A New Trip-Based Framework for Travel Demand Forecasting Consistent with Tours with Stop Interaction

Vince Bernardin, Jr., Ph.D.
Agenda

- Motivation for a New Approach
- Overview of Knoxville’s “Accessibility-based” Model
  - Five Key Features
    1. Hybrid Disaggregate / Aggregate Alternative
    2. Disaggregate Tour Mode Choice
    3. Departure Time Choice
    4. Feedback of Accessibilities & Foresight
    5. Double Destination Choice Framework
  - Advantages and Limitations
  - Progress in Knoxville

January 22, 2009
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Advantages of the New Approach

- **Consistency with Tours**
  - Travel patterns guaranteed **physically possible**
  - Elimination of problematic non-home-based trips
  - Trips grouped by tour type, **consistent mode choices, timing**

- **Interdependence of Choices**
  - Consideration of other choices through the incorporation of accessibility
    - Average tour/trip cost in tour/stop generation
      - Induced demand, built environment effects
    - **Trip chaining efficiencies** in stop location choice
      - Halo effects (e.g., around malls, factories, downtown, etc.)
Advantages of the New Approach

- **Reduced Aggregation Bias**
  - No information loss, model bias or insensitivity to demographics for activity generation or tour mode choices, possible in others
  - No simulation error – average forecasts from a single run – reasonable run times

- **Within-Day Dynamics**
  - Departure time choice can be pseudo-continuous
  - Able to model shifts in the time of travel from congestion, aging population, time specific parking costs / tolls
Disadvantages of the New Approach

❖ Some Remaining Aggregation Bias
  ➢ Possible information loss, model bias or insensitivity to demographics for destination choice
  ➢ Still using a zone system – poor non-motorized impedances

❖ Behavioral Limitations
  ➢ Departure time choices not interdependent as in activity-based models with interdependent scheduling
  ➢ Destination choice conditional on mode choice may lead to too little sensitivity for some work travel / choice riders
  ➢ Lack of explicit intra-household interactions may result in less fidelity in HOV travel behavior as compared to some activity-based models
Knoxville’s Motivation

❖ Focus on the Fundamentals:
  ➢ How many trips / how much VMT is affected?

❖ Focus on Current Planning Issues in Knoxville:
  ➢ Effects of Built Environment / Land Use
  ➢ Importance of Transit Ridership and Walking
  ➢ Future Tolling / Pricing Options

❖ Focus on Effectiveness:
  ➢ How much realism & policy sensitivity will be gained for how much money and model run time?

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Why not Activity-Based Models?

- So, why didn’t we recommend a shift to activity-based modeling?
  - They clearly improve the fundamentals of the travel forecast.
    - They eliminate aggregation bias in traditional models and the inconsistencies related to non-home-based trips.
  - They offer improved sensitivity and planning capabilities related to all the current, “hot-button” planning issues.
First Tour & Activity-Based Models

Portland, 1998
Boise, 1998

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Tour & Activity-Based Models
Completed (8)

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Tour & Activity-Based Models Under Development (+6)
Tour & Activity-Based Models
NOT in use (3)

Seattle, since 2008
Portland, 1998
Boise, 1995
Sacramento, 2007
San Francisco, Bay Area, since 2007

Columbus, 2005
New York, 2004

Dallas-Ft.Worth, 2006

- Activity/Tour-based Model Complete and In Use (5)
- Activity/Tour-based Model Complete and NOT In Use (3)
- Activity-based Model Under Development (6)
- Other MPO’s (374)

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A Mixed Picture

- After 10 years, only 4 activity-based models are in use by MPOs.
  - 99% of MPOs (381 of 385) still use more or less traditional models
  - 6 more under development – one under development for nearly eight years
- 3 MPOs have an activity-based model that they do NOT use

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What’s the Trouble?

- Activity-based models generally cost several times as much as traditional models to develop (~$1 mill vs. $250k, not including data)
- Their application costs in computer hardware, computing time and staff costs are often even more disproportional
  - Typically run on machines with more than 10 processors (one requires a 64 processor machine)
  - Computing times for an average result still require about **two weeks!** (1-2 days / run × 10 runs for an average)
Why not Activity-based?

- Although they address the fundamentals and current issues,
  - They are not necessarily cost effective for many MPO’s.
  - Their run times are not necessarily practical for many MPO’s.
Why not Four-step?

- **Issues of Aggregation:**
  - How is data combined?

- **Issues of Integration:**
  - How do model components work together?
  - *Vertical Integration* = consistency among the series of component models (down four steps)
  - *Horizontal Integration* = consistency across trips made by the same or related travelers (across the model segments)
Aggregation Bias

- **Spatial Aggregation:**
  - Continuous space is represented by discrete points (zone centroids); different locations within a zone are indistinguishable.
  - Difficulty in representing walk, bike and to some extent walk access transit which depend on travel costs within a zone.

- **Demographic Aggregation:**
  - All travelers from a zone are treated as though they were the same; distributions of demo. variables represented by their mean.
  - Information loss & model bias or insensitivity to demographics.

- **Temporal Aggregation:**
  - If any time, only as a few periods of the day.
  - Inability to model shifts in the time of travel from congestion, aging population, time specific parking costs / tolls.
Lack of Vertical Integration

- Inconsistency between Distribution and Assignment:
  - Destination and mode choices are independent of route choice (highway congestion / transit LOS).
  - Travel times assumed in distribution and mode choice are inconsistent with assignment.

- Insensitivity of Destinations to Mode Choice:
  - Destinations visited are chosen independent of mode chosen!
  - Transit / walk trips to distant locations with no / poor transit service
  - Spatial distribution independent of transit service

- Trip Inelasticity:
  - Trip rates independent of built environment
  - No induced trip-making
Lack of Horizontal Integration

- Lack of Traveler Coordination
  - Each traveler’s choices are independent of every other traveler’s choices. Family members, coworkers, friends do not coordinate, rendezvous, etc.
  - Difficulty in representing HOV trips

- Independence of Trips within a Tour
  - Each trip is independent of all other trips, even trips on the same tour.
  - Trips inconsistent with tour cost minimization – behaviorally implausible.
  - Trips do not form closed tours – physically impossible!
Independence of trips within the same tour

- Non-home-based trip locations, modes & times independent of tour
- Trips do not form closed tours – *physically impossible!*
- Trips inconsistent with tour cost minimization – *behaviorally implausible*
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A New, Alternative Model Design

- Objectives
  - Overcome the most serious limitations and inconsistencies in the four-step model
    - Emphasis on the spatial distribution of travel
Why Spatial Focus?

- Trip distribution or destination choice is the largest source of error in traditional travel models (Zhao & Kockelman, 2002)

- Gravity models typically explain only about 20%-30% of the variation in destination choices
A New, Alternative Model Design

- Objectives

- Overcome the most serious limitations and inconsistencies in the four-step model
  - Emphasis on the spatial distribution of travel
  - But improvements to every dimension of travel

- AND avoid the costs of activity-based models
  - Achieve lower development costs
  - And MUCH shorter run times
A New, Alternative Model Design

- Methodology

1. A hybrid **disaggregate** / **aggregate** system
   - To maximize model fidelity and minimize run time
Network

TAZ

Stop Location Choice

Tour Mode Choice

Activity / Tour Generation

Population Synthesizer

Disaggregate Models

Variables

Accessibility

Network

Travel Times

Flow Averaging

Link Flows

Models

Stop Location Choice

Stop Sequence Choice

Departure Time Choice

HOV and Toll Choices

Traffic Assignment

Aggregate Models

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Flow Averaging

Traffic Assignment
A New, Alternative Model Design

Methodology

1. A hybrid *disaggregate* / *aggregate* system
   - To maximize model fidelity and minimize run time
2. Disaggregate tour mode choice
3. Departure time choice
A New, Alternative Model Design

- **Methodology**
  1. A hybrid *disaggregate* / *aggregate* system
     - To maximize model fidelity and minimize run time
  2. Disaggregate tour mode choice
  3. Departure time choice
  4. Feedback of ACCESSIBILITY as well as travel time
     - To introduce sensitivity to ‘lower level’ choices in ‘upper level’ decisions

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A New, Alternative Model Design

Methodology

- A hybrid **disaggregate / aggregate** system
  - To maximize model fidelity and minimize run time
- Disaggregate tour mode choice
- Departure time choice
- Feedback of **ACCESSIBILITY** as well as travel time
  - To introduce sensitivity to ‘lower level’ choices in ‘upper level’ decisions
- A ‘**double destination choice**’ framework
  - To produce trips consistent with tours and with tour cost minimization

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Segmenting the Component Models

- This model produces *trip tables guaranteed to be consistent with tours without predicting the tours themselves*
- In traditional models, all component models were segmented by *trip purposes*
- Tours and stops are generated rather than trips and segmented by *tour and stop types*
  - Tour purposes are used for *mode, toll and departure time* choice models
  - Stop purposes are used to segment *stop location* choice models
Tour Types

- Three basic tour types are proposed:

<table>
<thead>
<tr>
<th>Tour Type</th>
<th>% Tours</th>
<th>Average Stops</th>
<th>% Stops</th>
<th>Frequency (/hh/day)</th>
<th>Frequency (/pers/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work</td>
<td>34.9%</td>
<td>2.19</td>
<td>39.7%</td>
<td>1.00</td>
<td>0.42</td>
</tr>
<tr>
<td>School</td>
<td>14.6%</td>
<td>1.54</td>
<td>11.6%</td>
<td>0.42</td>
<td>0.17</td>
</tr>
<tr>
<td>Non-Work</td>
<td>50.4%</td>
<td>1.85</td>
<td>48.7%</td>
<td>1.44</td>
<td>0.60</td>
</tr>
</tbody>
</table>

- UT student and tourism tours may also be used, but were not covered by the household survey.
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Hybrid **disaggregate / aggregate**

- **Disaggregate population**
  - individual households choose activities and modes
  - no aggregation bias in activity generation or tour mode choices
- **Deterministic outcomes**
  - no simulation = no simulation error
  - average forecasts from a single model run!
- **Aggregate spatial and temporal models**
  - some bias / insensitivity to demographics
  - reasonable run times
Motivation for a New Approach

Overview of Knoxville’s “Accessibility-based” Model

Five Key Features

1. Hybrid Disaggregate / Aggregate Alternative
2. Disaggregate Tour Mode Choice
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Advantages and Limitations

Progress in Knoxville
Variables

- TAZ
- Accessibility
- Network
- Travel Times
- Flow Averaging
- Link Flows

Models

Disaggregate Models

- Population Synthesizer
- Activity / Tour Generation
- Tour Mode Choice

Aggregate Models

- Stop Location Choice
- Stop Sequence Choice
- Departure Time Choice
- HOV and Toll Choices
- Traffic Assignment

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Disaggregate Tour Mode Choice

- Mode choices made by individual households
  - No aggregation bias
  - Consider the probability of transit use for:
    - 100 households with an average of 2.2 cars per household
    - 5 households with no cars, 15 hh with one car, 50 hh with two cars, 20 hh with three cars, 5 hh with four cars, 5 hh with five

- Mode choices consistent for whole tours
  - No auto trips on transit tours, etc.
    - Commuters can’t take the bus to work and then drive home
  - Can validate Work Tour Mode Choice against census JTW data (without definition problems)
Consistency with tours offers better mode shares (HBO / NHB on work tours, etc.)

Each tour type has very distinct mode shares:

- Work Tour Trips by Mode:
  - SOV: 79.8%
  - HOV: 17.9%
  - Sbus: 1.9%
  - PBus: 0.4%
  - NonM: -1.9%

- School Tour Trips by Mode:
  - SOV: 64.8%
  - HOV: 10.6%
  - Sbus: 21.8%
  - PBus: 0.4%
  - NonM: -1.9%

- Non-Work Tour Trips by Mode:
  - SOV: 56.9%
  - HOV: 41.1%
  - Sbus: -1.9%
  - PBus: 0.1%
  - NonM: -1.9%
Disaggregate Tour Mode Choice

- Destination choice based on Mode choice
  - In traditional four-step models, mode choice was modeled conditional on (after) destination choice
  - This was due to a preoccupation with choice riders and commuting.
  - However, for the majority of trips, there is evidence that destination choice should be modeled conditional on (after) mode choice.
  - *Because many travelers are more likely to change destinations than switch modes.*
  - Possible source of “optimism bias”
  - Shift of focus to captive rider markets

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- Population Synthesizer
- Activity / Tour Generation
- Tour Mode Choice
- Stop Location Choice
- Stop Sequence Choice
- Departure Time Choice
- HOV and Toll Choices
- Traffic Assignment

Disaggregate Models

Aggregate Models

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Departure Time Choice

- Complexity of Knoxville models will depend on data and budget
- At minimum, they will offer some sensitivity to congestion
  - Peak-spreading
- They may also be sensitive to demographics
  - Effects of aging population
- They will likely be capable of predicting demand by hour rather than period
  - Helpful for microsimulation
Consistency with tours offers better time-of-day distributions (HBO / NHB on work tours, etc.)

Each tour type has a very distinct temporal distribution:
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Aggregate Models
Disaggregate Models
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Accessibility

- What is Accessibility?

\[ Accessibility_i = \ln \left( \sum_{\text{zones}(j)} \text{Emp}_j \times \exp\left( \beta \times \text{time}_{ij} \right) \right) \]

- How easy is it to get somewhere else?

- The expected (average) cost of a trip from this zone [by a mode / during a time period]

  - We can measure accessibility in minutes!

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Accessibility

- Accessibility can be used to fix some of the important shortcomings of the four-step model

- How’s this work?
  - The four-step model is limited because it is *sequential* (memory, but no foresight)
  - Accessibility introduces expectation or *foresight* into the models to produce a reasonable *simultaneity* of considerations

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Accessibility

- What does Accessibility (the expected cost of a trip) affect?
  - The likelihood of making a trip
    - land use / built environment effects; induced trip-making
  - The mode used for a trip
    - expected cost by transit vs. car
  - The destination of the trip
    - Trip chaining effects: convenience = the expected cost of a further trip (next trip in the chain) from a destination
    - Residential location effects on trip length
Cost Elasticity and Policy Sensitivity

- Lower tour-making by residents of rural (lower-accessibility) areas,
- Decreased tour-making in response to congestion (decreased accessibility),
- Induced tour-making in response to added network capacity (increased accessibility),
- Induced tour-making in response to new land use developments in other nearby zones (increased accessibility)
Residential Location Effects on Trip Length

- Home-based shopping trips from NW Arkansas demonstrate that variables such as home zone accessibility can have major effects on trip length distributions.

![HBSB Trip Length Frequency Distribution](image)

- 0% to 10% range:
  - High Accessibility
  - Low Accessibility

- Observed Average (all):

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Cost Elasticity from Accessibility

- Including accessibility in both tour generation and stop location choice reflects fewer, but longer rural home-based trips; more shorter urban trips
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Understanding the Problem

- Two-fold problem with four-step spatial distributions
  - Open tours
  - Insensitivity to tour costs
An example of a possible trip table from a gravity model with seven trips (H-a, H-c, a-H, a-c, b-b, b-c, c-c):

- There is no way that all seven of these trips can be arranged into one or more tours.
- Real travelers could not produce the travel pattern in this trip table, but a four-step model can!
- For instance, one traveler doesn’t return home!
Tour Cost Minimization

- Stops Locations (trip ends) which Minimize Tour Costs:
  - Will be closer to home (radial dimension)
  - Will be closer to each other (angular dimension)

- In the Four-Step Model:
  - Home-based trips
    - Minimize radial costs, but NOT angular
  - Non-home-based trips
    - Minimize angular costs, but NOT radial
Non-home-based Trips

- The four-step approach represents the distribution of non-home-based trips as the result of a single gravity (destination choice) model.
- At least two destination or stop location choices are needed to define a non-home-based trip.
The Traditional (Sequential) Solution

- Proposed by Shiftan (1998), used in all tour / activity-based models in U.S.

\[
ATT = H_b + b_a - H_a
\]

\[
ATT = H_c + c_a - H_a
\]
The New Problem

- Building tours sequentially
  - Requires computationally intensive simulation
  - Takes as many steps as stops
  - Results in long model run times!
A New Simultaneous Solution

- First choose stop locations (where to go)
- Then choose how to sequence them (where to go from)
A New Simultaneous Approach

- **Advantage:** *only two steps regardless of how many stops = fast run times!*

- **Challenge 1:** *how to insure that sequences form closed tours?*

- **Challenge 2:** *how to include the cost of non-home-based trips in the choice of stop locations?*
Traveler Conservation Constraint

- Requiring that whoever goes in, comes out results in consistency with tours

\[ \sum_i T_{hij} = D_{hj} = T_{hj} = O_{hj} = \sum_k T_{hjk} \quad \forall h, j \]
An example of a possible trip table with a Traveler Conservation Constraint for seven trips (H-a, H-b, a-H, a-H, a-c, b-a, c-a):

- These trips could be produced by either the tours
  - H-a-H & H-b-a-c-a-H
  - H-b-a-H & H-a-c-a-H

- It can be proved that any trip table with identical row and column sums is consistent with some set of tours.
  - All travelers returns home!

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An example of a possible trip table from “forced symmetry” with a pathological tour

- The traveler could not make the pathological tour b-c-b because they never visit b or c

The probability of a pathological tour is related to the difference between the probability that the traveler will visit a subset of stops and the probability that the traveler will visit that subset of stops from home

- The double destination choice framework minimizes this.
Model Formulation

- Simple “double destination choice” framework

\[
T_{hi} = T_{h}P_{i|h} \quad \forall h, i \\
T_{hij} = T_{hi}P_{j|hi} \quad \forall h, i, j \\
\sum_{i} T_{hij} = T_{hj} \quad \forall h, j
\]
# Algorithmic Demonstration

<table>
<thead>
<tr>
<th>Step</th>
<th>Algorithm</th>
<th>Proof</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 0.</td>
<td>Begin with a set of trips which, for each location, has as many trips with that location as origin as have that location as destination.</td>
<td>The algorithm can only terminate at this step.</td>
</tr>
<tr>
<td>Step 1.</td>
<td>Choose a trip to begin a new tour, unless no trips remain and all have been assigned to tours.</td>
<td>Each time a tour is removed, the remaining set of trips retains the property of the original set, since the trips removed also have this property.</td>
</tr>
<tr>
<td>Step 2a.</td>
<td>If the destination of the new trip is the origin of the first trip in the tour, then this tour is complete. Set the trip(s) in this tour aside. Return to Step 1.</td>
<td>There must exist a successor trip to choose, otherwise, there would be at least one less trip with this location as origin as trips with this destination.</td>
</tr>
<tr>
<td>Step 2b.</td>
<td>Otherwise, there exists at least one remaining trip whose origin location is this trip’s destination. Choose one such trip and add it to the tour. Return to Step 2a.</td>
<td></td>
</tr>
</tbody>
</table>
Under-determination of Tours

- In general, there are far more possible tours than (independent) trip probabilities, so the probabilities of tours cannot be determined from this model alone without further assumptions.

\[
\sum_{s=1}^{S} Z^s \cdot Z^2 - 2Z + 1
\]

- The approach is fast because it produces trips consistent with tours without determining the tours, themselves.
A New Simultaneous Approach

- **Advantage:** *only two steps regardless of how many stops / tours = fast run times!*
- **Challenge 1:** *how to insure that sequences form closed tours?*
- **Challenge 2:** *how to include the cost of non-home-based trips in the choice of stop locations?*
Stop Location Choice

- **Gravity Model**
  - Stewart (1941), Huff (1963), Wilson (1967)
  - Based on a single impedance (time from home/origin) and employment / attractions
  - Still most widely used (TRB, 2007)

- **MNL Destination choice models**
  - Recent applications in practice (Chow et al., 2005; Jonnalagadda et al., 2001)
  - Mostly traveler heterogeneity
Limitations of Standard Methods

- Both gravity and more general MNL models are independent of the spatial arrangement or accessibility of alternative destinations.

**Scenario 1**

- Nodes: A, B, C
- Connections: A-B, A-C

**Scenario 2**

- Nodes: A, B, C
- Connections: A-B, A-C

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Independence

In traditional models, two equidistant, equal-size destinations are equally probable.
What about Accessibility?

What if one is more accessible to other possible destinations?
Complementarity

Maybe the more accessible one is more probable - because you have to go a nearby destination anyway, and so it’s convenient.

Higher accessibility means the expected cost of a possible subsequent trip is lower.
Substitution

Or, maybe the less accessible is more probable because half the time you go the other direction, you go to a nearby alternative instead.
Accessibility in Destination Choice

- Fotheringham (1983, 1986) formulated the Competing Destinations (CD) model
  - Captures NET substitution OR complementarity effect through a general accessibility variable
  - Observes substitution (studying long distance travel)

- Kitamura (1984) used accessibility to capture complementarity effects in daily urban travel
Different Findings

- Fotheringham finds substitution effects
  - $\text{Prob}(C)$ in Scenario 1 $> \text{Prob}(C)$ in Scenario 2

- Kitamura finds complementarity effects
  - $\text{Prob}(C)$ in Scenario 1 $< \text{Prob}(C)$ in Scenario 2
Accessibility in Destination Choice

- Bhat and collaborators (1998) generalize the CD model to incorporate more variables and find substitution dominant in shopping
- Bhat and collaborators (2001, 2004) find complementarity effects by using other accessibilities

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Accessibility in Destination Choice

- Mounting evidence supported the existence and significance of both substitution and complementarity effects.
- No models could incorporate both.
- Naïve attempts to incorporating trip-chaining or stop clustering complementarity effects are generally overwhelmed by substitution effects.

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ACDC Models
(Bernardin, Koppelman & Boyce, 2008)

- Agglomerating and Competing Destination Choice (ACDC) Models
  - Use 2 types of accessibility:
    - Accessibility to complements (other places you need to go, regardless)
    - Accessibility to substitutes (other places you might go, instead)

\[
P_{j|h} = \frac{e^{\ln \gamma S_j + \beta_c c_{hj} + \beta_{AS} A_j^S + \beta_{AC} A_j^C}}{\sum_{j'} e^{\ln \gamma S_{j'} + \beta_c c_{hj'} + \beta_{AS} A_{j'}^S + \beta_{AC} A_{j'}^C}}
\]
A Simple Rule

- Assume attractions to the **same** industry are competitors/substitutes
  - Reasonable depending on categories
  - Some exceptions: car dealers, jewelers, etc.

- Assume attractions to **different** industries are **complements**
  - Few exceptions: movie vs. park?
Lieberson’s dissimilarity statistic

Lieberson’s (1969) dissimilarity statistic (d)

Measures the probability that two items drawn at random from two different samples will belong to the same category

\[
d_{jk} = 1 - \sum_g \left[ \frac{\text{Attr}_j(g)}{\sum_g \text{Attr}_j(g)} \right] \left[ \frac{\text{Attr}_k(g)}{\sum_g \text{Attr}_k(g)} \right]
\]
Substitutes & Complements

• The number of substitutes and complements can therefore be expressed:

\[ S_{jk} = (1 - d_{jk}) D_k \]

\[ C_{jk} = d_{jk} D_k \]

• And the accessibility to each

\[ A_j^S = \ln \sum_k (1 - d_{jk}) D_k e^{\beta_j^S c_{jk}} \]

\[ A_j^C = \ln \sum_k d_{jk} D_k e^{\beta_j^C c_{jk}} \]
ACDC Models attempt to minimize both dimensions of tour costs:

- Stops will be closer to home (radial dimension)
- Stops will be closer to each other (angular dimension)

$$P_{j|h} = \frac{e^{\ln \gamma S_j + \beta_c c_{hj} + \beta_{AS} A_j^S + \beta_{AC} \ln \sum_k d_{jk} B_k e^{\beta_{BC} c_{jk}}}}{\sum_{j'} e^{\ln \gamma S_{j'} + \beta_c c_{hj'} + \beta_{AS} A_j^S + \beta_{AC} \ln \sum_k d_{j'k} B_k e^{\beta_{BC} c_{j'k}}}}$$
Policy Analysis & Planning

What happens if a new development occurs?

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In current models, all the other destinations get equally less probable.
In ACDC models, nearby destinations are affected more than distant ones.

Complements get more probable – new trips to old destinations!
Sensitivity Analyses
– Real World Examples

- Comparison of gravity and ACDC models for three new developments to illustrate spatial competition and trip-chaining effects.
  - A new factory employing 1,000 workers in Loudon county indirectly attracts 125 daily non-work stops to the county.
Sensitivity Analyses

- Loudon County factory’s effect on shopping stops
Sensitivity Analyses
– Real World Examples

- Comparison of gravity and ACDC models for three new developments to illustrate spatial competition and trip-chaining effects.
  - A new factory employing 1,000 workers in Loudon county indirectly attracts 125 daily non-work stops to the county.
  - A new Food City with 105 employees indirectly attracts a NET 27 (+55-28) daily trips to nearby zones (halo effect)
Sensitivity Analyses

- New Food City’s effect on shopping stops
Comparison of gravity and ACDC models for three new developments to illustrate spatial competition and trip-chaining effects.

- A new factory employing 1,000 workers in Loudon county indirectly attracts 125 daily non-work stops to the county.
- A new Food City with 105 employees indirectly attracts a NET 27 (+55-28) daily trips to nearby zones (halo effect).
- A new Panera restaurant with 35 employees shows no significant trip-chaining effects, but steals 52 more trips from nearby zones than the gravity model.

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Sensitivity Analyses

- New Panera’s effect on “other” stops
Agenda

- Motivation for a New Approach
- Overview of Knoxville’s “Accessibility-based” Model
  - Five Key Features
    1. Hybrid Disaggregate / Aggregate Alternative
    2. Disaggregate Tour Mode Choice
    3. Departure Time Choice
    4. Feedback of Accessibilities & Foresight
    5. Double Destination Choice Framework
  - Advantages and Limitations
  - Progress in Knoxville

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Advantages of the New Approach

❖ Consistency with Tours
   ➢ Travel patterns guaranteed physically possible
   ➢ Elimination of problematic non-home-based trips
   ➢ Trips grouped by tour type, consistent mode choices, timing

❖ Interdependence of Choices
   ➢ Consideration of other choices through the incorporation of accessibility
     ▪ Average tour/trip cost in tour/stop generation
       • Induced demand, built environment effects
     ▪ Trip chaining efficiencies in stop location choice
       • Halo effects (e.g., around malls, factories, downtown, etc.)
Advantages of the New Approach

- **Reduced Aggregation Bias**
  - *No information loss*, model bias or insensitivity to demographics for activity generation or tour mode choices, possible in others
  - *No simulation error* – average forecasts from a single run – reasonable run times

- **Within-Day Dynamics**
  - Departure time choice can be pseudo-continuous
  - *Able to model shifts in the time of travel* from congestion, aging population, time specific parking costs / tolls

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Disadvantages of the New Approach

- Some Remaining Aggregation Bias
  - Possible information loss, model bias or insensitivity to demographics for destination choice
  - Still using a zone system – poor non-motorized impedances

- Behavioral Limitations
  - Departure time choices not interdependent as in activity-based models with interdependent scheduling
  - Destination choice conditional on mode choice may lead to too little sensitivity for some work travel / choice riders
  - Lack of explicit intra-household interactions may result in less fidelity in HOV travel behavior as compared to some activity-based models

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Agenda

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Knoxville Schedule

- Data collection is complete
- Currently transitioning from early phases
  - Identified tour and stop types
  - Population synthesizer is nearly complete
  - Work on activity generation, stop location and sequence choice models underway
- Aggressive timetable
  - Aim to have validated model in time to present results at the Planning Applications Conference in Houston this May

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Thank you!

Questions?