DAY PATTERN CHOICE MODEL ESTIMATION

SOUNDCAST: ACTIVITY-BASED TRAVEL FORECASTING MODEL

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INTRODUCTION

This memo documents the models in the DaySim system that predict the number and purpose of tours and intermediate stops made by each individual. As shown in Figure 1, this occurs at 4 places in the model hierarchy:

Person-day level:

Model 2.1: **Day Activity Pattern**: The main Activity Pattern model, which predicts whether or not a person participates in tours and intermediate stops for 7 different activity purposes during the travel day, with the possible alternatives being 0 or 1+ tours/stops..

Model 2.2: Exact Number of Tours: For each activity purpose for which Model 2.1.predicts 1 or more tours, this model predicts the exact number of tours made for that purpose during the full day, with the possible alternatives being 1, 2 or 3 tours.

Model 3.2: Number and purpose of Work-based Subtours: For each home-based Work tour predicted by Models 2.1 and 2.2, this model predicts the exact number and primary purpose of Work-based subtours that originate from that tour. This model uses a stop/repeat structure, with 8 possible alternatives: 1 (more) subtour for any of 7 different activity purposes, or No (more) subtours.

Model 4.1: Number and purpose of intermediate stops: For each half-tour on all tours and work-based subtours predicted by models 2.1, 2.2 and 3.2, this model predicts the exact number and purpose of any intermediate stops made along the way between the tour origin and primary destination. This model uses a stop/repeat structure, with 8 possible alternatives: 1 (more) intermediate stop for any of 7 different activity purposes, or No (more) stops.

An important feature of this model system is that we do not predict the number of stops and allocate stops to tours completely at the upper person-day level, as is done in the Portland and SFCTA models, or completely at the tour level, as is done in other models, such as Columbus. Rather, the person-day level pattern model predicts the likelihood that ANY stops will be made during the day for a given purpose, at a level where the substitution between extra stops versus extra tours can be modeled directly (in Model 2.1). Then, once the exact destinations, times of day and modes of tours are known (from Models 3.1, 3.2 and 3.3), the exact allocation and number of stops is predicted using this additional tour-level information in Model 4.1. We feel that this approach provides a good balance between person-day-level and tour-level

sensitivities. In particular the allocation of stops to particular tours can be sensitive to where, when and how each tour takes place, and the exact total number of intermediate stops can also vary somewhat according to tour-level sensitivities, but only within limits, as each individual must complete at least one activity for each stop purpose predicted at the person-day level. One way to think of this is in the context of shopping stops. If person has easy access to a number of different stores during the day in the course of their travels, they may spread their shopping across multiple stops, and perhaps multiple tours. If they do not have good access to stores, they will be more likely to concentrate their shopping within fewer stops, but they still need to visit at least one store.

FIGURE 1—DAYSIM MODELS (NUMBERED) WITHIN THE PROGRAM LOOPING STRUCTURE

Begin

{Read run controls, model coefficients, TAZ data, LOS matrices,

population controls, and Parcel data into memory}

{Draw a synthetic household sample if specified}

{Pre-calculate destination sampling probabilities}

{Pre-calculate (or read in) TAZ aggregate accessibility arrays}

{Open other input and output files}

{Main loop on households}

{Loop on persons in HH}

{Apply model **1.1 Work Location for workers**}

{Apply model **1.2 School Location for students**}

{Apply model **1.1 Work Location for students**}

{End loop on persons in HH}

{Apply model **1.3 Household Auto Availability** }

{Loop on all persons within HH}

{Apply model **2.1 Activity Pattern** (0/1+ tours and 0/1+ stops)

and model **2.2 Exact Number of Tours** for 7 purposes}

{Count total home-based tours and assign purposes}

{Initialize tour and stop counters and time window for the person-day before looping on tours}

{If there are tours, loop on home-based tours within person in tour priority sequence,

with tour priority determined by purpose and person type}

{Increment number of home-based tours simulated for tour purpose (including current)}

{Apply model **3.1 Tour destination**}

{If work tour, apply model **3.2 Number and purpose of work-based subtours**}

{Loop on predicted work-based sub tours and insert then tour array after current tour}

{Apply model **3.3 Tour mode**}

{Apply model **3.4 Tour primary destination arrival and departure times**}

{Loop on tour halves (before and after primary activity)}

{Apply model **4.1Half tour stop frequency and purpose**}

{Loop on trips within home-based half tour (in reverse temporal order for 1st tour half)}

{Increment number of stops simulated for stop purpose (including current)}

{Apply model **4.2 Intermediate stop location**}

{Apply model **4.3 Trip mode**}

{Apply model **4.4 Intermediate stop departure time**}

{Update the remaining time window}

{End loop on trips within half tour}

{End loop on tour halves}

{End loop on tours within person}

{Write output records for person-day and all tours and trips}

{End loop on persons within household}

{End loop on Households}

{Close files}

{Create usual work location flow validation statistics}

End.

DAY ACTIVITY PATTERN (MODEL 2.1)

This model is a variation on the Bowman and Ben-Akiva approach, jointly predicting the number of home-based tours a person undertakes during a day for seven purposes, and the occurrence of additional stops during the day for the same seven purposes. The seven purposes are work, school, escort, personal business, shopping, meal and social/recreational. The pattern choice is a function of many types of household and person characteristics, as well as land use and accessibility at the residence and, if relevant, the usual work location. The main pattern model (2.1) predicts the occurrence of tours (0 or 1+) and extra stops (0 or 1+) for each purpose, and a simpler conditional model (2.2) predicts the exact number of tours for each purpose.

If the main pattern model were to include every combination of the 14 binary choice variables, there would be 2^14, or 16,384 alternatives. Based on an examination of the data, however, it is feasible to include only combinations that meet the following criteria:

- There can be no intermediate stop purpose with 1+ stops unless there is at least 1 tour purpose with 1+ tours.
- The maximum number of tour purposes with 1+ tours is 3.
- The maximum number of stop purposes with 1+ stops is 4.
- The maximum number of tour purposes + stop purposes with 1+ is 5.
- There can be no intermediate Work stops or School stops unless there are 1+ Work tours and/or 1+ School tours.
- The pattern cannot include both intermediate Work stops and School stops (if one is 1+, the other must be 0).

Following these rules, the number of alternatives in the model is reduced to 2,080, while approximately 99% of the observed patterns in the household survey data are accommodated.

The “base alternative” in the model is the “stay at home” alternative where all 14 dependent variables are 0 (no tours or stops are made).

The main utility component for each purpose-specific tour or stop alternative is a vector of person-specific and household-specific characteristics and accessibility measures. No set of variables used in the vector can cover the entire sample, so each characteristic used must have a base group. For the estimation, the following “base” characteristics are assumed to have coefficient 0, with the other person- and household-specific variables estimated relative to these:

- Person type : Full-time worker
- Age group : 36-50
- Gender/role : Male adult with no children under age 16
- HH composition: Family household with 2+ adults and 2+ workers.
- HH income : $45-75K/year

For all alternatives other than the base (stay at home) alternative, which has utility 0, the utility consists of the following components:

U = sum over p(Ip.BPp)

+ BT(NT)

+ BS(NS)

+ C(NT,NS)

+ sum over p,q (Tp.Tq.BXpq)

+ sum over p,q (Sp.Sq.BYpq)

+ sum over p,q (Tp.Sq.BZpq)

Where:

- p and q are indices that range from 1 to 7 for the 7 tour/stop purposes
- Ip is 1 if there are EITHER 1+ tours or 1+ stops for purpose p, otherwise 0
- Tp is 1 if there are 1+ tours for purpose p, otherwise 0
- NT is the sum of Tp across the 7 purposes (1<=NT<=3)
- Sp is 1 if there are 1+ stops for purpose p, otherwise 0
- NS is the sum of Sp across the 7 purposes (0<=NS<=4)

The estimated coefficients are:

- BPp a purpose-specific array of coefficients related to making 1+ tours/stops for a specific purpose p, including a constant.
- BT an array of coefficients related to making more tours, not including a constant (the effect of each variable is proportional to the log of the number of tours)

- BS an array of coefficients related to making more stops, not including a constant (the effect of each variable is proportional to the log of the number of stops)
- C(NT,NS) a set of constants related to making tours for exactly NT different purposes and stops for exactly NS different purposes.
- BX a matrix of coefficients for making tours for BOTH of a given pair of tour purposes. Only a half-matrix is estimated, with the diagonal constrained to 0.
- BY a matrix of coefficients for making stops for BOTH of a given pair of stop purposes. Only a half-matrix is estimated, with the diagonal constrained to 0.
- BZ a matrix of coefficients for making a stop of a given purpose in combination with a tour of a given purpose. Here, a nearly full matrix can be estimated, as all stop purposes and tour purposes can occur together in the same pattern.

The model was estimated, on 18631 person-day observations, and the estimation results are shown in Tables 1 to 4. The model fit statistics are shown below.

Observations	18361
Final log likelihood	-64977.3391
Rho-squared(0)	0.4874

The main findings that can be seen in Tables 1 to 4 are:

- Many household and person variables have significant effects on the likelihood of participating in different types of activities in the day, and on whether those activities tend to be made on separate tours or as stops on complex tours.
- The significant variables include employment status, student status, age group, income group, car availability, work at home dummy, gender, presence of children in different age groups, presence of other adults in the household, and family/non-family status.
- For workers and students, the accessibility (mode choice logsum) of the usual work and school locations is positively related to the likelihood of traveling to that activity on a given day.
- For workers, the accessibility to retail and service locations on the way to and from work is positively related to the likelihood of making intermediate stops for various purposes.

Table 1: Day Activity Pattern Model Estimation Results (part 1)

Purpose-specific variables *(BP)*	**Work**	***X=1***	**School**	***X=2***	**Escort**	***X=3***	**Per.Bus.**	***X=4***	**Shop**	***X=5***	**Meal**	***X=6***	**Soc+Rec**	***X=7***
	Coeff	**T-stat**	**Coeff**	**T-stat**	**Coeff**	**T-stat**	**Coeff**	**T-stat**	**Coeff**	**T-stat**	**Coeff**	**T-stat**	**Coeff**	**T-stat**
Constant-Tour	1.22	17.1	0.36	0.19	-2.6	-11.8	-4.84	-18.5	-4.23	-16.1	-3.6	-20.6	-2.01	-12.9
Constant-Stop	2.64	6.9	1.22	3	-0.8	-2.7	0.72	2.5	-0.04	-0.1	-0.17	-0.6	0.26	1
Person Type														
Part-time worker	-0.96	-15.1					0.12	1.6	0.39	5.8	0.06	0.7		
Retired	-5				-0.61	-7	0.4	5.1	0.4	5.5				
Other non-worker	-5						0.04	0.5	0.36	5.2				
University student	-1.06	-5.6	0.92	4.5			0		0.38	2.5				
Student age 16+	-1.27	-5.9	1.98	9.1			0.58	4.2	-0.1	-0.6	-0.07	-0.4		
Student age 5-15	-20		1.89	10.6			0.63	5.8	0.16	1.3	-0.18	-1.4		
Child age 0-4	-20		0.72	3.5	0.55	5.8	0.22	2.2			-0.28	-2.4	0.04	0.4
Adult age group														
Age 18-25					-0.79	-5.9	0.39	4.1	-0.17	-1.6				
Age 26-35					-0.32	-4	-0.1	-1.3	-0.01	-0.2				
Age 51-65			-0.43	1.5	-0.36	-5.9	0.06	1.2	0.1	1.9			0.02	0.5
Adult gender/chidren														
Male / age 0-4					0.34	3.1								
Male / age 5-15					1	12.3	0.48	6.5					0.02	0.2

Female / none								0.01	0.2	0.04	0.7	
Female / age 0-4	-0.4	-3.7	-1.02	-2.2	0.52	9	0.03	0.1				
Female / age 5-15	0.04	0.4			1.74	25.3	0.41	5.6		-0.21	-2.2	0.05	0.6
Household composition												
Only adult in HH					-0.04	-0.4	0.02	0.4	0.13	2.4		0.27	5
Only worker in HH					-0.22	-3						
Non-family 2+person HH												
Household income												
Income 0-25K	-0.35	0			-0.54	-4.5	0.18	-6.6	0.18	2	-0.29	-2.4	-0.38	-4
Income 25-45K	-0.26	-3.1			-0.28	-3.7	-0.36	-5.5			-0.14	-1.8	0.08	1.3
Income over 75K							-0.02	-0.5	0.1091	1.8			-0.05	-1.2
Other												
Cars per adult in HH	0.12	1.8	0.15	1.2			-0.28	-4.9	-0.03	-0.5	0.02	0.2	-0.17	-3.3
Work at home	-5											
Home mixed use density												
Home intersection density												
Home-work/school accessibility	0.4	5.1	0.22		-0.18	-2.4	-0.02		0.14	2.5	-0.05	0.07	-0.12	-2.2
Home aggregate accessibility	0.22	10.6												
Home-work stop accessibility					0.12	6.1	0.24	11.2	0.26	9.4	0.19	8.8	0.07	4.3

Table 2: Day Activity Pattern Model Estimation Results (part 2)

Additional constants (*C[NT,NS]*)	**Coeff**	**T-stat**
1 tour purpose + 1 stop purpose	-4.59	-9.3
1 tour purpose + 2 stop purposes	-5.15	-7.8
1 tour purpose + 3+stop purposes	-3.08	-10.3
2 tour purposes + 1 stop purpose	-4.81	-9.6
2 tour purposes + 2 stop purposes	-5.58	-8.5
2 tour purposes + 3 stop purposes	-3.17	-10.1
3 tour purposes + 1 stop purpose	-5.16	-9.8
3 tour purposes + 2 stop purposes	0.01	0.1

Table 3: Day Activity Pattern Model Estimation Results (part 3)

Frequency-specific variables	**LN(Tour purposes)**	***X=8***	**LN(Stop purposes)**	***X=9***	***Has Non-Mandatory Tours/Stops***
	Coeff	**T-stat**	**Coeff (X=9)**	**T-stat**	
Person Type					
Part-time worker	0.04	0.5			
Retired	-0.17	-1.4			
Other non-worker	0.09	0.9			
University student	0.25	1.4			
Student age 16+	0.12	0.7	-0.02	-0.1	
Student age 5-15	-0.16	-1	-0.14	-0.9	
Child age 0-4					
Adult age group					
Age 18-25	-0.02	-0.1			
Age 26-35					
Age 51-65					
Adult gender/chidren					

Male / age 0-4	-0.15	-2.5				
Male / age 5-15	0.03	0.3				
Female / none	-0.14	-1.4				
Female / age 0-4	0.13	1.2				
Female / age 5-15	-0.11	-1.1				
Other						
Cars per adult in HH					1.16/-.96	2.9/-1.7
Work at home	0.18	0.3	0.57	0.6	-5.3	-60
Home mixed use density					2.0	2
Home intersection density						
Home-work/school accessibiiity	0.01	2.1				
Home aggregate accessibility					0.01	0.1

Table 4: Day Activity Pattern Model Estimation Results (part 4)

Par #	**Purpose combination variables**	**Tour+Tour**	***Y=11***	**Stop+Stop**	***Y=12***	**Tour+Stop**	***Y=10***
		Coeff	**T-stat**	**Coeff**	**T-stat**	**Coeff**	**T-stat**
Y11	Work + Work					0.07	4.1
Y12	Work + School	-1.12	-6.8			-1.00	-4.1
Y13	Work + Escort	-0.05	-5.1	-1.35	-8.2	0.00	
Y14	Work + Per.Bus	-1.20	-9.6	-1.65	-10.1	1.47	13.6
Y15	Work + Shop	-0.81	-8.2	-1.59	-9.0	-0.38	-4.2
Y16	Work + Meal	0.14	-1.8	-1.65	-8.8	0.53	5.8
Y17	Work + Soc/Rec	-1.41	-4.0	-0.82	-3.0	0.24	2.4
Y21	School + Work					-0.69	-2.3
Y22	School + School					1.24	8.9
Y23	School + Escort	0.03	-5.3	-2.12	-6.0	-0.22	-1.9
Y24	School + Per.Bus	-1.43	-5.9	-1.52	-5.1	0.63	4.8
Y25	School + Shop	-0.94	-5.1	-1.23	-3.7	0.50	3.4
Y26	School + Meal	0.13	-2.0	-2.26	-4.3	-0.07	-6.8
Y27	School + Soc/Rec	0.06	-3.6	-1.25	-9.7		
Y33	Escort + Escort					-0.10	-1.2
Y34	Escort + Per.Bus	-0.23	-2.5	-1.24	-9.7	0.16	1.9
Y35	Escort + Shop	-0.32	-2.6	-1.20	-8.3	0.24	2.4
Y36	Escort + Meal	0.00	0.0	-1.27	-8.3	0.12	1.2
Y37	Escort + Soc/Rec	0.09	1.0	0.16	1.6		
Y43	Per.Bus + Escort					0.84	8.3
Y44	Per Bus + Per Bus					0.62	8.4
Y45	Per Bus + Shop	-0.13	-1.1	-0.10	-0.9	0.05	0.5
Y46	Per Bus + Meal	-0.29	-3.3	-0.60	-5.2	-0.33	-2.5
Y47	Per Bus + Soc/Rec	-0.16	-1.4	-0.32	-3.0		

Y53	Shop + Escort					-0.28	-3.1
Y54	Shop + Per Bus					0.33	3.0
Y55	Shop + Shop					0.11	1.1
Y56	Shop + Meal	0.02	0.2	-0.49	-4.3	-0.17	-1.0
Y57	Shop + Soc/Rec	-1.60	-8.8	-3.02	-10.2		
Y63	Meal + Escort					0.10	0.9
Y64	Meal + Per Bus					-0.03	-0.3
Y65	Meal + Shop					0.02	0.1
Y66	Meal + Meal					0.06	0.6
Y73	Soc/Rec + Escort					0.19	2.5
Y74	Soc/Rec + Per Bus					0.35	4.8
Y75	Soc/Rec + Shop					0.32	3.7
Y76	Soc/Rec + Meal					-1.65	-8.9

EXACT NUMBER OF TOURS (MODEL 2.2)

A much simple model specification was used to estimate models of the exact number of tours for any given purpose, conditional on making 1+ tours for that purpose.

The specification for this model is:

U(1 tour) = 0

U(2 tours) = C2 + BL2.L + BX.X + BY.Y

U(3 tours) = C3 + BL3.L + BX.X + BY.Y

Where:

- C2 and C3 are estimated alternative-specific constants for 2 and 3 tours, respectively
- L is an accessibility logsum for the purpose
- BL2 and BL3 are estimated accessibility logsum coefficients for 2 and 3 tours, respectively
- X is a vector of person and household characteristics.
- Y is a vector of outcomes from the main pattern model (2.1) and the outcomes for higher priority purposes from this model (2.2)

- BX and BY are vectors of estimated coefficients

An interesting result is that, compared to the main day pattern model, the person and household variables have less influence, but the accessibility variables have relatively more influence. This result indicates that the small percentage of people who make multiple tours for any given purpose during a day tend to be those people who live in areas that best accommodate those tours. Other people will be more likely to participate in fewer activities and/or chain their activities into fewer home-based tours.

Table 6: Exact Number of Tour by Purpose Model Estimation Results (part 1)

Observations	23766
Final log likelihood	-6524.9776
Rho-squared(0)	0.7501

	Work	***P=1***	**School**	***P=2***	**Escort**	***P=3***	**Per.Bus.**	***P=4***	**Shop**	***P=5***	**Meal**	***P=6***	**Soc+Rec**	***P=7***
Person//HH variables *(X)*	**Coeff**	**T-stat**	**Coeff**	**T-stat**	**Coeff**	**T-stat**	**Coeff**	**T-stat**	**Coeff**	**T-stat**	**Coeff**	**T-stat**	**Coeff**	**T-stat**
Person Type														
Full-time worker	-0.46	-3.20					-0.02	-0.11						
Part-time worker					0.45	2.94			0.23	0.93				
Retired									-0.70	-2.70			0.15	0.90
Other non-worker					0.51	3.64					0.11	0.31		
University student			1.38	3.52										
Student age 16+			1.31	4.00									0.08	0.22
Student age 5-15			0.00		0.70	2.60			-1.71	-1.65	-3.00	*		
Child age 0-4			-1.55	-1.49	1.17	5.75					-3.00	*		
Adult age group														
Age 18-25					-0.17	-0.50								
Age 26-35	-0.27	-1.44			0.05	0.27								
Age 51-65					-0.31	-2.09			-0.10	-0.49				

Adult gender/chidren												
Male / age 0-4					0.79	4.51			0.11	0.26		-0.64	-2.44
Female / age 0-4					0.27	1.71	0.31	1.13	-0.55	-1.47		-0.04	-0.15
Female / age 5-15					1.19	9.37	0.02	0.11	0.18	0.65		-0.9	-3.22
Household composition												
Only adult in HH									0.01	0.03		-0.21	-1.35
Only worker in HH													
Non-family 2+person HH													
Household income												
Income 0-25K	0.49	1.58			-0.25	-0.92	0.19	0.61					
Income 25-45K			0.68	1.80									
Income over 75K									0.04	0.19			
Other													
Cars per adult in HH			0.38	1.17	-0.31	-2.31	0.20	1.28					
Work at home					-0.21	-0.28							
Logsum variables *(L)*													
Accssibility logsum- 2 tours	0.10	2.80	0.15	0.77	0.00	-0.02	0.06	1.00	0.16	1.39			
Accssibility logsum- 3 tours	0.05	0.27	0.56	1.02	-0.03	-0.43	0.09		0.37	1.06			

Table 7: Exact Number of Tour by Purpose Model Estimation Results (part 2)

	Work	*P=1*	School	*P=2*	Escort	*P=3*	Per.Bus.	*P=4*	Shop	*P=5*	Meal	*P=6*	Soc+Rec	*P=7*
Pattern outcomes *(Y)*	**Coeff**	**T-stat**	**Coeff**	**T-stat**	**Coeff**	**T-stat**	**Coeff**	**T-stat**	**Coeff**	**T-stat**	**Coeff**	**T-stat**	**Coeff**	**T-stat**
Other tours in day														
Work tours (#)			-0.30	-0.40	-0.72	-5.30	0.01	0.03	-1.36	-4.37	-3.00	*	0.03	0.26
School tours (#)**	-1.33	-1.33			-1.53	-5.71	-0.17	-0.92			-3.00	*	-0.62	-3.09
Escort tours (#)**	0.09	0.60					0.18	1.79			-3.00	*		
Per.bus tours (#)									-0.12	-0.58				
Shop tours (0/1+)														
Other stops in day														
Work stops (0.1+)	0.35	5.61	0.70	1.49	0.10	0.61							-0.61	-2.15
School stops (0.1+)														
Escort stops (0.1+)	0.16	1.51			0.10	1.62			-0.57	-1.33				
Per.bus stops (0.1+)	0.19	1.78					0.21	3.17	0.18	1.30				
Shop stops (0.1+)	-0.10	-0.85							-0.41	-1.85				
Meal stops (0.1+)														
Soc/rec stops (0.1+)	0.04	0.16							0.13	0.63			0.13	0.87
Constants (*C*)													0.08	0.67
2 Tours	-3.11	-	-4.93	-	-1.59	-2.84	-3.24	-4.26	-3.83	-3.49	-2.89	-	-2.14	-

		21.70		13.55						10.06		19.92
3+ Tours	-6.37	-15.56	-8.04	-10.88	-2.69	-3.61	-6.13	-22.96	-8.00	-2.32	-20.00	-4.40	-22.38

NUMBER AND PURPOSE OF WORK-BASED SUBTOURS (MODEL 3.2)

For each home-based Work tour predicted by Models 2.1 and 2.2, this model predicts the exact number and primary purpose of Work-based subtours that originate from that tour. This model uses a stop/repeat structure, with 8 possible alternatives: 1 (more) subtour for any of 7 different activity purposes, or No (more) subtours, here called the 'quit' alternative. When the model is applied the choice is repeated until the purpose of the third subtour or the quit alternative is chosen, whichever comes first. Three subtours is the limit because that is the maximum number observed in the estimation data set.

For this model, the following activity schedule outcomes are known:

- number and purpose of all home based tours (from models 2.1 and 2.2)
- whether or not there are any stops and/or work-based subtours in the day pattern (but not whether they are intermediate stops or subtours) (from model 2.1). For cases where model 2.1 determines that there are no stops or work-based subtours, then the work-based subtour model is not needed.
- if there are stops and/or subtours, what purposes are included (from model 2.1)

For estimation purposes, the set of observed outcomes includes:

- all observed work-based subtours (in which case the outcome is one more subtour of the observed purpose).
- a record for each work tour where another subtour could have been chosen, but wasn't, representing the 'quit' outcome. This includes:
    - one additional record for each work tour with at least one observed work-based subtour
    - one record for each work tour where no work-based subtour was taken, as long as there was at least one intermediate stop predicted in the pattern model. If there were no intermediate stops and no observed work-based tours, then the outcome of pattern model 2.1 has already determined that there are no work-based subtours.

In a given choice case, a subtour purpose is available only if the pattern indicates that at least one intermediate stop or work-based subtour occurs for that purpose. In addition, education subtours are considered unavailable unless the person reported being a student. As a result, every choice case in the estimation data has a restricted choice set. The following table shows the number of cases grouped by the number of non-quit alternatives available for the choice:

Model estimation yielded the following summary results:

Summary statistics	
Number observed choices	2524
Log likelihood w coeffs=0	-2429.0

Final Log likelihood	-530.9
Rho squared	0.781

The table below shows the details of the estimation results. The first set of coefficients are for the alternative specific constants for the purpose alternatives, capturing the tendency to take a tour of a given purpose, given all the other factors affecting choice, with the quit alternative serving as the base case.

Several variables are factors affecting the tendency to quit, and one factor affectis the tendency to make an escort subtour. The results indicate that a subtour is less likely if it would be the second subtour of the tour , if the pattern has multiple home-based tours , and especially multiple home-based work tours . Subtours are seldom taken from work locations other than the usual workplace and workers in households with auto limitations take less subtours . Subtours of any purpose are more likely if there is a lot of commercial employment within a quarter mile of the work location and an escort subtour is more likely if there is a lot of grade school enrollment within a quarter mile of the work location.

TABLE 8: NUMBER AND PURPOSE OF WORK-BASED SUBTOURS ESTIMATION RESULTS

Description of utility term	**Coefficient Estimate**	**T stat**
Work subtour constant	-2.27	-4.21
education subtour constant	-5.00	constr
escort subtour constant	-3.38	-4.75
personal business subtour constant	-5.15	-7.92
shop subtour constant	-5.26	-8.41
meal subtour constant	-4.00	-6.90
social/recreation subtour constant	-5.57	-6.24
Quit--second or third subtour	0.94	4.12
Quit--Nat log of no. of HB tours	0.52	2.40
Quit--Pattern has 2+ HB work tours	0.18	0.51
Quit--HH has no car	-0.39	-0.59
Quit--HH has less cars than drivers	-0.04	-0.18
Quit—Work Aggregate logsum	-0.12	-2.11

NUMBER AND PURPOSE OF INTERMEDIATE STOPS (MODEL 4.1)

For each tour, once its destination, timing and mode have been determined, the exact number of stops and their purposes is modeled for the halftours leading to and from the tour destination. For each potential stop, the model predicts whether it occurs or not and, if so, its purpose. This repeats until the quit alternative is predicted or 5 stops have been made. The five stop limit arises because no halftours in the estimation data have more than five intermediate stops. In model application, for the last modeled tour, the model is constrained to accomplish all intermediate stop activity purposes prescribed by the activity pattern model that have not yet been accomplished on other tours.

The set of observed outcomes for model estimation includes

- all observed intermediate stops
- an additional record for each halftour on which one or more stops occurred
- a record for each halftour on which no stops occurred, unless the pattern model (2.1) determined that the pattern has no intermediate stops or work-based subtours.

The resulting data include 34,756 observed choices.

The results of model estimation are shown below. Many factors affect the choices. Some summary observations can be made:

- The outcomes of this model are strongly conditioned by the outcome of the day activity pattern model, including the presence and purpose of tours and stops.
- Known characteristics of the tour and halftour strongly affect the stop choices, including tour purpose and mode; and type, timing and time available for the halftour
- Outcomes of this model for higher priority tours have significant effects. For example, once a stop purpose has been taken, the likelihood of another stop for that purpose drops considerably.
- Person type and presence of children affect the likelihood and purpose of intermediate stops.
- Accessibility has a small but measurable effect. For auto-based modes, accessibility is measured by the aggregate intermediate stop logsum. For non-auto-based modes, stop tendency depends on street network connectivity and commercial employment density.

Likelihood with Zero Coefficients = -32913.1627

Final value of Likelihood = -26164.7678

"Rho-Squared" w.r.t. Zero = .2050

TABLE 9: NUMBER AND PURPOSE OF INTERMEDIATE STOPS ESTIMATION RESULTS

Alternative	Description	Coefficient	t-stat
no more stops	two Simulated Trips, Half Tour from Origin	0.41	8.17
no more stops	three Simulated Trips, Half Tour from Origin	0.54	7.46
no more stops	four Simulated Trips, Half Tour from Origin	0.63	5.84
no more stops	five Simulated Trips, Half Tour from Origin	0.8	4.84
no more stops	two Simulated Trips, Half Tour from Destination	0.93	23.08
no more stops	three Simulated Trips, Half Tour from Destination	1.45	26.8
no more stops	four Simulated Trips, Half Tour from Destination	1.46	18.44
no more stops	five Simulated Trips, Half Tour from Destination	1.48	12.34
no more stops	Home Based Tours	0.2	4.78
no more stops	Are Simulated Tours	0.15	2.31
no more stops	Work-Based Tour	1.55	12.54
no more stops	Before Mandatory Destination	0.38	6.6
no more stops	Non-auto tour*Intersection Density*Employment Density	0.2	constr
no more stops	Transit Tour	-1.07	-17.8
no more stops	School Tour Flag	0.16	2.67
escort stop	Work or School Tour	-0.44	-2.93
escort stop	escort Tour Flag	-0.97	-5.6
escort stop	half Tour From Origin Flag	-0.2	-2.33
escort stop	simulated Escort Stops	-0.69	-1.34
escort stop	remaining Tours Count	-0.18	-3.08
escort stop	duration	0.05	5.55
escort stop	From 7 to 9 am	0.07	0.72
escort stop	off peak	0.31	3.9
escort stop	adult female with children	0.04	0.56
escort stop	HOV2 Tour	0.38	3.85
escort stop	HOV3 Tour	0.75	7.84

escort stop	One Trip Simulated	0.08	1.33
meal stop	Work Tour	-1.34	-10.76
meal stop	School Tour	-1.25	-6.81
meal stop	Escort Tour	-1.64	-9.75
meal stop	Personal Business Tour	-1.86	-11.61
meal stop	Shopping Tour	-1.95	-11.32
meal stop	Meal Tour	-2.83	-10.08
meal stop	Social/Recreation Tour	-1.72	-11.03
meal stop	Half Tour from Origin	-0.21	-2.86
meal stop	Simulated Meal Stops	-1.93	-4.88
meal stop	Remaining Tours	-0.3	-4.93
meal stop	Duration	0.1	11.75
meal stop	morning or late night	-0.06	-0.6
meal stop	late morning or early afternoon	0.64	9.66
meal stop	evening	-0.04	-0.31
meal stop	one Person Household	0.09	1.33
meal stop	HOV 2 Tour	0.11	1.49
meal stop	HOV 3 Tour	0.29	3.52
meal stop	Part time Worker, retired, university students	-0.06	-0.75
meal stop	non-working adults, children	-0.05	-0.54
meal stop	one simulated trip	0.57	8.68
personal business stop	Work or School Tour	-0.84	-8.13
personal business stop	Escort Tour	-1.17	-8.59
personal business stop	Personal Business Tour	-1.25	-10.54
personal business stop	Shopping Tour	-1.25	-10.07
personal business stop	Meal Tour	-1.08	-7.74
personal business stop	Social Recreation Tour	-1.34	-10.76

personal business stop	Half Tour from Origin	-0.02	-0.28
personal business stop	Simulated Personal Business Stops	-0.91	-2.62
personal business stop	Remaining Tours	-0.25	-4.72
personal business stop	Duration	0.09	14.75
personal business stop	morning or evening	-0.42	-5.04
personal business stop	mid-day	0.62	9.55
personal business stop	one Person Household	0.03	0.64
personal business stop	HOV 2 Tour	-0.09	-1.45
personal business stop	HOV 3 Tour	0.08	1.13
school stop	Work or School Tour	-5.02	-7.11
school stop	Half Tour from Origin	2.17	6.46
school stop	Simulated School Stops	-5	constrained
school stop	Remaining tours	-0.14	-0.73
school stop	duration	0.43	8.09
school stop	morning, evening	-0.25	-0.77
school stop	one simulated trip	0.61	3.03
shopping stop	Work or School Tour	-0.4	-4.36
shopping stop	Escort Tour	-0.56	-4.46
shopping stop	Personal Business Tour	-0.64	-6.01
shopping stop	Shopping Tour	-0.46	-4.18
shopping stop	Meal Tour	-0.55	-4.24
shopping stop	Social Tour	-0.77	-7.06
shopping stop	Half Tour from Origin	-0.79	-14.51
shopping stop	Simulated Shoppping Stops	-0.56	-1.8
shopping stop	Remaining tours	-0.27	-5.25
shopping stop	duration	0.09	15.44
shopping stop	morning, evening	-0.47	-5.93

shopping stop	mid-day	0.33	7.37
shopping stop	adult female with children	0.08	1.49
shopping stop	HOV2 Tour	-0.05	-0.93
shopping stop	HOV3 Tour	-0.07	-0.92
social/rec stop	Work or School Tour	-0.71	-5.09
social/rec stop	Escort Tour	-0.86	-4.63
social/rec stop	Personal Business Tour	-1.16	-6.43
social/rec stop	Shopping Tour	-1.13	-5.35
social/rec stop	Meal Tour	-1.24	-5.52
social/rec stop	Social Recreation Tour	-1.03	-6.59
social/rec stop	Half Tour from Origin	-0.52	-5.65
social/rec stop	Simulated Social Stops	5	#DIV/0!
social/rec stop	Remaining Tours	-0.43	-5.37
social/rec stop	Duration	0.12	11.18
social/rec stop	morning, evening	-0.84	-5.18
social/rec stop	mid-day	0.03	0.41
social/rec stop	HOV 2 Tour	0.18	1.72
social/rec stop	HOV3 Tour	0.3	2.95
work stop	Work or School Tour	-3.2	-16.16
work stop	Half Tour from Origin	0.76	6.34
work stop	Simulated Work Stops (number)	1.53	2.71
work stop	Are Simulated Work Stops	-1.42	-1.96
work stop	Remaining Tours	0.01	0.1
work stop	Duration	0.26	16.26
work stop	morning, midday	0.9	8.46
work stop	Adult Male	0.12	1.74