**Kevin Saavedra**

USP 587 – Homework 3

1. Trip Distribution

2000 Census data for the City of Redmond, WA, combined with Urban Area 50,000 to 199,999 tables were used to generate trip distribution table by TAZ and household size (Table 1).

***Table 1. HBW Trip Distribution by HH Size***

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| TAZ | hh1 | hh2 | hh3 | hh4 | hh5+ | Total |
| 263 | 516.52 | 1419.528 | 642.466 | 571.064 | 344.284 | 3493.86 |
| 264 | 498.02 | 1254 | 672.676 | 602.072 | 400.724 | 3427.49 |
| 269 | 397.38 | 1105.192 | 545.794 | 576.232 | 316.064 | 2940.66 |
| 271 | 255.3 | 755.744 | 537.738 | 428.944 | 268.09 | 2245.82 |
| 272 | 91.02 | 63.536 | 10.07 | 15.504 | 0 | 180.13 |
| 274 | 485.44 | 1489.752 | 755.25 | 754.528 | 420.478 | 3905.45 |
| 499 | 170.94 | 443.08 | 171.19 | 126.616 | 118.524 | 1030.35 |
| 500 | 61.42 | 225.72 | 132.924 | 116.28 | 64.906 | 601.25 |
| 513 | 16.28 | 127.072 | 88.616 | 116.28 | 90.304 | 438.552 |
| 515 | 28.86 | 16.72 | 0 | 23.256 | 0 | 68.836 |
| 516 | 507.64 | 1093.488 | 418.912 | 224.808 | 124.168 | 2369.02 |
| 517 | 247.16 | 745.712 | 541.766 | 772.616 | 420.478 | 2727.73 |
| 518 | 402.56 | 1105.192 | 582.046 | 718.352 | 386.614 | 3194.76 |
| 519 | 421.8 | 1302.488 | 771.362 | 749.36 | 457.164 | 3702.17 |
| Total |  |  |  |  |  | 30326.1 |

The application of the formula *1.45 x Total Employment* for HBW trips allowed for the calculation of total trip attractions and balanced trip attractions using balance factor .299 (Table 2).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***Table 2. Balanced HBW Trip Attractions*** | | |  |  |
| TAZ | Attractions | Balance Factor | Balanced trip attractions | |
| 263 | 8689.85 | 0.29919375 | 2599.94881 |  |
| 264 | 983.1 | 0.29919375 | 294.137375 |  |
| 269 | 261 | 0.29919375 | 78.0895687 |  |
| 271 | 3448.1 | 0.29919375 | 1031.64997 |  |
| 272 | 40800.1 | 0.29919375 | 12207.1349 |  |
| 274 | 372.65 | 0.29919375 | 111.494551 |  |
| 499 | 15662.9 | 0.29919375 | 4686.24178 |  |
| 500 | 1003.4 | 0.29919375 | 300.211009 |  |
| 513 | 343.65 | 0.29919375 | 102.817932 |  |
| 515 | 11868.25 | 0.29919375 | 3550.90622 |  |
| 516 | 15764.4 | 0.29919375 | 4716.60995 |  |
| 517 | 1149.85 | 0.29919375 | 344.027933 |  |
| 518 | 648.15 | 0.29919375 | 193.922429 |  |
| 519 | 363.95 | 0.29919375 | 108.891565 |  |
| Total | 101359.35 |  | 30326.084 |  |

The Iterative Proportional Fitting worksheets for both uncalibrated and calibrated F-factors can be seen in the attached Excel spreadsheets.

The resulting estimated average travel time per trip for the uncalibrated IPF process is 9.71 minutes, 30% higher than the observed 7.45 minutes. This overestimation is likely due to the use of a single factor, household size, for trip generation. A more fine-grained analysis such as HH size / income / number of vehicles for trip generation would likely be closer to the observed data.

***Fig 1. Observed vs Estimated Trip Length Frequency Distribution***

***Fig 2. Observed vs Estimated Trip Length Frequency Distribution - Calibrated F-Factors***

Using Calibrated – F Factors, the estimated average total time was reduced to 8.77 minutes, 18% higher than the observed data. While still not quite matching the observed data, the use of calibrated F-factors noticeably reduced the observed to estimated discrepancy (Table 3).

|  |  |
| --- | --- |
| ***Table 3. Average Travel Times*** |  |
|  | Avg Travel Time (min) |
| Observed | 7.45 |
| Estimated | 9.71 |
| Estimated (Calibrated F-Factor) | 8.77 |

1. Mode Choice Models

**Model 1**

MTC is interested in the market share and mode choice probabilities based upon the provided data. A cursory examination of the data yields the information found in Table 4.

| ***Table 4. Mode Choice and Probabilities – Model 1*** | | | | | |
| --- | --- | --- | --- | --- | --- |
| **Alternative** | **Available** | **Chosen** | **Proportion by Mode** | **Proportion All Modes** | **MNL Probability** |
| Drive Alone | 2755 | 3637 | 1.32014519 | 0.184872668 | 0.66579934 |
| Shared Ride 2 | 5029 | 517 | 0.10280374 | 0.026279673 | 0.07849134 |
| Shared Ride 3+ | 5029 | 161 | 0.03201432 | 0.008183805 | 0.02443431 |
| Transit | 4003 | 498 | 0.12440669 | 0.025313882 | 0.09453672 |
| Bike | 1738 | 50 | 0.02876870 | 0.002541554 | 0.02378341 |
| Walk | 1119 | 159 | 0.14209115 | 0.008082143 | 0.11295487 |

Column “Proportion by Mode” was calculated by the formula Chosen / Available. “Proportion All Modes” was calculated by the formula Chosen / sum(Chosen).

“MNL Probability” was calculated using the utility formula for a Multinomial Logit model, where the provided constants for Model 1 modes = vMode:

MNL Probability = vMode / vAll

vAll = (exp(vCar) + exp(vShared2) + exp(vShared3) + exp(vTransit) + exp(vBike) + exp(vWalk))

Full calculations and formulas using *R* can be found in the attached Appendix. Seeing the results of Table 4, the Transit mode probability seems disproportionately low when compared to the Walk probability. As “Walk” is not always a viable option for longer trips and its inclusion can take away mode share, MTC produced the same table excluding this mode for more clarity (Table 5). We believe this result to be more representative of our observations.

| ***Table 5. Mode Choice and Probabilities – excluding walk – Model 1*** | | | | | |
| --- | --- | --- | --- | --- | --- |
| **Alternative** | **Available** | **Chosen** | **Proportion by Mode** | **Proportion All Modes** | **MNL Probability** |
| Drive Alone | 2755 | 3637 | 1.32014519 | 0.196022421 | 0.66579934 |
| Shared Ride 2 | 5029 | 517 | 0.10280374 | 0.027864611 | 0.08848630 |
| Shared Ride 3+ | 5029 | 161 | 0.03201432 | 0.008677374 | 0.02754574 |
| Transit | 4003 | 498 | 0.12440669 | 0.026840573 | 0.10657487 |
| Bike | 1738 | 50 | 0.02876870 | 0.002694837 | 0.02681195 |

MTC interprets the results of Model 1 to indicate that there is the least cost to the Drive Alone mode (i.e., vCar = 0 in our *R* calculations), and the cost of all other modes is higher in relation to Drive Alone. However, we have come to this conclusion solely based on the coefficients provided in the summary table. In future, MTC would like to see the assumptions of IVTT and OVTT as well as any additional factors used, so that we may be able to better interpret this model.

**Model 2 & Model 3**

MTC Analyzed Models 2 and 3 for the Implied Value of Time in dollars using the formula βIVTT / βCost (Table 6).

| ***Table 6: Travel Time Cost Analysis*** | | |
| --- | --- | --- |
| **Model 3 Travel Time** | **Coefficient** | **Implied Value of Time ($)** |
| Vehicle | -0.004 | 1.333333 |
| Walk | -0.071 | 23.666667 |
| Bike | -0.062 | 20.666667 |
| Waiting Transit | -0.072 | 24.000000 |
| Model 2 All Modes | -0.050 | 16.666667 |

Model 2’s implied Value of Time is $16.67, while the average of cost broken out by modes in Model 3 produces a slightly higher at $17.42. However, the cost of all non-vehicle traffic is noticeably higher than In Vehicle Travel Time.

MTC performed a Chi-squared analysis to determine if Model 3, which shows a slightly higher Rho-squared value, is significantly different from Model 2. MTC’s calculated Chi-squared value for Model 2 (unrestricted) against Model 3 (restricted) for level of significance 0.01 with 3 degrees of freedom is 0.01. As this is much smaller than the table value of 11.35, MTC concludes that Model 3 is not significantly different from Model 2.

**Model 4**

For Zero Vehicle Households, MTC operates under the assumption that the bias coefficients are relative to Shared Ride modes.

However, in the case where Vehicles Less Than Workers, there is a negative bias coefficient (-1.818) toward driving alone, and a positive (.329) bias toward transit. However, shared ride is not a viable method in this situation, where there is at least one vehicle per household? MTC cannot tell if the lack of coefficients for shared ride modes means that they are not statistically significant, or that their assumed bias coefficients are zero. We would like to see the data for this mode. Vehicles equal to Workers seems to exhibit this tendency as well, with a slight negative bias to Driving Alone. As a two-worker, two-vehicle household seems like a common demographic, MTC would like to see further data on all of the mode shares for these types of households.

**Recommendations**

Because of the relatively low difference in mode share between 2 and 3+ Shared rides, MTC is interested in combining these into a single “Shared Ride” category for future drafts. “Walk” as a mode impacts transit and can skew results for trips where “Walk” is not always a viable option for some. The statistically insignificant difference between Models 2 and 3 lead us to question the use of this more complicated model.

With regard to Model 4, the segmentation of households by number of vehicles is of interest, but we would like to see how the bias coefficients of Shared Rides as a mode of travel. We would like to see the raw data despite the fact that it may not be statistically significant.