Sample enumeration model for airport ground access

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Session 6B
“Cool model applications”
Sample enumeration model as example of data-driven approach

Use model to predict incremental changes pivoting off the observed data
Airport and Ground Access Choice Modeling

- Airports are large, important generators of regional trips
- They also face many of their own important planning issues
- Air passengers have very different behavior from other travelers
- Questions:
  - What will the mode split of trips to my region’s airport look like in the future?
  - What is the impact of adding rail transit service (AirTrain) to an airport on highway conditions around the airport?
  - How does changing the fare on transit service to the airport impact ridership? How does that impact transit conditions? Highway conditions?
Detailed ground access mode combinations, JFK

- **Mode**
  - Auto
    - Drop off/pick up
    - Auto park/short term
    - Auto park/off airport/shuttle
  - AirTrain w/ auto access
  - AirTrain w/ transit access
  - General transit
    - Local bus
    - Airport Shuttle Bus
    - Shared ride (Super Shuttle)
  - Other
    - Taxi/limousine
    - Uber/Lyft/Gett
  - Rental car + AirTrain
  - Long Term Parking + AirTrain
  - Commuter Rail + AirTrain
  - Subway A + AirTrain
  - Subway B + AirTrain
  - Local bus + AirTrain
  - General transit

Model output for analysis of JFK AirTrain operations
Data-driven micro-model rather than special generator in regional model

- Micro-model implemented in a micro-simulation fashion can have an unlimited segmentation with respect to air passengers.
- Micro-model can be integrated with a detailed intra-airport network that represents all important trip generators and facilities and access options between them such as AirTrain, driving, walking, or using special modes such as shuttle buses.
- Macro-model can be structurally different from the regional model (whether ABM or 4-step) and it can be built around specific data available for the airport:
  - For AirTrain ridership forecast for JFK and LGA, the micro-model was implemented using a disaggregate sample enumeration framework built upon special survey of the airport air passengers and employees.
- Micro-model can be conveniently run separately in a short period of time (with the fixed inputs from the regional model) for analysis and comparison of multiple alternatives:
  - It is more difficult to run an airport model by itself if it was implemented as a special generator embedded in the regional macro model.
Model flowchart for LGA AirTrain ridership forecasting

• Survey set of records
• Controls for expansion

Prepare database for baseline scenario

Expanded dataset with baseline (observed) modes

Apply mode switching model for each record

Expanded dataset with mode switches to AirTrain

Summarize mode switches and AirTrain ridership forecast

• LOS (time, cost, reliability) for each record and mode / baseline scenario
• LOS (time, cost, reliability) for each record and mode / AirTrain scenario

• Geographic aggregation for analysis
Overall model system structure for LGA: micro-macro relations

1. Regional travel model
   - Regional LOS, airport access
   - Airport development plans
   - Detailed facility & station-to-station passenger demand

2. LGA ground access sub-model
   - Detailed demand for facility-to-from-external zones
   - AirTrain operation sub-model
     - Detailed capacity & operation analysis
   - Detailed demand for traffic simulation
     - Detailed traffic impacts
Construction of LOS for Entire Trip

Regional model

Hotel → Subway → Penn St. → 14 St. → LIRR

LGA model

Gate at Term. 1 → Term. 1 → Term. 2 → Willets point
Switching model

Model structure to serve sample enumeration approach for policy analysis
Switching Logit Model

- Generalization of Incremental Logit:
  - No base case calibration
  - Standard Incremental Logit does not work with individual records
  - Switching Logit is a theoretically sound construct that does the trick

- Explicitly model mode switch:
  - Previous (observed) mode is known
  - Switching probabilities are consistent with the estimated core model

- Clarification:
  - Switching Logit is the way of model application
  - W/o transaction cost it is estimated as ordinary Logit
Formal Expression

Switch from $j$ to $i$  \[ \Delta P_{ij} = P(i)\times \tilde{P}(j) - P(j)\times \tilde{P}(i) \]

Probability after

Probability before

General:

\[ \Delta P_{ij} = P(i)\times \tilde{P}(j) - P(j)\times \tilde{P}(i) \]

MNL:

\[ \Delta P_{ij} = \tilde{P}(i)\times \tilde{P}(j) \times \frac{\exp(\Delta V_i) - \exp(\Delta V_j)}{\sum_{k\in I} \tilde{P}(k)\times \exp(\Delta V_k)} \]

Nested Logit:

\[ \Delta P_{ij} = \tilde{P}(i)\times \tilde{P}(j) \times \frac{\exp(\Delta V_i)\times \exp[(\mu - 1)\Delta U^m(i)] - \exp(\Delta V_j)\times \exp[(\mu - 1)\Delta U^m(j)]}{\sum_{k\in I} \tilde{P}(k)\times \exp(\Delta V_k)\times \exp[(\mu - 1)\Delta U^m(k)]} \]
Properties of Switching Model

- Pair-wise symmetry
- Total of switches equal to the modeled probability increment
  - Modeled probabilities match the parent model exactly
- No switch if alternatives have equal utility increments
  - Exact replication of observed choices for each individual record
  - Exact replication of probability shifts if only one alternative changes
**Application rules for switching model**

### Individual Record with Observed Choice (Auto without Toll)

### Individual Matrix of Switching Probabilities

<table>
<thead>
<tr>
<th>Modes Before</th>
<th>Auto</th>
<th>Auto/Toll</th>
<th>Transit</th>
<th>P&amp;R</th>
<th>Total Before</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto</td>
<td>0.4</td>
<td>0.2</td>
<td>0.0</td>
<td>0.1</td>
<td>0.7</td>
</tr>
<tr>
<td>Auto/Toll</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Transit</td>
<td>0.1</td>
<td>0.0</td>
<td>0.1</td>
<td>0.1</td>
<td>0.3</td>
</tr>
<tr>
<td>P&amp;R</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Total After</td>
<td>0.5</td>
<td>0.2</td>
<td>0.1</td>
<td>0.2</td>
<td>1.0</td>
</tr>
</tbody>
</table>

### Weight-Split Proportions

<table>
<thead>
<tr>
<th>Modes Before</th>
<th>Auto</th>
<th>Auto/Toll</th>
<th>Transit</th>
<th>P&amp;R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto</td>
<td>0.4/0.7</td>
<td>0.2/0.7</td>
<td>0.0/0.7</td>
<td>0.1/0.7</td>
</tr>
</tbody>
</table>
Airport ground access analysis with switching model

What makes data-driven approach in general and switching model in particular so attractive for practitioners
LGA Ground Access Mode Shares for Air Passengers for Baseline and Build Scenarios in 2025

<table>
<thead>
<tr>
<th>Mode combinations</th>
<th>Air passengers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
</tr>
<tr>
<td>Auto Drop-off/pick-up</td>
<td>20.0%</td>
</tr>
<tr>
<td>Auto Park - Short Term</td>
<td>5.6%</td>
</tr>
<tr>
<td>Auto Park - Long Term</td>
<td>1.0%</td>
</tr>
<tr>
<td>Auto Park - Off Airport/ Shuttle</td>
<td>1.5%</td>
</tr>
<tr>
<td>Rental Car - On airport</td>
<td>1.7%</td>
</tr>
<tr>
<td>Rental Car - Off airport</td>
<td>6.1%</td>
</tr>
<tr>
<td>Taxi/Limousine/FHVs</td>
<td>51.2%</td>
</tr>
<tr>
<td>Shared Ride/Van</td>
<td>2.5%</td>
</tr>
<tr>
<td>Hotel Courtesy</td>
<td>3.0%</td>
</tr>
<tr>
<td>NYC Airporter</td>
<td>1.1%</td>
</tr>
<tr>
<td>Local bus</td>
<td>3.4%</td>
</tr>
<tr>
<td>Subway + Bus</td>
<td>2.4%</td>
</tr>
<tr>
<td>Rail +Bus</td>
<td>0.4%</td>
</tr>
<tr>
<td>Auto Drop-off at Willets Point</td>
<td>1.2%</td>
</tr>
<tr>
<td>Taxi/Limo/FHV at WP/ AirTrain</td>
<td>1.2%</td>
</tr>
<tr>
<td>Subway to AirTrain</td>
<td>6.2%</td>
</tr>
<tr>
<td>LIRR to AirTrain</td>
<td>7.6%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>
Mode Switched from The Existing Modes to AirTrain for Air Passengers, 2025 Daily Trips

<table>
<thead>
<tr>
<th>Existing Mode in Base Scenario</th>
<th>Total for Base</th>
<th>Existing Mode in Build Scenario</th>
<th>New Mode in Build Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Auto Drop-off</td>
<td>Auto Short-Term Park</td>
</tr>
<tr>
<td>Auto Drop-off</td>
<td>15,497</td>
<td>12,764</td>
<td>-</td>
</tr>
<tr>
<td>Auto Short-Term Park</td>
<td>4,369</td>
<td>3,730</td>
<td>-</td>
</tr>
<tr>
<td>Auto Long-Term Park</td>
<td>783</td>
<td>-</td>
<td>783</td>
</tr>
<tr>
<td>Off-Airport Park</td>
<td>1,123</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rental Car - At Airport</td>
<td>1,296</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rental Car - Off Airport</td>
<td>4,735</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Taxis/FHVs</td>
<td>39,612</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hotel Courtesy Vehicle</td>
<td>1,960</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Shared Ride Van/Shuttle</td>
<td>2,352</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>NYC Airporter</td>
<td>876</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bus</td>
<td>2,616</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Subway + Bus</td>
<td>1,885</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>LIRR + Bus/Taxi</td>
<td>272</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total for Build</td>
<td>77,377</td>
<td>12,764</td>
<td>3,730</td>
</tr>
</tbody>
</table>
Example of Volume-over-Capacity (V/C) analysis for JFK AirTrain

Volume/Capacity for “Typical Summer Day” - Daily Peak Period (2:00PM – 3:00 PM)  
Jamaica Route, 2016
Conclusions

- Switching logit model applied in a sample enumeration fashion proved to be a useful innovative tool:
  - Practitioners have a better understanding of the impact of a project or policy if the results are presented in a switching fashion (i.e. for each mode it is known how many travelers will continue use it or switch to a different mode and why)

- Sample enumeration model based on the trips that were actually observed, is trusted somewhat more by practitioners than conventional trip generation and distribution models

- Switching logit model is easy to estimate and apply

- Switching logit model allows for many interesting extensions:
  - Nested structure
  - Any other assumption core probability model
  - Explicit transaction cost
  - Dynamic effects if a panel type data is available

- A micro-model switching model based on sample enumeration suites well the task of modeling such special generators as airports
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