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Tech Memo

DATE:	July 10, 1999.	**PROJECT:**	**Estudio Integral de Transporte (III)/ Multimodal Transportation Study:** Development of Travel Demand and Mobile Source Emissions Models for base year 1996, Juarez. (Contract No. 9880055000)
TO:	Carl Snow, Project Director / TNRCC Jim Yarbrough / EPA Jack Jones / TxDOT Zack Graham / TTI Luis Raul Cordova/SEMARNAP		
FROM:	Salvador Gonzalez-Ayala	**SERIAL:**	EITIII-02b
SUBJ:	Progress under Task 3: Improvements to Mode Split Model Application.		

Overview

After reviewing the initial mode choice models developed for Juarez by IMIP (detailed on Tech Memo EITIII-02), TTI made some suggestions to improve their overall forecasting ability. The most significant one recommends revisiting transformations on the utility functions to recover relevant policy variables dropped from the model.

The present Tech Memo summarizes the additional process undertaken to adopt TTI's recommendations.

Background

The following summarize the comments and/or suggestions expressed by TTI on the initial Juarez mode choice models:

1. Encouraged IMIP efforts to attempt mode choice before or together with the trip distribution step, as this growing trend in travel modeling is showing improved forecasting results. Consider developing destination choice models as one of the techniques.
2. Consider further disaggregation of trip purposes as a better foundation for activity-based mode choice models. Special attention on reviewing conventional criteria defining HBNW trips and that defining purpose for linked (chained) trips.
3. If applicable, consider further disaggregation of modes for the development of models. Moreover, under a context of additional modes and strong interaction between these, consider using nested-logit models instead of multinomial logit models.
4. Revisit model specification. Policy relevant variables were dropped from the model, which may adversely affect the model's ability to respond to transportation system changes; this is especially critical for the transit component, where usually the most emphasis is placed to characterize elasticities. Although the variables were discarded following appropriate criteria for resulting counterintuitive signs on utility functions, further transformations should be explored in an effort to keep these variables. The thread of complex interrelationship between the variables sometimes yields unexpected signs when specified under apparently simple expressions. Nevertheless, if transformations are used to overcome this, each must still be able to provide a reasonably logical (practical) explanation of its overall relation to the utility.

Recommendations on items 1 to 3 clearly represent state-of-the-art approaches that should be adopted in the near future. Nevertheless, due to time constraints these will be placed on hold for the present project. This is also convenient at this time in lieu of compatibility issues with the El Paso model, in particular regarding the criteria for defining type and number of trip purposes.

Recommendation on item 4 has been adopted immediately since evidently the model specification process ended somewhat prematurely, without further examination of transformations that could allow policy relevant variables to stay on the models. Obviously, experience plays a crucial role when identifying the appropriate transformations, and in general on the skills to find the optimum functional form.

Re-specifying the MNL model

Under the current revision of the model, the base variables remained the same, yet a new set of variable transformations was incorporated for examination.

Additional information on the household database

As previously described, the household trip database was restructured into a compacted format, adding to each trip record the respective O-D pair network skims for each of the three generic modes. Originally only the travelCost/HHincome transformation was incorporated into the database. For the current exercise four additional transformation were incorporated:

1) Squared travel times.
2) Travel times/network walking length (equivalent to reciprocal of speed).
3) Squared travel costs.
4) Travel costs/network walking length (equivalent to unit travel cost)

These transformations were only developed for AUTO and BUS modes, since WALK mode skims were used as transformation terms. In addition there are no out-of-pocket travel costs identified for this generic mode. Table 1 shows the final outline of fields on this revised version of the compacted file; included are the new transformations for AUTO and BUS modes

Table 1. Revised set of fields for MNL analysis, from HH survey trip records and network skims.

FIELD NAME	DESCRIPTION
UNIQUE	Trip record unique number
ISN1	Survey conducted by Elementary or Junior High
ISN2	Household sample no. (unique by Elementary or Jr High)
IPN	Household member number
ITP2	Trip number
PURP	Trip purpose (HBW=1, HBNW=2, NHB=3)
IZN	Trip origin TAZ
IZN2	Trip destination TAZ
MNLmode	Mode used (AUTO, BUS, WALK)
IncVal	Household income per day (1996 pesos)
NT_aT	Network travel time by AUTO (in minutes)
NT_bT	Network travel time by BUS (in minutes)
NT_wT	Network travel time by WALK (in minutes)
aT2	Square of travel time by AUTO = NT_aT*NT_aT
bT2	Square of travel time by BUS = NT_bT*NT_bT
NT_wL	Network travel length by WALK (in kilometers)
aTwL	quasiReciprocal of AUTO speed = NT_aT/NT_wL
bTwL	quasiReciprocal of BUS speed = NT_bT/NT_wL
AUTCST	Network out-of-pocket travel cost by AUTO (in 1996 pesos)
NT_F2	Network out-of-pocket travel cost by BUS (in 1996 pesos)
aC2	Square of travel cost by AUTO = AUTCST*AUTCST
bC2	Square of travel cost by BUS = NT_F2*NT_F2
aCwL	quasiUnitary travel cost by AUTO = AUTCST/NT_wL
bCwL	quasiUnitary travel cost by BUS = NT_F2/NT_wL
AUTCST_IDX	Travel cost index by AUTO = AUTCST/IncVal
BUSCST_IDX	Travel cost index by BUS = NT_F2/IncVal

Similarly to the previous exercise, for analysis simplification the database was divided into three separate ones according to the purpose of the trips (HBW, HBNW, and NHB). Again, these data files are in dBASE format under the names MNLprp1.dbf, MNLprp2.dbf, and MNLprp3.dbf, and with total records of 8,178, 17,158, and 2,352 respectively.

<u>Functional form</u>

For the functional form of the revised utility expressions, a total of 18 different parameters were incorporated (eight more than the original one) which included the new transformations and variables depicted in Table 1. Table 2 shows the components of the new model along with their respective parameters.

Table 2. Description of components of the utility functions (revised version).

COMPONENTS OF UTILITY FUNCTIONS				REFERENCE
PARAMETER	**VARIABLE**	**DESCRIPTION**	**TYPE**	**DATABASE FIELD**
β_{0b}			ASC (BUS)	
β_{0w}			ASC (WALK)	
β_{1a}	TT_a	Travel time (AUTO)	Alternative specific variable	NT_aT
β_{1b}	TT_b	Travel time (BUS)	Alternative specific variable	NT_bT
β_{1w}	TT_w	Travel time (WALK)	Alternative specific variable	NT_wT
β_{2a}	TT^2_a	Sq. Travel time (AUTO)	Alternative specific variable	aT2
β_{2b}	TT^2_b	Sq. Travel time (BUS)	Alternative specific variable	bT2
β_{3a}	TT_a_WD	1/Travel speed (AUTO)	Alternative specific variable	aTwL
β_{3b}	TT_b_WD	1/Travel speed (BUS)	Alternative specific variable	bTwL
β_4	HHINC	Household income	Generic variable	IncVal
β_{5a}	TC_a	Travel cost (AUTO)	Alternative specific variable	AUTCST
β_{5b}	TC_b	Travel cost (BUS)	Alternative specific variable	NT_F2
β_{6a}	TC^2_a	Sq. Travel cost (AUTO)	Alternative specific variable	aC2
β_{6b}	TC^2_b	Sq. Travel cost (BUS)	Alternative specific variable	bC2
β_{7a}	TC_a_WD	Unit Travel cost (AUTO)	Alternative specific variable	aCwL
β_{7b}	TC_b_WD	Unit Travel cost (BUS)	Alternative specific variable	bCwL
β_{8a}	TC_a_IDX	Travel cost index (AUTO)	Alternative specific variable	AUTCST_IDX
β_{8b}	TC_b_IDX	Travel cost index (BUS)	Alternative specific variable	BUSCST_IDX

The revised utility functions for the 3 generic modes have the following general form:

$$U_a = \beta_{1a}{*}TT_a + \beta_{2a}{*}TT^2_a + \beta_{3a}{*}TT_{a}\_WD + \beta_{5a}{*}TC_a + \beta_{6a}{*}TC^2_a + \beta_{7a}{*}TC_{a}\_WD + \beta_{8a}{*}TC_{a}\_IDX \quad \textbf{(Eq. 4)}$$

$$U_b = \beta_{0b} + \beta_{1b}{*}TT_b + \beta_{2b}{*}TT^2_b + \beta_{3b}{*}TT_{b}\_WD + \beta_4{*}HHINC + \beta_{5b}{*}TC_b + \beta_{6b}{*}TC^2_b + \beta_{7b}{*}TC_{b}\_WD + \beta_{8b}{*}TC_{b}\_IDX \quad \textbf{(Eq. 5)}$$

$$U_w = \beta_{0w} + \beta_{1w}{*}TT_w + \beta_4{*}HHINC \quad \textbf{(Eq. 6)}$$

This revised model was then setup for MNL calibration.

Calibration of the MNL model

Calibration of the MNL model was again accomplished through the statistical analysis tools of TransCAD. For this, a new TransCAD MNL table was specified as shown in Table 3 emulating the functional form depicted by equations 4, 5 and 6.

Table 3. The TransCAD MNL table used for estimation of the revised model.

Alternatives	ASCb	ASCw	TTa	TTb	TTw	TT2a	TT2b	TTa_WD	TTb_WD	HHINC	TCa	TCb	TC2a	TC2b	TCa_WD	TCb_WD	TCa_IDX	TCb_IDX
AUTO			NT_aT			aT2		aTwL			AUTCST		aC2		aCwL		AUTCST_IDX	
BUS	ONE			NT_bT			bT2		bTwL	IncVal		NT_F2		bC2		bCwL		BUSCST_IDX
WALK		ONE			NT_wT					IncVal								

The calibration process was undertaken for each trip purpose with the following results.

<u>HBW trip purpose</u>

After an extensive trial and error process, two different arrangements of variables seemed to yield the best fits for the HBW trip purpose; on each of these the new transformations accomplished the goal of recovering most of the policy relevant variables. For the first model shown on Table 4a travel speed reciprocals were used among other transformations. On the second arrangement shown on Table 4b instead the squares of travel speeds were used.

Table 4a. MNL estimation output for HBW purpose (alternative "a").

Valid Cases: 8178

Choice Distribution

AUTO	4718	57.7%
BUS	2700	33.0%
WALK	760	9.3%

Maximum likelihood reached at iteration 15

PARAMETER	**ESTIMATE**	**STD. ERR**	**t Test**
ASCb	0.258559	0.094731	2.729416
ASCw	0.662207	0.137926	4.801191
TTw	-0.045091	0.002110	-21.367457
TTa_WD	-0.010931	0.033390	-0.327385
TTb_WD	-0.017772	0.011094	-1.601955
HHINC	-0.003313	0.000150	-22.015359
TC^2a	-0.000489	0.000540	-0.904561
TCb_WD	-0.141907	0.038343	-3.700953

$l(0)$:	-8984.451297		
$l(\beta)$:	-6467.607334	$l(C)$:	-10600.921457
$-2(l(0)-l(\beta))$:	5033.687926		
ρ^2 :	0.280133		
ρ_{adj}^2 :	0.279243	ρ_m^2 :	0.389147

Table 4b. MNL estimation output for HBW purpose (alternative "b").

Valid Cases: 8178

Choice Distribution

AUTO	4718	57.7%
BUS	2700	33.0%
WALK	760	9.3%

Maximum likelihood reached at iteration 15

PARAMETER	**ESTIMATE**	**STD. ERR**	**t Test**
ASCw	0.710786	0.075115	9.462645
TTw	-0.048324	0.002069	-23.358050
TT^2a	-0.000966	0.000200	-4.826732
TT^2b	-0.000050	0.000027	-1.810224
HHINC	-0.003243	0.000129	-25.104308
TCb_WD	-0.112006	0.026210	-4.273424

$l(0)$:	-8984.451297		
$l(\beta)$:	-6451.789494	$l(C)$:	-10869.361104
$-2(l(0)-l(\beta))$:	5065.323605		
ρ^2 :	0.281894		
ρ_{adj}^2 :	0.281226	ρ_m^2 :	0.405872

The first model recovers all policy variables (all with proper signs), but with very weak significance levels for auto travel time and cost. The second model just dropped the auto travel cost variable but instead provided expected signs and strong significance levels for all other variables. In addition, all rho-squared for model "b" appear to be slightly better, thus this functional form was selected as the best one for HBW trip purpose.

HBNW trip purpose

For the HBNW trip purpose also two different arrangements of variables (Table 5a and Table 5b) seemed to yield the best fits after reviewing several alternatives. Again, on each of these the new transformations accomplished the goal of recovering all the policy variables originally dropped from the model.

Table 5a. MNL estimation output for HBNW purpose (alternative "a").

Valid Cases: 17158

Choice Distribution

AUTO	7622	44.4%
BUS	3578	20.9%
WALK	5958	34.7%

Maximum likelihood reached at iteration 12

PARAMETER	ESTIMATE	STD. ERR	t Test
ASCb	0.544455	0.092703	5.873115
ASCw	1.919998	0.065544	29.293186
TTw	-0.069659	0.001622	-42.948307
TTa_WD	-0.025838	0.014429	-1.790733
TTb_WD	-0.075644	0.007803	-9.693888
HHINC	-0.003380	0.000104	-32.427344
TCa	-0.050498	0.010902	-4.632148
TCb	-0.133624	0.028620	-4.668918
$l(0)$:	-18849.989649		
$l(\beta)$:	-13991.082755	$l(C)$:	-25320.644771
$2(l(0)-l(\beta))$:	9717.813788		
ρ^2 :	0.257767		
ρ_{adj}^2 :	0.257343	ρ_m^2 :	0.447128

Table 5b. MNL estimation output for HBNW purpose (alternative "b").

Valid Cases: 17158

Choice Distribution

AUTO	7622	44.4%
BUS	3578	20.9%
WALK	5958	34.7%

Maximum likelihood reached at iteration 12

PARAMETER	ESTIMATE	STD. ERR	t Test
ASCb	-0.099701	0.065569	-1.520552
ASCw	2.096398	0.040108	52.269057
TTw	-0.077462	0.001607	-48.212463
TT^2a	-0.000794	0.000312	-2.543798
TT^2b	-0.000118	0.000035	-3.329239
HHINC	-0.003379	0.000105	-32.212400
TCa	-0.104748	0.024795	-4.224621
TCb	-0.155435	0.030404	-5.112321
$l(0)$:	-18849.989649		
$l(\beta)$:	-14039.337903	$l(C)$:	-27445.915571
$-2(l(0)-l(\beta))$:	9621.303491		
ρ^2 :	0.255207		
ρ_{adj}^2 :	0.254783	ρ_m^2 :	0.488181

In this case both models show the correct signs for all the components as well as strong significance levels; a slightly better ρ_m^2 in option "b" has been used as the deciding criteria to select this model as the final one for the HBNW trip purpose.

NHB trip purpose

For the NHB trip purpose one arrangement of variables seemed to yield the best fit. All original policy variables were recovered with strong significance levels.

Table 6. MNL estimation output for NHB purpose.

Valid Cases:	2352			
Choice Distribution				
AUTO	1555	66.1%		
BUS	395	16.8%		
WALK	402	17.1%		
Maximum likelihood reached at iteration 10				
PARAMETER		**ESTIMATE**	**STD. ERR**	**t Test**
ASCb		-0.971454	0.233483	-4.160700
TTw		-0.054556	0.003235	-16.865073
TTa_WD		-0.076889	0.022465	-3.422603
TTb_WD		-0.048760	0.019920	-2.447754
TCa		-0.046023	0.024783	-1.857068
TCb		-0.185785	0.076558	-2.426714
$l(0)$:		-2583.936103		
$l(\beta)$:		-1800.604099	$l(C)$:	-2421.693749
$-2(l(0)-l(\beta))$:		1566.664007		
ρ^2 :		0.303155		
ρ_{adj}^2 :		0.300833	ρ_m^2 :	0.253992

Although its inclusion greatly enhances the model strength, the household income variable (HHINC) was left out again for this trip purpose due to the impossibility of establishing any attributes of the trip makers without knowing their respective household TAZs.

In summary, the following set of equations will be used as the functional forms of the utility functions for the revised MNL models in accordance with the base format presented under equations 4, 5, and 6.

1) Calibrated utility functions for HBW trip-purpose:

AUTO $U_a = - 0.00097 * TT^2_a$ (**Eq. 7**)

BUS $U_b = - 0.00005 * TT^2_b - 0.0032 * HHINC - 0.1120 * TC_{b}\_WD$ (**Eq. 8**)

WALK $U_w = 0.7108 - 0.0483 * TT_w - 0.0032 * HHINC$ (**Eq. 9**)

2) Calibrated utility functions for HBNW trip-purpose:

AUTO $U_a = - 0.00079 * TT^2_a - 0.1047 * TC_a$ (**Eq. 10**)

BUS $U_b = - 0.0997 - 0.00012 * TT^2_b - 0.0034 * HHINC - 0.1554 * TC_b$ (**Eq. 11**)

WALK $U_w = 2.0964 - 0.0775 * TT_w - 0.0034 * HHINC$ (**Eq. 12**)

3) Calibrated utility functions for NHB trip-purpose:

AUTO $U_a = - 0.0769 * TT_{a}\_WD - 0.0460 * TC_a$ (**Eq. 13**)

BUS $U_b = - 0.9715 - 0.0488 * TT_{b}\_WD - 0.1858 * TC_b$ (**Eq. 14**)

WALK $U_w = - 0.0546 * TT_w$ (**Eq. 15**)

Evaluation of the MNL model

With the calibrated functions the new MNL model was evaluated using aggregate O-D based data. Thus the six income ranges previously established and shown below were again used to develop mode shares for the HBW and HBNW trip purposes. Similarly to the initial exercise, this was performed at each income level, and then through the "classification approach" a weighted average of the mode share was obtained according to each TAZ income distribution.

Range Code	Household income range (1996 daily min wages)	Household income range (1996 pesos)	Range avg (1996 pesos)
R1	0 to 2	$ 0.00 to $ 52.96 /day	$ 26.48 /day
R2	2 to 6	$ 52.96 to $158.88 /day	$105.92 /day
R3	6 to 10	$158.88 to $264.80 /day	$211.84 /day
R4	10 to 12	$264.80 to $317.76 /day	$291.28 /day
R5	12 to 18	$317.76 to $476.64 /day	$397.20 /day
R6	18 to 34	$476.64 to $900.32 /day	$688.32 /day

The evaluation step was again accomplished by adapting the MNL TransCAD tables used for calibration to the formats shown on Table 7 for HBW trip purpose model, and Table 8 for HBNW trip purpose model, which include the estimates of the parameters. These tables are consistent with equations 7 to 12.

Table 7. The TransCAD MNL table used for evaluation of final HBW model.

Alternatives	ASCb	ASCw	TTw	TT2a	TT2b	TTa_WD	TTb_WD	HHINC	TCa	TCb	TC2a	TC2b	TCa_WD	TCb_WD
AUTO				Aut96|TIM2										
BUS					Bus96|TIM2			Rn_INC						Bus96|C_wl
WALK		ONE	Wlk96|TIME					Rn_INC						
Estimates		0.7108	-0.0483	-0.00097	-0.00005			-0.0032						-0.1120

Note: One Transcad MNL table like this for each of the six income ranges.

Table 8. The TransCAD MNL table used for evaluation of final HBNW model.

Alternatives	ASCb	ASCw	TTw	TT2a	TT2b	TTa_WD	TTb_WD	HHINC	TCa	TCb	TC2a	TC2b	TCa_WD	TCb_WD
AUTO				Aut96|TIM2					Aut96|COST					
BUS	ONE				Bus96|TIM2			Rn_INC		Bus96|COST				
WALK		ONE	Wlk96|TIME					Rn_INC						
Estimates	-0.0997	2.0964	-0.0775	-0.00079	-0.00012			-0.0034	-0.1047	-0.1554				

Note: One Transcad MNL table like this for each of the six income ranges.

As previously underlined, the source files or matrices specified on these tables are required to be open simultaneously with their respective MNL Transcad table. For the aggregation process the same computer programs developed for the initial exercise were used. As summary, Appendix A shows flow charts for the evaluation step and subsequent aggregation process for the HBW model, and Appendix B does the same thing for the HBNW model. The final products are the O-D mode share matrices under each trip purpose.

For the NHB trip purpose the aggregation process was by-passed since income was dropped from the model. As such only a single MNL run was required, and this directly provides the mode share between O-D pairs. Table 9 shows the MNL Transcad table format used under this trip purpose, which is consistent with equations 13 to 15.

Table 9. The TransCAD MNL table used for evaluation of final NHB model.

Alternatives	ASCb	ASCw	TTw	TT2a	TT2b	TTa_WD	TTb_WD	HHINC	TCa	TCb	TC2a	TC2b	TCa_WD	TCb_WD
AUTO						Aut96|T_wl			Aut96|COST					
BUS	ONE						Bus96|T_wl			Bus96|COST				
WALK		ONE	Wlk96|TIME											
Estimates	-0.9715		-0.0546			-0.0769	-0.0488		-0.0460	-0.1858				

Note: Only one Transcad MNL table like this required, since income was dropped as a variable.

Appendix C shows the flow chart of the process to develop the O-D mode share matrix under the NHB trip purpose. In this case all trip productions are generated from the origin (row) TAZ, thus only one final matrix is created.

Summary remarks on the mode split process

Similar to the result of the initial exercise, five final matrices were developed with the 1996 mode split between the O-D pairs: Two for HBW (refer to appendix A), two for HBNW (refer to appendix B), and one for NHB (refer to appendix C). Again, for the NHB trip purpose the final mode split matrix can be viewed either as an O-D or P-A matrix, since in this case origin is synonymous to production, and destination to attraction.

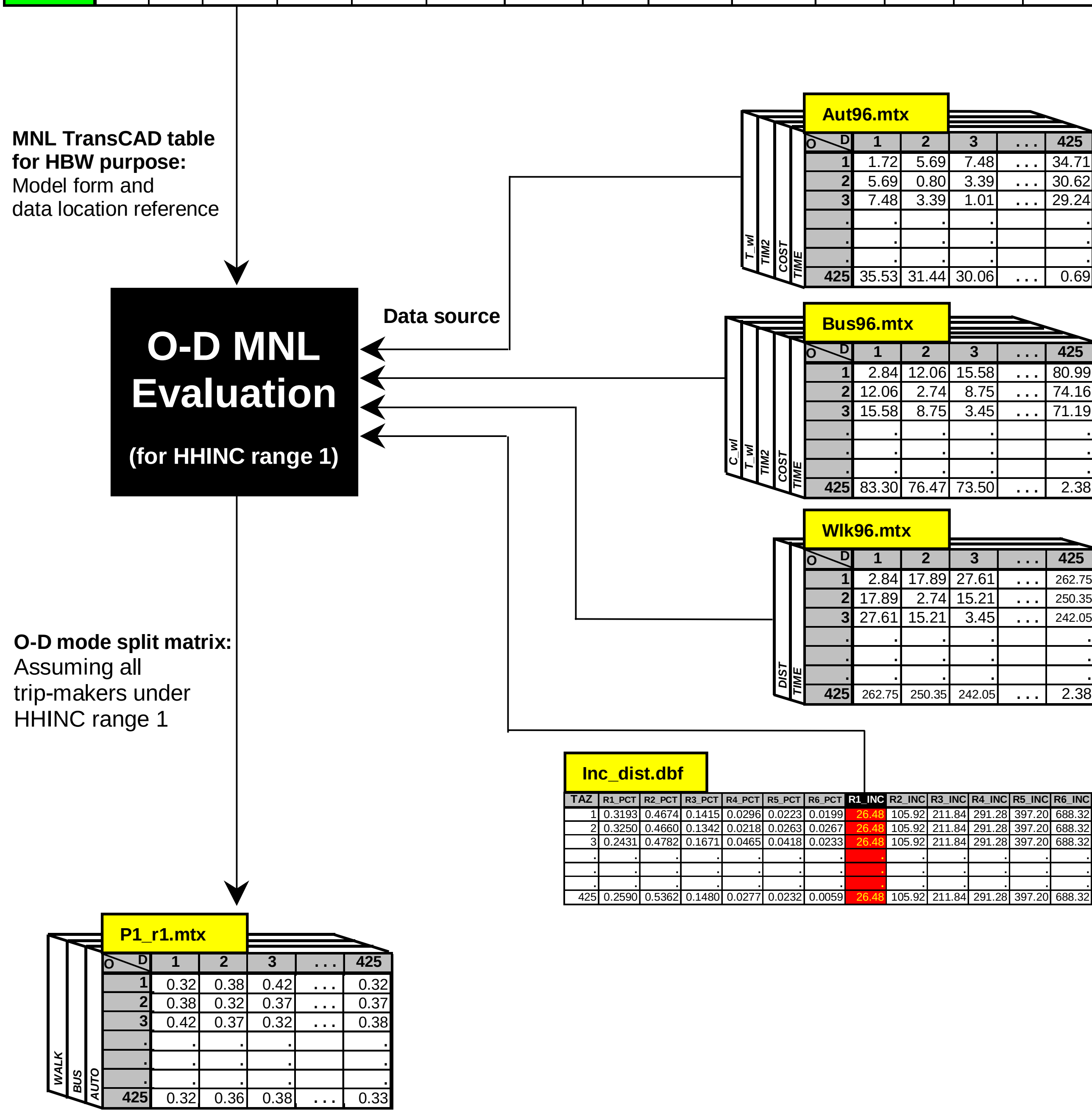
The results in terms of mode share values between the different O-D pairs are quite similar comparing the original exercise and this modified version. This was in a way expected, since both models yielded also similar fits to the data; yet the improvement with the second attempt comes with the recovery of relevant policy variables originally dropped from the model. This modification will notoriously improve the model's ability to respond to transportation system changes.

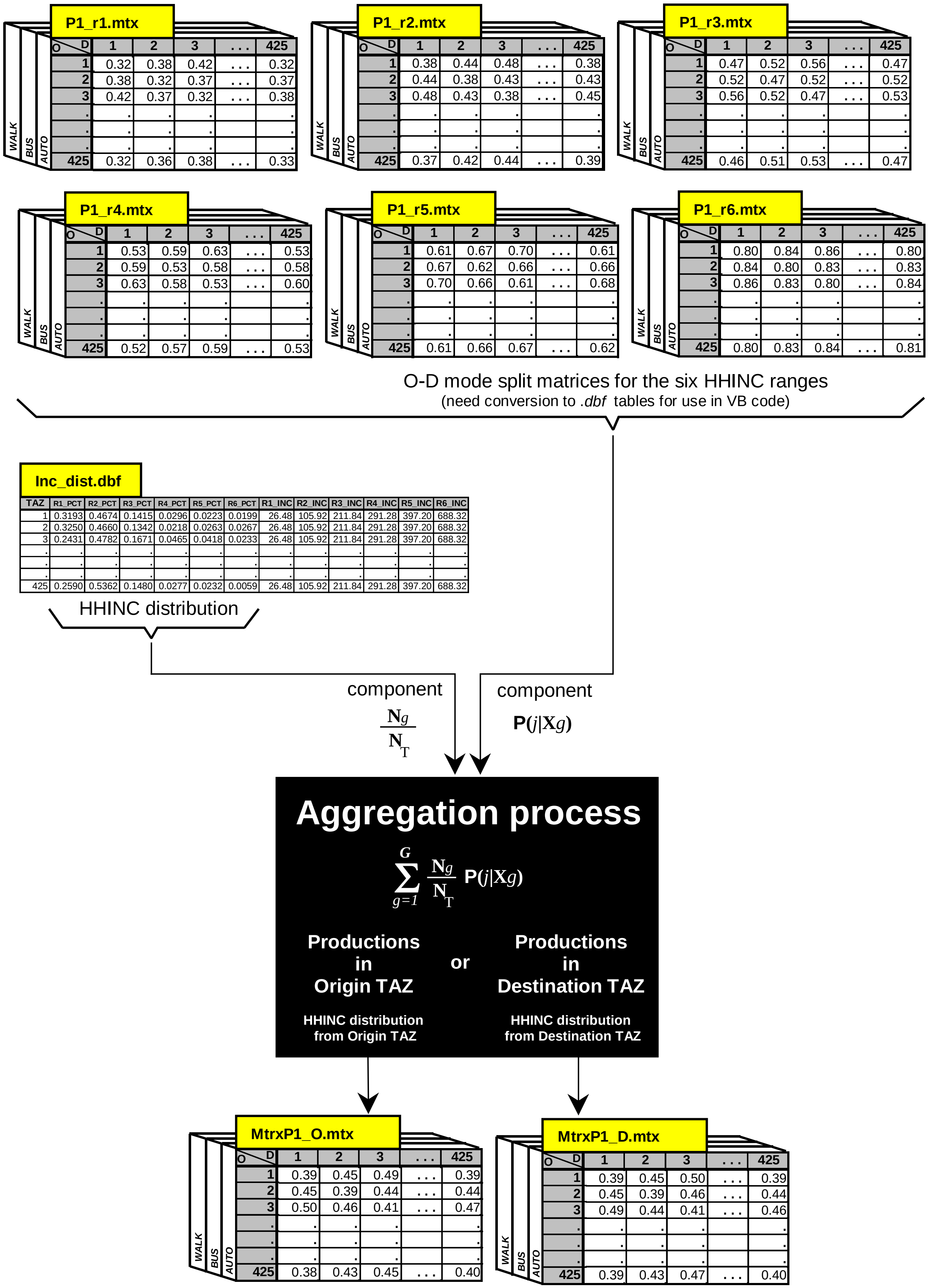
The complete final matrices are not shown as part of this document due the volume of information, but are available for review, as well as the base data sources.

Appendix A

Flow chart for MNL evaluation and aggregation process of HBW model.

Alternatives	ASCb	ASCw	TTw	TT2a	TT2b	TTa_WD	TTb_WD	HHINC	TCa	TCb	TC2a	TC2b	TCa_WD	TCb_WD
AUTO				Aut96|TIM2										
BUS					Bus96|TIM2			R1_INC						Bus96|C_wl
WALK		ONE	Wlk96|TIME					R1_INC						
Estimates		0.7108	-0.0483	-0.00097	-0.00005			-0.0032						-0.1120

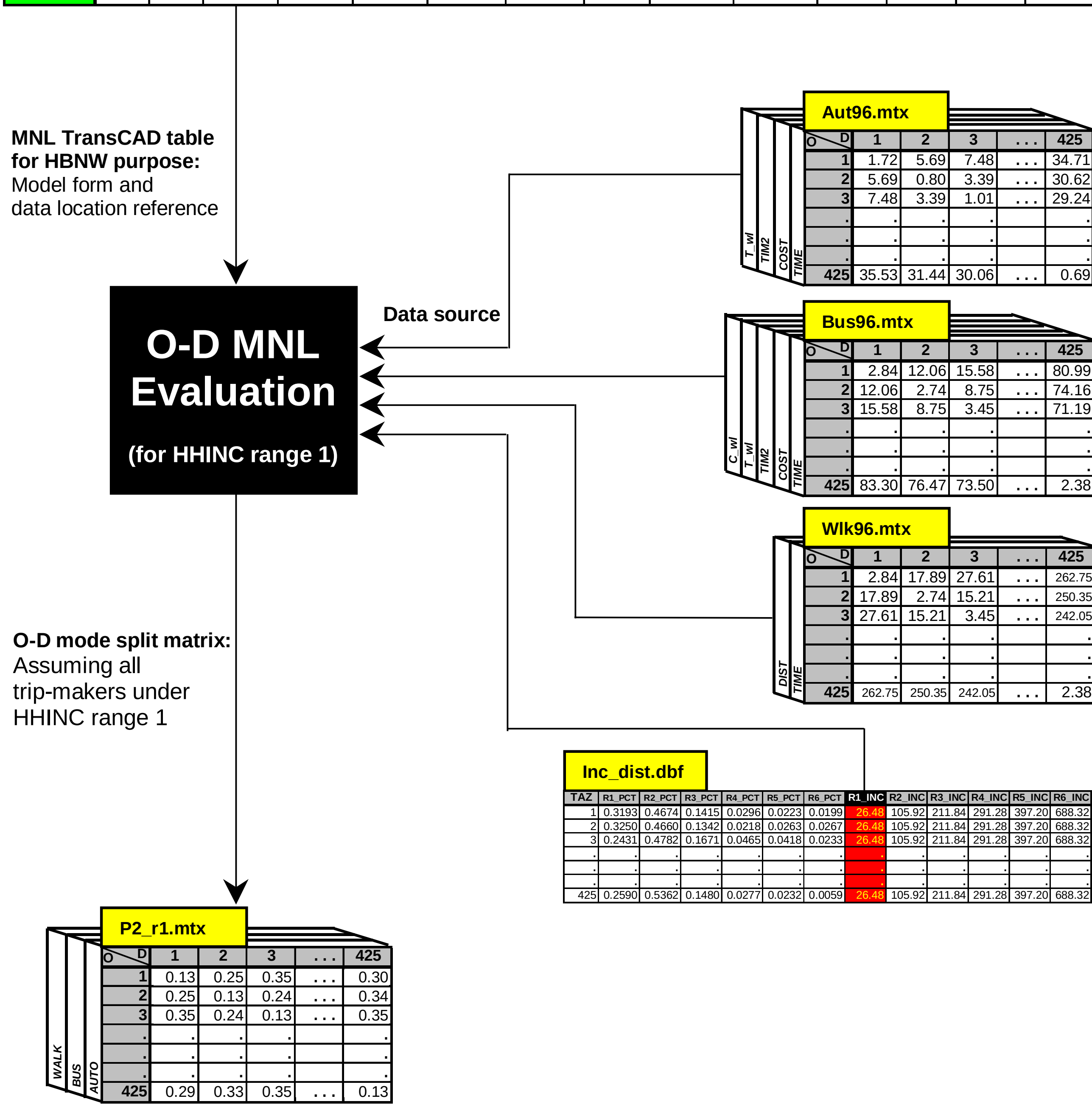


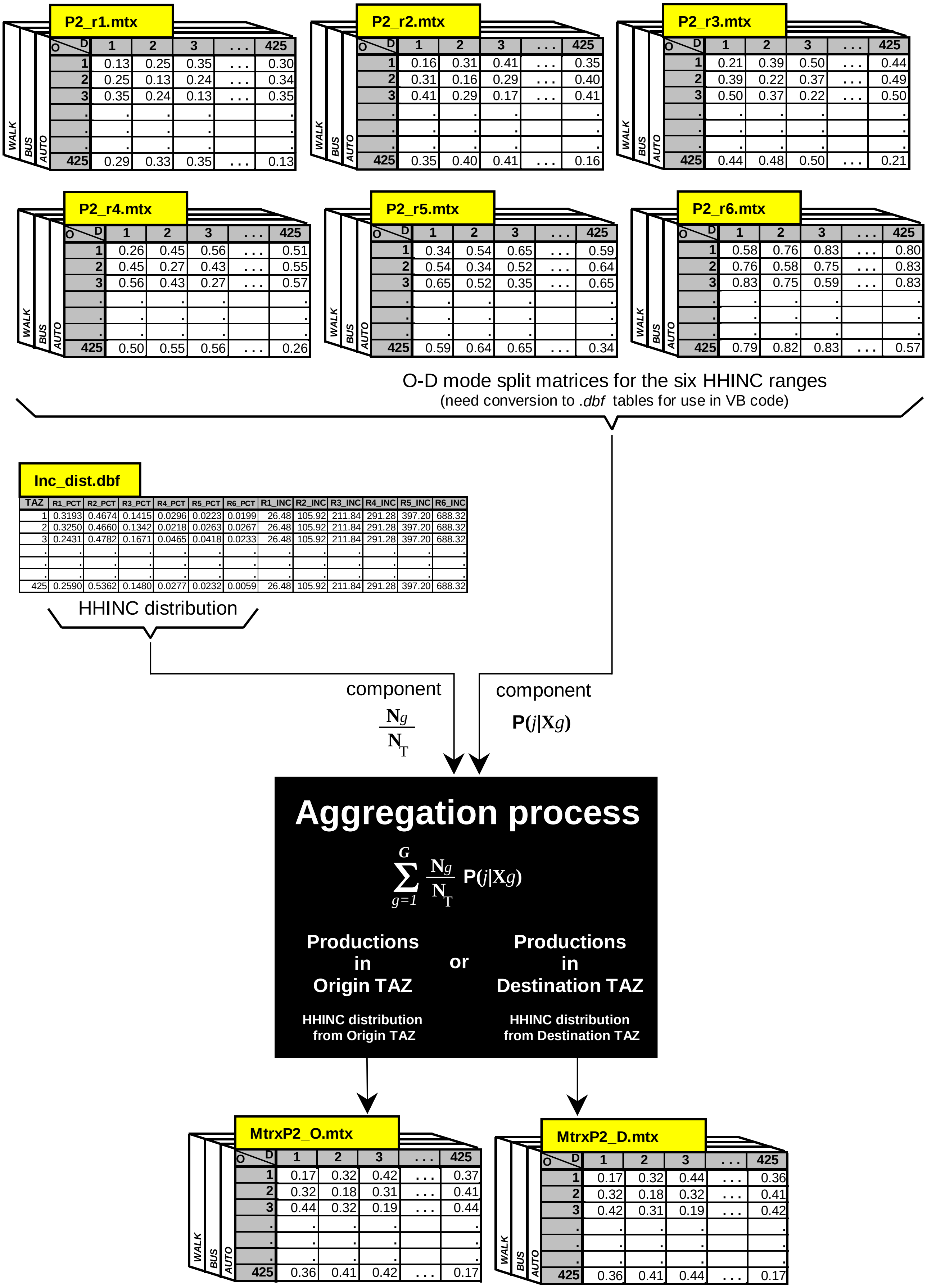

P1_r1.mtx
P1_r2.mtx
P1_r3.mtx
P1_r4.mtx
P1_r5.mtx
P1_r6.mtx
WALK
BUS
AUTO
O-D mode split matrices for the six HHINC ranges
(need conversion to .dbf tables for use in VB code)
Inc_dist.dbf
TAZ
R1_PCT
R2_PCT
R3_PCT
R4_PCT
R5_PCT
R6_PCT
R1_INC
R2_INC
R3_INC
R4_INC
R5_INC
R6_INC
HHINC distribution
component
component
P(j|Xg)
Aggregation process
Productions in Origin TAZ
or
Productions in Destination TAZ
HHINC distribution from Origin TAZ
HHINC distribution from Destination TAZ
MtrxP1_O.mtx
MtrxP1_D.mtx

Appendix B

Flow chart for MNL evaluation and aggregation process of HBNW model.

Alternatives	ASCb	ASCw	TTw	TT2a	TT2b	TTa_WD	TTb_WD	HHINC	TCa	TCb	TC2a	TC2b	TCa_WD	TCb_WD
AUTO				Aut96|TIM2					Aut96|COST					
BUS	ONE				Bus96|TIM2			R1_INC		Bus96|COST				
WALK		ONE	Wlk96|TIME					R1_INC						
Estimates	-0.0997	2.0964	-0.0775	-0.00079	-0.00012			-0.0034	-0.1047	-0.1554				

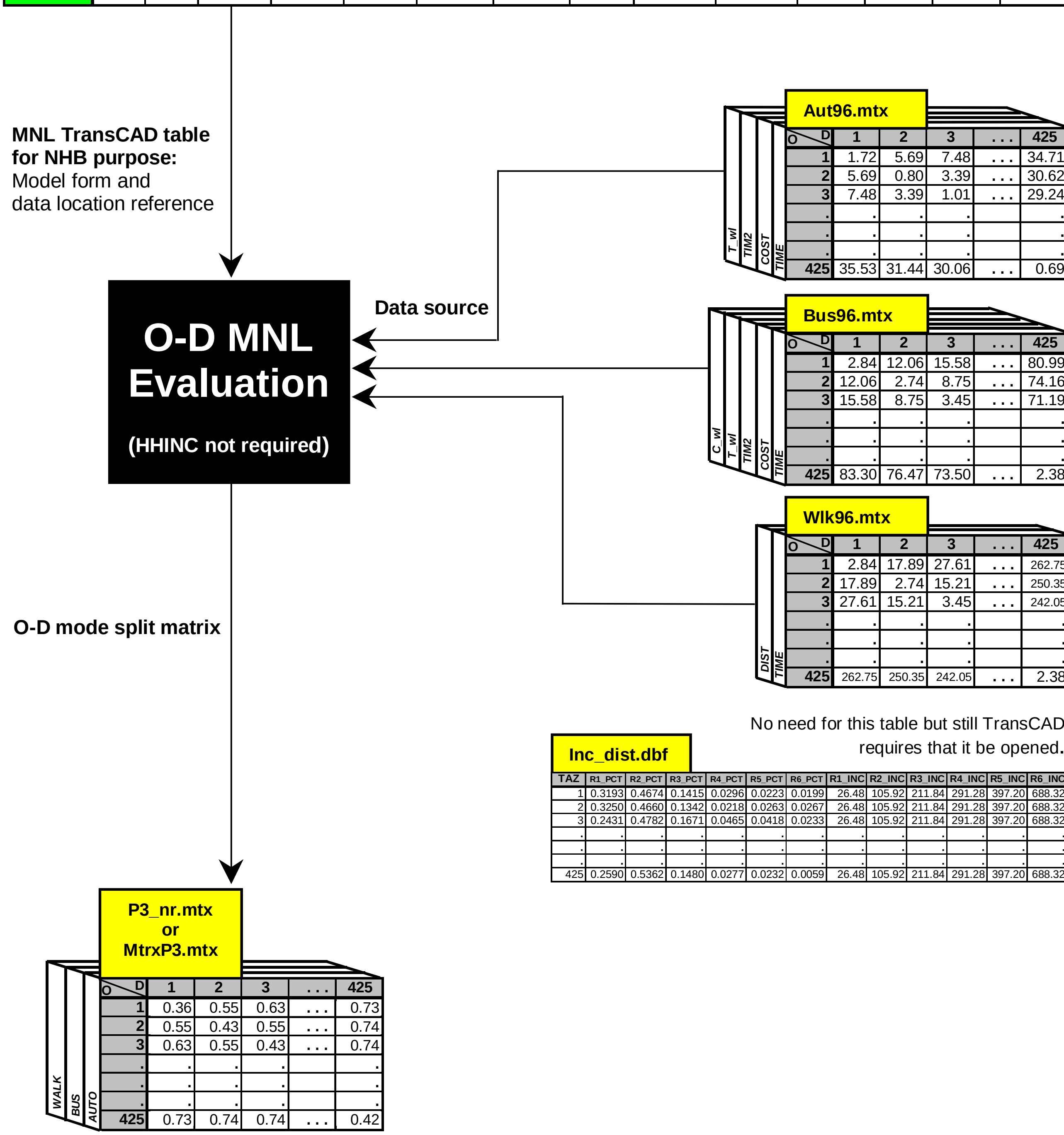



P2_r1.mtx
WALK BUS AUTO
O D 1 2 3 . . . 425
1 0.13 0.25 0.35 . . . 0.30
2 0.25 0.13 0.24 . . . 0.34
3 0.35 0.24 0.13 . . . 0.35
425 0.29 0.33 0.35 . . . 0.13
P2_r2.mtx
1 0.16 0.31 0.41 . . . 0.35
2 0.31 0.16 0.29 . . . 0.40
3 0.41 0.29 0.17 . . . 0.41
425 0.35 0.40 0.41 . . . 0.16
P2_r3.mtx
1 0.21 0.39 0.50 . . . 0.44
2 0.39 0.22 0.37 . . . 0.49
3 0.50 0.37 0.22 . . . 0.50
425 0.44 0.48 0.50 . . . 0.21
P2_r4.mtx
1 0.26 0.45 0.56 . . . 0.51
2 0.45 0.27 0.43 . . . 0.55
3 0.56 0.43 0.27 . . . 0.57
425 0.50 0.55 0.56 . . . 0.26
P2_r5.mtx
1 0.34 0.54 0.65 . . . 0.59
2 0.54 0.34 0.52 . . . 0.64
3 0.65 0.52 0.35 . . . 0.65
425 0.59 0.64 0.65 . . . 0.34
P2_r6.mtx
1 0.58 0.76 0.83 . . . 0.80
2 0.76 0.58 0.75 . . . 0.83
3 0.83 0.75 0.59 . . . 0.83
425 0.79 0.82 0.83 . . . 0.57
O-D mode split matrices for the six HHINC ranges
(need conversion to .dbf tables for use in VB code)
Inc_dist.dbf
TAZ R1_PCT R2_PCT R3_PCT R4_PCT R5_PCT R6_PCT R1_INC R2_INC R3_INC R4_INC R5_INC R6_INC
1 0.3193 0.4674 0.1415 0.0296 0.0223 0.0199 26.48 105.92 211.84 291.28 397.20 688.32
2 0.3250 0.4660 0.1342 0.0218 0.0263 0.0267 26.48 105.92 211.84 291.28 397.20 688.32
3 0.2431 0.4782 0.1671 0.0465 0.0418 0.0233 26.48 105.92 211.84 291.28 397.20 688.32
425 0.2590 0.5362 0.1480 0.0277 0.0232 0.0059 26.48 105.92 211.84 291.28 397.20 688.32
HHINC distribution
component
$\frac{N_g}{N_T}$
component
$P(j|X_g)$
Aggregation process
$\sum_{g=1}^{G} \frac{N_g}{N_T} P(j|X_g)$
Productions in Origin TAZ
or
Productions in Destination TAZ
HHINC distribution from Origin TAZ
HHINC distribution from Destination TAZ
MtrxP2_O.mtx
1 0.17 0.32 0.42 . . . 0.37
2 0.32 0.18 0.31 . . . 0.41
3 0.44 0.32 0.19 . . . 0.44
425 0.36 0.41 0.42 . . . 0.17
MtrxP2_D.mtx
1 0.17 0.32 0.44 . . . 0.36
2 0.32 0.18 0.32 . . . 0.41
3 0.42 0.31 0.19 . . . 0.42
425 0.36 0.41 0.44 . . . 0.17

Appendix C

Flow chart for MNL evaluation of NHB model.

Alternatives	ASCb	ASCw	TTw	TT2a	TT2b	TTa_WD	TTb_WD	HHINC	TCa	TCb	TC2a	TC2b	TCa_WD	TCb_WD
AUTO						Aut96|T_wl			Aut96|COST					
BUS	ONE						Bus96|T_wl			Bus96|COST				
WALK		ONE	Wlk96|TIME											
Estimates	-0.9715		-0.0546			-0.0769	-0.0488		-0.0460	-0.1858				



Aut96.mtx

O \ D	1	2	3	. . .	425
1	1.72	5.69	7.48	. . .	34.71
2	5.69	0.80	3.39	. . .	30.62
3	7.48	3.39	1.01	. . .	29.24
.	.	.	.		.
.	.	.	.		.
.	.	.	.		.
425	35.53	31.44	30.06	. . .	0.69

Bus96.mtx

O \ D	1	2	3	. . .	425
1	2.84	12.06	15.58	. . .	80.99
2	12.06	2.74	8.75	. . .	74.16
3	15.58	8.75	3.45	. . .	71.19
.	.	.	.		.
.	.	.	.		.
.	.	.	.		.
425	83.30	76.47	73.50	. . .	2.38

Wlk96.mtx

O \ D	1	2	3	. . .	425
1	2.84	17.89	27.61	. . .	262.75
2	17.89	2.74	15.21	. . .	250.35
3	27.61	15.21	3.45	. . .	242.05
.	.	.	.		.
.	.	.	.		.
.	.	.	.		.
425	262.75	250.35	242.05	. . .	2.38

No need for this table but still TransCAD requires that it be opened.

Inc_dist.dbf

TAZ	R1_PCT	R2_PCT	R3_PCT	R4_PCT	R5_PCT	R6_PCT	R1_INC	R2_INC	R3_INC	R4_INC	R5_INC	R6_INC
1	0.3193	0.4674	0.1415	0.0296	0.0223	0.0199	26.48	105.92	211.84	291.28	397.20	688.32
2	0.3250	0.4660	0.1342	0.0218	0.0263	0.0267	26.48	105.92	211.84	291.28	397.20	688.32
3	0.2431	0.4782	0.1671	0.0465	0.0418	0.0233	26.48	105.92	211.84	291.28	397.20	688.32
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.
425	0.2590	0.5362	0.1480	0.0277	0.0232	0.0059	26.48	105.92	211.84	291.28	397.20	688.32

P3_nr.mtx or MtrxP3.mtx

O \ D	1	2	3	. . .	425
1	0.36	0.55	0.63	. . .	0.73
2	0.55	0.43	0.55	. . .	0.74
3	0.63	0.55	0.43	. . .	0.74
.	.	.	.		.
.	.	.	.		.
.	.	.	.		.
425	0.73	0.74	0.74	. . .	0.42

No need aggregation process under this trip purpose, since HHINC was not used. This is the final O-D mode split matrix for NHB purpose.