California Statewide Travel Demand Model, Version 2.0

Short Distance Personal Travel Model: Part 1 of 3

final

report

prepared for

California Department of Transportation

prepared by

Cambridge Systematics, Inc.

and

HBA Specto, Inc.

May 2014

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date

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1.0 Introduction and Model Review

This technical note is Part 1 of a series of three technical notes that describe the Short Distance Personal Travel Model (SDPTM) component of the updated California Statewide Travel Demand Model Version 2.0 (CSTDM 2.0). The documentation is split into three parts to keep individual document and computer file size to a manageable level. Together they describe the complete model features, calibration, and implementation.

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

- Model Overview;
- Long-Term Decision Models:
  - Person Driving License Models,
  - Household Auto Ownership Models,
  - Person Work at Home Model;
  - 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 the following:

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

Technical Note Part 3 contains details of the following:

- Primary Destination Choice Models for "Other" Tours;
- Subtour Mode Choice Models;

- Secondary Destination Choice Models;
- Trip Mode Choice Models;
- Calibration of Primary and Secondary Destination/Subtour and Trip Mode Choice Models; and
- Implementation in CSTDM 2.0 Model Framework.

2.0 Model Overview

The CSTDM 2.0 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 apply for all trips made up to 100 miles from home. The Long Distance Personal Travel Model will apply to all trips made greater than 100 miles.

The SDPTM is a disaggregate microsimulation tour-based choice demand model that was upgraded for the CSTDM 2.0, and calibrated using 2012 fall/spring weekday Travel Survey data from the 2012 California Household Travel Survey (CHTS), and 2012 releases of the American Community Survey (ACS).

The upgraded model has been improved and extended in the following areas:

- A revised work/school location model that references the long-term location of work, rather than the destination of work trips on the survey day of travel;
- An additional model that assigns a work-at-home status; and
- An upgraded day pattern model that is more explicitly sensitive to the effect of travel conditions and links short and long distance travel decisions.

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" file specially generated as part of the CSTDM 2.0 operation.

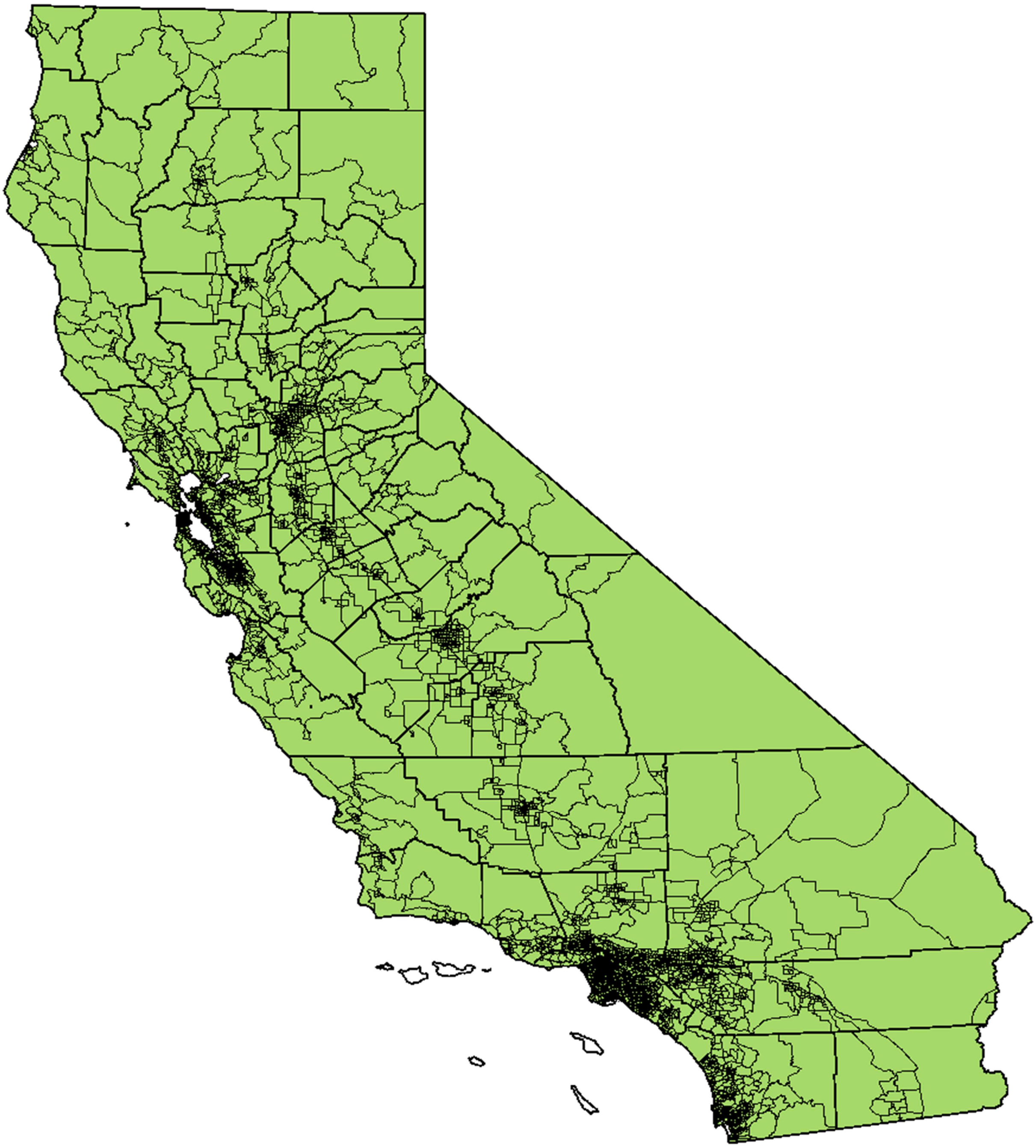
Each person/household is assigned to a home transportation analysis zone (TAZ). The State is subdivided into 5,454 TAZ. The TAZ nest both within the 58 California counties and the 524 land use zone (LUZ) system used in the California PECAS spatial economic model. Figure 2.1 illustrates the CSTDM 2.0 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 timeframe of the models is split into four time periods for demand modeling and travel assignment purposes:

- An AM peak period (6AM to 10AM);
- A midday period (10AM to 3PM);
- A PM peak period (3PM to 7PM); and
- An off-peak period (12AM to 6AM plus 7PM to midnight).

Figure 2.1 TAZ System



The demand models generally further subdivide the off-peak period into an early time period and a late time period. The early period is defined as being between 3AM and 6AM, and the late time 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 is defined as starting at 3AM.

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 eight 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; and
8. School Bus.

The SDPTM is a tour-based, activity-based travel forecasting model. It considers the underlying activity patterns of model area residents as the key to travel decisions, and it uses the concept of a Tour as a unit of analysis in the development of model components. A tour represents 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 2.2 illustrates a typical day pattern with two separate tours from/to home; and one subtour from/to work.

For each tour, a "tour mode" is identified. The tour mode is the overall mode for the tour. The mode that is the "fastest" mode in the trips of a tour is used as the tour mode, defined in a hierarchical order (SOV, HOV2, HOV3+, School Bus, Drive Access Transit, Walk Access Transit, Bicycle, and Walk).

The SDPTM has six main components, applied to each person, as shown in Figure 2.3.

Figure 2.2 A Typical Day Pattern with Tours

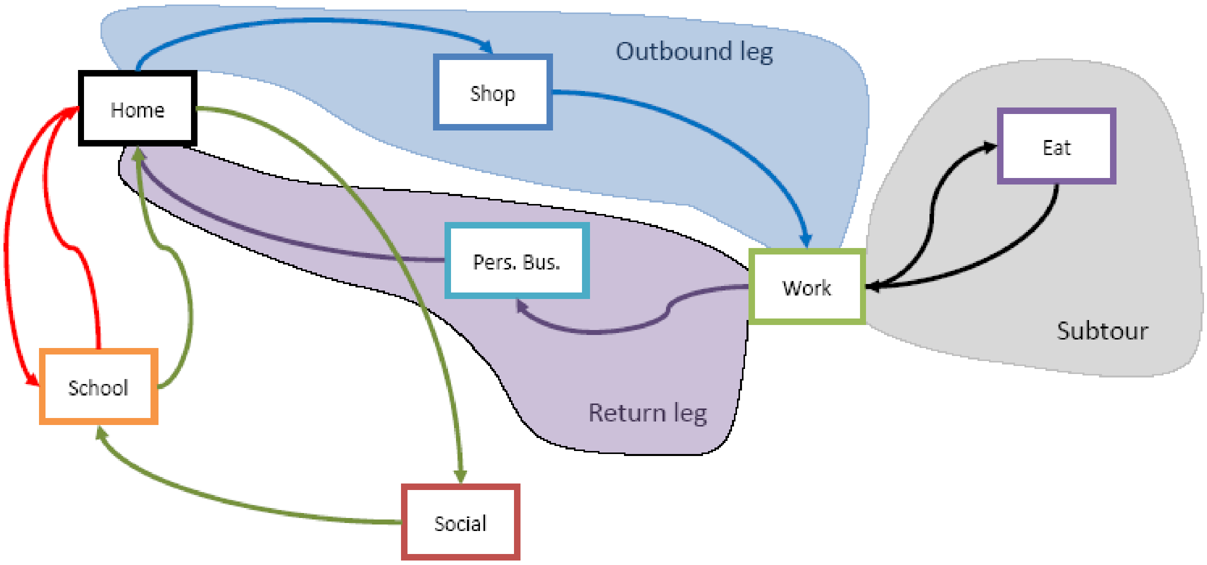


Figure 2.3 Components of the Short Distance Personal Travel Model

Model Components

Long-Term Decision	Driving License for each Person; Household Car Ownership; work and school locations for each HH member
Day Patterns	Number and purpose of tours for each HH member; time periods for tour legs; presence and purpose of secondary stops
Primary Destination	Destination of primary stop on tour for each tour
Tour Mode	Overall tour mode choice for each tour
Secondary Destination	Destination of each secondary stop on tour
Trip Mode	Mode choice for each trip on tour

The **Long-Term Decision** component of the SDPTM contains the following submodels 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 from 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 models and the household auto ownership models 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 submodels for all person types:

- A **Work At Home** model, which forecasts if a person classified as a Worker works at home or, at a location outside the home. Persons who are identified as working at home do not have a primary work location assigned in the Work Location model, and have different day patterns.
- 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 also is used to identify primary work locations for other person types that 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, and
  - The purpose of the first stop for non Work or School Tours; and
- 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 2.4 shows the submodel 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 2.4 SDPTM Application: Work and School Tours

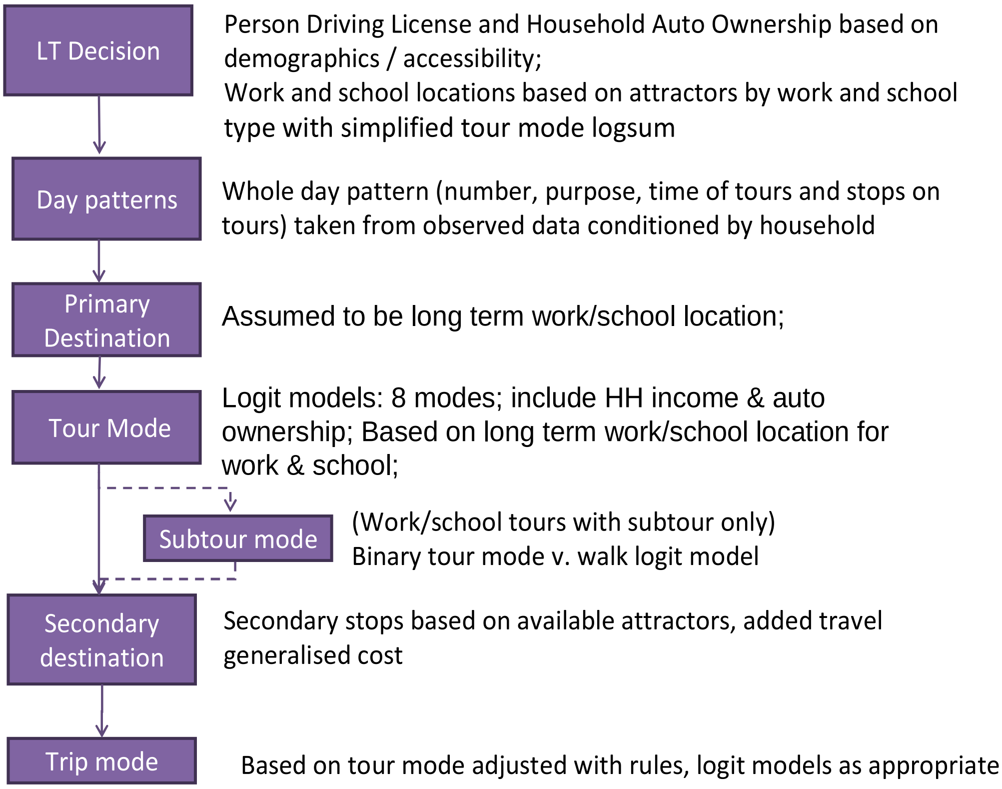
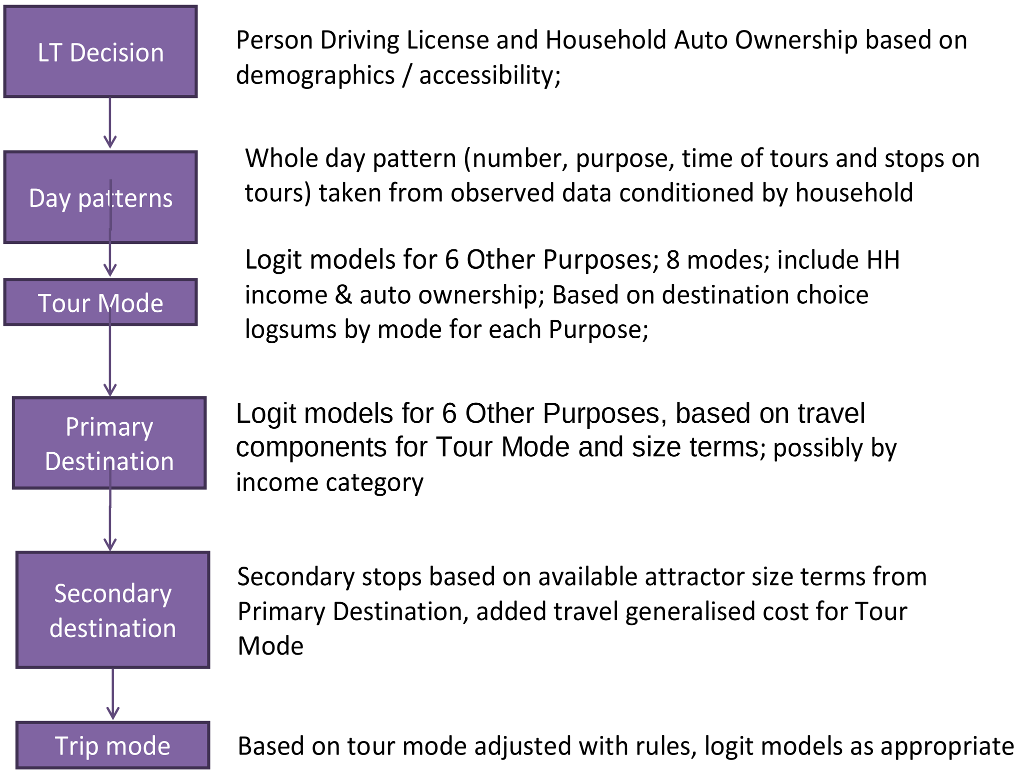


Figure 2.5 shows the submodel detail and flow for tours where the tour purpose is Other. It has a nontraditional travel model order with tour mode chosen before primary destination.

Figure 2.5 SDPTM Application: Other Tours



Section 3.0 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 4.0 describes the calibration of these models to year 2010 targets.

3.0 Long-Term Decision Models

This section describes the form and final parameter values of the individual long-term decision models estimated for the CSTDM 2.0.

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 the 2010-2012 CHTS. Unfortunately, this important explanatory variable is not present in the Public Use Microdata Sample (PUMS) data used for the synthetic population in the CSTDM 2.0.

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 was estimated for the original CSTDM and calibrated to match observed data from the 2010-2012 CHTS.

The final estimated model is shown below in Table 3.1. Additional age group calibration parameters were adjusted during CSTDM 2.0 model calibration, which is shown in Table 3.2.

Note: The values shown below in Tables 3.1 and 3.2 are the utility function for holding a driver's license; the utility of not having a driver's license is set to 0.

Table 3.1 Driving License Model Parameters

Parameter	Parameter Value
Constant – Holding a Driving License	7.9386
Person under 35: (35 – age)	-0.2706
Person under 35: $(35 - \text{age})^2$	0.03187
Person under 35: $(35 - \text{age})^3$	-0.001402
Person aged 65+: $(\text{age-}64)^2$	-0.003434
Has physical disability	-1.2324
Has mental disability	-1.8452
Has sensory disability	-2.2375
HH income under $10,000	-1.7832
HH income $10,000-25,000	-1.3971

Parameter	Parameter Value
HH income $25,000-35,000	-0.7642
HH income $35,000-50,000	-0.2968
HH income $75,000-100,000	0.3412
HH income $100,000-150,000	0.5529
HH income $150,000 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 < $25,000 and size 5+	-0.7395
HH income $25,000-50,000 and size 5+	-0.8982
HH income $50,000-100,000 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 3.2 Driving License Model Additional Age Parameters from Calibration

Age Range	Parameter Value
16	-0.7705
17	-0.4109
18	-0.3678
19	-0.3099
20-24	-0.3953
25-29	-0.3738
30-34	-0.3929
35-39	-1.0193
40-44	-1.0221
45-49	-0.8881
50-54	-0.9663
55-59	-0.8874

Age Range	Parameter Value
60-64	-0.9932
65-69	-0.9406
70-74	-0.9767
75-79	-0.7904
80-84	-0.7682
85+	-0.4589

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 percent 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 they age, 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:

1. For persons under 35, a cubic function based on (35 – age) (i.e., years younger than 35), is used;
2. For persons 65 and older, a quadratic function based on (age – 64) (i.e., years older than 64), is used;
3. 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 percent for incomes over $150,000 down to just 91.1 percent 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 percent increased likelihood of having a license if they also have a job, but this difference drops to an 12.9 percent 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 an 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 five or more people) have an additional likelihood to not hold a driver's license. Note that these terms are additive; a member of a six-person household with $28,000 income incurs the 6+ person household utility term, plus the $25,000 to $35,000 utility term, plus the 5+ person $25,000 to $50,000 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 one 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; less than $25,000; $25,000 to $100,000; and more than $100,000. 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 percent and 95.0 percent, respectively. The 10^{th} and 90^{th} 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 percent, or even 98 percent. 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 percent 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 Household 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 noninstitutionalized 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; and

V_i = Utility associated with each alternative.

From the surveyed household dataset, households with a maximum of nine vehicles were observed, but households with five autos or greater only account for 1.2 percent 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 3.3 for demographic parameters; and Table 3.4 for logsum accessibility parameters. The probabilities used to disaggregate the 5+ auto choice are shown in Table 3.5.

Table 3.3 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 <10,000	2.7068	0.9253	0	-0.5926	-0.7306	-1.5408
HH income 10,000-25,000	1.8964	0.8319	0	-0.4126	-0.7306	-1.5408
HH income 25,000-35,000	1.0484	0.6078	0	-0.4476	-0.6905	-1.1164
HH income 35,000-50,000	0.4122	0.2546	0	-0.1725	-0.4261	-0.5579
HH income 50,000-75,000	0	0	0	0	0	0
HH income 75,000-100,000	-1.0177	-0.4343	0	0.2115	0.02914	0.02914
HH income 100,000-150,000	-0.7764	-0.3235	0	0.1889	0.02914	0.02914
HH income > 150,000	-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)	0.1320	0.0	-0.2771	0.2755	0.0914	0.3165
2 adults (16+ y.o.)	-1.3712	0.0731	0.0	-0.0822	--0.3296	-0.4678
3 adults (16+ y.o.)	1.7857	0.4999	0.0	-0.0457	-0.4642	-1.1789
4+ adults (16+ y.o.)	2.2500	0.5298	0.1150	0.0	-0.7695	-1.5782

Table 3.4 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 < 25,000	1.5520	1.6760	1.5933	1.4599
Destination choice logsums for work – full-time workers in HH income 25,000-100,000	2.9485	3.5128	3.3340	3.1937
Destination choice logsums for work – full-time workers in HH income >100,000	5.8765	7.6134	7.2047	7.0633
Destination choice logsums for work – part-time workers in HH income < 25,000	1.0273	1.1987	1.0957	0.9372
Destination choice logsums for work – part-time workers in HH income 25,000-100,000	1.7210	2.1146	1.9862	1.8485
Destination choice logsums for work – part-time workers in HH income >100,000	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 3.5 High Auto Ownership Disaggregation Probabilities

	5 Autos	6 Autos	7 Autos	8 Autos	9 Autos
HH Income < 50,000	83.78%	8.73%	3.76%	3.31%	0.42%
HH Income 50,000-100,000	62.07%	21.78%	12.36%	3.16%	0.63%
HH Income 100,000+	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 $50,000 to $75,000 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 and attached and mobile home are related to lower levels of auto ownership – parking availability may be a factor for these housing types.
- Presence of children – Young children (five 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 zero- to five-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 household income ($0 to $25,000; $25,000 to $100,000; and more than $100,000), 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 3.5, 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 nonwork, nonschool 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 At Home Model

The work at home model determines if the person being modeled works at the home, or at a location outside the home. A location outside the home includes workers who work at mobile or multiple locations outside the home (such as a taxi driver, construction worker or travelling salesperson). Someone who works in the same TAZ as the home, but outside the home is considered to not work at home. This model is an addition to the CSTDM 2.0, and is not present in the original CSTDM.

This model takes the form of a binary choice, with the utility of working outside the home fixed at 0. The model was originally estimated in ALOGIT, using data from the original CSTDM combined survey dataset and base year run for travel conditions. For the accessibility logsum, it takes (depending on the auto ownership/driver's license status) either the no car, low-income logsum; or the sufficient car, medium-income logsum, as described in the Work Location Simplified Mode Choice model below. The occupation parameters are different for different income groups (considering household income). The low density function is calculated as max (1000-density, 0) for each TAZ, where density is (population + employment) per square mile.

During calibration of the CSTDM 2.0, specific calibration parameters were added for each of 36 calibration areas developed for the CSTDM 2.0 development, with targets based on the 2007-2011 ACS table S0801 The parameters are described in Table 3.6.

Table 3.6 Work At-Home Model Parameters

Parameter	Low Income (<$25K)	Medium Income ($25K-75K)	High Income ($75K+)
Management and Business occupation	1.7312	1.2520	0.8991
Clerical and Administration occupation	0.0000	0.0000	1.4300
Education occupation	0.0000	0.0000	0.0000
Health occupation	1.2858	1.0451	1.0512
Professional and Technical occupation	1.2408	1.4943	1.7768
Sales, Food and Entertainment occ.	1.3552	1.7815	2.2263
Non-Sales Service occupation	1.3348	1.5785	1.8369
Blue collar occupation	0.7759	1.0716	1.3640

Parameter	Value
Worker is part time	0.9529
Worker is also postsecondary student	-0.1915
Worker is also high school student	-1.7633
Worker is man in household with children (persons under 16)	-0.3941
Worker age under 25	-1.0125
Worker aged 25 to 34	-0.4827
Worker aged 55 to 64	0.1835
Worker aged 65+	0.5480
Household income over $150K	0.2421
Low density value, Management/Business occupation worker	0.000749
Low density value, Blue collar occupation worker	0.001251
Accessibility (no car or no license) - Work None Low logsum	-0.04130
Accessibility (HH has car, worker has license) - Work Suff. Med. Logsum	-0.03960
Work at home constant, Far North (Coast)	-3.9326
Work at home constant, Far North (Shasta, Cascade)	-3.9428
Work at home constant, Far North (North Sierras)	-3.7202
Work at home constant, Far North (Valley)	-4.0449
Work at home constant, Far North (Wine)	-3.6987

Parameter	Value
Work at home constant, SACOG (Yuba, Sutter)	-4.0936
Work at home constant, SACOG (Placer, El Dorado)	-3.6482
Work at home constant, SACOG (Sacramento)	-3.9221
Work at home constant, SACOG (Yolo)	-4.1222
Work at home constant, MTC (Solano)	-4.2481
Work at home constant, MTC (Sonoma, Napa)	-3.7759
Work at home constant, MTC (Marin)	-3.4216
Work at home constant, MTC (San Francisco)	-3.5972
Work at home constant, MTC (San Mateo)	-3.9793
Work at home constant, MTC (Contra Costa)	-3.8867
Work at home constant, MTC (Alameda)	-3.8807
Work at home constant, MTC (Santa Clara)	-4.0207
Work at home constant, SJV (San Joaquin)	-4.0193
Work at home constant, SJV (Stanislaus)	-4.0748
Work at home constant, SJV (Merced)	-4.1271
Work at home constant, SJV (Fresno, Madera)	-4.1116
Work at home constant, SJV (Kings, Tulare)	-4.2156
Work at home constant, SJV (Kern)	-4.4176
Work at home constant, Western Sierra Nevada (Central)	-4.1740
Work at home constant, Western Sierra Nevada (South)	-4.2311
Work at home constant, AMBAG (San Benito, Santa Cruz)	-3.8008
Work at home constant, AMBAG (Monterey)	-3.9605
Work at home constant, Central Coast (San Luis Obispo)	-3.7361
Work at home constant, Central Coast (Santa Barbara)	-3.7607
Work at home constant, SCAG (Ventura)	-3.9083
Work at home constant, SCAG (Los Angeles)	-3.8852
Work at home constant, SCAG (San Bernardino)	-4.1020
Work at home constant, SCAG (Riverside)	-3.8569
Work at home constant, SCAG (Imperial)	-4.2018
Work at home constant, SCAG (Orange)	-3.9104
Work at home constant, SANDAG	-3.6125

This model is consistent with general expectations about at-home workers. The large constant (relative to the 0 utility for working outside the home) ensures most workers work outside the home. The key occupations that work at home are higher-paid sales and service workers – a significant portion of these are real estate sales workers – as well as lower income management/business workers – many of whom are likely small business people. Younger workers, especially high school students, are less likely to work at home, while part-time, older and high income workers are more likely. Men with children are less likely to work at home, which may reflect the traditional "primary breadwinner" role they often play. While accessibility has the role expected, where persons in lower accessibility locations are more likely to work outside the home, it is small. The density is somewhat more significant, where blue collar and management workers in low density areas are more likely to work at home. It should be noted that "Farmers and Farm Managers" are classified as Management workers by the SOC. Density plays a stronger role than accessibility; a farmer is likely to work at home on their farm, whether it is near a city or a long way away.

3.4 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 3.7 below.

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.

Table 3.7 Employment Occupation Categories Used in Work Location Model

Employment Occupations in CSTDM 2.0
Management and Business
Clerical and Administration
Education
Health
Professional and Technical
Sales, Food and Entertainment
Nonsales Service
Blue Collar
Military

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, <$25,000; medium, $25,000 to $100,000; and high, more than $100,000).

The models were originally 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 power function with respect to distance in the form axdistance^{b}, where a and b are the parameters, and distance is in miles. An additional increase or decrease in slope is applied after a specified distance; this slope must be such that the curve is monotonically decreasing for distances up to 150 miles. The distance used is the free-flow HOV3 one-way (home to work) network distance, in miles.

Tables 3.8 through 3.11 give final model parameters for the Work Location models. 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, wages or other 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 would hopefully obviate the need for these coefficients.

Table 3.8 Work Location Model Parameters

Auto own/income	Logsum	Size Term	Multiplicative Parameter a	Exponential Parameter b	Additional Distance	Additional Slope
Suff./low	0.8847	1.0000	-0.2850	0.5570	17.50	-0.0161
Suff./med	0.8464	1.0000	-0.1318	0.7899	47.50	0.0477
Suff./high	0.9052	1.0000	0.1197	-0.0496	10.00	0.0059
Insuf/low	0.8336	1.0000	--0.2551	0.7058	36.14	0.0415
Insuf/med	0.6922	1.0000	--0.2551	0.7058	36.14	0.0415
Insuf/high	0.6136	1.0000	--0.2551	0.7058	36.14	0.0415
None/low	0.7348	1.0000	--0.1742	1.0029	13.69	0.1239
None/med	0.8540	1.0000	--0.1742	1.0029	13.69	0.1239
None/high	0.9811	1.0000	--0.1742	1.0029	13.69	0.1239

Table 3.9 Work Location Model Regional Interchange Parameters – North Destinations

Parameter	Far North-North Sierras	SACOG – Sacramento	SACOG – Yolo	MTC – Solano	MTC – Sonoma/ Napa	MTC – Marin	MTC – San Francisco	MTC – San Mateo	MTC – Contra Costa	MTC – Alameda	MTC – Santa Clara
SACOG – Yuba/Sutter	0	0	0.8068	0	0	0	0	0	0	0	0
SACOG – Pacer/ El Dorado	-1.0168	-0.1791	0	0	0	0	0	0	0	0	0
SACOG – Sacramento	0	0	0	0.9461	0	0	2.9362	0	1.2899	2.1880	3.3063
SACOG – Yolo	0	-0.6976	0.4465	0	0	0	0	0	0	0	0
MTC – Solano	0	-0.8493	-0.9447	0	0	0.7297	1.1195	1.7783	0	0.4843	1.0885
MTC – Sonoma/Napa	0	0	0	-0.8615	0	0	0.8494	1.1884	-0.7410	0	0
MTC – Marin	0	0	0	0	0	0.2875	0	0	-0.9728	-0.7462	0
MTC – San Francisco	0	0	0	0	0.7670	0	0	0	0	0	1.3602
MTC – San Mateo	0	0	0	0	0	0	0	0.1530	0	-0.6451	-0.2552
MTC – Contra Costa	0	0	0	-0.7518	0	0	0.4900	0.9216	0	0	0.6128
MTC – Alameda	0	1.3618	0	0	0	0	0.1952	0.2618	-0.3102	0	0
MTC –Santa Clara	0	0	0	0	0	0	0	0	0	0	0
SJV – San Joaquin	0	0	0	0	0	0	2.7498	2.2300	0.5427	1.6044	2.2654
SJV – Stanislaus	0	0	0	0	0	0	0	2.7103	1.0201	1.8663	2.3919
SJV – Merced	0	0	0	0	0	0	0	0	0	0	2.0842

To avoid overfitting, coefficients were only developed where observed flows were in excess of 1000 workers, and where the model results without adjustment were significantly different from the real observed patterns. The data used to develop targets was ultimately the 2006 to 2010 ACS county-to-county home to work flow information, aggregated by the 36 districts used for model validation. These parameters are shown in Tables 3.10 to 3.11; each row represents the home zone and each column represents the work location, so a Contra Costa resident has an additional 0.4900 added to the utility for working in zones in San Francisco, while an Alameda resident has -0.3102 utility, a reduction, for working in Contra Costa. (Note that the tables are organized by destination district; some origin districts appear in more than one table.)

Table 3.10 Work Location Model Regional Interchange Parameters – Central Destinations

Parameter	SJV – San Joaquin	SJV – Stanislaus	SJV – Fresno/ Madera	SJV – Kings/Tulare	SJV – Kern	Western Sierra Nevada – Central	AMBAG – San Benito/ Santa Cruz
MTC – Contra Costa	-1.6179	0	0	0	0	0	0
MTC – Alameda	-0.7409	0	0	0	0	0	0
MTC – Santa Clara	0	0	0	0	0	0	-0.9132
SJV – San Joaquin	0	-0.7996	0	0	0	0.8760	0
SJV – Stanislaus	0	0	0	0	0	1.2736	0
SJV – Merced	0	-0.4320	0	0	0	0	0
SJV – Fresno/Madera	0	0	0	-0.5370	0	0	0
SJV – Kings/Tulare	0	0	-0.6412	0	0	0	0
SCAG – Los Angeles	0	0	0	0	0.9252	0	0

Table 3.11 Work Location Model Regional Interchange Parameters – South Destinations

Parameter	Central Coast – Santa Barbara	SCAG – Ventura	SCAG – Los Angeles	SCAG – San Bernardino	SCAG – Riverside	SCAG – Imperial	SCAG – Orange	SANDAG
SJV – Kern	0	0	-1.0238	0	0	0	0	0
Central Coast – Santa Barbara	0	-1.2996	0	0	0	0	0	0
SCAG – Ventura	0.7492	0	-0.3995	0	0	0	0	0
SCAG – Los Angeles	1.4369	0	0	-0.2934	0	0	-0.3093	-1.7466
SCAG – San Bernardino	0	0	0.2662	0	-0.4743	0	0	0
SCAG – Riverside	0	0	0.3709	-0.4086	0	0	0.7349	0.8020
SCAG – Imperial	0	0	0	0	0	0	0	0
SCAG – Orange	0	0	-0.4780	0	0	0	0	0
SANDAG	0	0	0	0	-0.7568	0	0.6962	0

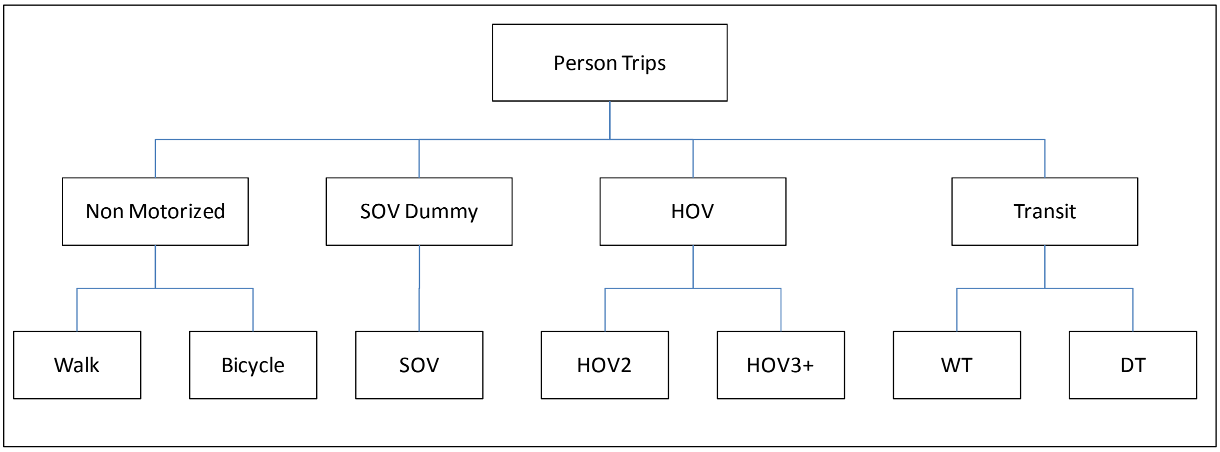
3.4.1 Simplified Tour Mode Choice Model: Work

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 model is used for practical considerations 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: nonmotorized, 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 two-person and three-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 3.1 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 3.12 gives the parameters in the simplified Tour Mode Choice Model for Work.

Table 3.12 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 < 25,000 (min)	-0.02336
Auto In-vehicle time, HH income 25,000-100,000 (min)	-0.02435
Auto In-vehicle time, HH income >= 100,000 (min)	-0.04135
Transit In-vehicle time, HH income <100,000 (min)	-0.00839
Transit In-vehicle time, HH income >=100,000 (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

Parameter	Parameter Value
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

3.5 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. The parameters are described in Table 3.13.

Table 3.13 School Location Model Parameters

Grade	Logsum	Size Term	Multiplicative Parameter a	Exponential Parameter b	Additional Distance	Additional Slope
K-8	0.6393	1.0000	-4.1381	0.3715	0.50	0.0528
9-12	0.7297	1.0000	-1.2225	0.7289	6.55	0.2196
PSE	0.8094	1.0000	--8.2650	0.1190	47.50	0.0438

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 3.2 and 3.3, with the parameters provided in Tables 3.14 and 3.15.

Figure 3.2 Simplified Tour Mode Choice Model Nesting Structure: Grade School

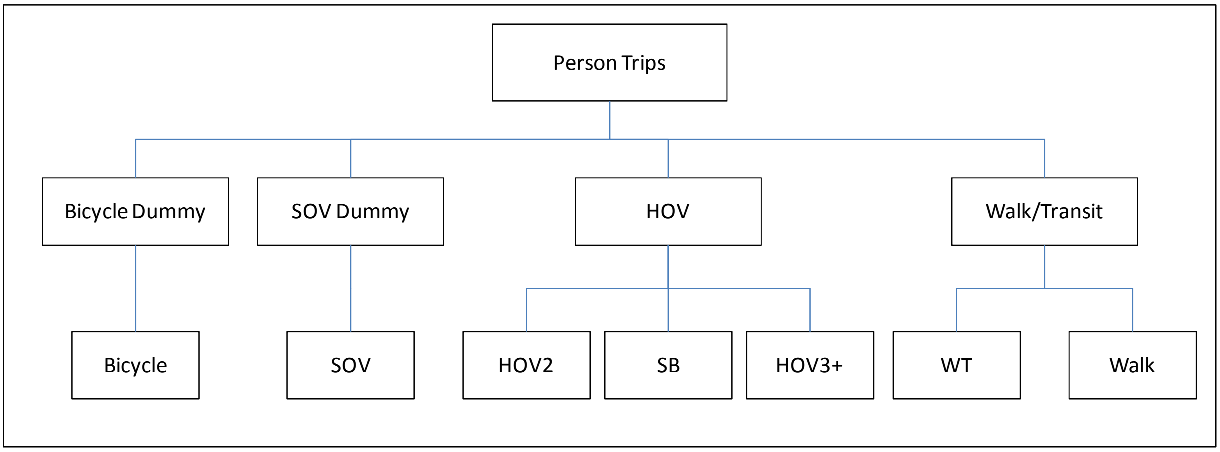


Figure 3.3 Simplified Tour Mode Choice Model Nesting Structure: PSE

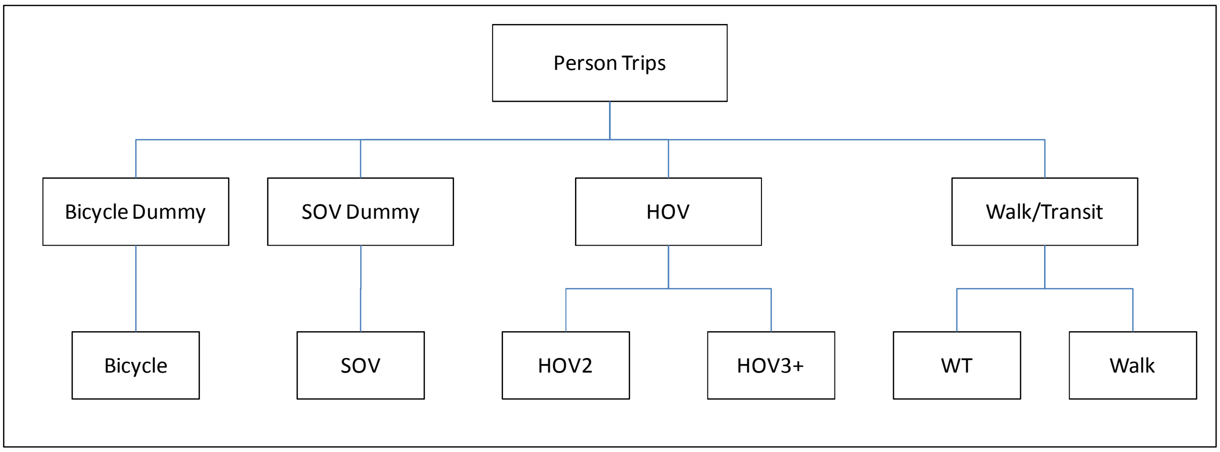


Table 3.14 Simplified Tour Mode Choice Model: Grade School

Parameter	Parameter Value
Level of Service	
Cost (Operation fee, parking, toll, fare) ($)*	-0.004418
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

Parameter	Parameter Value
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 3.15 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
HOV2	
Constant	-3.6491
No Autos in HH	5.8560
Autos in HH > 0 but < drivers	2.0179

Parameter	Parameter Value
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

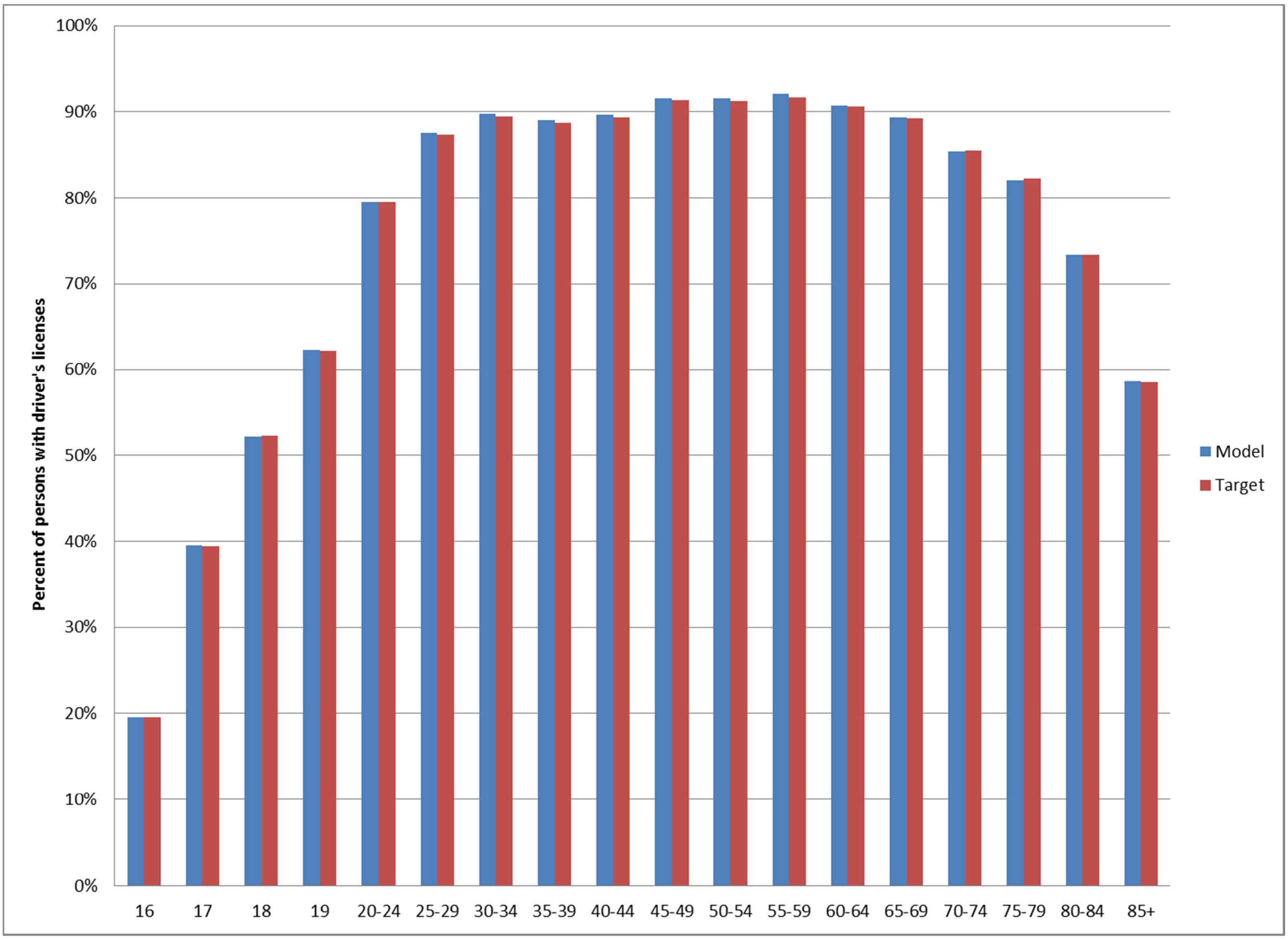
4.0 Calibration of Long-Term Decision Models

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, D.C., 2001. This data detailed the licensed driver totals for California by 15 age groups; five year brackets to 85+. The 16 to 19 group was further split by year using data taken from the California Department of Motor Vehicles Report RSS-03-194[1]. Figure 4.1 shows the fit of licensed drivers by age group. The model matches the observed data very well.

[1] California Department of Motor Vehicles, Report RSS-03-194. http://apps.dmv.ca.gov/about/profile/rd/r_d_report/Section_6/S6-194.pdf. Accessed May 2014.

Figure 4.1 Driver's License Model Calibration Status by Age



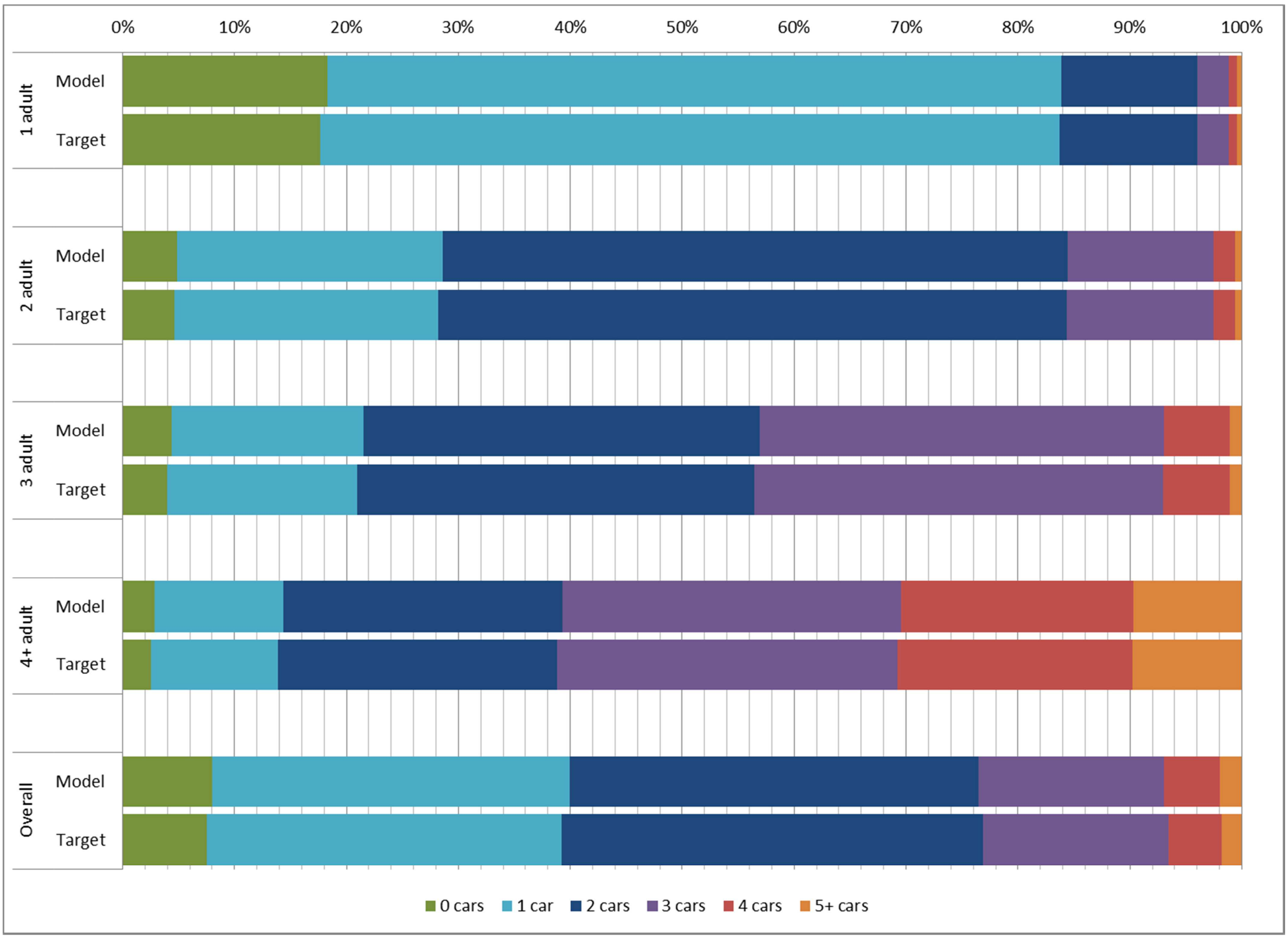
4.2 HOUSEHOLD AUTO OWNERSHIP MODEL

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 3.4 are the calibrated parameters.

In the second phase, the model was calibrated to data from the 2012 California Household Travel Survey (CHTS). These calibration coefficients are also reported in Table 3.4.

The model fit with the observed data is shown in Figure 4.2 below; the fit is excellent for all household sizes.

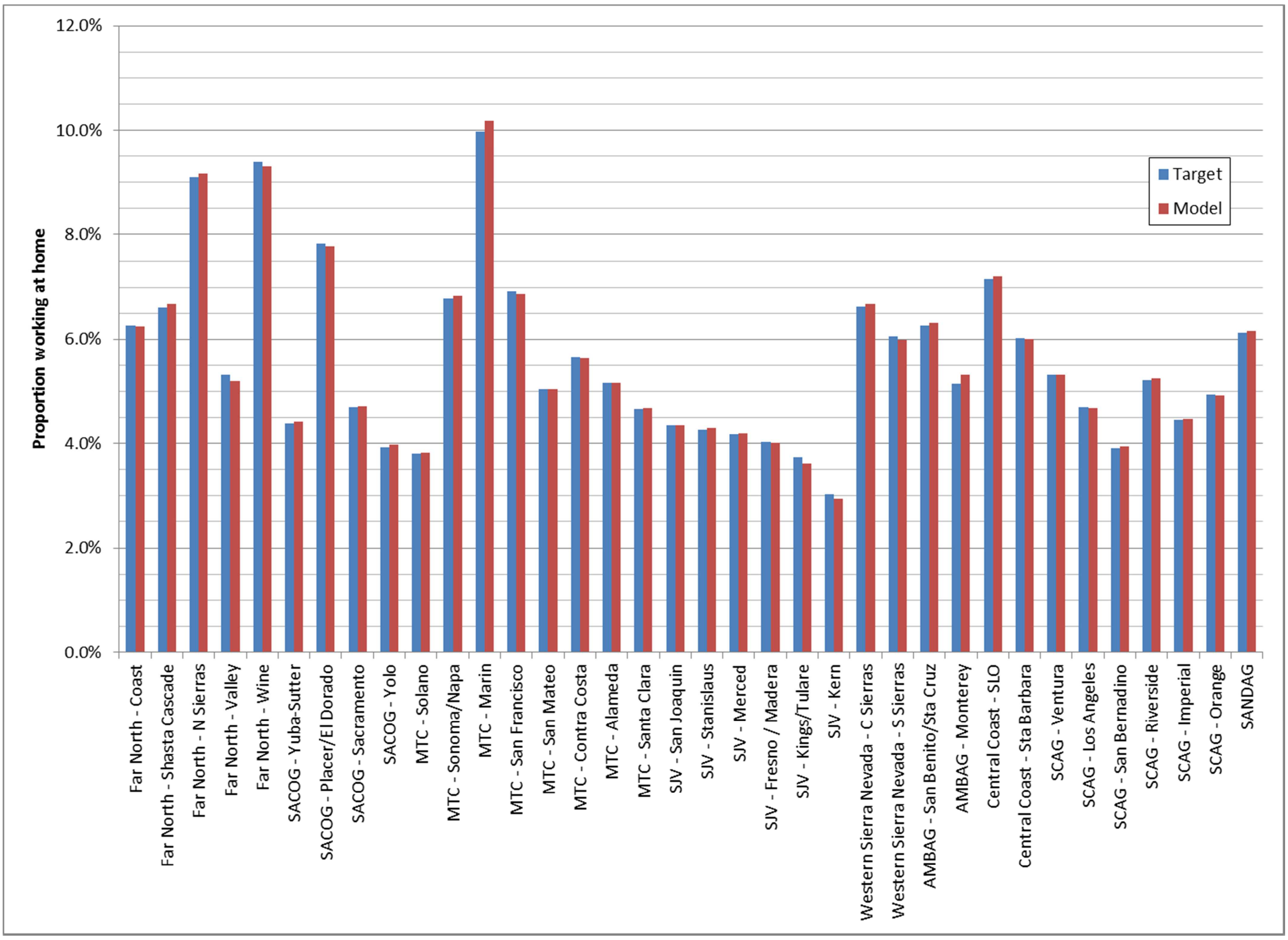
Figure 4.2 Auto Ownership Calibration by Number of Adults (16+)



4.3 Work At Home Model

The Work At Home model was calibrated in conjunction with the origin-destination patterns described in section 4.4 below, since an incorrect proportion of at-home workers would lead to incorrect OD patterns and vice-versa. During calibration of the CSTDM 2.0, specific calibration parameters were added for each of 36 calibration areas developed for the CSTDM 2.0 development, with targets based on the 2007-2011 ACS Table S0801. The parameters are described in Table 3.6. Figure 4.3 below shows the calibration fit; it is excellent.

Figure 4.3 Work At Home Model Calibration



4.4 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 Tables 3.8 and 3.9. 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 3.10 to 3.12.

The first stage calibration status of the Work Location Model is shown in Figure 4.4 and table 4.1. Figures 4.4 shows the trip length distribution by income and auto ownership levels; for no-car households, for households with insufficient autos and for low, medium and high income households with sufficient autos. Figure 4.7 shows the intrazonal proportion by zonal density. The trip length distribution is calculated using 20 'bands' of distances, from 0 to 1 mile up to more than 100 miles. These distances are in free-flow network miles from home to work, and targets were developed from the 2012 CHTS. The trip proportion rate used for the y axis in Figures 4.4 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.

Table 4.1 summarizes two accepted measures of destination choice model performance set out in the 2010 TMIP Model Validation Report; the average distance error and the coincidence index (measuring the correspondence between the trip length bins for the model and the observed data). In general, the calibration matches the observed data well.

Figure 4.4 Work Location Model Calibration – Trip Length

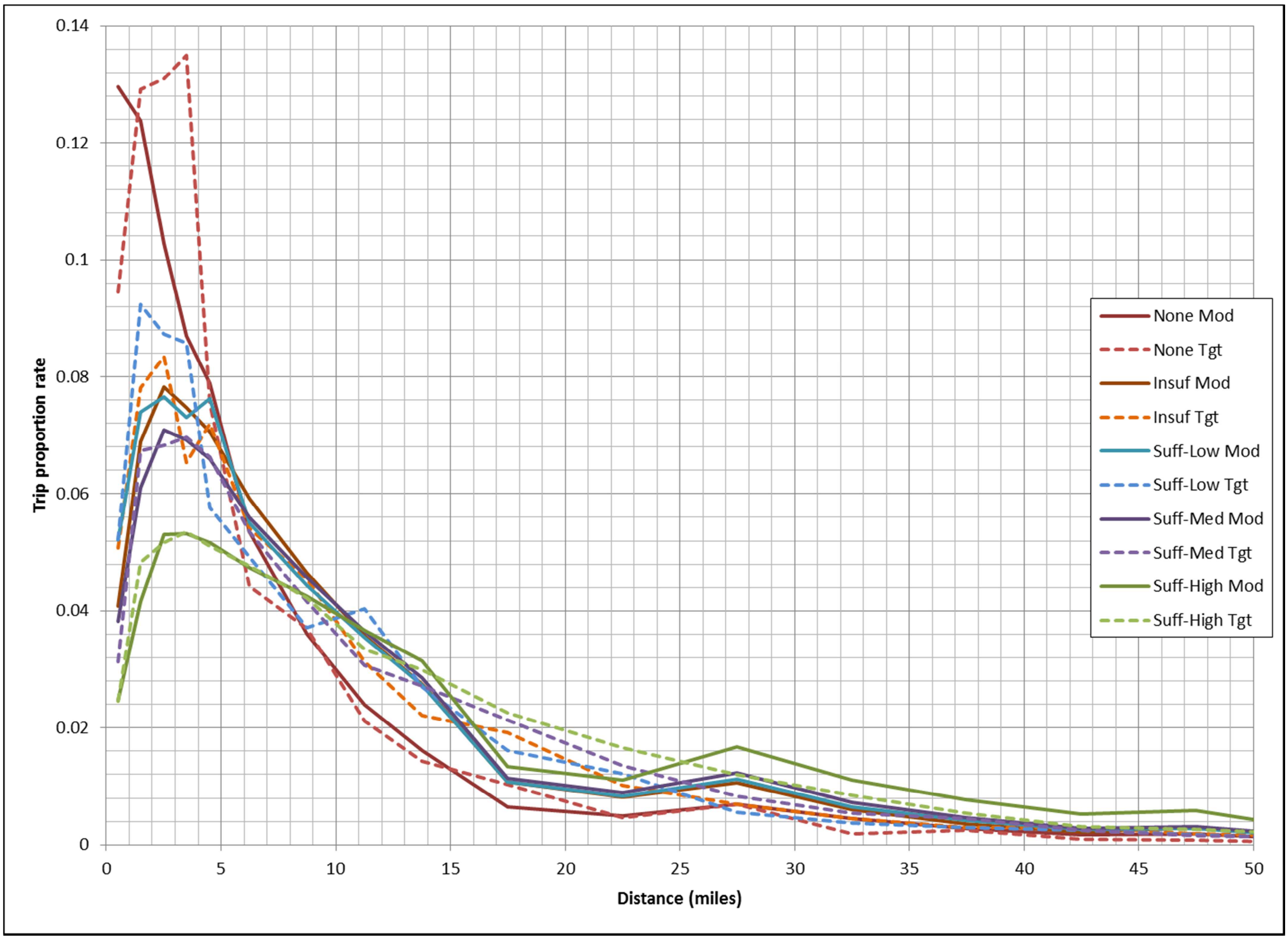


Table 4.1 Work Location Model Calibration – Key Statistics

	Average Trip Length		Trip Length Error	Coincidence Index
	Model	Target		
No autos	8.65	8.11	6.6%	0.811
Insufficent autos	12.60	12.35	2.1%	0.842
Sufficient auto, low income	11.88	11.38	4.4%	0.809
Sufficient auto, med income	13.67	13.60	0.5%	0.845
Sufficient auto, high income	16.54	15.78	4.8%	0.836
2010 TMIP Model Validation Report Recommendation			<5%	>0.70

The second phase of calibration involved matching the ACS origin-destination data at the district level. Because this theoretically involves 36 x 36 = 1296 OD pairs (in reality, about one-half of that because of the 100-mile limit), three selected key measures are presented here. The first is Figure 4.5 and 4.6, which shows the number of workers from a given home district working in a given work district, as a scatter plot, with targets scaled to match the total number of workers for each home district – because the ACS data and model have slightly different numbers of workers in a given county, this compensates for that difference.

The second two are Figures 4.7 and 4.8, which show the number work location ODs from home to work for selected key pairs of districts. The 15 pairs in Figure 4.7 are the 15 with the highest two-way volumes within an MPO (SCAG , MTC or SACOG), and the 15 pairs in Figure 4.8 are the 15 with the highest volume crossing between different MPO or parts of the state. (Note the scales differ; the top ranked interchange on the second chart, San Diego-Riverside, has slightly fewer workers than the 15th ranked interchange on the first chart.) The chart shows the proportions in both directions; the “forward” and “reverse” directions are based on the more frequent / less frequent directions respectively. As an example of how to read these charts, the third set of data in Figure 4.7 is the commute between Contra Costa and Alameda Counties. The red bars show that in the forward direction (Contra Costa to Alameda), the model has 94.5K workers versus 96.5K workers in ACS. In the reverse direction, the green bars show that the model has 40.9K of Alameda County residents working in Contra Costa, where the observed data show 41.3K. The fits are quite good overall.

Figure 4.5 Work Location Model Calibration – Workers by home-work distance pair

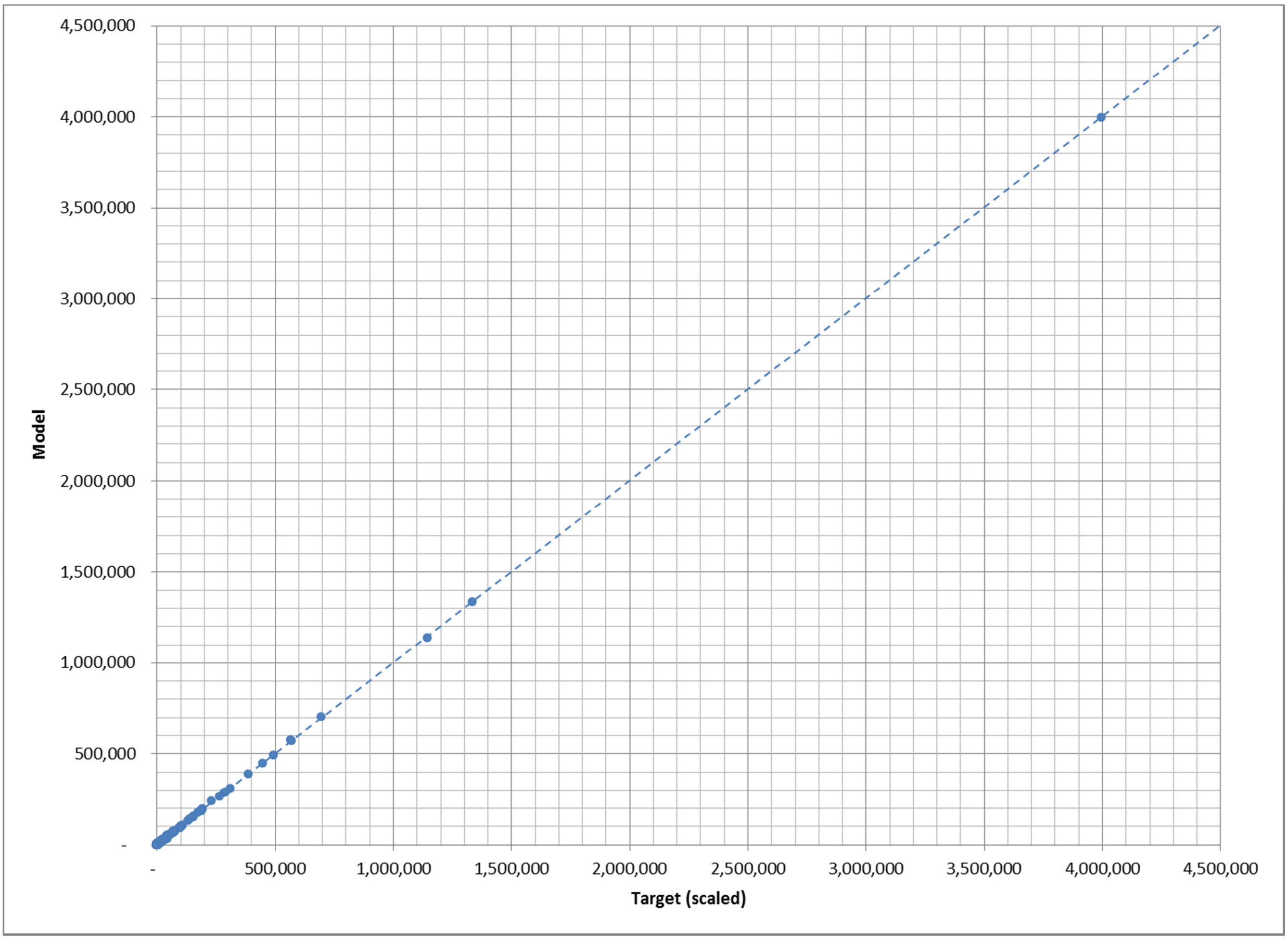


Figure 4.6 Work Location Model Calibration – Workers by home-work distance pair (detail)

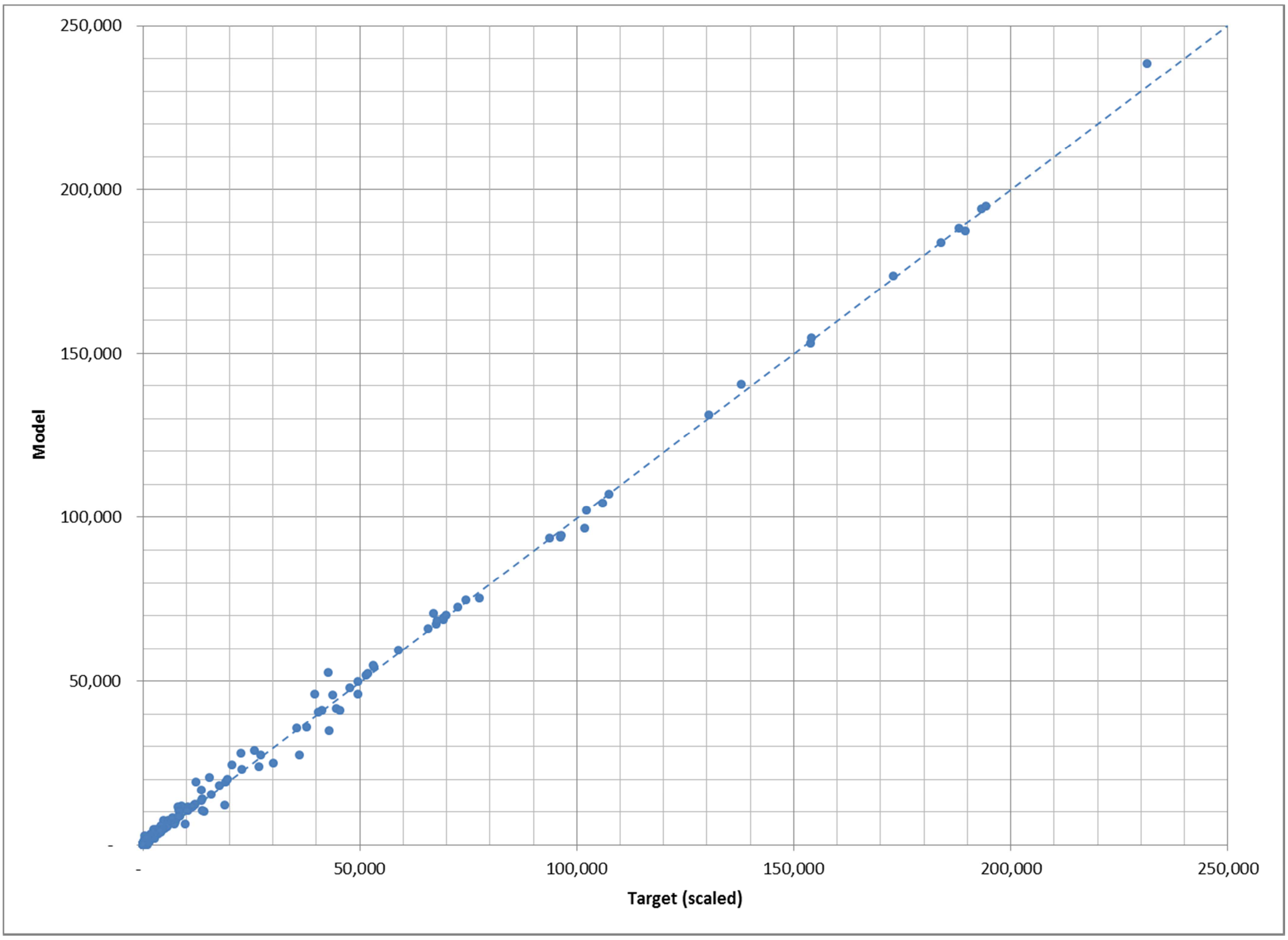


Figure 4.7 Work Location Model Calibration – Key OD Pairs; Intra-MPO

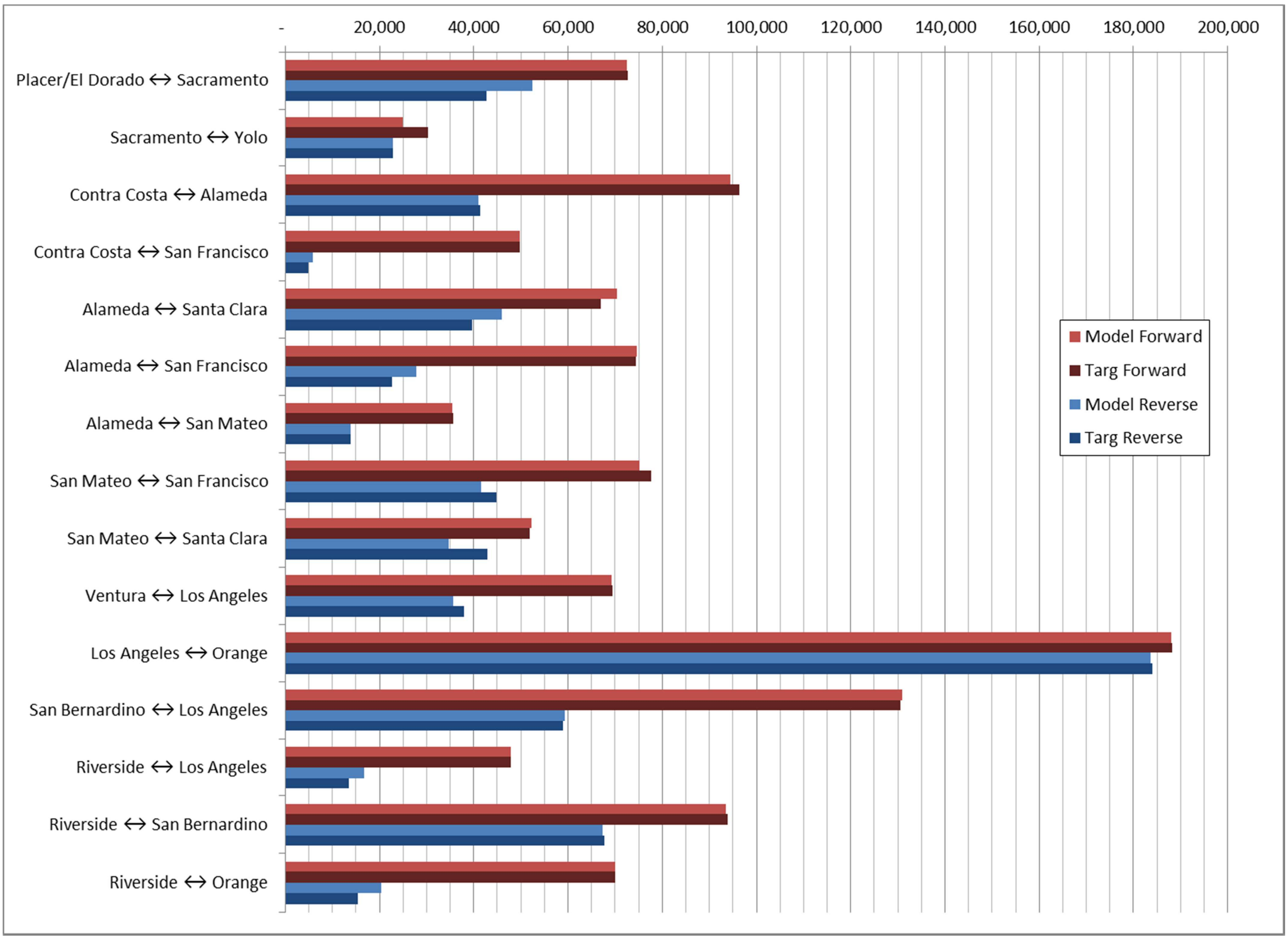
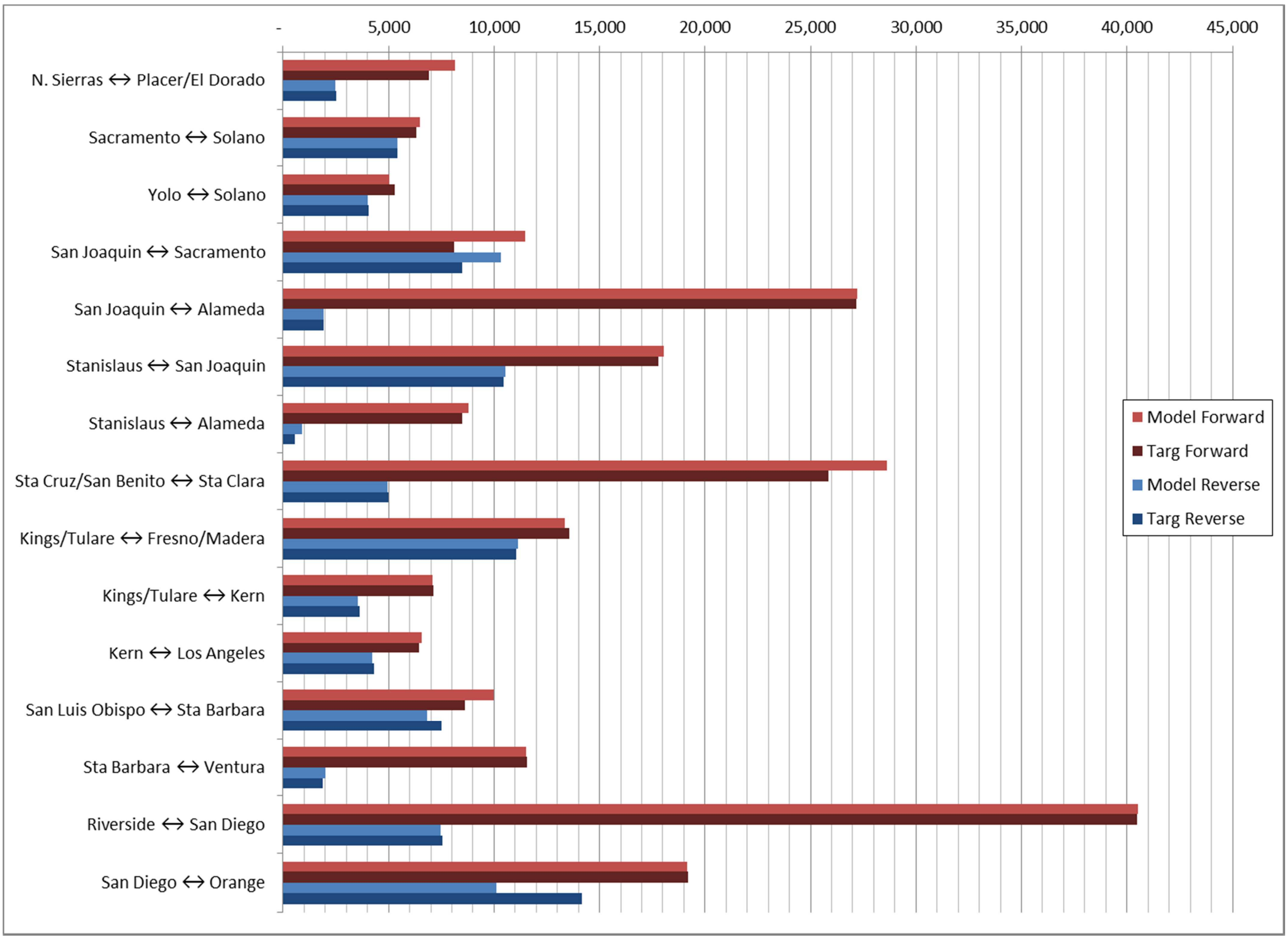


Figure 4.8 Work Location Model Calibration – Key OD Pairs; Interregional



Note: "N. Sierras" are Lassen, Plumas, Sierra and Nevada counties

4.5 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. These updated values are shown in Tables 3.14 and 3.15. Figure 4.9 is the trip length distribution for school by grade, and Table 4.2 shows key statistics. The fit of model to observed data is quite good; there are some distributional issues with very short PSE trips perhaps related to the sampling of dormitory students in the CHTS data.

Figure 4.9 School Location Model Calibration – Trip Length Distribution

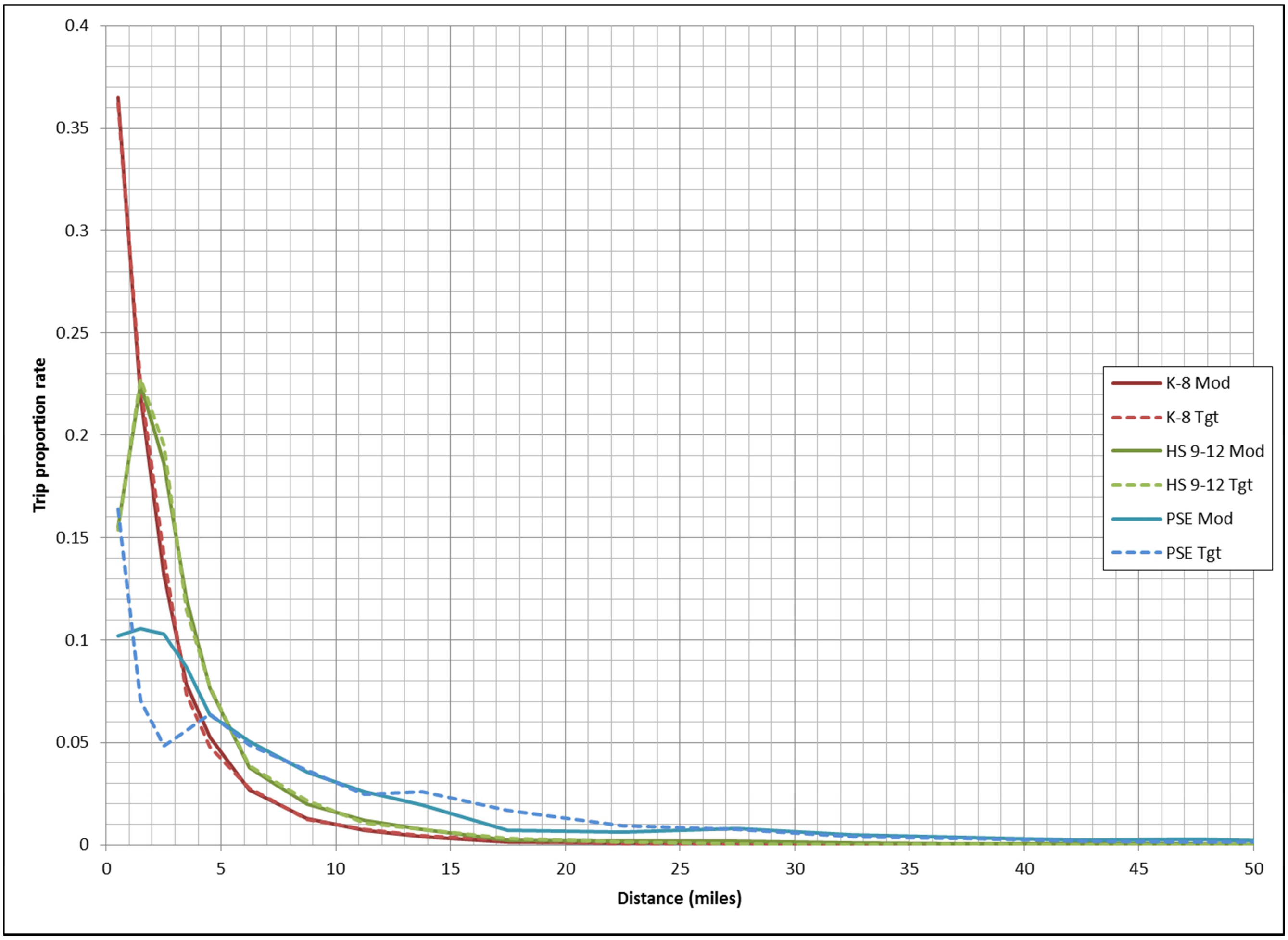


Table 4.2 School Location Model Calibration – Key Statistics

	Average Trip Length		Trip Length Error	Coincidence Index
	Model	Target		
K-8 students	3.12	3.01	3.6%	0.956
High school (9-12) students	4.52	4.27	5.9%	0.952
College (PSE) students	12.02	12.17	-1.2%	0.733
2010 TMIP Model Validation Report Recommendation			<5%	>0.70