2015 Trip-Based Travel Demand Model
Methodology Report

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2015 Trip-Based Demand Model

This document summarizes the technical specifications for the travel demand model used in the Portland-Vancouver metropolitan area. It includes descriptions of the model structure, model application, the variables employed in model equations and their coefficients.

This model uses the person trip as the unit of analysis and, as such, does not address the tour-based activity model under development.

On a regular basis, the region’s trip-based model is modified to incorporate new data and research findings. Since the last report in 2008, a number of model enhancements have been implemented. The current model offers the following methodological advances:

- The transit assignment pathfinding algorithm and mode choice model have been updated to account for relative perceptions of wait and in-vehicle time by stop and vehicle type that were derived from a stated preference survey
  - wait times are adjusted by stop type-specific scalars that vary by time period
  - in-vehicle times times are adjusted by vehicle type-specific scalars that vary by time period
- The transit assignment pathfinding algorithm has been further modified to promote consistency with the mode choice model utility equations
  - boarding time: time equivalent of the coefficient on number of transfers
  - wait time weight: time equivalent of the coefficient on initial wait time
  - walk time weight: time equivalent of the coefficient on walk time
- The transit assignment procedures have been updated such that only one assignment is required per time period and the resulting in-vehicle time skim matrices represent each mode's portion of total in-vehicle time
- A nested park-and-ride lot choice model has been implemented, thus replacing the previous shed-based approach to modeling park-and-ride behavior
- A newly implemented suite of bicycle modeling tools calculate bicycle utilities using path attractiveness attributes and network distances as opposed to the previous approach that relied solely on shortest path distance

Features of former models that have been rendered unnecessary by these enhancements include:

- boarding penalty affecting path choice only
- shed-based park-and-ride allocation
- preparation of skims for multiple walk-access transit modes:
  - Bus only
  - LRT only
  - Combo (LRT and Bus)

An outline of the document structure is provided below. Most of the document describes the modeling of internal person trips. The flow chart shown in Appendix A gives a visual description of the logic contained in sections B through H. Sections I through K describe models that are independent of the main model structure, although their output is integrated with the main model prior to trip assignment.

- Section A describes the base input data used in all stages of model specification.
- Section B describes pre-generation—the development of household characteristics by TAZ.
- Section C describes the trip generation models for internal person trips by trip purpose.
- Section D describes the multimodal accessibility functions used in the mode choice model.
- Section E describes the destination choice model for internal person trips.
- Section F describes the mode choice model.
- Section G describes the time of day (peaking) factors.
- Section H describes the trip assignment process.
- Section I describes the model for external trips.
- Section J describes the Metro Interim Truck model, used to develop a truck trip table.
- Section K describes the Portland International Airport Model.

A Input Data

Metro's model requires a variety of input data.

A.1 Land Use and Access Measurement Data

A.1.a Socioeconomic and Land Use Data

The socioeconomic and land use data used in Metro's modeling process are listed below:

- H.I.A. – Sixty-four categories of households are formed when the following characteristics are cross-classified:
  - Household size by four groups (1, 2, 3, 4+)
  - Income class by four groups (< $15K, $15-25K, $25-63K, > $63K), 2010 dollars
  - Age of household head by four groups (0-25, -55, -65, >65)
- Employment by two-digit NAICS category
  - Agriculture and forestry (NAICS 11, 21)
  - Construction (NAICS 23)
  - Manufacturing (NAICS 31-33)
  - Transport, warehousing, utilities (NAICS 22, 48, 49)
  - Wholesale trade (NAICS 42)
  - Retail trade (NAICS 44, 45, 72)
  - Financial, insurance, real estate (NAICS 52, 53, 55)
  - Consumer, health, business services (NAICS 51, 54, 56, 61, 62, 71, 81)
  - Government, K-12 education (government ownership)
- Number of local intersections

A.1.b Accessibility Measure Calculation

The following base accessibility variables are computed for use in the model:

- Number of employees within 30 minutes of transit travel time (includes walk and wait time)
- Households within ½ mile of each zone
- Retail employment within ½ mile of each zone
- Total employment within ½ mile of each zone
- Number of local intersections within ½ mile of each zone

Composite accessibility measures (commonly referred to as “mix” variables) are then developed to account for both the relative magnitudes of and the interactions between three urban design variables known to affect travel behavior. This has an added benefit of eliminating the collinearity problem associated with using these variables individually:

- Household density
- Employment density
- Intersection density (a measure of street connectivity)

Two accessibility variables are computed: one uses retail employment density (MixRet) and the other uses total employment density (MixTot). The household and employment values are normalized to intersection units using geometric means. The natural log is used to transform the variables’ units for compatibility with other variables in the auto ownership, multimodal accessibility, and mode choice models. Here is the equation form:

Mix = Ln ((int*(emp*(int.mean / emp.mean)) * (hh*(int.mean / hh.mean))) /
(int + (emp*(int.mean / emp.mean)) + (hh*(int.mean / hh.mean))))

where:

- int = Number of local intersections within ½ mile of each zone
- emp = Retail OR Total employment within ½ mile of each zone
- hh = Households within ½ mile of each zone
- int.mean = Mean int value across all zones
- emp.mean = Mean emp value across all zones
- hh.mean = Mean hh value across all zones

A.1.c Special Trip Generators

Major shopping centers and universities receive special treatment in the generation and distribution models. Due to the unique trip generation characteristics of these locations, the following data are required for each site:

- Shopping center square footage
- College students and staff

A.2 Travel Time Data

Travel time is an important variable in the destination choice and mode choice models.

Door-to-door travel time is used for the model estimation, and zone-to-zone travel time is used for the calibration. Travel time data in this section refer to zone-to-zone travel time.

For all modes but bike and walk, two sets of weekday travel time matrices are developed:

- Peak: A.M. 2-hour peak (07:00-08:59)
- Off-Peak: Mid-day 1-hour (12:00-12:59)

Household survey data are used to estimate the percentage of peak vs. off-peak travel for each trip purpose (except school). These factors determine which proportion of trips experience peak vs. off-peak travel times in the multimodal accessibility functions and mode choice models:

TABLE 1. Peak Factors Applied to Skims in Mode Choice Models

Trip Purpose		Peak Skims	Off-Peak Skims
HBW	Home-Based Work	0.606	0.394
HBshop	Home-Based Shopping	0.300	0.700
HBrec	Home-Based Recreation	0.309	0.691
HBoth	Home-Based Other	0.377	0.623
NHBW	Non-Home-Based Work	0.382	0.618
NHBNW	Non-Home-Based Non-Work	0.331	0.669
HBcoll	Home-Based College	0.407	0.593

A.2.a Auto Skims

Auto skims are prepared using the results of previous Emme assignments.

A.2.b Transit Skims

The peak and off-peak transit skims account for differences in levels of transit service and network congestion. Six transit impedance matrices are developed for each time period:

- In-vehicle time by transit sub-mode
- Walk time
- First wait time
- Transfer wait time
- Number of total boardings
- Number of transfer boardings

Boarding time is calculated as the time equivalent of the coefficient on the number of transfers, with the resulting value of 8.31 minutes applied universally.

For model application, wait times are modeled at 50% of headway. Timed transfer locations receive no special consideration.

Total walk time, initial wait time, and total accumulated transfer wait time each have a maximum value of 30 minutes. This means that no zone pair with transit access (see Section F) has more than 30 minutes walk time, 30 minutes initial wait time, and 30 minutes transfer wait time.

The walk and wait time weights used in the demand model are identical to those applied in pathfinding:

- Transit skim wait time weight: 1.6
- Transit skim auxiliary transit (walk) time weight: 2.76

For each zone pair, in-vehicle time skims are prepared by transit mode; in the case of multimodal journeys and/or path sets, these values represent the individual mode's constituent portion of total in-vehicle time.

A.3 Trip Cost Data

Travel cost is an input to the mode choice model. All cost values are in 2010 dollars.

A.3.a Auto Operating Cost

Auto operating cost varies by mode:

- Drive Alone = ($0.211 / mile*distance) + (½ of parking charge in attraction zone)
- Shared Ride = [($0.211 / mile*distance) + (½ of parking charge in attraction zone)] / 2
- Park and Ride = $0.211 / mile*distance (between production zone and lot)

A.3.b Parking Charges

The parking charge used as an input to auto cost varies by trip purpose:

- Home-based work (HBW) and home-based college (HBcoll) use long-term parking charge.
- Other trip purposes use short-term parking charge (½ of long-term parking charge).

A.3.c Transit Fare

Transit fares are based on the average fares charged by the region’s transit providers in May 2010. Average fares for all transit providers providing a transit pass option were estimated at 73% of the cash fare price, which is the 2010 ratio for TriMet.

- TriMet
  - Travel within CBD-Lloyd District Free Rail Zone : $0
  - All other travel: $1.678
- C-Tran
  - For intra-Clark County service : $1.095
  - For Clark County-North/Northeast Portland: $1.716
  - For Clark County-Portland premium service: $2.190
    - 2010-2017: to Portland CBD, Lloyd District, Marquam Hill
    - 2018 and beyond: to Marquam Hill only
- Sandy Area Metro (SAM)
  - For Sandy-Rhododendron service: $1.460
- SMART
  - For Wilsonville-Portland service: $2.591
- South Clackamas Transportation District (SCTD)
  - For Molalla-Portland service: $2.678
  - For Molalla-Clackamas Community College service: $1.000

A.4 Transportation Service Inputs

Various transportation service inputs are applied at different stages in the model:

- Average weekday volumes at external station locations
- Household transit coverage factor by TAZ for both the peak and off-peak periods: percent of the households within a zone that are within 0.2 miles of a bus stop or 0.5 miles of a rail station (straight line distances)
- Employment transit coverage factor by TAZ for both the peak and off-peak periods: percent of the jobs within a zone that are within 0.2 miles of a bus stop or 0.5 miles of a rail station (straight line distances)
- Park-and-ride lot locations, capacities, and types

B Pre-Generation

Several models must be run before starting the travel demand process. This stage is called pre-generation and includes the worker model, the auto ownership model, and the children model.

These models were estimated using a multinomial logit procedure. The listed utilities are converted into probabilities to determine the number of workers, cars, and children in each TAZ. The following example probability is used for zero-worker households:

$$Prob_{0\text{-worker HH}} = U_{0\text{-workerHH}} \, / \, (U_{0\text{-workerHH}} + U_{1\text{-workerHH}} + U_{2\text{-workerHH}} + U_{3\text{-workerHH}})$$

B.1 Worker Model

The worker model estimates the number of households with 0, 1, 2, and 3 or more workers.

B.1.a Variable Definitions

HHsize	=	1 person, 2 person, 3 person, 4+ person
Workercl	=	0 worker, 1 worker, 2 worker, 3+ worker
Income1	=	1 if 2010 household income < $15,000
Income2	=	1 if 2010 household income >= $15,000 and < $25,000
Income3	=	1 if 2010 household income >= $25,000 and < $62,500
Income4	=	1 if 2010 household income >= $62,500
Agecat1	=	1 if age of household head 18-24
Agecat2	=	1 if age of household head 25-55
Agecat3	=	1 if age of household head 56-65
Agecat4	=	1 if age of household head > 65

B.1.b Calibrated Choice Utilities

Constants may differ from the original estimation due to the calibration process. These coefficients are the same as in the calibration code.

0 worker households

U = **exp (** 7.034 – 1.406*HHsize + 2.823*Income1 + 2.024*Income2 + 0.5145*Income3 – 4.396*Agecat1 – 5.054*Agecat2 – 2.8*Agecat3 **)**

1 worker households

U = **exp (** 5.101 – 1.125*HHsize + 1.64*Income1 + 1.909*Income2 + 0.9023*Income3 – 1.605*Agecat1 – 1.478*Agecat2 – 1.095*Agecat3 **)**

2 worker households

U = **exp (** 3.4 – 0.571*Hhsize - 0.4828*Income1 + 0.502*Income2 + 0.235*Income3 **)**

3+ worker households

U = **exp (** 0 **)**

B.1.c Estimated Variable Coefficients

TABLE 2. Worker Model

Variable	0 worker		1 worker		2 worker	
	Coefficient	T-Statistic	Coefficient	T-Statistic	Coefficient	T-Statistic
Calib Constant	*7.034*		*5.101*		*3.4*	
Constant	8.011	25.1	6.083	20.2	3.73	17.6
HHsize	-1.406	-16.5	-1.125	-19.1	-0.571	-10.9
Income1	2.823	5.9	1.64	3.6	-0.4828	-1.0
Income2	2.024	5.3	1.909	5.4	0.502	1.4
Income3	0.5145	2.6	0.9023	5.3	0.235	1.4
Agecat1	-4.936	-13.9				
Agecat2	-5.054	-22.5	-1.478	-6.7		
Agecat3	-2.8	-11.9	-1.095	-4.6		

The 3+ worker choice utility is held constant at zero.

B.2 Auto Ownership Model

Auto ownership is an important input to the mode choice models.

The model estimation dataset includes all surveyed households that reported income and whose locations could be geocoded.

B.2.a Variable Definitions

Hhsize1 = 1 person
Hhsize2 = 2 person
Hhsize3 = 3 person
Hhsize4 = 4 person
Worker0 = 0 worker
Worker1 = 1 worker
Worker2 = 2 worker
Worker3 = 3 worker
Income1 = 1 if 2010 household income < $15,000
Income2 = 1 if 2010 household income >= $15,000 and < $25,000
Income3 = 1 if 2010 household income >= $25,000 and < $62,500
Income4 = 1 if 2010 household income >= $62,500
Sfdwell = 1 if single family house, 0 if other dwelling type
MixTot = Total employment accessibility within ½ mile (see Section A.1.b)
Tot30t = (Total employment within 20 minutes by mid-day transit) /1000

B.2.b Calibrated Choice Utilities

0 car households

U = **exp (** -7.152 + 2.81*Hhsize1 + 0.562*Hhsize2 + 2.822*Worker0 + 1.965*Worker1 + 2.587*Income1 + 1.344*Income2 – 1.056*Sfdwell + 0.2737*MixTot + 0.01495*Tot30t **)**

1 car households

U = **exp (** -3.678 + 2.829*Hhsize1 + 0.9735*Hhsize2 + 0.3272*Hhsize3 + 1.493*Worker0 + 1.326*Worker1 + 1.335*Income1 + 1.212*Income2 + 0.2684*Income3 – 0.4071*Sfdwell + 0.2251*MixTot + 0.007245*Tot30t **)**

2 car households

U = **exp (** -2.342+ 0.3485*Hhsize2 – 0.2177*Hhsize3 + 2.299*Worker1 + 2.355*Worker2 + 1.908*Worker3 + 0.5937*Income2 + 0.3964*Income3 + 0.4813*Income4 + 0.09206*MixTot + 0.002282*Tot30t **)**

3+ car households

U = **exp (** 0 **)**

B.2.c Estimated Variable Coefficients

TABLE 3. Auto Ownership Model

Variable	**0 car**		**1 car**		**2 car**	
	Coefficient	T-Statistic	Coefficient	T-Statistic	Coefficient	T-Statistic
Calib Constant	*-7.152*		*-3.678*		*-2.342*	
Constant	-7.145	-11.9	-3.501	-12.3	-2.211	-8.9
Hhsize1	2.81	9.7	2.829	18.8		
Hhsize2	0.562	1.9	0.9735	6.4	0.3485	3.4
Hhsize3			0.3272	1.9	-0.2177	-1.9
Hhsize4						
Worker0	2.822	7.7	1.493	9.1		
Worker1	1.965	5.6	1.326	1019	2.299	10.6
Worker2					2.355	12.5
Worker3					1.908	10.8
Income1	2.587	12.0	1.335	7.6		
Income2	1.344	6.3	1.212	7.7	0.5937	3.9
Income3			0.2684	2.5	0.3964	3.9
Income4					0.4813	4.5
Sfdwell	-1.056	-6.5	-0.4071	-4.8		
MixTot	0.2737	4.1	0.2251	6.1	0.09206	3.6
Tot30t	0.01495	8.7	0.007245	6.2	0.002282	2.3

The 3+ car choice utility is held constant at zero.

The land use variables (along with the binary dwelling type variable) are the sole model inputs that can be modified for future scenario testing.

B.3 Children Model

The school trip purpose requires the calculation of the number of households with 0, 1, 2, or 3+ children.

B.3.a Variable Definitions

HHsize = 1 person, 2 person, 3 person, 4+ person
Agecat4 = 1 if age of household head > 65

B.3.b Calibrated Choice Utilities

This model was not changed in calibration.

0 child households

U = **exp (** -3.239336*HHsize + 5.537674*Agecat4 **)**

1 child households

U = **exp (** -1.81999*HHsize + 3.458333*Agecat4 **)**

2 child households

U = **exp (** 0.0118144*HHsize + 0.3199485*Agecat4 **)**

3+ child households

U = **exp (** 0 **)**

B.3.c Estimated Variable Coefficients

TABLE 4. Children Model

Variable	**0 child**		**1 child**		**2 child**	
	Coefficient	T-Statistic	Coefficient	T-Statistic	Coefficient	T-Statistic
HHsize	-3.239336	-26.9	-1.81999	-16.5	0.0118144	0.1
Agecat4	5.537674	26.2	3.458333	16.9	0.3199485	1.5

The 3+ child choice utility is held constant at zero.

C Trip Generation

Average weekday person trips are generated for eight trip purposes:

- HBW – Home-Based Work
- HBshop – Home-Based Shopping
- HBrec – Home-Based Recreation
- HBoth – Home-Based Other (excludes school and college)
- NHBW – Non-Home-Based Work
- NHBNW – Non-Home-Based Non-Work
- HBcoll – Home-Based College
- HBsch – Home-Based School

For each zone, the number of households in each demographic category is multiplied by a production rate. The number of trips is then factored up to match regional control totals by applying a calibration factor which varies by purpose. The demographic categories, production rates, and calibration factors are described by purpose in the following subsections.

Most home-based trips are generated by production zone in the two steps described above, then they are attached to an attraction zone within the destination choice models. Non-home-based trips add an extra step within generation: the allocation of trip productions to zones according to their total households and employment. Finally, school and college generation models incorporate trip attraction, whereas the other purposes address attraction through the destination choice models.

C.1 HBW (Home-Based Work)

C.1.a Productions

HBW trips are produced solely by the number of workers in a household:

- Input Variable: Number of workers
- Output: Person trips (all modes), by zone of production (home)

TABLE 5. HBW Production Rates

Workers	Rate
1	1.38325222
2	2.39110122
3+	3.88667372

C.1.b Attractions

HBW trip attractions are estimated by the following procedure:

- A regional average trip rate per employee is generated by dividing the sum of HBW productions by total employees.
- Trip attractions are generated by multiplying the average trip rate by the total employment in each TAZ.

C.1.c Scaling

Final HBW trips are generated by the following procedure:

- Total employment (multiplied by a calibration factor of 1.36) is divided by total productions to produce a production factor.
- Final HBW trips are calculated by multiplying the number of productions in each TAZ by the production factor.

C.2 HBshop (Home-Based Shopping)

HBshop productions are generated by a cross-classification model:

- Input Variables: Household size, Number of workers
- Output: Person trips (all modes), by zone of production (home)

TABLE 6. HBshop Production Rates

	Workers			
HHsize	**0**	**1**	**2**	**3+**
1	0.65370595	0.36543758		
2	1.4747858	0.96459839	0.66841305	
3	1.4397819	1.1695282	0.93650663	1.0063395
4+	1.7925876	1.8066825	1.5106965	1.2347277

The resulting trips are multiplied by a calibration factor of 1.1.

C.3 HBrec (Home-Based Recreation)

HBrec productions are generated by a cross-classification model:

- Input Variable: Household size by worker status
- Output: Person trips (all modes), by zone of production (home)

TABLE 7. HBrec Production Rates

HHsize	all household members work	some household members do not work
1	0.50317472	0.47897259
2	0.57970395	0.8811184
3	1.1656474	1.2137337
4+	.	2.2400753

The resulting trips are multiplied by a calibration factor of 1.1.

C.4 HBoth (Home-Based Other)

HBoth productions are generated by a cross-classification model:

- Input Variable: Household size by worker status
- Output: Person trips (all modes), by zone of production (home)

TABLE 8. HBoth Production Rates

HHsize	all household members work	some household members do not work
1	0.54391065	0.89368165
2	1.2416304	1.628105
3	1.4489857	2.2256102
4+		3.4876336

The resulting trips are multiplied by a calibration factor of 1.1.

C.5 NHBW (Non-Home-Based Work)

Production of non-home-based travel in trip-based models requires some measure of attraction.

C.5.a Pre-Production

Total NHBW productions are initially generated solely by number of workers:

- Input Variable: Number of workers
- Output: Person trips (all modes), by zone of production (work)

TABLE 9. NHBW Pre-Production Rates

Workers	Rate
0	0.02585558
1	0.72965676
2	1.5252267
3+	1.9130584

C.5.b Scaling

NHBW productions are scaled to total employment by the following procedure:

- Total employment (multiplied by a calibration factor of 0.803) is divided by total productions to produce a production factor.
- Adjusted NHBW productions are calculated by multiplying the number of productions in each TAZ by the production factor.

Resulting trips are summed to develop a control total of NHBW trips produced by all zones.

C.5.c Variable Definitions

Hhold = Number of households in production (work) zone

Employment in production (work) zone by two-digit NAICS codes…

RetEmp = retail trade (NAICS 44, 45, 72)
SvcEmp = service (NAICS 51, 54, 56, 61, 62, 71, 81)
GvtEmp = government ownership
NonRetSvcGvt = all employment other than retail, service and government

C.5.d Choice Utility

U = **exp (ln (** 0.1427*Hhold + 2.3955*SvcEmp + 1.7828*GvtEmp + 1.2263NonRetSvcGov + RetEmp **))**

C.5.e Estimated Variable Coefficients

TABLE 10. NHBW Production Utility

Variable	NHBW	
	Coefficient	T-Statistic
Hhold	0.1427	12.4
SvcEmp	2.3955	7.3
GvtEmp	1.7828	4.8
NonRetSvcGvt	1.2263	1.8
Retail	1	0

For each production zone, the control total (described in Section C.5.b) is multiplied by the ratio of the zone's production utility (calculated by the utility equation in Section C.5.d) to the sum of all zones' production utilities. In this manner total NHBW trip productions are allocated according to proportion of production by zone.

C.6 NHBNW (Non-Home-Based Non-Work)

C.6.a Pre-Production

NHBNW productions are initially estimated by a cross-classification model:

- Input Variables: Household size by worker status
- Output: Person trips (all modes), by zone of production

TABLE 11. NHBNW Pre-Production Rates

HHsize	all household members work	some household members do not work
1	0.55627805	0.98518294
2	0.94975883	1.2483164
3	1.2344123	1.802035
4+	.	2.8792371

Resulting trips are multiplied by a calibration factor of 1.1 then summed to develop a control total of NHBNW trips.

C.6.b Variable Definitions

Employment in production zone by two-digit NAICS codes…
RetEmp = retail trade (NAICS 44, 45, 72)
SvcEmp = service (NAICS 51, 54, 56, 61, 62, 71, 81)

GvtEmp = government ownership
NonRetSvcGvt = all employment other than retail, service, and government

C.6.c Choice Utility

U = **exp (ln (**RetEmp + 0.5086*SvcEmp + 0.388*GvtEmp + 0.05239*NonRetSvcGvt **))**

C.6.d Estimated Variable Coefficients

TABLE 12. NHBNW Production Utility

Variable	NHBW	
	Coefficient	T-Statistic
RetEmp	1	0
SvcEmp	0.5086	14.3
GvtEmp	0.388	16.9
NonRetSvcGvt	0.05239	25.5

For each production zone, the control total (detailed in Section C.6.a) is multiplied by the ratio of the zone's production utility (calculated by the utility equation in Section C.6.c) to the sum of all zones' production utility. In this manner total NHBNW trip productions are allocated according to proportion of production by zone.

C.7 HBcoll (Home-Based College)

C.7.a Productions

HBcoll productions are generated by a cross-classification model:

- Input Variables: Household size, Age group (age of household head)
- Output: Person trips (all modes), by zone of production (home)

TABLE 13. HBcoll Production Rates

	Age Group			
Hhsize	**<25**	**25-54**	**55-64**	**>65**
1	0.52380952	0.05958549	0.02985075	0.01823708
2	0.48387097	0.17915691	0.03581267	0.03353057
3	1.0	0.23421927	0.33980583	0.06557377
4+	0.45833333	0.38158996	0.58510638	0

Productions are adjusted upward by a calibration factor of 1.074.

C.7.b Attractions

College vehicle trips are used as the HBcoll attraction factor. The vehicle computation is derived from ITE rates (modified to avoid double counting):

- 4 year college vehicle trips = students*2.5 or staff*9.8
- 2 year college vehicle trips = students*1.5 or staff*28.2

Each college is assigned vehicle trips according to whichever formula (student or staff) generates the fewest number of trips.

Attractions are scaled to productions by multiplying the vehicles in each zone by the ratio of total productions to total vehicles.

C.8 HBsch (Home-Based School)

HBsch productions are generated by a cross-classification model, which is based on Metro's 1985 household travel survey.

- Input Variables: Household size, Number of children
- Output: Person trips (all modes), by zone of production (home)

TABLE 14. HBsch Production Rates

	Children			
Hhsize	**0**	**1**	**2**	**3+**
1	0	1.0	0.8	.
2	0	1.3933333	2.5	.
3	0	1.313253	2.9808102	4.875
4+	0	1.0	0.8	.

HBsch attractions are set equal to productions because school employment is difficult to obtain at any degree of zonal accuracy and because most schools are located close to students' homes.

Unadjusted HBsch attractions (schat):	equal to total productions by zone
HH Growth rate "1985 to current" (hhgrow):	households / 501,701 (1985 HH)
School Target (schtar – scalar):	hhgrow*392,005 (1985 sch prod)
Total Raw Productions (totsch – scalar):	schat
Adjusted Productions (schat):	(schat/totsch)*schtar

D Multimodal Accessibility Functions

Modal accessibility functions were estimated for use in the destination choice model. For each trip purpose, they measure the utility of choosing one of seven discrete modes:

Drive alone – only available to households with at least one car
Drive with passenger – only available to households with at least one car
Auto passenger
Transit by walk access – only available if both trip ends are within either 0.2 miles of a bus stop or 0.5 miles of a rail station
Transit by park-and-ride access – only available if destination trip end is within 0.2 miles of a bus stop or 0.5 miles of a rail station; only available for home-based non-school trips; utilities and lot usage for formal park-and-ride lots and informal park-and-ride locations are calculated by a nested park-and-ride lot choice model
Bike – utilities and distances are produced by a stand-alone tool based on a dedicated bicycle network
Walk – only available for trips with a distance less than five miles

The logsum of all modal utilities is a key input to the destination choice model (Section E). It is generated as follows for each trip purpose (and for some purposes, by income group):

$$\mathbf{Ln}\ (\ U_{\text{Drive Alone}} + U_{\text{Drive with Passenger}} + U_{\text{Auto Passenger}} + U_{\text{Walk to Transit}} + U_{\text{Park\&Ride}} + U_{\text{Bike}} + U_{\text{Walk}}\ )$$

D.1 HBW (Home-Based Work)

D.1.a Variable Definitions

IvTime = In-vehicle travel time (varies by mode)
WalkTime = Walk time, by mode:
  Drive Alone: vehicle egress at trip end (5 min in CBD, 2 min elsewhere)
  Shared Ride: Drive Alone walk time plus 5 minutes
  Transit Modes: access to first stop plus egress from last stop at 3 mph
TranWait1 = Transit initial wait time
TranWait2 = Transit transfer wait time
TranXfrs = Transit # of transfers
Cbdist = Bicycle Commute Trip Distance
Cbcost = Bicycle Commute Route Attractiveness
Wdist = Total Walk Distance
Formal = 1 if considering formal park-and-ride lots
Informal = 1 if considering informal park-and-ride locations

D.1.b Calibrated Choice Utilities

Drive Alone

U = **exp (**-0.03608*IvTime – 0.09956*WalkTime **)**

Drive with Passenger

U = **exp (**-0.03608*IvTime – 0.09956*WalkTime **)**

Auto Passenger

U = **exp (**-0.03608*IvTime – 0.09956*WalkTime **)**

Transit by Walk Access

U = **exp (**-0.03608*($IvTime_{Bus}$ + 0.88*$IvTime_{LRT}$ + $IvTime_{SC}$ + 0.88*$IvTime_{Rail}$) – 0.0576*TranWait1 – 0.04002*TranWait2 – 0.09956*WalkTime – 0.3*TranXfrs **)**

Park and Ride

U = **exp (**-6.12 + 0.75***ln(**exp(Formal*0.5***ln(** $\sum_{1 \to N}$ [exp(($U_{AutoLeg}$ + $U_{TransitLeg}$) / (0.5*0.75))] **)**) + exp(Informal*0.5***ln(** $\sum_{1 \to N}$ [exp(($U_{AutoLeg}$ + $U_{TransitLeg}$) / (0.5*0.75)) **)))**

where

$U_{AutoLeg}$ = **exp(** -0.03608*IvTime **)**

and

$U_{TransitLeg}$ = **exp(** -0.03608*($IvTime_{Bus}$ + 0.88*$IvTime_{LRT}$ + $IvTime_{SC}$ + 0.88*$IvTime_{Rail}$) – 0.0576*TranWait1 – 0.04002*TranWait2 – 0.09956*WalkTime – 0.3*TranXfrs **)**

and

N = number of formal park-and-ride lots or informal par-and-ride locations under consideration

Bike

U = **exp (**-0.8*Cbdist - 0.365*Cbcost **)**

Walk

U = **exp (** -4.307***ln**(Wdist) **)**

D.1.c Estimated Variable Coefficients

The generic multimodal accessibility functions use the same variable coefficients estimated for the mode choice model, which also includes extra variables relating to specific household characteristics. The estimated coefficients for the HBW accessibility functions are included in the tables in Section F.1.c.

D.2 HBshop, HBrec, HBoth (Other Home-Based)

Mode choice model variable coefficients do not vary between the HBshop, HBrec, and HBoth trip purposes. However, the model features different constants by purpose for some modes.

D.2.a Variable Definitions

Shop	=	1 if HBshop trip
Rec	=	1 if HBrec trip
Oth	=	1 if HBoth trip
IvTime	=	In-vehicle travel time (varies by mode)
WalkTime	=	Walk time, by mode:

Drive Alone: vehicle egress at trip end (5 min in CBD, 2 min elsewhere)
Shared Ride: Drive Alone walk time plus 5 minutes
Transit Modes: access to first stop plus egress from last stop at 3 mph

TranWait1 = Transit initial wait time
TranWait2 = Transit transfer wait time
TranXfrs = Transit # of Transfers
Nbdist = Bicycle Non-commute Trip Distance
Nbcost = Bicycle Non-commute Route Attractiveness
Wdist = Total Walk Distance
Formal = 1 if considering formal park-and-ride lots
Informal = 1 if considering informal park-and-ride locations

D.2.b Calibrated Choice Utilities

Drive Alone

U = **exp (** -0.0215*IvTime – 0.1033*WalkTime **)**

Drive with Passenger

U = **exp (** -0.0215*IvTime – 0.1033*WalkTime**)**

Auto Passenger

U = **exp (** -0.0215*IvTime – 0.1033*WalkTime **)**

Transit by Walk Access

U = **exp (** – 0.0215*(IvTime$_{Bus}$ + 0.86*IvTime$_{LRT}$ + IvTime$_{SC}$ + 0.86*IvTime$_{Rail}$) – 0.06847*TranWait1 – 0.0524*TranWait2 – 0.1033*WalkTime – 0.3*TranXfrs **)**

Park and Ride

U = **exp(**-5.9*Shop – 5.0*Rec – 6.3*Oth + 0.75***ln(**exp(Formal*0.5***ln(** $\sum_{1\rightarrow N}$ [exp((U$_{AutoLeg}$ + U$_{TransitLeg}$) / (0.5*0.75))] **))** + exp(Informal*0.5***ln(** $\sum_{1\rightarrow N}$ [exp((U$_{AutoLeg}$ + U$_{TransitLeg}$) / (0.5*0.75)) **))** **)**

where

U$_{AutoLeg}$ = **exp(** -0.0215*IvTime **)**

and

U$_{TransitLeg}$ = **exp(** -0.0215*(IvTime$_{Bus}$ + 0.86*IvTime$_{LRT}$ + IvTime$_{SC}$ + 0.86*IvTime$_{Rail}$) – 0.06847*TranWait1 – 0.0524*TranWait2 – 0.1033*WalkTime – 0.3*TranXfrs **)**

and

N = number of formal park-and-ride lots or informal par-and-ride locations under consideration

Bike

U = **exp (** -0.9*Nbdist - 0.22*Nbcost **)**

Walk

U = **exp (**-2.466 * **ln**(Wdist)**)**

D.2.c Estimated Variable Coefficients

The generic multimodal accessibility functions use the same variable coefficients estimated for the mode choice model, which also includes extra variables relating to specific household characteristics. The estimated coefficients for the HBshop, HBrec, and HBoth accessibility functions are included in the tables in Section F.2.c.

D.3 NHBW & NHBNW (Non-Home-Based)

Cost coefficients do not vary by income group for non-home-based trips.

D.3.a Variable Definitions

IvTime = In-vehicle travel time (varies by mode)
WalkTime = Walk time, by mode:
  Drive Alone: vehicle egress at trip end (5 min in CBD, 2 min elsewhere)
  Shared Ride: Drive Alone walk time plus 5 minutes
  Transit Modes: access to first stop plus egress from last stop at 3 mph
TranWait1 = Transit initial wait time
TranWait2 = Transit transfer wait time
TranXfrs = Transit # of Transfers
Nbdist = Bicycle Non-commute Trip Distance
Nbcost = Bicycle Non-commute Route Attractiveness
Wdist = Total Walk Distance

D.3.b Calibrated Choice Utilities

Drive Alone

U = **exp (** -0.025*IvTime – 0.1493*WalkTime **)**

Drive with Passenger

U = **exp (** – 0.025*IvTime – 0.1493*WalkTime **)**

Auto Passenger

U = **exp (** – 0.025*IvTime – 0.1493*WalkTime **)**

Transit by Walk Access

U = **exp (**– 0.025*($IvTime_{Bus}$ + 0.86*$IvTime_{LRT}$ + $IvTime_{SC}$ + 0.86*$IvTime_{Rail}$) – 0.1337*TranWait1 – 0.07895*TranWait2 – 0.1493*WalkTime) – 0.3*TranXfrs **)**

Bike

U = **exp (** -0.9*Nbdist - 0.1*Nbcost **)**

Walk

U = **exp (** – 1.524***ln**(Wdist)**)**

D.3.c Estimated Variable Coefficients

The generic multimodal accessibility functions use the same variable coefficients estimated for the mode choice model. The estimated coefficients for the Non-Home Based accessibility functions are shown in the tables in Section F.3.b.

D.4 HBcoll (Home-Based College)

Cost coefficients do not vary by income group for college commute trips.

D.4.a Variable Definitions

IvTime = In-vehicle travel time (varies by mode)
WalkTime = Walk time, by mode:
Drive Alone: vehicle egress at trip end (5 min in CBD, 2 min elsewhere)
Shared Ride: Drive Alone walk time plus 5 minutes
Transit Modes: access to first stop plus egress from last stop at 3 mph
TranWait1 = Transit initial wait time
TranWait2 = Transit transfer wait time
TranXfrs = Transit # of Transfers
Cbdist = Bicycle Commute Trip Distance
Cbcost = Bicycle Commute Route Attractiveness
Wdist = Total Walk Distance
Formal = 1 if considering formal park-and-ride lots
Informal = 1 if considering informal park-and-ride locations

D.4.b Calibrated Choice Utilities

Drive Alone

U = **exp (** -0.05319*IvTime – 0.2111*WalkTime**)**

Drive with Passenger

U = **exp (**– 0.05319*IvTime – 0.2111*WalkTime**)**

Auto Passenger

U = **exp (**– 0.05319*IvTime – 0.2111*WalkTime**)**

Transit by Walk Access

U = **exp (**– 0.05319*($IvTime_{Bus}$ + 0.86*$IvTime_{LRT}$ + $IvTime_{SC}$ + 0.86*$IvTime_{Rail}$) – 0.0652*TranWait1 – 0.05302*TranWait2 – 0.2111*WalkTime – 0.3*TranXfrs **)**

Park and Ride

U = **exp(** -1.36 + 0.75***ln(**exp(Formal*0.5***ln(** $\sum_{1\rightarrow N}$ [exp(($U_{AutoLeg}$ + $U_{TransitLeg}$) / (0.5*0.75))] **))** + exp(Informal*0.5***ln(** $\sum_{1\rightarrow N}$ [exp(($U_{AutoLeg}$ + $U_{TransitLeg}$) / (0.5*0.75)) **))** **)**

where

$U_{AutoLeg}$ = **exp(** -0.05319*IvTime **)**

and

$U_{TransitLeg}$ = **exp(** -0.05319*($IvTime_{Bus}$ + 0.86*$IvTime_{LRT}$ + $IvTime_{SC}$ + 0.86*$IvTime_{Rail}$) – 0.0652*TranWait1 – 0.05302*TranWait2 – 0.2111*WalkTime – 0.3*TranXfrs **)**

and

N = number of formal park-and-ride lots or informal par-and-ride locations under consideration

Bike

U = **exp (** -0.8*Cbdist - 0.6*Cbcost **)**

Walk

U = **exp (** – 2.264***ln**(Wdist) **)**

D.4.c Estimated Variable Coefficients

The generic multimodal accessibility functions use the same variable coefficients estimated for the mode choice model. The estimated coefficients for the HBcoll accessibility functions are shown in the tables in Section F.4.c.

E Destination Choice

The destination choice models were developed using a multinomial logit estimation procedure. Estimation was based on the 1994-95 household activity survey. The models were calibrated to observed flows for 2005, at which point West Hills crossing dummy variables were added with half the value of the Willamette River crossing dummy variables. The parameters on the West Hills crossing dummy variables were updated following a review of flows revealed by the 2011 household activity survey.

E.1 HBW (Home-Based Work)

E.1.a Variable Definitions

Logsum of multimodal accessibility functions (all modes, by income)…
- LowLogSum = low income households (<$25K)
- MidLogSum = middle-income households ($25-50K)
- HighLogSum = high income households ($50K+)
- WashOr = 1 if trip crosses Columbia River from Washington to Oregon
- OrWash = 1 if trip crosses Columbia River from Oregon to Washington
- WillWE = 1 if trip crosses Willamette River from west to east
- HillWE = 1 if trip crosses West Hills from west to east

Employment in attraction zone by two-digit NAICS codes…
- RetEmp = retail trade (NAICS 44, 45, 72)
- FinEmp = financial, insurance, real estate (FIRE) (NAICS 52, 53, 55)
- SvcEmp = service (NAICS 51, 54, 56, 61, 62, 71, 81)

Other employment variables…
- TotEmp = total employment
- NonRet = all employment other than retail
- NonRetSvcFin = all employment other than retail, service, and FIRE

E.1.b Calibrated Choice Utilities

HBW – Low Income Households

U = **exp (** 2.235*LowLogSum – 0.4198*(LowLogSum^{2}) + 0.0222*(LowLogSum^{3}) – 1.502*WashOr – 1.378*OrWash – 0.4949*WillWE – 0.4949/2*HillWE+ **ln (** TotEmp **))**

HBW – Middle Income Households

U = **exp (**2.097*MidLogSum – 0.3995*(MidLogSum^{2}) + 0.02524*(MidLogSum^{3}) – 0.8209*WashOr – 1.635*OrWash – 0.3138*WillWE – 0.3138/2*HillWE + **ln (** RetEmp + 1.6005*NonRet **))**

HBW – High Income Households

U = **exp (**1.777*HighLogSum – 0.3908*(HighLogSum^{2}) + 0.02555*(HighLogSum^{3}) – 1.139*WashOr – 1.429*OrWash – 0.4325*WillWE – 0.4325/2*HillWE + **ln (** RetEmp + 2.8605*SvcEmp + 5.6013*FinEmp + 2.4312*NonRetSvcFin **))**

E.1.c Estimated Variable Coefficients

TABLE 15. HBW Destination Choice Model

Variable	Low Income <25K	Middle Income 25-50K	High Income 50K+

	Coefficient	T-Statistic	Coefficient	T-Statistic	Coefficient	T-Statistic
Calib LogSum	*2.235*		*2.097*		*1.777*	
Calib LogSum^2	*-0.4198*		*-0.3995*		*-0.3908*	
Calib LogSum^3	*0.0222*		*0.02524*		*0.02555*	
LogSum	2.203	21.6	1.891	37.0	1.562	30.2
LogSum^2	-0.3701	-6.0	-0.3614	-11.1	-0.3164	-9.1
LogSum^3	0.01899	2.1	0.02154	4.5	0.02195	3.9
WashOr	-1.502	-8.6	-0.8209	-10.6	-1.139	-14.2
OrWash	-1.378	-5.1	-1.635	-9.7	-1.429	-9.2
WillWE	-0.4949	-3.0	-0.3138	-3.4	-0.4325	-5.6
HillWE	*-0.24745*		*-0.1569*		*-0.21625*	
TotEmp	1	0				
RetEmp			1	0	1	0
SvcEmp					2.8605	5.3
FinEmp					5.6013	7.9
NonRet			1.6005	4.1		
NonRetSvcFin					2.4312	5.0

E.2 HBshop, HBrec, HBoth (Other Home-Based)

E.2.a Variable Definitions

MsLogSum = Logsum of multimodal accessibility functions
WashOr = 1 if trip crosses Columbia River from Washington to Oregon
OrWash = 1 if trip crosses Columbia River from Oregon to Washington
WillWE = 1 if trip crosses Willamette River from west to east
WillEW = 1 if trip crosses Willamette River from east to west
HillWE = 1 if trip crosses West Hills from west to east
HillEW = 1 if trip crosses West Hills from east to west
Hhold = Number of households in attraction zone
ParkAcres = Park acres in attraction zone
Employment in attraction zone by two-digit NAICS codes…
RetEmp = retail trade (NAICS 44, 45, 72)
SvcEmp = service (NAICS 51, 54, 56, 61, 62, 71, 81)
GvtEmp = government ownership
Other employment variables…
NonRet = all employment other than retail
NonRetSvcGvt = all employment other than retail, service, and government

E.2.b Calibrated Choice Utilities

HBShop

U = exp (7.595*((LowLogSum+MidLogSum+HighLogSum)/3) – 2.839*(((LowLogSum+MidLogSum+HighLogSum)/3)^2) + 0.3125*(((LowLogSum+MidLogSum+HighLogSum)/3)^3) – 0.698*WashOr – 1.873*OrWash – 0.4855*WillWE – 0.2656*WillEW – 0.4855/2*HillWE – 0.2656/2*HillEW + ln (RetEmp +.008396*NonRet + .022126*Hhold))

HBRec

U = exp (5.546*((LowLogSum+MidLogSum+HighLogSum)/3) – 1.801*(((LowLogSum+MidLogSum+HighLogSum)/3)^2) + 0.1907*(((LowLogSum+MidLogSum+HighLogSum)/3)^3) – 1.209*WashOr – 1.539*OrWash – 0.2962*WillWE – 0.1703*WillEW – 0.2962/2*HillWE – 0.1703/2*HillEW + ln (TotEmp + 1.278*Hhold + 4.6833*ParkAcres))

HBoth

U = exp (6.476*((LowLogSum+MidLogSum+HighLogSum)/3) – 2.284*(((LowLogSum+MidLogSum+HighLogSum)/3)^2) + 0.2505*(((LowLogSum+MidLogSum+HighLogSum)/3)^3) – 1.36*WashOr – 1.546*OrWash – 0.456*WillWE – 0.456/2*HillWE + ln (0.2393*Hhold + RetEmp + 0.6419*SvcEmp + 0.6109*GvtEmp + 0.06802*NonRetSvcGvt))

E.2.c Estimated Variable Coefficients

TABLE 16. HBshop, HBrec, HBoth Destination Choice Model

Variable	**HBshop**		**HBrec**		**HBoth**	
	Coefficient	T-Statistic	Coefficient	T-Statistic	Coefficient	T-Statistic
Calib LogSum	*7.595*		*5.546*		*6.476*	
Calib LogSum^2	*-2.839*		*-1.801*		*-2.284*	
Calib LogSum^3	*0.3125*		*0.1907*		*0.2505*	
LogSum	7.765	46.1	5.616	45.7	6.586	64.6
LogSum^2	-2.801	-24.0	-1.793	-19.7	-2.274	-29.7
LogSum^3	0.3179	14.5	0.1907	10.9	0.2505	17.0
WashOr	-0.698	-8.0	-1.209	-15.5	-1.36	-21.0
OrWash	-1.873	-6.3	-1.539	-9.2	-1.546	-10.2
WillWE	-0.4855	-4.8	-0.2962	-4.0	-0.456	-7.1
WillEW	-0.2656	-2.7	-0.1703	-2.4		
HillWE	*-0.24275*		*-0.1481*		*-0.228*	
HillEW	*-0.1328*		*-0.08515*			
Hhold	0.22126	-41.5	1.2780	4.4	0.2393	-24.2
ParkAcres			4.6833	12.2		
TotEmp			1	0		
RetEmp	1	0			1	0
SvcEmp					0.6419	-5.9
GvtEmp					0.6109	-5.9
NonRet	0.008396	-22.5				
NonRetSvcGvt					0.06802	-14.2

E.3 NHBW & NHBNW (Non-Home-Based)

E.3.a Variable Definitions

MsLogSum = Logsum of multimodal accessibility functions
WashOr = 1 if trip crosses Columbia River from Washington to Oregon
OrWash = 1 if trip crosses Columbia River from Oregon to Washington
WillWE = 1 if trip crosses Willamette River from west to east
HillWE = 1 if trip crosses West Hills from west to east
Hhold = Number of households in attraction zone
Employment in attraction zone by two-digit NAICS codes…
RetEmp = retail trade (NAICS 44, 45, 72)
SvcEmp = service (NAICS 51, 54, 56, 61, 62, 71, 81)
GvtEmp = government ownership
Other employment variable…
NonRetSvcGvt = all employment other than retail, service, and government

E.3.b Calibrated Choice Utilities

The NHBW OrWash coefficient as originally estimated carried a positive sign, which is logically counterintuitive. Given that the negative effect of the river crossing associated with these trips is assumed to be similar to that for HBW trips but in the opposite direction, the NHBW OrWash coefficient is asserted as the average of the HBW WashOr coefficients (low, middle, and high income).

NHBW

U = **exp (**2.874*****MsLogSum – 0.3828*(MsLogSum^2) + 0.003828*(MsLogSum^3) – 1.927*WashOr - 1.154*OrWash – 0.2039*WillWE – 0.2039/2*HillWE + **ln (** 0.2089*Hhold + RetEmp + 0.316*SvcEmp + 0.236*GvtEmp + 0.06911*NonRetSvcGvt **))**

NHBNW

U = **exp (**3.741*****MsLogSum – 0.8652*(MsLogSum^2) + 0.003402*(MsLogSum^3) – 1.796*WashOr – 0.2155*OrWash – 0.208*WillWE – 0.208/2*HillWE + **ln (** 0.1722*Hhold + RetEmp + 0.1125*SvcEmp + 0.1877*GvtEmp + 0.01555*NonRetSvcGvt **))**

E.3.c Estimated Variable Coefficients

TABLE 17. Non-Home-Based Destination Choice Model

Variable	**NHBW**		**NHBNW**	
	Coefficient	T-Statistic	Coefficient	T-Statistic
Calib LogSum	*2.874*		*3.741*	
Calib LogSum^2	*-0.3828*		*-0.8652*	
Calib LogSum^3	*0.003828*		*0.003402*	
MsLogSum	2.886	46.9	3.841	65.4
MsLogSum^2	-0.3828	-10.5	-0.7402	-23.3
MsLogSum^3	N/A		N/A	
WashOr	-1.927	-17.6	-1.796	-19.7
OrWash	-1.154	N/A	-0.2155	-2.5

WillWE	-0.2039	-3.4	-0.208	-3.1
HillWE	*-0.10195*		*-0.104*	
Hhold	0.2089	-22.3	0.1722	-33.6
RetEmp	1	0	1	0
SvcEmp	0.316	-10.6	0.1125	-17.0
GvtEmp	0.236	-10.9	0.1877	-15.4
NonRetSvcGvt	0.06911	-14.6	0.01555	-13.2

E.4 HBcoll (Home-Based College)

HBcoll destination choice is a function of multimodal accessibility and college attractions. The multimodal accessibility value has a calibration coefficient. This simple model was not estimated by multinomial logit.

E.4.a Variable Definitions

MsLogSum = Logsum of multimodal accessibility function
Collat = HBcoll attractions

E.4.b Calibrated Choice Utility

$U = \exp(2.50 \cdot MsLogSum - 0.6 \cdot (MsLogSum^2) + 0.004 \cdot (MsLogSum^3) + \ln(Collat))$

E.5 HBsch (Home-Based School)

$U = \exp(\ln(ATTR_j) - 0.6 \cdot T_{ij} + 0.012 \cdot T_{ij}^2)$

Where:

i = from zone
j = to zone
T = mid-day auto travel time

F Mode Choice Model

Modal accessibility functions were estimated as an input to the destination choice and mode choice models. For each trip purpose, they measure the utility of choosing one of seven discrete modes.

Drive alone – only available to households with at least one car
Drive with passenger – only available to households with at least one car
Auto passenger
Transit by walk access – only available if both trip ends are within 0.2 miles of a bus stop, 0.35 miles of a streetcar or BRT stop, or 0.5 miles of a rail station
Transit by park-and-ride access – only available if destination trip end is within 0.2 miles of a bus stop, 0.35 miles of a streetcar or BRT stop, or 0.5 miles of a rail station; only available for home-based non-school trips; utilities and lot usage for formal park-and-ride lots and informal park-and-ride locations are calculated by a nested park-and-ride lot choice model
Bike – utilities and distances are produced by a stand-alone tool based on a dedicated bicycle network
Walk – only available for trips with a distance less than five miles

Probabilities are applied to distributed trips to determine the number of trips by each mode. An example probability of choosing the Drive Alone mode follows:

$$Prob_{Drive\ Alone} = U_{Drive\ Alone} \mathbin{/} (U_{Drive\ Alone} + U_{Drive\ with\ Passenger} + U_{Auto\ Passenger} + U_{Walk\ to\ Transit} + U_{Park\&Ride} + U_{Bike} + U_{Walk})$$

F.1 HBW (Home-Based Work)

F.1.a Variable Definitions

IvTime	=	In-vehicle travel time (varies by mode)
WalkTime	=	Walk time, by mode: Drive Alone: vehicle egress at trip end (5 min in CBD, 2 min elsewhere) Shared Ride: Drive Alone walk time plus 5 minutes Transit Modes: access to first stop plus egress from last stop at 3 mph
TranWait1	=	Transit initial wait time
TranWait2	=	Transit transfer wait time
TranModc	=	Transit mode constant (varies by transit path)
TranStypc	=	Transit stop type constant (varies by transit path)
TranXfrs	=	Transit # of Transfers
Tdist	=	Total Trip Distance
Cbdist	=	Bicycle Commute Trip Distance
Cbcost	=	Bicycle Commute Route Attractiveness
Wdist	=	Total Walk Distance
LowInc	=	1 if household income <$25K
MidInc	=	1 if household income $25-50K
HighInc	=	1 if household income $50K+
OpCost	=	Out-of-pocket cost, by mode: Drive Alone: $0.211 / mile + ½ of long-term parking charge in attraction zone Shared Ride: ½ of Drive Alone out-of-pocket cost Walk-access Transit: transit fare Park-and-ride: $0.211 / mile for auto leg, transit fare for transit leg
MixTotA	=	Total employment access within ½ mile of attraction zone (see Section A.1.b)
MixRetP	=	Retail employment access within ½ mile of production zone (see Section A.1.b)
Work1	=	1 if one (and only one) worker in household
Cval0	=	1 if no cars in household
Cval1	=	1 if fewer cars than workers in household (cars > 0)
Cval2	=	1 if same number of cars and workers (cars > 0)
LrgHH	=	1 if large household (3+ persons)
Formal	=	1 if considering formal park-and-ride lots
Informal	=	1 if considering informal park-and-ride locations
Shadow	=	Park-and-ride lot shadow cost (calculated by lot choice model)

F.1.b Calibrated Choice Utilities

Drive Alone

U = **exp (**-0.03608*IvTime – 0.09956*WalkTime – 0.6587*LowInc*OpCost – 0.6097*MidInc*OpCost – 0.4029*HighInc*OpCost – 2.169*Cval1 – 0.02914*Cval2 – 1.887***ln**(Tdist)**)**

Drive with Passenger

U = **exp (**-2.97 – 0.03608*IvTime – 0.09956*WalkTime – 0.6587*LowInc*OpCost – 0.6097*MidInc*OpCost – 0.4029*HighInc*OpCost – 0.8725*Cval1 + 0.5853*LrgHH – 1.887***ln**(Tdist)**)**

Auto Passenger

U = **exp (**-3.48 – 0.03608*IvTime – 0.09956*WalkTime – 0.6587*LowInc*OpCost – 0.6097*MidInc*OpCost – 0.4029*HighInc*OpCost + 0.07042*MixTotA – 1.887***ln**(Tdist)**)**

Transit by Walk Access

U = **exp (**-3.38 + TranModc + TranStypc – 0.03608*($IvTime_{Bus}$ + 0.88*$IvTime_{LRT}$ + $IvTime_{SC}$ + 0.88*$IvTime_{Rail}$) – 0.0576*TranWait1 – 0.04002*TranWait2 – 0.09956*WalkTime – 0.3*TranXfrs –1.304***ln**(Tdist)– 0.6587*LowInc*OpCost – 0.6097*MidInc*OpCost – 0.4029*HighInc*OpCost + 0.1314* **ln**(MixRetP) + 0.09828***ln**(MixTotA) + 0.2842*Work1 + 1.268*Cval0**)**

Park and Ride

The coefficient on auto in-vehicle time is doubled in order to maintain a balance between auto and transit time that is comparable to the observed relationship; otherwise, too many trips include unreasonably high auto times as travelers choose to drive to the periphery of the CBD before boarding transit.

U = **exp (**-6.12 + 0.75***ln**(**exp**(Formal*0.5***ln**($\sum_{1 \to N}$ [**exp**(($U_{AutoLeg}$ + $U_{TransitLeg}$ + Shadow – 1.498*Cval1) / (0.5*0.75))])) + **exp**(Informal*0.5***ln**($\sum_{1 \to N}$ [**exp**((-1.2 + $U_{AutoLeg}$ + $U_{TransitLeg}$ + Shadow – 1.498*Cval1) / (0.5*0.75))])) **)**

where

$U_{AutoLeg}$ = -0.03608*2*IvTime – 0.6587*LowInc*OpCost – 0.6097*MidInc*OpCost – 0.4029*HighInc*OpCost

and

$U_{TransitLeg}$ = -0.03608*($IvTime_{Bus}$ + 0.88*$IvTime_{LRT}$ + $IvTime_{SC}$ + 0.88*$IvTime_{Rail}$) – 0.0576*TranWait1 – 0.04002*TranWait2 – 0.09956*WalkTime – 0.3*TranXfrs – 0.6587*LowInc*OpCost – 0.6097*MidInc*OpCost – 0.4029*HighInc*OpCost + 0.09828***ln**(MixTotA)

and

N = number of formal park-and-ride lots or informal par-and-ride locations under consideration

Bike

U = **exp (**-3.03 – 0.8*Cbdist – 3.650*Cbcost + 0.1279*ln(MixTotA) **)**

Walk

U = **exp (**-5.07 **–** 4.307***ln**(Wdist) + 0.3345***ln**(MixRetP)**)**

F.1.c Estimated Variable Coefficients

TABLE 18. HBW Mode Choice Model – Auto Modes

Variable	Drive Alone		Drive with Passenger		Auto Passenger	
	Coefficient	T-Statistic	Coefficient	T-Statistic	Coefficient	T-Statistic
Calib Constant			*-2.97*		*-3.48*	
Constant			-3.262	-26.8	-3.044	-20.3
IvTime	-0.03608	-6.3	-0.03608	-6.3	-0.03608	-6.3
WalkTime	-0.09956	-9.7	-0.09956	-9.7	-0.09956	-9.7
LogTdist	-1.887	-6.4	-1.887	-6.4	-1.887	-6.4
LowIncOpCost	-0.6587	-9.5	-0.6587	-9.5	-0.6587	-9.5
MidIncOpCost	-0.6097	-12.1	-0.6097	-12.1	-0.6097	-12.1
HighIncOpCost	-0.4029	-7.1	-0.4029	-7.1	-0.4029	-7.1
MixTotA					0.07042	4.0
Cval1	-2.169	-20.7	-0.8725	-5.0		
Cval2	-0.02914	-0.4				
LrgHH			0.5853	5.0		

TABLE 19. HBW Mode Choice Model – Transit Modes

Variable	Walk Access		Park and Ride	
	Coefficient	T-Statistic	Coefficient	T-Statistic
Calib Constant	*-3.38*		*-6.12*	
Constant	-4.678	-10.0	-6.504	-7.3
Ivtime	-0.03608	-6.3	-0.03608	-6.3
Wait1	-0.0576	-5.8	-0.0576	-5.8
Wait2	-0.04002	-5.2	-0.04002	-5.2
WalkTime	-0.09956	-9.7	-0.09956	-9.7
Transfers	-0.3	*	-0.3	*
LogTdist	-1.304	-4.4	-1.304	-4.4
LowIncOpCost	-0.6587	-9.5	-0.6587	-9.5
MidIncOpCost	-0.6097	-12.1	-0.6097	-12.1
HighIncOpCost	-0.4029	-7.1	-0.4029	-7.1
MixRetP	0.1314	3.9		
MixTotA	0.09828	3.1	0.05178	1.0
Work1	0.2842	2.5		
Cval0	1.268	6.6		
Cval1			-1.498	-3.3
Nested Park & Ride Lot Choice Model				
Informal Constant			-1.2	
Park & Ride Nest			0.75	
Formal Nest			0.5	
Informal Nest			0.5	

TABLE 20. HBW Mode Choice Model – Nonmotorized Modes

Variable	Bike		Walk	
	Coefficient	T-Statistic	Coefficient	T-Statistic
Calib Constant	*-3.03*		*-5.07*	
Constant	-4.867	-13.6	-5.216	-13.7
Cbdist	-0.8			
Cbcost	-0.365			
LogWdist			-4.307	-13.9
MixTotA	0.1279	3.0		
MixRetP			0.3345	7.7

F.2 HBshop, HBrec, HBoth (Other Home-Based)

F.2.a Variable Definitions

Shop	=	1 if HBshop trip
Rec	=	1 if HBrec trip
Oth	=	1 if HBoth trip
IvTime	=	In-vehicle travel time (varies by mode)
WalkTime	=	Walk time, by mode: Drive Alone: vehicle egress at trip end (5 min in CBD, 2 min elsewhere) Shared Ride: Drive Alone walk time plus 5 minutes Transit Modes: access to first stop plus egress from last stop at 3 mph
TranWait1	=	Transit initial wait time
TranWait2	=	Transit transfer wait time
TranModc	=	Transit mode constant (varies by transit path)
TranStypc	=	Transit stop type constant (varies by transit path)
TranXfrs	=	Transit # of Transfers
Tdist	=	Total Trip Distance
Nbdist	=	Bicycle Non-commute Trip Distance
Nbcost	=	Bicycle Non-commute Route Attractiveness
Wdist	=	Total Walk Distance
LowInc	=	1 if household income <$25K
MidInc	=	1 if household income $25-50K
HighInc	=	1 if household income $50K+
OpCost	=	Out-of-pocket cost, by mode: Drive Alone: $0.211 / mile + ½ of short-term parking charge in attraction zone Shared Ride: ½ of Drive Alone out-of-pocket cost Walk-access Transit: transit fare Park-and-ride: $0.211 / mile for auto leg, transit fare for transit leg
MixTotA	=	Total employment access within ½ mile of attraction zone (see Section A.1.b)
MixRetP	=	Retail employment access within ½ mile of production zone (see Section A.1.b)
Cval0	=	1 if no cars in household
Cval1	=	1 if fewer cars than workers in household (cars > 0)
Cval2	=	1 if same number of cars and workers (cars > 0)
SingHH	=	1 if 1-person household
LrgHH	=	1 if large household (3+ persons)
Formal	=	1 if considering formal park-and-ride lots
Informal	=	1 if considering informal park-and-ride locations
Shadow	=	Park-and-ride lot shadow cost (calculated by lot choice model)

F.2.b Calibrated Choice Utilities

Drive Alone

U = **exp (**-0.0215*IvTime – 0.1033*WalkTime – 0.4724*LowInc*OpCost – 0.2457*MidInc*OpCost – 0.2457*HighInc*OpCost – 0.747***ln**(Tdist)**)**

Drive with Passenger

U = **exp (**-0.97*Shop – 0.54*Rec – 0.74*Oth – 0.0215*IvTime – 0.1033*WalkTime – 0.4724*LowInc*OpCost – 0.2457*MidInc*OpCost – 0.2457*HighInc*OpCost –1.51*SingHH + 0.8491* LrgHH – 0.747***ln**(Tdist)**)**

Auto Passenger

U = **exp (**-1.07*Shop – 0.47*Rec – 1.09*Oth – 0.0215*IvTime – 0.1033*WalkTime – 0.4724*LowInc*OpCost – 0.2457*MidInc*OpCost – 0.2457*HighInc*OpCost – 1.288*SingHH + 1.307*LrgHH – 0.747***ln**(Tdist)**)**

Transit by Walk Access

U = **exp (**-3.68*Shop – 3.46*Rec – 4.12*Oth + TranModc + TranStypc – 0.0215*(IvTime$_{Bus}$ + 0.86*IvTime$_{LRT}$ + IvTime$_{SC}$ + 0.86*IvTime$_{Rail}$) – 0.06847*TranWait1 – 0.0524*TranWait2 – 0.1033*WalkTime – 0.3*TranXfrs – 0.4724*LowInc*OpCost – 0.2457*MidInc*OpCost – 0.2457*HighInc*OpCost + 0.1664* **ln**(MixTotA) + 1.971*Cval0 + 1.129*Cval1 + 0.2874*Cval2**)**

Park and Ride

The coefficient on auto in-vehicle time is doubled in order to maintain a balance between auto and transit time that is comparable to the observed relationship; otherwise, too many trips include unreasonably high auto times as travelers choose to drive to the periphery of the CBD before boarding transit.

U = **exp (**-5.90*Shop – 5.00*Rec – 6.30*Oth + 0.75***ln**(**exp**(Formal*0.5***ln**($\sum_{1\rightarrow N}$ [**exp**((U$_{AutoLeg}$ + U$_{TransitLeg}$ + Shadow) / (0.5*0.75))])) + **exp**(Informal*0.5***ln**($\sum_{1\rightarrow N}$ [**exp**((-2.0 + U$_{AutoLeg}$ + U$_{TransitLeg}$ + Shadow) / (0.5*0.75))])) **)**

where

U$_{AutoLeg}$ = -0.0215*2*IvTime – 0.4724*LowInc*OpCost – 0.2457*MidInc*OpCost – 0.2457*HighInc*OpCost

and

U$_{TransitLeg}$ = -0.0215*(IvTime$_{Bus}$ + 0.86*IvTime$_{LRT}$ + IvTime$_{SC}$ + 0.86*IvTime$_{Rail}$) – 0.06847*TranWait1 – 0.0524*TranWait2 – 0.1033*WalkTime – 0.3*TranXfrs – 0.4724*LowInc*OpCost – 0.2457*MidInc*OpCost – 0.2457*HighInc*OpCost + 0.1664***ln**(MixTotA)

and

N = number of formal park-and-ride lots or informal par-and-ride locations under consideration

Bike

U = **exp (**-1.26*Shop – 0.11*Rec – 1.49*Oth – 0.9*Nbdist – 0.22*Nbcost **)**

Walk

U = **exp (**-2.82*Shop – 1.80*Rec – 2.76*Oth – 2.466***ln**(Wdist)+ 0.1248***ln**(MixRetP) + 0.5997*LrgHH**)**

F.2.c Estimated Variable Coefficients

TABLE 21. HBshop, HBrec, HBoth Mode Choice Model – Auto Modes

Variable	Drive Alone		Drive with Passenger		Auto Passenger	
	Coefficient	T-Statistic	Coefficient	T-Statistic	Coefficient	T-Statistic
Calib Shop			*-0.97*		*-1.07*	
Calib Rec			*-0.54*		*-0.47*	
Calib Oth			*-0.74*		*-1.09*	
Shop			-0.4904	-6.3	-0.5719	-7.4
Rec			-0.585	-7.3	-0.2595	-3.3
Oth			0.153	2.1	-0.3144	-4.2
IvTime	-0.0215	-3.2	-0.0215	-3.2	-0.0215	-3.2
WalkTime	-0.1033	-8.3	-0.1033	-8.3	-0.1033	-8.3
LogTdist	-0.747	-7.8	-0.747	-7.8	-0.747	-7.8
LowIncOpCost	-0.4724	-6.8	-0.4724	-6.8	-0.4724	-6.8
MidIncOpCost	-0.2457	-5.2	-0.2457	-5.2	-0.2457	-5.2
HighIncOpCost	-0.2457	-5.2	-0.2457	-5.2	-0.2457	-5.2
Cval1	-0.3965	-5.4	-0.1503	-2.1		
SingHH			-1.51	-18.7	-1.288	-17.6
LrgHH			0.8491	21.1	1.307	32.8

TABLE 22. HBshop, HBrec, HBoth Mode Choice Model – Transit Modes

Variable	Walk Access		Park and Ride	
	Coefficient	T-Statistic	Coefficient	T-Statistic
Calib Shop	*-3.68*		*-5.90*	
Calib Rec	*-3.46*		*-5.00*	
Calib Oth	*-4.12*		*-6.30*	
Constant	-4.429	-11.3	-7.023	-3.8
IvTime	-0.0215	-3.2	-0.0215	-3.2
TranWait1	-0.06847	-5.4	-0.06847	-5.4
TranWait2	-0.0524	-4.8	-0.0524	-4.8
WalkTime	-0.1033	-8.3	-0.1033	-8.3
TranXfrs	-0.3	*	-0.3	*
LowIncOpCost	-0.4724	-6.8	-0.4724	-6.8
MidIncOpCost	-0.2457	-5.2	-0.2457	-5.2
HighIncOpCost	-0.2457	-5.2	-0.2457	-5.2
MixTotA	0.1664	4.4	0.3073	1.5
Cval0	1.971	11.3		
Cval1	1.129	5.5		
Cval2	0.2874	1.8		
Nested Park & Ride Lot Choice Model				
Informal Constant			-2.0	
Park & Ride Nest			0.75	
Formal Nest			0.5	
Informal Nest			0.5	

TABLE 23. HBshop, HBrec, HBoth Mode Choice Model – Nonmotorized Modes

Variable	Bike		Walk	
	Coefficient	T-Statistic	Coefficient	T-Statistic
Calib Shop	*-1.26*		*-2.82*	
Calib Rec	*-0.11*		*-1.80*	
Calib Oth	*-1.49*		*-2.76*	
Constant	-3.734	-37.2	-2.622	-18.3
Nbdist	-0.9			
Nbcost	-0.22			
LogWdist			-2.466	-22.1
MixRetP			0.1248	7.6
LrgHH			0.5997	9.7

F.3 NHBW & NHBNW (Non-Home-Based)

Cost coefficients do not vary by income group for non-home-based trips.

F.3.a Variable Definitions

NHBW	=	1 if NHBW trip
NHBNW	=	1 if NHBNW trip
IvTime	=	In-vehicle travel time (varies by mode)
WalkTime	=	Walk time, by mode: Drive Alone: vehicle egress at trip end (5 min in CBD, 2 min elsewhere) Shared Ride: Drive Alone walk time plus 5 minutes Transit Modes: access to first stop plus egress from last stop at 3 mph
TranWait1	=	Transit initial wait time
TranWait2	=	Transit transfer wait time
TranModc	=	Transit mode constant (varies by transit path)
TranStypc	=	Transit stop type constant (varies by transit path)
TranXfrs	=	Transit # of Transfers
Tdist	=	Total Trip Distance
Nbdist	=	Bicycle Non-commute Trip Distance
Nbcost	=	Bicycle Non-commute Route Attractiveness
Wdist	=	Total Walk Distance
OpCost	=	Out-of-pocket cost, by mode: Drive Alone: $0.211 / mile + ½ of short-term parking charge in attraction zone Shared Ride: ½ of Drive Alone out-of-pocket cost Walk-access Transit: transit fare
MixRetP	=	Retail employment access within ½ mile of production zone (see Section A.1.b)

F.3.b Calibrated Choice Utilities

Drive Alone

U = **exp (**-0.025*IvTime – 0.1493*WalkTime – 0.2916*OpCost**)**

Drive with Passenger

U = **exp (**-1.65*NHBW + 0.30*NHBNW – 0.025*IvTime – 0.1493*WalkTime – 0.2916*OpCost**)**

Auto Passenger

U = **exp (**-2.15*NHBW + 0.60*NHBNW – 0.025*IvTime – 0.1493*WalkTime – 0.2916*OpCost – 0.06557***ln**(Tdist)**)**

Transit by Walk Access

U = **exp (**-1.92*NHBW – 1.64*NHBNW + TranModc + TranStypc – 0.025*($IvTime_{Bus}$ + 0.86*$IvTime_{LRT}$ + $IvTime_{SC}$ + 0.86*$IvTime_{Rail}$) – 0.1337*TranWait1 – 0.07895*TranWait2 – 0.1493*WalkTime – 0.3*TranXfrs – 0.2916*OpCost + 0.771*ln(Tdist)**)**

Bike

U = **exp (**-1.60*NHBW – 2.00*NHBNW **–** 0.9*Nbdist – 0.1*Nbcost **)**

Walk

U = **exp (**-3.95*NHBW – 4.18*NHBNW – 1.524***ln**(Wdist) + 0.2553***ln**(MixRetP)**)**

F.3.c Estimated Variable Coefficients

TABLE 24. Non-Home-Based Mode Choice Model – Auto Modes

Variable	**Drive Alone**		**Drive with Passenger**		**Auto Passenger**	
	Coefficient	T-Statistic	Coefficient	T-Statistic	Coefficient	T-Statistic
Calib NHBW			*-1.65*		*-2.15*	
Calib NHBNW			*0.30*		*0.60*	
NHBW			-1.393	-12.0	-1.476	-12.6
NHBNW			0.4992	4.7	0.7225	6.8
IvTime	-0.025	*	-0.025	*	-0.025	*
WalkTime	-0.1493	-7.6	-0.1493	-7.6	-0.1493	-7.6
LogTdist					-0.06557	-3.0
OpCost	-0.2916	-7.3	-0.2916	-7.3	-0.2916	-7.3

TABLE 25. Non-Home-Based Mode Choice Model – Transit Modes

Variable	**Walk Access**	
	Coefficient	T-Statistic
Calib NHBW	*-1.92*	
Calib NHBNW	*-1.64*	
Constant	-2.384	-15.2
IvTime	-0.025	*
TranWait1	-0.1337	-6.3
TranWait2	-0.07895	-5.2
WalkTime	-0.1493	-7.6
TranXfrs	-0.3	*
LogTdist	0.771	8.6
OpCost	-0.2916	-7.3

TABLE 26. Non-Home-Based Mode Choice Model – Nonmotorized Modes

Variable	**Bike**		**Walk**	
	Coefficient	T-Statistic	Coefficient	T-Statistic
Calib NHBW	*-1.60*		*-3.95*	
Calib NHBNW	*-2.00*		*-4.18*	
Constant	-4.367	-37.6	-3.924	-18.9
Nbdist	-0.9			
Nbcost	-0.1			
LogWdist			-1.524	-32.2
MixRetP			0.2553	10.6

F.4 HBcoll (Home-Based College)

Cost coefficients do not vary by income group for college commute trips.

F.4.a Variable Definitions

IvTime = In-vehicle travel time (varies by mode)
WalkTime = Walk time, by mode:
  Drive Alone: vehicle egress at trip end (5 min in CBD, 2 min elsewhere)
  Shared Ride: Drive Alone walk time plus 5 minutes
  Transit Modes: access to first stop plus egress from last stop at 3 mph
TranWait1 = Transit initial wait time
TranWait2 = Transit transfer wait time
TranModc = Transit mode constant (varies by transit path)
TranStypc = Transit stop type constant (varies by transit path)
TranXfrs = Transit # of Transfers
Tdist = Total Trip Distance
Cbdist = Bicycle Commute Trip Distance
Cbcost = Bicycle Commute Route Attractiveness
Wdist = Total Walk Distance
OpCost = Out-of-pocket cost, by mode:
  Drive Alone: $0.211 / mile + ½ of long-term parking charge in attraction zone
  Shared Ride: ½ of Drive Alone out-of-pocket cost
  Walk-access Transit: transit fare
  Park-and-ride: $0.211 / mile for auto leg, transit fare for transit leg
MixRetP = Retail employment access within ½ mile of production zone (see Section A.1.b)
MixTotA = Total employment access within ½ mile of attraction zone (see Section A.1.b)
Cval0 = 1 if no cars in household
Cval1 = 1 if fewer cars than workers in household (cars > 0)
LrgHH = 1 if large household (3+ persons)
Formal = 1 if considering formal park-and-ride lots
Informal = 1 if considering informal park-and-ride locations
Shadow = Park-and-ride lot shadow cost (calculated by lot choice model)

F.4.b Calibrated Choice Utilities

Drive Alone

U = **exp (**-0.05319*IvTime – 0.2111*WalkTime – 0.1407*OpCost – 0.5914*Cval1**)**

Drive with Passenger

U = **exp (**-2.02 – 0.05319*IvTime – 0.2111*WalkTime – 0.1407*OpCost + 1.175*LrgHH**)**

Auto Passenger

U = **exp (**1.40 – 0.05319*IvTime – 0.2111*WalkTime – 0.1407*OpCost + 1.128*Cval1 – 0.7154*ln(Tdist) – 0.1271***ln**(MixTotA)**)**

Transit by Walk Access

U = **exp (**-0.13 + TranModc + TranStypc – 0.05319*(IvTime$_{Bus}$ + 0.86*IvTime$_{LRT}$ + IvTime$_{SC}$ + 0.86*IvTime$_{Rail}$) – 0.0652*TranWait1 – 0.05302*TranWait2 – 0.2111*WalkTime – 0.3*TranXfrs – 0.1407*OpCost + 0.1941*Cval0 + 1.022***ln**(Tdist)**)**

Park and Ride

The coefficient on auto in-vehicle time is doubled in order to maintain a balance between auto and transit time that is comparable to the observed relationship; otherwise, too many trips include unreasonably high auto times as travelers choose to drive to the periphery of the CBD before boarding transit.

U = **exp (**-1.36 + 0.75***ln**(**exp**(Formal*0.5***ln**($\sum_{1 \rightarrow N}$ [**exp**((U$_{AutoLeg}$ + U$_{TransitLeg}$ + Shadow) / (0.5*0.75))])) + **exp**(Informal*0.5***ln**($\sum_{1 \rightarrow N}$ [**exp**((-3.0 + U$_{AutoLeg}$ + U$_{TransitLeg}$ + Shadow) / (0.5*0.75))])) **)**

where

U$_{AutoLeg}$ = -0.05319*2*IvTime – 0.1407*OpCost

and

U$_{TransitLeg}$ = -0.05319*(IvTime$_{Bus}$ + 0.86*IvTime$_{LRT}$ + IvTime$_{SC}$ + 0.86*IvTime$_{Rail}$) – 0.0652*TranWait1 – 0.05302*TranWait2 – 0.2111*WalkTime – 0.3*TranXfrs – 0.1407*OpCost + 1.022***ln**(Tdist)

and

N = number of formal park-and-ride lots or informal par-and-ride locations under consideration

Bike

U = **exp (**2.40 – 0.8*Cbdist – 0.6*Cbcost **+** 0.2431*MixTotA**)**

Walk

U = **exp (**-4.43 – 2.264***ln**(Wdist) + 0.386* **ln**(MixRetP)**)**

F.4.c Estimated Variable Coefficients

TABLE 27. HBcoll Mode Choice Model – Auto Modes

Variable	Drive Alone		Drive with Passenger		Auto Passenger	
	Coefficient	T-Statistic	Coefficient	T-Statistic	Coefficient	T-Statistic
Calib Constant			*-2.02*		*1.40*	
Constant			1.839	-4.2	0.8889	2.2
IvTime	-0.05319	-2.9	-0.05319	-2.9	-0.05319	-2.9
WalkTime	-0.2111	-3.7	-0.2111	-3.7	-0.2111	-3.7
LogTdist	-0.8608	-8.0			-0.7154	-5.5
OpCost	-0.1407	-1.2	-0.1407	-1.2	-0.1407	-1.2
LrgHH			1.175	3.7		
Cval1	-0.5914	-1.9			1.128	3.4
MixTotA					-0.1271	-3.6

TABLE 28. HBcoll Mode Choice Model – Transit Modes

Variable	Walk Access		Park and Ride	
	Coefficient	T-Statistic	Coefficient	T-Statistic
Calib Constant	*-0.13*		*-1.36*	
Constant	-1.175	-3.4	-1.175	-3.4
IvTime	-0.05319	-2.9	-0.05319	-2.9
TranWait1	-0.0652	-2.7	-0.0652	-2.7
TranWait2	-0.05302	-2.3	-0.05302	-2.3
WalkTime	-0.2111	-3.7	-0.2111	-3.7
TranXfrs	-0.3	*	-0.3	*
LogTdist	-0.8608	-8.0		
OpCost	-0.1407	-1.2	-0.1407	-1.2
Cval0	0.1941	0.5		
Nested Park & Ride Lot Choice Model				
Informal Constant			-3.0	
Park & Ride Nest			0.75	
Formal Nest			0.5	
Informal Nest			0.5	

TABLE 29. HBcoll Mode Choice Model – Nonmotorized Modes

Variable	Bike		Walk	
	Coefficient	T-Statistic	Coefficient	T-Statistic
Calib Constant	*2.40*		*-4.43*	
Constant	-4.211	-5.5	-4.271	-5.8
Cbdist	-0.8			
Cbcost	-0.6			
LogWdist			-2.264	-11.2
MixRetP			0.3855	4.5
MixTotA	0.2431	2.8		

F.5 HBsch (Home-Based School)

The HBsch model is a simple cross-classification into mode by location of production (home). This accounts for varying levels of school bus service provision between school districts. District definitions refer to the 8-district boundaries shown in Appendix B.

TABLE 30. HBsch Mode Choice Model

Location	Dist	Auto Driver	Auto Passenger	City Transit	Walk or Bike	School Bus
City of Portland	1,5,7	0.0383	0.2487	0.1406	0.4068	0.1656
East Suburbs	4,6	0.062	0.2256	0.0143	0.2178	0.4803
West Suburbs	2,3	0.1015	0.1936	0.0148	0.1943	0.4958
Clark County	8	0.1184	0.2485	0.0065	0.2469	0.3797

G Time of Day Factors

UPDATE TO THIS SECTION PENDING

Time of day travel is estimated separately for auto and transit, and the factors are direction-specific. Factors can be estimated for any hour by using start time data from the 2010-11 household activity survey. The most commonly used time of day factors are given in the following tables.

TABLE 31. Auto Peaking Factors

	AM2 0700-0859	**AM4 0600-0959**	**MD1_12-1 1200-1259**	**PM2 1600-1759**	**PM4 1500-1859**
HBW					
1-2 person HH Attractions	0.0062	0.0124	0.0193	0.1853	0.2965
3-4 person HH Attractions	0.0066	0.0098	0.0193	0.1932	0.3137
1-2 person HH Productions	0.2456	0.3695	0.0154	0.0169	0.0284
3-4 person HH Productions	0.2342	0.3626	0.0154	0.0173	0.0352
HBshop,rec,other					
0-1 worker HH Attractions	0.0264	0.0446	0.0281	0.0888	0.1732
2-3 worker HH Attractions	0.0246	0.0403	0.0281	0.1104	0.2142
0-1 worker HH Productions	0.0760	0.1340	0.0253	0.0518	0.1303
2-3 worker HH Productions	0.0947	0.1397	0.0253	0.0638	0.1477
NHBW					
Attractions	0.1250	0.1683	0.0437	0.0121	0.0227
Productions	0.0262	0.0534	0.0839	0.1897	0.2913
NHBNW					
Total - divide by 2 for P&A	0.0819	0.1365	0.0862	0.1630	0.3061
College					
Attractions	0.0067	0.0137	0.0509	0.0869	0.1411
Productions	0.2577	0.3228	0.0289	0.0161	0.0821
School					
Attractions	0.0011	0.0119	0.0182	0.0513	0.1524
Productions	0.5054	0.5275	0.0102	0.0250	0.0140

Auto trips are adjusted to match counts during some peak periods.

TABLE 32. Adjustments to Auto Peaking Factors

	AM2 0700-0859	**AM4 0600-0959**	**MD1_12-1 1200-1259**	**PM2 1600-1759**	**PM4 1500-1859**
Columbia River Crossings					

Oregon to Washington	1.0	1.6	0.8	0.7	0.78
Washington to Oregon	1.0	0.7	0.85	1.0	1.2
Hayden Island – Washington					
Hayden Island to Washington	1.0	1.0	2.0	1.0	2.0
Washington to Hayden Island	1.0	1.0	2.0	1.0	1.5
West Hills Crossings					
West to East	1.0	1.0	1.0	1.0	1.0
East to West	1.0	1.0	1.0	0.7	1.0
Willamette River Crossings					
West to East	1.0	1.0	1.0	0.75	1.0
East to West	1.0	1.0	1.0	1.0	1.0

TABLE 33. Transit Peaking Factors

	Peak Portion of All Day	Off-Peak Portion of All Day		PM 1-Hour Peak	PM 2-Hour Peak
HBW			**HBW**		
Peak Direction	0.4806	0.5194	Attractions	0.1554	0.2380
Off-Peak Direction	0.0106	0.9894	Productions	0.0009	0.0046
HBshop,rec,other			**HBshop,rec,other**		
Peak Direction	0.2423	0.7577	Attractions	0.0627	0.1311
Off-Peak Direction	0.0607	0.9393	Productions	0.0208	0.0558
NHBW			**NHBW**		
Peak Direction	0.0353	0.9647	Attractions	0.0001	0.0094
Off-Peak Direction	0.3426	0.6574	Productions	0.1695	0.2404
NHBNW			**NHBNW**		
Peak Direction	0.10045	0.89955	Attractions	0.0209	0.04095
Off-Peak Direction	0.10045	0.89955	Productions	0.0209	0.04095
College			**College**		
Peak Direction	0.3421	0.6579	Attractions	0.0254	0.0543
Off-Peak Direction	0.0696	0.9304	Productions	0.0057	0.0696
School			**School**		
Peak Direction	0.4468	0.5532	Attractions	0.0390	0.0922
Off-Peak Direction	0.0088	0.9912	Productions	0.0088	0.0088

H Assignment

H.1 Auto Assignment

Auto assignment procedures are developed in Emme macro language and run with Emme software. This package has a full capacity-restrained equilibrium path-finding algorithm. The number of lanes, lane capacity, initial speed, and distance are all link attributes. The link capacity, initial speed, and distance are attributes used in estimating the speed under two given flow rates. Autos and trucks are typically assigned simultaneously using a multi-class assignment technique. Additional truck delay is included on various links in the arterial system in order to account for factors such as slope that are known to affect truck path choice. Hence, truck flows tend to use higher order facilities in the path choice algorithm. Trucks are assigned as passenger car equivalents (PCEs) to account for the different space consuming characteristics.

H.2 Transit Assignment

The multi-path transit assignment follows the auto assignment, with transit speed determined as a function of underlying auto speed except where transit vehicles operate on exclusive right-of-way. Transit time consists of auxiliary (walk) time, wait time (initial and transfer), boarding time, and in-vehicle time. Actual wait time at certain nodes and actual in-vehicle time on certain line segments are reduced by applying factors designed to account for perceptions of time that vary by stop and vehicle type. The transit assignment algorithm allocates trips among eligible paths by (1) distributing flow between multiple outgoing centroid connectors using an embedded logit model based on total transit time to the destination; and (2) distributing flow between multiple lines at a stop node by considering frequency and total transit time to destination.

I External Model

The characteristics of external trips are different from the other purposes, so the procedure to calculate the trips is not the same as the others. The following steps are used to model external trip generation.

1. Calculate Average Weekday (AWD) target volume for each external location
2. Calculate Average Weekday (AWD) target volume for five trip components at each station by using percents from the 1987 external travel survey. The components follow:

- External-Internal Home-Based Work Trips
- External-Internal Non-Home-Based Work Trips
- Internal-External Recreational Trips
- Internal-External Non-Recreational Trips
- External-External Trips

TABLE 34. External Destination Choice Equations

Ext-Int HBW	**Estimation & Calibration**	$U = \exp(\ln(ATTR_j) – 0.135*T_{ij})$
Ext-Int NonHBW	**Estimation & Calibration**	$U = \exp(\ln(ATTR_j) – 0.125*T_{ij})$
Int-Ext Rec	**Estimation & Calibration**	$U = \exp(0.0002448*AWD – 0.03474*T_{ij})$
Int-Ext NonRec	**Estimation & Calibration**	$U = \exp(0.0001106*AWD – 0.07041*T_{ij})$
Ext-Ext	**Calibration**	using percents from 1987 cordon survey

Where:

i = from zone
j = to zone
T = travel time
AWD = average weekday traffic volume

Certain movements are restricted within the externals program; this is done to prevent illogical entry and exit combinations. External trips are added to the auto trip table at the end of the modeling process, but before trip assignment.

J Truck Model

The truck model forecasts the quantity, type, and distribution of truck trips generated by the flow of goods into, out from, and within the 4-county region. The model is based on a commodity flow (CF) database that forecasts annual tonnage flows of 44 commodity groups (2-digit SCTG) by primary mode, origin and destination regions and forecast year (2000 to 2035, in 5-year increments). The CF database was prepared for the Port of Portland in 1997, updated in 2002, and most recently validated and augmented by a 2006 trade capacity study.

Adjustments to Base Year (2010) Commodity Flows
The Port of Portland maintains annual statistics of freight tonnage entering and leaving Port facilities. Overall tonnage growth between 2005 and 2010 was generally consistent with forecasts flows in the CF database. However, ship-borne vehicle imports and all air freight shipments were reduced to 0.75 times 2005 levels to maintain consistency with Port data.

Adjustments to Future Year (2035) Commodity Flows
Forecasted regional employment growth has been significantly reduced since the time that the CF database was last validated. Accordingly, growth in internal flows of commodity groups associated with each employment sector has been scaled to maintain consistency with employment forecasts, while still allowing for marginal increases in productivity.

J.1 Allocation of Flows to Truck Sub-modes

Where truck is not the primary mode of travel, Port of Portland staff provided estimates of the proportion of each commodity flow that will utilize the truck sub-mode for part of the journey. It is assumed that 100% of air freight entering and leaving the region will utilize trucks to access and egress the airport. Similarly, 100% of rail-truck intermodal freight utilizes trucks. For other rail and for ship and barge, the proportion utilizing a truck submode varies by commodity. About one-fourth of total rail tonnage entering and leaving the region utilizes a truck sub-mode in 2005, increasing to one-third in 2035. About one-half of total water-borne tonnage is assumed to utilize a truck submode. It is assumed that no pipeline-borne commodities utilize a truck sub-mode en route to consumption or processing destinations.

The Port of Portland also provided estimates of the proportion of truck-borne flows in each commodity group that should be allocated to private carriers and truck load shipments with the balance allocated to less-than-truckload shipments.

J.2 Flows Modeled

FROM: \ To:	Internal Zones	External	Port Facilities	Rail / Intermodal	PDX
Internal Zones	x	x	x	x	x
External	x	x	x	x	x
Port Facilities	x	x	na	na	na
Rail / Intermodal	x	x	na	na	na
PDX	x	x	na	na	na

J.3 Application of Weekday Factor

A simple 1/264 factor is used to reduce annual flows to daily. No seasonal adjustments are made.

J.4 Allocation of Flows with local Origins/Destinations to TAZs

Metro Data Resource Center provided both base year and forecasted employment by industrial sector for each transportation analysis zone (TAZ). The sector groupings are as follows:

- Agriculture/Farming/Forestry (AGFF)
- Mining (MIN)
- Construction (CON)
- Manufacturing (MAN)
- Transportation/Communications/Public Utilities (TCPU)
- Wholesale (WHLS)
- Retail (RET)
- Finance/Insurance/Real Estate (FIRE)
- Service (SERV)
- Government (GOV)

With guidance from Cambridge Systematics, the SCTG2 commodities were consolidated into 16 commodity groups and allocated to employment sectors as follows:

	Commodity Group	Produced by	Attracted To
1	Farm	AFM	AFM, MFG
2	Metallic Minerals*	n/a	n/a
3	Non-metallic Minerals	CON	MFG
4	Chemicals	MFG	AFM, MFG
5	Petroleum	MFG	MFG, TPU
6	Stone	MIN, MFG	CON, MFG
7	Food	AFM, MFG	all
8	Wood	AFM, MFG	CON, MFG, RET
9	Paper	AFM, MFG	MFG, TPU, RET, FIRE, SERV, GOV
10	Metals	MFG	MFG
11	Machinery	MFG	MFG
12	Transportation Equipment	MFG	TPU
13	Manufactured Goods	MFG	MFG, RET
14	Textiles	MFG	RET
15	Waste Products	all	MFG
16	Courier	all	all

* no internal trip ends

J.5 Allocation of Flows to Terminals and Other Regional "Gateways"

Trucks carrying commodities that enter or leave the region at specific sites such as railyards, barge terminals, marine facilities, the airport, and external points are assigned one trip end at those places. Based on discussions with the Port staff, each of the specific rail, barge, ship, and air facilities was allocated a predetermined percentage of total flows to that facility type.

Rail flows are allocated about equally to the three main railyards in the region. All commodities are given the same percentage.

Railyard	Percent of Total Rail_Truck Flows
Albina	33%
Brooklyn	33%
Wilbridge	34%

Ship and barge flows are allocated among port terminal facilities as follows:

Commodity	Port Facility	TAZ (2162)	Flow Portion
Farm Products	POP Terminal 6	128	12%
	POP Terminal 5	129	22%
	POP Terminal 4	162	22%
	Albina Docks	197	22%
	Albina Docks	201	22%
Metallic Minerals		(No Products to/from Port Terminals)	
Non-Metalic Minerals	Rivergate	154	80%
	Ross Island	220	20%
Chemicals	Rivergate	154	100%
Petroleum	POP Terminal 2	34	25%
	Wilbridge - South	38	25%
	Wilbridge - North	48	25%
	POV Terminal 2	1508	25%
Stone	POP Terminal 2	34	14%
	Wilbridge - North	48	14%
	Pier 99	134	14%
	Albina Docks	197	14%
	Ross Island	220	15%
	POV Terminal 1	1506	15%
	POV Terminal 3/4/5	1531	14%
Food	POP Terminal 6	128	100%
Wood	POP Terminal 2	34	50%
	POV Terminal 2	1508	50%
Paper		34	72%
	POP Terminal 6	128	25%
	POV Terminal 3/4/5	1531	3%
Metals	POP Terminal 2	34	33%

	POP Terminal 6	128	33%
	Rivergate	154	34%
Machinery	POP Terminal 2	34	100%
Transportation Equipment	POP Terminal 6	128	53%
	POP Terminal 4	162	34%
	POV Terminal 2	1508	13%
Manufactured Goods & Electronics		(No Products to/from Port Terminals)	
Textiles	POP Terminal 6	128	100%
Waste Products	POV Terminal 1	1506	33%
	POV Terminal 3/4/5	1531	34%
	Columbia Way	1561	33%
Courier Services	(No Products to/from Port Terminals)		

External highway cordon locations are gateways for flows entering or leaving the region by truck. The commodity flow origin-destination database identifies the distribution of each commodity entering or leaving the region by direction. For each direction, the flows are distributed among the various highways, based on available truck count data, as follows:

Direction	Facility	Cordon ID (2162)	Distribution to/from TAZs and PDX	Distribution to/from Railyards and Port
North	I-5	2149	100%	100%
East	SR 14	2148	11%	0%
	US 26	2161	19%	0%
	I-84	2162	70%	100%
South	Bald Peak Rd.	2154	1%	0%
	OR 219	2155	2%	0%
	I-5	2157	84%	100%
	US 99E	2158	8%	0%
	OR211	2159	3%	0%
	OR 213	2160	2%	0%
West	US 30	2150	45%	55%
	US 26	2151	6%	0%
	OR 6	2152	12%	0%
	US 99W	2156	32%	45%
	OR 47	2153	5%	0%

All **Air Freight** is assumed to enter or leave the region via Portland International Airport (PDX), TAZ 139.

J.6 Linkage of Commodity Flows to Reload Facilities or Terminals

Reload facilities consist of truck terminals and major warehouse and distribution facilities. The model assumes that 60% of LTL shipments and about 6% of TL and PVT shipments are routed through a reload facility. The list of facilities in the region was compiled by the Data Resource Center using both employment security (ES202) data, ESRI Business Analyst data, and other available sources. Facilities were classified by type, and only those locations that are primarily engaged in trucking, warehousing, and distribution, and that have at least 50,000 square feet of floor space or 30 employees were retained. For example, the stores in a grocery chain are not included, but the chain's distribution center is. Actual base year employment, if available, was compiled. Otherwise, employment was estimated by business type and floor area. The employment, which serves as a proxy for level of freight activity at each facility, was summed for each TAZ.

Total LTL and TL/PVT tonnage for reload is calculated and routed from origin TAZs, in proportion to the total employment at reload facilities, and then on to destination TAZs. No unique factors were obtained for separate commodity groups.

J.7 Modeling Pickup and Delivery Tours

Insufficient data were available to simulate pickup and delivery tours, including deliveries of goods and services to houses and apartments. This version of the model does not contain additional processing to replicate this type of trip. However, shipments to and from zones having just a few businesses and employees are accounted for in fractional truck trips, the fraction being determined by the commodity load factor.

J.8 Determine Tonnage Allocation by Vehicle Type

Highway vehicle classification counts were used to develop average percentages of heavy vs. medium trucks on the system. This, combined with average weight carried by each vehicle type. produced a vehicle split of 70% heavy truck and 30% medium truck. To obtain this split, about 92% of total commodity tonnage is allocated to heavy trucks and the remainder to medium trucks.

J.9 Determine Number of Trucks by Commodity Type

Separate commodity class tons to truck trip factors were obtained for the heavy and medium trucks using data from the VIUS (Vehicle Inventory and Use Survey) which was provided to us by Cambridge staff. Separate payload factors were developed for internal and external truck trips.

Commodity Group	Heavy Trucks		Medium Trucks	
	Internal	External	Internal	External
Farm Products	19	22	6	11
Metallic Minerals & Coal	23	23	12	16
Non-metallic Minerals	23	23	12	16
Chemicals	18	21	6	12

Petroleum Products	21	24	5	10
Stone, Clay, Concrete, Ceramic, or Glass	23	23	12	16
Lumber or Wood Products, Furniture	16	19	3	8
Food, Fish, & Marine Products, Tobacco	18	20	4	7
Pulp, Paper, & Printed Matter	18	19	4	9
Primary & Fabricated Metal Products	18	20	4	7
Machinery & Electrical Equipment	17	19	3	5
Transportation Equipment	17	18	3	5
Misc. Manufactures, Instruments, Ordnance	13	17	2	5
Textiles, Apparel, Leather, and Products	15	17	3	7
Waste by-Products	11	16	5	5
Courier Services (packages)	17	19	7	10

These values were in line with the Port's estimate of average FEU weight overall of 21 tons/FEU. Based on discussions with Port staff, all TL/PVT flows were assigned to heavy trucks, except for those with origins/destinations in high density, central city areas. Flows with origins or destinations in the central city are assumed to be transported by medium trucks. All LTL and TL/PVT flows were allocated to medium trucks for those TAZs.

J.10 Estimate Additional Vehicle Trip Segment Trip Ends (Unbalanced)

Each matrix of commodity flows was reviewed to determine unbalanced trip origins and destinations. For any given zone, if the origins did not equal the destinations, the smaller of the two was increased to match the other. The purpose of this step is to partially account for empty truck moves.

J.11 Estimate Additional Vehicle Trip Segment Trip Ends (Balanced)

Certain movements such as repositioning and container maintenance require the addition of more truck trips to the trip table(s). However, at this point, there were limited data to estimate such trips. The only additional trips generated in this step were LTL trips to make up the difference between the reload and truck terminal counts (summed by TAZ) and the volumes produced by the tactical model.

J.12 Create Initial Truck Trip Tables

LTL and TL/PVT vehicle tables are combined by truck type. These tables represent average weekday truck vehicle trips having an internal origin and/or destination, and prior to reconciliation of internal-external flows trips with external truck counts or projected volumes.

J.13 Estimate External Truck Trips

External truck base year control totals are currently derived from traffic counts and vehicle classification counts. Future year control totals employ a traffic count growth trends analysis. The results represent total truck volumes at the externals, including internal-external, external-internal, and through-trip shipments.

External-to-external flows which do not involve a mode change inside the region are not included in the strategic model database. Trip tables for medium and heavy truck through-trips were developed independently of the commodity flow model. The 2006 Freight Data Collection study found that about half the total trucks counted while entering or leaving the region on the main Interstate highways and U.S routes were traveling through, with the vast majority of those using I-5. (Since each through-trip passes through 2 counting points, about ¼ of all external truck trips are through-trips) The truck model uses vehicle classification counts at each external station along with estimates of the through-trip percentage and a “seed” matrix that reflects the 2007 FDCS observed distribution of through-trips between stations to produce medium and heavy truck through-trip matrices that account for about half of total observed base year and forecasted future year truck volumes entering and leaving the region. Then, the external-internal and internal-external component of the truck matrices from the commodity flow model are scaled so that the combined E-I, I-E, and through-trips match the observed or forecasted truck counts.

J.14 Estimate Truck Trip Table by Time of Day

Peaking factors were developed using regional highway count data and reload facility counts. A weighted average of all vehicle classification counts was used to develop the following factors as percent of weekday total:

	Heavy Truck	Medium Truck	Reload Facility Midday
AM Peak 2-Hour	11.09%	12.99%	na
Midday 1-Hour	6.68%	8.20%	5.60%
PM Peak 2-Hour	8.52%	9.95%	na

J.15 Assign Truck Trips to Network

Average Weekday (AWD), peak, and off-peak trip tables are prepared for heavy and medium trucks. Prior to assignment to the highway network, a passenger-car equivalent (PCE) factor of 1.7 is applied to account for the extra space trucks take up on the road, the slower acceleration, and longer stopping times.

Heavy and medium truck PCEs are assigned to the roadway network along with other vehicle classes using a multi-class assignment. Coding for the truck mode is removed from links where truck prohibitions are in place. A truck path attribute is used to represent the additional truck travel time associated with steep upgrades, narrow lanes, difficult turns, etc on certain portions of the network.

A vehicle classification count program was undertaken as part of the Freight Data Collection program in 2006 which provided validation data for AWD truck volumes. Additional truck volume estimates have been obtained from the ODOT Automatic Traffic Recorder (ATR) database. Assigned truck volumes have typically been 10%-15% lower than counts, which reflects in part the exclusion of non-freight trucks as well as under-representation of pickup and delivery tour stops.

K Portland International Airport Model

UPDATE TO THIS SECTION PENDING

Trips to/from the zone containing the Portland International Airport (PDX) terminal are generated by a special model.

Home-Based Work trips to/from the PDX zone are retained from the household model. The sole change is an auto out-of-vehicle time of 5 minutes (equivalent to CBD zones) rather than 2 minutes (as in the rest of the region) to account for distance to the free employee parking.

Household model trips to/from the PDX zone for all other trip purposes are replaced by airport passenger trips as described in the following sections.

K.1 Enplanements as Inputs to the Model

Total number of enplanements (less transferring passengers) was used as the starting point. The Port of Portland supplied the average number of passengers that boarded their first flight or arrived on their last flight at PDX on a typical weekday in May 2005. The Airport Model assumes that on any given weekday, half of these passengers arrive at PDX and half depart PDX.

In 2005 the Port of Portland forecasted 2.8% annual growth in PDX passenger traffic over the period 2006-2010. This rate is applied to all future years to determine future enplanements/deplanements. For example, 34,617 passengers in 2005 grows to 69,043 in 2030. For 2030, 34,521.5 are treated as productions and 34,521.5 are treated as attractions.

K.2 Airport Mode Choice

While there is a diverse array of potential travel modes to/from PDX (including rental cars, taxis, limousines, vans, and shuttles), Metro lacks survey data on ground transportation choices of PDX passengers that date from the installation of LRT service to PDX in 2001. The PDX mode choice model thus splits arriving and departing passengers into Auto and LRT modes on the basis of the following data provided by the Port of Portland for FY 2006 (July 2005-June 2006):

- Business travelers represent 41% of passengers; 4% of them use LRT.
- Leisure travelers represent 59% of passengers; 7.1% of them use LRT.

For both productions and attractions, mode choice for passenger trips to/from PDX is determined as follows:

- Business Auto: Trips * 41% * 96% (in the case of 2030 productions, 13,587.7)
- Business LRT: Trips * 41% * 4% (in the case of 2030 productions, 566.2)
- Leisure Auto: Trips * 59% * 92.9% (in the case of 2030 productions, 18,921.6)
- Leisure LRT: Trips * 59% * 7.1% (in the case of 2030 productions, 1,446.1)

Auto occupancy of Airport auto trips is assumed to be 2.0. In the 2030 example, this generates 13,587.7 total Business vehicles trips and 18,921.6 total Leisure vehicle trips (productions + attractions / 2).

Neither parking cost nor transit fare play any role in this airport passenger mode choice model.

K.3 Airport Trip Distribution

Distribution of airport passenger trips takes place after mode choice. Airport passenger trips are apportioned among all zones (other than the airport zone) according to the following protocol:

- Business Vehicles: apportioned among all zones according to their share of the region's total employment
- Business LRT: apportioned among all zones with walk access to LRT according to their share of those zones' total employment
- Leisure Vehicles: apportioned among all zones according to their share of the region's total households
- Leisure LRT: apportioned among all zones with walk access to LRT according to their share of those zones' total households

Distance from PDX is not considered by this distribution model. Absent data on transfers of airport LRT trips to Bus or Park-and-ride, all airport passenger LRT trips are LRT-only.

K.4 Airport Peaking

Airport peaks do not correspond to peaks in the rest of the region. Here are peaking factors applied to passenger trips to/from PDX, along with their basis:

TABLE 35. Peaking Factors for Trips to PDX

based on 2005 average weekday enplanements by hour

Enplane-ments	Peaking Factor	
6,152	0.322	AM4 Trips to PDX: Enplanements on Flights Departing 0600-0959
2,384	0.125	AM2 Trips to PDX: Enplanements on Flights Departing 0800-0959
1,110	0.058	MD1 (12-1) Trips to PDX: Enplanements on Flights Departing 1100-1159
1,759	0.092	MD1 (2-3) Trips to PDX: Enplanements on Flights Departing 1300-1359
3,407	0.178	PM4 Trips to PDX: Enplanements on Flights Departing 1600-1959
1,749	0.092	PM2 Trips to PDX: Enplanements on Flights Departing 1700-1859
640	0.034	PM1 Trips to PDX: Enplanements on Flights Departing 1800-1859
9,559	0.501	PKAD Trips to PDX: AM4 + PM4
9,530	0.499	OPAD Trips to PDX: AWD – PKAD
19,089		Total Average Weekday Enplanements

TABLE 36. Peaking Factors for Trips from PDX

based on 2005 average weekday deplanements by hour

Deplane-ments	Peaking Factor	
1,771	0.092	AM4 Trips from PDX: Deplanements on Flights Arriving 0500-0859
864	0.045	AM2 Trips from PDX: Deplanements on Flights Arriving 0600-0759
870	0.045	MD1 (12-1) Trips from PDX: Deplanements on Flights Arriving 1300-1359
1,007	0.052	MD1 (2-3) Trips from PDX: Deplanements on Flights Arriving 1500-1559
3,743	0.194	PM4 Trips from PDX: Deplanements on Flights Arriving 1500-1859
1,846	0.096	PM2 Trips from PDX: Deplanements on Flights Arriving 1500-1659
839	0.044	PM1 Trips from PDX: Deplanements on Flights Arriving 1600-1659
5,514	0.287	PKAD Trips from PDX: AM4 + PM4
13,729	0.713	OPAD Trips from PDX: AWD – PKAD
19,242		Total Average Weekday Deplanements

In the absence of vehicle occupancy data for auto trips to/from PDX, half of the resulting vehicle trips are assigned as SOV, while the other half are assigned as HOV.

Appendix A – Metro Model Forecasting Model Structure