SACSIM/05

Activity-Based Travel Forecasting Model for SACOG

Featuring ***DaySim***—the Person Day Activity and Travel Simulator

Technical Memo Number 7

Time of Day / Activity Scheduling Models

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Prepared for

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Time of Day Models

Model Specification

Two types of models were estimated:

Tour primary destination arrival and departure time: For each home-based or work-based tour, the model predicts the time that the person arrives at the tour primary destination, and the time that the person leaves that destination to begin the return half-tour. The model uses 48 half-hour periods in the day—3:00-3:29 AM, 3:30-3:59 constant AM, …, 2:30 AM-2:59 constant AM. Given the way that the activity diary data was collected, no tour begins before 3:00 AM or ends after 2:59 constant AM. The tour model includes as alternatives every possible combination of the 48 alternatives, or 48 x 49 / 2 = 1,716 possible alternatives. The model is applied after the tour primary destination and main mode have already been predicted.

Intermediate stop arrival or departure time: For each intermediate stop made on any tour, this model predicts either the time that the person arrives at the stop location (on the first half tour), or else the time that the person departs from the stop location (on the second half tour). On the second (return) half tour, we know the time that the person departs from the tour primary destination, and, because the model is applied after the stop location and trip mode have been predicted, we also know the travel time from the primary destination to the first intermediate stop. As a result, we know the arrival time at the first intermediate stop, so the model only needs to predict the departure time from among a maximum of 48 alternatives (the same 30 minute periods that are used in the tour models). This procedure is repeated for each intermediate stop on the half tour. On the first (outbound) half tour, the stops are simulated in reverse order from the primary destination back to the tour origin, so we know the departure time from each stop and only need to predict the arrival time.

Estimation Data

Table 1 below shows the number of tours and intermediate stops in the survey data by purpose. These observations were used to estimate 5 separate models:

1. Home-based work tours
2. Home-based school tours
3. Home-based other tours (escort, shopping, personal bus., meal, and social/recreation)
4. Work-based subtours
5. All intermediate stops

Table 1: Sample Sizes

Purpose	Work	School	Escort	Shopping	Pers.Bus	Meal	Soc/Recr	Work-Based	TOTAL
Tours	3,532	1,562	958	1,862	1,569	457	1,235	695	11,870
Intermediate Stops	522	116	1,997	2,145	2,117	880	974	NA	8,751

Figure 1 shows the distribution of observed arrival times at the tour primary destination by tour purpose. School has the highest peak at 8 AM. Work and escort also have a peak at around 8 AM, and escort has another peak at around 2-3 PM, presumably picking up kids at school. Meal activities have the largest peak at dinner time, with a smaller peak at lunch time. Most work-based tours begin near lunch time, while social/recreation activities tend to begin in the evening. Shopping and personal business activities are spread fairly evenly across the day.

Figure 2 shows the distribution of departure times from tour primary activities. Note that for all purposes except work and school, Figures 1and 2 are very similar, indicating that those activities tend to be of shorter duration with similar start and end times. This is confirmed by Figure 3 which shows duration of stay at the tour destination. Most escort (pick up/drop off) activities have duration 0, meaning that they begin and end in the same ½ hour period. The most common duration for school is roughly 7 hours, and for work is 9 hours.

Figure 4 shows the duration distribution for intermediate stops by activity purpose at the stop. In general, intermediate stops are of shorter duration than activities at primary destinations. This is partly by definition, since the rule for determining primary destination uses both activity purpose and duration. In general, work-related stops have the longest duration.

A related question is whether the duration of intermediate stops is a function of the tour purpose and direction. Figure 5 shows that there is not much variation in the duration distribution by tour type/direction. The largest difference is for work tours, with intermediate stops on the way home from work tending to have longer duration than stops on the way to work.

Figure 1

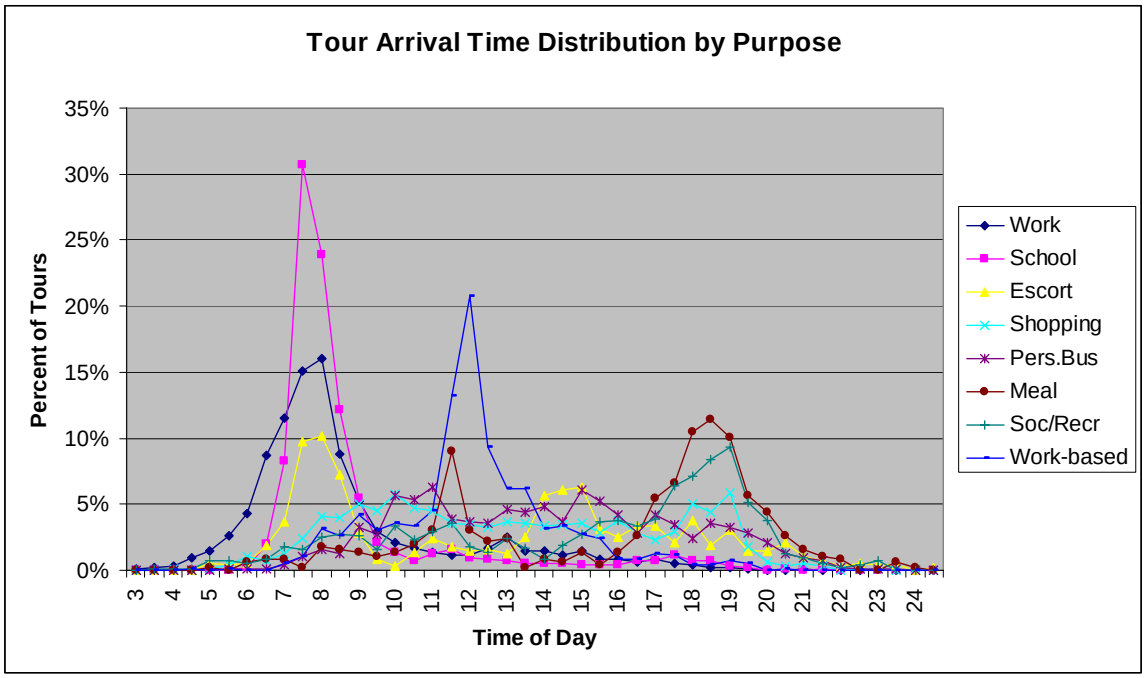


Figure 2

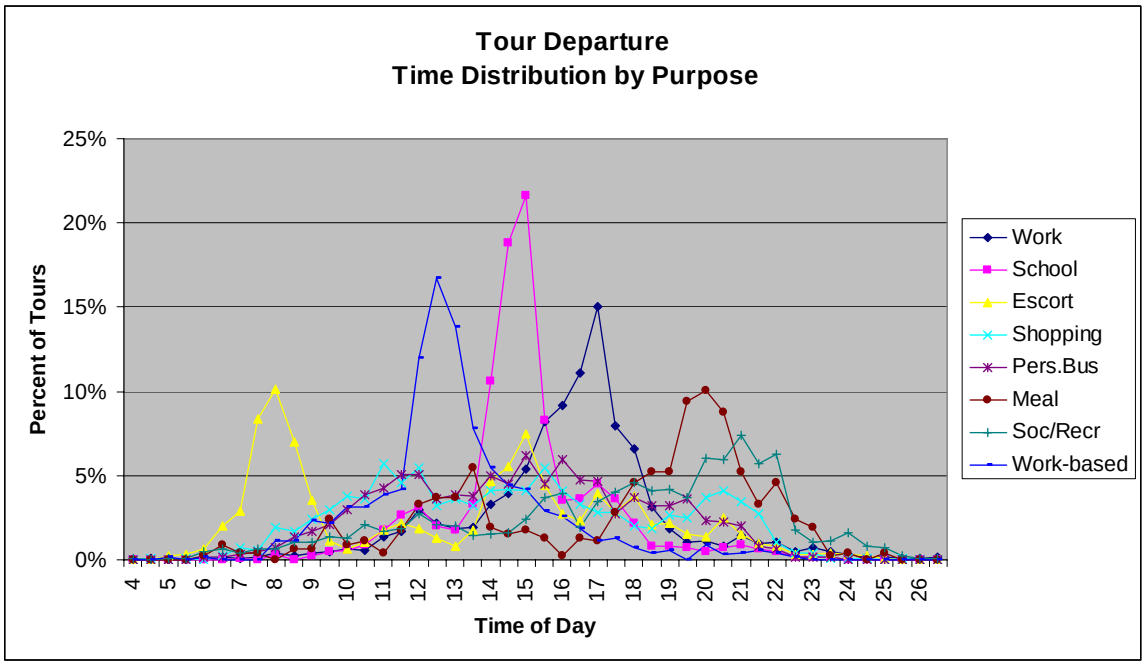


Figure 3

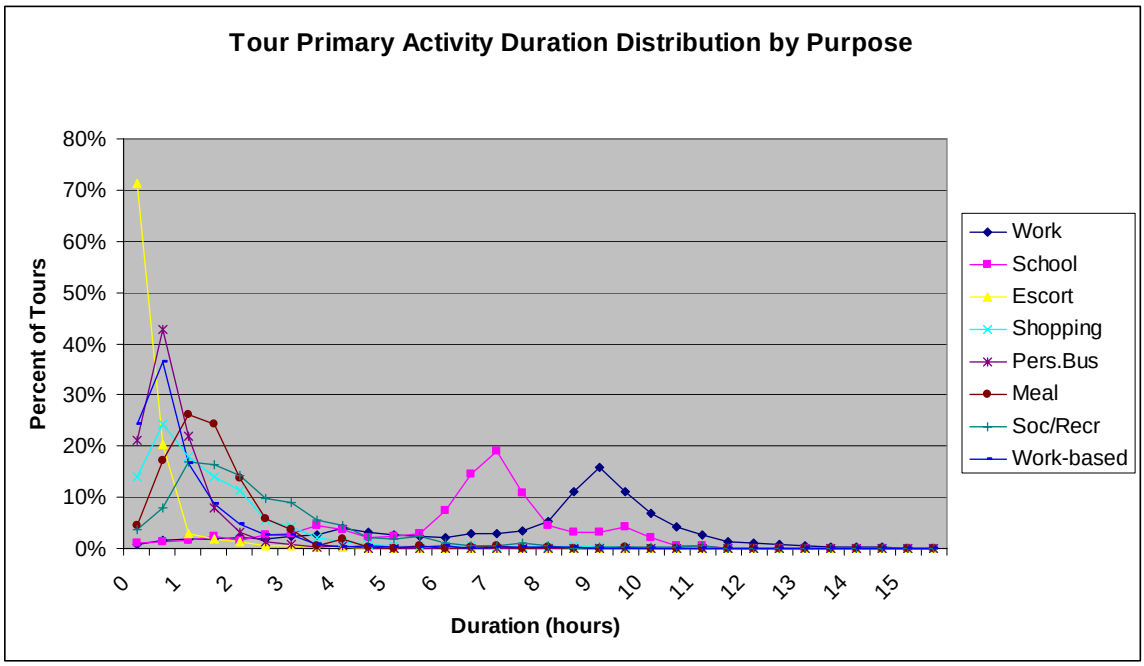


Figure 4

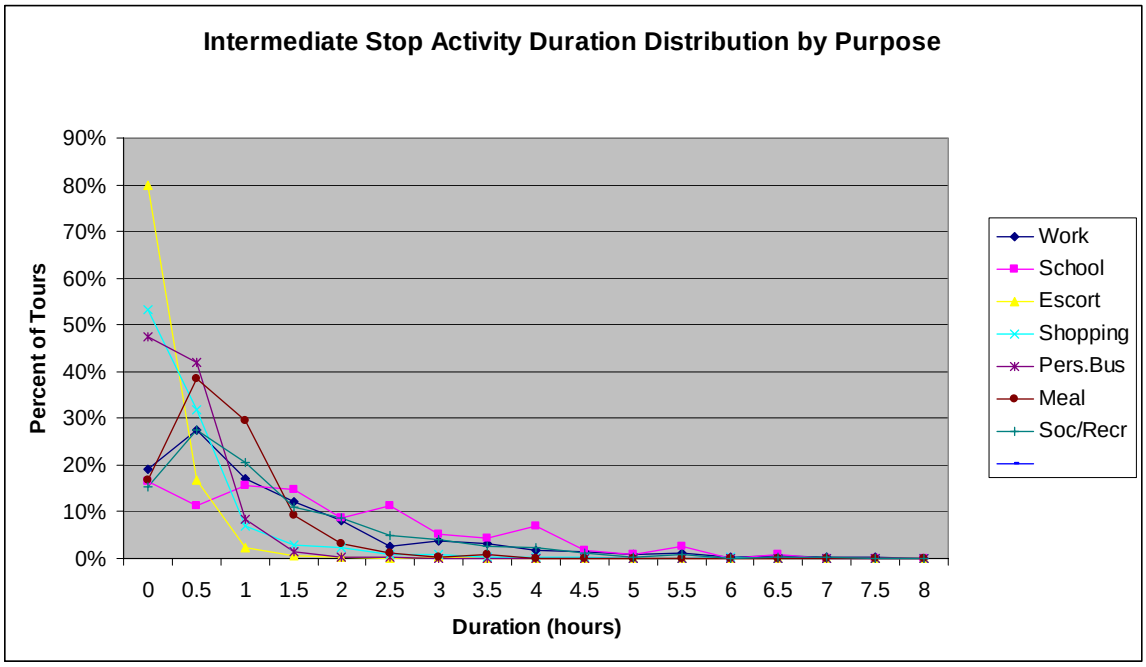
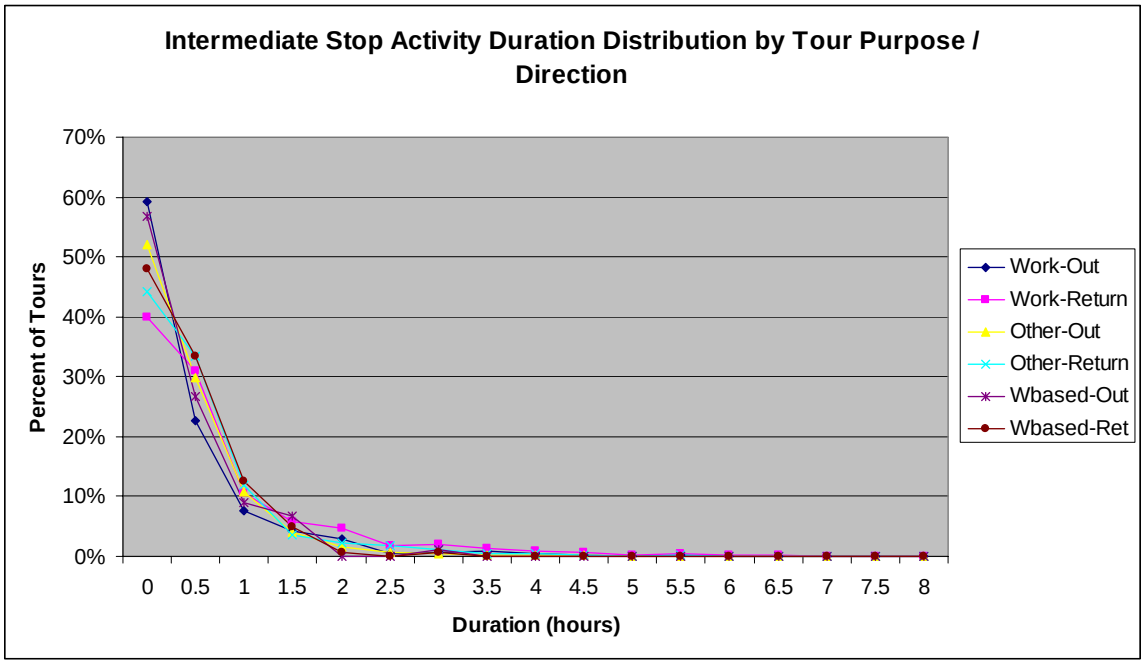


Figure 5


Intermediate Stop Activity Duration Distribution by Tour Purpose / Direction
Percent of Tours
70%
60%
50%
40%
30%
20%
10%
0%
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
Duration (hours)
Work-Out
Work-Return
Other-Out
Other-Return
Wbased-Out
Wbased-Ret

Estimation Results

The estimation results are shown in Tables 2-6, and the model fit statistics in Table 7. Below is a brief description of the key results, listed by variable type:

Constants

Each alternative in the models is characterized by three separate dimensions: arrival time, departure time, and duration of stay. Any one of these is defined by the other two—for example, the departure time equals the arrival time plus the duration of stay. In all of the models, we use 10 period-specific constants for each of the three dimensions (parameters 11-40). One of the 10 constants is constrained to 0, and the other 9 are estimated relative to the constrained one. It would be possible to estimate many more constants (the tour models have 1716 alternatives, so could support 1715 constants), but it is best to use constants only for the key periods, and let the rest of the variables explain the time periods as much as possible.

In the intermediate stop model, the departure time is fixed for stops on the outbound half tour, so those observations only contribute to the constants for arrival time and duration, and the arrival time is fixed for stops on the return half tour, so those observations only contribute to the constants for departure time and duration.

For work and school tours, which are generally the highest priority tour of the day and thus have the entire day available for scheduling, the constants are generally negative, because the coefficients for the most commonly chosen times are constrained to 0. For other tours and work-based subtours, the set of available alternatives is generally much more restricted because other tours and trips have already been scheduled and those limit the available time window. As a result, the constants for those models do not follow a clear pattern, because the (non-) availability of alternatives is doing much of the "job" that the constants would do otherwise. The same is true for the intermediate stop models, which tend to have the most restricted time windows.

Person type variables

People with different roles in the household may tend to schedule their activities differently. This is captured in the models mainly through the role of **shift variables.** These are dummy variables interacted with the arrival time and the duration of the alternative. If the arrival shift variable is negative, it means that activities tend to made earlier, and if is positive, it means that activities tend to be made later. If the duration shift variable is negative, it means that activities tend to be shorter, and if it positive, activities tend to be longer. No departure shift variable is estimated because the departure shift is simply the sum of the arrival shift and the duration shift (e.g. if the arrival shift is an hour earlier and the duration shift is an hour longer, the departure shift is 0). For that reason, if either the arrival or duration shift is significant, both variables have been retained in the model. (This is not true for the intermediate stop model, where in most cases only the duration shift is relevant.)

Findings for the person type variables are:

- Work: Part-time workers, university students, K-12 students age 16+, and other adults tend to all begin work later than full-time workers. Part-time workers and other adults

also tend to work for the shortest duration. A dummy variable was added to capture the fact that full time workers rarely have work duration of less than 9 hours.

- School: Relative to the base group, K-12 students age 5-15, K-12 students age 16+ tend to arrive at school earlier and stay longer. All other person types tend to arrive at school later. University students stay at school for a somewhat shorter duration, while preschool children stay for a longer duration—presumably for as long as their parents stay at work.

- Other tours: University and K-12 students tend to begin their non-mandatory tours somewhat later in the day, while retired persons age 65+ tend to begin their non-mandatory tours earlier in the day, even after taking into account previously scheduled tours. Non-working adults, both over and under age 65, tend to make shorter non-mandatory tours.

- Work-based subtours: Part-time workers make subtours of slightly longer duration, although this coefficient may be offsetting availability effects (part-time workers have a shorter available time window).

- Intermediate stops: University students and children tend to make longer duration stops than adults do.

Income variables:
Income-related variables were only significant for work tours. The findings are:

- Low income workers tend to work slightly shorter duration, while high income workers tend to work somewhat longer duration.

- High income workers are less likely to have extreme hours: they are less likely to arrive at work before 6 AM or depart after 10 PM.

Purpose variables:
Other than the work and school tour models, several activity purposes were combined in the models. Thus, activity purpose variables are very important for determining scheduling:

- Other tours: Relative to personal-business activities, people tend to arrive earlier for escort activities and later for shopping, meal and social/recreation activities. Escort and shopping activities also tend to be much shorter in duration, while social/recreation activities are much longer.

- In addition to the shift variables, some dummy variables are also significant: Escort and shopping activities are likely to last less than an hour, and shopping and meal activities are likely to last 1-2 hours. Shopping activities are unlikely to begin before 7 AM or end after 9 PM. Meal activities are also unlikely to end after 9 PM. Escort activities are relatively likely to end after 9 PM.

- Work-based subtours: Relative to work-related activities on subtours, escort, meal and shopping activities tend to start later and be of shorter duration. Social/recreation

activities also tend to start later, while personal business activities are also of shorter duration.

- Intermediate stops: Compared to work-related activities, stops for escort, shopping, meal, and personal business activities all tend to be of shorter duration. Escort, shopping, social/recreation and personal business stops also tend to be somewhat later in the day. These results are very similar to those in the work-based subtour model.

Presence of stops and subtours

Activities may be scheduled differently depending on the complexity of the tour and how many stops need to be scheduled. The tour time of day models are applied before the exact number and purpose of stops for a tour are determined. So, all we know at this stage is the number of purposes for which 1+ intermediate stops must be made, as well as the number of tours to be made.

- Work tours**:** The more purposes for which intermediate stops must be made, the shorter the duration at the primary destination. This effect is stronger when the work tour is the only tour of the day, in which case all stops must be part of that work tour. When the person makes 1+ escort stops in the day, the work activity tends to be both earlier and longer, presumably staying at work longer to coordinate schedules with a passenger. (The escort stop is not always part of the work tour, but it is in most cases.) The more work-based subtours that are part of the tour, the longer the total duration of the work activity (including the subtour). There is also a slight shift to later arrival times for tours with subtours, indicating that those people tend to depart later from work.

- School tours: The results are generally the same as for work tours, except that the influence of escort stops on duration is not as large.

- Other tours: These same variables for other non-mandatory tours have much less significant effects, with only the positive effect of escort stops on activity duration significant. Even if the tour is the only tour of the day, the duration of stay at the primary destination is not affected by the number of intermediate stops.

- Intermediate stops: Compared to stops made on the outbound half of a non-work tour, stops made on the return half of a non-work tour or on either half of a work-based subtour tend to be shorter. On the other hand, stops made as part of work tours tend to last longer.

Position of the tour in simulation priority order: Due to the rules for ordering tours by purpose and duration, there are some systematic effects on scheduling related to the simulation order:

- Work tours: If there are 2+ work tours made during the day, the lower priority one(s) tend to happen later and last longer than would be expected based on the available time window alone. In such cases, all work tours are more likely to last less than 8 hours, particularly the lower priority one(s). If the work tour is complimented by one or more tours of different purposes, then it is somewhat less likely to last less than 8 hours. (This effect probably offsets schedule pressure effects described below.)

- Other tours: If there are 2+ tours in the day for the same purpose, the highest priority one tends to be of longer duration, and the lower priority one(s) tend to be both shorter and earlier, compared to cases with just 1 tour. If there are 2+ tours in the day for different purposes, the lower priority one(s) tend to be both shorter and earlier than otherwise, and also tend to be of less than 4 hours duration. These latter effects are in addition to the availability effects of "shrinking" the available time window by the time spent in the higher priority tour(s).

Periods partially used

In the simulation, it is possible to arrive at the primary destination if another tour ended in that period, and possible to leave a primary destination if another tour began in that period. Such cases should be less likely, however, because part of the period is already "used up". These variables have negative and significant coefficients in all 5 models.

Schedule pressure effects

For each time period, six variables are used to calculate time pressure effects:

1. Duration of the adjacent empty window before period starts
2. Duration of the maximum consecutive empty window before the period starts
3. Total duration of all empty windows in the day before the period starts
4. Duration of the adjacent empty window after the period ends
5. Duration of the maximum consecutive empty window after the period ends
6. Total duration of all empty windows in the day after the period ends

These variables, along with the remaining number of tours to be scheduled in the day after scheduling the current tour, are used to calculate several other variables:

- Work tours: The overall scheduling pressure is given by the number of tours remaining to be scheduled divided by the total empty window that would remain if an alternative is chosen. The negative effect indicates that people are less likely to choose schedule alternatives that would leave them with much time to schedule and little time to schedule it in. A similar variable is the number of tours remaining divided by the maximum consecutive time window. This is also negative, meaning that people with more tours to schedule will tend to try to leave a large consecutive block of time rather than two or more smaller blocks. In other words, they will tend to "crowd" the work tour and any other tours together rather than spacing them evenly across the day. As an offsetting effect, they will tend to avoid leaving small blocks of time immediately before the work activity.

- School tours: The estimated effects are very similar to those found for work tours.

- Other tours: Again, the effects are similar to those found for work and school tours. The main difference is that the overall time pressure effect is stronger, but the other effects are weaker, and there is evidence that people will try to space tours more evenly in the day.

- Work-based subtours: People try to leave consecutive windows both before and after the tour, meaning a tendency to "center" the subtour during the duration of the work activity.

- Intermediate stops: Stops will tend to be shorter when there are more tours to be scheduled in the day, and also when there more stops to scheduled on the half tour.

Travel time

The travel time for the period is based on the network travel times for the 4 periods of the day – AM peak, midday, PM peak, and off-peak. The variable is applied for both the outbound half tour (tour origin to tour destination) and the return half (tour destination to tour origin). For auto, the time is just the in-vehicle time, while transit time is in-vehicle time plus first wait time, transfer time, and drive access time. Walk access/egress time is not included, as that does not vary by time period. These variables are not applied for walk, bike or school bus tours.

- Work tours: For both auto and transit tours, both outbound and return half tours, the travel time coefficient is marginally significant at about -0.04 to -0.05. (One coefficient was constrained to have a value similar to the unconstrained ones.) If there is no network transit path in the period, that has a significant negative effect for transit tours (equivalent to about 70 minutes travel time). Note that not every trip in a transit tour has to be by transit, so it would be possible for somebody making a transit tour to arrive or depart work during a period when transit is not available.

- School tours: No significant travel time effects were found for school tours.

- Other tours: Large and significant negative travel time effects were found for auto tours, but not for transit tours. (There are relatively few transit tours for these purposes.) There were no transit tours observed to begin or end in periods when transit was not available, so this coefficient was constrained to -5.0.

- Work-based subtours: No significant travel time effects were found for subtours.

- Intermediate stops: The results are very similar to those for non-mandatory tours, with significant effects for auto time and for transit path not available.

Auto congestion effects

There may also be effects for time shifts **within** the AM peak and PM periods. For this purpose, the variable used was the extra time spent on links where the congested time is over 20% higher than the free flow time. (Include formula here). This extra congested time was converted to shift variables by multiplying by the time difference between the period and the "peak of the peak":

1. AM shift earlier: If the period is 6 AM to 8 AM, multiply by (8 AM – time)
2. AM shift later: If the period is 8 AM to 10 AM, multiply by (time – 8 AM)
3. PM shift earlier: If the period is 3 PM to 5 PM, multiply by (5 PM – time)
4. PM shift later: If the period is 5 PM to 7 PM, multiply by (time – 5 PM)

With this formulation, the more positive the coefficient and the larger the congested time, the more that the peak demand is spread away from the peak of the peak.

- Work tours: For both AM and PM, the tendency is to move the work activity earlier as the time in very congested conditions increases. Note that a number of "time missing" variables are also included. These are included so that non-auto tours or auto tours with

missing geocodes do not bias the estimates, as they would if they were treated as auto tours with 0 congestion. Behaviorally, these coefficients are not of interest.

- School tours and work-based subtours: No significant congestion effects were estimated.

- Other tours: The PM peak was found to shift both earlier and later with high congestion. No effects were found for the AM peak, where there are fewer such tours.

- Intermediate stops: Small positive effects were found for the AM peak shifting both earlier and later and the PM peak shifting earlier. Although these effects are not significant, they are of the correct sign, so were retained.

Table 2: Home-based Work Tour Arrival and Departure Time Model

Coef #	Variable description	Estimate	T-stat
11	Arrival 0300 - 0559 constant	-2.1958	-13.1
12	Arrival 0600 - 0659 constant	-0.6919	-6.6
13	Arrival 0700 - 0759 constant	-0.1168	-1.7
14	Arrival 0800 - 0859 constant	0.0000	Constr.
15	Arrival 0900 - 0959 constant	-0.9072	-11.5
16	Arrival 1000 - 1259 constant	-1.7580	-13.1
17	Arrival 1300 - 1559 constant	-1.8168	-7.9
18	Arrival 1600 -1859 constant	-2.4870	-7.5
19	Arrival 1900 - 2159 constant	-3.8442	-7.7
20	Arrival 2200 - 0259 constant	-5.1755	-6.3
21	Depart 0300 - 0659 constant	-0.8102	-1.8
22	Depart 0700 - 0959 constant	-0.9947	-3.6
23	Depart 1000 - 1259 constant	-0.1798	-1.1
24	Depart 1300 - 1559 constant	-0.0962	-1.3
25	Depart 1600 - 1659 constant	0.0000	Constr.
26	Depart 1700 - 1759 constant	0.0029	0.0
27	Depart 1800 - 1859 constant	-0.8363	-8.1
28	Depart 1900 - 2059 constant	-2.2834	-15.0
29	Depart 2100 - 2359 constant	-2.7267	-12.5
30	Depart 2400 - 0259 constant	-4.5953	-13.2
31	Duration 0 - 259 constant	-0.4520	-1.5
32	Duration 300 - 459 constant	0.1503	0.6
33	Duration 500 - 659 constant	0.1030	0.5
34	Duration 700 - 859 constant	0.4339	2.8
35	Duration 900 - 959 constant	0.0000	Constr.
36	Duration 1000 - 1059 constant	-0.4829	-7.2
37	Duration 1100 - 1159 constant	-1.3272	-11.8
38	Duration 1200 - 1359 constant	-2.3789	-14.1
39	Duration 1400 - 1759 constant	-4.5120	-14.2
40	Duration 1800 - 2359 constant	-7.0030	-8.2
41	Part-time worker-Arrival shift	0.0307	2.8
42	Part-time worker-Duration shift	-0.0442	-2.9
45	Uinversity student -Arrival shift	0.0927	5.3
46	University student-Duration shift	0.0224	0.9
49	K12 student 16+ -Arrival shift	0.1889	7.3
50	K12 student 16+ -Duration shift	-0.0190	-0.5
43	Other non-worker -Arrival shift	0.0559	2.3
44	Other non-worker -Duration shift	-0.1011	-3.0
71	Full-time worker - Duration < 900	-1.3676	-8.6
51	Income <$15K - Arrival shift	0.0155	1.3
52	Income <$15K - Duration shift	-0.0307	-2.1
53	Income >$75K - Arrival shift	0.0097	0.9
54	Income >$75K - Duration shift	0.0259	2.5
72	Income <$75K - Arrival before 0600	-0.3683	-3.0
73	Income >$75K - Depart after 2200	-0.8499	-3.4

Table 2: Home-based Work Tour Arrival and Departure Time Model (continued)

Coef #	Variable description	Estimate	T-stat
61	# stop purposes/only tour - Arrival shift	-0.0048	-0.8
62	# stop purposes/only tour - Duration shift	-0.0759	-12.5
63	# stop purposes/mult. tours - Arrival shift	0.0084	1.7
64	# stop purposes/mult. tours - Duration shift	-0.0506	-8.2
67	Escort stops in day - Arrival shift	-0.0269	-2.6
68	Escort stops in day - Duration shift	0.0430	3.7
69	# subtours in tour - Arrival shift	0.0171	1.8
70	# subtours in tour - Duration shift	0.1487	14.3
57	Lower of 2+ work tours - Arrival shift	0.0597	2.2
58	Lower of 2+ work tours - Duration shift	0.1964	4.3
81	Higher of 2+ work tours- Duration<800	1.9103	8.7
82	Lower of 2+ work tours- Duration<800	5.0000	Constr.
83	Higher of 2+ different tours- Duration<800	-0.4524	-3.8
91	Arrival period partially used	-1.5832	-4.0
92	Departure period partially used	-1.5249	-2.5
93	Empty window remaining before- 1st tour	-0.1084	-3.9
94	Empty window remaining after - 1st tour	-0.2046	-7.5
95	Empty window remaining before- 2nd+ tour	0.0962	1.9
96	Empty window remaining after - 2nd+ tour	0.0946	2.5
97	Remaining tours/total remaining window	-77.5309	-6.1
98	Remaining tours/maximum remaining window	-20.7164	-5.0
99	Remaining tours/adjacent window before	-0.8229	-3.1
100	Remaining tours/adjacent window after	-0.0679	-0.3
85	Auto travel time (min) - outbound period	-0.0526	-1.7
86	Auto travel time (min) - return period	-0.0400	Constr.
87	Transit travel time (min) - outbound period	-0.0410	-1.7
88	Transit travel time (min) - return period	-0.0433	-1.9
89	No transit path in period	-2.8379	-1.9
101	Auto AM congested time - shift earlier	0.0323	5.5
103	Auto PM congested time - shift earlier	0.0347	5.2
105	Auto AM time missing - shift earlier	0.1380	1.3
106	Auto AM time missing - shift later	-0.1187	-1.0
107	Auto PM time missing - shift earlier	0.1672	1.7
108	Auto PM time missing - shift later	-0.3751	-3.3

Table 3: Home-based School Tour Arrival and Departure Time Model

Coef #	Variable description	Estimate	T-stat
11	Arrival 0300 - 0559 constant	-10.0000	Constr
12	Arrival 0600 - 0659 constant	-3.1769	-15.4
13	Arrival 0700 - 0759 constant	-0.1488	-2.0
14	Arrival 0800 - 0859 constant	0.0000	Constr
15	Arrival 0900 - 0959 constant	-1.2758	-10.9
16	Arrival 1000 - 1259 constant	-2.3804	-12.9
17	Arrival 1300 - 1559 constant	-3.1937	-9.4
18	Arrival 1600 -1859 constant	-2.3961	-5.2
19	Arrival 1900 - 2159 constant	-4.0757	-6.2
20	Arrival 2200 - 0259 constant	-10.0000	Constr
21	Depart 0300 - 0659 constant	-10.0000	Constr
22	Depart 0700 - 0959 constant	-0.9307	-2.3
23	Depart 1000 - 1259 constant	0.9092	4.2
24	Depart 1300 - 1559 constant	1.7734	14.1
25	Depart 1600 - 1659 constant	0.0000	Constr
26	Depart 1700 - 1759 constant	-0.1961	-1.3
27	Depart 1800 - 1859 constant	-1.3392	-6.2
28	Depart 1900 - 2059 constant	-1.9347	-7.6
29	Depart 2100 - 2359 constant	-2.7719	-8.1
30	Depart 2400 - 0259 constant	-10.0000	Constr
31	Duration 0 - 259 constant	-2.2150	-5.9
32	Duration 300 - 459 constant	-1.2738	-4.4
33	Duration 500 - 659 constant	-1.0923	-5.2
34	Duration 700 - 859 constant	-0.0272	-0.2
35	Duration 900 - 959 constant	0.0000	Constr
36	Duration 1000 - 1059 constant	0.3146	1.8
37	Duration 1100 - 1159 constant	-0.5924	-1.9
38	Duration 1200 - 1359 constant	-2.3843	-4.2
39	Duration 1400 - 1759 constant	-2.7444	-3.8
40	Duration 1800 - 2359 constant	-10.0000	Constr
41	Part-time worker-Arrival shift	0.1900	3.4
42	Part-time worker-Duration shift	-0.0236	-0.3
139	Full-time worker-Arrival shift	0.2606	8.5
140	Full-time worker-Duration shift	0.0974	2.7
47	Non-worker 65+ -Arrival shift	0.1900	3.4
48	Non-worker 65+ -Duration shift	-0.0236	-0.3
43	Other non-worker -Arrival shift	0.1900	3.4
44	Other non-worker -Duration shift	-0.0236	-0.3
45	Uinversity student -Arrival shift	0.1728	8.4
46	University student-Duration shift	-0.0380	-1.9
49	K12 student 16+ -Arrival shift	-0.0701	-2.1
50	K12 student 16+ -Duration shift	0.0741	3.6
143	Child age 0-4 -Arrival shift	0.0920	2.2
144	Child age 0-4 -Duration shift	0.1670	5.8

Table 3: Home-based School Tour Arrival and Departure Time Model

Coef #	Variable description	Estimate	T-stat
61	# stop purposes/only tour - Arrival shift	-0.0101	-0.7
62	# stop purposes/only tour - Duration shift	-0.0510	-4.3
65	# stop purposes/mult. tour - Arrival shift	-0.0262	-2.0
66	# stop purposes/mult. tour - Duration shift	-0.0661	-5.3
67	Escort stops in day - Arrival shift	-0.0342	-1.4
68	Escort stops in day - Duration shift	0.0750	3.4
91	Arrival period partially used	-1.8658	-3.1
92	Departure period partially used	-2.7304	-2.6
93	Empty window remaining before- 1st tour	-0.0230	-0.8
94	Empty window remaining after - 1st tour	-0.0641	-2.7
95	Empty window remaining before- 2nd+ tour	0.0965	2.4
96	Empty window remaining after - 2nd+ tour	0.0607	2.0
97	Remaining tours/total remaining window	-78.6755	-5.6
99	Remaining tours/adjacent window before	-2.0269	-2.1
100	Remaining tours/adjacent window after	-1.59 constant74	-1.5

Table 4: Home-based Other Tour Arrival and Departure Time Model

Coef #	Variable description	Estimate	T-stat
11	Arrival 0300 - 0559 constant	-4.1869	-17.1
12	Arrival 0600 - 0659 constant	-1.9909	-13.1
13	Arrival 0700 - 0759 constant	-0.7600	-8.9
14	Arrival 0800 - 0859 constant	0.0000	Constr
15	Arrival 0900 - 0959 constant	-0.0294	-0.4
16	Arrival 1000 - 1259 constant	0.2904	3.1
17	Arrival 1300 - 1559 constant	0.5652	4.1
18	Arrival 1600 -1859 constant	1.0069	5.6
19	Arrival 1900 - 2159 constant	0.6179	2.8
20	Arrival 2200 - 0259 constant	-1.1000	-3.6
21	Depart 0300 - 0659 constant	-0.2679	-0.9
22	Depart 0700 - 0959 constant	0.0319	0.2
23	Depart 1000 - 1259 constant	0.1363	1.1
24	Depart 1300 - 1559 constant	0.2635	3.5
25	Depart 1600 - 1659 constant	0.0000	Constr
26	Depart 1700 - 1759 constant	-0.3129	-4.0
27	Depart 1800 - 1859 constant	-0.5627	-6.1
28	Depart 1900 - 2059 constant	-0.4799	-4.5
29	Depart 2100 - 2359 constant	-0.7410	-4.8
30	Depart 2400 - 0259 constant	-2.2996	-9.2
31	Duration 0 - 59 constant	-0.8314	-8.7
32	Duration 100 - 159 constant	-0.1588	-2.5
33	Duration 200 - 259 constant	0.0000	Constr
34	Duration 300 - 459 constant	-0.4028	-5.5
35	Duration 500 - 659 constant	-0.8494	-5.3
36	Duration 700 - 859 constant	-0.8150	-3.2
37	Duration 900 - 1159 constant	-0.7825	-2.2
38	Duration 1200 - 1359 constant	-2.7541	-3.2
39	Duration 1400 - 1759 constant	-1.6635	-2.2
40	Duration 1800 - 2359 constant	-10.0000	Constr
41	Part-time worker-Arrival shift	-0.0085	-1.2
42	Part-time worker-Duration shift	-0.0140	-0.6
43	Other non-worker -Arrival shift	-0.0049	-0.9
44	Other non-worker -Duration shift	-0.0344	-2.2
45	Uinversity student -Arrival shift	0.0239	2.4
46	University student-Duration shift	0.0201	0.8
47	Non-worker 65+ -Arrival shift	-0.0261	-4.9
48	Non-worker 65+ -Duration shift	-0.0467	-3.3
49	K12 student 16+ -Arrival shift	0.0325	2.2
50	K12 student 16+ -Duration shift	0.0509	1.6
141	Child age 5-15 -Arrival shift	0.0123	1.4
142	Child age 5-15 -Duration shift	0.0165	0.9
143	Child age 0-4 -Arrival shift	-0.0115	-1.2
144	Child age 0-4 -Duration shift	0.0154	0.7

Table 4: Home-based Other Tour Arrival and Departure Time Model (continued)

Coef #	Variable description	Estimate	T-stat
145	Escort tour - Arrival shift	-0.0271	-3.8
146	Escort tour - Duration shift	-0.4407	-8.7
147	Shopping tour - Arrival shift	0.0245	4.4
148	Shopping tour – Duration shift	-0.1175	-3.5
149	Meal tour - Arrival shift	0.0872	8.9
150	Meal tour - Duration shift	0.0530	1.6
151	Social/recreation tour - Arrival shift	0.0353	6.1
152	Social/recreation tour - Duration shift	0.1839	13.3
169	Escort tour - Duration 0 - 59 constant	1.3779	9.8
170	Shopping tour – Duration 0 -59 constant	1.3456	7.4
171	Meal tour - Duration 0 -59 constant	-0.5644	-2.6
173	Shopping tour – Duration 100 - 159 constant	1.2175	8.8
174	Meal tour - Duration 100 -159 constant	0.3127	2.1
176	Shopping tour - Arrival before 0700	-1.6702	-3.9
177	Meal tour - Arrival before 0700	0.6782	1.6
178	Escort tour - Depart after 2100	0.5536	3.0
179	Shopping tour - Depart after 2100	-0.9987	-6.2
180	Meal tour - Depart after 2100	-0.6477	-3.8
55	Higher of 2+ same tours - Arrival shift	0.0077	0.6
56	Higher of 2+ same tours - Duration shift	0.1535	3.6
57	Lower of 2+ same tours - Arrival shift	-0.0689	-4.5
58	Lower of 2+ same tours - Duration shift	-0.5021	-9.0
155	Higher of 2+ diff. tours - Arrival shift	-0.0027	-0.2
156	Higher of 2+ diff. tours - Duration shift	0.1213	2.1
157	Lower of 2+ diff. tours - Arrival shift	-0.0594	-4.5
158	Lower of 2+ diff. tours - Duration shift	-0.1947	-7.1
84	Lower of 2+ different tours- Duration<400	0.4969	3.9
59	Only tour of the day - Arrival shift	-0.0207	-1.2
60	Only tour of the day - Duration shift	0.0636	1.2
61	# stop purposes/only tour - Arrival shift	0.0034	0.9
62	# stop purposes/only tour - Duration shift	-0.0068	-0.9
63	# stop purposes/mult. tour - Arrival shift	0.0039	1.9
64	# stop purposes/mult. tour - Duration shift	-0.0083	-1.2
67	Escort stops in day - Arrival shift	-0.0010	-0.2
68	Escort stops in day - Duration shift	0.0562	3.7
91	Arrival period partially used	-1.2923	-13.4
92	Departure period partially used	-0.8166	-5.0
93	Empty window remaining before- 1st tour	0.1674	2.8
94	Empty window remaining after - 1st tour	0.2213	3.8
95	Empty window remaining before- 2nd+ tour	0.0006	0.1
96	Empty window remaining after - 2nd+ tour	0.0220	4.1
97	Remaining tours/total remaining window	-131.4534	-6.1
98	Remaining tours/maximum remaining window	-2.7639	-1.1
99	Remaining tours/adjacent window before	-0.2774	-3.1
100	Remaining tours/adjacent window after	-0.1569	-1.5

Table 4: Home-based Other Tour Arrival and Departure Time Model (continued)

Coef #	Variable description	Estimate	T-stat
85	Auto travel time (min) - outbound period	-0.1675	-5.0
86	Auto travel time (min) - return period	-0.1210	-3.5
89	No transit path in period	-5.0000	Constr
103	Auto PM congested time - shift earlier	0.0435	4.1
104	Auto PM congested time - shift later	0.0301	2.5
105	Auto AM time missing - shift earlier	-0.0686	-0.6
106	Auto AM time missing - shift later	0.0345	0.4
107	Auto PM time missing - shift earlier	0.0390	0.5
108	Auto PM time missing - shift later	0.0971	1.2

Table 5: Work-based Sub-tour Arrival and Departure Time Model

Coef #	Variable description	Estimate	T-stat
11	Arrival 0300 - 0559 constant	-0.4519	-0.2
12	Arrival 0600 - 0659 constant	-5.0000	Constr
13	Arrival 0700 - 0759 constant	-0.2749	-0.7
14	Arrival 0800 - 0859 constant	0.0000	Constr
15	Arrival 0900 - 0959 constant	-0.4405	-1.8
16	Arrival 1000 - 1259 constant	-0.1867	-0.7
17	Arrival 1300 - 1559 constant	-1.6032	-4.4
18	Arrival 1600 -1859 constant	-2.6232	-4.7
19	Arrival 1900 - 2159 constant	-4.4149	-5.2
20	Arrival 2200 - 0259 constant	-10.0000	Constr
21	Depart 0300 - 0659 constant	2.5150	0.9
22	Depart 0700 - 0959 constant	0.0470	0.1
23	Depart 1000 - 1259 constant	0.5978	2.0
24	Depart 1300 - 1559 constant	0.6220	2.7
25	Depart 1600 - 1659 constant	0.0000	Constr
26	Depart 1700 - 1759 constant	0.0969	0.3
27	Depart 1800 - 1859 constant	0.1199	0.2
28	Depart 1900 - 2059 constant	1.0428	2.0
29	Depart 2100 - 2359 constant	2.1327	3.0
30	Depart 2400 - 0259 constant	-10.0000	Constr
31	Duration 0 - 59 constant	0.3405	1.4
32	Duration 100 - 159 constant	0.7208	4.1
33	Duration 200 - 259 constant	0.0000	Constr
34	Duration 300 - 459 constant	-0.2508	-1.0
35	Duration 500 - 659 constant	-0.5567	-1.1
36	Duration 700 - 859 constant	0.4981	0.7
37	Duration 900 - 1159 constant	0.0520	0.0
38	Duration 1200 - 1359 constant	-10.0000	Constr
39	Duration 1400 - 1759 constant	-10.0000	Constr
40	Duration 1800 - 2359 constant	-10.0000	Constr
41	Part-time worker-Arrival shift	0.0026	0.1
42	Part-time worker-Duration shift	0.1281	1.6
145	Escort subtour - Arrival shift	0.1819	3.1
146	Escort subtour - Duration shift	-1.9103	-3.4
147	Shopping subtour - Arrival shift	0.0581	1.8
148	Shopping subtour - Duration shift	-0.8893	-7.1
149	Meal subtour - Arrival shift	0.0473	1.8
150	Meal subtour - Duration shift	-0.3517	-6.6
151	Social/recreation subtour - Arrival shift	0.1500	2.9
152	Social/recreation subtour - Duration shift	-0.0377	-0.5
153	Personal business subtour - Arrival shift	0.0162	0.5
154	Personal business subtour - Duration shift	-0.2996	-4.9
91	Arrival period partially used	-5.0000	Constr
92	Departure period partially used	-2.0366	-3.5
93	Empty window remaining before	0.1606	2.9
94	Empty window remaining after	0.0665	1.3

Table 6: Intermediate Stop Arrival or Departure Time Model

Coef #	Variable description	Estimate	T-stat
11	Arrival 0300 - 0559 constant	-2.6105	-8.1
12	Arrival 0600 - 0659 constant	-1.3833	-7.0
13	Arrival 0700 - 0759 constant	-0.2411	-1.9
14	Arrival 0800 - 0859 constant	0.0000	Constr
15	Arrival 0900 - 0959 constant	0.2108	1.7
16	Arrival 1000 - 1259 constant	0.1696	1.0
17	Arrival 1300 - 1559 constant	0.0331	0.1
18	Arrival 1600 -1859 constant	0.2444	0.8
19	Arrival 1900 - 2159 constant	-0.5341	-1.3
20	Arrival 2200 - 0259 constant	0.5407	0.4
21	Depart 0300 - 0659 constant	0.9533	1.0
22	Depart 0700 - 0959 constant	-0.6163	-2.3
23	Depart 1000 - 1259 constant	-0.2667	-1.8
24	Depart 1300 - 1559 constant	-0.1694	-2.0
25	Depart 1600 - 1659 constant	0.0000	Constr
26	Depart 1700 - 1759 constant	0.0819	0.9
27	Depart 1800 - 1859 constant	-0.2144	-1.7
28	Depart 1900 - 2059 constant	-0.3800	-2.3
29	Depart 2100 - 2359 constant	-0.6197	-2.6
30	Depart 2400 - 0259 constant	-1.1813	-3.0
31	Duration 0 - 59 constant	1.3863	14.0
32	Duration 100 - 159 constant	0.8280	11.0
33	Duration 200 - 259 constant	0.0000	Constr
34	Duration 300 - 459 constant	-0.7698	-6.9
35	Duration 500 - 659 constant	-2.4074	-10.1
36	Duration 700 - 859 constant	-4.3928	-8.8
37	Duration 900 - 1159 constant	-5.0901	-7.7
38	Duration 1200 - 1359 constant	-10.0000	Constr
39	Duration 1400 - 1759 constant	-10.0000	Constr
40	Duration 1800 - 2359 constant	-10.0000	Constr
46	University student-Duration shift	0.1407	4.6
50	K12 student 16+ -Duration shift	0.2022	6.3
52	Child age 5-15 -Duration shift	0.2147	8.4
54	Child age 0-4 -Duration shift	0.1067	2.7
145	Escort stop - Arrival shift	0.1862	4.1
146	Escort stop - Duration shift	-1.3598	-29.4
147	Shopping stop - Arrival shift	0.0867	2.8
148	Shopping stop - Duration shift	-0.6900	-21.8
149	Meal stop - Arrival shift	0.0169	0.7
150	Meal stop - Duration shift	-0.1512	-6.0
151	Social/recreation stop - Arrival shift	0.0678	3.1
152	Social/recreation stop - Duration shift	-0.0021	-0.1
153	Personal business stop - Arrival shift	0.1178	4.7
154	Personal business stop - Duration shift	-0.5103	-19.6
155	School stop - Arrival shift	0.0466	1.3
156	School stop - Duration shift	0.0391	1.0

Table 6: Intermediate Stop Arrival or Departure Time Model (continued)

Coef #	Variable description	Estimate	T-stat
132	Work tour outbound - Duration shift	0.1342	4.5
134	Work tour return - Duration shift	0.0815	2.5
136	Non-work tour return - Duration shift	-0.1363	-3.7
138	Work-based subtour - Duration shift	-0.2404	-3.7
91	Arrival period partially used	-0.5719	-5.1
92	Departure period partially used	-2.0076	-3.4
97	Remaining tours/total remaining window	-2.4493	-2.4
99	Remaining stops on half tour/adjacent window	-1.6976	-4.3
86	Auto travel time (min) in period	-0.0533	-1.2
88	Transit travel time (min) in period	-0.1143	-2.3
89	No transit path in period	-5.0000	Constr
101	Auto AM congested time - shift earlier	0.0282	1.2
102	Auto AM congested time - shift later	0.0146	0.9
103	Auto PM congested time - shift earlier	0.0077	0.5
105	Auto AM time missing - shift earlier	0.0021	0.0
106	Auto AM time missing - shift later	0.3041	1.6
107	Auto PM time missing - shift earlier	-0.0757	-0.5
108	Auto PM time missing - shift later	0.0208	0.1

Table 7: Additional Model Estimation Statistics

Model	Home-based Work Tours	Home-based School Tours	Home-based Other Tours	Work-based Sub-tours	Inter-mediate Stops
# Observations	3,532	1,561	6,062	682	8,508
Final log(likelihood)	-18,785.9	-7,142.7	-29,569.4	-2817.5	-10,531.6
Rho-squared (0)	0.239	0.343	0.239	0.162	0.550