Tour-Based Model for Metrolina

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What is Simplified Tour Modelling?

- New way of modelling individual tours
- Better represents the way people travel
- Concepts are similar, math is different
- Avoids unnecessary complexity
- Quick to calibrate, runs fast
Improvement Over Four-Step

- RT tours are how people actually travel
- Stops are less important locations from O to D
- No Non-Home-Based garbage can
- More accurate trip table
- Avoids problems of tiny fractions of trips
  - Lost trips
  - Slow assignment
  - Large trip tables
Differences from Activity-Based

- Less ambitious, less complex, faster
- Omits some relationships, interactions
- HH level, not person level
- 75% of the benefit of ABM for 10% of development cost, run time
- More suitable for most cities
Round-Trip Tour

- Tours start at home or work
- End is an “anchor point”: work, school, location of max duration
- “Leg 1” is first half of tour (home-nonhome), “Leg 2” is second half (nonhome-home)
- 40-45% of the number of trips
Individual Choices

- No longer use aggregate statistics
- Treat every single tour separately
- Individual choice vs. aggregate totals
- Replace zone-zone tables with a list of tours
  - Like a 100% household survey
Logit Function

- Well-suited for estimating probabilities of discrete options
- Many existing mode choice models use it
- Probabilities sum to 100%

\[ p_i = \frac{e^{U_i}}{\sum e^U} \]

- U = “utility” = linear function of attributes
Logit Curve
Monte Carlo Simulation

- Determine a choice scenario
  - Tour frequency: how many tours by purpose?
  - Intermediate stop: how many stops?
  - Stop location: which zones?
  - Time of day: what time period?

- Establish a set of options
  - 0, 1, 2, 3+ work RT tours per HH

- Compute probability of each choice

- Spin the wheel
“Wheel of Fortune”

Tour Frequency

- 0 tour: 40%
- 1 tour: 30%
- 2 tours: 20%
- 3+ tours: 10%

Legend:
- Blue: 0 tour
- Green: 1 tour
- Orange: 2 tours
- Yellow: 3+ tours
Spin the Wheel

- Sort probabilities by option
  - Larger probability = bigger wedge
- Compute cumulative probability
- Select first option whose cumulative probability exceeds a random number
- Mathematically equivalent to spinning the wheel
- Do this for each tour, for each choice
That Was Part 1, This is Part 2

- Part 1 was presented in May
- Covered household synthesis, tour frequency
- Model calibration is now complete
- Next modules:
  - Tour destination choice
  - Intermediate stop frequency, location
  - Truck, External models
  - Time of Day, part 1
Recap of Part 1

- HH synthesis: create a list of every HH with TAZ, size, income, workers, and life cycle
  - Similar to 4-step HH stratification submodel
- Tour Frequency: for each HH, estimate number of RT tours by purpose
  - Similar to 4-step trip generation
Tour Destination Choice

- “Main” destination zone of the tour
- School, university, or work
  - Otherwise, place of longest stay
- Logit model
- Key variables: travel time, area type, same
  AT dummy, CBD dummy, intra-county
dummy, accessibility
- Size variables: jobs, pop, enrollment
Destination Choice Features

- Most tours start/end at home
  - ATW start/end at work
- Majority of tours are “simple”
- HBW, HBS, HBO split by income (high / low)
  - Higher income = longer HBW, HBS tours
- Double-constrained model
- Includes submodel to split I/I vs. I/X
Intermediate Stops

• Stops along the tour
  - Do separately for leg 1 vs. leg 2
  - More stops on leg 2

• Secondary purposes, mostly shop and personal business

• 10 - 30% of tours make stops

• Max of 7 stops in each direction
More Likely to Make Stops If...

- Higher HH income
- Have kids
- High retail employment near tour O or D
- Home zone densely developed
- Rural destination
- Longer tour time
- More likely to stop on leg 2 if stopped on leg 1
Less Likely to Make Stops If...

- Fewer people in HH
- Lowest HH income
- Tour O and D in same zone
- CBD destination
- Rural origin
- If HH made more tours (some purposes)
## IS Validation: HBW

<table>
<thead>
<tr>
<th>Stops</th>
<th>Leg 1 Obs</th>
<th>Leg 1 Est</th>
<th>Leg 2 Obs</th>
<th>Leg 2 Est</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>85.6%</td>
<td>85.3%</td>
<td>74.4%</td>
<td>73.6%</td>
</tr>
<tr>
<td>1</td>
<td>11.2</td>
<td>11.9</td>
<td>17.6</td>
<td>18.2</td>
</tr>
<tr>
<td>2</td>
<td>2.2</td>
<td>2.0</td>
<td>5.6</td>
<td>5.7</td>
</tr>
<tr>
<td>3</td>
<td>0.6</td>
<td>0.5</td>
<td>1.5</td>
<td>1.6</td>
</tr>
<tr>
<td>4</td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>5</td>
<td>0.1</td>
<td>0.1</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td>0.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>
Stop Locations

- Different models by work/non-work, by stop number, by direction
- Don’t consider all 3,000+ zones for each tour
  - Max search radius: twice the tour O-D distance
  - Max detour time: 30-90 min (by purpose)
  - Avoid looking at zones that aren’t viable choices
- Still consider a few hundred zones for each tour
Detour Time

\[ \text{detour time} = 10 + 5 - 12 = 3 \]
Zone More Likely to Be a Stop If...

- Lower detour time (esp. < 10 min.)
- More development (esp. retail emp.)
- Urban area type
- Closer to CBD
- Lower time from last stop
- Closer to tour destination
Sequence of Stop Locations

- O & D locations influence stop 1 location
- For stops 2, 3, ... location of previous stop is important
  - Time to the tour destination also important
- Surveyed stop locations mostly look random
Actual Non-Work Tour
Actual Work Tour
Time of Day

- Metrolina uses two ToD models
  1) Pre-mode choice: peak vs. off-peak
  2) Post-mode choice: AM, MD, PM, NT

- Logit model by tour direction, purpose

- Tour model includes ToD 1 now

- Mode Choice and ToD 2 to be included later
More Likely to Be Peak If...

- Higher HH income
- Fewer people in HH
- HH has kids
- Suburban home zone
- Tour destination has high job density
- Tour destination does not have much retail
- Leg 2 more likely to be peak if leg 1 is peak
## ToD Validation: HBS

<table>
<thead>
<tr>
<th></th>
<th>Leg 2 peak</th>
<th>Leg 2 off-pk</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Observed</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leg 1 peak</td>
<td>17.9%</td>
<td>15.3%</td>
</tr>
<tr>
<td>Leg 1 off-peak</td>
<td>9.4</td>
<td>57.4</td>
</tr>
<tr>
<td><strong>Estimated</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leg 1 peak</td>
<td>18.1%</td>
<td>15.1%</td>
</tr>
<tr>
<td>Leg 1 off-peak</td>
<td>9.3</td>
<td>57.5</td>
</tr>
</tbody>
</table>
Other Components

- Tour-based truck model transferred from Atlanta
  - (Light) Commercial, Medium Truck, Heavy Truck
  - Developed from GPS data
  - Tour structure more important for trucks
- I/X (resident) and X/I (non-resident) tour models included
- X/X is the only non-tour travel component
Trip Accumulator

- Use tour records to build trip tables
- Person trips by HBW, HBU, HBO, NHB
  - By income
  - By peak vs. off-peak
  - Input to existing mode choice model
- Build external & truck trip tables for assignment
Model Application

- Model applied in TransCAD
  - GISDK code, written by CDOT
- Greater understanding of the model
- Application code in progress
- Expected to run overnight
  - Including skims and MC
Next Steps

- **This winter**
  - Documentation
  - Finish application code
  - Connect to trip-based mode choice
  - Traffic assignment & validation

- **2015**
  - Sensitivity analysis, testing

- **Future:** incorporate mode choice, ToD 2
So What?

- Improved representation of travel
  - More accurate trip table
- Some evidence of improved assignment accuracy
- New capabilities for summarizing impacts
- Staff understands the new model
- Stepping stone to possible future ABM
Questions?

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