

CEE 123 Transport Systems 3: Planning & Forecasting

Spring 2026: Michael G. McNally (mmcnally-at-uci-dot-edu) [15450]

Homework #6 -- Trip Distribution [S O L U T I O N S]

The following base and future data pertain to a hypothetical five zone region. The data set includes surveyed production, attractions, and activity system variables for 2020, as well as estimates of activity system variables for the year 2030. Note that some zones are **strict** productions and others are **strict** attractions (hint!).

Table 1a. Travel Times ; HBW Ps & As ; Base and Future Demographics

From\To	2020					2020		2020		2030	
	-Base Travel Time-					-Base Trips-		-Base Demo-		-Future Demo-	
	1	2	3	4	5	PROD	ATTR	WORK	EMPL	WORK	EMPL
1	1	3	3	6	3	0	450	0	220	0	216
2	3	1	2	6	5	0	250	0	110	0	118
3	3	2	1	5	6	300	0	140	0	250	0
4	6	6	5	1	4	0	300	0	140	0	166
5	3	5	6	4	1	700	0	360	0	472	166
Totals						1000	1000	500	470	722	666

Table 1b. Base 2020 Trip Distribution

FROM\TO	1	2	4	Prod
3	125	125	50	300
5	325	125	250	700
Attr	450	250	300	1000

Problem 1. Trip Generation (10 points)

Household HBW trip production and attraction models for the region have been estimated as functions of workers per zone (WORK) and employees per zone (EMPL), respectively:

$$P_i = 50.0 + 1.8 \text{ WORK}_i$$

$$A_j = 30.0 + 1.9 \text{ EMPL}_j$$

- Estimate** a measure of goodness-of-fit for each of the above models using the base data. **Comment** on fit.
- Use the demographic forecasts provided to **predict** future trip ends for the P and A models. **Tabulate**.

Solution: Validation: note the dependent variable (P_i or A_j) is set to zero when the explanatory variable (WORK_i or EMPL_j) is zero so that trips are not generated in zones which do not have activity. RMS Error provides a suitable measure of Goodness-of-Fit to supplement the tabulated relative (percent) errors.

Table 1A. Trip Generation: (a) Validation and (b) Forecasts

Zone	a1. Validation 1				a2. Validation 2				(b) Forecast		
	HBW P(i)				HBW A(j)				HBW Forecast		
	Base	Est	Err(%)		Base	Est	Bal	Err(%)	P(i)	A(j)	A(j)*
1					450	448	456	1.33	0	440	445
2					250	239	243	-2.80	0	254	257
3	300	302	0.67						500	0	0
4					300	296	301	0.33	0	345	349
5	700	698	-0.29						900	345	349
Total	1000	1000			1000	983	1000		1400	1385	1400
RMSE			2.00					5.35			

Note: The forecast $A(j)^*$ values are normalized to forecast $P(i)$. $\text{RMSE} = \sqrt{(\sum (\text{est-obs})^2)/n}$

Problem 2. Trip Distribution: Calibration (20 points)

Calibrate a HBW singly-constrained gravity model for trip distribution for the base year data in Table 1.

- Develop** the travel time frequency distribution based on one minute travel time intervals. Set all initial friction factors equal to one. **Complete** a minimum of 3 iterations. Use a 5 percent convergence tolerance. **Apply** Attraction Factoring or Column and Row factoring at each iteration. **Show** all work.
- How** close are the trip matrix cells to the base distribution? **How** could you adjust the cells for a better fit? **What** are the limitations of your adjustment process?
- Estimate** the mean trip length (time) for the base trip distribution results (note: these estimates do not reflect congested travel times).

(a) Solution:

Table 2. Friction Factor Calibration Iterations (with Attraction Factoring)

Travel Time Category	O-D Pairs in Time Category	Observed			Iter #1		Iter #2		Iter #3	
		Trips	(%)	Fk	(%)	Fk	(%)	Fk	(%)	Fk
1 < t ≤ 2	32	125	12.5	1.00	7.5	1.67	11.7	1.78	12.7	1.75
2 < t ≤ 3	31,51	450	45.0	1.00	45.0	1.00	45.1	1.00	45.0	1.00
3 < t ≤ 4	54	250	25.0	1.00	21.0	1.19	25.7	1.16	24.4	1.19
4 < t	34,42	175	17.5	1.00	26.5	0.66	17.5	0.66	18.0	0.65

- If Attraction Factoring is NOT done at each iteration, only the 3rd iteration changes, with final frequencies of 12.2, 45.0, 25.3, and 17.5, and final friction factors of 1.82, 1.00, 1.15, and 0.66
- Results differ if Column & Row factoring is used at each iteration. First, convergence occurs after two iterations (the first iteration in all three cases is the same). Final category frequencies would be 12.25, 45.02, 24.8, and 17.93 and final friction factors would be 1.70, 1.00, 1.20, and 0.64
- See attached for BURPP! software outputs, including details for the above table.

(b) Solution:

The individual cells of the matrix are quite close (a RMS or similar error term could be computed). The fit could be improved by using Kij-factors to adjust individual matrix cells but these are somewhat arbitrary parameters that are difficult to assess in terms of validity in forecasting. Appended are model outputs for three calibration runs (with Destination Balancing, with Column and Row Factoring, and with no attraction adjustments).

- Without A Adjustment: RMSE(Wj)=6.1042; RMSE(Tij)=3.28
- Attraction Factoring: RMSE(Wj)=4.1096; RMSE(Tij)=3.67
- Column+Row Factoring: RMSE(Wj)=0.7272; RMSE(Tij)=1.86

(c) Solution:

The mean trip length (time) for the base trip distribution: $= [\sum_i \sum_j T_{ij} t_{ij}] / \sum_i \sum_j T_{ij} = 3.475$ minutes

Table 1a. Base Travel Times and Base Trip Distribution

From\To	-Base Travel Time-					-- Base Trip Distribution --				
	1	2	3	4	5	FROM\TO	1	2	4	Prod
1	1	3	3	6	3	1	0	0	0	0
2	3	1	2	6	5	2	0	0	0	0
3	3	2	1	5	6	3	125	125	50	300
4	6	6	5	1	4	4	0	0	0	0
5	3	5	6	4	1	5	325	125	250	700
Attr							450	250	300	1000

Problem 3. Trip Distribution: Application (10 points)

Using future forecasts from the trip generation models in Problem 1 and an effective change in travel time to 2 minutes for Zone 3 to Zone 1, **estimate** future trip distribution. **Estimate** the mean trip length (time) for the future distribution and compare to the base mean trip length.

Solution:

The presence of both trip productions and attractions in zone 5 (as computed in Problem 1) means that the prior representation of the problem as a 2 by 3 matrix must be changed to a 2 by 4. Using the calibrated model (with destination balancing), the output for the full 5 by 5 matrix problem is shown below. Note that not only does the F_{ij} -factor for cell (3,1) change (due to its change in travel time), but also trips are now distributed to zone 5, travel times for which are 6 minutes from zone 3 and 1 minute intrazonal. Since friction factors were not calibrated for these trip lengths (due to the absence of trips of this length in the base year), the factor for category 1 (1-2 minutes) is used for (0-1 minutes) and that for category 4 (4-5 minutes) is used for (5-6 minutes) (the last category is always used for any travel times in excess of the maximum calibrated). Appended is a BURPP! SCGM prediction output.

Table 3. Future Productions, Attractions & Travel Times (2030)

Fut. Travel Time Future Trips								----- Future Trip Matrix -----					
From\To	1	2	3	4	5	P(i)	A(j)*	1	2	3	4	5	P(i)
1	1	3	3	6	3	0	444	0	0	0	0	0	0
2	3	1	2	6	5	0	258	0	0	0	0	0	0
3	2	2	1	5	6	500	0	213	151	0	78	57	500
4	6	6	5	1	4	0	349	0	0	0	0	0	0
5	3	5	6	4	1	900	349	230	105	0	272	293	900
Totals	Change in (3,1)					1400	1400	443	256	0	350	350	1400

$$\text{mean travel time} = [\sum_i \sum_j T_{ij} t_{ij}] / \sum_i \sum_j T_{ij} = 2.897 \text{ minutes}$$

The base mean travel time was 3.475 minutes. The decrease is due to the reduction in travel time for trips from 3 to 1 and the new intrazonal trips in zone 5 with a 1 minute travel time.

• Do Either Problem 4a or 4b • (a little advanced thinking)

Problem 4a. Trip Distribution: DCGM (10 points)

Using the *calibrated* friction factors from the HBW Singly-Constrained Gravity Model of Problem 2, complete one iteration of a Doubly-Constrained Gravity Model.

- a. **Compute** the balancing terms (a_i and b_j) and **estimate** the trip matrix.

Solution: Results attached for (a) one iteration of DCGM starting with SCG (w/ Attr Factoring) results, and (b) two iterations starting with initial $F(k)=1.0$ (results include balancing terms, friction factors, and the estimated matrix). The two results, summarized below for (a), are virtually identical. Note that the balancing terms are normalized to equate their scale.

BALANCING CONSTRAINTS			
ZONE	A(i) FACTOR	B(j) FACTOR	ZONE
1	0.029651	0.031158	1
2	0.033141	0.033172	2
3		0.029858	3

CALIBRATED FRICTION FACTORS				
CATEGORY	RANGE	TRIPS(%)	F_{ij}	FACTOR
1	1.0 - 2.0	12.5000	1.6945	
2	2.0 - 3.0	45.0000	1.0000	
3	3.0 - 4.0	25.0000	1.2031	
4	4.0 - 5.0	17.5000	0.6432	

ESTIMATED TRIP INTERCHANGE				
FROM\TO	1	2	4	Prod
3	124.7	122.9	52.6	300.3

5	325.3	127.1	247.4	699.7
Attr	450.0	250.0	300.0	1000.0

- b. **Determine** the corresponding Trip Length Frequency Distribution. Is the DCGM within the final convergence tolerance of the SCGM in Problem 2?

Solution: Results in both cases were improved over the SCGM results. TLFD varying little from the observed (note RMSE and χ^2 stats in attached BURPP! output). Also note that this software solution stops prematurely with a column balancing rather than with a row balancing, thus, the row sums do not exactly match.

Problem 4b. Trip Distribution: Growth Factors (10 points)

Using future forecasts from the trip generation models in Problem 1, estimate future HBW trip distribution using the Furness growth factor model (Row and Column Factoring). Use a 5 percent convergence tolerance or a maximum of two iterations. Growth Factor Models cannot project growth in zones where no base activity exists, so ignore the added future employment in Zone 5. **Hint:** use future productions and attractions to "column and row factor" the base trip matrix.

Table 4b1. Base Trip Distribution

FROM\TO	Base O/D				TG Forecast			
	1	2	4	Prod	P(i)	A(j)	A(j)*	Adj
1	0	0	0	0	0	464	464	591
2	0	0	0	0	0	270	270	344
3	125	125	50	300	500	0	0	0
4	0	0	0	0	0	365	365	465
5	325	125	250	700	900	365*	0	0
Attr	450	250	300	1000	1400	1465	1099	1400

* Ignore future growth in Zone 5 for GF-model

Table 4b2. Base Growth Factor Matrix

FROM\TO	Base O/D				Future
	1	2	4	Prod	P(i)
3	125	125	50	300	500
5	325	125	250	700	900
Base Aj	450	250	300	1000	1400
Fut. Aj	591	344	465	1400	
Col Fact	1.31	1.38	1.55		

Table 4b3. Column-factored Matrix 1

FROM\TO	Est O/D			Est.	Fut.	Row
	1	2	4	P(i)	P(i)	Fact.
3	164	172	78	414	500	1.21
5	427	172	387	986	900	0.91
Est. Aj	591	344	465	1400	1400	
Fut. Aj	591	344	465	1400		

Table 4b4. Row-factored Matrix 1

FROM\TO	Base O/D				Future
	1	2	4	Prod	P(i)

3	198	208	94	500	500
5	390	157	353	900	900

Est. Aj	588	365	447	1400	1400
Fut. Aj	591	344	465	1400	

Col Fact	1.01	0.94	1.04		

Table 4b5. Column-factored Matrix 2

FROM\TO	--	Est O/D		--	Est.	Fut.
	1	2	4	P(i)	P(i)	Row

3	199	196	98	493	500	1.01
5	392	148	367	907	900	0.99

Est. Aj	591	344	465	1400	1400	
Fut. Aj	591	344	465	1400		

Note: within tolerance but always end on a RF!

Table 4b6. Row-factored Matrix 2

FROM\TO	-----	Base O/D		-----	Future
	1	2	4	Prod	P(i)

3	202	199	99	500	500
5	389	147	364	900	900

Est. Aj	591	346	463	1400	1400
Fut. Aj	591	344	465	1400	

Col Fact	1.00	0.99	1.00		

Problem 5. Travel Surveys (20 points)

The [spreadsheet](#) provides 2020 household socio-economic and travel diary data for a sub-sample of Miasma Beach households. **Use only households 10 through 12 in this exercise.**

- a. **Calculate** the trip travel time, activity duration, and trip purpose classification (HBW, HBO, or NHB) for each trip and append to the table. **Compute** the mean travel time by mode and mean activity duration by purpose. Submit a hardcopy (e-copy optional) of the updated spreadsheet.

SOLUTION: Calculation [results](#). Mean travel time was 12 minutes (5 min for 6 walk trips (27%); no bike trips (0%); 20 minutes for 5 bus trips (23%); and 13 min for 11 car trips (50%)). Mean activity duration was 4:05, with 7:42 for work/school activities linked to home (HBW); 1:00 for non-work activities linked to home (HBO); and 1:00 for non-home activities (NHB). At home activity duration was not completed for return home trips).

- b. **Plot** the travel patterns on a Miasma Beach network map. Label each trip end as a production (P) or attraction (A) and label the trip type (HBW, HBO, NHB). Use color and/or line types to distinguish individuals and/or trip types. You may need to plot households on separate maps.

Solution Map not shown in this solution key. Trips can be drawn as straight lines between the origin and destination centroids, and should be color-coded by trip type (e.g., HBW).

- c. **Calculate** the associated OD trip table and the PA trip table.

Solution 2024 (23 trips for HH10, HH11, and HH12)

PA Table	1	2	3	4	5	6
=====	===	===	===	===	===	===
1	0	0	0	0	0	0
2	0	2	0	0	0	0

3	1	2	4	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	1	0
6	5	2	4	0	2	0
=====	===	===	===	===	===	===
OD Table	1	2	3	4	5	6
=====	===	===	===	===	===	===
1	0	0	0	0	0	3
2	0	2	1	0	0	1
3	1	1	4	0	0	1
4	0	0	0	0	0	0
5	0	0	0	0	1	1
6	2	1	2	0	1	0
=====	===	===	===	===	===	===

Appendices -- BURPP! SCGM and DCGM outputs.

*** Calibration *WITH* Attraction Factoring ***

S I N G L Y - C O N S T R A I N E D M O D E L

ZONE	ORIGINS	ATTRACTION	---- DESTINATIONS ----		Zone
			OBSERVED	PREDICTED	
3	300.	450.00	450.	450.	1
5	700.	250.00	250.	255.	2
		300.00	300.	295.	4
TOTAL	1000.		1000.	1000.	

* FHWA FRICTION FACTOR *

PROPORTIONALITY CONSTANT = 1.0000
 MEAN TRIP LENGTH (COST) = 3.4758
 DESTINATION BALANCING

*** CALIBRATION ***

CALIBRATED FRICTION FACTORS

RMS ERROR [Destinations] = 4.1096

CATEGORY	RANGE	TRIPS(%) Fij	FACTOR
1	1.0 - 2.0	12.5000	1.7454
2	2.0 - 3.0	45.0000	0.9990
3	3.0 - 4.0	25.0000	1.1876
4	4.0 - 5.0	17.5000	0.6446

ADJUSTED DESTINATION ATTRACTORS

ZONE	ORIGINAL	ADJUSTED
1	450.00	449.56
2	250.00	259.15
3	300.00	292.31

ESTIMATED TRIP INTERCHANGE					OBSERVED TRIP INTERCHANGE				
FROM\TO	C #1	C #2	C #4	P(i)	FROM\TO	C #1	C #2	C #4	P(i)
C #3	121.4	127.1	51.5	300.0	C #3	125.0	125.0	50.0	300.0
C #5	328.3	128.1	243.6	700.0	C #5	325.0	125.0	250.0	700.0
A(j)	449.7	255.2	295.1	1000.0	A(j)	450.0	250.0	300.0	1000.0

*** Calibration *WITH* Column & Row Factoring ***

S I N G L Y - C O N S T R A I N E D M O D E L

---- DESTINATIONS ----

ZONE	ORIGINS	ATTRACTION	OBSERVED	PREDICTED	Zone
3	300.	450.00	450.	450.	1
5	700.	250.00	250.	249.	2
		300.00	300.	301.	4
TOTAL	1000.		1000.	1000.	

* FHWA FRICTION FACTOR *

PROPORTIONALITY CONSTANT = 1.0000

MEAN TRIP LENGTH (COST) = 3.4840

COLUMN & ROW FACTORING

*** CALIBRATION ***

CALIBRATED FRICTION FACTORS

RMS ERROR [Destinations] = 0.7272

CATEGORY	RANGE	TRIPS(%) Fij	FACTOR
1	1.0 - 2.0	12.5000	1.7045
2	2.0 - 3.0	45.0000	0.9995
3	3.0 - 4.0	25.0000	1.2000
4	4.0 - 5.0	17.5000	0.6445

ESTIMATED TRIP INTERCHANGE					OBSERVED TRIP INTERCHANGE				
FROM\TO	C #1	C #2	C #4	P(i)	FROM\TO	C #1	C #2	C #4	P(i)
C #3	124.8	122.5	52.8	300.0	C #3	125.0	125.0	50.0	300.0
C #5	325.4	126.6	248.0	700.0	C #5	325.0	125.0	250.0	700.0
A(j)	450.2	249.1	300.8	1000.0	A(j)	450.0	250.0	300.0	1000.0

*** Calibration WITHOUT Attraction Factoring ***

S I N G L Y - C O N S T R A I N E D M O D E L

* FHWA FRICTION FACTOR *

---- DESTINATIONS ----					
ZONE	ORIGINS	ATTRACTION	OBSERVED	PREDICTED	Zone
3	300.	450.00	450.	450.	1
5	700.	250.00	250.	242.	2
		300.00	300.	307.	4
TOTAL	1000.		1000.	1000.	

* FHWA FRICTION FACTOR *

PROPORTIONALITY CONSTANT = 1.0000

MEAN TRIP LENGTH (COST) = 3.4806

DESTIN. UNCONSTRAINED

*** CALIBRATION ***

CALIBRATED FRICTION FACTORS

RMS ERROR [Destinations] = 6.1042

CATEGORY	RANGE	TRIPS(%) Fij	FACTOR
1	1.0 <= 2.0	12.5000	1.8189
2	2.0 <= 3.0	45.0000	0.9973
3	3.0 <= 4.0	25.0000	1.1450
4	4.0 <= 5.0	17.5000	0.6619

ESTIMATED TRIP INTERCHANGE					OBSERVED TRIP INTERCHANGE				
FROM\TO	C #1	C #2	C #4	P(i)	FROM\TO	C #1	C #2	C #4	P(i)
C #3	123.5	122.0	54.6	300.0	C #3	125.0	125.0	50.0	300.0
C #5	326.9	120.4	252.7	700.0	C #5	325.0	125.0	250.0	700.0
A(j)	450.4	242.3	307.3	1000.0	A(j)	450.0	250.0	300.0	1000.0

*** Prediction with Future Times and Zone 5 Activity ***

PREDICTION SUMMARY [with Furness (Column & Row) Balancing]

ZONE	PRODUCTIONS			ATTRACTIONS		
	BASE	FORECAST	DIFF(%)	BASE	FORECAST	DIFF(%)
1				450.	444.	-1.33
2				250.	258.	3.20
3	300.	500.	66.67			
4				300.	349.	16.33
5	700.	900.	28.57		349.	*,**
TOT	1000.	1400.		1000.	1400.	

S I N G L Y - C O N S T R A I N E D M O D E L

ZONE	ORIGINS	ATTRACTION	---- DESTINATIONS ----		Zone
			OBSERVED	PREDICTED	
1	0.	444.00	444.	443.	1
2	0.	258.00	258.	257.	2
3	500.	0.00	0.	0.	3
4	0.	349.00	349.	350.	4
5	900.	349.00	349.	350.	5
TOTAL	1400.		1400.	1400.	

* FHWA FRICTION FACTOR *
 MEAN TRIP LENGTH (COST) = 3.4009
 FINAL: C & R FACTORING

CALIBRATED FRICTION FACTORS

CATEGORY	RANGE	TRIPS(%)	Fij	FACTOR
1	0.0 - 1.0	0.0000		1.7450
2	1.0 - 2.0	0.0000		1.7450
3	2.0 - 3.0	0.0000		0.9990
4	3.0 - 4.0	0.0000		1.1880
5	4.0 - 5.0	0.0000		0.6450
6	5.0 - 6.0	0.0000		0.6450

PREDICTED TRIP INTERCHANGE

FROM\TO	1	2	3	4	5	P(I)
3	213.0	151.3	0.0	78.3	57.4	500.0
5	229.9	105.4	0.0	271.7	293.0	900.0
A(J)	442.8	256.7	0.0	350.0	350.4	1400.0

DOUBLY - CONSTRAINED GRAVITY MODEL
 *** Starting with all F(k) = 1.0 ***

----- C A L I B R A T I O N -----
 FHWA GRAVITY MODEL: FRICTION FACTOR ESTIMATION
 ----- PARAMETER SPECIFICATION -----
 1. Initial Factors Set to = 1
 [If 0, Fij are User supplied]
 2. Factor Smoothing (%) = 0
 3. K-Factors (1; 0=calculated). = 1
 4. Convergence Tolerance (10ths of %) . = 50
 5. Maximum Steps. = 10
 6. Intermediate Output (1,2,3=yes). . . = 1
 7. Matrix Output Precision. = 0
 8. Constraint Balancing = 0
 9. Balancing Tolerance (10ths of %). . = 10
 10. Balancing Iterations. = 5

```

*   FHWA FRICTION FACTOR   *
IMPEDANCE PARAMETER      =    0.0000
MEAN TRIP LENGTH (COST)  =    3.4838

```

```

*** CALIBRATION ***
Root Mean Squared Error  =    1.9266
CHI-SQ [df= 2] Statistic =    0.2326

```

BALANCING CONSTRAINTS

ZONE	A(i) FACTOR	B(j) FACTOR	ZONE
1	0.029651	0.031158	1
2	0.033141	0.033172	2
3		0.029858	3

CALIBRATED FRICTION FACTORS

CATEGORY	RANGE	TRIPS(%)	Fij FACTOR
1	1.0 - 2.0	12.5000	1.6945
2	2.0 - 3.0	45.0000	1.0000
3	3.0 - 4.0	25.0000	1.2031
4	4.0 - 5.0	17.5000	0.6432

ESTIMATED TRIP INTERCHANGE

FROM\TO	1	2	4	Prod
3	124.7	122.9	52.6	300.3
5	325.3	127.1	247.4	699.7
Attr	450.0	250.0	300.0	1000.0

DOUBLY - CONSTRAINED MODEL
 *** Starting with F(k) = SCG (w/AF) results ***

```

----- CALIBRATION -----
FHWA GRAVITY MODEL: FRICTION FACTOR ESTIMATION
----- PARAMETER SPECIFICATION -----
1. Initial Factors Set to . . . . . = 0
   [If 0, Fij are User supplied]
2. Factor Smoothing (%) . . . . . = 0
3. K-Factors (1; 0=calculated). . . . = 1
4. Convergence Tolerance (10ths of %) . = 10
5. Maximum Steps. . . . . = 10
6. Intermediate Output (1,2,3=yes). . . = 1
7. Matrix Output Precision. . . . . = 0
8. Constraint Balancing . . . . . = 0
9. Balancing Tolerance (10ths of %). . = 10
10. Balancing Iterations. . . . . = 5

```

```

*   FHWA FRICTION FACTOR   *
IMPEDANCE PARAMETER      =    0.0000
MEAN TRIP LENGTH (COST)  =    3.4747

```

```

*** CALIBRATION ***
Root Mean Squared Error  =    0.7974
CHI-SQ [df= 2] Statistic =    0.0326

```

BALANCING CONSTRAINTS

ZONE	A(i) FACTOR	B(j) FACTOR	ZONE
1	0.029512	0.031149	1
2	0.033238	0.033238	2
3		0.029739	3

CALIBRATED FRICTION FACTORS

CATEGORY	RANGE	TRIPS(%)	Fij-IN	Fij-OUT
1	1.0 - 2.0	12.5000	1.7045	1.6991
2	2.0 - 3.0	45.0000	0.9995	0.9995
3	3.0 - 4.0	25.0000	1.2000	1.2044
4	4.0 - 5.0	17.5000	0.6445	0.6426

ESTIMATED TRIP INTERCHANGE

FROM\TO	1	2	4	Prod
3	124.0	125.4	50.9	300.3
5	326.0	124.6	249.1	699.7
Attr	450.0	250.0	300.0	1000.0

Intermediate Results for Calibration *WITH* Attraction Factoring

Observed Frequency Distribution

CAT	RANGE	10	20	30	40	50
1	1.0 - 2.0	*****				
2	2.0 - 3.0	*****	*****	*****	*****	*****
3	3.0 - 4.0	*****	*****			
4	4.0 - 5.0	*****				

Observed Mean Trip Cost = 3.4750

Iteration 1. Estimated Trip Matrix:

FROM\TO	1	2	4	TOT
3	135.0	75.0	90.0	300
5	315.0	175.0	210.0	700
TOT	450.0	250.0	300.0	1000

ESTIMATED TRAVEL TIME DISTRIBUTION

ITERATION NO. 1

CAT	RANGE		10	20	30	40	50
1	1.0 -	2.0	*****				
2	2.0 -	3.0	*****				
3	3.0 -	4.0	*****	*****			
4	4.0 -	5.0	*****	*****	*****		

R-SQ ATTRACTIVENESS = 1.0000

MEAN TRIP COST: OBS = 3.4750

CHI-SQ FREQUENCIES = 0.4501 (df= 3)

EST = 3.6650

COMPUTATION OF NEW FRICTION FACTORS

ITERATION NO. 1

CAT	RANGE		O/D PERCENT	INITIAL FF(K)	MODEL PCNT	DEVIATION ABSOLUTE (PCNT)		NEW FF(K)	EXCEED TOLER?
1	1.0 -	2.0	12.50	1.0000	7.50	-5.00	-40.00	1.6667	Yes
2	2.0 -	3.0	45.00	1.0000	45.00	0.00	0.00	1.0000	
3	3.0 -	4.0	25.00	1.0000	21.00	-4.00	-16.00	1.1905	Yes
4	4.0 -	5.0	17.50	1.0000	26.50	9.00	51.43	0.6604	Yes

Iteration 2. Estimated Trip Matrix:

FROM\TO	1	2	4	TOT
3	126.8	117.4	55.8	300
5	324.0	118.9	257.1	700
TOT	450.8	236.3	312.9	1000

ESTIMATED TRAVEL TIME DISTRIBUTION

ITERATION NO. 2

CAT	RANGE		10	20	30	40	50
1	1.0 -	2.0	*****				
2	2.0 -	3.0	*****				
3	3.0 -	4.0	*****	*****			
4	4.0 -	5.0	*****	*****			

R-SQ ATTRACTIVENESS = 0.9861

MEAN TRIP COST: OBS = 3.4750

CHI-SQ FREQUENCIES = 0.0045 (df= 3)

EST = 3.4891

COMPUTATION OF NEW FRICTION FACTORS

ITERATION NO. 2

CAT	RANGE		O/D PERCENT	INITIAL FF(K)	MODEL PCNT	DEVIATION ABSOLUTE (PCNT)		NEW FF(K)	EXCEED TOLER?
1	1.0 -	2.0	12.50	1.6667	11.74	-0.76	-6.08	1.7746	Yes
2	2.0 -	3.0	45.00	1.0000	45.08	0.08	0.17	0.9983	
3	3.0 -	4.0	25.00	1.1905	25.71	0.71	2.86	1.1574	
4	4.0 -	5.0	17.50	0.6604	17.47	-0.03	-0.18	0.6616	

Iteration 3. Estimated Trip Matrix:

FROM\TO	1	2	4	TOT
3	121.4	127.1	51.5	300
5	328.3	128.1	243.6	700
TOT	449.7	255.2	295.1	1000

ESTIMATED TRAVEL TIME DISTRIBUTION

ITERATION NO. 3

CAT	RANGE		10	20	30	40	50
1	1.0 -	2.0	*****				
2	2.0 -	3.0	*****	*****	*****	*****	*****
3	3.0 -	4.0	*****	*****			
4	4.0 -	5.0	*****				

R-SQ ATTRACTIVENESS = 0.9978

MEAN TRIP COST: OBS = 3.4750

CHI-SQ FREQUENCIES = 0.0016 (df= 3)

EST = 3.4758

COMPUTATION OF NEW FRICTION FACTORS

ITERATION NO. 3

CAT	RANGE		O/D PERCENT	INITIAL FF(K)	MODEL PCNT	DEVIATION ABSOLUTE (PCNT)		NEW FF(K)	EXCEED TOLER?
1	1.0 -	2.0	12.50	1.7746	12.71	0.21	1.67	1.7454	
2	2.0 -	3.0	45.00	0.9983	44.97	-0.03	-0.08	0.9990	
3	3.0 -	4.0	25.00	1.1574	24.36	-0.64	-2.54	1.1876	
4	4.0 -	5.0	17.50	0.6616	17.96	0.46	2.63	0.6446	

Last Updated: 27 May 2026