TMIP Webinar Series

Activity-Based Modeling

Session 7: Long-Term & Mobility Choice Models

The Travel Model Improvement Program

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2012 Activity-Based Modeling Webinar Series

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Institutional Topics for Managers	February 23
Technical Issues for Managers	March 15
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Forecasting, Performance Measures and Software	September 20

Learning Outcomes

By the end of this session, you will be able to:

- Determine which long-term and mobility decisions are important to model
- Describe how long- and mobility decision models are integrated into the activity-based model system
- Consider the benefits, costs and key challenges of modeling long-term and mobility decisions

Session Outline

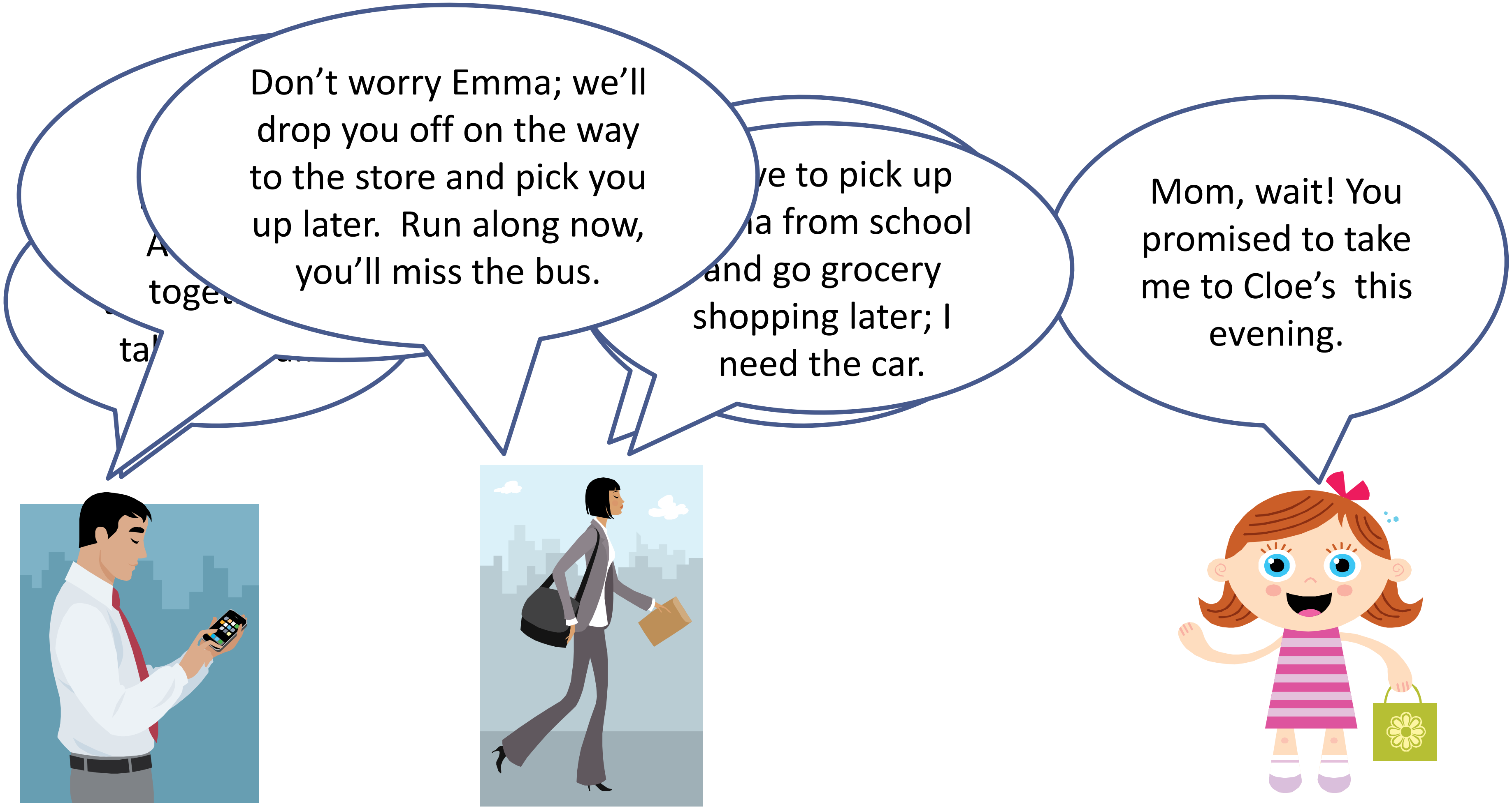
In this session we will cover…

- Why modeling long-term and mobility decisions is useful
- Where long-term and mobility decision models fit into travel model systems
- How these models are developed
- What data sources are needed
- The benefits and costs of system integration

Terminology

- Usual workplace location choice models
- Usual school/college location choice models
- Vehicle availability models
- Vehicle type choice models
- Daily auto allocation models
- Mobility models
- Toll transponder models

Effect of Long-term And Mobility Models on Activity Generation, Location And Mode Choice – An Illustration



Why are these long-term and mobility choices important?

- Long-term and medium-term/mobility choices pre-condition, contextualize activity generation and scheduling choices
  - Long term models directly represent long-term elasticities
  - Mobility choices can help explain travel decisions
- Outputs provide important variables needed in activity generation and scheduling models
  - Often not available in a single data source
  - Need to be able to forecast these variables

What can we do with the long-term and mobility choices?

- Provide important policy-sensitivity … of interest in their own right
  - Often desirable to model these decisions rather than just accept static inputs
  - Scenario testing under varying assumptions
- Modeling variables that are not well-represented in households surveys, using other data sources
  - Questions not asked of household survey respondents, or poor response quality
  - Infrequently or unobserved decisions (vehicle purchases, TDM program participation, transponder purchases, transit pass holding)

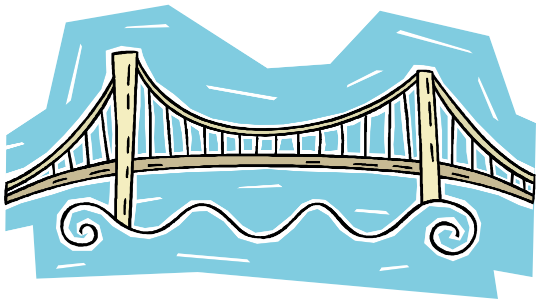
Bridge Expansion Example

- No Build Alternative
  - 4 lanes (2 in each direction, no occupancy restrictions)
  - No tolls
  - Regional transit prices do not change by time of day
- Build Alternative(s)
  - Add 1 lane in each direction (total of 6)
  - New lanes will be HOV (peak period or all day?)
  - Tolling (flat rate or time/congestion-based)
  - Regional transit fares priced higher during peak periods

Bridge Expansion Mobility Effects

New school locations may be possible due to changes in traffic using the new bridge

Vehicle ownership may decrease with tolls or new HOV and transit options



Work location may change due to tolls or new HOV and transit lanes

Vehicle type may change to take advantage of fuel efficient vehicle toll reductions

Owning a transit pass may increase with new transit lanes

Owning a transponder may encourage more use of the bridge

Bridge Expansion Example—Location Choices

- **Workplace location choice**
  - Work location is likely to affect expected traffic volume on the new road and projected toll revenue
  - Tolls and improved travel times will affect location choices for workplaces
  - Accurate prediction of telecommuters will ensure that toll revenue for peak period is not over estimated
- **School /college location choice**
  - Location of school/college is likely to affect HOV lane use (e.g., parents may drop their children off to school on the way to work)
  - Tolls and improved travel times will affect locations choices for colleges, possibly schools as well.

Bridge Expansion Example—Vehicle Choices

- **Vehicle ownership**
  - Likely to affect predicted traffic flow as only individuals from households with one or more vehicle households should be considered for the toll road study
  - Households where household size is greater than the number of vehicles are more likely to use HOV lanes
  - Tolls and improved travel times will affect vehicle ownership
- **Vehicle choice**
  - Hybrid and other green vehicles may incur a smaller toll (thus, generate less revenue) relative to regular/less fuel efficient vehicles
  - Fuel efficient vehicles may be chosen for bridge crossings more often than other cars, especially in the peak when tolls are higher
  - Other vehicles may be chosen for bridge crossing trips during off-peak periods when tolls are lower

Bridge Expansion Example—Personal Mobility

- **Personal Mobility Models**
  - Transponder ownership model – Travelers who make more frequent trips across the bridge will more likely get a transponder and be more likely to make other trips; tolls will likely be less with a transponder
  - Transit pass model – Travelers with a transit pass will more likely take advantage of transit improvements on the bridge
  - Drivers license – Travelers with a drivers license are more likely to drive across the bridge, even with tolls
  - Bicycle ownership – Households how own more bicycles are more likely to bike for work or recreation, new bike lanes on bridge would encourage use

Bridge Expansion Example—Worker Mobility

- **Work Mobility Models**
  - Usual work arrival and departure times – Lower off-peak tolls may encourage travelers to work longer hours or to adjust arrival or departure times to avoid peak periods
  - Work schedule flexibility – Lower off-peak tolls may encourage travelers to work fewer days or work different hours if they have some schedule flexibility at their workplace
  - Parking Subsidy – Employers may offer subsidies for parking at work that encourage driving, especially if bridge tolls improve travel times
  - Travel Subsidy – Employers may offer general travel subsidies that could be used to pay for tolls, encouraging driving across the bridge instead of other modes
  - Transit subsidy – Employers may offer subsidies for transit passes, encouraging use of transit on the bridge

Summary of Mobility Model Decisions

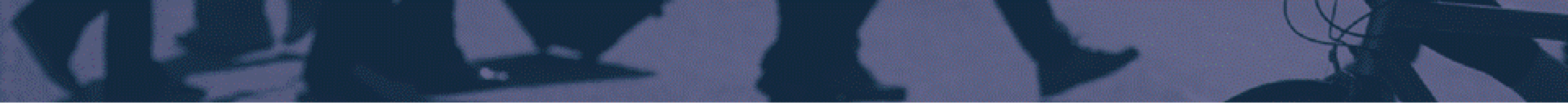
	Household Decision	Person Decision	Worker Decision	Student Decision
Location Models			Workplace Location Work at Home	School/College Location
Vehicle Models	Auto Ownership Bike Ownership Toll Transponder	Auto Allocation Driver's License		
Personal Mobility		Transit Pass	Transit Pass	
Worker Mobility			Usual Work Times Work Schedule Usual Mode Pay to Park	

Design Decisions for Each Model Component

- Identify a variable of interest (e.g., locations of work activities)
- What are the theoretical motivations behind the outcomes? (e.g., reduce personal transportation costs, maximize household welfare, personal schedule flexibility)
- How should this variable be used in other model components?
  - As a pre-condition (e.g., given auto availability or usual workplace…)
  - As a covariate (e.g., holds a transit pass, participates in a cash-out parking program)
  - … different roles in different models
- Other model components might provide similar functionality
  - Day pattern models
  - Land use models
  - Population synthesizers

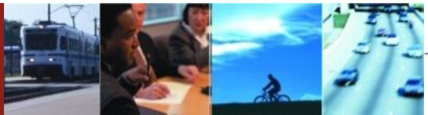
Mobility Decisions within Day Pattern Models

- Typically includes a component to determine work/*school* travel
  - If a person works/*goes to school* outside the home usually, did they go to work/*school* on the day of travel?
  - If so, was it made to the usual location or another location?
  - If not, were they working at home/*taking classes on-line* that day?
- Sometimes specified to include a "work/*school* at home" usual pattern
  - If a person works/*goes to school* at home usually, did they work/*attend school* at home that day?
  - If not, do they travel to another location for work/*school* that day?
- Includes work mode, duration and schedule
  - Usual work mode, duration and schedule is determined as part of the mobility models, then used to influence work mode, duration and schedule on day of travel



Mobility Decisions within Land Use Models

- Might include a workplace or school location choice component
  - May be formulated as joint residential-workplace location choice (research)
  - May directly connect each worker to each job (UrbanSim), identifying unemployment (workers without jobs) and jobs without workers
- Might include vehicle ownership choice
  - May be formulated as joint residential-vehicle ownership choice (research)
- May include home-based jobs at the workplace end, which may be used to complement an exogenous workplace location choice model
  - UrbanSim (example- PSRC)



Mobility Decisions within Population Synthesizers

- Might include household automobile ownership, person driver's license holding, work-at-home, etc.
- May be a controlled population attribute, but more likely uncontrolled
- Advantages
  - Easy to add other variables, subject to availability in PUMS or comparable source
  - Don't need to create another model component
- Disadvantages
  - Assumes that households/persons of the same type will make similar choices in the future
  - Does not account for important policy and cost variables that influence these decisions
  - Can't do scenario analysis

Typical Activity-based Model System (Minimum)

- Workplace location choice
  - Replaces home-based work trip distribution in trip-based model
- School/college location choice
  - Replaces home-based school/college trip distribution in trip-based model
- Vehicle ownership/availability
  - Common in both trip-based and activity-based models
  - Used as input to activity patterns, destination and mode choice

Workplace Location Choice

- Spatial resolution - Zone, micro-zone or parcel
- Formulation as destination choice with size variables
- Usual workplace location (mobility model) and day-of-work location (day pattern)
- Work at home
  - Home-based businesses (full-time work at home)
  - Telecommuters (part-time work at home)
  - Work at usual workplace and work-at-home in same day
- Advanced methods match workers to jobs
  - Employment industry
  - Work flexibility

Location Choice Variables

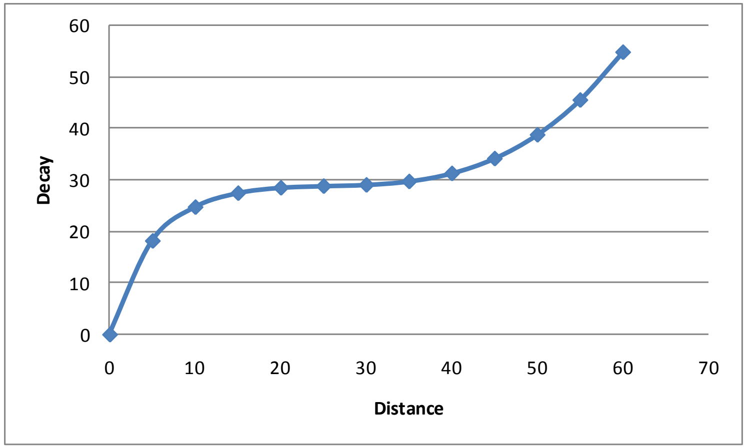
Households	Persons	Land Use	Accessibility
• Income • Size • Children • Seniors • Autos (none, workers than cars, more adults than cars)	• Worker (FT/PT) • Occupation • Driver • Gender • Telecommuter	• Employment Density by Type • Household Density • Student Enrollment • Mixed Use • Parking Density • Intersection Density • Agglomeration and Competition Affects	• Distance or Distance Decay Function • Mode Choice Logsum • Mode/ destination Logsum

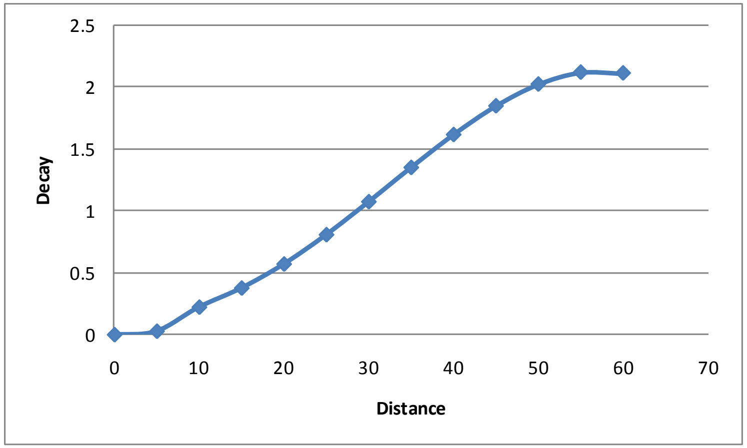
Segmentation of Workers and Jobs by Occupation
(Example from Phoenix and Tucson)

- Workers classified by 5 occupation categories (2008 NHTS)
  - Sales, marketing
  - Clerical, administrative, retail,
  - Production, construction, farming, transport
  - Professional, managerial, technical
  - Personal care or services
- Jobs classified by 2-digit NAICS codes (26 categories)
- 26 to 5 correspondence used to segment the size variables by 5 categories

Distance Decay Function

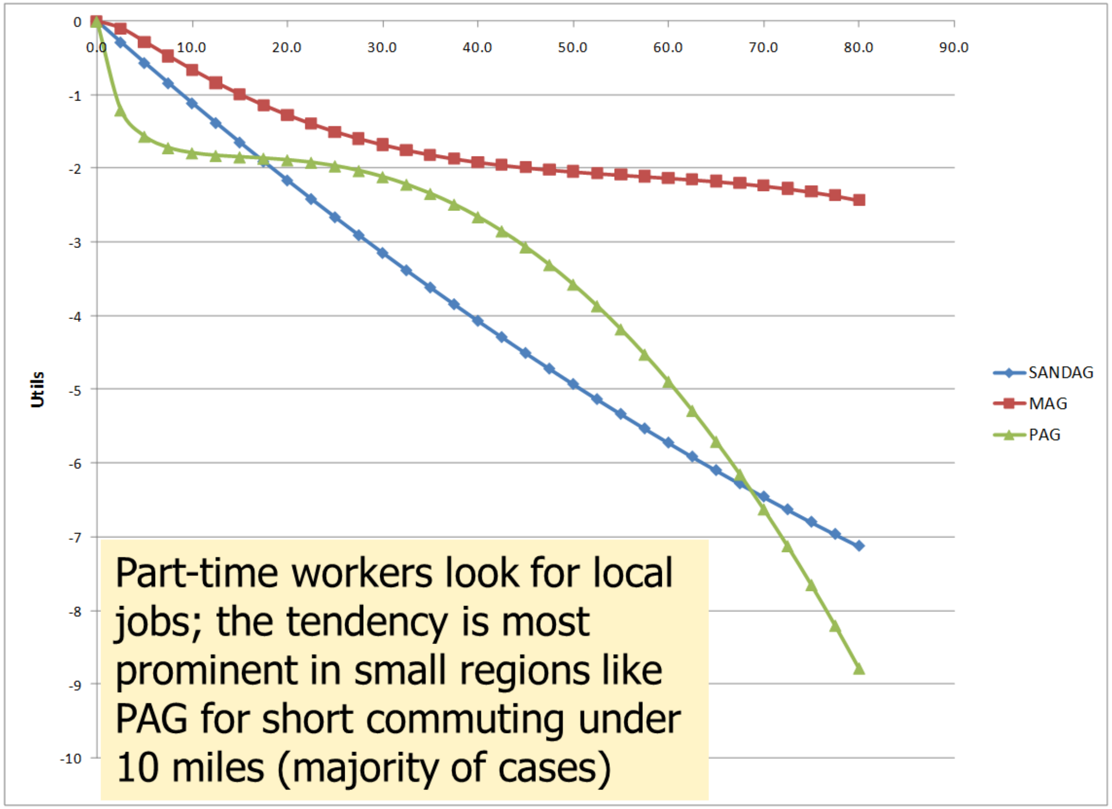
- Linear combination of elemental distance (D) functions:
  - LN(D)
  - $D^{0.5}$
  - D
  - D^2
  - D^3
- Great degree of flexibility in describing various non-linear effects





Distance Decay Function Impacts

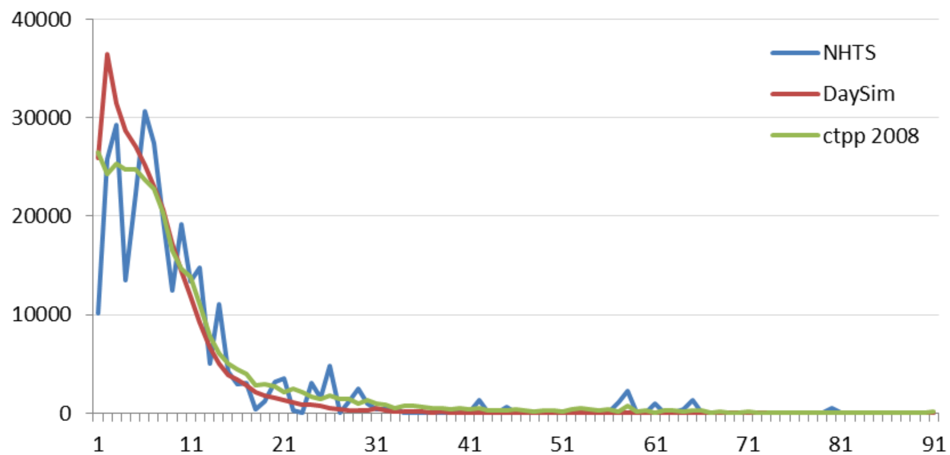
- Baseline worker case (male, full-time, medium income)
- Main impacts on top of the baseline found in San Diego, Phoenix and Tucson
  - Female
  - With preschool child under 6
  - Without preschool child under 6
  - Part-time
  - Low income (<$50K)
  - High income (>=$100K)

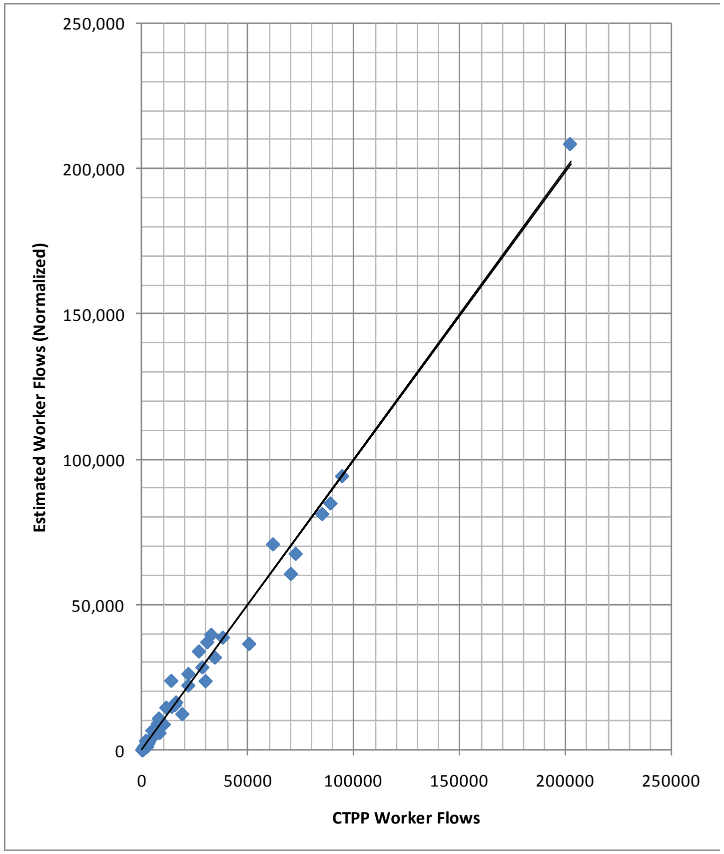


Part-time workers look for local jobs; the tendency is most prominent in small regions like PAG for short commuting under 10 miles (majority of cases)

Work Location Choice Results
(Fresno and San Diego)

- Work Trip Length Distribution
- Work Trip Distance Distribution
- District to District Flows
- Work at Home by District





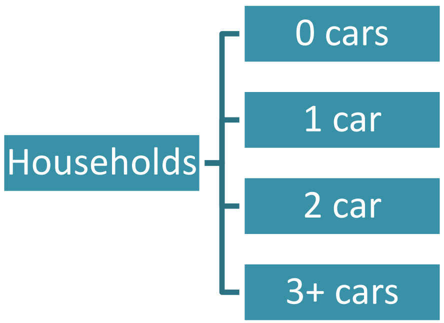
Work at Home

- Work at home is rapidly growing because of
  - Communications technology
  - Structural shifts in occupation and industries
- Will these trends continue?
  - Is there a saturation point? If so, what is it?
  - Can models forecast or back-cast the rise in this trend or are the factors changing?
- There are potentially significant impacts on congestion
  - Which makes this an effective policy lever
  - Sensitivity tests may help to evaluate these impacts

School /College Location Choice

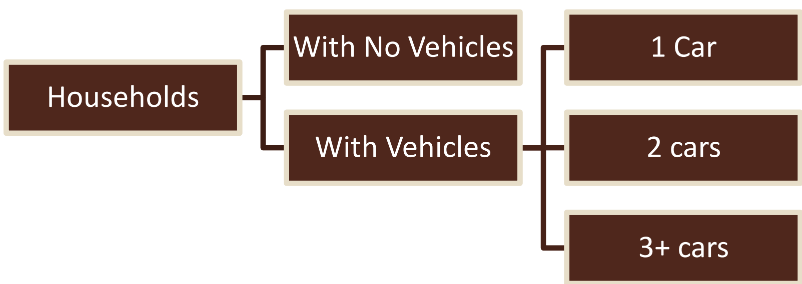
- Spatial resolution - Zone, micro-zone or parcel
- Formulation as destination choice with size variables
- Usual school location (mobility model) and day-of-school location (day pattern)
- Approaches
  - Deterministic approach where kids go to the nearest school; this is not typically used for college
  - Multinomial logit choice modeling approach with separate location models by student grade level (elementary school, middle school, high school, college)
- Advanced methods match students to enrollment

Vehicle Availability/Auto Ownership



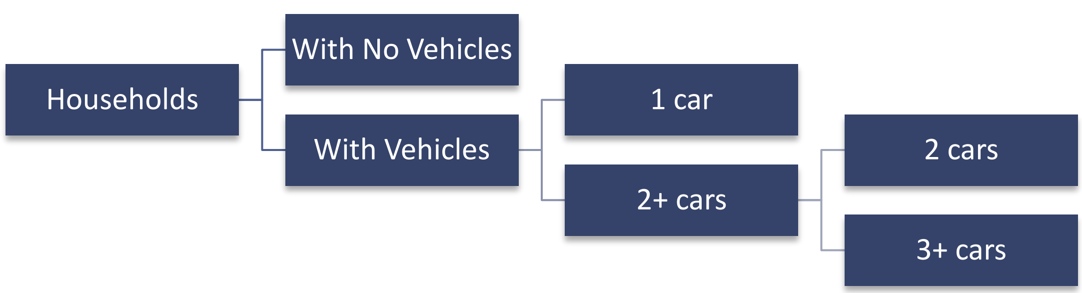
Multinomial Logit

- Primary structure in use
- Simply structure and easy to estimate



Nested Logit

- Least common approach



Ordered Response

- Theoretically appealing
- May be more difficult to estimate

Questions and Answers

The Travel Model Improvement Program

Overview of Mobility Models

Advanced policy analysis capabilities might also require the need to model…

- Driver license holding
- Transit pass holding
- Bicycle availability
- Toll pass/transponder
- Disability/limited mobility

Useful for Mode Choice Models

- TDM program participation (flextime, travel subsidies, free parking, company car, etc.)

Useful for Daily Pattern Models and Mode Choice

- Vehicle purchase
- Vehicle usage/allocation

Useful for Mode Choice Models and Emissions Analysis

- Usual mode and usual departure and arrival times to work

Useful for Mode Choice and Time-of-Day

Role of Mobility Attributes

- Add behavioral realism and ***explanatory power*** to subsequent models of travel choices
- Endogenous interdependent mobility attributes enhance ***integrity & consistency*** of the model system (e.g. car ownership × transit pass)
- Mobility attributes are frequently determined by ***commuting needs***; then, they dictate travel behavior for other trips
- Provide ***policy-sensitive*** variables for certain scenarios like new transit (multimodal) pass, discounts, employer-provided parking
- Allows ***variation*** in individual mobility attributes to avoid aggregation bias

Example: Travel Demand Management Programs (TDM)

- Different types of programs
  - Flexible hours
  - Telecommuting
  - Carpool/vanpool
  - Parking subsidies
  - Subsidized transit passes
- Different incentive structures
- Level of participation
  - Which employers and which workers (match to employers)
  - Which programs
  - Modeled based on industry type, location, size
  - Assumed through scenario analysis

Modeling Methods for Long-Term and Mobility Choices

- Non-parametric:
  - Population Synthesis
- Parametric:
  - Discrete (Logit) Choice Models (MNL, NL, CNL) applied for each mobility attribute
  - Joint Choice (Logit) Models of several mobility attributes with trade-offs
  - Multiple Discrete-Continuous Extreme Value (MDCEV) Models (generalizations of logit) where choice of mobility attributes is combined with some measure of use (VMT)

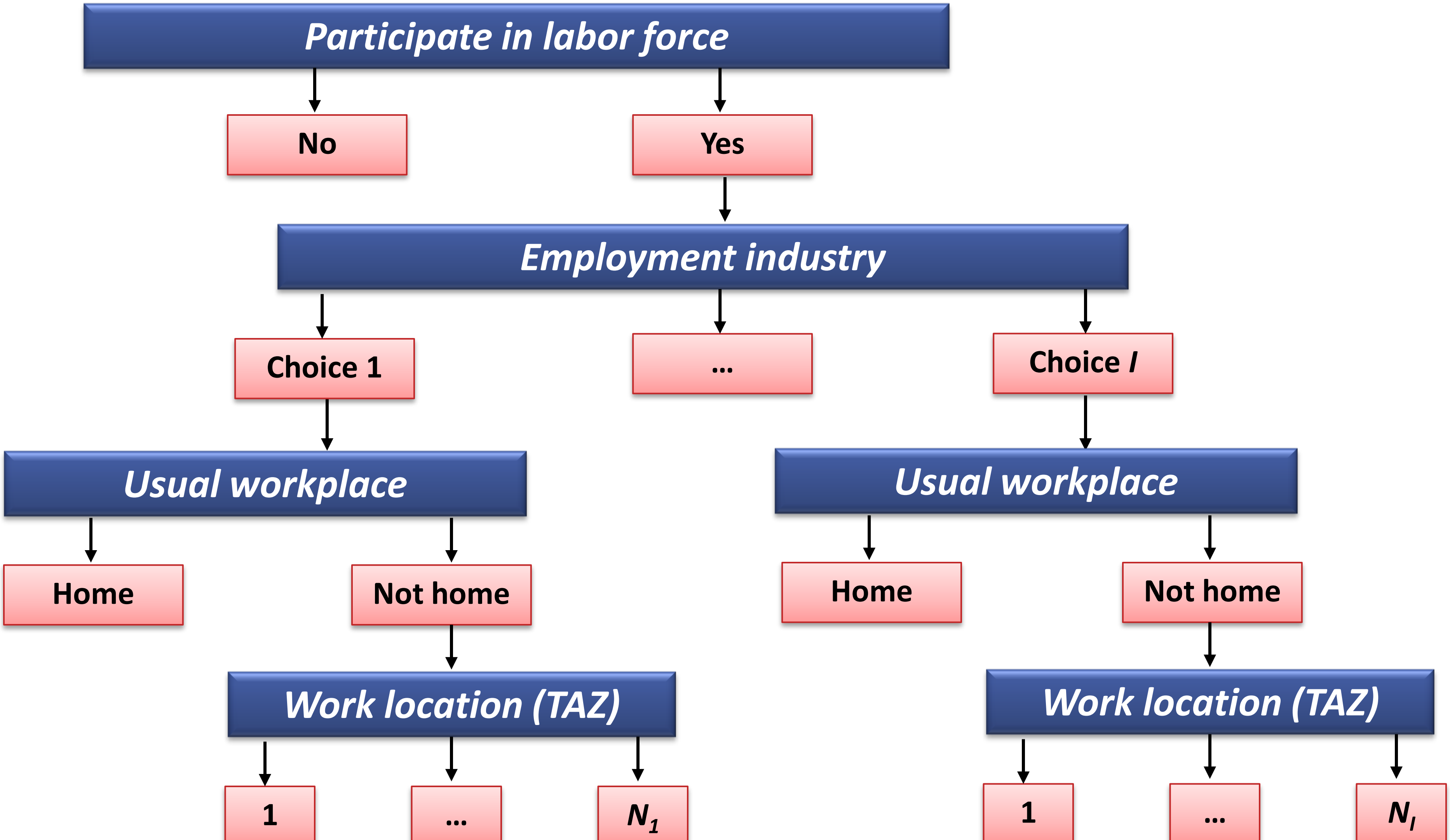
Modeling Methods: Non-Parametric

- Draw from empirical distributions (population synthesis), assumes future distributions are much like today for the same population group
- Adds variation through cross-classification (i.e. market stratification)
- Useful for scenario analysis where surveys and local data not available
- Advantages:
  - Easy to implement, no additional computation burden
  - Good when lacking covariate data or when only aggregate data are available
- Drawbacks
  - Not appropriate for location choices
  - Very limited policy sensitivity
  - Availability, programs/incentives, technologies, and costs may change in future
  - Insensitive to LOS and feedbacks between model system components

Modeling Methods: Parametric – Discrete Choice

- Flexibility to consider many variables
- Parameterization enables sensitivity and scenario testing of availability, preferences, programs/incentives, technologies and costs
- Can represent hierarchical or ordered choices of different mobility attributes with trade-offs with
- Sensitive to level-of-service and feedback
- Alternative-specific constants can be adjusted to form future scenarios
- Drawbacks:
  - Requires data assembly, special (local) surveys, model estimation and calibration
  - May need additional, exogenous data inputs (for example, workplace stratification by company size or work schedule flexibility)

Example of Hierarchical Choice of Workplace



Ordered Choices of Car Ownership

$$y_q^* = \beta' x_q + \varepsilon_q,\ \ y_q = k \quad \textbf{if} \quad \theta_k < y_q^* < \theta_{k+1}$$

Where

q = An index for household

y_q^* = The latent propensity of household's vehicle/car ownership level

y_q = Observed household's vehicle/car ownership level

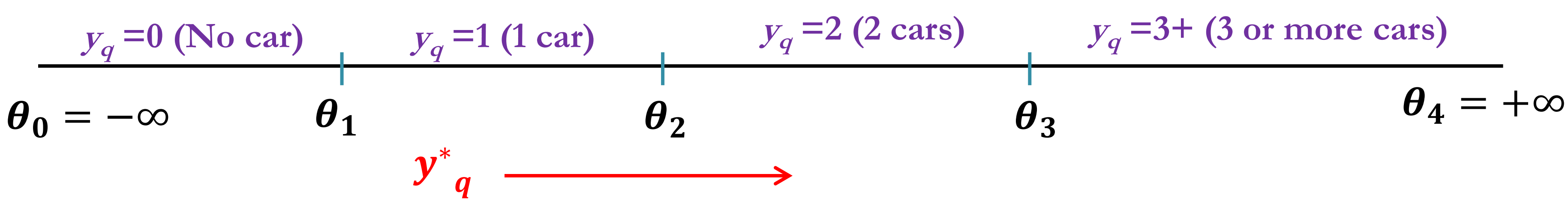
k = An index for the number of vehicle/cars in a household (k = 0, 1, 2, 3)

x_q =A vector of exogenous variables

β = A corresponding vector of coefficients

ε_q = An error term (standard normal or Gumbel distributed)

θ_k = The lower bound threshold for vehicle ownership level k

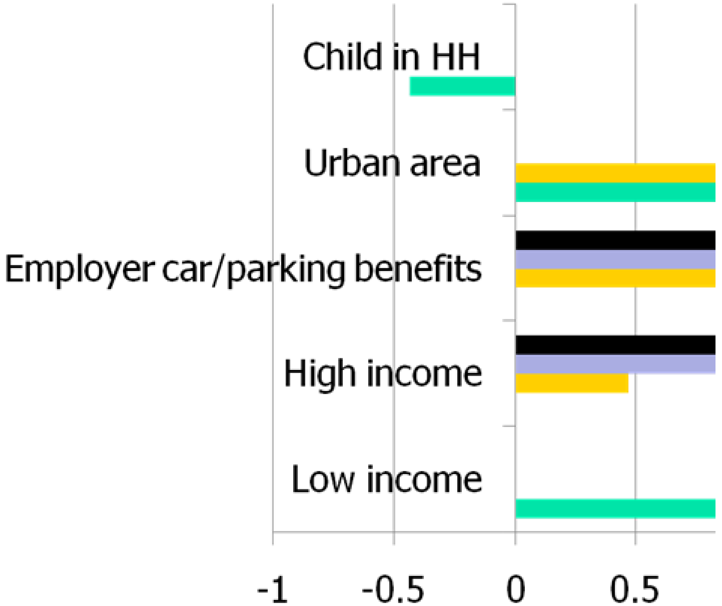


Joint Multi-Dimensional Choices

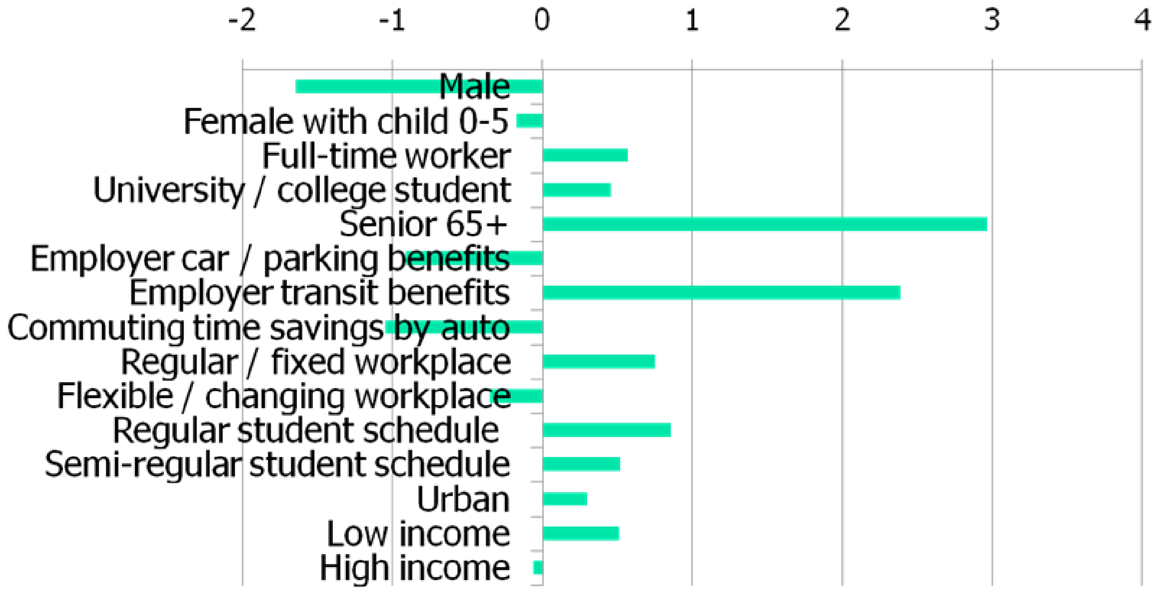
- Theoretically appealing to represent inter-related choices
- Examples:
  - Residential location and workplace location
  - Residential location and school location
  - Workplace location and auto ownership
  - Residential location and workplace location and auto ownership
  - Auto ownership and transit pass holding
  - Auto ownership and reserved / subsidized parking at work

Joint Choice of Auto Ownership and Transit Pass (London, UK)

Estimation Results for Auto Ownership Component



Estimation Results for Transit Pass Component



Challenging to Sort out Causality in Multi-dimensional Choices

- Self-selection bias:
  - E.g., Do people choose to own a car because they prefer to live in the suburbs, or do they prefer to live in the suburbs because they enjoy driving and it is difficult to maintain a car in the central city?
- Ordering of decisions:
  - E.g., Did a household move to the neighborhood because of a new job, or did the workplace choice follow the choice of residence… or was school location/quality the deciding factor?
- That's why joint choice is preferable but might result in infeasible dimensionality

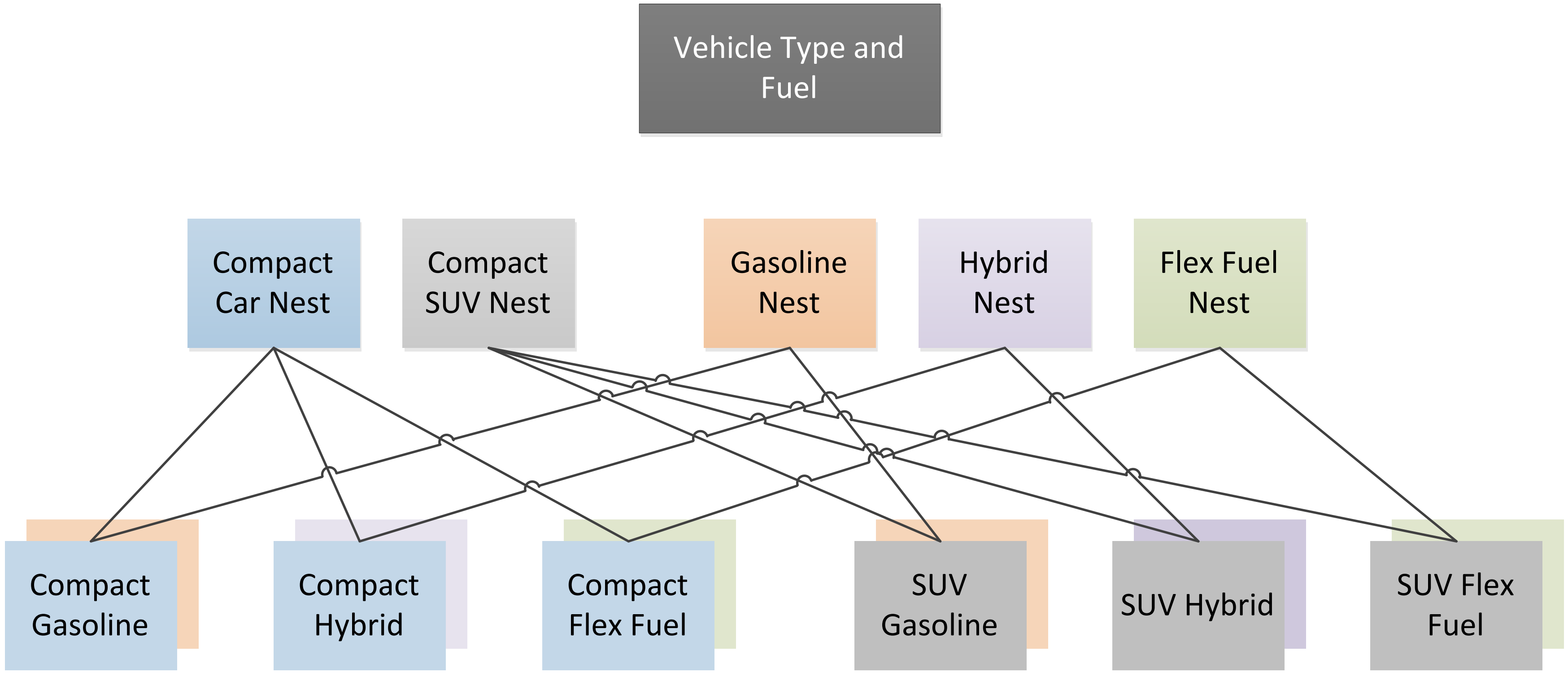
Cross-Nested Logit Model

- A member of the Generalized Extreme Value (GEV) family of (logit) models and is consistent with random utility theory
- Allows flexibility to assign alternatives to several nests and capture mixed interactions across alternatives (generalization of NL)
- The CNL model is appealing to capture complex situations where correlations cannot be handled by the NL model

Cross-Nested Choice of Vehicle Purchase and Use Decisions (California)

- Useful for estimating energy consumption and emissions
- Estimates make, model, engine type, fuel efficiency
  - Gasoline
  - Hybrid
  - Electric-Plugin
  - Hybrid-Electric
- Cost, performance and attitudes come into play
- Given a fleet of vehicles in a household, model the usage of each type (VMT)
- Incorporate into mode choice as a nested alternative, or represent as a daily auto allocation decision between individuals?

Cross-Nested Vehicle Choice Model Structure



Compare Nested (NL) and Cross-Nested (CNL) Logit Vehicle Choice Models

	NL (fuel)		NL (vehicle)		CNL	
Nesting parameter	no mixture	mixture	no mixture	mixture	no mixture	mixture
Standard Gasoline	0.68	0.81	-	-	0.4	0.59
Flex Fuel/E85	0.76	0.88	-	-	0.08	0.08
Clean Diesel	0.82	1	-	-	0.8	1
Compressed Natural Gas	0.9	1	-	-	0.97	1
Hybrid-electric	0.56	0.45	-	-	0.46	0.33
Plug-in Hybrid-electric	0.74	0.88	-	-	0.6	0.79
Full Electric	1	1	-	-	1	1
Subcompact car	-	-	0.9	0.63	0.81	0.21
Compact car	-	-	0.72	0.57	0.53	0.23
Mid-size car	-	-	0.71	0.59	0.48	0.20
Large car	-	-	1	1	1	1
Sport car	-	-	1	1	1	1
Small cross-utility car	-	-	0.77	0.79	0.65	0.68
Small cross-utility SUV	-	-	0.61	0.69	0.37	0.27
Mid-size cross-utility SUV	-	-	0.75	0.65	0.66	0.34
Compact SUV	-	-	0.68	0.48	0.15	0.16
Mid-size SUV	-	-	0.77	0.67	0.6	0.20
Large SUV	-	-	0.76	0.81	0.4	0.45
Compact van	-	-	1	1	1	1
Large van	-	-	0.63	0.88	0.47	0.87
Compact pick-up truck	-	-	0.71	0.76	0.39	0.46
Standard pick-up truck	-	-	1	1	1	1

Discrete-Continuous Choices

- Discrete allocation of autos to household members and continuous allocation of vehicle type usage (VMT)
- Potentially useful for studies of alternative vehicle technologies, fuel efficiency, greenhouse gas emissions, environmental studies
- Can also be used for modeling usual work arrival and departure times (or usual work duration)

Benefits and Costs of System Integration

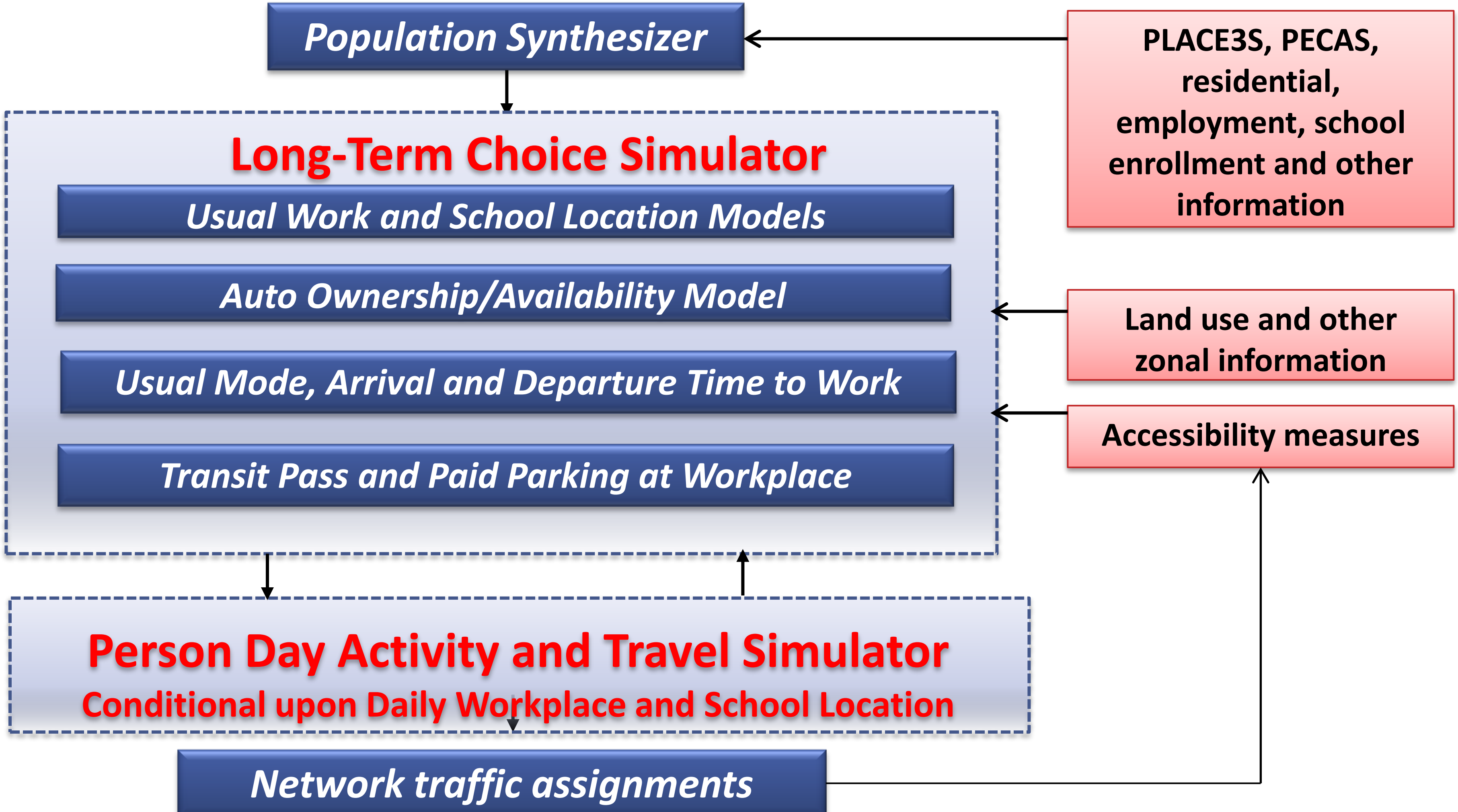
Benefits

- Long term choices are affected by transportation investments
- Long term choices are sensitive to pricing and demand management policies
- Long term choices have different characteristics and elasticities than short-term choices
- Long-term choice have strong impact on daily travel choices

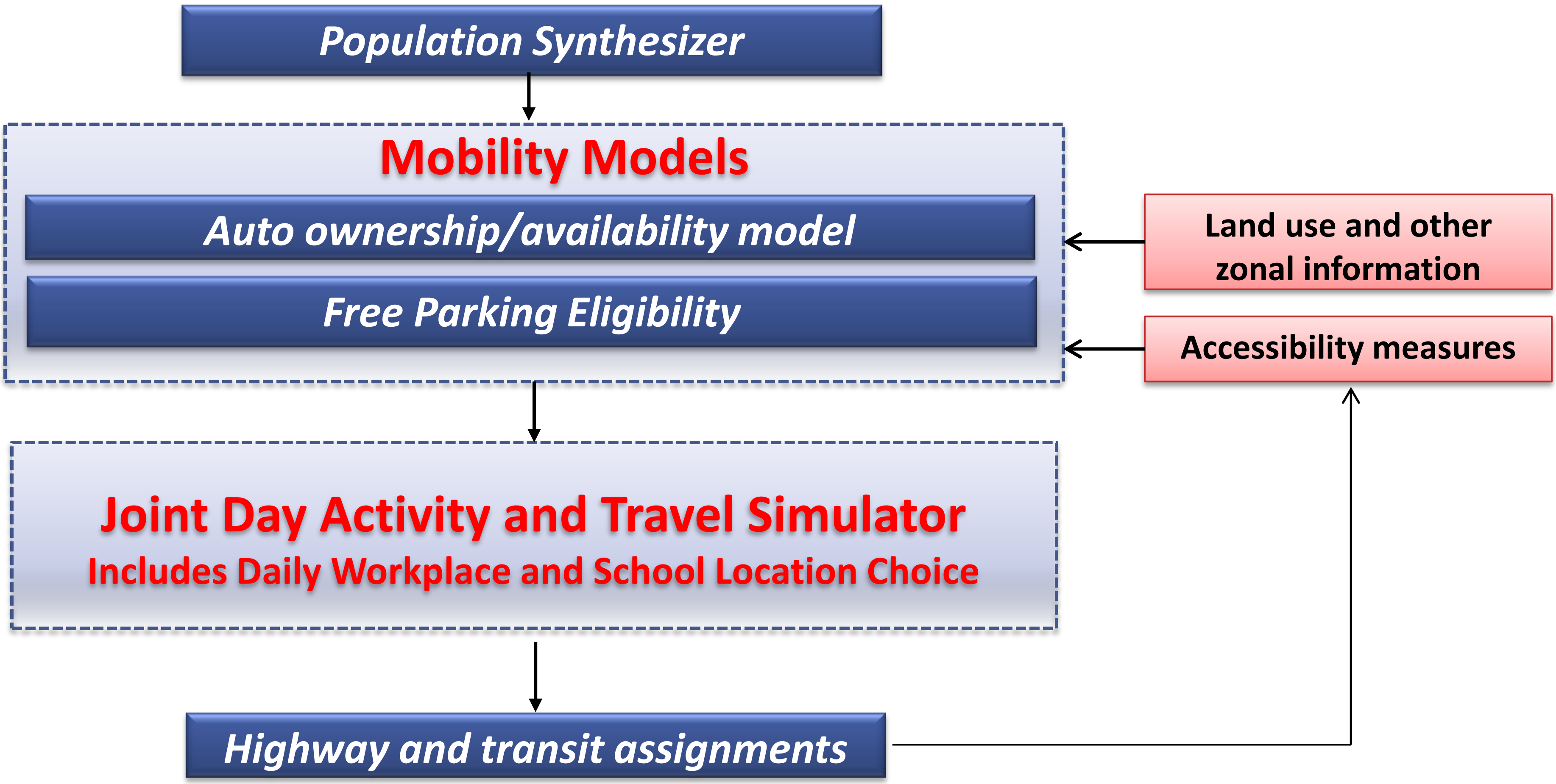
Costs

- More choice dimensions in the model system and more complex causality linkages
- Feedback loops for accessibility add run time to the process

Long-term & Mobility Decision Models in Activity-Based Model System (Example 1 – PSRC Model System)



Long-term & Mobility Decision Models in Activity-Based Model System (Example 2 – MORPC Model System)



Long-term & Mobility Decision Models in Activity-Based Model System (Example 3 – SANDAG Model System)

Population Synthesizer

Long-Term Choices

- *Usual Work and School Location Models*
- *Auto ownership/availability model*
- *Free Parking Eligibility / Reimbursement*
- *Toll Transponder*

Land use and other zonal information

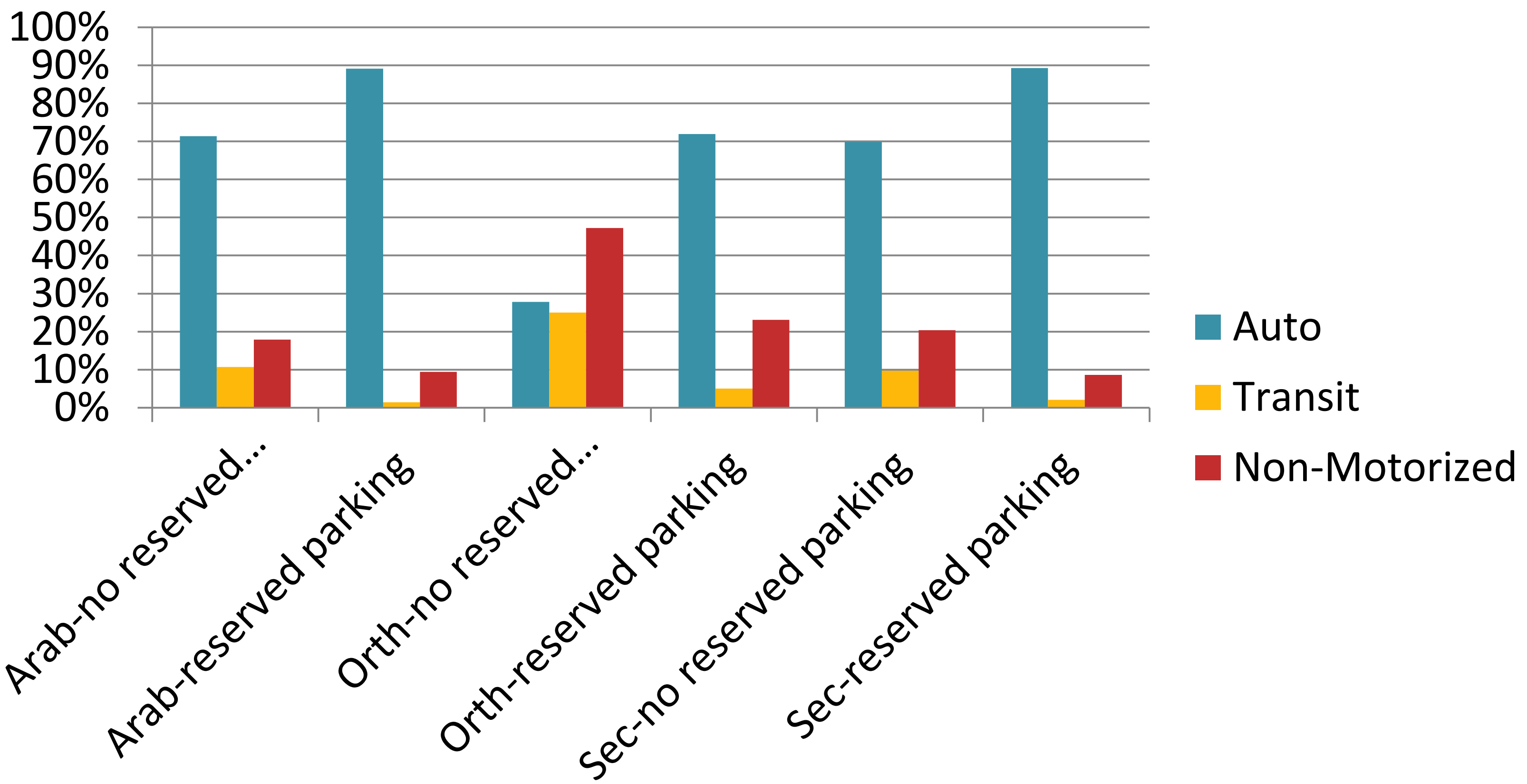
Accessibility measures

Joint Day Activity and Travel Simulator

Conditional upon Daily Workplace and School Location

Highway and transit assignments

Modal Split for Non-Work Trips Made by Workers (Jerusalem, 2010)



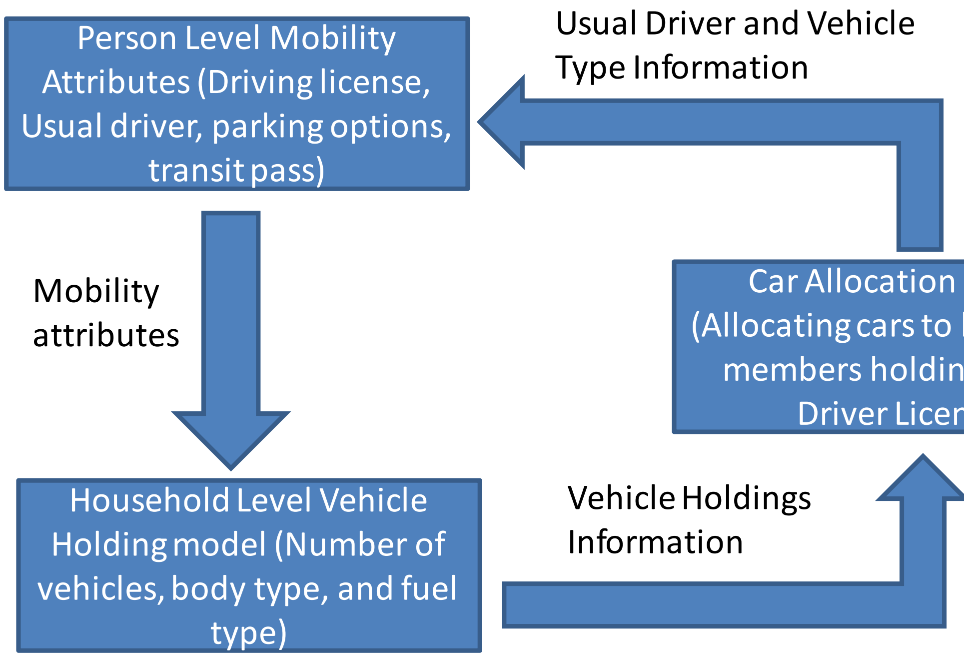
How Modality is Formed

- Commuting to work/school is the most frequent trip:
  - Mobility attributes (car ownership, transit pass) are largely defined by commuting
  - Modality style is formed
- Mode choice for other trips is largely driven by mobility attributes and modality:
  - Inclusion of this sub-model in the model system enables this important linkage of mode choice decisions across different trips made by the same individual

Approach to Forecasting

- Jerusalem ABM has a special extended sub-model for mobility attributes:
  - Modeled with interactions and trade-offs between different mobility attributes
  - Sensitive to socio-economic, demographic, and travel variables
  - Allow for scenario analysis, policy levers, and dynamic trends through adjustment of alternative-specific constants

Modeling Mobility Attributes (Jerusalem ABM)



7 Vehicle Types (Combination of body and fuel type)
<u>Body Type</u>: (1) Car, sedan, or station wagon, (2) Van, SUV, PU Truck, Truck, (3) Motorcycle
<u>Fuel Type</u>: (1) Gasoline, benzene, (2) GAS/LPG, Hybrid, charge, (3) Diesel
NOTE: Motorcycle is combined with only Gasoline

Challenges with New Policies and Technologies

- Currently little or no observed choice data:
  - Telecommuting
  - Fuel price and taxation
  - Toll transponders and other advanced toll collection methods
- Reliance on stated choice studies:
- Field experiments, pilot studies:
- Scenario testing is more reasonable approach than trying to predict a single state

Data Sources

- Estimation Datasets
  - Regional Household Travel Surveys
  - National Household Travel Survey (NHTS)
  - Focused research experiments, pilot studies
  - Stated Preference (SP) studies
  - Parking surveys
  - Transit On-Board surveys

Combined with network accessibility measures and land-use data

- Application Datasets (Inputs)
  - American Community Survey (ACS) Public Use Microdata Sample (PUMS)
- Validation Datasets
  - Census Transportation Planning Package (CTPP)
  - Household survey data (expanded aggregate targets)

Emerging Practices and Ongoing Research

- Investigation of multi-dimensional choice structures and other advanced econometric methods
- Figuring out how to model new/emerging policies and technologies
- Modeling household budgets, which drives other cost decisions
- Modeling individual modality styles, attitudes, and preferences, awareness and consideration of different modes

Summary: Long-term and mobility decisions may include…

- Workplace and school/college location choices
- Vehicle availability and usage choices
- Personal mobility decisions, such as driver's license holding, transit pass holding, transponder acquisition
- Worker mobility decisions, such as usual mode to work, usual departure and arrival time to work, parking or travel subsidies,
- Usual work-at-home and/or telecommuting

Summary: Long-term and mobility decisions are important to activity-based modeling because they…

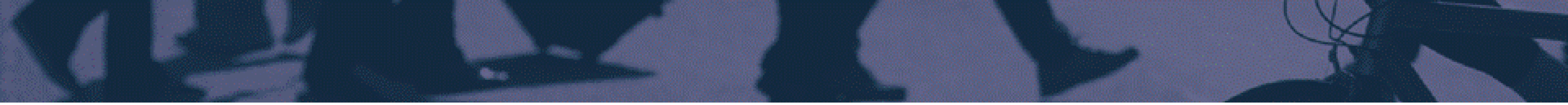
- Create important policy variables are needed for forecasting, often not found in household survey data
- Pre-condition, contextualize many activity generation and scheduling decisions as well as choice of modes
- Enable scenario analysis on household and person decisions that tend to be longer-term in nature
- Enable analysis of TDM policies such as pricing, subsidized parking or transit pass, etc., that are difficult to model otherwise

Summary: Long-term and mobility decision models are integrated into activity-based model systems in various ways

- These are design decisions that reflect how the model will be used and the perspective the analyst:
  - Still variation from ABM to ABM but some convergence of approaches is observed
- Models vary in complexity, with parametric, discrete choice models providing more flexibility, and sensitivity, but requiring richer data sources and (marginally) more computation

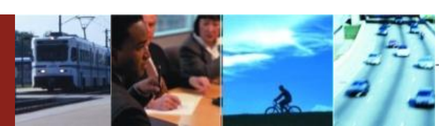
Questions and Answers

The Travel Model Improvement Program



2012 Activity-Based Modeling Webinar Series

Executive and Management Sessions	
Executive Perspective	February 2
Institutional Topics for Managers	February 23
Technical Issues for Managers	March 15
Technical Sessions	
Activity-Based Model Frameworks and Techniques	April 5
Population Synthesis and Household Evolution	April 26
Accessibility and Treatment of Space	May 16
Long-Term and Mobility Choice Models	June 7
Activity Pattern Generation	**June 28**
Scheduling and Time of Day Choice	July 19
Tour and Trip Mode, Intermediate Stop Location	August 9
Network Integration	August 30
Forecasting, Performance Measures and Software	September 20



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