RTC Washoe Travel Demand Model

Development Documentation

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# Resident Productions

Productions are predicted at the person level using decision trees for the machine learning stack. Compared to traditional cross-classification matrices, they use the survey samples more efficiently and can consider more variables. While state of the art decision trees methods including bagging and boosting achieve slightly higher prediction accuracy, they are opaque. The models below are simple trees that are easy to understand and perform nearly as well.

Trip purposes in the model are first stratified by the tour type they occur on (work vs non-work), and are laid out below:

* Trips on work tours
  + Home-based work (W\_HBW)
  + Home-based other (W\_HBO)
* Trips on non-work tours
  + Home-based social/recreational (N\_HBSR)
  + Home-based other (N\_HBO)
  + Home-based school (N\_HBSCH)
  + Home-based shop (N\_HBSHP)

For most purposes, separate decision trees were estimated for each market segment. The market segments are:

* Zero vehicle (v0)
* Vehicle insufficient (vi)
* Vehicle sufficient (vs)

## W\_HBW

The home-based work purpose is sensitive to the usual variables like employment status of the person, their age, and their households income per capita (income divided by size). The models are also sensitive to various measure of accessibility:

* Transit accessibility (t\_access)
* General/auto accessibility (g\_access)
* Walk accessibility (w\_access)

### v0

A diagram of a number

Description automatically generated

### vi

A diagram of a number

Description automatically generated

### vs

A diagram of a number

Description automatically generated

## W\_HBO

This purpose is sensitive to variables like the presence of seniors, gender, size, income, and age.

### v0

A diagram of a number

Description automatically generated

### vi

A diagram of a number of individuals

Description automatically generated

### vs

A diagram of a number of individuals

Description automatically generated

# N\_HBSR

The social/recreational models are sensitive to variables like accessibility, employment, per capita income, age, and presence of children.

### v0

A diagram of a number

Description automatically generated

### vi

A diagram of a number of adults

Description automatically generated

### vs

A screenshot of a computer screen

Description automatically generated

## N\_HBO

These models are sensitive to variables like age, gender, accessibility, and employment status.

### v0

A diagram of a number of adults

Description automatically generated with medium confidence

### vi

A diagram of a number of people

Description automatically generated

### vs

A diagram of a family tree

Description automatically generated

## N\_HBSCH

The most important predictor for these model is the age of the person, but other factors like accessibility and income do influence the number of school trips made. This purpose is not stratified by market segment.

A diagram of a number

Description automatically generated

## N\_HBSHP

Shopping trips are influenced by employment status, accessibility, age, income, along with the presence of kids and seniors.

### v0

A diagram of a number of individuals

Description automatically generated

### vi

A diagram of a number of individuals

Description automatically generated

### vs

A diagram of a tree

Description automatically generated

## Calibration

Calibrating the production rates is done to ensure that the final model is producing the same number of trips per person on average as the survey. One complicating factor in this comparison is that the survey and model socio-economic data have different total populations.

* Survey: 476,187
* Model: 523,542

As a consequence, the survey trip totals are increased by 1.1 and then compared to model results. The table below shows the production model results compared back to the total trips in the survey (factored up). While some purposes are higher or lower than the survey, the model does a good job of predicing total trips even before calibration.

A screenshot of a data table

Description automatically generated

The calibration factors below are the ratio of the observed to modeled trips. These are applied by trip type and auto sufficiency segment to ensure total trip making matches the survey (based on trip weight).

A screenshot of a screen

Description automatically generated

# Non-motorized Split

After resident productions are estimated, the model removes non-motorized trips (bike and walk) using a binary logit model. For each trip purpose, the estimated coefficients are shown along with the adjusted rho-squared and the calibration constant applied to match survey shares of non-motorized trips.

## W\_HBW

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable** | **Coefficient** | **t-Statistic** | **Alternatives** | |
| **moto** | **non-moto** |
| HH Kids | 0.066 | 2.8107 |  | X |
| HH Adults | 0.047 | -1.3555 |  | X |
| Vehicle per Adult | 0.254 | -11.657 |  | X |
| Walk Access | 0.073 | 1.2553 |  | X |
| Constant | 0.270 | -3.7151 |  | X |
| **Rho^2** | **0.66** |  |  |  |
|  |  |  |  |  |
| Calibration Constant | 0.60 |  |  | X |

## W\_HBO

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable** | **Coefficient** | **t-Statistic** | **Alternatives** | |
| **moto** | **non-moto** |
| HH Kids | -0.290 | -2.213 |  | X |
| HH Adults | 0.149 | 2.2412 |  | X |
| Vehicle per Adult | -3.807 | -7.922 |  | X |
| Walk Access | 0.093 | 0.7413 |  | X |
| Constant | -1.156 | -2.528 |  | X |
| **Rho^2** | **0.69** |  |  |  |
|  |  |  |  |  |
| Calibration Constant | 1.03 |  |  | X |

## N\_HBO

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable** | **Coefficient** | **t-Statistic** | **Alternatives** | |
| **moto** | **non-moto** |
| Vehicle per Adult | -0.490 | -2.9348 |  | X |
| Walk Access | 0.470 | 5.9330 |  | X |
| Senior | -0.942 | -2.5293 |  | X |
| Constant | -2.786 | -11.476 |  | X |
| **Rho^2** | **0.56** |  |  |  |
|  |  |  |  |  |
| Calibration Constant | 0.31 |  |  | X |

## N\_HBSCH

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable** | **Coefficient** | **t-Statistic** | **Alternatives** | |
| **moto** | **non-moto** |
| HH Kids | 0.320 | 4.4758 |  | X |
| HH Adults | -0.527 | -3.325 |  | X |
| Vehicle per Adult | -1.060 | -3.888 |  | X |
| Walk Access | 0.609 | 4.2519 |  | X |
| Constant | -1.843 | -3.051 |  | X |
| **Rho^2** | **0.48** |  |  |  |
|  |  |  |  |  |
| Calibration Constant | 0.19 |  |  | X |

## N\_HBSHP

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable** | **Coefficient** | **t-Statistic** | **Alternatives** | |
| **moto** | **non-moto** |
| Vehicle per Adult | -3.054 | -10.159 |  | X |
| Walk Access | 0.253 | 2.6459 |  | X |
| Senior | -0.661 | -2.0033 |  | X |
| Constant | -1.315 | -5.0432 |  | X |
| **Rho^2** | **0.65** |  |  |  |
|  |  |  |  |  |
| Calibration Constant | 0.66 |  |  | X |

## N\_HBSR

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable** | **Coefficient** | **t-Statistic** | **Alternatives** | |
| **moto** | **non-moto** |
| HH Kids | 0.369 | 6.6602 |  | X |
| HH Adults | -0.117 | -1.481 |  | X |
| Vehicle per Adult | -2.378 | -9.723 |  | X |
| Walk Access | 0.453 | 4.8056 |  | X |
| Senior | -0.612 | -1.515 |  |  |
| Constant | -1.816 | -5.326 |  | X |
| **Rho^2** | **0.63** |  |  |  |
|  |  |  |  |  |
| Calibration Constant | 0.46 |  |  | X |

# Time of Day

Peak period determination is based on an analysis of the trips in motion throughout the day. First, the day is broken up into 15-minute increments. A trip from the household survey is said to be “in motion” if any portion of the trip occurs within the 15-minute bin. As a result, a single trip can be counted in multiple bins. Determining the peak period considers the distribution of all trips as well as the distribution of trips on work tours individually. The chart below shows these two distributions, which look as expected with the AM peak being shorter and more condensed than the PM.

A graph of blue and orange lines

Description automatically generated

The next step is to determine the peak hour for all trips and those on work tours. In the tables below, the AM and PM peak hours by type are presented. At a minimum, the AM and PM peak periods should contain the respective peak hour for work trips and all trips.

A screenshot of a computer

Description automatically generated

A graph of different colored lines

Description automatically generated

Based on the trips in motion profile, there are four distinct periods of the day. AM and PM peaks have the highest intensity of trip making, followed by mid-day, with the overnight period containing the fewest trips in motion. Boundaries for these periods are defined such that the variance of trips in motion within periods is smallest while variance between periods is largest.

The final period definitions are shown in the table below including the mid-day (MD) period. The remaining hours of the day are captured in the night (NT) period. In the chart, the final period is represented by the gray rectangle.

A screenshot of a schedule

Description automatically generated

A graph of different colored lines

Description automatically generated

# Destination Choice

Rama/Srini

# Mode Choice

Rama/Srini

# Validation

Once the behavioral models were estimated and calibrated using survey data, Caliper ran the full model and compared outputs to traffic counts (2023 counts). This data provided a check on model performance in the base year and built confidence that the model can be used in the future.

The table below presents the percent difference and percent root mean square error, which are measures of how well the model matches counts in aggregate. The table further breaks down this metric by volume group. The model matches count closely both overall and by volume group.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Volume Group | N | Total Count | Total Volume | % Difference | %RMSE |
| 10000 | 517 | 2052000 | 2147510 | 4.65 | 69.33 |
| 25000 | 199 | 3160300 | 3152887 | -0.23 | 38.24 |
| 50000 | 57 | 1908600 | 1912780 | 0.22 | 18.69 |
| 100000 | 17 | 1199900 | 1285451 | 7.13 | 13.96 |
| 100000+ | 11 | 1509300 | 1527212 | 1.19 | 8.19 |
| All | 801 | 9830100 | 10025839 | 1.99 | 37.01 |

The second table presents the same metrics by HCM type. The model uses independent capacities for each of these roadway types, and this table makes sure each is performing well. Major collectors show large metrics, but with only two counts, this is not cause for concern.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| HCM Type | N | Total Count | Total Volume | % Difference | %RMSE |
| Arterial | 235 | 1865100 | 1807053 | -3.11 | 48.98 |
| Collector | 109 | 276800 | 210763 | -23.86 | 86.79 |
| Freeway | 252 | 4543800 | 4885856 | 7.53 | 25.41 |
| Local | 30 | 56600 | 61305 | 8.31 | 94.52 |
| MajorArterial | 173 | 3087000 | 3059609 | -0.89 | 35.8 |
| MajorCollector | 2 | 800 | 1253 | 56.62 | 148.27 |
| All | 801 | 9830100 | 10025839 | 1.99 | 37.01 |

In addition to aggregate checks, Caliper performed link-level validation using maps like the one shown below. In this map, red colors show where the model is higher than counts while blue show where it is lower. Green indicates that the deviation is within the maximum desirable deviation range. No model with useful sensitivity will achieve a green color for all links. These maps guide the review process by showing where errors are largest and suggesting the presence of network or other errors.

A map of a city

Description automatically generated

## Transit

Transit validation is done by checking total transit ridership to observed boardings and alightings. The table below shows unlinked trips (total boardings) for both model and observed. The observed boardings come from the 2024 APTA report.

Model: 18,490

Observed: 17,700

The model accurately predicts the aggregate level of transit usage.