	-4.38
Female	-0.106	-2.70

Table B.1.9 Child's travel mode to school (Model GA09)

Explanatory Variables	Param.	t-stat.
Drive by parent		
Number of non-school going children	-0.289	-3.82
Both parents work	0.730	4.31
Both parents work starts earlier to school	-3.071	-6.58
Drive by other		
Constant	-8.649	-9.53
Age	0.219	3.67
Hispanic	-1.264	-2.80
Distance to school	0.024	1.73
Number of employed adults	1.431	5.47
Number of unemployed adults	1.311	7.00
School Bus		
Constant	-1.708	-6.70
Age	0.136	6.73
Caucasian	-0.299	-2.28
Distance to school	0.021	3.39
Total number of vehicles	-0.337	-4.79
Number of unemployed adults	0.155	1.88
Walk or Bike		
Constant	-1.155	-4.69
Age	0.113	6.49
Hispanic	0.426	3.77
African American	0.675	3.22
School zone is adjacent to home	0.298	2.89
Distance to school	-0.059	-3.91
Total number of vehicles	-0.852	-12.20
Number of employed adults	0.609	6.33
Number of unemployed adults	0.534	6.47

Table B.1.10 Child's travel mode from school (Model GA10)

Explanatory Variables	Param.	t-stat.
Drive by parent		
Number of children not going to school	0.777	1.79
Father works on the specific day	-0.314	-2.72
Mother works on the specific day	-0.172	-1.29
Pickup by other		
Constant	-6.893	-9.51
Age	0.149	2.74
Total number of vehicles	-0.372	-2.14
Number of employed adults in the household	1.306	5.71
Number of unemployed adults in the household	0.588	3.61
School bus		
Constant	-2.242	-8.64
Age	0.167	8.96
Hispanic	0.350	2.85
Total number of vehicles	-0.333	-5.17
Number of unemployed adults in the household	0.292	3.20
Number of children not going to school	0.986	2.27
Walk or bike		
Constant	-1.383	-6.05
Age	0.171	10.67
Hispanic	0.616	5.73
African-American	0.466	2.58
Distance to school	-0.021	-2.14
Total number of vehicles	-0.613	-9.97
Number of employed adults in the household	0.093	1.35
Number of unemployed adults in the household	0.336	4.03
Number of children not going to school	0.957	2.22

Table B.1.11 Allocation of the drop-off episode (Model GA11)

Explanatory Variables	Father		Mother	
	Param.	t-stat	Param.	t-stat.
Constant	-0.064	-0.25	--	--
Number of children going to school	-0.49	-3.95	--	--
Work duration	-0.005	-9.40	-0.005	-9.40
Work starts earlier than school	-3.284	-11.66	3.284	-11.66

Table B.1.12 Allocation of the pick-up episode (Model GA12)

Explanatory Variables	Father		Mother	
	Param.	t-stats	Param.	t-stat.
Constant	-0.439	-1.78	--	--
Number of children going to school	-0.483	-3.55	--	--
Work ends later than school	-2.789	-9.74	-2.789	-9.74

Table B.1.13 Binary Logit Model to Determine Households with Non-Zero Out of Home Activity Durations (Model GA13)

Explanatory Variables	Param.	t-stat.
Constant	0.388	3.11
Household Characteristics		
Vehicles		
One vehicle	-0.983	-12.40
Two vehicles	-1.182	-13.59
Three vehicles	-1.400	-13.11
Four or more vehicles	-1.310	-9.71
Own home	-0.167	-3.58
Multiple workers	-1.162	-14.21
Number of non-workers	-0.220	-5.45
Number of seniors	0.061	1.66
Number of school-going children	-1.540	-19.21
Number of non-school-going children	-0.087	-2.22
Number of female adults	-0.056	-1.55
Total work and school duration (minutes)	0.002	15.76
Average work and school end time (minutes *1000)	0.192	2.47
Income less than $35,000	0.142	3.04
Accessibility Measures		
Retail and service employment accessibility of work zone	-0.060	-3.67
Population accessibility	0.013	2.67
Retail employment accessibility of work zone (in 1000's)	0.215	2.56
Miles of freeway within 10 minutes (in 1000000s)	-1.413	-1.25
Miles of arterial within 10 minutes (in 1000000s)	-0.686	-1.68
Miles of minor arterial within 10 minutes (in 1000000s)	-0.936	-2.25
Miles of collector within 10 minutes (in 1000000s)	0.264	1.86
Miles of ramp within 10 minutes (in 1000000s)	3.872	2.24
Maximum number of retail employees reachable within 10 minutes (in 10000s)	-0.526	-2.40
Maximum number of financial employees reachable within 10 minutes (in 10000s)	-0.859	-3.75
Maximum number of professional employees reachable within 10 minutes (in 10000s)	0.481	2.70
Maximum number of education employees reachable within 10 minutes (in 10000s)	0.891	4.19
Maximum number of art employees reachable within 10 minutes (in 10000s)	0.780	3.09

Table B.1.14 Determination of total out-of home time of a household (Model GA14)

Explanatory Variables	In-home Time		Out-home Time		Travel Time	
	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.
Constant	--	--	-1.396	-9.12	-2.002	-24.28
Household characteristics						
Household Size						
Number of adult non-workers and non-students	--	--	-0.170	-4.10	-0.304	-5.77
Number of senior adults	--	--	-0.232	-5.08	-0.119	-1.75
Vehicles						
One vehicle	--	--	0.306	2.07	--	--
Two vehicles	--	--	0.352	2.37	--	--
Three vehicles	--	--	0.436	0.16	--	--
More than three vehicles	--	--	0.460	0.18	--	--
Work or school characteristics						
Work						
Total work or school duration/1000	--	--	-0.594	-6.94	-0.207	-2.62
Average work or school end time/1000	--	--	-0.252	-2.60	--	--

Table B.1.15 MDCEV I for household size less than five (Model GA15)

Explanatory Variables	Parameter	t-statistic
Household Demographics		
Number of school going children		
Activity Purpose (Base is maintenance activity purpose)		
Shopping	-0.131	-4.64
Entertainment	-0.069	-1.71
Visiting Friends	0.025	0.76
Active Recreation	0.194	6.40
Eat-out	-0.284	-8.99
Other	0.636	21.60
Work-related	0.214	5.57
Number of non-school going children		
Activity Purpose (Base is maintenance activity purpose)		
Shopping	-0.155	-6.48
Social	-0.323	-5.90
Eat-out	-0.161	-5.59
Other	0.666	24.31
Work-related	0.139	4.70
Number of senior adults		
Activity Purpose (Base is work-related activity purpose)		
Shopping	0.766	13.85
Maintenance	0.867	15.97
Social	0.984	14.32
Entertainment	0.756	11.06
Visiting Friends	0.625	10.03
Active Recreation	0.777	12.44
Eat-out	0.733	12.15
Other	0.479	6.57
High Income Household (Income> $100K)		
Activity Purpose (Base is work-related and active recreation purposes)		
Shopping	-0.227	-5.02
Maintenance	-0.233	-5.13
Social	-0.427	-4.46
Entertainment	-0.319	-4.20
Visiting Friends	-0.656	-10.40
Other	-0.307	-4.65
Number of participating people		
One	0.522	6.21
At least two people	0.101	1.22

Table B.1.15 MDCEV I for household size less than five (Model GA15)

Explanatory Variables	Parameter	t-statistic
Total number of vehicles		
Activity Purpose (Base is work-related activity purpose)		
Shopping	-0.241	-10.32
Maintenance	-0.283	-12.71
Social	-0.168	-4.92
Entertainment	-0.234	-7.38
Visiting Friends	-0.124	-4.66
Active Recreation	-0.151	-5.30
Eat-out	-0.239	-9.45
Other	-0.275	-9.05
Individual Characteristics		
Latest Work End time among people in the alternative (in		
Activity Purpose		
Shopping	-1.321	-7.84
Social	-1.058	-2.40
Entertainment	-0.648	-5.59
Active Recreation	-0.770	-2.71
Other	-2.325	-7.84
Work-related	-3.133	-14.32
Maximum Work Duration among people in the alternative (in		
Activity Purpose)		
Shopping	-1.153	-19.09
Maintenance	-1.153	-19.09
Social	-0.377	-1.44
Active Recreation	-0.023	-0.13
Eat-out	0.189	4.41
Other	0.331	1.96
Work-related	0.825	6.70
Number of children among the people in the alternative		
Number of participating people		
One	-0.639	4.83
Interaction of Number of participating people and activity purpose		
Shopping*At least two participating people	0.457	9.44
Maintenance*At least two participating people	-0.640	7.53
Social*At least two participating people	0.457	9.44
Entertainment*At least two participating people	0.040	0.55
Number of adults with school drop-off/pick-up commitments in the		
Activity Purpose		
Shopping	0.559	7.53
Maintenance	0.390	4.83
Eat-out	0.803	9.44
Work-related	-0.505	-3.34
Presence of a woman adult and a child in the alternative		
Number of participating people		
At least two people	0.036	1.32

Table B.1.15 MDCEV I for household size less than five (Model GA15)

Explanatory Variables	Parameter	t-Statistic
Accessibility Measures		
Retail and Service Employment Accessibility		
Activity Purpose		
Shopping	0.014	2.30
Maintenance	0.011	1.82
Entertainment	0.022	2.13
Active Recreation	0.071	8.57
Eat-out	0.046	6.69
Population Accessibility		
Activity Purpose		
Shopping	-0.008	-4.09
Maintenance	-0.006	-3.10
Entertainment	-0.008	-2.51
Active Recreation	-0.023	-8.45
Eat-out	-0.017	-7.86
Baseline Preference Constants		
Activity Purpose (Base is work-related activity)		
Shopping	1.478	16.00
Maintenance	1.503	16.85
Social	-0.870	-10.80
Entertainment	-0.534	-3.91
Visiting Friends	-0.226	-3.41
Active Recreation	-0.272	-2.21
Eat-out	0.638	5.96
Other	-0.583	-7.38
Number of participating people		
Two	-1.666	-59.35
Three	-2.598	-60.91
Four	-2.568	-42.43
Five	-2.006	-19.70
Interaction of Number of participating people and activity purpose		
Shopping*At least two participating people	0.205	3.60
Entertainment*At least two participating people	0.537	5.93
Eat-out*At least two participating people	0.407	7.66
Translation Parameters		
Activity Type		
Shopping	3.639	155.23
Maintenance	3.754	119.46
Social	5.123	59.88
Entertainment	6.108	81.48
Visiting Friends	5.442	116.99
Active Recreation	5.107	85.85
Eat-out	3.673	99.72
Other	5.126	130.82
Work-related	6.343	96.83
Number of participating people		
Two	1.027	23.14
Three	1.615	18.64
Four	2.295	13.88
Five	3.025	7.13

Table B.1.16 Independent and Joint Activity participation for all household members for household size more than five (Model GA16)

Explanatory Variables	Maintenance		Shopping		Visit		Social		Entertainment	
	Param.	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**
Constant	1.167	5.36	0.448	1.45	-0.694	-2.03	-1.262	-3.69	-3.467	-4.11
Household characteristics										
Household size equal to 6 or 7	--	--	0.978	4.11	--	--	--	--	2.004	3.02
Income	--	--	--	--	--	--	--	--	--	--
Less than $34,999	--	--	--	--	0.334	1.54	--	--	-0.645	-1.85
Between $35,000 and $74,999	0.413	2.83	--	--	--	--	--	--	--	--
Person-level characteristics										
Female	0.278	2.24	0.463	3.32	--	--	--	--	--	--
Child	-0.362	-1.15	-1.043	-7.99	--	--	--	--	--	--
Worker	--	--	--	--	--	--	--	--	--	--
Student	--	--	--	--	0.876	3.12	--	--	0.731	2.53
Pick up from school	--	--	--	--	--	--	--	--	1.192	2.51
Drop off to school	0.355	1.27	--	--	--	--	--	--	--	--
Caucasian	--	--	--	--	0.522	2.28	1.974	6.97	--	--
Work duration	1.542	7.49	-0.001	-4.01	-0.001	-1.78	-0.002	-3.44	--	--
Residence Zone Characteristics										
Retail and Service Employment Accessibility	--	--	--	--	--	--	--	--	0.047	2.55
CBD	--	--	0.341	1.57	--	--	--	--	--	--
Number of households in zone	--	--	--	--	--	--	--	--	--	--
Zonal Population	--	--			0.166	4.73	--	--	--	--
Number of Construction employees reachable within 10 minutes/10000	3.339	6.18	--	--	--	--	--	--	--	--
Number of Transportation employees reachable within 10 minutes/10000	--	--	0.711	2.14	0.635	1.51	--	--	--	--

Table B.1.16 Independent and Joint Activity participation for all household members for household size more than five (Continued) (Model GA16)

Explanatory Variables	Maintenance		Shopping		Visit		Social		Entertainment	
	Param.	t-stat.	Param.	t-stat.	Param.	Param.	t-stat.	Param.	t-stat.	Param.
Number of Finance employees reachable within 10 minutes/10000	--	--	--	--	--	--	3.271	6.44	--	--
Number of Education employees reachable within 10 minutes/10000	--	--	-1.327	-3.01	--	--	--	--	--	--
Number of Health employees reachable within 10 minutes/10000	-1.652	-6.09	--	--	--	--	-2.281	-4.23	--	--
Number of Art employees reachable within 10 minutes/10000	--	--	--	--	-1.063	-1.29	--	--	--	--
Satiation parameters (g)	50.319	9.11	38.147	9.30	113.331	6.89	117.533	5.66	189.726	4.61

Table B.1.16 (cont.) Independent and Joint Activity participation for all household members for household size more than five (Model GA16)

Explanatory Variables	Active recreation		Eat		Other		Work related		Other serve passenger	
	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.
Constant	-0.891	-3.04	0.145	0.49	-0.910	-2.91	--	--	0.349	1.55
Household characteristics										
Household size equal to 6 or 7	--	--	--	--	0.881	3.52	--	--	1.011	5.75
Income	--	--	--	--	--	--	--	--	--	--
Less than $34,999	--	--	-1.019	-3.19	--	--	--	--	--	--
Between $35,000 and $74,999	-0.622	-2.79	0.467	1.91	--	--	--	--	0.182	1.43
Person-level characteristics										
Female	--	--	--	--	--	--	--	--	0.408	4.25
Child	-0.540	-3.59	--	--	0.660	3.31	--	--	--	--
Worker	--	--	--	--	0.670	1.73	--	--	--	--
Student	--	--	0.525	2.34	--	--	--	--	--	--
Pick up from school	0.726	1.55	--	--	--	--	--	--	1.336	6.19
Drop off to school	--	--	--	--	--	--	--	--	0.559	2.37
Caucasian	--	--	--	--	-0.325	-1.83	--	--	--	--
Work duration	--	--	--	--	-0.001	-1.56	-0.002	-4.03	--	--
Accessibility Measures										
Retail and Service Employment Accessibility	--	--	--	--	--	--	--	--	--	--
CBD	--	--	--	--	--	--	--	--	--	--
Number of households	0.571	4.32	--	--	--	--	--	--	0.098	1.23
Zonal Population	--	--	--	--	--	--	--	--	--	--
Number of Construction employees reachable within 10 minutes/10000	--	--	--	--	--	--	--	--	--	--
Number of Transportation employees reachable within 10 minutes/10000	--	--	--	--	--	--	--	--	--	--
Number of finance employees reachable within 10 minutes/10000	--	--	--	--	--	--	--	--	--	--

Table B.1.16 (cont.) Independent and Joint Activity participation for all household members for household size more than five (Model GA16)

Explanatory Variables	Active recreation		Eat		Other		Work related		Other serve passenger	
	Param.	t-stat.	Param.	t-stat.	Param.	Param.	t-stat.	Param.	t-stat.	Param.
Number of education employees reachable within 10 minutes/10000	--	--	-0.753	-1.29	--	--	--	--	--	--
Number of health employees reachable within 10 minutes/10000	--	--	--	--	--	--	--	--	--	--
Number of art employees reachable w minutes/10000	--	--	2.436	3.16	--	--	--	--	--	--
Satiation parameters (g)	120.183	6.34	41.494	7.25	112.430	7.22	343.286	4.22	12.583	11.46

Table B.1.17 Decision of an adult to undertake other serve-passenger activities (Model GA17)

Explanatory Variables	Param.	t-stat.
Constant	-3.076	-35.38
Activity Type		
Maintenance activities	0.670	16.24
Shopping activities	0.554	13.26
Visit	0.278	4.77
Social activities	0.588	7.57
Entertainment	0.344	4.66
Active recreation	0.250	3.86
Eat-out activities	0.624	14.02
Household Characteristics		
Number of school going children	0.298	11.64
Number of children not going to school	0.199	7.86
Number of adult workers	0.254	7.71
Number of adult non-workers	-0.084	-2.43
Single person household	-0.193	-2.58
Single parent household	0.272	3.60

Appendix B.2 Joint Activity Scheduling Model System

Table B.2.1 Decision of Joint or Separate Travel (Model JASCH01)

Explanatory Variable	Param.	t-stat.
Constant	0.8	2.78
Number of senior adults in joint activity	-0.231	-1.55
Number of school going children in joint activity	0.589	3.76
Number of non-school going children in joint activity	1.036	6.33
Number of adults who went to school or work	0.235	1.39
Number of adults who made drop off	0.726	3.09
Number of people participating in joint activity	-0.495	-3.35
Maximum work or school end time among participating people (in 1000s)	- 0.450	-2.41

Table B.2.2 Joint Activity Start time (Model JASCH02)

Explanatory Variables	Param.	t-stat.
Constant	5.609	156.58
Number of senior adults in joint activity	-0.148	-5.51
Number of non-school going children in joint activity	-0.046	-1.89
Number of adults who went to school or work	0.123	3.14
Number of adults who made drop off	-0.417	-5.96
Joint travel	0.263	7.21
Maximum work or school end time among participating people	-0.002	-23.82

Table B.2.3 Joint Activity travel time to stop (Model JASCH03)

Explanatory Variables	Param.	t-stat.
Constant	2.191	32.66
Household Characteristics		
Number of senior adults in joint activity	-0.043	-1.76
Number of school going children in joint activity	-0.328	-7.20
Number of non-school going children in joint activity	-0.199	-5.37
Number of adults who went to school or work	-0.099	-3.52
Number of adults who made drop off	-0.195	-2.68
Number of people participating in joint activity	0.280	7.67
Joint Activity Type		
Shopping activities	-0.124	-3.21
Social activities	0.194	3.19
Entertainment	0.380	5.23
Eating-out activities	-0.139	-2.96

Table B.2.4 Joint Activity location (Model JASCH04)

Explanatory Variables	Param.	t-stat.
Auto in vehicle travel time	-0.075	-40.34
Maximum number of art employees reachable within 10 minutes* Entertainment	1.343	1.063
Retail and Service Employment Accessibility (in 1000s)	0.152	5.69
Same zone as home zone	2.277	10.79
Adjacent zone to home	1.624	10.26
Population Accessibility	-0.018	-6.66
Maximum number of agriculture employees reachable within 10 minutes	-3.085	-2.20
Maximum number of retail employees reachable within 10 minutes	1.937	3.89
Maximum number of professional business employees reachable within 10 minutes	-0.568	-2.59

Table B.2.5 Vehicle Used For the Joint Home-Based Tour (Model JASCH05)

Explanatory Variables	Parameter	t-statistic
Annual Fuel Cost (in 100000s dollars)	0.067	6.71
Horse Power	0.005	3.24
Engine (Liters)	-0.273	-4.37
Car	0.392	4.10
Van	0.843	6.31
SUV	0.572	4.34
Annual Fuel Cost (in 100000s)*Joint Activities of Size 2 * Distance to Destination more than 20 miles	-0.019	-3.11
Length of vehicle* Joint activity of size equal to 2	-0.008	-17.80
Length of vehicle*Joint activity of size greater than 2*Distance to Destination more than 20 miles	0.002	1.89

Appendix B.3 Worker Scheduling Model System

Table B.3.1 Commute mode (Model WSCH01)

Explanatory Variables	Drive Solo		Drive With Passenger		Shared Ride		Walk		Transit	
	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.
Constant	--	--	-1.975	-16.43	7.613	4.06	6.242	3.32	6.783	3.53
Person and Household level characteristics										
Household Income	--	--	0.002	-2.25	-0.007	-4.97	-0.015	-6.70	-0.011	-3.89
Number of non-workers	--	--	-0.291	-5.43	--	--	--	--	0.127	1.38
Single person household	--	--	-0.846	-6.31	-1.174	-6.64	--	--	--	--
Couple household	--	--	-0.458	-4.54	--	--	--	--	--	--
Female	--	--	--	--	0.557	5.77	--	--	--	--
White	--	--	--	--	-0.438	-4.09	--	--	-1.092	-5.18
Hispanic	--	--	0.285	3.28	--	--	--	--	-0.871	-4.37
Age 26 to 40	--	--	0.240	3.158	-0.395	-3.37	--	--	--	--
Age 41 to 60	--	--	--	--	-0.510	-4.20	--	--	--	--
Mother	--	--	1.096	11.17	--	--	--	--	--	--
Licensed			--	--	-9.289	-4.97	-8.927	-4.77	-9.838	-5.25
Type of Profession										
Construction	--	--	--	--	--	--	-0.795	-3.03	--	--
Professional	--	--	-0.168	-2.24	-0.314	-3.14	--	--	--	--
Government	--	--	--	--	-0.557	-2.03	--	--	--	--
Work Factors										
Work location adjacent to home	--	--	--	--	--	--	1.341	8.21	--	--
IVTT to work (minutes)	-0.008	-2.19	-0.008	-2.19	-0.008	-2.19	--	--	-0.008	-2.19
OVTT to work (minutes)	-0.014	-1.36	-0.014	-1.36	-0.014	-1.36	--	--	-0.014	-1.36
Distance (miles)	--	--	--	--	--	--	-0.104	-6.13	--	--
Travel cost to work ($)	-0.130	-1.93	-0.130	-1.93	-0.130	-1.93	--	--	-0.130	-1.93
Travel cost to work ($)/Household Income ($/1000)	-1.251	-1.82	-1.251	-1.82	-1.251	-1.82	--	--	--	--

Table B.3.2 Commute mode (Model WSCH01)

Explanatory Variables	Drive Solo		Drive With Passenger		Shared Ride		Walk		Transit	
	Param.	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**
Activity Participation										
Serving passenger Activities	--	--	0.019	9.62	-0.073	3.26	--	--	--	--
Maintenance Activities	--	--	0.002	2.19	--	--	--	--	--	--
Shopping Activities	--	--	0.003	2.02	-0.021	-4.08	-0.012	-2.34	--	--
Visit Activities	--	--	--	--	-0.004	-1.99	-0.007	-1.93	--	--
Eat-out Activities	--	--	0.003	2.39	--	--	--	--	--	--
Joint Shopping Activities	--	--	-0.007	2.76	--	--	0.011	2.72	--	--
Accessibility Measures										
Miles of arterial roadway reachable within 10 minutes from work	--	--	--	--	-0.066	-3.23	--	--	-0.097	-3.94
Max. number of employees (in 1000s) reachable within 10 minutes from work										
Construction	--	--	--	--	0.294	2.96	-0.241	-1.50	--	--
Retail	--	--	--	--	--	--	--	--	0.639	6.74
Transportation	--	--	--	--	0.120	1.39	--	--	--	--
Arts	--	--	--	--	--	--	0.485	3.30	--	--

Table B.3.3 Number of before-work, work-based, and after-work tours (Models WSCH02, WSCH03 and WSCH04)

Explanatory Variables	Number of Before Work Tours (WSCH02)		Number of Work Based Tours (WSCH03)		Number of After Work Tours (WSCH04)	
	Param.	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**
Threshold parameters						
0 and 1 tour	4.016	44.98	1.831	24.12	3.148	37.62
1 and 2 tours	--	--	3.099	38.25	4.657	50.51
Individual and Household level characteristics						
Age between 41 and 60 years	0.195	4.18	--	--	--	--
Is Mother	0.430	7.54	--	--	--	--
Student	--	--	-0.322	-10.84	--	--
Hispanic	--	--	-0.362	-11.14	--	--
Licensed	--	--	--	--	0.149	3.32
Professional	--	--	--	--	0.062	2.29
Single Parent HH	0.228	1.91	--	--	--	--
Couple HH	--	--	0.146	4.48	--	--
Number of Child	0.111	6.27	--	--	--	--
Number of School Going Children	--	--	--	--	0.091	6.08
Activity Participation						
Serving Other Passenger	1.077	19.43	--	--	0.804	21.49
Maintenance Activities	0.510	9.10	--	--	0.794	23.15
Visit	--	--	--	--	0.940	19.75
Entertainment	--	--	--	--	0.936	16.99
Active Recreation	1.082	16.05	--	--	0.957	20.01
Eat-out activities	--	--	--	--	0.731	21.28

Table B.3.3 (cont.) Number of before-work, work-based, and after-work tours (Models WSCH02, WSCH03 and WSCH04)

Explanatory Variables	Number of Before Work Tours (WSCH02)		Number of Work Based Tours (WSCH03)		Number of After Work Tours (WSCH04)	
	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.
Pattern-level attributes						
Home to Work Stops	-0.482	-10.27	0.183	7.14	-0.178	-6.28
Work to Home Stops	-0.150	-3.57	0.160	7.18	-0.571	-22.08
Available Time	0.004	35.68	0.003	30.06	0.002	30.69
Commute mode is driver, solo	0.297	5.76	--	--	--	--
Joint Activity Participation	0.333	5.69	--	--	--	--
Accessibility Variables						
CBD	--	--	--	--	0.052	1.32
Miles of freeway within 10 minutes (in 100000s)	--	--	--	--	0.076	1.91
Population reachable within 10 minutes (in 100000s)	--	--	-0.032	-2.95	--	--
Miles of minor arterial within 10 minutes (in 100000s)	--	--	--	--	0.018	1.69
Miles of ramp within 10 minutes (in 100000s)	--	--	--	--	-0.140	-2.57
Max. number of employees reachable within 10 minutes from work (*in* 1000s)						
Construction	--	--	-0.003	-4.73	--	--
Finance	--	--	0.016	3.75	1.600	2.46
Health	--	--	0.025	5.22	--	--
Manufacture	--	--	0.003	1.89	--	--
Transportation	--	--	-0.009	-3.13	--	--
Information	--	--	-0.020	-5.05	-0.020	-3.23
Public	-0.002	-2.33	-0.020	-5.17	-0.007	-1.89
Professional	--	--	--	--	-0.009	-1.68
Education	--	--	--	--	-0.02	-1.99
Food	--	--	--	--	0.055	3.02
Maximum number of transit stops within 10 minutes (in 1000s)	0.054	3.73	--	--	--	--

Table B.3.4 Before-work tour mode (Model WSCH05)

Explanatory Variables	Drive Solo		Drive with Passenger		Shared Ride		Walk		Transit	
	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.
Constant	--	--	-0.520	-0.91	0.459	0.34	-1.035	-1.32	-5.001	-8.22
Person and Household Level Characteristics										
Household size	--	--	-0.249	-1.83	--	--	--	--	--	--
Total Number of Vehicles	--	--	--	--	--	--	-0.721	-3.03	--	--
Single Person household	--	--	-1.436	-2.33	--	--	-1.417	-2.53	--	--
Number of Children	-0.321	-2.21	--	--	--	--	--	--	--	--
Number of School Going Children	--	--	--	--	--	--	0.556	2.29	--	--
Age	--	--	--	--	-0.084	-2.59	--	--	--	--
Female	--	--	--	--	--	--	1.104	3.22	--	--
African-American	--	--	1.628	2.26	--	--	--	--	--	--
Activity Participation										
Serve Passenger Activities	--	--	-2.549	-2.01	--	--	--	--	--	--
Maintenance Activities	--	--	4.626	12.04	--	--	-0.885	-2.75	--	--
Shopping Activities	--	--	-0.767	-2.16	-0.732	-2.22	-1.552	-1.56	--	--
Visit	--	--	--	--	-1.189	-3.03	1.182	1.49	--	--
Social Activities	--	--	-2.396	-2.18	--	--	--	--	--	--
Entertainment	--	--	--	--	-1.966	-2.77	1.589	1.89	--	--
Active Recreation	--	--	-1.312	-1.65	--	--	-1.592	-3.62	--	--
Other Activity	0.647	1.78	--	--	--	--	--	--	--	--
Work Related Activity	--	--	--	--	--	--	--	--	-0.865	-1.82

Table B.3.4 (cont.) Before-work tour mode (Model WSCH05)

Explanatory Variables	Drive Solo		Drive with Passenger		Shared Ride		Walk		Transit	
	Param.	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**
Accessibility Factors										
Retail and Service Employment Accessibility	--	--	--	--	--	--	0.098	3.88	--	--
CBD	--	--	0.905	1.94	--	--	--	--	--	--
Miles of freeway within 10 minutes (in 10000s)	--	--	--	--	-0.27	-2.95	-0.053	-3.56	--	--
Miles of ramps within 10 minutes (in 10000s)	--	--	--	--	0.365	3.00	--	--	--	--
Number of agriculture employees within 10 minutes (in 1000s)	--	--	-0.355	-2.33	--	--	--	--	--	--
Number of manufacturing employees within 10 minutes (in 1000s)	--	--	-0.015	-4.08	--	--	--	--	--	--
Number of informational employees within 10 minutes (in 1000s)	--	--	--	--	0.155	1.71	--	--	--	--
Number of professional employees within 10 minutes (in 1000s)	--	--	--	--	-0.136	-1.89	--	--	--	--

Table B.3.5 Work-based tour mode (Model WSCH05)

Explanatory Variables	Drive Solo		Drive with Passenger		Shared Ride		Walk		Transit	
	Param.	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**
Constant	--	--	-1.675	-7.18	-2.627	-6.43	-3.39	-9.98	-4.209	-5.31
Individual and Household level characteristics										
Number of Workers	--	--	-0.251	-2.57	--	--	--	--	--	--
Total Number of Vehicles	--	--	--	--	-0.314	-3.32	-0.218	-2.56	-2.271	-4.58
Household Income between $35k and $75k	--	--	--	--	--	--	-0.353	-2.24	--	--
Couple Household	--	--	--	--	0.503	2.67	--	--	--	--
Household Size	-0.081	-1.95	--	--	--	--	--	--	--	--
Female	-0.162	-1.54	--	--	0.282	1.41	--	--	--	--
White	--	--	--	--	--	--	0.508	3.10	--	--
Age between 41 to 60 years	--	--	--	--	-0.625	-3.17	--	--	--	--
Type of Profession										
Construction	--	--	--	--	--	--	-0.459	-1.51	--	--
Transportation	--	--	-0.765	-2.35	--	--	--	--	--	--
Professional	--	--	-0.351	-2.60	--	--	--	--	--	--
Government	--	--	-0.626	-2.06	--	--	--	--	--	--
Retail	--	--	-0.515	-1.84	--	--	--	--	--	--
Activity Participation decisions										
Drop off at School	0.609	2.00	--	--	--	--	--	--	--	--
Serve Passenger	--	--	1.248	9.15	--	--	--	--	--	--
Maintenance	--	--	-0.444	-3.24	-0.583	-2.79	-0.208	-1.3	--	--
Visit	--	--	-0.479	-1.91	--	--	--	--	--	--
Active Recreation	--	--	-0.409	-1.69	--	--	--	--	--	--
Eat out	--	--	0.61	4.65	1.379	7.05	0.854	5.53	--	--
Work Related	--	--	-0.218	-1.40	--	--	-0.523	-2.66	--	--
Joint Activity	--	--	0.424	2.49	--	--	--	--	--	--

Table B.3.5 (cont.) Work-based tour mode (Model WSCH05)

Explanatory Variables	Drive Solo		Drive with Passenger		Shared Ride		Walk		Transit	
	Param.	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**
Zonal characteristics										
Retail employment accessibility of work zone	--	--	0.372	1.54	0.854	2.85	--	--	1.747	2.32
Retail and service employment accessibility of work zone	--	--	--	--	-0.095	-2.55	0.154	2.01	--	--
Total employment acc. of work zone	--	--	--	--	--	--	-0.095	-1.74	--	--
Population accessibility	--	--	--	--	0.021	1.90	--	--	--	--
Work zone is CBD	--	--	--	--	--	--	0.249	1.36	--	--
Work zone parking cost	--	--	--	--	0.004	1.59	--	--	--	--
Max. no. of employees reachable within 10 minutes(in 1000s)										
Manufacturing	--	--	--	--	--	--	-0.013	-2.21	--	--
Wholesale trade	--	--	--	--	--	--	--	--	--	--
Informational	--	--	--	--	--	--	-0.037	-1.57	0.073	2.56
Food	--	--	--	--	0.034	1.34	0.153	2.48	--	--

Table B.3.6 After-work tour mode (Model WSCH05)

Explanatory Variables	Driver, Solo		Drive With Passenger		Shared Ride		Walk		Transit	
	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.
Constant	--	--	-1.273	-3.53	-3.393	-5.91	-2.650	-8.75	-3.491	-5.54
Individual and Household level characteristics										
Household Size	--	--	0.077	1.72	--	--	--	--	--	--
Number of Workers	--	--	--	--	0.311	1.37	--	--	--	--
Total Vehicles	--	--	--	--	--	--	-0.245	-2.08	-0.953	-1.69
Couple Household	--	--	--	--	--	--	--	--	1.095	1.14
Single Parent Household	--	--	--	--	--	--	0.833	1.22	--	--
Single Person	--	--	--	--	0.597	1.52	--	--	--	--
Number of School Going Children	--	--	--	--	0.339	1.64	0.478	3.03	--	--
Age	--	--	-0.011	-1.54	--	--	--	--	--	--
Female	--	--	--	--	0.935	3.50	--	--	--	--
Age 26 to 40	--	--	0.367	1.85	--	--	--	--	--	--
Age 41 to 60	--	--	0.459	2.06	-0.896	-3.17	--	--	--	--
Father	--	--	--	--	--	--	-0.535	-1.41	--	--
Activity Participation										
Serving Passenger	--	--	2.282	17.12	-0.712	-1.63	-0.789	-2.06	--	--
Maintenance	--	--	-0.368	-2.81	-0.490	-1.73	--	--	--	--
Shop	--	--	-0.457	-3.40	-0.651	-2.31	--	--	--	--
Visit	--	--	--	--	-0.857	-1.65	--	--	--	--
Social	0.414	1.95	--	--	--	--	--	--	--	--
Entertainment	--	--	0.364	1.99	1.447	4.83	--	--	--	--
Recreation	--	--	-0.601	-3.17	--	--	0.856	3.28	--	--
Eat	--	--	0.299	2.14	0.801	2.94	--	--	--	--
Work Related	--	--	-0.373	-1.92	-1.030	-2.04	--	--	0.737	1.02

Joint Activity Participation	--	--	--	--	--	--	0.649	1.83	--	--

Table B.3.6 (cont.) After-work tour mode (Model WSCH05)

Explanatory Variables	Drive Solo		Drive with Passenger		Shared Ride		Walk		Transit	
	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.
Accessibility Measures										
Max. no. of information employees reachable within 10 minutes (in 1000s)	--	--	0.033	-2.60	--	--	--	--	--	--
Max. no. of financial employees reachable within 10 minutes (in 1000s)	--	--	0.016	1.84	--	--	--	--	--	--
Max. no. of art employees reachable within 10 minutes (in 1000s)	--	--	--	--	--	--	0.042	3.75	--	--

Table B.3.7 Number of stops in a tour (Model WSCH06)

Explanatory Variables	Before Work		Work Based		After Work		Home to Work		Work To Home	
	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.
Threshold Parameters										
Threshold01(1 and 2 stops)	2.068	8.56	1.381	10.49	2.771	15.42	1.753	40.99	1.380	16.52
Threshold02(2 and 3 stops)	2.925	11.61	2.171	15.92	3.631	19.36	2.641	55.52	2.404	27.93
Threshold03(3 and 4 stops)	3.356	12.85	2.711	18.87	4.311	21.69	--	--	--	--
Individual and Household level characteristics										
Household Income (in $)	--	--	--	--	--	--	--	--	0.001	2.75
Female	--	--	--	--	--	--	--	--	0.075	2.21
Professional	--	--	-0.179	-3.04	0.130	1.97	--	--	0.103	3.54
Government	--	--	--	--	0.285	1.83	--	--	--	--
White	-0.289	-2.22	--	--	--	--	--	--	-0.100	-2.70
Hispanic	-0.732	-5.22	--	--	--	--	--	--	-0.201	-4.84
African American	--	--	0.275	2.19	-0.212	-1.53	--	--	--	--
Father	--	--	--	--	--	--	--	--	0.109	2.57
Single Parent Household	-0.668	-2.02	--	--	--	--	0.350	4.23	--	--
Single Person Household	--	--	--	--	0.344	4.12	--	--	0.208	4.43
Number of School Going Children	0.235	5.21	--	--	--	--	--	--	-0.104	-5.60
Number of Non-workers in Household	--	--	--	--	--	--	-0.053	-3.41	-0.063	-3.76
Activity Participation decisions										
Serve Passenger Activities	0.514	5.15	--	--	0.780	10.33	1.126	35.07	0.660	18.50
Maintenance Activities	0.990	9.74	0.620	9.92	0.672	9.87	0.638	19.57	0.899	26.48
Visit	0.775	5.41	--	--	0.651	7.84	--	--	0.759	14.23
Shopping Activities	--	--	0.425	6.39	0.664	9.48	--	--	0.890	24.91
Social Activities	--	--	--	--	0.661	6.05	--	--	--	--
Eating out Activities	--	--	0.106	1.78	0.595	8.11	0.307	8.67	0.559	15.30
Work Related Activities	--	--	0.737	10.52	--	--	0.636	13.66	--	--
Entertainment	--	--	--	--	0.612	6.29	--	--	--	--
Joint Activity Participation	--	--	--	--	--	--	--	--	-0.781	-16.39

Table B.3.7 (cont.) Number of stops in a tour (Model WSCH06)

Explanatory Variables	Before Work		Work Based		After Work		Home to Work		Work To Home	
	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.
Pattern-level attributes										
Home to Work Stops	-0.208	-1.97	--	--	--	--	--	--	--	--
Work to Home Stops	--	--	-0.081	-1.68	-0.205	-3.71	--	--	--	--
Available Time	0.001	3.38	0.001	5.49	0.002	9.72	--	--	0.001	15.38
Number of Work Based Tours	--	--	-0.185	-2.47	--	--	--	--	--	--
Number of Before Work Tours	--	--	--	--	-0.482	-3.90	--	--	--	--
Number of After Work Tours	--	--	--	--	-0.490	-6.09	--	--	--	--
Zonal Characteristics										
Service employment (in 1000s)	0.139	4.06	--	--	--	--	--	--	--	--
Miles of minor arterials within 10 minutes (in 100000s)	0.0138	1.34	--	--	--	--	--	--	--	--
Miles of freeway within 10 minutes (in 100000s)	--	--	0.114	2.15	--	--	--	--	--	--
Miles of ramp within 10 minutes (in 100000s)	--	--	-0.147	-2.49	--	--	--	--	--	--
Miles of primary arterials within 10 minutes (in 100000s)	--	--	--	--	0.015	2.84	--	--	--	--
Work start time (in 1000s)	--	--	--	--	--	--	0.434	6.08	-1.000	-7.30
Work zone adjacent to home	--	--	--	--	--	--	-0.173	-2.89	-0.324	-5.33
Auto IVTT to work	--	--	--	--	--	--	0.004	7.77	0.002	4.13
Max. no of transit stops within 10 minutes (in 1000s)	--	--	--	--	--	--	0.018	6.25	--	--
Tour mode is drive alone	--	--	--	--	--	--	--	--	-0.771	-24.38

Table B.3.8 Home or work stay duration before the tour (Model WSCH07)

Explanatory Variables	Before work tours		Work Based Tours		After Work Tours	
	Param.	t-Stat.	Param.	t-Stat.	Param.	t-Stat.
Constant	4.654	42.32	4.940	35.09	4.287	26.43
Household- and individual-level characteristics						
Female	--	--	--	--	-0.082	-2.05
Age	-0.003	-1.54	--	--	-0.007	-5.32
Hispanic	-0.152	-2.78	--	--	--	--
Number of children in the household	--	--	--	--	-0.122	-6.10
Single person household	--	--	--	--	0.163	2.83
Government	0.209	1.58	--	--	--	--
Professional	--	--	0.056	1.64	--	--
Individual activity participation decisions						
Serving Passenger activities	-0.133	-2.63	--	--	--	--
Maintenance	--	--	--	--	-0.217	-4.91
Social Activity	--	--	--	--	0.168	2.322
Entertainment	--	--	--	--	0.157	2.586
School related activity	-0.159	-2.60	--	--	--	--
Work Related Activities	--	--	-0.383	-8.54	--	--
Work	--	--	0.340	4.85	--	--
Visit	--	--	-0.143	-2.34	--	--
Other Activities	-0.402	-4.56	--	--	--	--
Pattern-level attributes						
Number of stops in WH commute	--	--	--	--	0.106	3.13
Tour-level attributes						
Available time for the tour	0.002	21.018	0.002	19.49	0.003	20.11
Number of stops in this tour	-0.058	-2.061	-0.120	-6.32	-0.191	-7.40
Number of work based tours	--	--	-0.804	-14.16	--	--
Number of after work tours			--	--	-0.786	-12.04
First tour in this period	--	--	-0.217	-2.91	-0.790	-9.40

Table B.3.9 Activity type at a stop (Model WSCH08)

Explanatory Variables	Work Related		Maintenance		Shop		Social		Visit	
	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.
Constant	--	--	0.899	7.79	0.973	3.99	-1.074	-3.87	-1.062	-3.15
Tour-level attributes										
Number of stops in the tour/commute	--	--	-0.201	-8.86	-0.401	-11.77	-0.428	-8.09	-0.562	-6.63
Tour Mode										
Driver, alone	--	--	--	--	0.406	2.95	--	--	-0.417	-2.87
Driver, with passenger	--	--	--	--	0.302	1.98	0.599	5.29	--	--
Passenger	--	--	-0.463	-3.29	--	--	0.639	3.65	--	--
Walk or Bike	-0.641	-2.66	--	--	0.848	4.52	0.925	4.48	--	--
Transit	--	--	--	--	--	--	--	--	--	--
Stop-level attributes										
Stop is in										
Home to work commute	-0.733	-5.99	-0.258	-2.91	-1.342	-8.46	--	--	--	--
Work to home commute	-0.577	-5.09	--	--	0.337	2.74	1.296	8.79	0.359	1.67
First work based tour	--	--	-0.901	-8.13	-1.099	-6.88	-0.461	-2.18	-0.889	-2.84
Second work based tour	--	--	-0.831	-4.44	-1.239	-4.66	--	--	--	--
First before work tour	-0.774	-3.96	--	--	--	--	0.716	2.78	1.324	4.74
Second before work tour	--	--	1.183	3.81	1.477	4.44	2.108	4.26	--	--
First after work tour	-0.553	-4.08	0.467	4.95	1.188	8.45	2.408	15.84	2.302	11.72
Second after work tour	-0.814	-2.02	0.803	3.37	1.149	4.38	2.347	7.65	2.529	7.02
Position of stop in tour/commute										
First stop	--	--	--	--	-0.663	-5.77	-0.475	-2.51	-0.394	-2.03
Second stop	--	--	--	--	-0.152	-1.45	-0.226	-1.28	--	--
Third stop	--	--	--	--	--	--	--	--	--	--

Table B.3.9 (cont.) Activity type at a stop (Model WSCH08)

Explanatory Variables	Entertainment		Recreational Activities		Eat out		Other Activities		Serve Passengers	
	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.
Constant	-2.597	-6.51	-0.069	-0.45	2.313	9.35	-0.389	-1.59	2.388	18.22
Tour-level attributes										
Number of stops in the tour/commute	-0.471	-6.49	-0.649	-12.06	-0.624	-14.76	-0.421	-5.34	-0.717	-23.55
Tour Mode										
Driver, alone	-1.188	-8.33	--	--	--	--	-1.014	-5.50	-3.255	-27.42
Driver, with passenger	--	--	--	--	0.939	12.15	--	--	1.604	16.99
Passenger	--	--	--	--	0.889	7.42	--	--	--	--
Walk or Bike	-1.989	-2.75	1.182	7.08	1.033	7.54	--	--	--	--
Transit	--	--	--	--	--	--	--	--	--	--
Stop-level attributes										
Stop is in										
Home to work commute	--	--	-1.026	-6.15	-1.228	-10.96	-1.292	-4.79	--	--
Work to home commute	2.706	8.28	--	--	-0.726	-7.23	-0.603	-2.75	--	--
First work based tour	--	--	-1.959	-8.59	--	--	-1.884	-5.83	-2.604	-18.09
Second work based tour	--	--	-2.036	-3.41	--	--	-2.208	-2.26	-1.635	-5.83
First before work tour	--	--	1.084	6.96	-1.458	-6.89	--	--	0.342	2.53
Second before work tour	--	--	--	--	--	--	1.747	3.26	1.478	4.28
First after work tour	4.521	14.26	1.455	11.54	--	--	--	--	--	--
Second after work tour	4.610	10.82	0.909	2.65	--	--	--	--	0.655	2.88
Position of stop in tour/commute										
First stop	-0.513	-2.82	--	--	-1.265	-6.24	--	--	--	--
Second stop	--	--	--	--	-0.757	-4.14	--	--	--	--
Third stop	--	--	--	--	-0.305	-1.67	--	--	--	--

Table B.3.10 Activity duration at a stop (Model WSCH09)

Explanatory variables	Before Work		Home to Work		Work Based		Work to Home		After Work	
	Param.	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**
Constant	1.170	8.87	0.984	32.80	0.786	7.49	1.322	15.26	1.422	14.59
Pattern Level Attributes										
One tour in this period	0.134	1.88	--	--	0.539	6.52	--	--	--	--
Two tours in this period	--	--	--	--	0.335	3.76	--	--	--	--
Tour-level attributes										
Tour mode										
Drive Alone	--	--	0.079	1.28	--	--	-0.182	-2.92	--	--
Driver with passenger	-0.374	-4.11	--	--	--	--	-0.140	-2.44	--	--
Shared Ride	--	--	--	--	0.230	2.66	--	--	0.425	4.78
Walk/Bike	--	--	0.705	4.22	--	--	--	--	-0.233	-2.44
One stop in the tour	--	--	--	--	0.497	11.50	0.333	7.54	0.411	7.21
Stop-level attributes										
Available time for activity and travel	0.001	3.86	0.005	24.22	0.001	9.55	0.001	7.48	0.000	3.02
First Stop in the commute	--	--	--	--	--	--	-0.186	-4.07	-0.165	-2.69
Activity type at destination										
Maintenance	1.187	9.86	0.538	7.72	0.761	9.11	0.849	13.64	1.107	15.08
Visit	2.226	9.81	1.400	9.32	1.699	11.51	2.510	29.28	2.591	29.83
Social	1.917	7.53	1.885	9.51	2.024	9.22	2.530	15.03	2.762	24.11
Shopping	1.399	11.20	0.947	8.89	1.128	12.12	1.416	22.63	1.429	21.94
Entertainment	2.737	5.68	1.164	2.05	2.620	7.25	3.180	26.45	2.963	30.62
Active Recreation	2.315	16.27	2.392	15.67	2.402	14.71	2.732	26.86	2.559	28.56
Eating	1.370	7.12	1.035	11.28	1.249	16.35	1.589	21.39	1.749	20.70
Work Related	3.051	16.82	1.744	18.05	1.749	21.78	2.099	26.54	2.138	17.23
Other	2.420	15.79	1.595	12.36	1.890	15.11	2.256	25.13	2.359	20.90

Table B.3.11 Travel time to a stop (Model WSCH10)

Explanatory variables	Before Work		Home to Work		Work Based		Work to Home		After Work	
	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.
Constant	1.888	19.28	1.854	30.60	2.066	28.65	2.815	50.49	2.302	68.55
Pattern Level Attributes										
One tour in this period	0.276	3.85	--	--	0.369	5.81	--	--	--	--
Two tours in this period	0.150	1.87	--	--	0.262	3.82	--	--	--	--
Tour-level attributes										
Tour mode										
Drive Alone	--	--	--	--	-0.077	-2.07	--	--	-0.145	-4.23
Driver with passenger	-0.103	-2.04	-0.092	-2.69	--	--	--	--	--	--
Shared Ride	--	--	--	--	--	--	--	--	0.130	1.95
Walk/Bike	-0.149	-1.74	-0.330	-2.51	-0.435	-7.16	--	--	-0.451	-6.25
One stop in the tour	--	--	--	--	0.075	2.23	--	--	-0.091	-2.23
Stop-level attributes										
Available time	0.000	1.83	0.003	16.91	--	--	--	--	--	--
First Stop in the commute	--	--	0.364	6.68	--	--	--	--	0.108	2.45
Second Stop in the commute	--	--	0.280	4.52	--	--	--	--	--	--
Activity type at destination										
Maintenance	--	--	-0.247	-5.92	-0.230	-4.06	-0.153	-4.22	--	--
Visit	0.487	3.32	--	--	--	--	0.093	1.58	0.231	4.07
Social	--	--	0.208	1.40	--	--	--	--	0.328	4.19
Shopping	--	--	-0.0980	-1.32	-0.1981	-3.03	-0.112	-3.16	--	--
Entertainment	0.667	2.05	--	--	--	--	--	--	--	--
Active Recreation	--	--	--	--	--	--	0.166	2.37	0.438	6.82
Eating	--	--	--	--	-0.311	-6.24	-0.118	-2.38	0.248	4.16
Work Related	0.408	3.46	0.262	4.06	0.422	8.07	0.273	5.39	0.361	4.21
Other	0.376	3.93	--	--	0.130	1.44	--	--	0.294	3.80

Table B.3.12 Location of a Stop (Model WSCH11)

Explanatory Variables	Param.	t-stat.
Distance to ultimate destination/100	-0.088	-10.66
Distance to ultimate destination * Maintenance activity/100	-0.029	-1.55
Distance to ultimate destination * Social activity/100	-0.340	-3.14
Distance to ultimate destination * Shopping activity/100	-0.089	-4.07
Generalized cost (minutes)	-0.031	-16.16
Maximum number of food employees reachable within 10 minutes * Eat out Activity/10000	1.072 E -4	1.27
Maximum number of art employees reachable within 10 minutes * Entertainment/10000	2.304 E -4	1.63
(Retail and Service Employment)/10000	1.058 E -4	8.24
Same zone as origin zone	2.222	13.42
Adjacent zone to origin zone	1.621	12.67
Population accessibility/100	-0.012	-2.56

Appendix B.4 Non-worker Scheduling Model System

Table B.4.1 Number of independent tours (Model NWSCH01)

Explanatory variables	Param.	t-stat.
Thresholds		
1 and 2 tours	1.251	25.71
2 and 3 tours	2.332	43.55
3 and 4 tours	3.173	50.78
Individual and household-level characteristics		
Number of children in the household	0.312	17.19
Transportation Employee	-0.418	-3.54
Household-level activity participation decisions		
Number of non-workers	-0.049	-2.99
Individual activity participation decision		
Drop-off child at school	0.350	3.49
Serving Passenger Activities	1.048	28.77
Shopping	0.568	17.92
Visit	0.278	6.26
Entertainment	0.179	2.92
Maintenance	0.421	13.51
Active Recreational Activities	0.632	13.56
Eating Out	0.345	8.71
Other Activities	0.204	2.90
Work Related Activities	0.155	3.95
Social Activities	0.526	9.39
Accessibility Factors		
Maximum number of wholesale trade employees reachable within 10 minutes (in 1000s)	0.025	5.17

Table B.4.2 Decision to undertake an independent tour before a pick-up or joint discretionary tour (Model NWSCH2)

Explanatory Variables	Param.	t-stat.
Constant	-8.403	-18.73
Individual - and household-level characteristics		
Licensed	0.547	4.79
Couple household	0.157	1.52
Hispanic	0.278	2.67
Number of school going children in the household	0.805	13.08
Individual activity participation decisions		
Serving Passenger activities	1.931	16.73
Maintenance activities	1.060	11.78
Shopping activities	0.674	7.73
Social Activity	1.098	7.77
Entertainment activities	0.428	2.39
Active Recreational activities	0.965	7.63
Eating-out activities	0.341	2.84
Visit	0.579	4.25
Other Activities	0.964	7.88
Joint activity participation decisions		
Joint activity participation	-0.622	-4.61
Joint activity duration	-0.003	-3.76
Visit activity duration	0.002	1.97
Entertainment activity duration	0.004	4.48
Eating Out duration	0.004	2.46
Available time before pick up or joint discretionary tour	0.007	23.26
Available time after pick up or joint discretionary tour	0.002	4.59

Table B.4.3 (cont.) Decision to undertake an independent tour before a pick-up or joint discretionary tour (Model NWSCH2)

Explanatory Variables	Param.	t-stat.
Accessibility measures		
Minimum shopping distance from home zone	0.044	1.97
Retail employment in home zone	-117.200	-2.07
Basic employment in home zone (in 1000s)	-0.090	-1.47
Minimum travel time to shopping from home zone	-0.039	-2.26
Miles of Freeway within 10 minutes (in 1000s)	0.004	1.79
Miles of Collector roads within 10 minutes (in 100000s)	0.046	2.51
Miles of Ramp roads within 10 minutes (in 1000s)	-0.008	-2.46
Maximum number of health employees reachable within 10 minutes (in 1000s)	0.042	1.51
Maximum number of food employees reachable within 10 minutes (in 1000s)	-0.160	-1.89
Maximum number of transit stops within 10 minutes (in 1000s)	0.184	2.36

Table B.4.4 Decision to undertake an independent tour after a pick-up or joint discretionary tour (Model NWSCH3)

Explanatory variables	Param.	t-stat.
Constant	-7.871	-21.78
Individual- and household-level characteristics		
Licensed	0.606	4.38
Individual activity participation decisions		
Serving Passenger activities	1.535	12.69
Maintenance	0.704	6.68
Shopping	0.485	4.62
Social Activity	1.398	7.06
Active Recreational Activities	1.144	6.64
Other Activities	0.548	3.99

Table B.4.4 (cont.) Decision to undertake an independent tour after a pick-up or joint discretionary tour (Model NWSCH3)

Explanatory variables	Param.	t- stat.
Joint activity participation decisions		
Joint activity participation	-0.419	-3.09
Recreational activity duration	-0.008	-3.18
Social activity duration	-0.007	-2.79
Available time after drop off or joint discretionary tour	0.006	20.59
Zonal characteristics		
Retail and service employment accessibility	0.477	3.56
Total employment accessibility	-0.330	-3.55
Median income in the zone	0.003	1.47
Basic employment in the zone (in 1000s)	0.108	1.63
Miles of Freeway within 10 minutes (in 100000s)	0.477	1.66
Miles of Minor arterials within 10 minutes (in 100000s)	0.181	2.08
Miles of Ramps within 10 minutes (in 100000s)	-0.618	-1.38
Maximum number of manufacture employees reachable within 10 minutes (in 1000s)	0.035	2.43
Maximum number of retail employees reachable within 10 minutes (in 1000s)	-0.014	-2.47
Maximum number of information employees reachable within 10 minutes (in 1000s)	-0.120	-2.69
Maximum number of health employees reachable within 10 minutes (in 1000s)	0.119	3.44
Maximum number of public employees reachable within 10 minutes (in 1000s)	-1.000	-3.14

Table B.4.5 Tour mode (Model NWSCH4)

Explanatory Variables	Drive Alone		Drive with passenger		Shared Ride		Walk		Transit	
	Param.	t-Stat.	Param.	t-Stat.	Param.	t-Stat.	Param.	t-Stat.	Param.	t-Stat.
Constant	--	--	-1.443	-9.08	-2.407	-10.23	-2.632	-13.24	-2.308	-8.73
Household- and individual-level characteristics										
Household Size	--	--	0.175	5.43	0.350	9.45	0.292	6.41	0.585	7.41
Female	--	--	0.136	2.17	0.730	7.74	0.254	3.14	--	--
Age	--	--	-0.009	-5.42	-0.004	-1.76	--	--	--	--
Age between 26 to 40	--	--	--	--	-0.256	-2.12	0.535	6.01	--	--
Age between 41 to 60	--	--	--	--	-0.49	-4.91	--	--	--	--
Mother	--	--	0.223	2.34	-0.599	-4.16	--	--	--	--
Father	--	--	--	--	--	--	--	--	-0.745	-2.23
Hispanic	--	--	0.283	3.57	--	--	--	--	--	--
Caucasian	--	--	--	--	-0.333	-3.39	-0.334	-3.64	-0.673	-3.93
Number of children in the household	--	--	--	--	--	--	--	--	-0.482	-4.35
Single person household	--	--	0.152	1.78	--	--	--	--	--	--
Low income	--	--	--	--	0.353	3.80	0.359	4.13	--	--
Number of vehicles	--	--	-0.094	-3.01	-0.27	-5.75	-0.437	-8.87	-1.415	-15.15
Number of students	--	--	--	--	--	--	-0.106	-1.88	--	--
Number of school going children	--	--	-0.116	-2.25	--	--	0.505	7.28	--	--

Table B.4.5 (cont.) Tour mode (Model NWSCH4)

Explanatory Variables	Drive Alone		Drive with passenger		Shared Ride		Walk		Transit	
	Param.	t-Stat.	Param.	t-Stat.	Param.	t-Stat.	Param.	t-Stat.	Param.	t-Stat.
Individual activity participation decisions										
Drop-off child at school	--	--	--	--	--	--	-0.998	-3.14	--	--
Serving Passenger Activities	--	--	2.878	50.03	-0.799	-4.46	-0.627	-4.49	--	--
Shopping	--	--	-0.413	-7.32	-0.676	-7.40	-0.342	-4.12	-0.909	-5.75
Social Activity	--	--	-0.435	-5.10	--	--	--	--	--	--
Entertainment	--	--	0.368	4.04	0.481	3.33	--	--	--	--
Maintenance	--	--	-0.398	-7.10	-0.316	-3.15	-0.359	-4.28	-0.346	-2.33
Active Recreational Activities	--	--	-0.346	-4.44	--	--	0.466	4.69	-0.599	-2.07
Eating Out	--	--	0.314	5.32	0.568	5.72	-0.228	2.24	-0.680	-2.85
Other Activities	--	--	0.256	2.68	0.518	3.52	--	--	--	--
Work Related Activities	--	--	-0.549	-7.45	-0.266	-2.15	-1.141	-9.23	-0.457	-2.13
Joint activity participation decisions										
Joint activity participation	--	--	--	--	--	--	0.553	5.20	--	--
Accessibility Variables										
Service employment accessibility	--	--	--	--	--	--	0.212	5.56	--	--
Total employment accessibility	--	--	--	--	--	--	-0.132	-4.84	--	--
Meters of minor arterial within 10 minutes (in 10000s)	--	--	--	--	0.007	3.15	--	--	--	--
Meters of ramps within 10 minutes (in 10000s)	--	--	0.009	2.90	-0.012	-1.10	--	--	--	--
Informational	--	--	--	--	--	--	--	--	0.025	2.45
Finance	--	--	--	--	--	--	--	--	0.010	1.16
Professional	--	--	0.009	-3.82	--	--	--	--	--	--
Education	--	--	--	--	-0.220	-1.44	--	--	--	--

Table B.4.6 Number of stops in a tour (Model NWSCH5)

Explanatory Variables	Param.	t-stat.
Thresholds		
Threshold01 (1 and 2 stops)	3.940	25.29
Threshold02 (2 and 3 stops)	4.607	29.39
Threshold03 (3 and 4 stops)	5.188	32.86
Threshold04 (4 and 5 stops)	5.593	35.18
Person level characteristics		
Female	0.109	4.74
Age	0.002	2.70
Individual activity participation decisions		
Pick Up from School	-0.457	-6.90
Serve other passengers Activities	0.333	11.21
Maintenance Activities	0.704	30.11
Shopping Activities	0.683	28.58
Visit	0.477	16.11
Entertainment	0.306	7.10
Active Recreation	0.324	10.30
Eating-out Activities	0.592	22.53
Other Activities	0.294	7.14
Work Related Activities	0.552	18.57
Joint activity participation decisions		
Joint Activity Participation	-0.632	-8.67
Accessibility Measures		
Population accessibility	0.001	1.56
Miles of Freeway within 10 minutes (in 100000s)	-0.110	-2.21
Miles of Ramp roads within 10 minutes (in 100000s)	0.203	3.00
Pattern-level Attributes		
Available Time	0.001	15.54
One Tour	0.817	21.85
Two Tour	0.384	11.44
Work Tour	-0.897	-18.16

Table B.4.6 (cont.) Number of stops in a tour (Model NWSCH5)

Explanatory Variables	Param.	t-stat.
Tour-level Attributes		
Second Tour	0.494	9.15
Third Tour	0.576	7.53
Forth Tour	0.307	2.74
Drive alone Tour	-0.275	-10.43

Table B.4.7 Number of stops in a tour following a pick-up or drop-off stop (Model NWSCH6)

Explanatory Variables	Param.	t- stat.
Tour start time	-0.003	-5.814
After drop-off	-0.948	-4.589
Individual activity participating		
Serving Passenger	0.467	5.008
Maintenance	0.408	4.136
Visit	0.279	1.707
Accessibility measures		
Max. number of wholesale trade employees reachable within 10 minutes (in 1000s)	-0.180	-5.069
Max. number of retail employees reachable within 10 minutes (in 1000s)	0.155	3.197
Max. number of information employees reachable within 10 minutes (in 1000s)	-0.150	-4.553
Max. number of education employees reachable within 10 minutes (in 1000s)	-0.120	-2.036
Max. number of art employees reachable within 10 minutes (in 1000s)	0.188	3.285
Max. number of transit stops reachable within 10 minutes (in 1000s)	0.326	4.036
Miles of collector roads within 10 minutes (in 100000s)	-0.061	-2.454
Threshold		
0 and 1 stop	-1.187	-3.251

Table B.4.8 Home-stay duration before a tour (Model NWSCH7)

Explanatory Variables	Tour 1		Tour 2		Tour 3		Tour 4	
	Param.	t-Stat.	Param.	t-Stat.	Param.	t-Stat.	Param.	t-Stat.
Constant	5.337	129.42	3.326	19.91	3.712	24.68	3.086	10.37
Individual- and household-level characteristics								
Licensed	--	--	-0.189	-2.29	--	--	--	--
Female	0.053	5.50	--	--	-0.155	-2.25	--	--
Age (in 10s)	-0.005	-2.07	--	--	--	--	--	--
Age between 41 to 60	--	--	--	--	-0.223	-3.18	--	--
Couple household	--	--	--	--	-0.243	-3.20	--	--
Number of vehicles in the household	--	--	--	--	--	--	-0.142	-2.20
Professional job	--	--	--	--	0.162	1.91	--	--
Government job	--	--	--	--	0.398	1.58	--	--
Retail job	--	--	--	--	0.339	1.74	--	--
Individual activity participation decisions								
Pick-up from school	--	--	0.385	3.18	--	--	--	--
Drop-off child at school	--	--	--	--	--	--	0.399	2.25
Serving Passenger Activities	-0.057	-4.20	-0.103	-1.97	--	--	--	--
Shopping	0.108	10.40	-0.086	-2.15	--	--	--	--
Visit	0.033	2.42	-0.072	-1.42	--	--	--	--
Entertainment	0.068	3.87	--	--	--	--	--	--
Maintenance	--	--	-0.214	-5.29	--	--	--	--
Active Recreational Activities	-0.094	-6.35	-0.114	-2.21	--	--	--	--
Eating Out	0.068	5.69	--	--	--	--	--	--
Other Activities	-0.015	-0.71	-0.226	-3.02	--	--	--	--
Work Related Activities	-0.338	-26.52	-0.253	-4.70	-0.331	-3.23	--	--
Joint activity participation decisions								
Joint activity participation	--	--	0.239	3.58	--	--	--	--

Table B.4.8 (cont.) Home-stay duration before a tour (Model NWSCH7)

Explanatory Variables	Tour 1		Tour 2		Tour 3		Tour 4	
	Param.	t-Stat.	Param.	t-Stat.	Param.	t-Stat.	Param.	t-Stat.
Pattern Level Attributes								
One Tour	0.263	15.39	--	--	--	--	--	--
Two Tours	0.133	7.60	0.319	4.17	--	--	--	--
Three or more tours	--	--	-0.236	-2.90	--	--	--	--
Tour-level attributes								
Available time for the tour (in 100s))	0.030	13.33	0.002	15.97	0.001	6.56	0.002	4.71
Tour Mode	--	--	--	--	--	--	--	--
Drive Alone	0.066	6.15	--	--	--	--	--	--
Drive with passenger	--	--	0.169	3.24	--	--	--	--
One Stop in the tour	0.024	2.30	0.209	4.85	0.159	2.08	0.296	1.85

Table B.4.9 Activity type at a stop (Model NWSCH8)

Explanatory Variables	Work Related		Maintenance		Shop		Social		Visit	
	Param.	**t-stat**	**Param.**	**t-stat**	**Param.**	**t-stat**	**Param.**	**t-stat**	**Param.**	**t-stat**
Constant	--	--	2.948	15.33	2.718	17.61	0.250	1.49	2.644	10.64
Undertakes drop-off in this tour	--	--	--	--	--	--	--	--	-1.587	-2.25
Participate in joint activities	-0.260	-2.83	--	--	-0.261	-3.54	-0.549	-4.02	-2.200	-3.69
Tour-level attributes										
Number of stops in the tour/commute	--	--	0.054	3.50	-0.122	-6.25	-0.133	-4.58	-0.162	-5.46
Tour Mode										
Driver, alone	--	--	-1.524	-9.89	--	--	--	--	-1.856	-10.08
Driver, with passenger	--	--	-1.612	-10.23	-0.356	-5.67	--	--	-1.459	-7.57
Passenger	--	--	-1.446	-8.39	--	--	0.511	3.42	-1.220	-5.73
Walk or Bike	--	--	--	--	1.609	10.02	1.201	5.01	--	--
Transit	--	--	-0.972	-4.98	--	--	--	--	-0.941	-3.58
Tour Number										
First Tour	0.899	7.25	--	--	-0.190	-4.59	-0.436	-3.42	--	--
Second Tour	0.293	2.19	--	--	--	--	-0.246	-1.79	--	--
Stop-level attributes										
Position of stop in tour/commute										
First stop	--	--	--	--	-1.143	-14.43	--	--	-0.590	-5.51
Second stop	--	--	--	--	-0.258	-3.64	--	--	-0.209	-2.06
Third stop	--	--	--	--	-0.139	-1.93	--	--	--	--

Table B.4.9 (cont.) Activity type at a stop (Model NWSCH8)

Explanatory Variables	Entertainment		Recreational Activities		Eat out		Other Activities		Serve Passengers	
	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.	Param.	t-stat.
Constant	1.275	5.29	2.394	10.27	1.866	11.65	0.5302	1.88	4.106	29.60
Undertakes drop-off in this tour	--	--	--	--	-0.873	-2.36	--	--	-0.555	-3.07
Participate in joint activities	-3.697	--	--	--	-0.302	-2.54	--	--	0.342	4.26
Tour-level attributes										
Number of stops in the tour/commute	-0.337	-6.16	-0.223	-6.58	-0.111	-4.53	--	--	-0.303	-15.89
Tour Mode										
Driver, alone	-1.243	-10.21	-2.224	-12.93	-0.679	-9.08	-2.298	-8.43	-4.551	-47.20
Driver, with passenger	--	--	-2.286	-11.98	--	--	-2.138	-7.06	--	--
Passenger	--	--	-2.064	-9.32	0.394	3.38	-2.031	-5.09	-1.519	-15.19
Walk or Bike	--	--	--	--	0.837	3.94	--	--	0.442	2.86
Transit	--	--	-1.986	-5.75	--	--	-0.803	-1.98	-0.447	-3.34
Tour Number										
First Tour	-0.649	-5.46	--	--	-0.413	-6.74	--	--	-0.695	-9.67
Second Tour	--	--	--	--	--	--	--	--	-0.365	-4.87
Stop-level attributes										
Position of stop in tour/commute										
First stop	-0.755	-5.07	0.211	2.16	-0.975	-14.08	--	--	--	--
Second stop	--	--	--	--	--	--	--	--	--	--
Third stop	--	--	--	--	--	--	--	--	--	--

Table B.4.10 Activity duration at a stop (Model NWSCH9)

Explanatory variables	Stops in Tour 1		Stops in Tour 2		Stops in Tour 3		Stops in Tour 4	
	Param.	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**
Constant	1.357	18.79	1.477	14.01	2.092	13.42	1.505	12.66
Tour Level Attributes								
Number of stops in tour								
One	0.745	23.94	0.575	10.09	0.326	5.48	0.340	2.81
Two	0.416	12.64	0.362	5.97	--	--	--	--
Three	0.236	6.99	0.239	3.71	--	--	--	--
Four	0.195	5.09	0.142	1.87	--	--	--	--
Tour Mode								
Drive Alone	-0.534	-15.16	-0.283	-4.12	-0.366	-2.93	--	--
Drive with Passenger	-0.519	-14.03	-0.277	-3.90	-0.480	-3.82	--	--
Walk/Bike	-0.947	-17.29	-0.571	-6.32	-0.870	-5.46	--	--
Stop Level Attributes								
Available time for activity and travel	0.0004	8.63	0.0002	3.21	0.0001	1.58	--	--
Destination activity type								
Maintenance	1.252	34.07	1.021	18.07	0.840	8.09	1.156	5.71
Visit	2.615	50.34	2.549	32.37	1.998	14.09	2.460	9.10
Social	2.639	40.68	2.454	25.62	2.233	13.73	2.444	8.03
Shopping	1.606	43.80	1.523	27.48	1.126	11.86	1.227	7.23
Entertainment	3.632	50.21	3.129	31.52	2.824	16.12	3.494	8.92
Active Recreation	2.553	46.58	2.387	25.28	2.131	12.44	1.694	5.25
Eating Out	1.829	37.38	1.720	24.87	1.589	13.16	1.294	5.49
Work Related	3.278	79.68	2.441	31.27	2.103	13.02	2.560	8.17
Other	2.255	46.36	2.134	26.97	1.758	12.06	2.416	8.75

Table B.4.11 Travel time to a stop (Model NWSCH10)

Explanatory variables	Stops in Tour 1		Stops in Tour 2		Stops in Tour 3		Stops in Tour 4	
	Param.	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**	**Param.**	**t-stat.**
Constant	2.256	95.19	2.290	164.42	2.146	19.17	2.131	53.78
Tour Level Attributes								
Number of stops in tour								
One	0.110	5.03	--	--	-0.197	-2.29	--	--
Two	0.186	7.89	--	--	-0.279	-3.07	--	--
Three	0.140	5.81	--	--	-0.209	-2.16	--	--
Four	0.120	4.39	--	--	-0.279	-2.40	--	--
Tour Mode								
Drive Alone	-0.084	-4.85	--	--	0.330	4.11	--	--
Drive with Passenger					0.267	3.32	--	--
Shared Ride					0.471	4.02	--	--
Transit	0.105	2.87	0.273	2.57	0.647	3.29	--	--
Stop Level Attributes								
Destination activity type								
Visit	0.468	12.75	0.365	7.37	--	--	--	--
Social	0.299	6.51	0.267	4.29	--	--	--	--
Entertainment	0.545	10.59	0.349	5.26	0.549	4.72	--	--
Maintenance	0.137	5.30	--	--	--	--	--	--
Shopping	0.074	2.89	--	--	--	--	--	--
Active Recreation	0.330	8.53	0.303	4.94	--	--	0.506	2.40
Eating Out	0.138	3.96	0.126	2.97	--	--	--	--
Work Related	0.819	28.16	0.504	10.54	0.373	3.61	0.607	2.97
Other	0.516	15.09	0.324	6.45	0.261	2.79	0.268	1.49

Table B.412 Location of a stop (Model NWSCH11)

Explanatory Variables	Param.	t-stat.
Distance to ultimate destination (in 100s)	-0.044	-6.50
Distance to ultimate destination (in 100s) * Shopping activity	-0.090	-6.49
Generalized cost (in minutes)	-0.022	-12.45
Same zone as origin	3.031	25.24
Adjacent zone to origin zone	1.934	18.44
Maximum number of retail employees reachable within 10 minutes	3.906 E -5	1.91
Maximum number of education employees reachable within 10 minutes	-4.262 E -5	-1.49
Population accessibility(in 100s)	-0.010	-2.52
Retail and Service Employment accessibility	1.149 E -4	11.09

Appendix B.5 The children scheduling model system

Table B.5.1 School-to-home (Model CSCH1) and home-to-school (Model CSCH2) commute durations

Explanatory Variables	School-to-home duration (Model CSCH1)		Home-to-school duration (Model CSCH2)	
	Param.	t-stat.	Param.	t-stat.
Constant	2.670	61.98	2.587	57.54
Commute mode is walk or bike	0.189	4.16	0.148	3.27
Commute mode is school bus	0.486	9.69	0.748	15.09
School zone adjacent to home zone	-0.245	-5.87	-0.314	-7.61
Distance from home zone	0.004	2.22	0.002	1.21
School zone same as home zone	-0.495	-10.68	-0.609	-13.27

Table B.5.2 Mode for the independent discretionary tour (Model CSCH3)

Explanatory Variables	Param.	t-stat.
Constant	-1.551	-4.64
Male	.989	3.02
Child goes to school	.466	1.46

Table B.5.3 Departure time for the independent discretionary tour (Model CSCH4)

Explanatory Variables	Param.	t-stat.
Constant	5.613	35.09
School End time	0.001	14.31
Age	0.032	2.44

Table B.5.4 Activity duration at the independent discretionary stop (Model CSCH5)

Explanatory Variables	Param.	t-stat.
Constant	6.291	29.32
Departure time for tour	-.002	-8.24

Table B.5.5 Travel time to the independent discretionary stop (Model CSCH6)

Explanatory Variables	Param.	t-stat.
Constant	1.738	4.35
Tour mode is Walk or bike	-0.801	-6.10
Age	0.066	2.01
School End Time	-0.001	-3.16

Table B.5.6 Location of the independent discretionary stop (Model CSCH7)

Explanatory Variables	Param.	t-stat.
Same zone as origin	0.564	2.44
Auto in-vehicle travel time	-0.229	-13.64
Auto in-vehicle travel time * Walk or bike mode	-0.419	-10.52
Maximum number of retail employees reachable within 10 minutes (in	-1.48 E-04	-1.67
Maximum number of food employees reachable within 10 minutes (in)	6.92 E-04	2.75
Maximum number of transit stops reachable within 10 minutes (in)	-7.25 E-04	-1.91
Population of the zone	6.558E-05	1.72
Population accessibility (in100s)	0.035	-7.34