CSTDM09 – California Statewide Travel Demand Model

Model Development

Short Distance Personal Travel Model: Part 1 of 3

System Documentation: Technical Note

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1. Introduction and Model Overview

This technical note is Part 1 of a series of 3 Technical Notes that describe the Short Distance Personal Travel Model (SDPTM) component of the California Statewide Travel Demand Model (CSTDM09). The documentation is split into 3 parts to keep individual document and computer file size to a manageable level. Together they describe the complete model features, calibration and implementation. The original estimations of the models are mainly described in separate Technical Notes.

Technical Note Part 1 (this document) contains details of:

- Model Overview;
- Long Term Decision Models:
    - Person Driving License Models;
    - Household Auto Ownership Models;
    - Person Work Location Models;
        - "Simplified" Work Tour Mode Choice Models;
    - Person School Location Models;
        - "Simplified" School Tour Mode Choice Models;
- Calibration of Long Term Decision Models.

Technical Note Part 2 contains details of:

- Day Pattern Choice Models
- Main Tour Mode Models:
    - Work Tour Mode Models;
    - School Tour Mode Models;
    - "Other" Tour Mode Models.
- Calibration of Day Pattern and Main Tour Mode Models.

Technical Note Part 3 contains details of:

- Primary Destination Choice Models for "Other" Tours
- Sub-Tour Mode Choice Models;
- Secondary Destination Choice Models;
- Trip Mode Choice Models;
- Calibration of Primary and Secondary Destination / Sub-Tour and Trip Mode Choice Models;
- Implementation in CSTDM09 Model Framework.

2. Model Overview

The CSTDM09 has defined two distinct models to be applied to forecast personal travel by California residents on a typical weekday in the fall. The Short Distance Personal Travel Model (SDPTM) will correspond to all person's trips made up to 100 miles on a typical weekday. The Long Distance Personal Travel Model will correspond to all trips made greater than 100 miles.

The SDPTM is a disaggregate micro-simulation tour-based choice travel demand model that was developed from scratch for the CSTDM09. Travel survey data for the years 2000 / 01 from the California State-wide Household Travel Survey and similar surveys conducted in SCAG, MTC and SANDAG regions were used to estimate choice-based logit sub-models for various components of SDPTM. The model is applied to forecast trips made by every resident of California. Details of each person and their household are obtained from a "synthetic population" experimentation , which was generated as part of the CSTDM09 model development part. operation.

Each person / household is assigned to a home traffic analysis zone (TAZ). The state is subdivided into 5,191 TAZs. The TAZ nest both within the 58 California counties and the 524 land use zones (LUZs) system used in the California CALSIM (PECAS) spatial economic model. Figure 1 illustrates the CSTDM09 TAZ system:

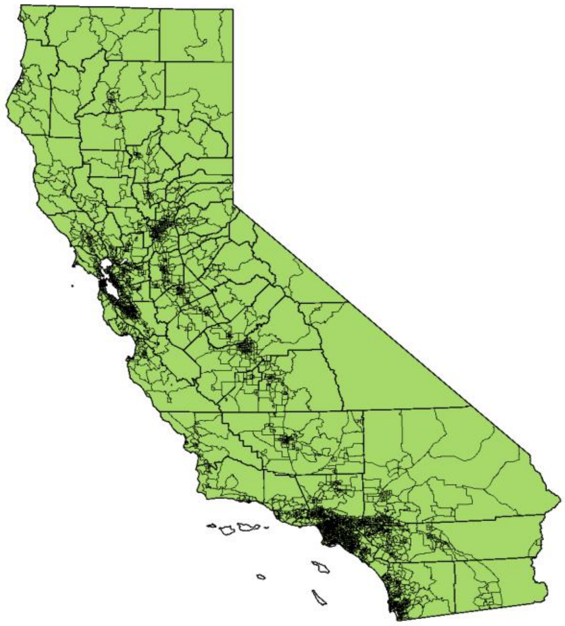

Figure 1: TAZ System

The cut-off distance between short and long distance personal travel model is 100 miles (defined by the straight-line distance between TAZ centroids).

The weekday time-frame of the models is split into four time periods for demand modeling and traffic assignment purposes:

- AM Peak Period (6AM to 10AM);
- Midday Period (10AM to 3PM);
- PM Peak Period (3PM to 7PM);
- Off-peak Period (12AM to 6AM plus 7PM to midnight).

The Off-peak period is further sub-divided into an Early off-peak period and a Late off-peak period. The Early off-peak period is defined as being between 3AM and 6AM and the Late off-peak period as being between 7PM and 3AM. These definitions are consistent with the data collection approach for household travel surveys, where the travel survey day starts at 3AM morning.

Road and public transit network descriptions for each time period are coded in the CUBE software. Travel time and cost skims are extracted using CUBE.

The SDPTM considers 8 travel modes:

1. Single Occupant Auto (SOV);
2. High Occupant Auto with 2-persons in the auto (HOV2);
3. High Occupant Auto with 3+persons in the auto (HOV3):
4. Walk Access Local Transit (bus, light rail, heavy rail);
5. Drive Access Local Transit (access to or egress from a rail station is by auto);
6. Walk;
7. Bicycle;
8. School Bus.

The SDPTM is a tour-based travel forecasting model. It uses the concept of a Tour as a unit of analysis in the development of model components. A tour represents a closed or half closed chains of trips starting and ending at home or at the workplace. Each tour includes at least one destination and at least two successive trips. A tour is developed by connecting the person trips in a trip chain by time of day, travel activities and stop sequence. Figure 2 illustrates a typical day pattern with two separate tours from / to home; and one sub-tour from / to work.

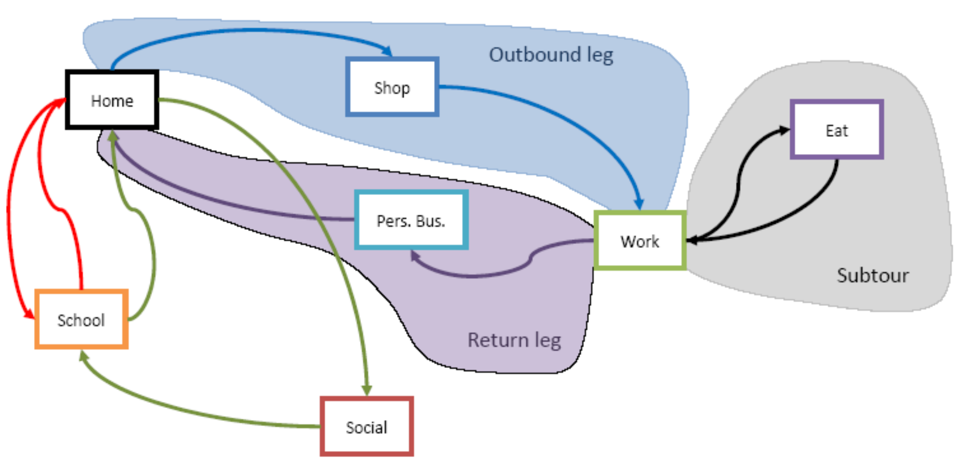

Figure 2: A Typical Day Pattern with Tours

For each tour, a "tour mode" is defined. The tour mode is the overall mode for the tour. The trip mode, which is the "fastest" mode in all the trips of a tour is called the tour mode, defined in a hierarchical order (SOV, HOV2, HOV3+, School Bus, Drive Access Transit, Walk Access Transit, Bicycle, Walk).

The SDPTM has 6 main components, applied to each person, as shown in Figure 3.

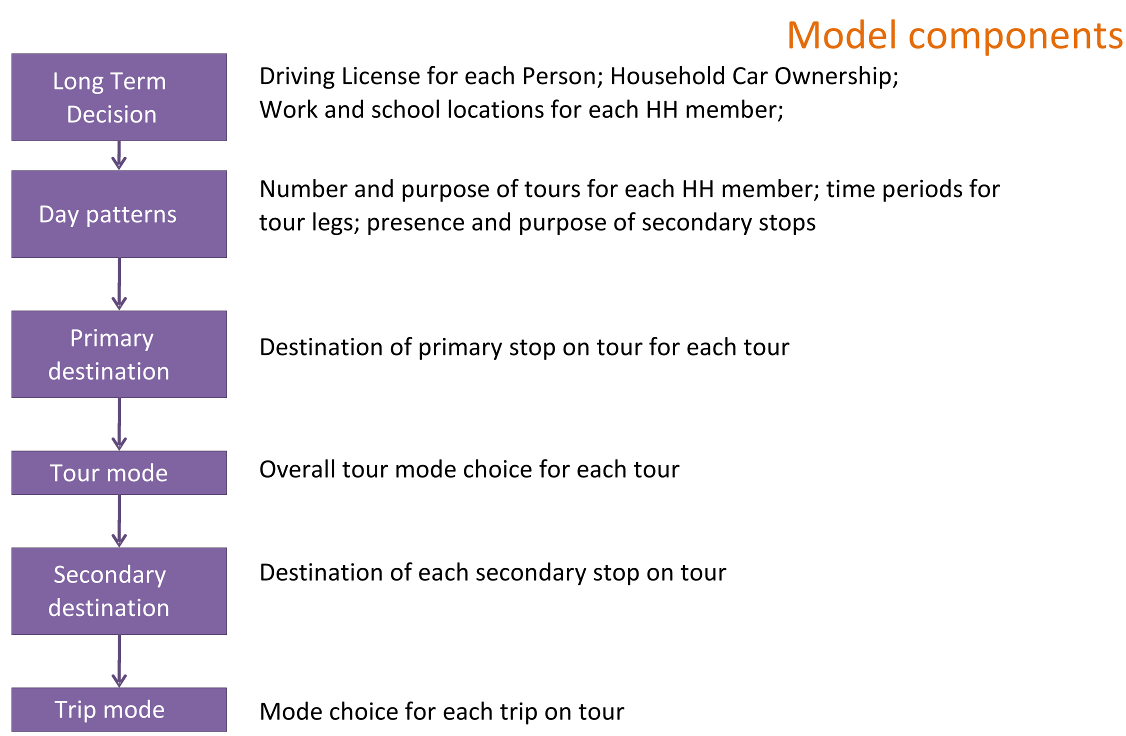

Figure 3: Components of the Short Distance Personal Travel Model

The **Long Term Decision** component of the SDPTM contains the following sub-models for all persons and households:

- A **Driving License** model, which forecasts whether the individual being modeled has a driving license. This model is required because the availability of a driving license is used as an explanatory variable in the household auto ownership and mode choice models of the SDPTM. The "synthetic population" data for each person is obtained using the Federal Census PUMS data, and this data does not contain details of a person's driving license status.

- A **Household Auto Ownership** model for each individual household, which forecasts whether the household has 0, 1, 2, 3 or 4+ automobiles in the household. Household Auto availability (defined in 3 categories – 0-auto households, autos < drivers (insufficient), and autos>= drivers (sufficient)) is an explanatory variable used to forecast mode choice and destination choice (through accessibility measures).

Both the driving license ownership model and the household auto ownership model include demographic and travel "accessibility" explanatory variables. They are thus policy sensitive to change in both demographics and travel "accessibility".

The **Long Term Decision** component of the SDPTM also contains the following sub-models for all person types:

- A **Work Location** model, which forecasts the potential primary workplace TAZ of the individual being modeled. This location is used as the primary destination for all Work tours made by the individual. (Although this model is used mainly for persons classified as Workers, it is also used to identify primary work locations for other person types, who are forecast to make a work tour as part of their day pattern).

- A **School Location** model, which forecasts the primary school location TAZ of the individual being modeled. This location is used as the primary destination for all School tours made by the individual. (Although this model is primarily used for persons classified as Grade School children or Post-Secondary Education Students, it is also used to identify primary school locations for other person types, who are forecast to make a school tour as part of their day pattern).

The **Day Pattern** model component of the SDPTM allocates "whole day patterns" for each person, in terms of:

- The number of tours made from home (or the tour start purpose type location if not home);
- The number of stops on each tour, by tour purpose;
- For each tour, the primary tour purpose - defined in a hierarchical fashion:
    - any tour with a Work purpose stop is defined as a Work Tour;
    - any tour with a School purpose stop is defined as a School Tour;
    - the purpose of the first stop for non Work or School Tours;
- For each tour, the start and end time periods of the tour;

Note: A tour is generally defined as a set of travel activities to locations other than home that starts and ends at home. However some tours at the beginning of the travel day can have a start location other than home – in these cases a tour is defined as complete when the stop location is finally home. Tours not ending at home are treated in a similar fashion.

The **Primary Destination** model component of the SDPTM forecasts the destination of the primary stop on the tour. For Work and School Tours the primary destination has already been forecast by the Long Term Decision Work Location and School Location models. The Primary Destination Models are thus applied for tours where the primary purpose is "Other" i.e. not Work or School. In these cases the primary purpose and destination is defined as the purpose and destination of the first stop.

The **Main Tour Mode** model component of the SDPTM forecasts the main mode used for the tour. This mode is generally used for all trips on the tour, although for certain tour types the **Trip Mode Models** forecast the use of an alternative mode to the main mode.

The **Secondary Destination** model component of the SDPTM forecasts the destination of all secondary stops on the tour, for all tour purposes (Work, School or Other).

The above models are applied differently depending upon whether the tour purpose is Work or School, or whether the tour purpose is Other.

Figure 4a shows the sub-model detail and flow for tours where the tour purpose is Work or School. It has a traditional travel model order, with primary destination chosen before mode choice:

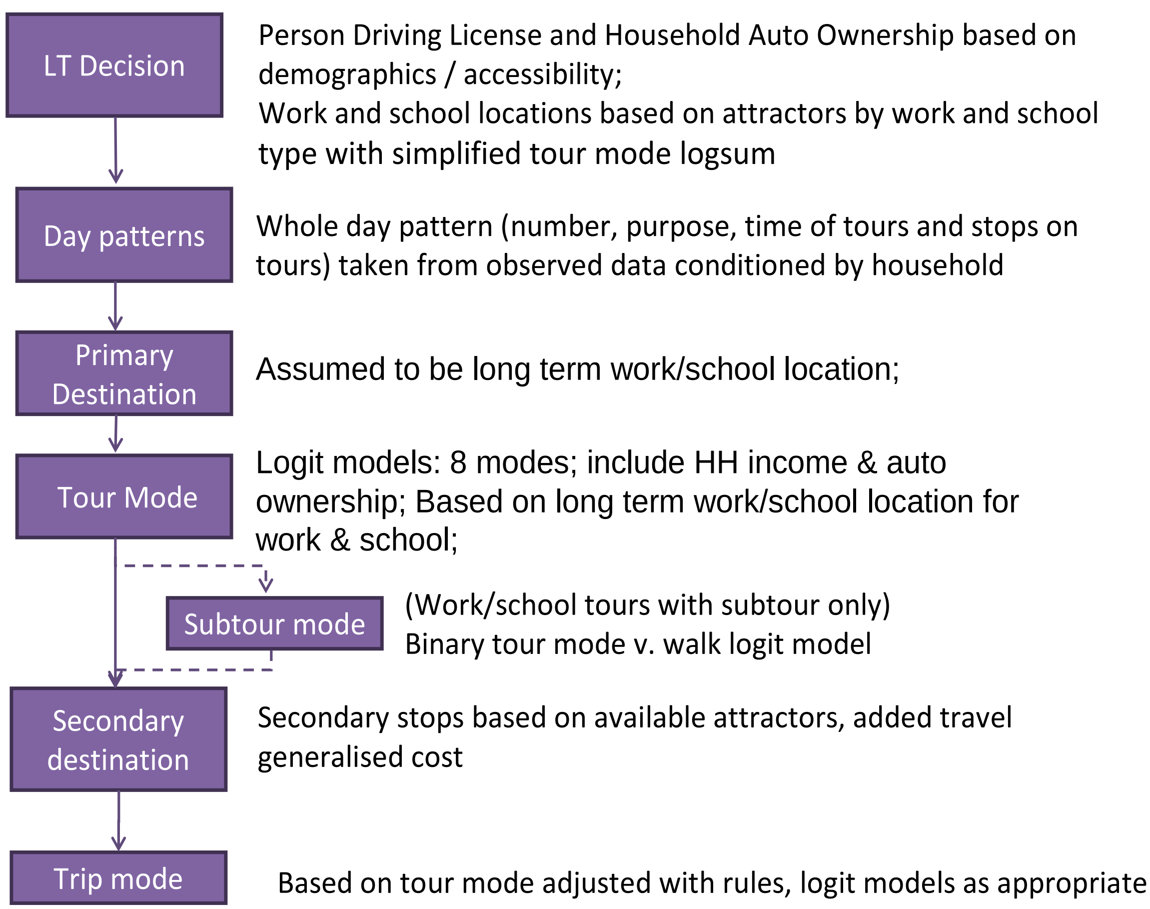

Figure 4a: SDPTM Application: Work and School Tours

Figure 4b shows the sub-model detail and flow for tours where the tour purpose is "Other". It has a non-traditional travel model order, with tour mode chosen before primary destination:

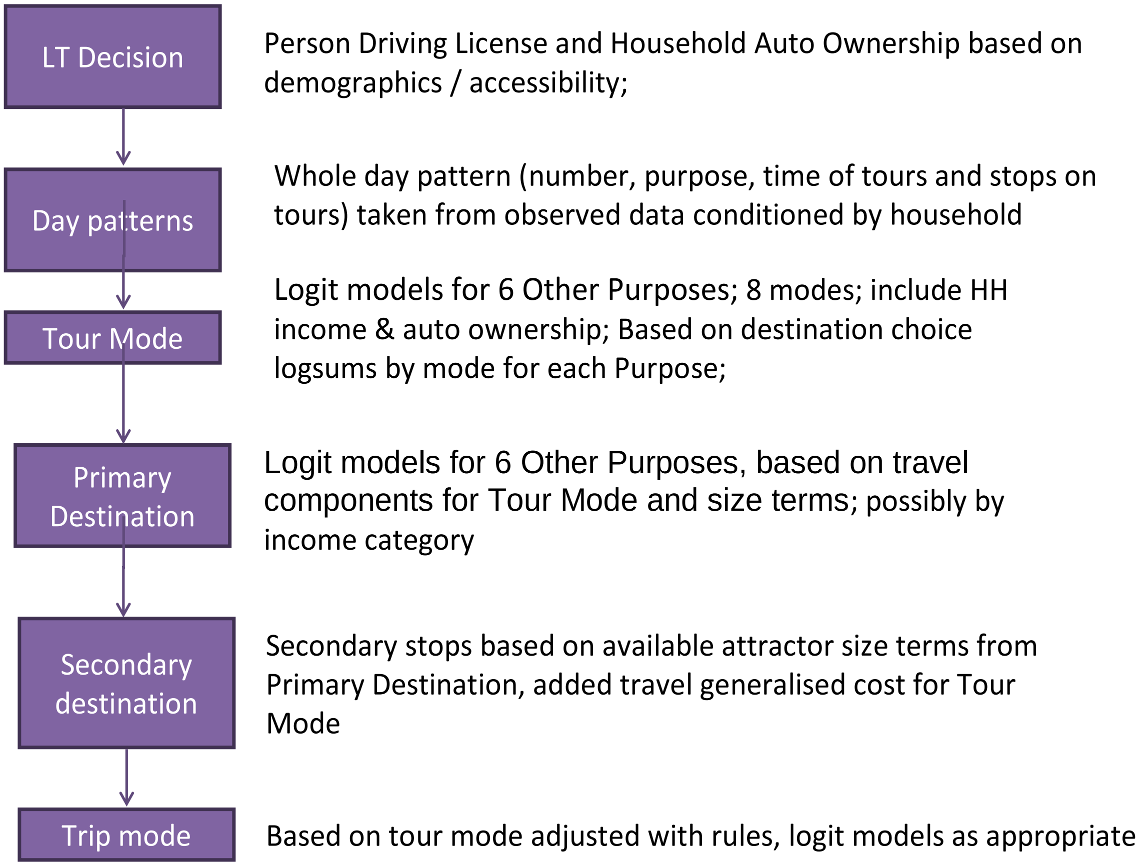

Figure 4b: SDPTM Application: Other Tours

Section 3 of this Technical Note describes the form of the Long Term Decision Models, including the “simplified” mode choice models used in Work and School Location choice. Section 4 describes the calibration of these models to year 2000 targets.

3. Long Term Decision Models

This section describes the form and final parameter values of the individual long term decision models estimated for the CSTDM09.

3.1 Person Driving License Model

Holding a driver's license is important for a number of decisions related to transportation, including household auto ownership and the mode choice of individual trips and tours.

The driver's license status is commonly collected in travel survey data, including all four of the surveys comprising the available data for the production of the California Statewide Travel Demand Model (CSTDM09). Unfortunately, this important explanatory variable is not present in the Public Use Microdata Sample (PUMS) data used for the synthetic population in the CSTDM09.

Rather than assuming that every person 16 and older is a licensed driver (which fails to take a number of aspects into account, most notably the potential aging population), a simple binary logit choice model that predicts the driver's license status for persons 16 and older has been estimated.

The input data used was the single California statewide survey, using the seven day expansion factor provided by the original survey firm. After removing persons under 16, observations with incomplete data and observations with geo-coding problems, a total of 27,459 observations remained. ALOGIT was used to try several model structures and parameters, with the final estimated model shown below in Table 1a. Additional age group calibration parameters were added during model calibration, given in Table 1b, and additional district-level geographic parameters were also added during calibration, shown in Table 1c.

Note: The values shown below in Table 1a and 1b are the utility function for holding a driver's license; the utility of not having a driver's license is set to 0.

Table 1a : Driving License Model Parameters (Estimated in ALOGIT)

Parameter	Parameter Value
Constant - Holding a Driving License	7.9386
Person under 35: (35 - age)	-0.2706
Person under 35: $(35 - age)^2$	0.03187
Person under 35: $(35 - age)^3$	-0.001402
Person aged 65+: $(age-64)^2$	-0.003434
Has physical disability	-1.2324
Has mental disability	-1.8452
Has sensory disability	-2.2375
HH income under $10K	-1.7832
HH income $10-25K	-1.3971
HH income $25-35K	-0.7642
HH income $35-50K	-0.2968
HH income $75-100K	0.3412
HH income $100-150K	0.5529
HH income $150K or more	1.1207
Person is "Other" (does not work, is not student)	-0.5686
"Other" person in a HH that also has a worker	-0.5098
Person is only worker in HH	0.3083
Person under 21 and not working: (21 - age)	-0.2744
HH size 1 person	0.6238
HH size 6+ people	-0.3363
HH income < $25K and size 5+	-0.7395
HH income $25-50K and size 5+	-0.8982
HH income $50-100K and size 5+	-0.5244
Work logsum, no autos	-0.7139
Work logsum, sufficient autos	0.5601
Constant - Not holding driver's license	0

Table 1b : Driving License Model Additional Age Parameters from Calibration

Age range	Parameter Value
16	-0.7237
17	-0.4178
18	-0.0120
19	0.2132
20-24	-0.2874
25-29	-0.2407
30-34	0.1083
35-39	-0.2048
40-44	-0.0779
45-49	-0.3088
50-54	-0.3600
55-59	0.1176
60-64	-0.6594
65-69	-0.8567
70-74	-1.2817
75-79	-1.0116
80-84	-1.1733
85+	-1.3226

Table 1c: Driving License Model Additional District Parameters from Calibration

Geographical district	Parameter Value
Far North	0.4261
SACOG	0.0901
MTC - Solano	-0.0713
MTC - Marin / Sonoma / Napa	0.2761
MTC - San Francisco	-0.3214
MTC - San Mateo	0.3613

MTC - Contra Costa	0.5144
MTC - Alameda	0.1938
MTC - Santa Clara	0.3136
SJV - Merced / San Joaquin / Stanislaus	-0.2022
SJV - Fresno / Madera	-0.5290
SJV - Kern / Kings / Tulare	-0.5918
Western Sierra Nevada	0.4698
AMBAG	-0.4362
Central Coast	-0.1159
SCAG - Ventura	0.3838
SCAG - Los Angeles	-0.1584
SCAG - San Bernardino	-0.0991
SCAG - Riverside	-0.1683
SCAG - Imperial	-0.4748
SCAG - Orange	0.3666
SANDAG	0.1568

The alternative specific constant is the single largest contributor to utility, which is expected; society as a whole tends to have a strong bias in favor of holding a driver's license, about 95% in the observed data. Most of the parameters in the model relate to aspects that reduce a person's likelihood of holding a license.

The age of the person plays a significant role, particularly at the extremes of the reasonable range.

The lowest incidences of driver's license holding are amongst young adults who have not obtained their driver's license, with the licensed proportion increasing as the age increases, and amongst the elderly, with the oldest members of society the least likely to hold a driver's license. The age utility component has three parts:

- for persons under 35, a cubic function based on (35 - age), i.e. years younger than 35, is used;
- for persons 65 and older, a quadratic function based on (age - 64), i.e. years older than 64, is used
- There is no age function for persons in the 35-64 year age range.

The second aspect included is the disability status of the person. There is a significant decrease in likelihood for the disabled to hold a driver's license, most strongly for the sensory disability category, which includes both the hearing and visually impaired.

Income also has a strong impact in the likelihood of owning a driver's license; as income increases, the likelihood of holding a driver's license increases. For a typical person, the observed likelihood of holding a driver's license ranges from 99.5% for incomes over $150,000 down to just 91.1% for incomes under $10,000.

The person's status also plays a role in the likelihood of owning a driver's license.

An "other" person, who is neither a worker nor a student, is less likely to own a driver's license, with this decrease even larger for "other" persons in households with a worker, implying a bit of a division of labor.

If a person is the only worker in their household, they have an increase in the utility of holding a driver's license, which reinforces this aspect. The gender of the person has a small impact, with women modestly less likely to possess driver's licenses.

The final status aspect is also an age-related component; for nonworking persons under 21, a linear function based on the number of years under 21 is used, with significant effects for the youngest people (16 year olds in the base case have a 32.8% increased likelihood of having a license if they also have a job, but this difference drops to an 12.9% increased likelihood for 18 year olds). This shows the combination of two factors for high school students and recent graduates; those who also hold a job are more likely to need a auto, but also many high school students take part time jobs to pay for their first auto. Note that this parameter is only based on work status, not the student status.

Household size also plays a role in holding a driving license. One person households are more likely to hold a driver's license, and persons in 6+ person households are less likely. A size/income interaction is also present, where persons in large lower income households (with 5 or more people) have an additional likelihood to not hold a driver's license. Note that these terms are additive; a member of a 6 person household with $28K income incurs the 6+ person household utility term, plus the $25-35K utility term, plus the 5+ person $25-50K income term.

Finally, two logsum values provide sensitivity to travel conditions. The logsums are taken from the Work Location Choice model described later in this document; they each include a cost logsum across all available modes, and a size term using total employment, with both the cost and size parameters fixed at 1 and no distance function. There are six logsums used in this component, two logsums each (one for households without autos, and one for households with sufficient autos, i.e. at least one per driver) for three income levels; under $25K, $25-100K and $100K+. Depending on the household income level, the appropriate logsum pair is used; the coefficient is estimated across all three values.

The strong positive coefficient for sufficient auto and the strong negative coefficient for no auto logsums indicate the expected relationship -- fewer drivers' licenses where the opportunities without an auto are better relative to those with an auto.

In urban areas with many opportunities available by transit and walking, the importance of having a driver's license is lower, compared with a rural area where an auto is almost required for daily life. The range of the net utility provided by these two logsums ranges from around -2.4 in remote areas, such as far northern Modoc and Siskiyou counties to

-5.0 in San Francisco's dense and transit-oriented financial district, with base case driver's license holding at 99.6% and 95.0% respectively. The 10th and 90th percentiles are -3.36 and -4.23.

In application, the strong alternative specific constant tends to produce very high driver's license holding, which is consistent with the observed data. Most people will have a probability in excess of 95% or even 98%. In many cases where one or two of the negative parameters apply, the license holding probability is still fairly high; in general, it takes a combination of negative parameters (or a strongly negative parameter, such as sensory or mental disability, or an age under 21 or over 85) to effect a probability more than 5% lower than the base case.

To apply the model, a Python script has been written that assigns the utility component to each person net of logsums. The logsum components are added in during the Long Term Decision component of each Short Distance Personal Travel Model run, and the driver's licenses assigned.

For some person types – those with disabilities, and those living in group quarters – the model application required specific “rules” to bridge between the travel survey data used in model estimation, and the person data available from the “synthetic population” PUMS data.

The California statewide travel survey had a number of specific codes referring to specific disabilities, with only one applying. These categories were straightforward to recode to the three PUMS disability fields shown in the estimations above. However, PUMS reports three more disability categories; self-auto disabilities, employment disabilities and ability to leave home disabilities. For the purposes of the application of the model, the ability to leave home is assumed as having the same parameter as physical disability, the lowest of the three disability categories in the model. Further, the script applies the single highest disability parameter to a person, so someone who had both a mental and a physical disability would have the mental disability parameter applied -- this is the most consistent with the California statewide travel survey's design of a single disability parameter.

It is assumed that persons in institutionalized group quarters (primarily prisons and nursing homes) are not eligible for driver's licenses (they were not present in the travel survey population). Persons in non-institutionalized group quarters, such as college dorms and military barracks, are explicitly included in the driving license model application.

3.2 Household Auto Ownership Model

Household auto availability is a major determinant of its trip making behavior and plays a significant role in travel demand forecasting. The household's choice of auto ownership is closely related to driving license holdings. There is a strong interdependence between the choice of auto ownership level and the number of drivers in a household. Auto ownership model predict the number of vehicles owned by each household as a function of number of household drivers, composition and income, as well as accessibility measures to work, school and other activities.

The structure of auto ownership model is based on the relative auto-sufficiency indices which reflect the relationship between number of drivers and number of autos in each household. The primary modeling technique is discrete choice analysis with Monte-Carlo simulation, which is different from the aggregate prediction of auto ownership at the zonal level. A multinomial logit model structure is applied to understand the choice behavior for each household. It yields the probabilities of having a certain number of vehicles owned by a household. The Number of autos in each household is set as choice alternatives. The multinomial logit model for auto ownership choice model has the following form:

$$P(i) = \frac{\exp(V_i)}{\sum_{j=0}^{5} \exp(V_j)}$$

where:

i, j = 0, 1, 2, 3, 4, 5+ = available choice alternatives,

$P(i)$ = probability of each alternative to be chosen,

V_i = utility associated with each alternative.

From the surveyed household dataset, households with a maximum of 9 vehicles were observed, but households with 5 autos or greater only account for 1.2% of total samples. A multinomial logit model with five available alternatives: 0 autos, 1 auto, 2 autos, 3 autos, 4 autos and 5+ autos was developed to predict the number of vehicles owned by each household. If 5+ autos is the chosen alternative, observed probabilities by income are used to produce a specific number of autos.

The model was estimated by the application of the ALOGIT package with combined household interview survey data from the combined travel behavior data set. During the model estimation, a number of model specifications were run on the estimation data set. The variables and their forms finally retained in the model were based on how well the estimated coefficients conformed to the expectations on their signs and relative magnitudes and on their statistical significance. The final model estimation results are summarized in Table 2a for demographic parameters; and Table 2b for logsum accessibility parameters. The probabilities used to disaggregate the 5+ auto choice are shown in Table 2c.

Table 2a: Household Auto ownership Model Parameters (Demographic)

Parameter	0 Autos	1 Auto	2 Autos	3 Autos	4 Autos	5+ Autos
0 drivers in HH	0.098	-0.271	-0.843	-1.318	n/a	n/a
1 driver in HH	-8.855	-0.011	0.873	-0.293	-1.571	-2.391
2 drivers in HH	-12.859	-1.822	0.028	0.513	-0.673	-1.921
3 drivers in HH	-13.614	-2.688	-0.613	0.026	0.740	-0.315
4 drivers in HH	-13.614	-3.936	-1.701	-0.565	-0.014	0.579
5+ drivers in HH	-13.614	-3.936	-3.329	-3.022	-0.216	0.090
HH income <10K	2.7068	0.9253	0	-0.5926	-0.7306	-1.5408
HH income 10K -25K	1.8964	0.8319	0	-0.4126	-0.7306	-1.5408
HH income 25K - 35K	1.0484	0.6078	0	-0.4476	-0.6905	-1.1164
HH income 35K - 50K	0.4122	0.2546	0	-0.1725	-0.4261	-0.5579
HH income 50K - 75K	0	0	0	0	0	0
HH income 75K - 100K	-1.0177	-0.4343	0	0.2115	0.02914	0.02914
HH income 100K - 150K	-0.7764	-0.3235	0	0.1889	0.02914	0.02914
HH income > 150K	-0.7764	-0.3235	0	0.2431	0.02914	0.02914
Number of grade student drivers /total number of drivers in HH	4.0506	-0.4678	0	-0.6886	-2.9099	-4.2972
Number of post-secondary student drivers /total number of drivers in HH	-1.2038	-0.3483	0	0.4461	0.3748	0.4105
Number of part time worker drivers / total number of drivers in HH	1.9065	-0.1467	0	0.005974	-0.2378	-0.08084
Number of adult other drivers / total number of drivers in HH	7.4586	-0.1662	0	-0.3382	-0.5262	-0.01894
Number of senior drivers / total number of drivers in HH	6.7024	0.09251	0	-0.2366	-0.7668	-0.6386
Number of blue worker drivers / total number of drivers in HH	-0.4853	-0.6820	0	-0.2779	0.1229	0.7377
Number of office worker drivers / total number of drivers in HH	0.1507	0.02325	0	0.05151	0.00248	0.2615
HH has children under age 5	-0.5083	-0.00678	0	-0.2230	-0.6565	-0.8041
HH has children under age 15	-0.1124					
Housing type - multifamily	2.89832	2.39328	1.49527			
Housing type - attached	1.42950	1.19772	0.52591			
Housing type - mobile home	0.26284	0.45664				
1 adult (16+ years old)	0.1140	0.0158	-0.1818	-0.4230	0.0773	0.0773
2 adults (16+ y.o.)	0.1342	0.0031	0.0227	-0.1055	-0.2473	-0.2473
3 adults (16+ y.o.)	1.8892	0.3465	-0.0497	-0.2704	-0.4085	-0.4085
4+ adults (16+ y.o.)	3.4031	0.7741	0.2118	-0.1030	-0.9005	-0.9005

Table 2b: Household Auto ownership Model Parameters (Accessibility logsums)

	No Autos	Autos < Drivers	Auto = Drivers	Autos > Drivers
Destination choice logsums for work - full time workers in HH income < 25K	1.5520	1.6760	1.5933	1.4599
Destination choice logsums for work - full time workers in HH income 25K-100K	2.9485	3.5128	3.3340	3.1937
Destination choice logsums for work - full time workers in HH income >100K	5.8765	7.6134	7.2047	7.0633
Destination choice logsums for work - part time workers in HH income < 25K	1.0273	1.1987	1.0957	0.9372
Destination choice logsums for work - part time workers in HH income 25K-100K	1.7210	2.1146	1.9862	1.8485
Destination choice logsums for work - part time workers in HH income >100K	1.7210	5.1387	4.8571	4.6970
Destination choice logsums for school - post secondary students	2.6366	2.7667	2.8823	2.6813
Destination choice logsum for shopping by transit - adult other	0.1304			
Destination choice logsum for shopping by transit - seniors	0.3205			
Destination choice logsum for shopping by auto - adult other		0.3834	0.3400	0.1997
Destination choice logsum for shopping by auto - seniors		0.4571	0.4356	0.2756
Destination choice logsums by transit - household together	0.03535			
Destination choice logsums by walk - household together	0.08147			

Table 2c: High Auto Ownership Disaggregation Probabilities

	5 Autos	6 Autos	7 Autos	8 Autos	9 Autos
HH Income < 50K	83.78%	8.73%	3.76%	3.31%	0.42%
HH Income 50-100K	62.07%	21.78%	12.36%	3.16%	0.63%
HH Income 100K+	66.70%	16.80%	10.13%	5.11%	1.26%

A brief description of the explanatory parameters included in the model is given below.

- 0, 1, 2, 3, 4, 5+ drivers in Household: drivers equal to number of autos are set as base reference. The more drivers in the household, the higher the probabilities to own more autos.(In the model application the option to choose 4+ autos for 0-driver households is not available; nor is the option to choose 0 autos for 4+ driver households).
- 8 groups of household income: household income 50K-75K was set as a base reference across all alternatives. Income plays a very important role in the household auto ownership.
- The proportion of each driver person type (post secondary students, full time workers, part time workers, adult other, seniors) in household drivers.
- Proportion of each driver occupation (blue collar workers, office workers) in household drivers. Blue collar workers are more likely to own autos.
- Housing type: single family was set as the base reference across all alternatives. Housing type with multifamily, attached and mobile home is related to lower levels of auto ownership – parking availability may be a factor for these housing types.
- Presence of children: young children (5 years old and younger) decrease the utility of choosing no autos or only one auto, but they also decrease the utility of higher numbers of autos, perhaps reflecting budgetary constraints. If the household has any children under driving age, the utility of the no auto alternative is reduced; this is additive with the 0-5 year old parameter.

The influence of accessibility, which is derived from the mode choice logsums and destination choice logsums, are included in the model. Accessibility measures have a significant impact on the level of auto ownership, and are of great interest in the context of public transport and building environment issues.

Auto sufficiency reflects the realistic household need in autos relative to the number of drivers. Four levels are defined: no autos, autos less than drivers, autos equal to drivers, autos greater than drivers.

- Full time and part time workers: These drivers use logsums derived from the simplified mode choice models used in the Work Location Choice model, described later in this document. Total employment is used for the size term, and the size term and mode choice logsum parameters are set at 1 for calculating this logsum and there are no additional distance function or regional interchange parameters. There are three auto ownership specific logsums (autos equal to and greater than the number of drivers use the same logsum), which are further stratified by three groups of annual household income (0-25K, 25K-100K and 100K+), with the appropriate one used for each household. Full time workers and higher income workers tend to be more sensitive to transportation conditions.
- Post secondary students: These drivers use the logsum derived from the School Location Choice Model, described later in this document. This logsum uses the simplified mode choice logsums by auto ownership level, with size and logsum parameters set at 1 and no distance function.
- Seniors/Adult Others: These drivers use logsums developed for the Other Tour Mode Choice model, described in part B of this document. The logsums calculated for a Shop tour with midday outbound and return legs are used. For the no auto alternative, the walk and walk access transit logsums are used; for the other alternatives, the SOV logsum is used.

These logsums are multiplied by the parameters described in Table 2b, and scaled by the proportion of drivers in each person type out of the total household drivers. This reflects the total makeup of the household. All transit logsums have a floor of -5.0, which is worse than the worst transit logsum seen in an area with service in the base year.

In addition to these logsums, two additional "household level" logsums are used; one for walk access transit and one for walk. These are calculated using the average of the Other Tour Mode Choice model logsums for a Personal Business tour with AM Peak outbound and Midday return and for a Recreation tour with PM Peak outbound and Late Offpeak return. These two tours, which are quite common in the day patterns, were chosen to represent both a broad spectrum of non-work, non-school activities and a broad range of time periods for travel. These logsums are used to indicate the additional commitment needed to go without autos entirely; a household with insufficient autos can negotiate over who does not drive to work, but still do the other errands necessary by driving. A household with no autos is dependent on walking and transit to deal with all of their needs.

3.3 Person Work Location Model

The long term destination choice model determines the primary work locations for workers. The general form of the model is a choice-based logit formulation, where each TAZ within 100 miles of the home TAZ is a potential destination for the workplace location.

The utilities for choosing a destination TAZ j, from a home zone i, are of the form:

Utility choosing zone j = a * ln(size zone j) + b * travel logsum + distance function i-j + intrazonal parameter (if i=j) + OD regional interchange constant i-j

The model uses employment by occupation type as a size term attractor – the occupation of each Worker is known from the synthetic population PUMS data. The nine occupation categories described as part of the Socioeconomic Input Data are all considered individually. For instance, workers in Health occupations only consider locations of Health employment as possible destinations; a shopping mall or office tower built next door to the worker's residence will have no effect on these workers (assuming no Health occupation employment), whereas a hospital opening 50 miles away will have a (small) effect. The occupation categories are listed in Table 3 below.

Table 3: Employment Occupation Categories Used in Work Location Model

Employment Occupations in CSTDM09
Management and Business
Clerical and Administration
Education
Health
Professional and Technical
Sales, Food and Entertainment
Non-Sales Service
Blue Collar
Military

These occupation categories are consistent with those used in the California PECAS model.

For the home TAZ travel accessibility logsums a modeling approach similar to the SACSIM (Sacramento Area) Activity-based Travel Forecasting Model is used.

A “simplified mode choice logsum” is fed up from the tour mode choice, rather than the “full main tour mode choice” logit model logsums. This simplified approach avoids having to estimate and retain hundreds of potential tour start / end time period and household / person type combinations.

For long term work location, the model uses the work simplified tour mode choice logsum, described in the subsequent section. This logsum uses travel times and costs for the outbound tour in the AM period and return tour in the PM period. For each worker, the appropriate tour mode logsum is used. There are nine possible tour mode logsums, representing the possible combinations of three classes of auto ownership (sufficient, i.e. at least one auto per driver; insufficient, i.e. fewer cars than drivers; and none, i.e. no autos or no driver's license) and three classes of income (low, <$25K; medium, $25-100K; and high, $100K+).

The models were estimated by setting initial values for the size term parameter and logsum parameter to 1.0, and comparing the resulting modeled trip length distribution to observed trip length distributions from the survey dataset. The size term and travel logsum parameter was then adjusted, to improve the model performance. Additional distance-based parameters were added to further improve the model performance. This model estimation was used for its relative simplicity. Because the simplified tour mode choice models produce different logsums by auto ownership level and by income, it was found during calibration that separate parameters for all nine combinations of auto ownership and income significantly improved model fit.

The distance based parameters describe a quadratic function with respect to distance; to avoid the potential for an increase in utility with additional distance from home, this quadratic was transitioned into a linear cost tangent to the slope of this curve at a certain distance (which is also considered a parameter). An additional increase or decrease in slope is applied after a second distance; this is also measured from the home and can be closer or farther than the transition distance described above. The shapes of these curves are shown in Figure 5 below. The distance used is the freeflow HOV3 one way (home to work) network distance, in miles.

An additional set of calibration parameters are a series of intrazonal travel constants; these are additional utilities added to the same zone as the home location. These intrazonal parameters add additional utility for working at home in some cases, and also reflect the zone structure, particularly in low density areas. In these low density areas, a zone may cover a large area, and thus have a large intrazonal travel distance assumed, since the intrazonal distance is calculated based on the zone area. However, often these zones contain one or more small towns, with a large area of mountains, desert or other very low intensity land uses. For people who live in these zones, the vast majority of intrazonal travel may be within the small town, rather than to random points in the mountains; thus, the calculated intrazonal distance overstates the travel cost significantly. The intrazonal constants are thus divided by density (population plus employment divided by the area in square miles) to reflect this issue.

Tables 4a and 4b give final model parameters for the Work Location models:

Table 4a: Work Location Model Parameters

Auto own / income	Logsum	Size term	Distance linear	Distance squared (param* 1000)	Transition distance	Transition slope	Additional distance	Additional slope
Suff. / low	0.7971	0.3351	-0.1709	2.244	34.74	-0.0150	63.47	-0.0067
Suff. / med	0.9504	0.5261	-0.1095	1.933	23.83	-0.0174	65.44	-0.011
Suff. / high	0.9199	0.7059	-0.0017	0.200	19.77	-0.0038	50.35	0.0015
Insuf / low	0.8931	0.5229	-0.1547	0.362	152.02	-0.0448	20.28	0.0065
Insuf / med	0.8906	0.4935	-0.1185	0.924	47.59	-0.0306	5.84	0.0079
Insuf / high	1.0000	0.7565	-0.0330	0.771	17.88	-0.0054	25.10	-0.0093
None / low	0.8046	0.8171	-0.0246	0.552	17.37	-0.0055	1.08	-0.1411
None / med	0.8672	0.9812	-0.1154	0.134	360.06	-0.0189	19.69	0.0031
None / high	0.3175	0.8220	-0.0949	0.105	317.08	-0.0285	2.04	0.0029

Table 4b: Work Location Model Intrazonal Parameters

Density (per+emp / sq. mi)	Parameter
0-25	1.0257
25-100	0.5092
100-200	1.0568
200-500	0.2732
500-1000	0.1477
1000-2500	-0.0398
2500-5000	0.7628
5000-10000	0.2875
10000-25000	1.058
25000-50000	1.5864
50000+	1.9376

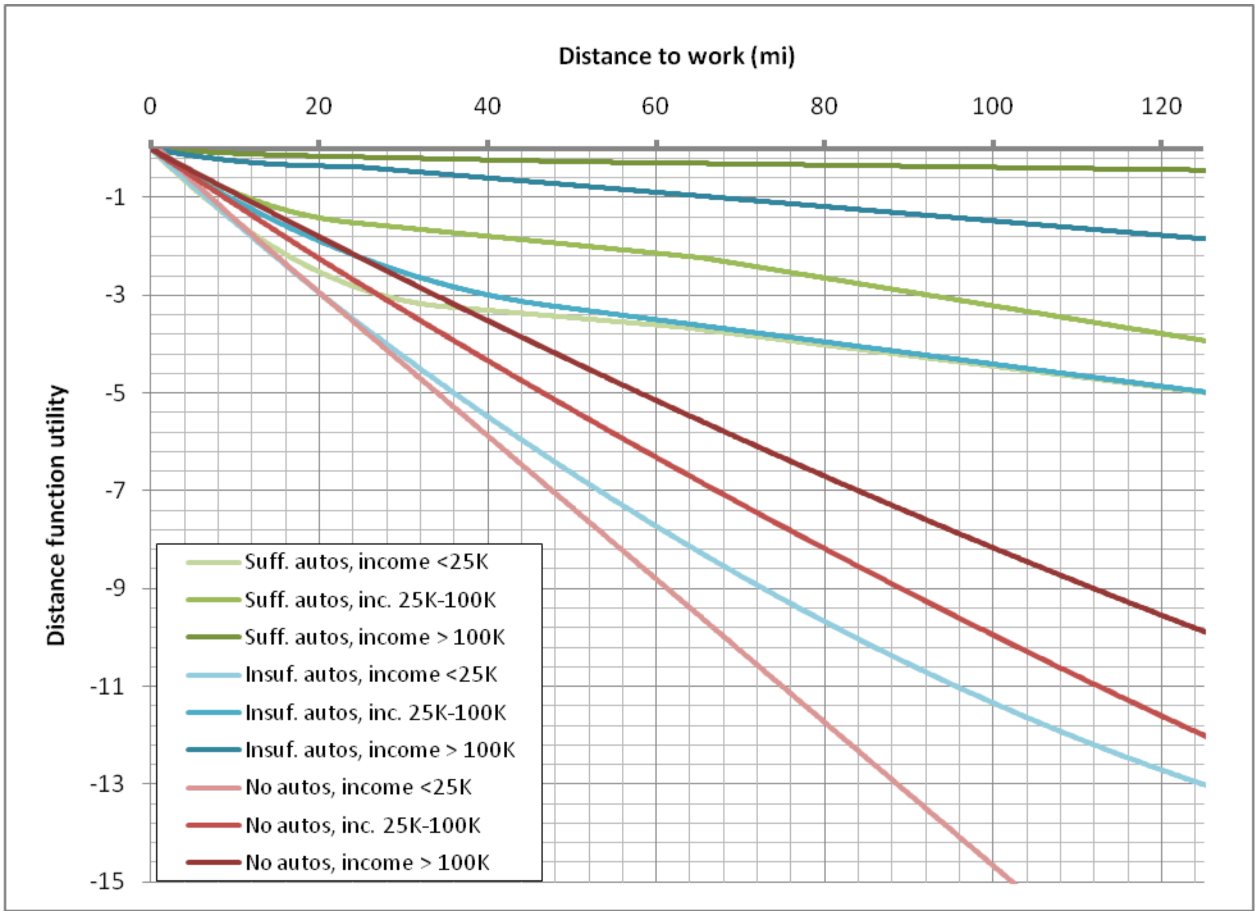

Figure 5: Work Location Model Distance Functions

Note: In the full application of the short distance personal travel model, if a person makes a work tour without having an occupation (which is quite rare), they use total employment as the size term.

During the calibration and validation phases of model development, a need arose for additional regional interchange parameters affecting interregional commutes. There are a number of situations where workers live in one area and work in another, often in response to housing prices or quality of life issues. A substantial net flow of workers travels from San Joaquin County to Alameda and Santa Clara counties, for instance. This is primarily due to the relatively low wages and cost of housing in San Joaquin relative to the higher wage / higher housing cost in the Bay area. Workers are living in low cost San Joaquin and enduring long commutes to work in high wage Santa Clara and Alameda. Without regional coefficients, it is very difficult to represent these trends in a travel demand model. An integrated land use/transport model system such as PECAS will hopefully obviate the need for these coefficients. To avoid over-fitting, coefficients were only developed where two-way flows were in excess of 5000 workers. The data used to develop targets was ultimately the 2006-2008 ACS home to work flow information, aggregated by the 22 districts used for model validation. These parameters are shown in Tables 5a to 5c; each row represents the home zone and each column represents the work location, so a Contra Costa resident has an additional 0.9266 added to the utility for working in zones in San Francisco, while a San Francisco resident has -0.5987 utility, a reduction, for working in Contra Costa. (Note that the Merced / San Joaquin / Stanislaus district appears in both 5a and 5b.)

Table 5a: Work Location Model Regional Interchange Parameters; North

Parameter	Far North	SACOG	MTC - Solano	MTC - Marin / Sonoma / Napa	MTC - San Francisco	MTC - San Mateo	MTC - Contra Costa	MTC - Alameda	MTC - Santa Clara	AMBAG
Far North	-0.0175	-0.4009	0	0.2579	0	0	0	0	0	0
SACOG	0.4735	-0.0581	0.3206	0	0	0	0.9965	2.6557	0	0
MTC - Solano	0	-0.8240	-0.1210	0.6823	1.6786	0	-0.1657	0.5534	0	0
MTC - Marin / Sonoma / Napa	1.2220	0	-1.9053	0.0116	0.3471	0.1496	-1.4255	-0.5321	0	0
MTC - San Francisco	0	0	-0.2082	-0.0676	-0.0055	0.0158	-0.5987	-0.4695	1.1068	0
MTC - San Mateo	0	0	0	-0.2498	0.0726	0.1536	-0.7074	-0.9030	-0.2900	0
MTC - Contra Costa	0	0.2293	-1.1806	0.1224	0.9622	1.1914	-0.1123	-0.0443	0.3764	0
MTC - Alameda	0	1.7750	-0.5862	0.1406	0.7238	0.3322	-0.4368	-0.0689	-0.0692	0
MTC - Santa Clara	0	0	0	0	0.4224	0.1356	-0.0124	-0.2616	-0.0025	-0.8925
SJV - Merced / San Joaquin / Stanislaus	0	-0.4929	0	0	0	0	0.7911	2.2634	3.0820	0

Table 5b: Work Location Model Regional Interchange Parameters; Central

Parameter	MTC - Santa Clara	Merced / San Joaquin / Stanislaus	Fresno / Madera	Kern / Kings / Tulare	Western Sierra Nevada	AMBAG	Central Coast	SCAG - Ventura	SCAG - Los Angeles
Merced / San Joaquin / Stanislaus	See 5a	-0.2237	-0.3581	0	0.9575	0	0	0	0
Fresno / Madera	0	0.1877	-0.0241	-0.1012	0	0	0	0	0
Kern / Kings / Tulare	0	0	-0.7157	-0.0228	0	0	0	0	0.3041
Western Sierra Nevada	0	-0.5703	0	0	0.1724	0	0	0	0
AMBAG	0.1969	0	0	0	0	-0.0487	0	0	0
Central Coast	0	0	0	0	0	0	-0.0261	-1.2689	1.0959

Table 5c: Work Location Model Regional Interchange Parameters; South

Parameter	Kern / Kings / Tulare	Central Coast	SCAG - Ventura	SCAG - Los Angeles	SCAG - San Bernardino	SCAG - Riverside	SCAG - Imperial	SCAG - Orange	SANDAG
SCAG - Ventura	0	0.8464	0.0551	-0.4009	0	0	0	0	0
SCAG - Los Angeles	1.2541	1.7523	-0.0522	0.0105	-0.2802	-0.1317	0	-0.2478	2.5226
SCAG - San Bernardino	0	0	0	0.2453	-0.0211	-0.3886	0	0.6634	0
SCAG - Riverside	0	0	0	0.4327	-0.4027	-0.0606	0	1.0692	0.5749
SCAG - Imperial	0	0	0	0	0	0	-0.1315	0	0
SCAG - Orange	0	0	0	-0.5675	-0.6254	-0.3014	0	0.1144	0.6029
SANDAG	0	0	0	1.9895	0	-0.3288	0	1.3298	-0.0275

3.3.1 Simplified Tour Mode Choice Model: Work

The simplified mode choice model is not actually used for choosing a mode. Rather, it provides logsums that are used in the Long Term Decision module to select work location (and thus to choose the primary destination of a Work tour). This model is intended to impart some of the complexity and availability of multiple modes that can determine a tour's destination; a location that is costly or time-consuming to drive to is unappealing, but if high quality transit is available, it may still be attractive. Similarly, very close destinations are more appealing because walking becomes an option.

A simplified mode choice model is used for practical consideration, to avoid having to estimate and retain hundreds of potential tour start / end time period and household / person type combinations.

The simplified mode choice model is a nested logit model. The upper level has four alternatives: non-motorized, which is a nest of walk and bicycle; transit, which is a nest of walk access transit and drive access transit; HOV, which is a nest of 2 person and 3 person HOV, and a dummy SOV node that has SOV as the single alternative at the lower level. (The dummy node is needed to ensure consistent estimates of parameters at the lower level in ALOGIT.)

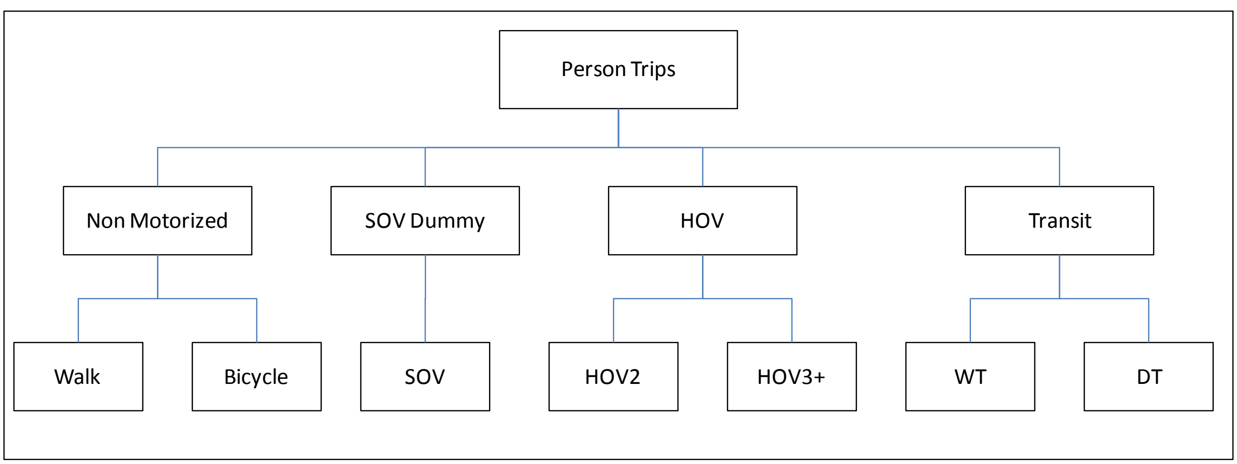

Figure 6: Simplified Tour Mode Choice Model nesting structure: Work

The simplified mode choice model for Work uses travel times and costs for the outbound tour in the AM period and return tour in the PM period. Model parameters sensitive to household auto ownership status are included. Table 6 gives the parameters in the simplified Tour Mode Choice Model for Work:

Table 6: Simplified Tour Mode Choice Model: Work

Parameter	Parameter Value
Level of Service	
Cost (Operation fee, parking, toll, fare) ($)	-0.09311
Auto In-vehicle time, HH income < 25K (min)	-0.02336
Auto In-vehicle time, HH income 25K -100K (min)	-0.02435
Auto In-vehicle time, HH income >= 100K (min)	-0.04135
Transit In-vehicle time, HH income <100K (min)	-0.00839
Transit In-vehicle time, HH income >=100K (min)	-0.01406
Walk time less than 20 minutes (min)	-0.05666
Walk time between 20 minutes and 70 minutes (min)	-0.04805
Walk time more than 70 minutes (min)	-0.03296
SOV	
Autos in HH > 0 but < drivers	-1.20248
HOV2	
Constant	-3.57265
No Autos in HH	5.33594
Autos in HH > 0 but < drivers	0.48118
HOV3+	
Constant	-5.28886
No Autos in HH	6.20900
Autos in HH > 0 but < drivers	0.70035
Walk Access Transit	
Constant	-4.64145
No Autos in HH	7.06378
Autos in HH > 0 but < drivers	0.96431
SQRT of destination population and employment density	0.00412
Drive Access Transit	
Constant	-4.09388
No Autos in HH	4.58726
Autos in HH > 0 but < drivers	-0.44067
Walk	
Constant	-0.59442
No Autos in HH	6.05018

Bicycle	
Constant	-3.91336
No Autos in HH	6.05018
Nesting Parameters	
All Modes	0.89598

3.4 Person School Location Models

The long term destination choice models determine the primary school locations for grade school students and post-secondary education students. The general form of the model is a choice-based logit formulation, where each TAZ within 100 miles of the home TAZ is a potential destination for the school place location.

The utilities for choosing a destination TAZ j, from a home zone I, are of the form:

Utility choosing zone j = a * ln(size zone j) + b * travel logsum + distance function

For long term school location, the model considers the level of schooling of the student (grades K-8, grades 9-12 and postsecondary education) for the size term; a grade 10 student will only consider zones with grade 9-12 enrollment as possible school locations.

The model also incorporates simplified school tour mode choice logsums, using travel times and costs for the outbound tour in the AM period and return tour in the PM period. For each school student type, the appropriate mode choice logsum considering student grade and household auto ownership is used.

The models were estimated by setting initial values for the size term parameter and logsum parameter to 1.0, and comparing the resulting modeled trip length distribution to observed trip length distributions from the travel survey data. The travel logsum parameter was then adjusted, to improve the model performance. Additional distance-based parameters were added during calibration to improve further the model performance. The distance function form is the same as described in the Work Location

Model section above. Intrazonal constants by grade level were also applied, as described in the Work Location Model section. The parameters are described in Table 7a and 7b, with the distance function curves shown in Figure 7 below.

Table 7a: School Location Model Parameters

Grade	Logsum	Size term	Distance linear	Distance squared (param* 1000)	Transition distance	Transition slope	Additional distance	Additional slope
K-8	0.9528	0.8709	-1.3004	78.642	6.82	-0.2276	40.85	0.1855
9-12	0.1359	0.6171	-0.7920	26.40	14.25	-0.0394	11.67	-0.1312
PSE	0.1554	0.9969	-0.2421	0.093	1000	-0.2421	14.34	0.1365

Table 7b: Work Location Model Intrazonal Parameters

Density (per+emp / sq. mi)	K-8	9-12	PSE
0-25	2.2957	-0.3134	5.0000
25-100	1.4848	0.7556	-0.1136
100-200	0.3184	-1.8695	5.0000
200-500	-0.0927	0.1183	-0.6430
500-1000	0.484	-0.8893	-2.0914
1000-2500	-0.2753	-1.0746	-0.3991
2500-5000	-0.2068	0.5226	4.1058
5000-10000	0.0084	-0.3365	-0.6474
10000-25000	0.5886	1.3330	2.9980
25000-50000	0.8303	5.0000	5.0000
50000+	-1.2603	5.0000	3.0391

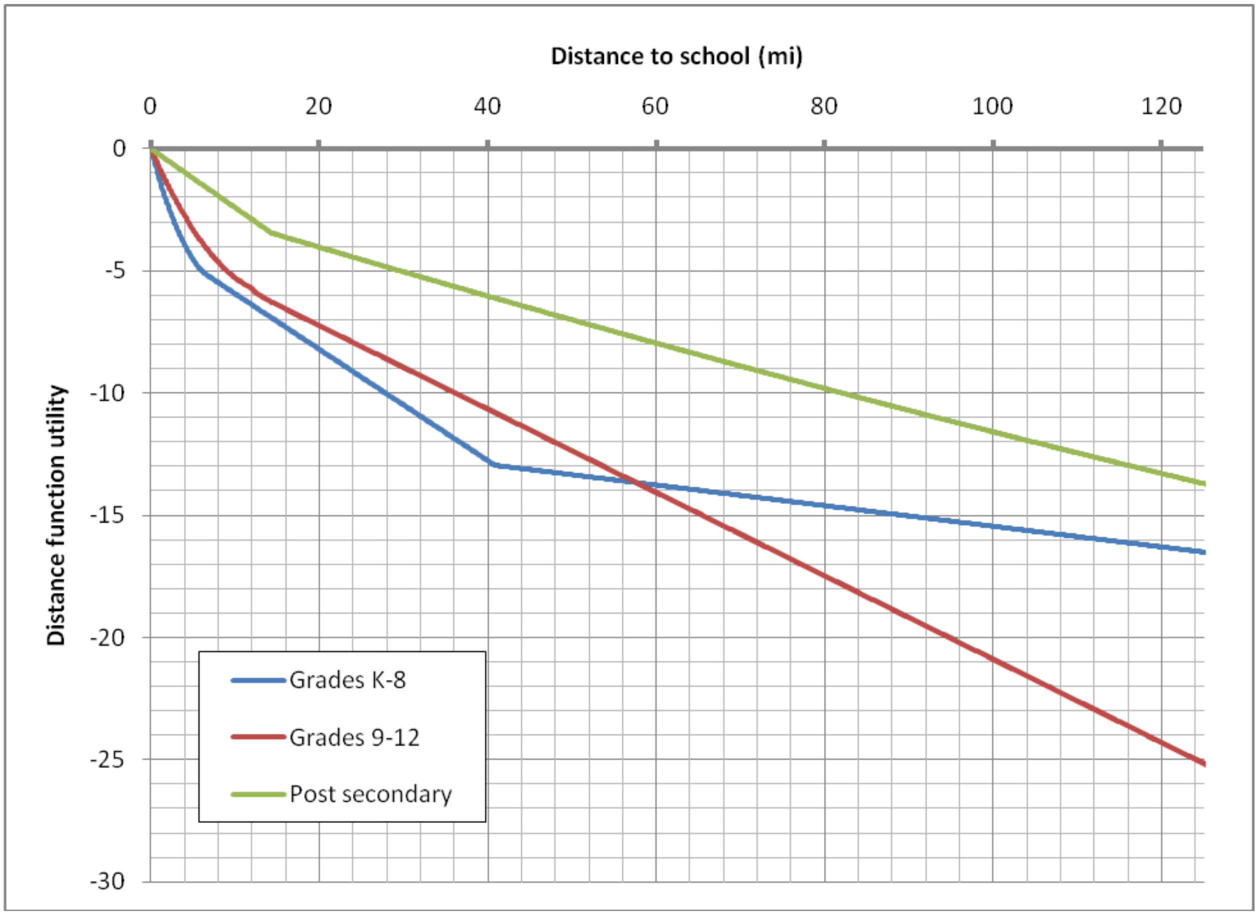

Figure 7: School Location Model Distance Functions

Note: In the full application of the short distance personal travel model, if a person who does not have a school status makes a school visit, they are assigned a school location at the time of the tour. This often occurs with work training, or with adults taking evening classes, including those for recreation purposes, such as a cooking class. Persons less than 18 are assigned to the appropriate grade school class. Persons 18 and over are assigned to the post-secondary education class.

3.4.1 Simplified School Tour Mode Choice Models

Two School Tour mode models are estimated – one for post-secondary education students, and one for Grade School students. They use travel times and costs for the outbound tour in the AM period and return tour in the PM period. Model parameters sensitive to household auto ownership status are included; postsecondary students have three possible auto ownership levels (sufficient, insufficient, none).

For grade school students, the three auto ownership levels are combined with four possible student age/status groups: K-8 (kindergarten to grade 8) student under 10; K-8 student 10+ years old; high school student without driver's license and high school student with driver's license (in households with one or more auto). The SOV mode is only available for this last group. The school bus mode is available for K-8 students; these are the only places school bus is available in the simplified tour mode choice models. School bus uses HOV3 travel times and 0 cost.

The nesting structures for these models are shown in Figures 8a and 8b, with the parameters provided in Tables 9a and 9b.

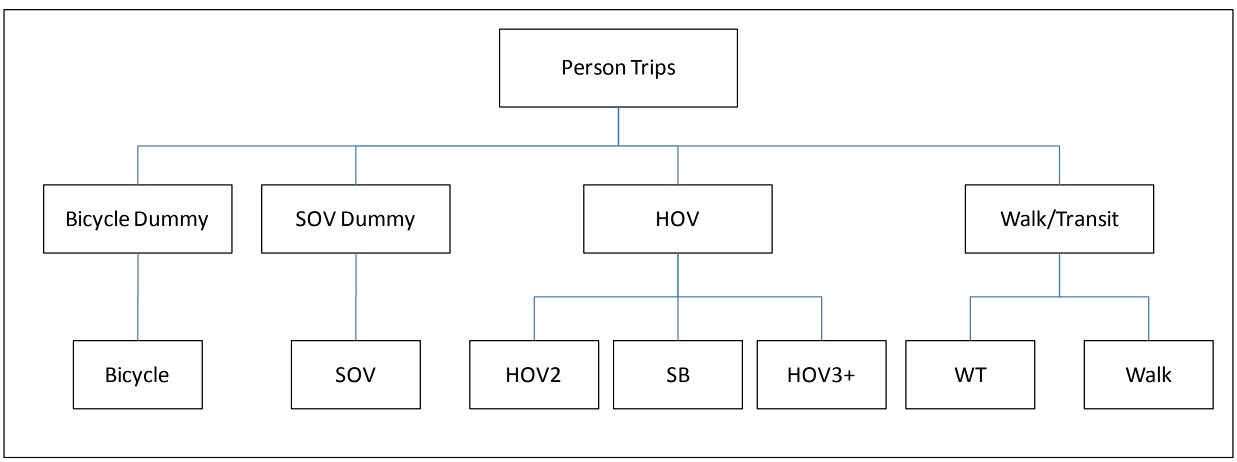

Figure 8a: Simplified Tour Mode Choice Model nesting structure: Grade school

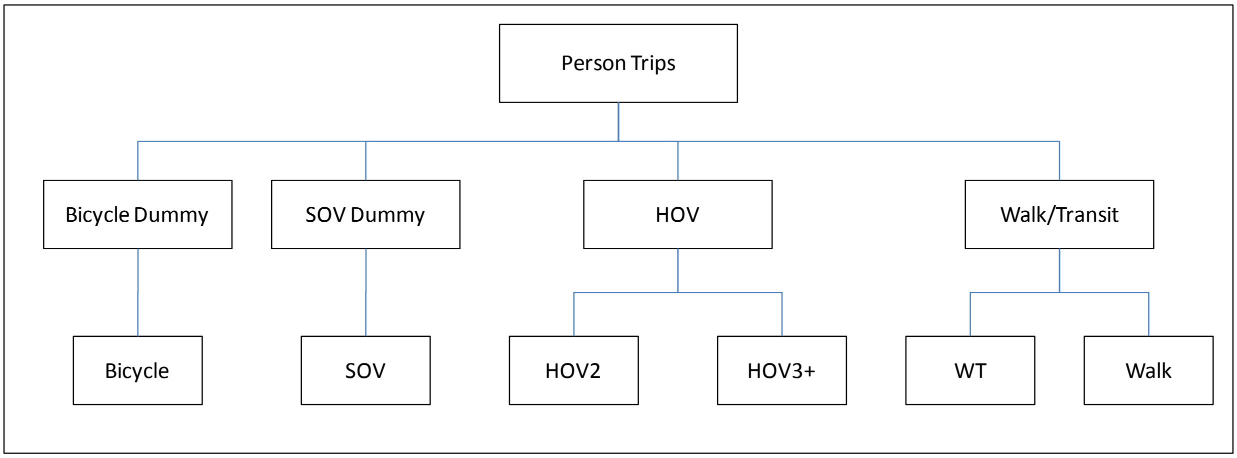

Figure 8b: Simplified Tour Mode Choice Model nesting structure: PSE

Table 8a: Simplified Tour Mode Choice Model: Grade School

Parameter	Parameter Value
Level of Service	
Cost (Operation fee, parking, toll, fare) ($)*	-0.0.04418
Auto In-vehicle time (min)	-0.0044418
Transit In-vehicle time (min)	-0.004244
Walk / Bike time (min)	-0.002606
SOV	
Constant - Age >15 with driving license	4.4811
Autos in HH > 0 but < drivers	-2.6867
HOV2	
Constant - Age 0-9	1.6848
Constant - Age 10-14	1.0911
Constant - Age >15 with driving license	2.7877
Constant - Age >15 without driving license	0.9438
No Autos in HH	2.1897
Autos in HH > 0 but < drivers	-0.4833
HOV3+	
Constant - Age 0-9	1.8882
Constant - Age 10-14	1.2983
Constant - Age >15 with driving license	2.0540
Constant - Age >15 without driving license	0.5953
No Autos in HH	3.1580
Autos in HH > 0 but < drivers	-0.4706
School Bus	

Constant - Age 0-9	0.4250
Constant - Age 10-14	0.3843
No Autos in HH	5.2036
Autos in HH > 0 but < drivers	-0.4061
Walk Access Transit	
Constant - Age 0-9	-2.4252
Constant - Age 10-14	-1.2839
Constant - Age >15 with driving license	-0.2237
Constant - Age >15 without driving license	-0.1386
No Autos in HH	7.5180
Walk	
No Autos in HH	6.5435
Autos in HH > 0 but < drivers	0.8003
Bicycle	
Constant - Age 0-9	-4.4767
Constant - Age 10-14	-2.7525
Constant - Age >15 with driving license	-3.1014
Constant - Age >15 without driving license	-3.2478
No Autos in HH	6.5435
Autos in HH > 0 but < drivers	0.8003
Nesting Parameters	
All Modes	0.7358

* Value of time for grade students was set to $6/hour.

Table 8b: Simplified Tour Mode Choice Model: Post-Secondary Education

Parameter	Parameter Value
Level of Service	
Cost (Operation fee, parking, toll, fare) ($)	-0.2000
Auto In-vehicle time (min)	-0.01603
Transit In-vehicle time (min)	-0.006174
Walk time less than 20 minutes (min)	-0.09048
Walk time between 20 minutes and 70 minutes (min)	-0.07132
Walk time more than 70 minutes (min)	-0.00452
Bike time less than 70 minutes (min)	-0.05421
Bike time more than 70 minutes (min)	-0.02974
SOV	

HOV2	
Constant	-3.6491
No Autos in HH	5.8560
Autos in HH > 0 but < drivers	2.0179
HOV3+	
Constant	-5.0851
No Autos in HH	5.9755
Autos in HH > 0 but < drivers	2.2618
Walk Access Transit	
Constant	-3.4596
No Autos in HH	7.5826
Autos in HH > 0 but < drivers	2.4735
Walk	
Constant	0.5205
No Autos in HH	6.3955
Autos in HH > 0 but < drivers	2.4473
Bicycle	
Constant	-4.1714
No Autos in HH	6.3955
Autos in HH > 0 but < drivers	2.4473
Nesting Parameters	
All Modes	0.6896

4. Calibration of Long Term Decision Models

4.1 Person Driving License Model

The model was calibrated against driver's license data from U.S. Department of Transportation, Federal Highway Administration, Highway Statistics 2000, Washington, DC: 2001. This data detailed the licensed driver totals for California by 15 age groups; five year brackets to 85+. The 16-19 group was further split by year using data taken from the California Department of Motor Vehicles; report RSS-03-194 (http://www.dmv.ca.gov/about/profile/rd/r_d_report/Section%206/194TeenandSeniorReport.pdf). Figure 9 shows the fit of licensed drivers by age group. The model matches the observed data very well.

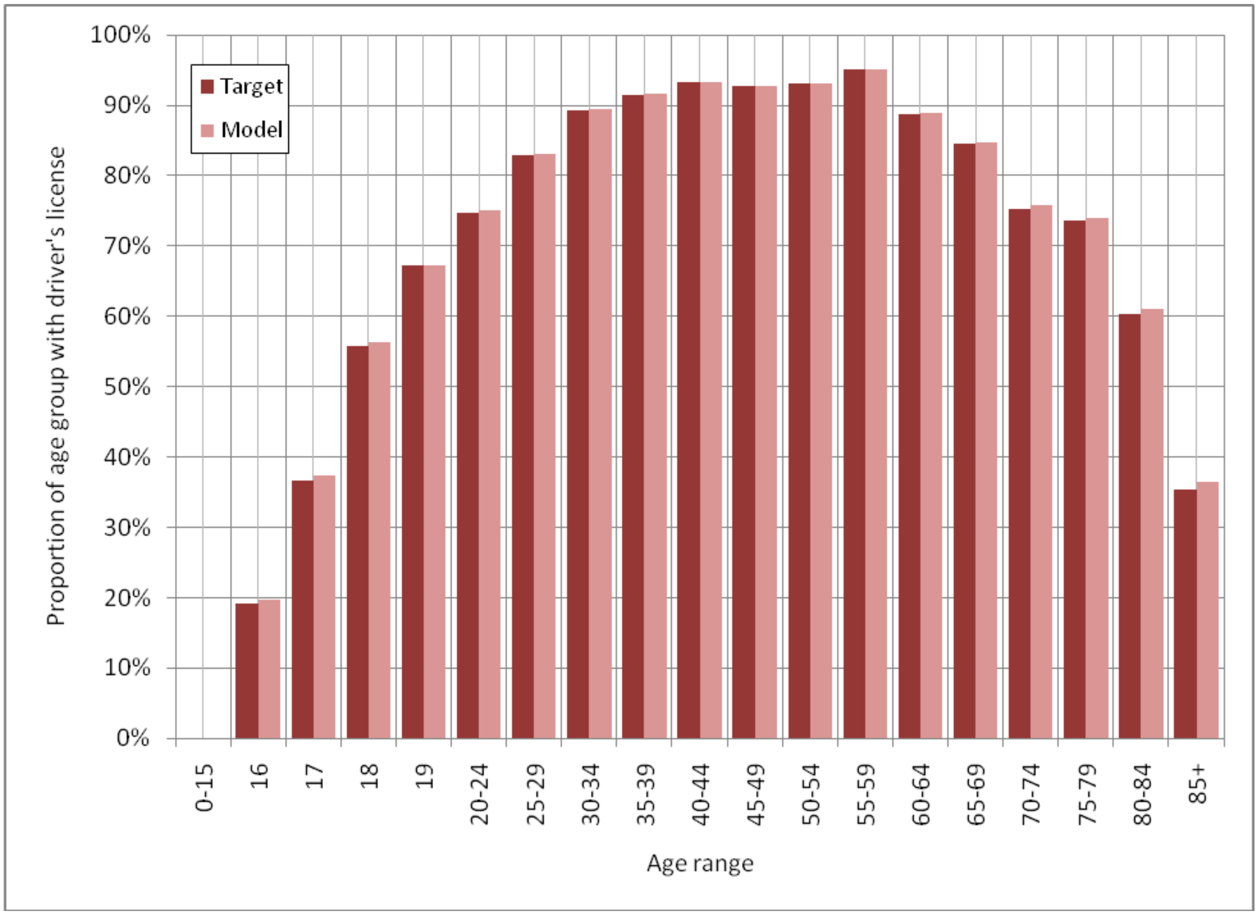

Figure 9: Driver's License Model Calibration Status by Age

Further calibration data was taken from the California Highway Patrol Statewide Integrated Traffic Records System (SWITRS), which provides licensed drivers by county. These parameters are summarized in Tables 1b and 1c. Figure 10 shows the proportion of adults who are licensed drivers by the 22 calibration districts; the model is an excellent match to the observed data.

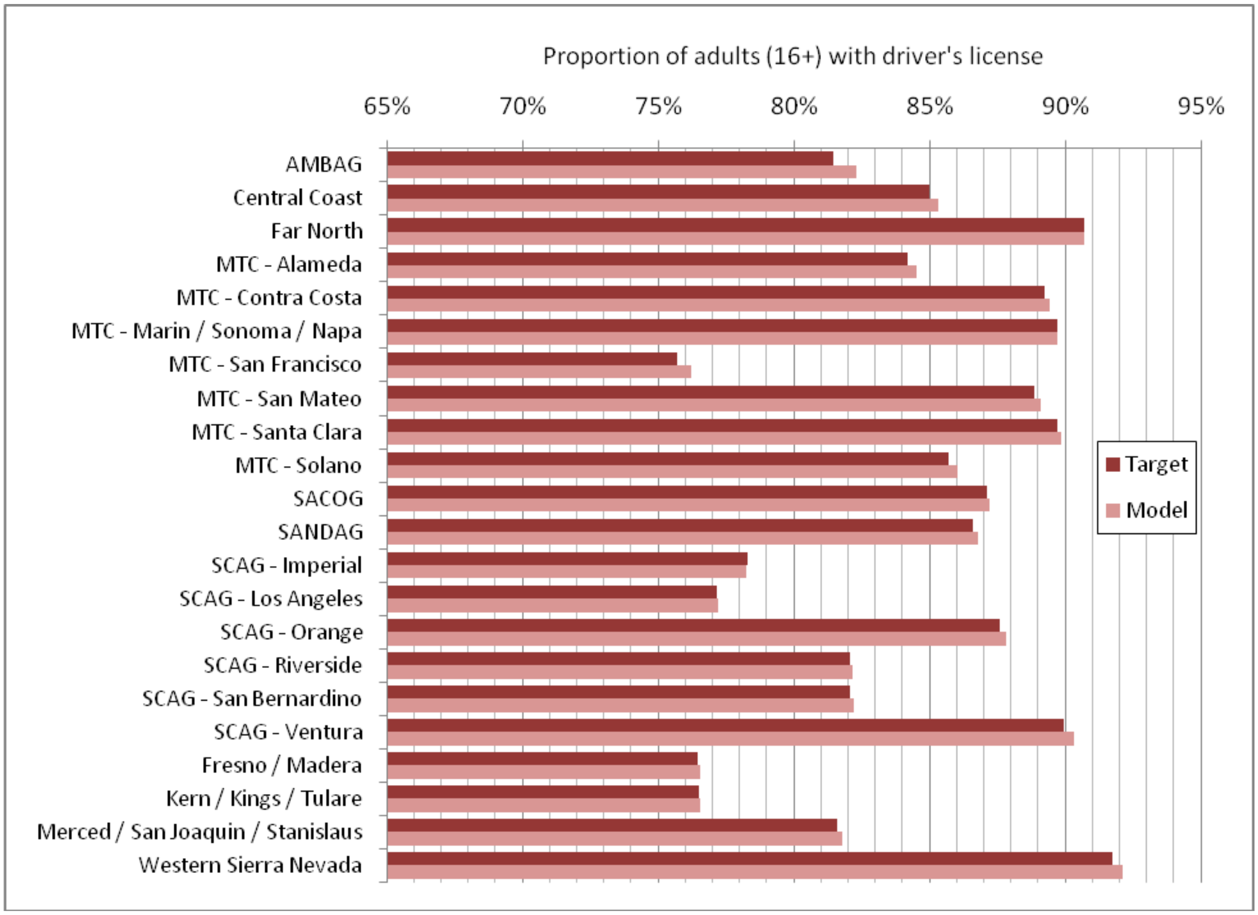

Figure 10: Driver's License Model Calibration Status by District

4.2 Household Auto Ownership Model

The model was calibrated in two phases. In the first phase, the estimated parameters for auto ownership by the number of drivers were adjusted to match survey data; the parameters reported in Table 2a are the calibrated parameters.

In the second phase, the model was calibrated to data from the Census Transportation Planning Package (CTPP) data for California, which provides a cross tabulation of auto ownership in California by the number of adults 16 and older (1, 2, 3, or 4+) and the number of autos (0, 1, 2, 3 and 4+). These values were quite different from the numbers of autos per driver seen in the survey data, particularly for the number of 3+ adult households with no autos. These calibration coefficients are also reported in Table 2a.

The model fit with the observed data is shown in Figure 11 below; the fit is excellent for 1 and 2 adult households (the large majority); for 3 and especially 4+ adult households, the no auto alternative fit is less than perfect. This is because the CTPP data indicates 6-7% of these large households have no autos (and that a slightly larger proportion of 4+ adult households are auto free than 3+); whereas the survey data had virtually no observations of this occurring.

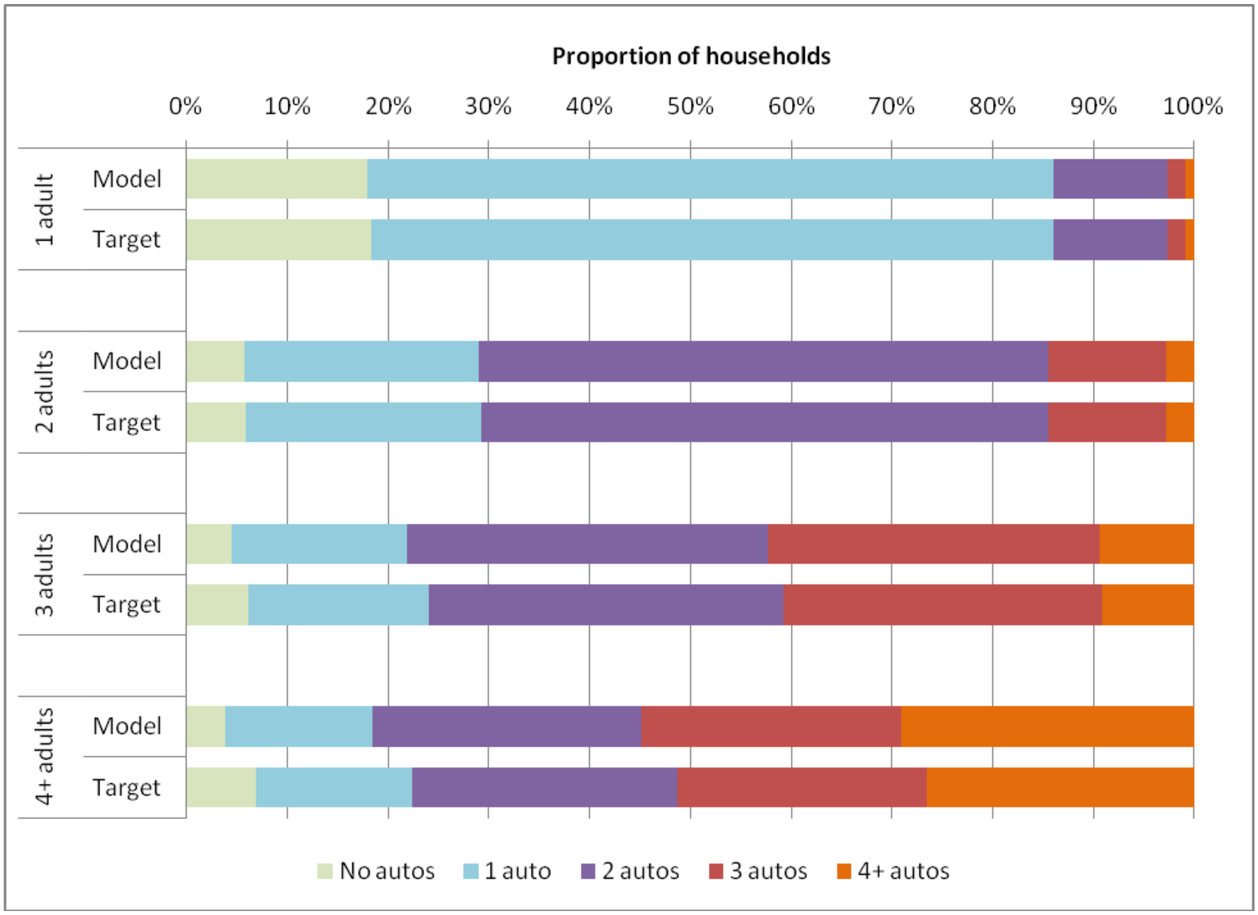

Figure 11: Auto Ownership Calibration by Number of Adults (16+)

4.3 Person Work Location Model

The work location model was calibrated in two stages. The first stage was by adjusting the parameters of the main location model; these are the size term and mode choice logsum parameters as well as the parameters of the distance function. This was done to match trip length distributions derived from the survey data by income level and auto ownership status. Intrazonal constants were also added by density level to match observed distributions of work locations in the home zone. These updated values are shown in Table 4a and 4b. The second stage was to apply the regional interchange parameters to the model to improve the match to Census ACS data. These parameters are shown in Tables 5a to 5c.

The first stage calibration status of the Work Location Model is shown in Figures 12a-12c and 13. Figures 12a-12c show the trip length distribution by income for the three auto ownership levels; Figure 13 shows the intrazonal proportion by zonal density. The trip length distribution is calculated using 23 'bands' of distances, from 0-0.5 mi up to 90+ mi. These distances are in freeflow network miles from home to work. The trip proportion rate used for the y axis in Figures 12a-12c is the proportion of trips that would be at a certain distance from home, normalized to consistent 1 mile bands to avoid the discontinuities where bands change size. In general, the calibration matches the observed data well. The most problematic fits are in two areas. The first is no auto medium/high income, which is a very small sample (the two were combined for a target) and correspondingly small population. The second is insufficient auto ownership, where there is both a steep peak of short distance travel and a "fatter tail" for long distance travel; this may be characteristic of these households typically having one person who drives every day and one who doesn't drive, so the curve contains some of the more extreme elements of both the sufficient and no auto curves. In the SDPTM at present, because there is no explicit selection of the driver, the curve lies somewhere between the two extremes.

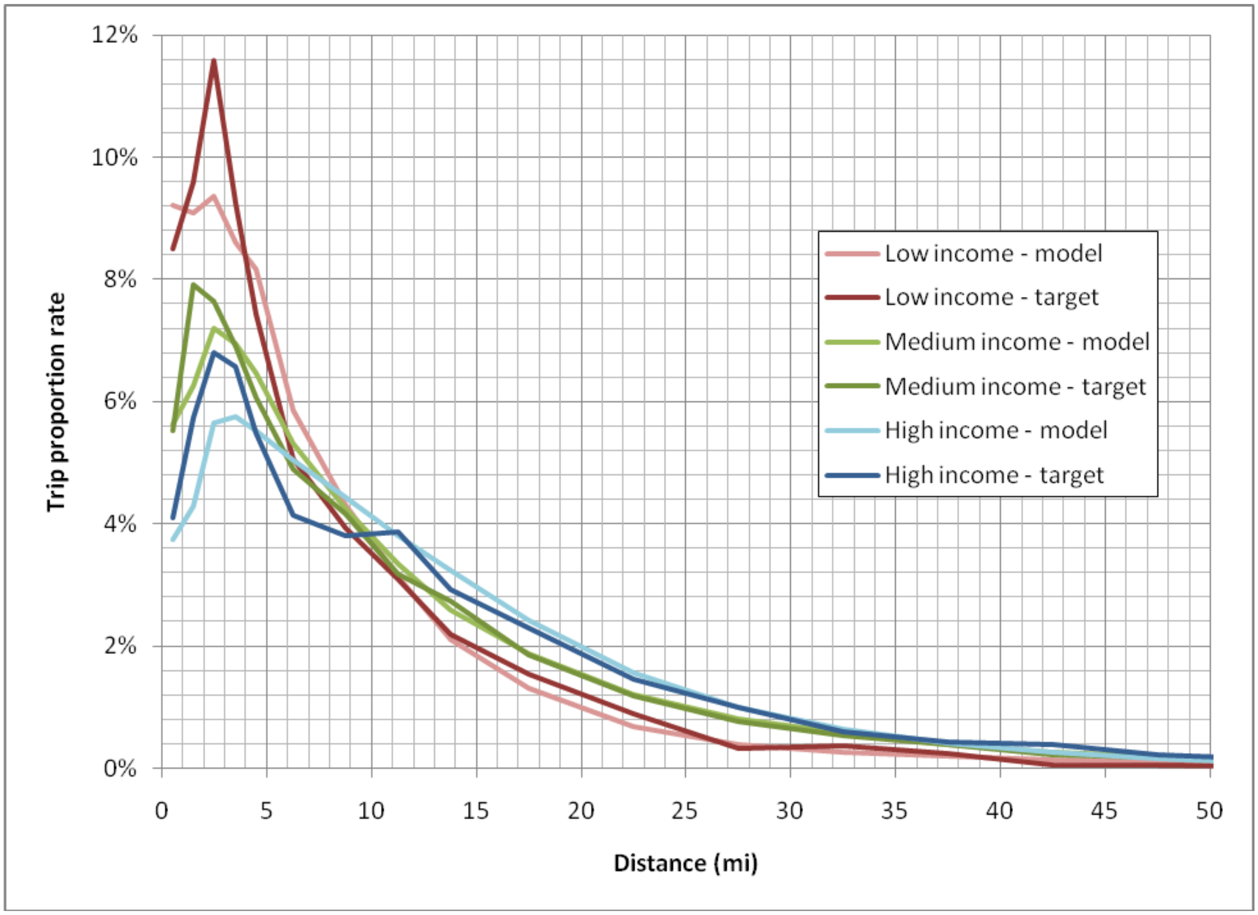

Figure 12a: Work Location Model Calibration - Trip Length (sufficient autos)

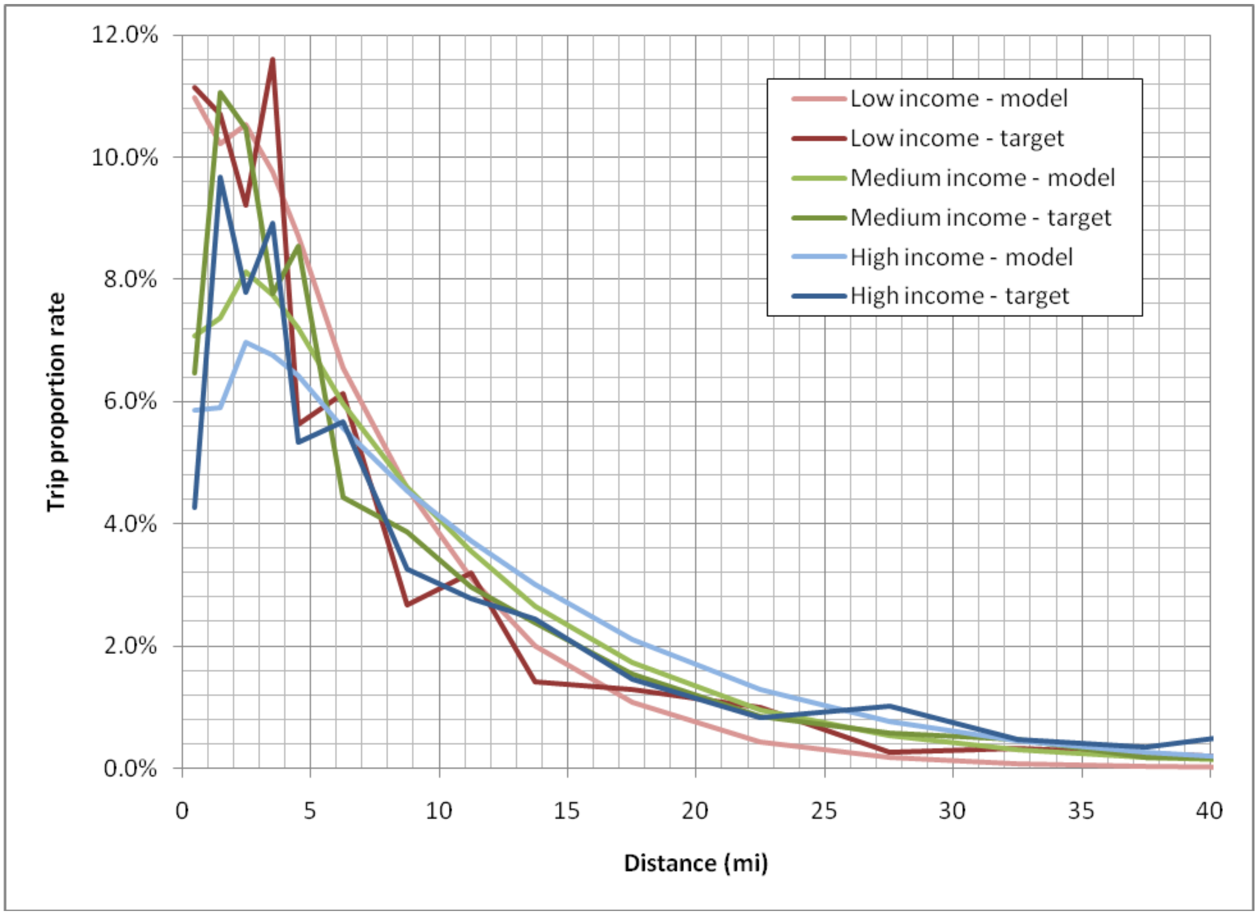

Figure 12b: Work Location Model Calibration - Trip Length (insufficient autos)

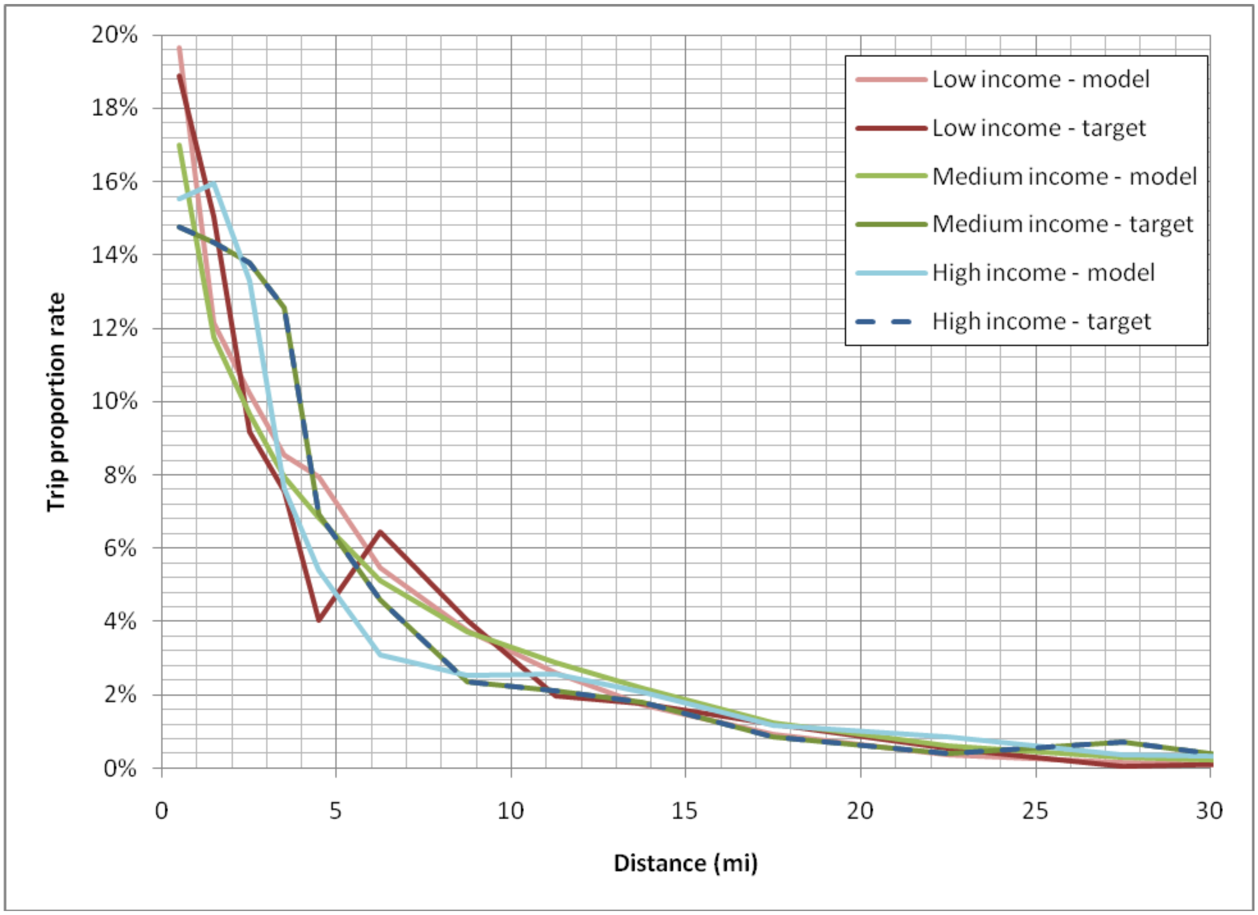

Figure 12c: Work Location Model Calibration - Trip Length (no autos)

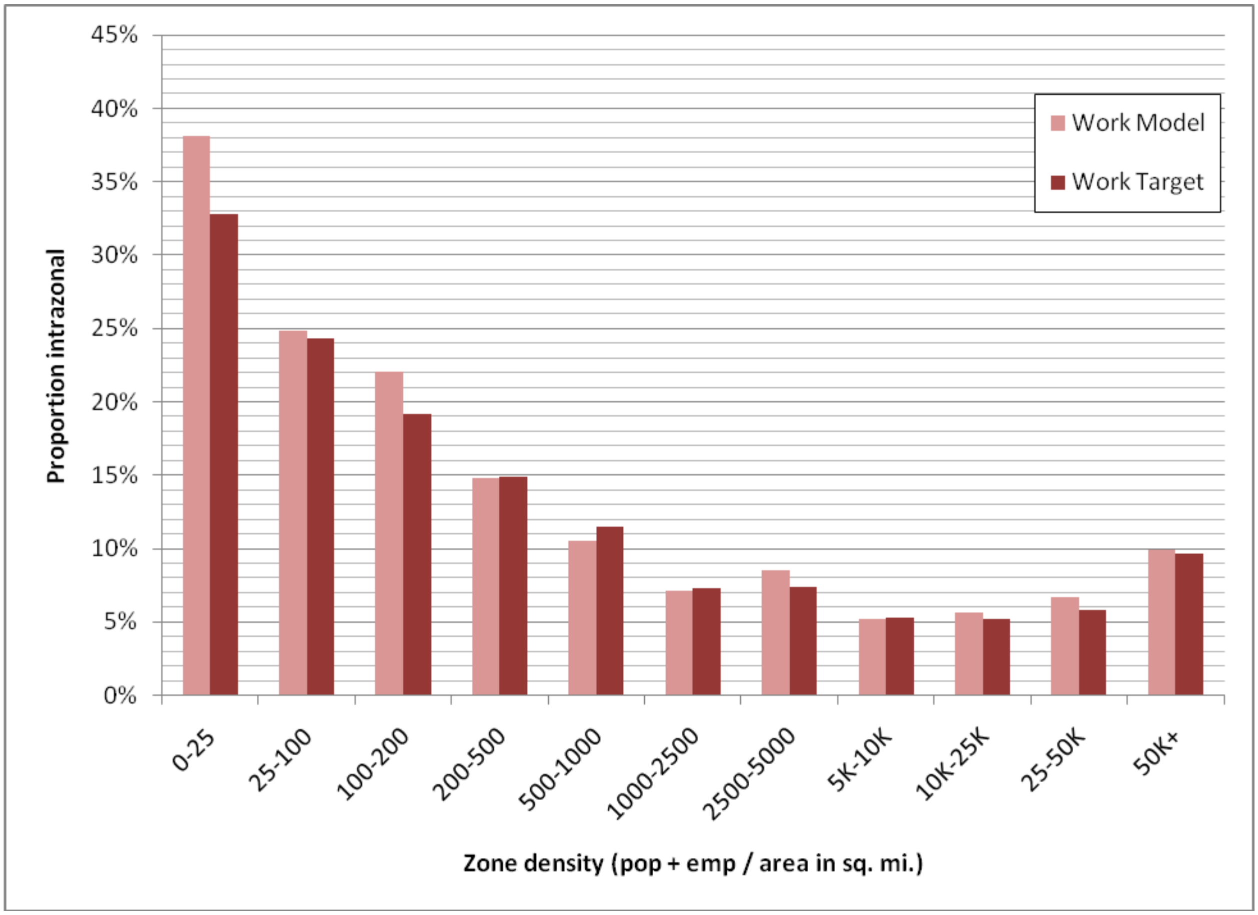

Figure 13: Work Location Model Calibration - Intrazonal proportions

The second phase of calibration involved matching the ACS origin-destination data at the district level. Because this theoretically involves 22x22 = 484 OD pairs (in reality, about half of that because of the 100 mile limit), three selected key measures are presented here. The first is Figure 14, which shows for each of the districts the proportion of work locations in the same district as the home. The second two are Figures 15a and 15b, which show the proportions of travel from home to work for selected key pairs of districts. The 15 pairs in Figure 15a are the 15 with the highest two-way volumes within an MPO (SCAG or MTC), and the 15 pairs in Figure 15b are the 15 with the highest volume crossing between different MPOs. (The top ranked interchange on the second chart, SANDAG-Riverside would be the 14th ranked interchange on the first one.) The chart shows the proportions in both directions; the "forward" and "reverse" directions are arbitrary, but the pairs do descend in volume from left to right. As an example of how to read these charts, the leftmost data in Figure 15a is the commute between Los Angeles and Orange counties. The red bars show that in the forward direction (Los Angeles to Orange), the model has 4.5% of Los Angeles residents working in Orange, versus an ACS target of 4.2%. In the reverse direction, the green bars show that the model has 12.9% of Orange County residents working in Los Angeles, where the observed data show 12.3%. The fits are quite good overall.

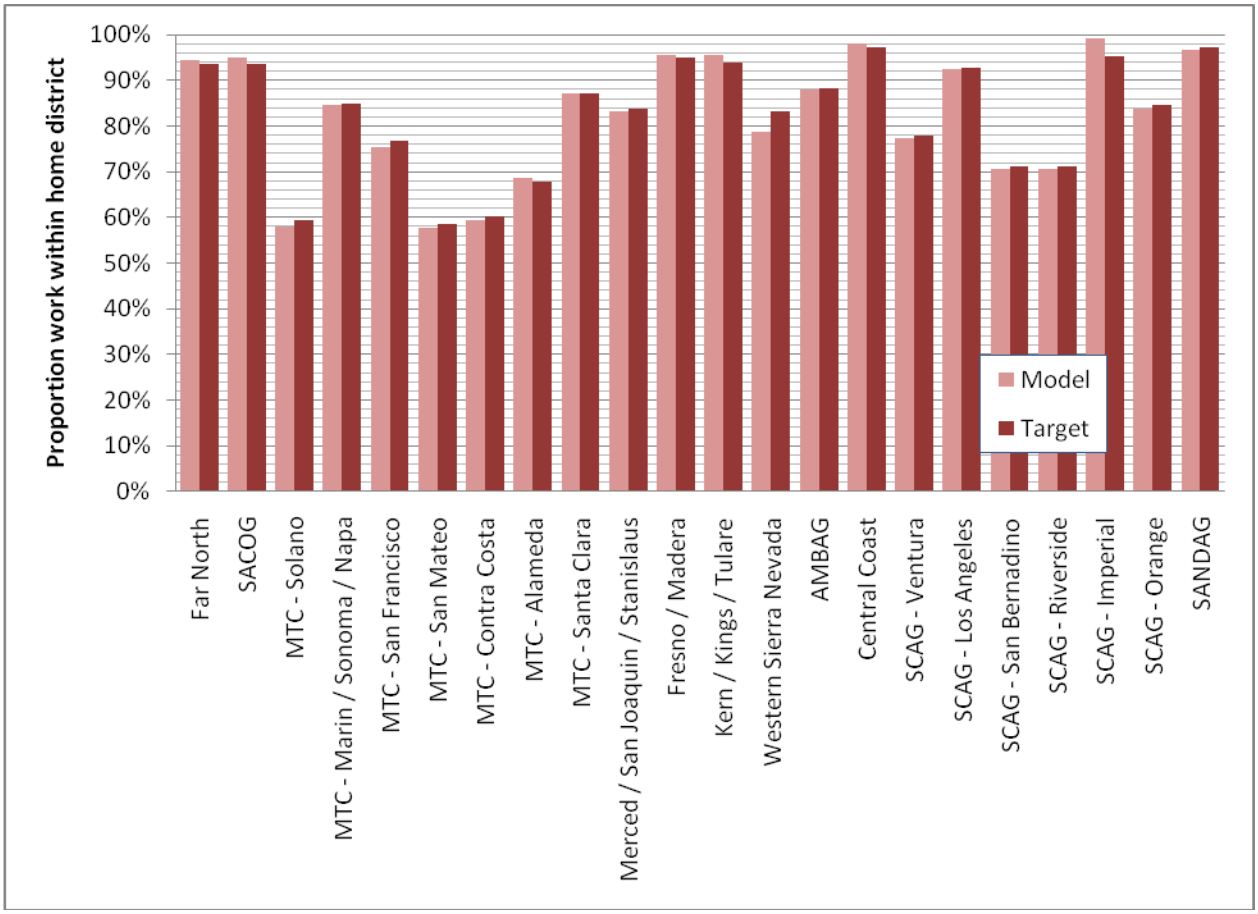

Figure 14: Work Location Model Calibration - Proportion working in home region

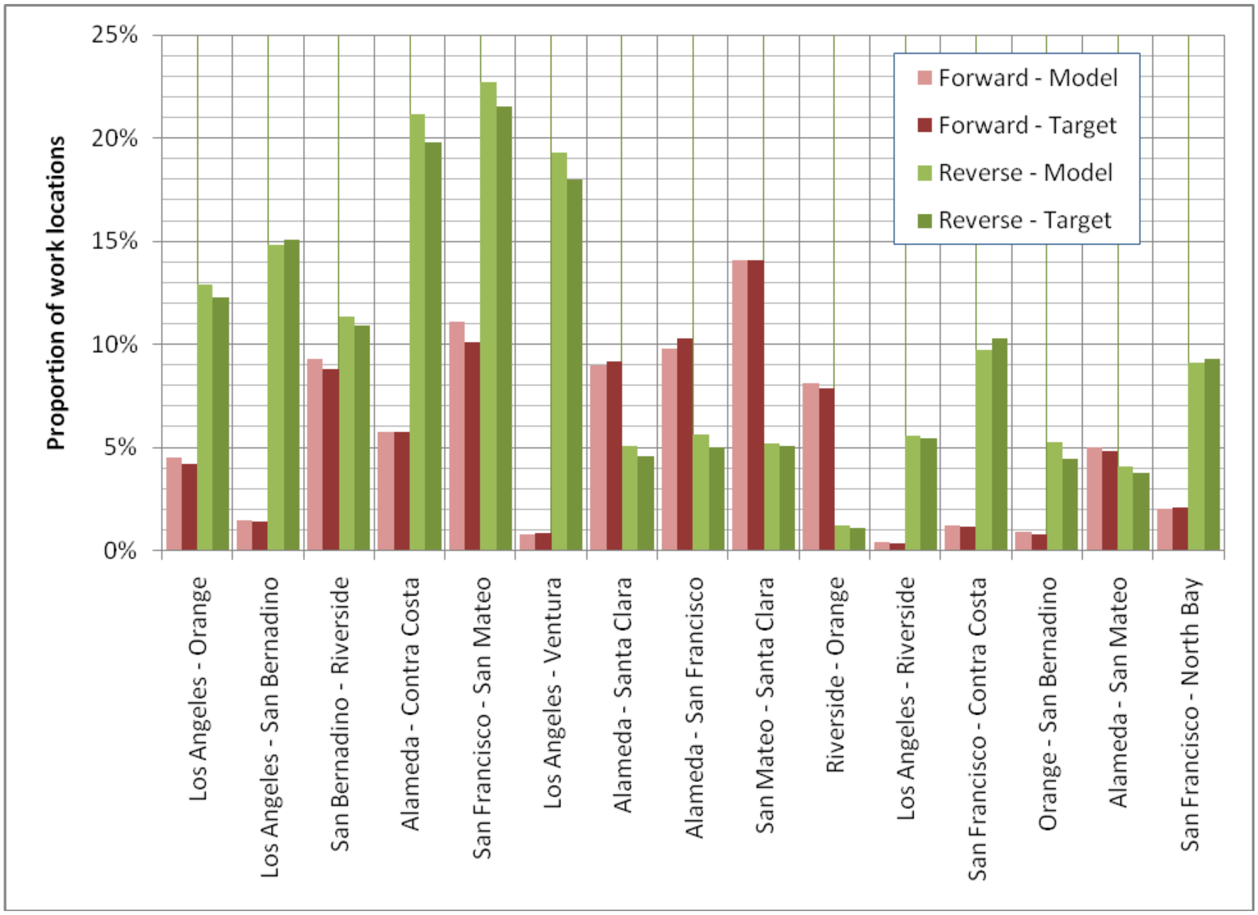

Figure 15a: Work Location Model Calibration - Key OD pairs; intra-SCAG / intra-MTC

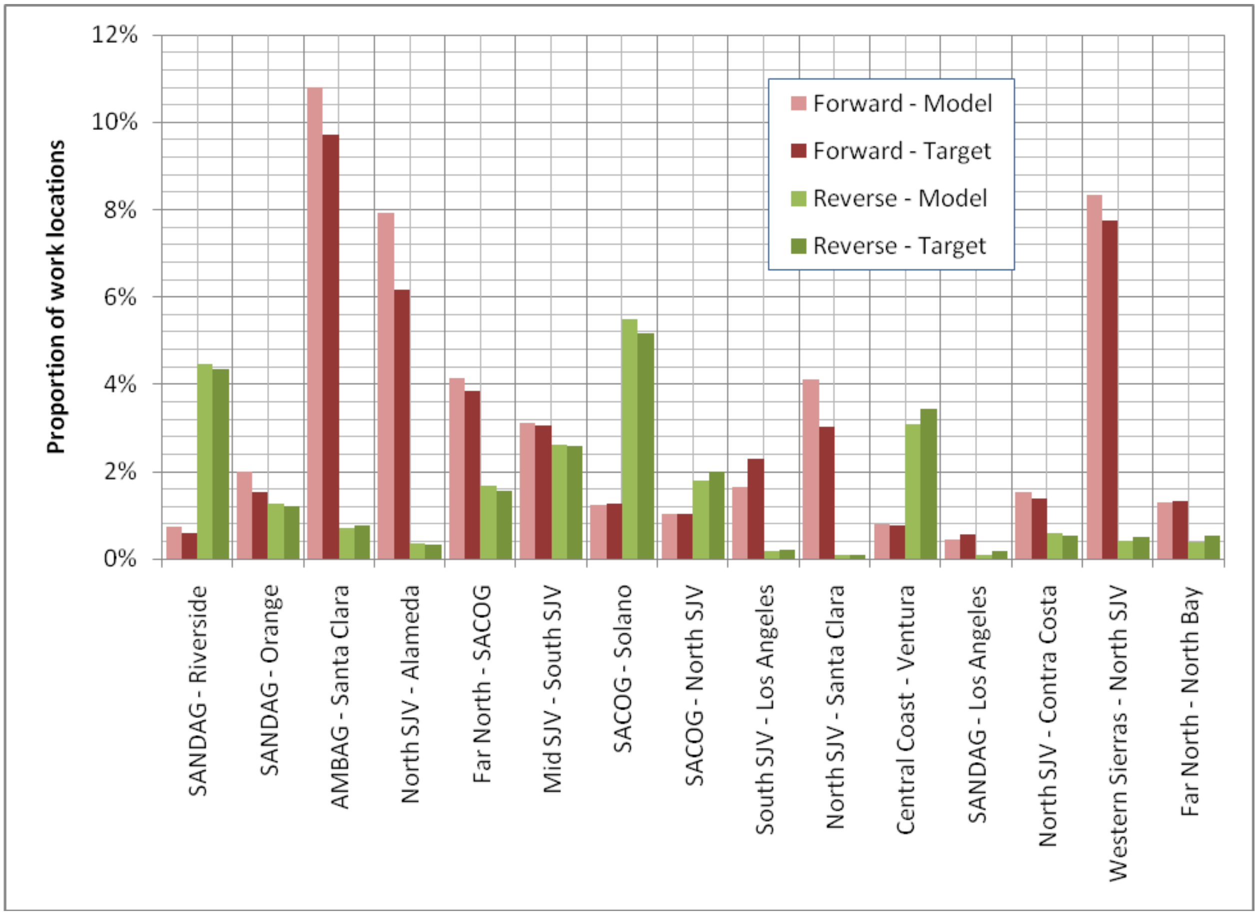

Figure 15b: Work Location Model Calibration - Key OD pairs; interregional

Note: "North Bay" refers to Marin, Sonoma and Napa counties; North SJV to San Joaquin, Stanislaus and Merced; Mid SJV to Fresno and Madera; and South SJV to Kings, Tulare and Kern.

4.4 Person School Location Model

The school location model was calibrated by adjusting the parameters of the main location model; these are the size term and mode choice logsum parameters as well as the parameters of the distance function. This was done to match survey data trip length distributions by school level. Intrazonal constants were also added by density level and grade to match observed distributions of school locations in the home zone. These updated values are shown in Table 7a and 7b. Figure 16 is the trip length distribution for school by grade, and Figure 17 is the proportion of intrazonal travel. The fit of model to observed data is quite good.

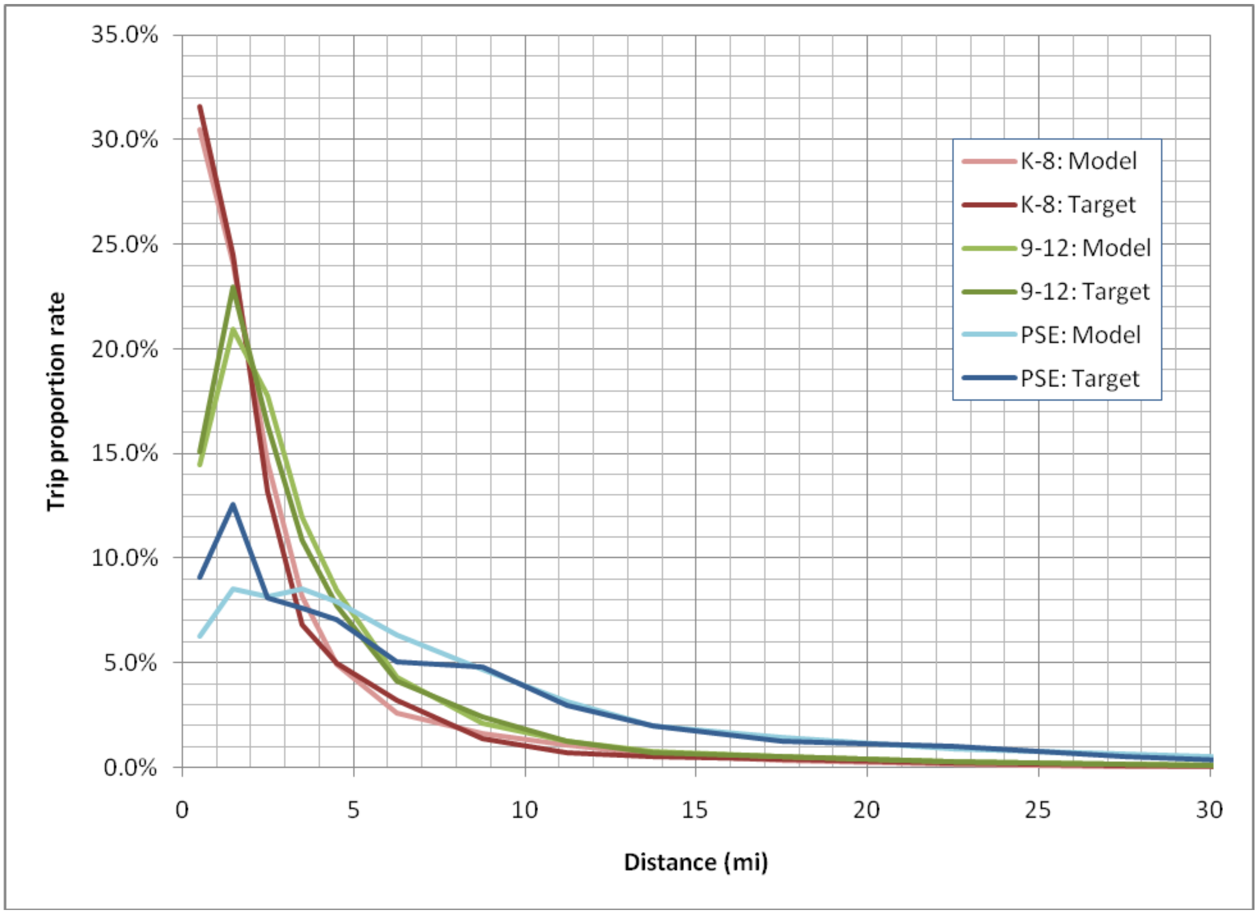

Figure 16: School Location Model Calibration - Trip length distribution

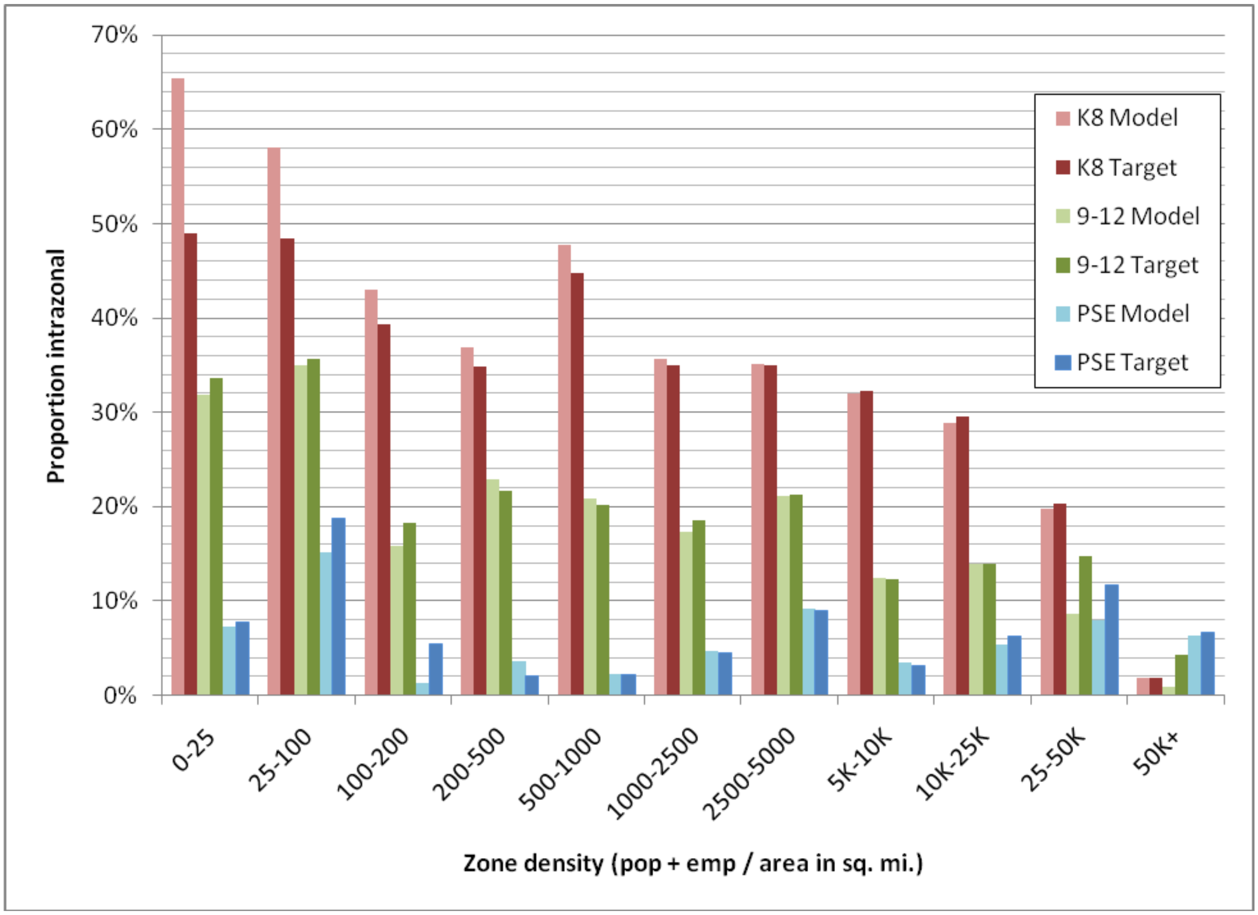

Figure 17: School Location Model Calibration - Intrazonal proportion