Derivation of Travel Demand Elasticities from a Tour-Based Microsimulation Model

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Introduction

- NCHRP 25-21: Predicting Short-Term and Long-Term Air Quality Effects of Traffic-Flow Improvement Projects
- Several model components
  - Land use
  - Air quality
  - Travel demand

Requirements for 25-21 method

- Quick to apply
- Transferable
- Incorporate appropriate travel behavioral responses
- Applicable at local and regional levels
- Cover a range of projects

Case studies for method

- Puget Sound region
- Several types of capacity changes
  - Freeway lane addition, removal
  - Signal coordination
  - Intersection channelization
  - Transit improvements

Travel behavior changes

- Route
- Time of day
- Mode
- Destination
- Work or home location
- Amount of travel

Assessment of model types

Four-step model	▪In place for most areas ▪Omits significant behaviors
Tour-based model	▪Models all significant behavior ▪Difficult to implement and use
Economic theory model	▪Reflects effects on all time use ▪Explicitly incorporates income, VOT ▪Does not produce trip tables

Travel model chosen

- Portland microsimulation tour model
- Run model to get elasticities
- Advantages
  - Incorporates main travel behavior effects
  - Elasticities are easy to apply

Elasticity

$$\frac{\text{Marginal \% change in demand}}{\text{Marginal \% change in cost}}$$

Definition of elasticity

- Theory: $$\varepsilon = \frac{\partial \log Q}{\partial \log P}$$

- Practice: $$\varepsilon_A = \frac{\log(Q^1 / Q^0)}{\log(P^1 / P^0)}$$ (arc elasticity)

Existing data on elasticities

- Some data on elasticities, e.g. HERS
- Very little data on modal cross-elasticities
- No data on time-of-day cross-elasticities

Regressions to estimate elasticity

$$\log\left[\frac{\tilde{T}_{ij}^{mp}}{T_{ij}^{mp}}\right] = \sum_{m',p'} \varepsilon_{m'p'}^{mp} \log\left[\frac{\tilde{t}_{ij}^{m'p'}}{t_{ij}^{m'p'}}\right]$$

Elasticities to be estimated

Demand		Travel time					
		AM peak			PM peak		
		Drive alone	Shared ride	Transit	Drive alone	Shared ride	Transit
AM peak	DA	●	●	●	●	×	×
	SR	●	●	●	×	●	×
	TR	●	●	●	×	×	●
PM peak	DA	●	×	×	●	●	●
	SR	×	●	×	●	●	●
	TR	×	×	●	●	●	●
Offpeak	DA	●	×	×	●	×	×
	SR	×	●	×	×	●	×
	TR	×	×	●	×	×	●

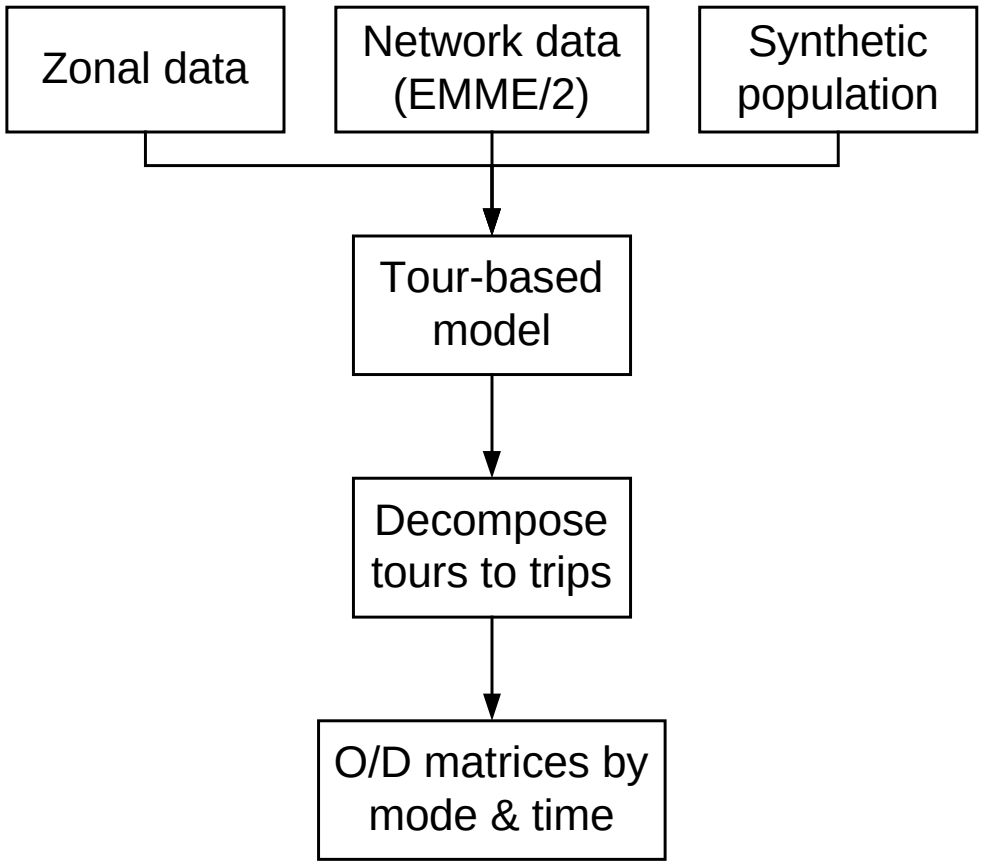
Portland tour-based model

- Descendent of STEP model (Harvey)
- Model of full day of activity
- Activities occur at home or on tour
- Time of day, mode, main destination
- Subtour and intermediate stop models

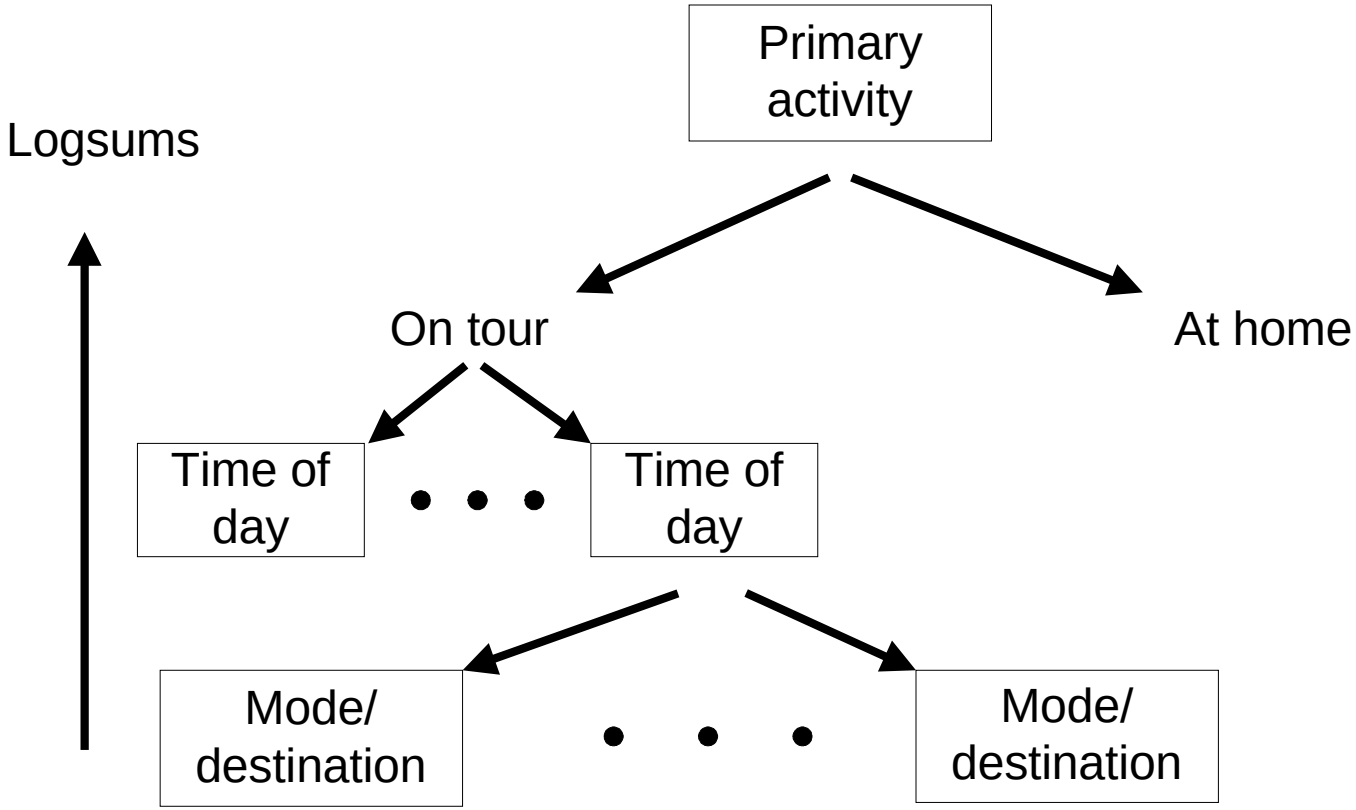
Features

- Simultaneous modeling of all travel choices except route choice
- Model applied to individuals (sample enumeration)
- Higher-level choices incorporate utilities from lower levels
- Works on synthetic population sample

Portland tour-based model – 1



Portland tour-based model – 2



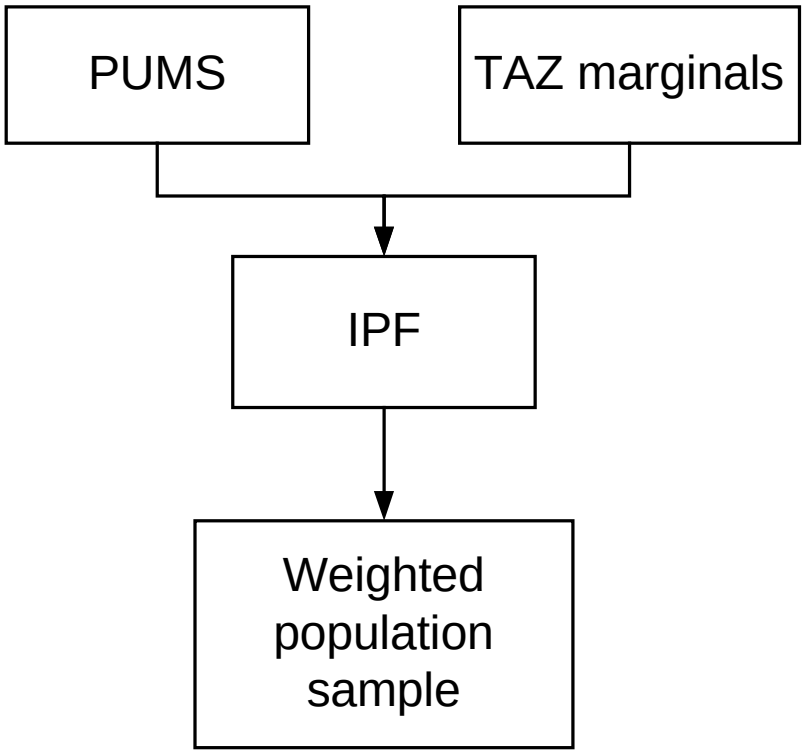
NCHRP 25-21 implementation – 1

- Did not use subtour models
- LRT mode not used
- 3 off-peak periods in Portland model = 1 off-peak period

NCHRP 25-21 implementation – 2

- Multiple model runs on different synthetic populations
- Software engineering improvements
  - Object-oriented design: data encapsulation, maintenance, code reuse
  - High-quality random-number generator: avoid serial correlations

Population synthesis



Developing data for elasticities

- Adapt Portland model to Puget Sound region by adjusting model constants
- Select *i, j* zone pairs proportional to trips
- Run model for base case and changed travel times
- Collect data from model runs
- Regression analysis to get elasticities

Estimated elasticities

Demand		Travel time					
		AM peak			PM peak		
		Drive alone	Shared ride	Transit	Drive alone	Shared ride	Transit
AM peak	DA	-0.225	0.030	0.010	-0.024	–	–
	SR	0.037	-0.303	0.032	–	-0.028	–
	TR	0.036	0.030	-0.129	–	–	-0.007
PM peak	DA	-0.124	–	–	-0.151	*0.015*	*0.005*
	SR	–	-0.109	–	*0.019*	-0.166	*0.016*
	TR	–	–	-0.051	*0.018*	*0.015*	-0.040
Offpeak	DA	-0.170	–	–	-0.069	–	–
	SR	–	-0.189	–	–	-0.082	–
	TR	–	–	-0.074	–	–	-0.014

Applying the results

- Determine network links affected by capacity improvements
- Run select link to determine O, D zones
- Apply elasticities to O, D interchanges by time of day and mode
- Reassign revised trip table to network

Observations – elasticities

- Elasticities easy to apply
- May oversimplify complex travel behavior effects
- Adequate for purposes considered in this study
  - Small overall travel time changes
  - Capacity improvements affect peak times

Observations – microsimulation – 1

- Captures significant effects left out by four-step models
  - Trip generation
  - Time of day
- Avoid aggregation bias in choice models

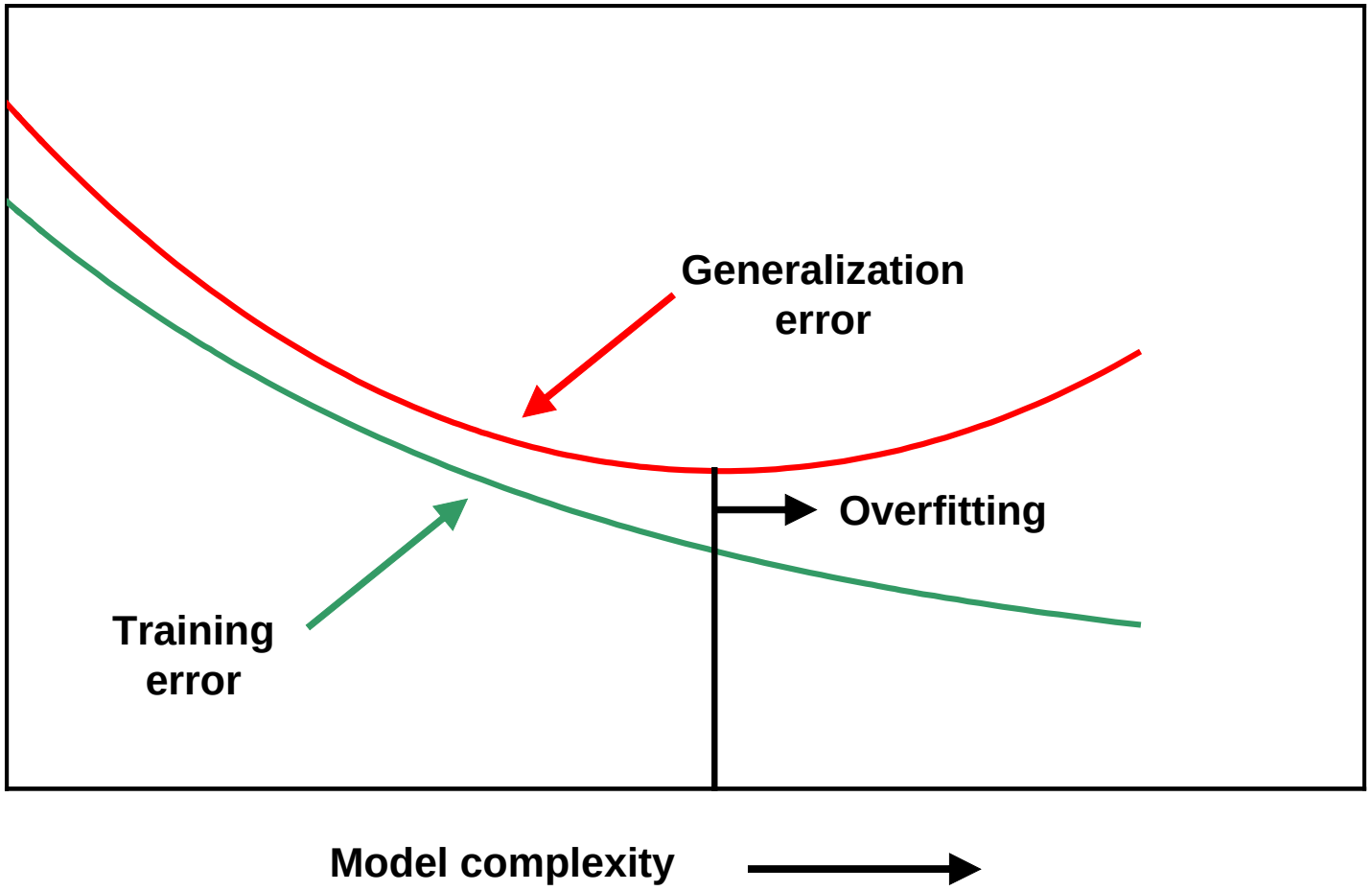
Observations – microsimulation – 2

- Software engineering
  - Object-oriented design a must:
    - Data encapsulation
    - Code reuse/extensibility
  - Multithreaded applications
- Significant issues:
  - Random number generation: most sources are suspect
  - Overfitting: easy trap to fall into

Overfitting

- Lessons from statistical learning theory
  - Model that fits the data best is not the best predictive model
  - Limits to ability of a data set to support model complexity
  - Number of parameters model: over 500 in Portland!
  - Unlikely that any data set can support more than ~ 100 variables

Overfitting



Observations – microsimulation – 3

- How will microsim models evolve?
  - New approaches to modeling
  - New hardware & software capabilities
- Data for population synthesis
  - No more long form in US Census
  - Problems with American Community Survey