TMIP Webinar Series

Activity-Based Modeling

Session 9: Scheduling & Time-of-Day (TOD) Choice

The Travel Model Improvement Program

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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	
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Accessibility and Treatment of Space	May 17
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Network Integration	August 30
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Learning Outcomes

- Role and placement of TOD choice in ABM
- Advantages of ABM TOD approach with fine temporal resolution vs. traditional peak factors
- Structure of TOD choice model and alternatives in choice set
- Consistency of individual daily schedules with all activities, trips, and tours w/o gaps or overlaps
- Main variables explaining individual TOD choice
- TOD choice sensitivity to congestion, pricing, and other policies

Outline

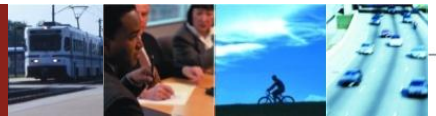
- Basic terminology
- Temporal level of resolution for different TOD choice models
- Structure of statistical models for TOD choice with fine temporal resolution
- Examples of statistical analysis and model estimation
- Individual daily schedule consistency and concept of dynamically updated time windows
- Examples of TOD choice model validation and policy analysis
- Ongoing research, main directions, and challenges

Terminology – Tour TOD Choice

Actual time	Event	Entire Tour	Primary Activity
7:00am	Depart from home	Start (outbound)	
7:10am	Stop at Starbucks	Tour duration 12hours 20min	
7:20am	Depart from Starbucks		
7:50am	Arrive at work		Start
12:00am	Leave for lunch		Activity duration 8hours 10min
12:50am	Return to workplace		
5:00pm	Depart from work		End
5:30pm	Arrive at shopping mall		
6:40pm	Depart from shopping mall		
7:20:pm	Arrive back home	End (inbound)	
8:00pm	Depart from home	Start	…
….	….	…	…

Terminology – Trip TOD Choice

Actual time	Event	Trip	Activity at Destination
7:00am	Depart from home	Departure	
7:10am	Stop at Starbucks	Arrival	Duration 10min
7:20am	Depart from Starbucks	Departure	
7:50am	Arrive at work	Arrival	Duration 8hours 10min
12:00am	Leave for lunch	Departure	…
12:50am	Return to workplace	Arrival	…
5:00pm	Depart from work	Departure	
5:30pm	Arrive at shopping mall	Arrival	Duration 1hour 10min
6:40pm	Depart from shopping mall	Departure	
7:20:pm	Arrive back home	Arrival	Duration 40 min
8:00pm	Depart from home	Departure	…
….	….	…	…

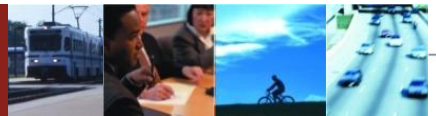


Terminology – Person Schedule Consistency

- Real schedules are always consistent w/o gaps or overlaps
- Surveys and model outcomes can be inconsistent
  - "Negative" travel time
    - Depart from home at 9:00am
    - Arrive at work at 8:30am
  - Overlap of activity participations
    - At work from 9:00am through 6:00pm,
    - Shopping from 5:00pm through 7:00pm
- In addition to formal consistency
  - Reasonable travel time obeying time-space constraints
  - Reasonable activity duration obeying time allocation rules

Possible Levels of Temporal Resolution

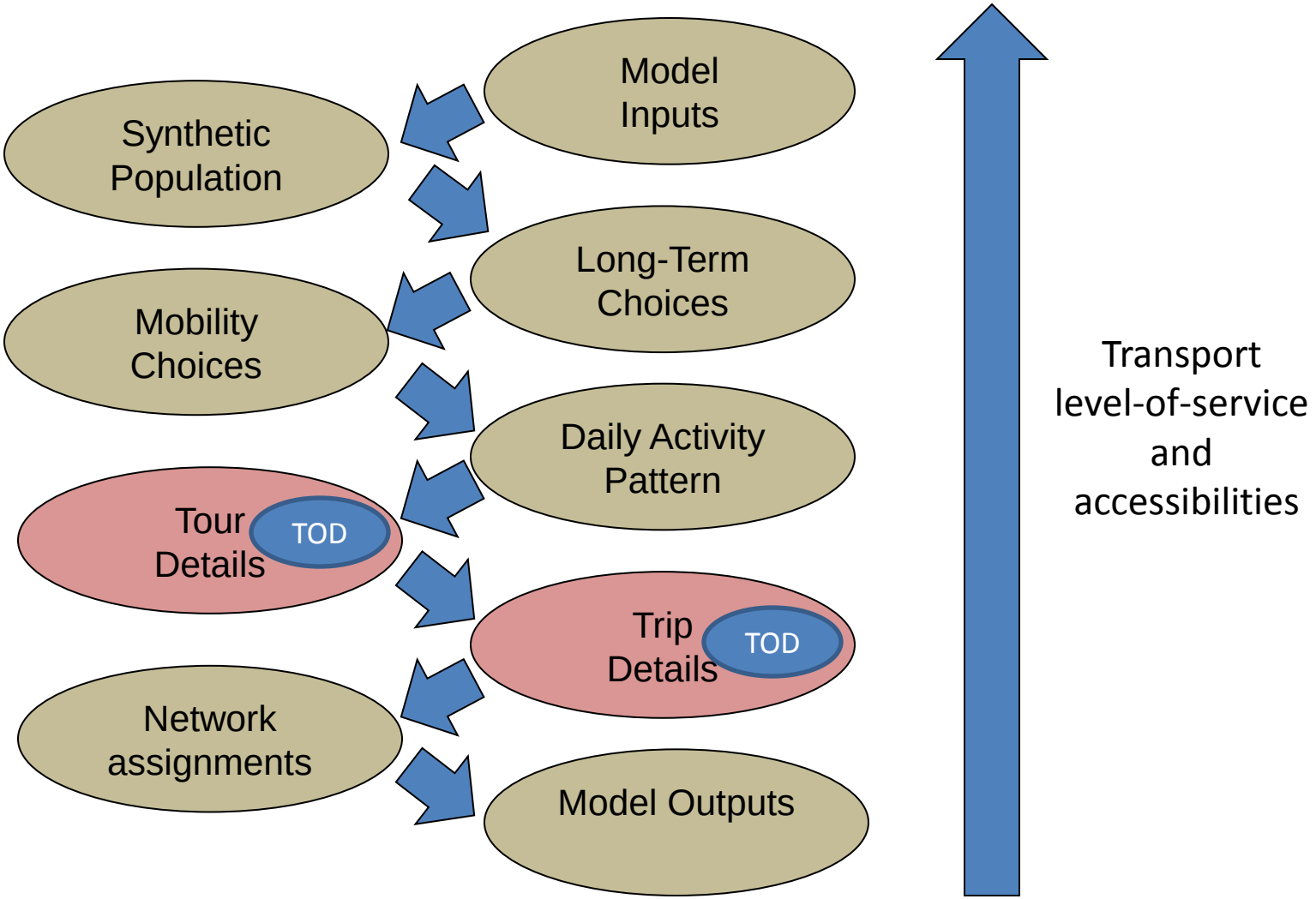
Continuous time – 1,440 min	5 min (ABM/trips) – 288 bins	30 min (ABM/tours) – 48 bins	Aggregate TOD periods (4-Step)
3:00am, 3:01am…	3:00am-3:04am	3:00am-3:29am	Night
3:05am, 3:06am…	3:05am-3:09am		
…	…		
3:25am, 3:26am…	3:25am-3:29am		
…	…	…	
5:55am, 5:56am…	5:55am-5:59am…	5:30am-5:59am	
6:00am, 6:01am	6:00am-6:04am…	6:00am-6:29am	AM
…	…	….	
8:30am, 8:31am	8:30am-8:34am…	8:30am-8:59am	
…	…	…	…
4:00am, 4:01am	4:00pm-4:04am	4:00pm-4:29pm	PM
…	….	…	



TOD Choice in ABM System

- Importance of Time of Day (TOD) choice:
  - Consistent scheduling of all activities, trips, and tours
  - Integral component of ABM and day-level approach
  - Yet another major feature differentiating ABM from 4-Step
- Advantages of ABM TOD choice:
  - Fine temporal resolution (30 min or less, up to continuous)
  - Sensitivity to congestion, pricing, and multi-modal LOS
- As in most other sessions we consider regular weekday:
  - Commuting TOD patterns for workers and students
  - TOD-specific congestion effects and policies

Placement of TOD Choice in ABM



Limitations of 4-Step w.r.t. TOD Choice

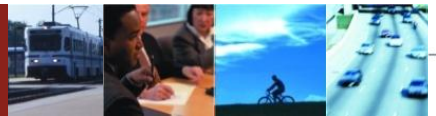
- Placement and structure of TOD choice never established
  - Between trip generation and trip distribution?
  - Between trip distribution and mode choice?
  - Between mode choice and assignment?
- Aggregate level of temporal resolution
  - Normally corresponds to 3-5 network TOD periods
  - Post-model 30-60 min peak-spreading procedures applied to AM and/or PM
- Cannot adequately address tour-level consistency
  - Simplified symmetry assumptions (PA format)
  - Ignoring activity duration
- Cannot adequately address congestion and pricing effects
  - All round-trip TOD combinations with 30 min resolution results in 800 segments per each travel segment (trip purpose, income, car ownership, etc)
  - Microsimulation ABM framework offers a better solution

Bridge Expansion Example (as usual!)

- 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

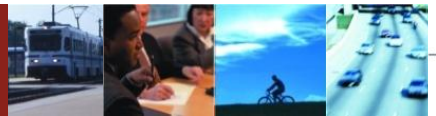
Bridge Expansion Example: Relevance to Time of Day Choice

- Congestion pricing results in shifting SOV trips to off-peak periods
  - More SOV trips in the off-peak periods
  - Less SOV trips in the peak periods
- Potential increase in intra-household ridesharing to take advantage of HOV
  - More HOV trips in both peak and off-peak periods:
    - Peak HOV trips take advantage of better conditions in the peak period (including a shift from peak)
    - Off-peak HOV trips generated by overall improvement of accessibility for HOV in all periods



TOD Principal Modeling Approaches

- General tendency
  - Aggregate TOD periods → 30-60 min → 5-15 min → continuous
- Continuous duration models
  - Operate with continuous time
  - Large body of research on different activities & valuable behavioral insights
  - First examples of complete ABM with continuous time scheduling (CEMDAP, DASH, FAMOS)
  - Not easy to calibrate and apply if activities, tours, and trips are scheduled in a non-chronological order
- Compromise in most applied ABMs
  - Time discretized with a reasonable level of resolution
  - Hybrid discrete-duration models mimic continuous models
  - Activities, tours, and trips scheduled by priority and not necessarily in chronological order



Practical Aspects of Discretizing Time: #Alts

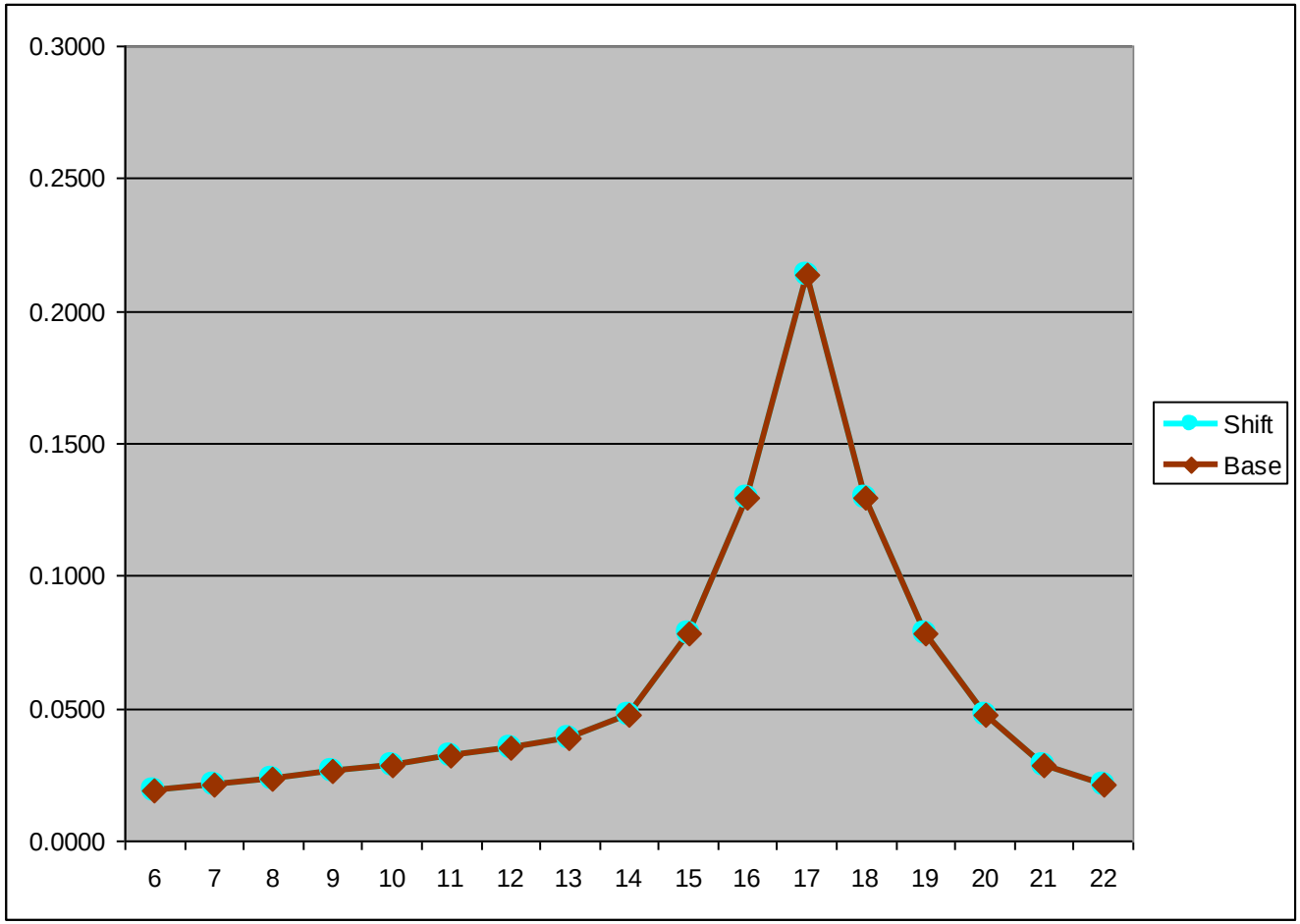
Resolution	Model	Entire day with the same resolution	Earlier than 5am and later than midnight collapsed
60 min	Trip departure	24	21
	Tour TOD	24×(24+1)/2 = 300	21×(21+1)/2=231
30 min	Trip departure	48	40
	Tour TOD	48×(48+1)/2 = 1,176	40×(40+1)/2 = 820
5 min	Trip departure	288	230
	Tour TOD	288×(288+1)/2 = 41,616	230×(230+1)/2 = 26,565
Continuous, 1 min	Trip departure	1,440	1,142
	Tour TOD	1,440×(1,440+1)/2 = 1,037,520	1,142×(1,142+1)/2 = 652,653

Limits of discrete technique

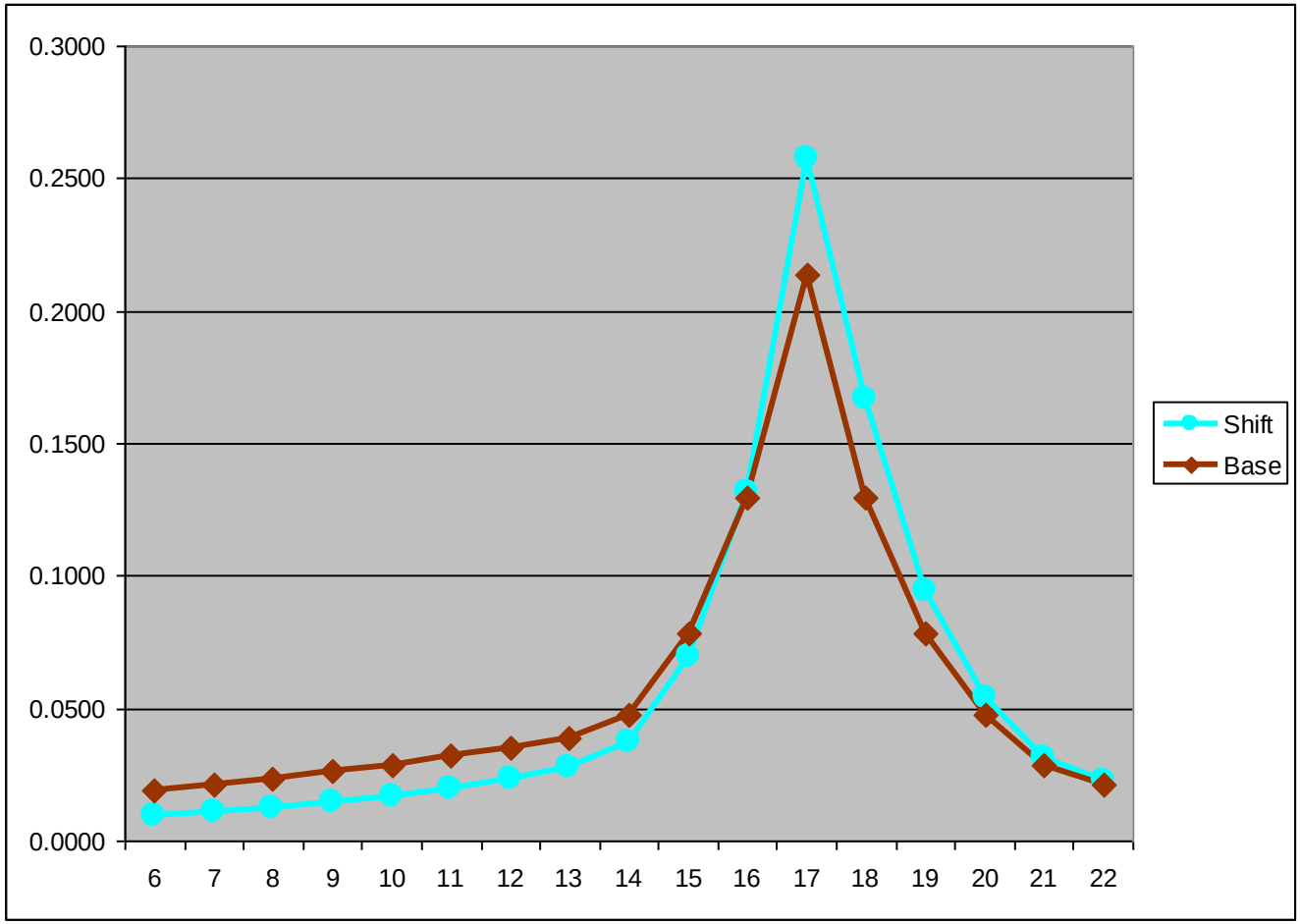
Core Utility Structure

- Consider 1-dimensional choice of duration in discrete space
  - 0 hours
  - 1 hour
  - 2 hours
  - …
- Consider a utility structure with a single linear "shift" variable X and coefficient C
  - $U(0)=A(0)+0\times X\times C$
  - $U(1)=A(1)+1\times X\times C$
  - $U(2)=A(2)+2\times X\times C$
  - ….

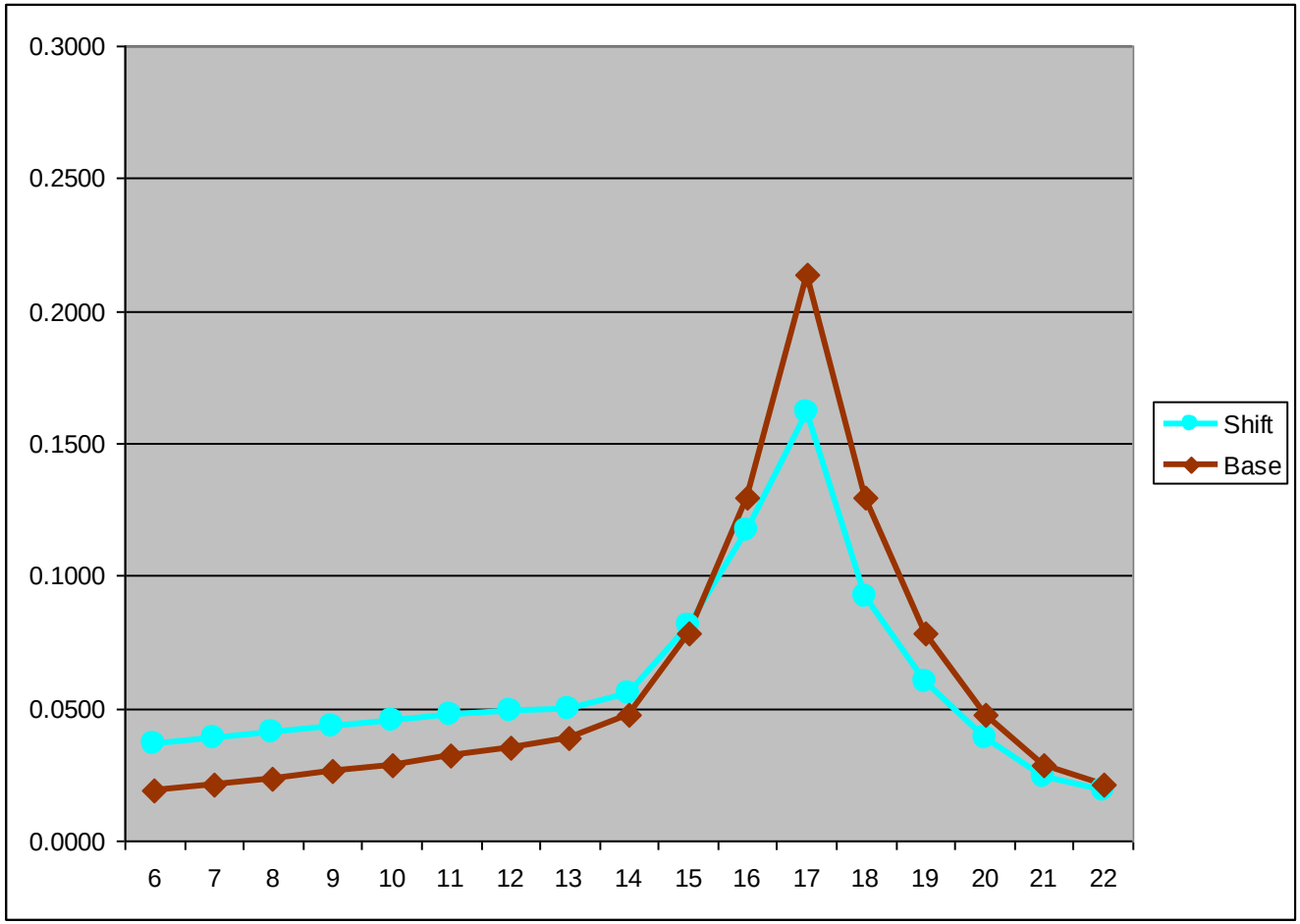
Shift Effect Example - Base



Shift Effect Example – Positive (to Later)

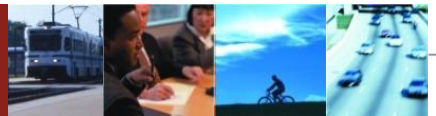


Shift Effect Example – Negative (to Earlier)

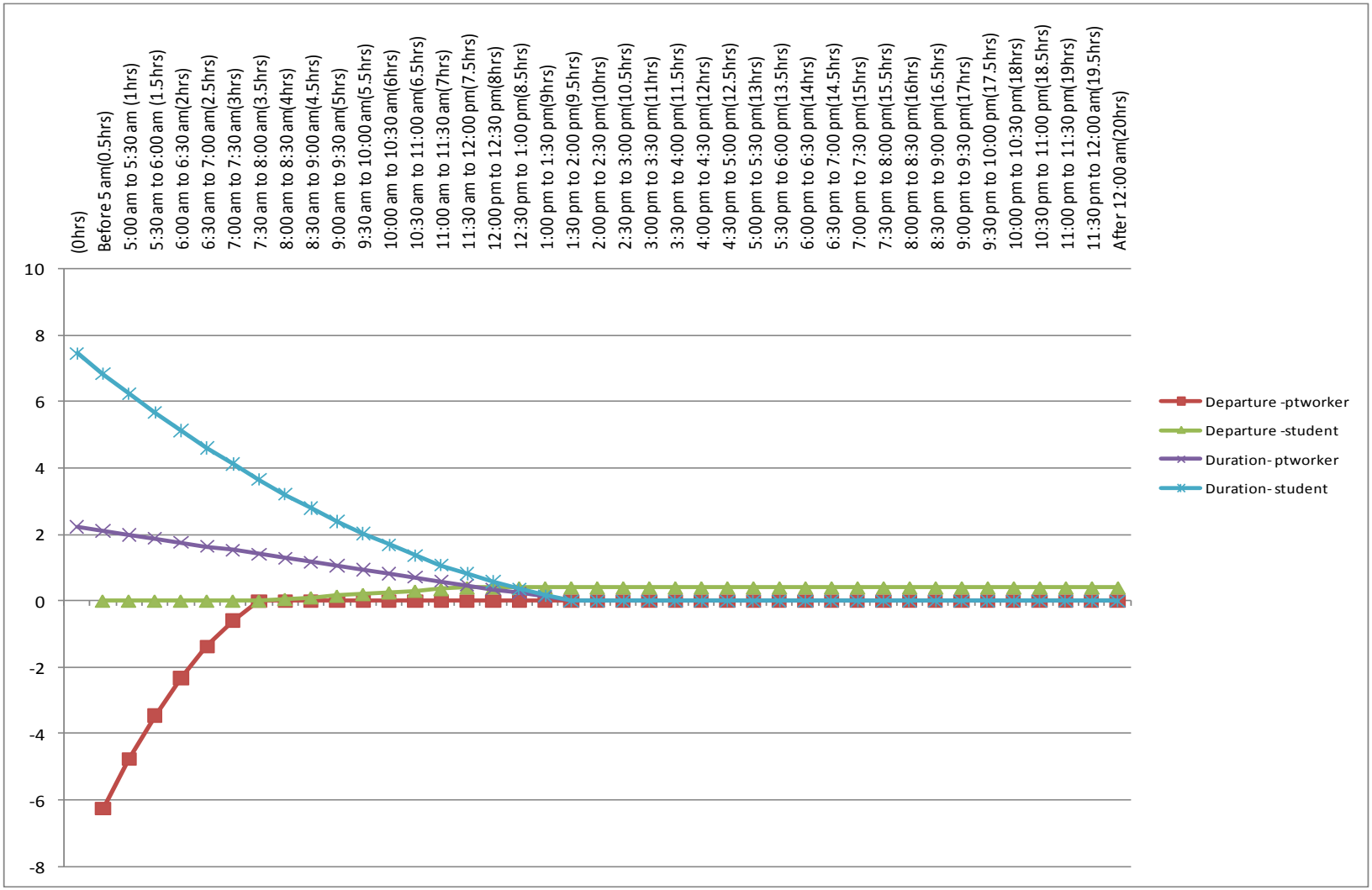


Non-Linear Shift Variables (CT-RAMP, DaySim)

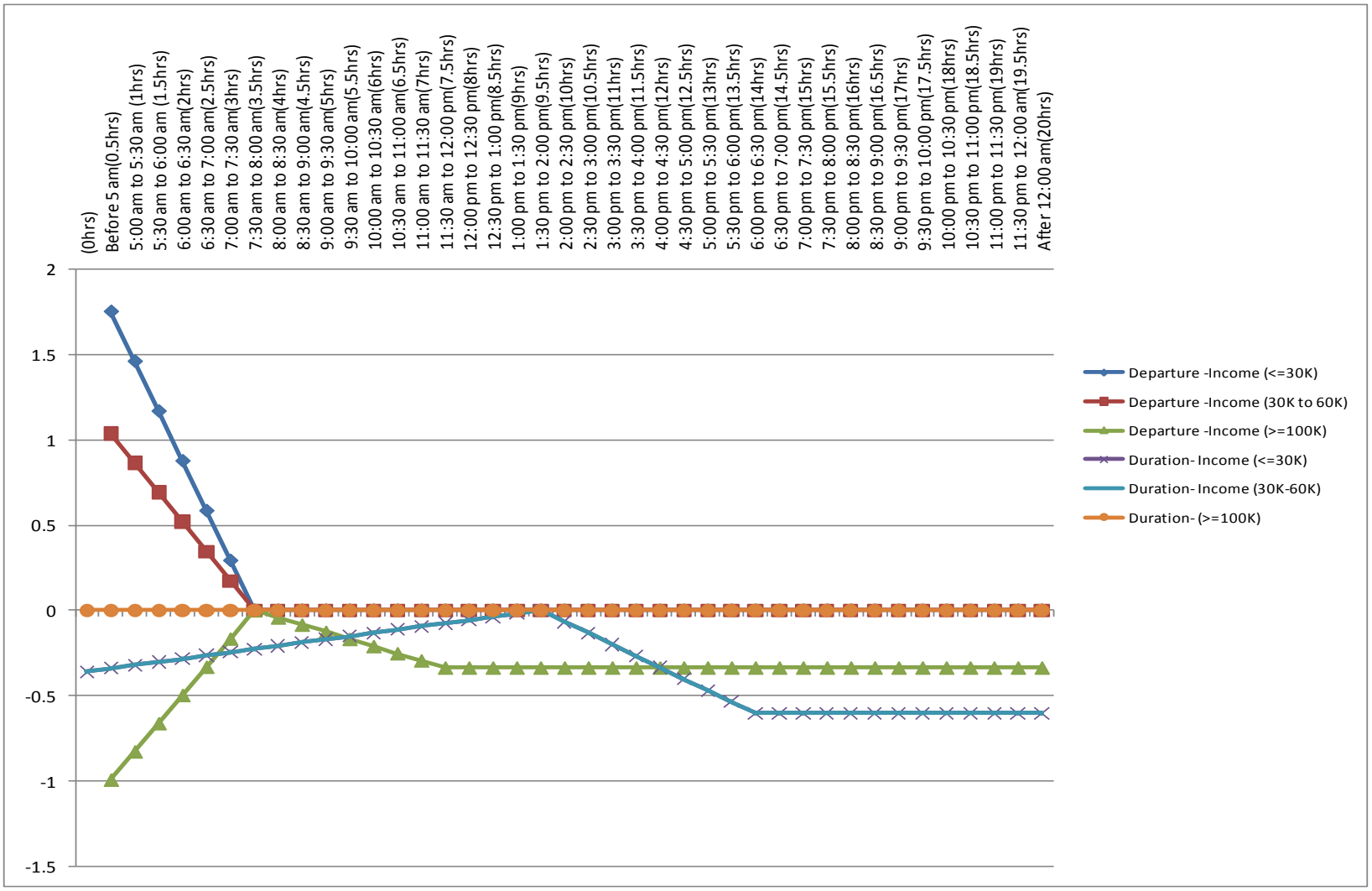
- Consider a utility structure with a single polynomial "shift" variable X and coefficients B, C, D…
  - $U(0)=A(0)+0\times X\times B+0^2\times X\times C+0^3\times X\times D\ldots$
  - $U(1)=A(1)+1\times X\times B+1^2\times X\times C+1^3\times X\times D\ldots$
  - $U(2)=A(2)+2\times X\times B+2^2\times X\times C+2^3\times X\times D\ldots$
  - ….
- Further generalized to account for constrained intervals of impact, piece-wise functions, trigonometric functions, and referencing to a certain (peak) point
  - Every variable X is associated with a temporal profile:
  - $F(t)=t\times B+t^2\times C+\ldots$ or
  - $F(t)=\mathrm{Sin}(2\pi t/24)\times B+\mathrm{Sin}(4\pi t/24)\times C+\ldots$
  - Temporal profiles are convenient to analyze in graphical form (examples will be shown)



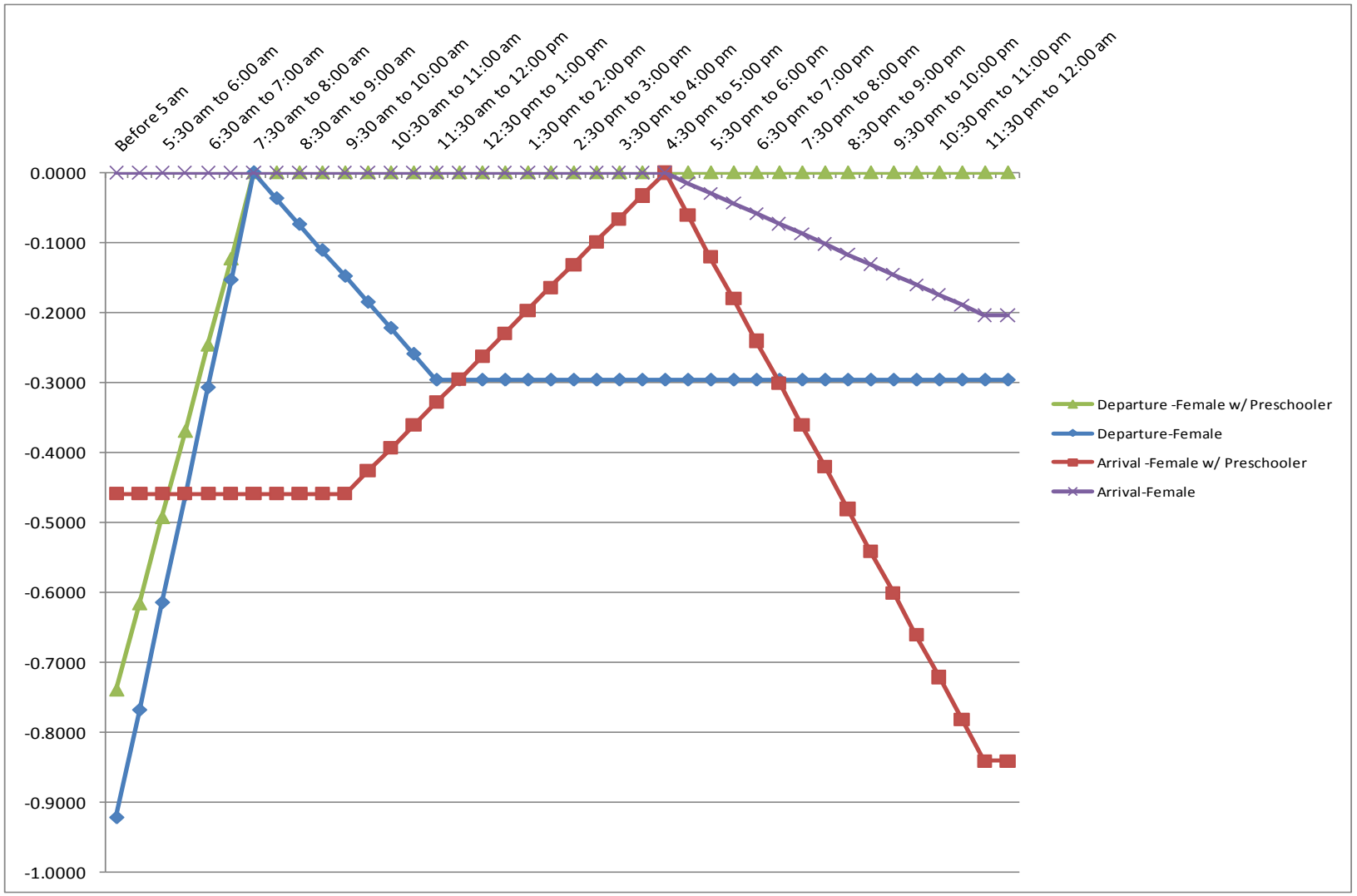
Example of Worker Status Effects (San-Diego ABM)



Example of Income Effects (San-Diego ABM)

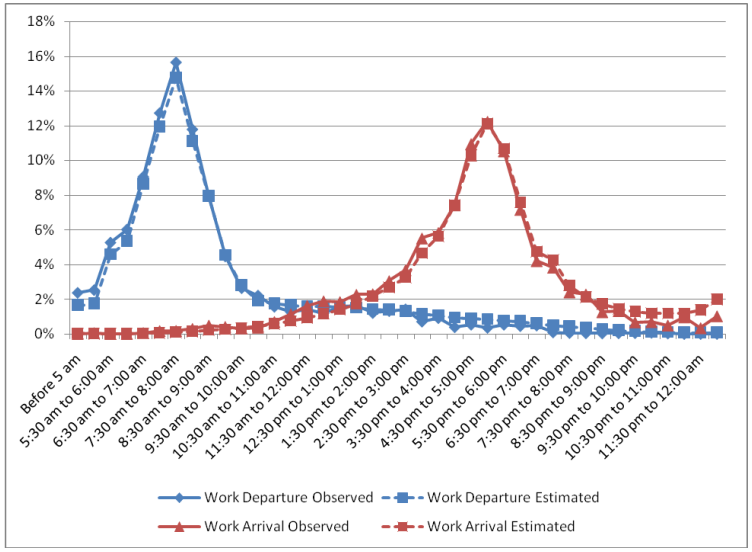


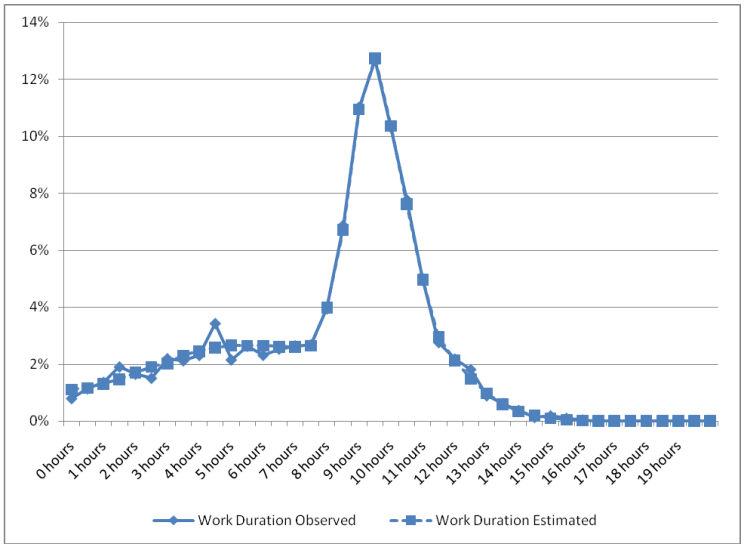
Example of Gender Effects (San-Diego ABM)



Resulted Temporal Profiles

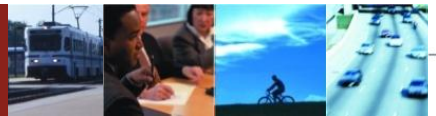
- Temporal profiles modeled for each travel purpose and person type as a combination of multiple impacts and shifts
- They are compared to the observed distributions across multiple dimensions at the validations stage (see Part 2)





Practical Advantages of Continuous Models in Discrete Space

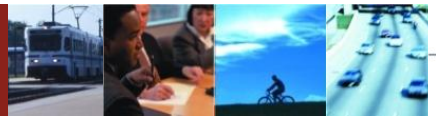
- Properties of continuous models are mimicked
  - Any shift variables and profiles can be incorporated
  - Parsimonious parametric structure since each variable and profile can serve entire temporal range
- Actual model structure is simple
  - Logit model (MNL, NL, CNL)
  - Standard estimation software (ALOGIT, BIOGEME, etc)
  - Less coefficients to estimate than alternatives in choice set
- However continuous time models have there own merits:
  - Better and more natural incorporation of activity duration
  - Integration with discrete choice models possible



TOD Choice and Assignments

- Ideally
  - TOD choice integrated with entire-day DTA
  - Trip tables and LOS variables generated by 5 min slices
- Practically
  - TOD choice integrated with SUE by 6-12 TOD periods (carrying over incomplete trips from period to period)
  - Trip tables and LOS variables aggregated by 6-12 TOD periods
  - HH, person, and zonal variables differentiate beyond TOD periods

8 periods (Chicago ABM)
Night (7pm-6am)
Early AM shoulder (6am-7am)
AM peak (7am-9am)
Late AM shoulder (9am-10am)
Midday (10am-3pm)
Early PM shoulder (3pm-4pm)
PM peak (4pm-6pm)
PM late shoulder (6pm-7pm)



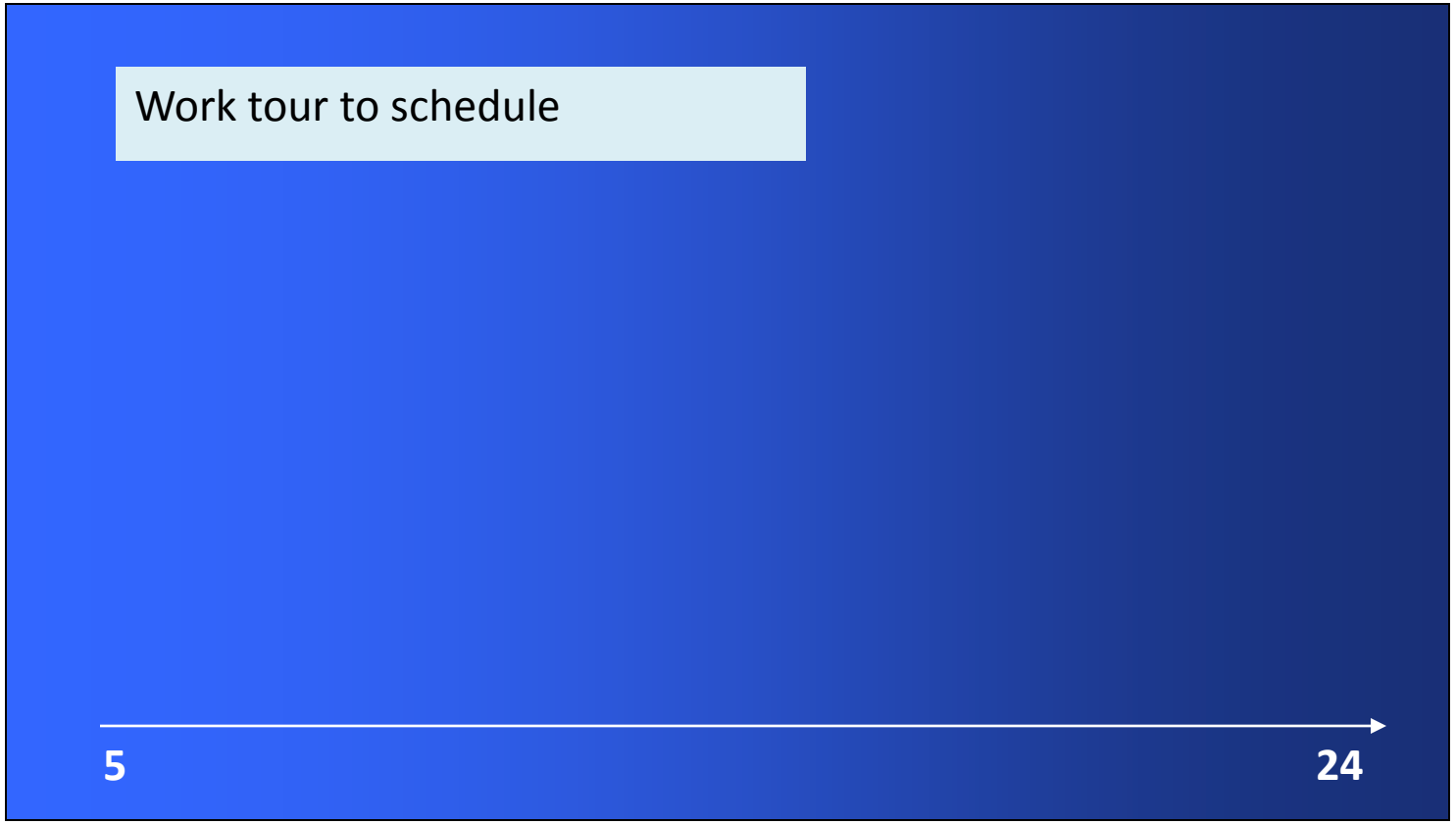
Example Tour TOD Model Formulation

- Unit of modeling – travel tour
- Joint choice of
  - Departure time from home (or arrival at work)
  - Arrival time back home (or departure from work)
  - (Derived) Total duration including activity and travel (or activity duration only)
- Temporal resolution
  - 30 min (from 5am to 24pm)
  - Reported time rounded up to the nearest half-hour

Example Tour TOD Choice Dimensions

- Formal (820)
  - 40 departure half-hours (5am-24pm) by
  - 40 arrival half-hours (departure-24pm) leads to
  - 820 feasible combinations
- Real & meaningful (120)
  - 40 departure half-hours and
  - 40 arrival half-hours and
  - 40 possible durations rounded to half-hour

Impacts on TOD choice



Impacts on TOD choice

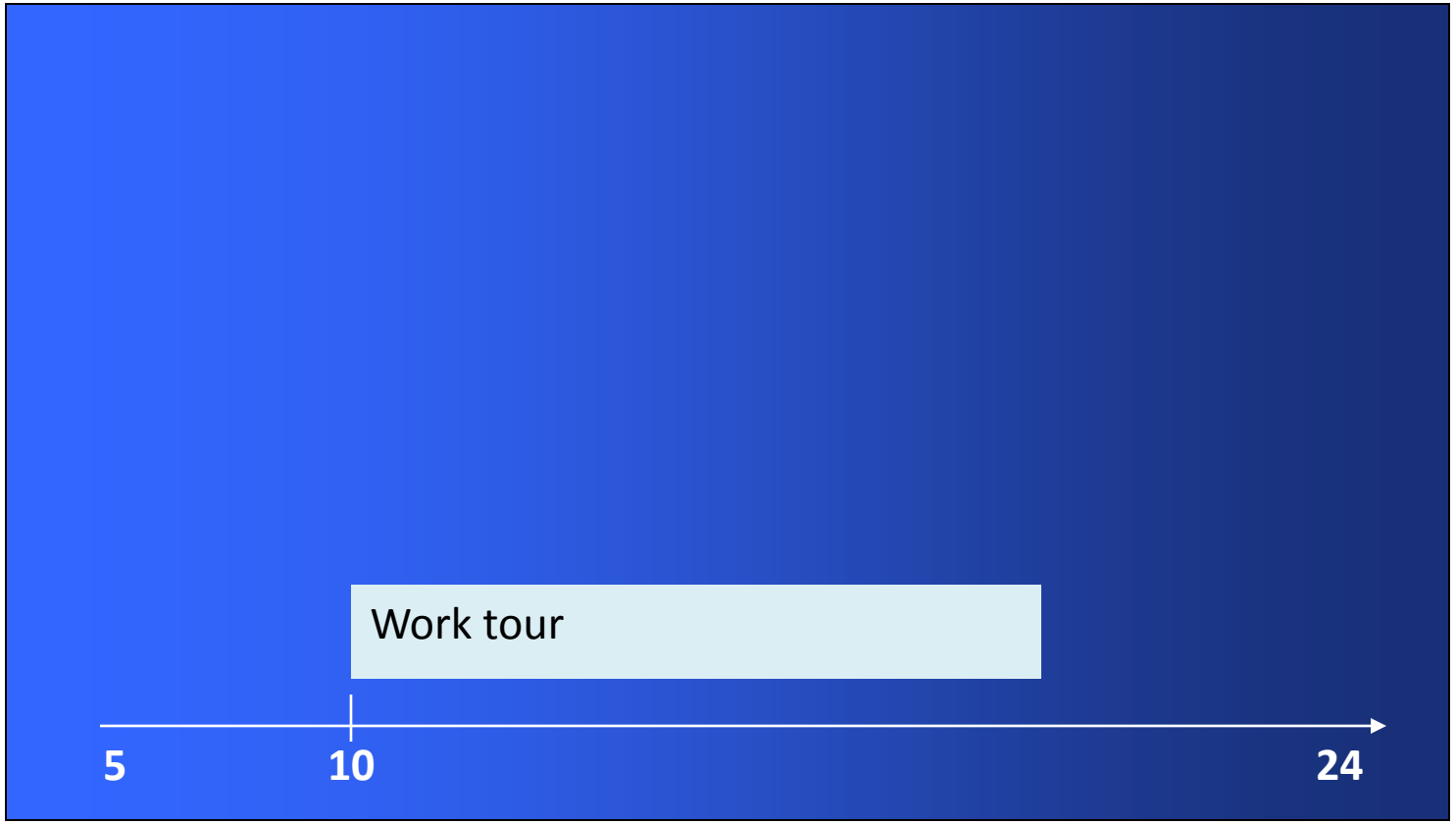
Work tour to schedule

Considerations for departure time:

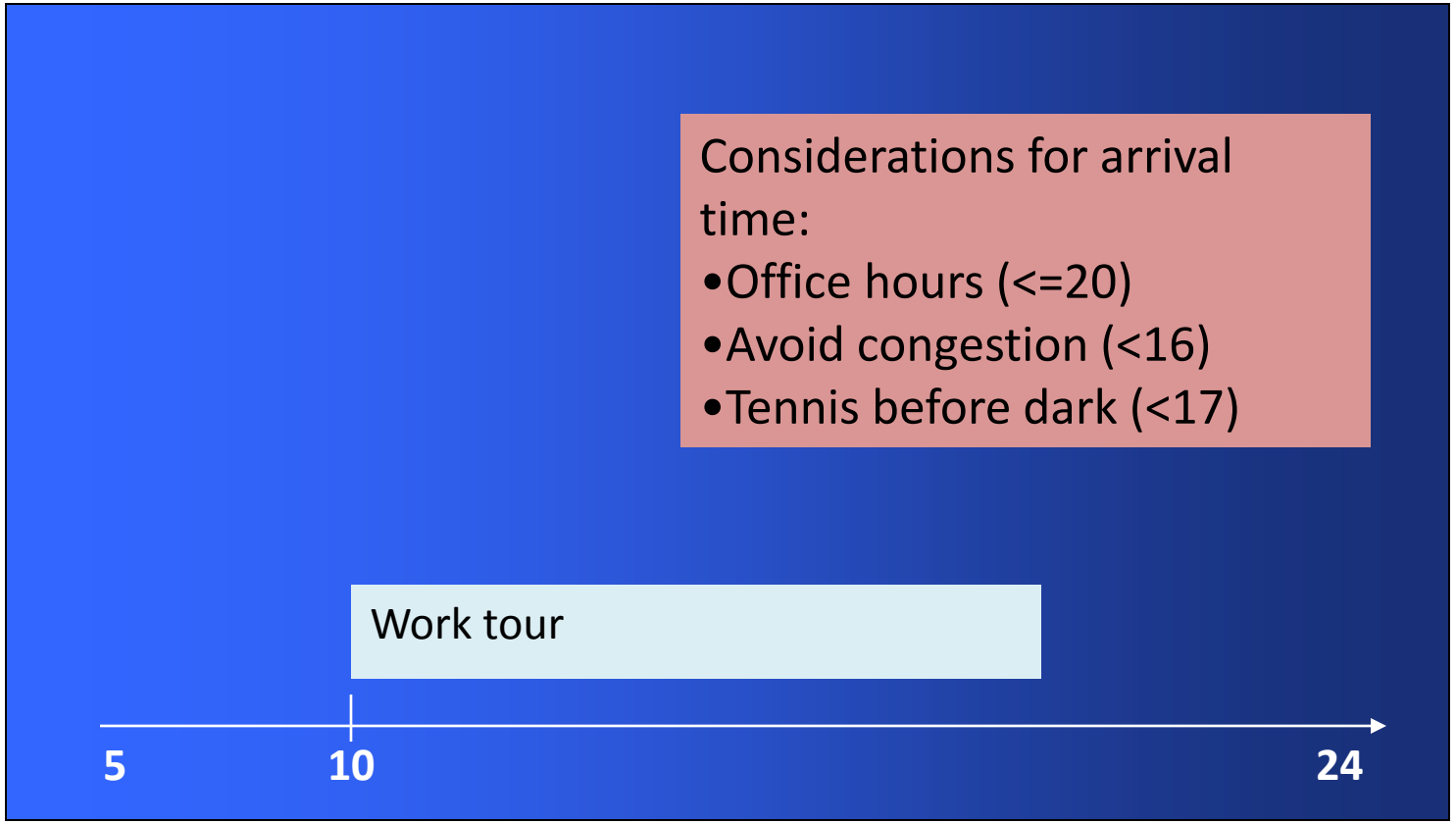
- Office hours (7-10)
- Avoid congestion (10+)
- Give ride to child (7)

5 — 24

Impacts on TOD choice

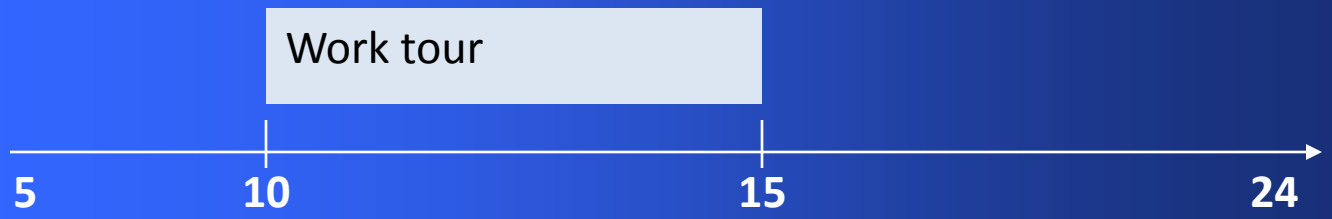


Impacts on TOD choice

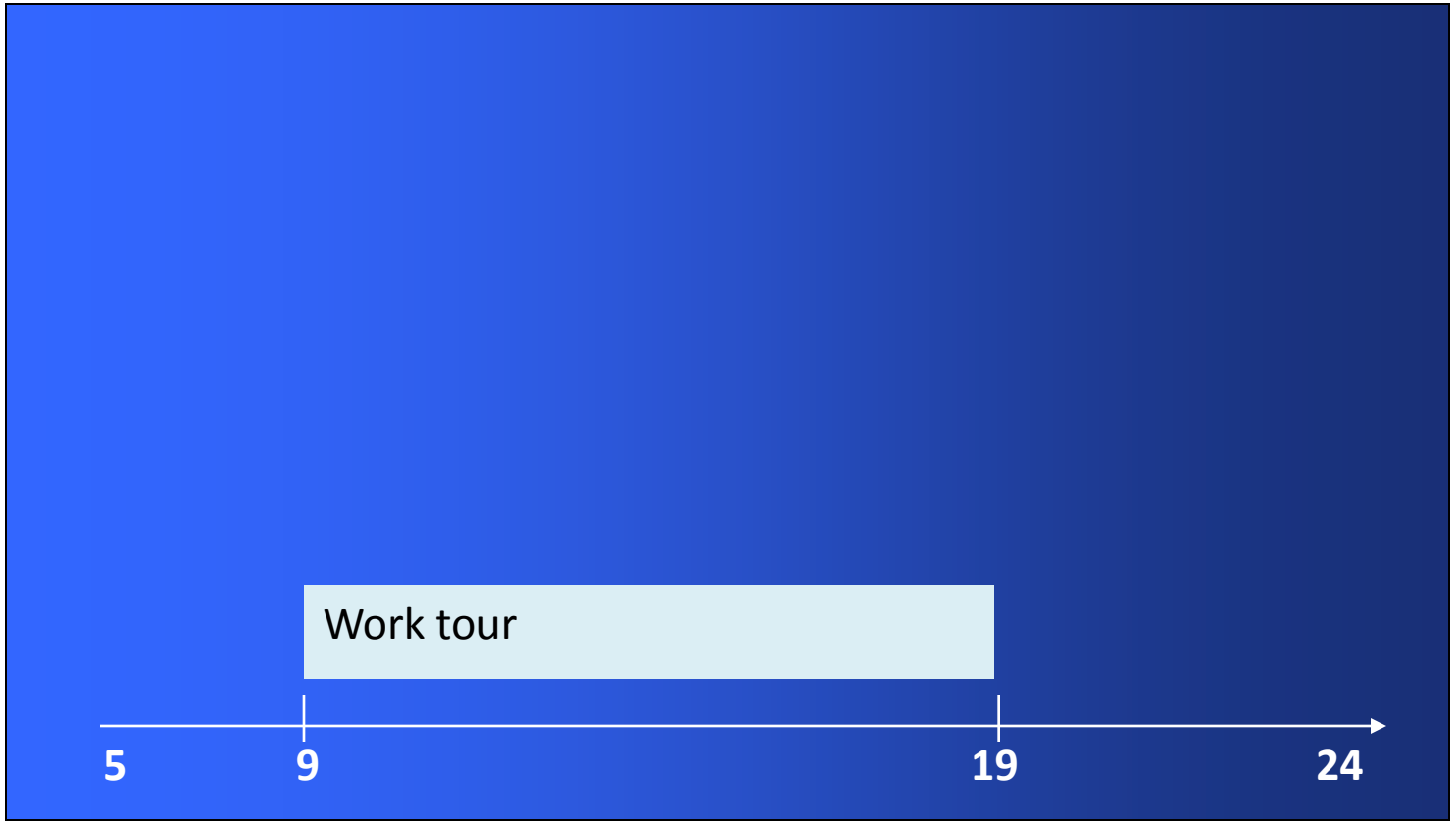


Impacts on TOD choice

Considerations for duration:
- 8 work hours
- Finish presentation for webinar



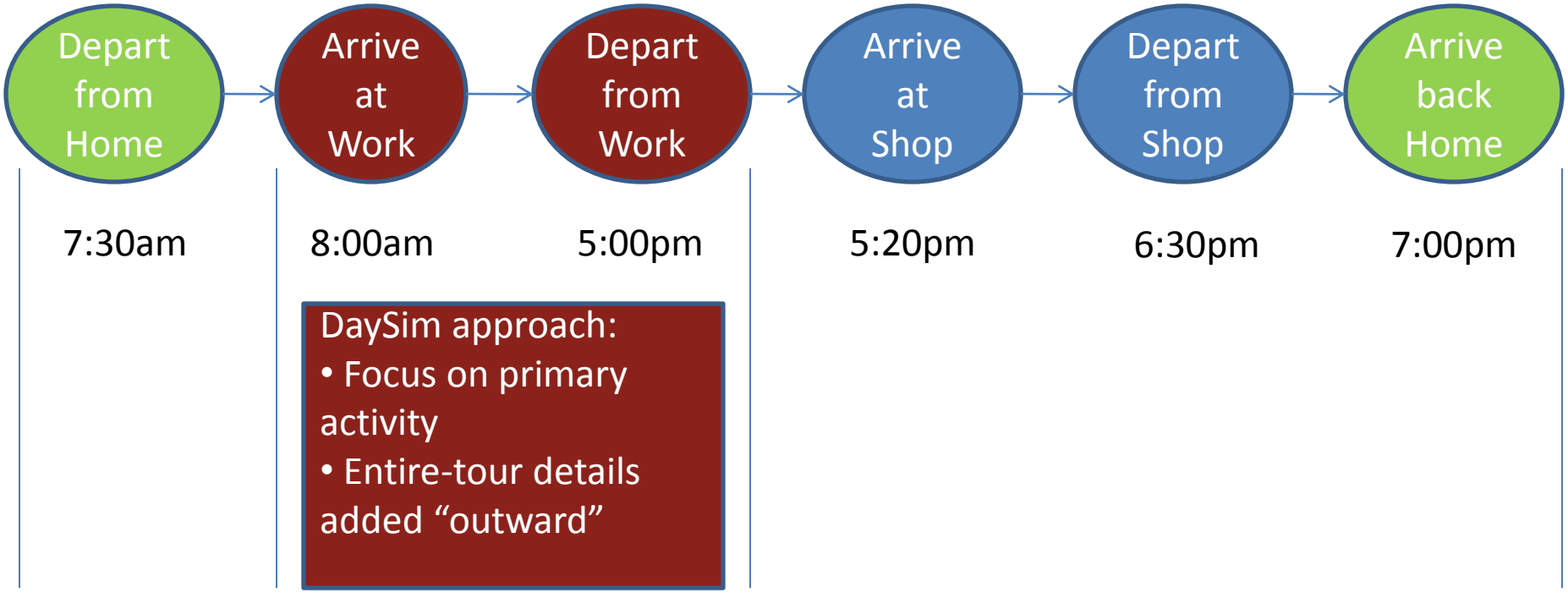
Impacts on TOD choice



Tour TOD Dimensions (DaySim)

- Joint choice of arrival time at primary destination and departure time from primary destination
- Entire-tour duration, departure from home, and arrival back home modeled later when stops are added
- 666 combined alternatives (similar to CT-RAMP):
  - 36 arrival half-hour bins from 5am through 10pm
  - 36 departure half-hour bins from arrival through 10pm
  - 36 possible activity durations rounded to half-hour

Pros and Cons of 2 TOD Choice Approaches

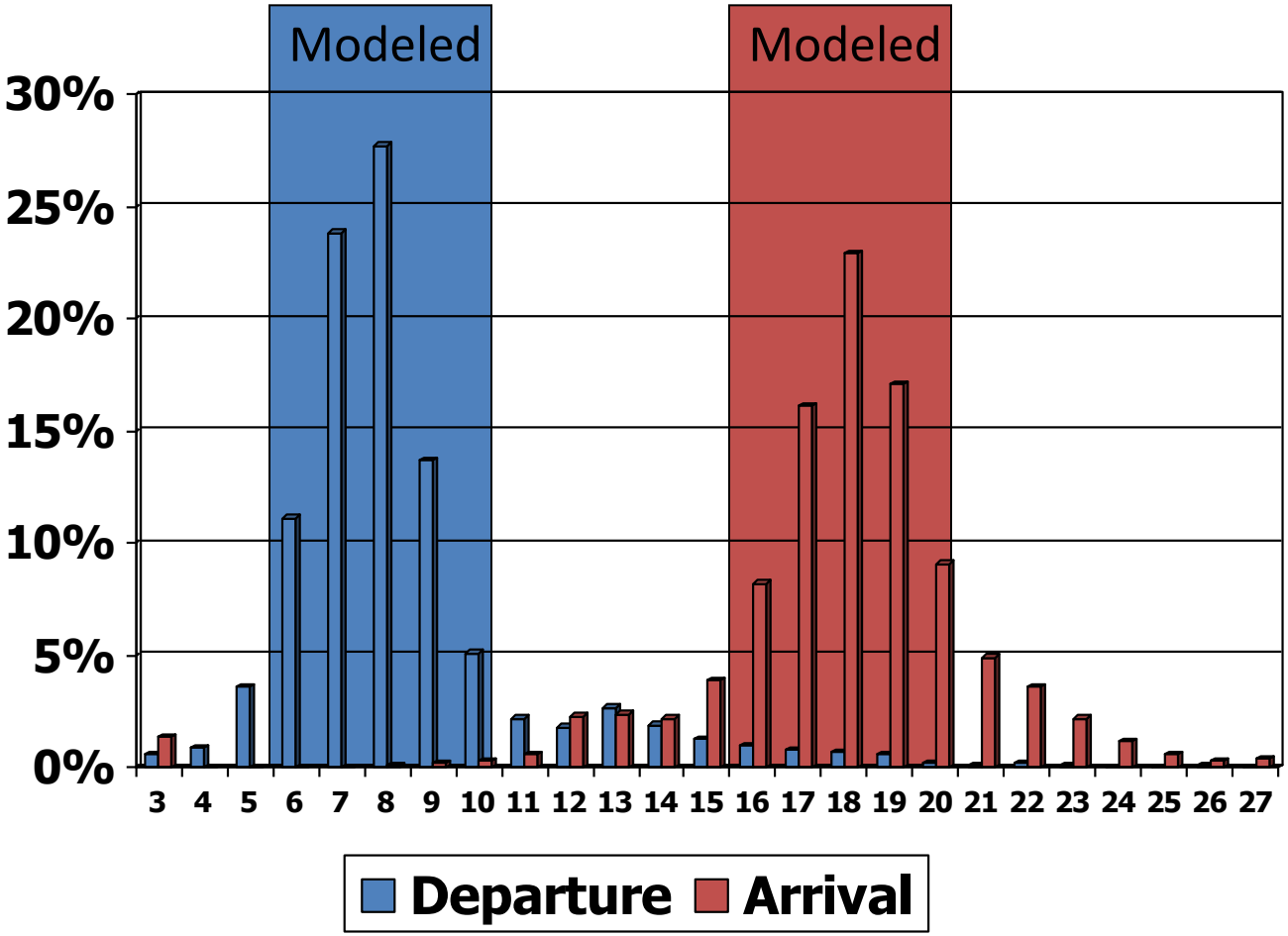


CT-RAMP approach:
- Start with entire tour framework (convenient for constructing day schedule)
- Tour details added "inward" by inserting stops and departure times

Simplified Example

- Commuting tours to work
- 1 hour temporal resolution (instead of 30 min)
- Complete prototype TOD structure but the choice set is limited to a subset of most frequent alternatives
- Real stats from Bay Area Travel Survey (BATS), 2000

TOD Work Tour Stats, BATS 2000



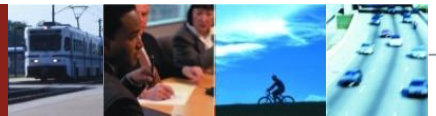
TOD Work Tour Stats, BATS 2000

Departure from home	Arrival back home				
	3-5	6-10	11-15	16-20	21-27
3-5	0.0%	0.1%	1.2%	3.4%	0.3%
6-10		0.6%	9.3%	62.9%	8.0%
11-15			1.0%	6.1%	2.7%
16-20				0.9%	2.0%
21-27					0.3%

Departure from home	Arrival back home	Duration	Alternative	Utility
6 (5:30-6:29 AM)	16 (15:30-16:29 PM)	10	1	DEP6 + ARR16 + DUR10
	17 (16:30-16:29 PM)	11	2	DEP6 + ARR17 + DUR11
	18 (17:30-16:29 PM)	12	3	DEP6 + ARR18 + DUR12
	19 (18:30-16:29 PM)	13	4	DEP6 + ARR19 + DUR13
	20 (19:30-16:29 PM)	14	5	DEP6 + ARR20 + DUR14
7 (6:30-7:29 AM)	16 (15:30-16:29 PM)	9	6	DEP7 + ARR16 + DUR9
	17 (16:30-16:29 PM)	10	7	DEP7 + ARR17 + DUR10
	18 (17:30-16:29 PM)	11	8	DEP7 + ARR18 + DUR11
	19 (18:30-16:29 PM)	12	9	DEP7 + ARR19 + DUR12
	20 (19:30-16:29 PM)	13	10	DEP7 + ARR20 + DUR13
8 (7:30-8:29 AM)	16 (15:30-16:29 PM)	8	11	DEP8 + ARR16 + DUR8
	17 (16:30-16:29 PM)	9	12	DEP8 + ARR17 + DUR9
	18 (17:30-16:29 PM)	10	13	DEP8 + ARR18 + DUR10
	19 (18:30-16:29 PM)	11	14	DEP8 + ARR19 + DUR11
	20 (19:30-16:29 PM)	12	15	DEP8 + ARR20 + DUR12
9 (8:30-9:29 AM)	16 (15:30-16:29 PM)	7	16	DEP9 + ARR16 + DUR7
	17 (16:30-16:29 PM)	8	17	DEP9 + ARR17 + DUR8
	18 (17:30-16:29 PM)	9	18	DEP9 + ARR18 + DUR9
	19 (18:30-16:29 PM)	10	19	DEP9 + ARR19 + DUR10
	20 (19:30-16:29 PM)	11	20	DEP9 + ARR20 + DUR11
10 (9:30-10:29 AM)	16 (15:30-16:29 PM)	6	21	DEP10 + ARR16 + DUR6
	17 (16:30-16:29 PM)	7	22	DEP10 + ARR17 + DUR7
	18 (17:30-16:29 PM)	8	23	DEP10 + ARR18 + DUR8
	19 (18:30-16:29 PM)	9	24	DEP10 + ARR19 + DUR9
	20 (19:30-16:29 PM)	10	25	DEP10 + ARR20 + DUR10

Statistical Estimation of Tour TOD Choice

- Conventional Household Travel Survey:
  - Processed in the tour format
  - Reported travel time rounded to the nearest half-hour (bin)
- LOS variables and mode choice logsums by broader TOD Periods:
  - Interpolations applied in some models to vary LOS within periods
- No sampling needed, all 820 alternatives are modeled
- Parsimonious utility structure:
  - 35-40 constants, and 30-55 other coefficients
  - Statistical fit much better than for the reference model with 820 constants because of the shift variables that capture many impacts

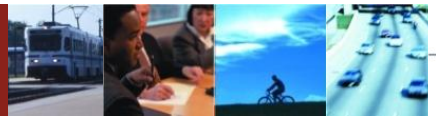


Questions and Answers

The Travel Model Improvement Program

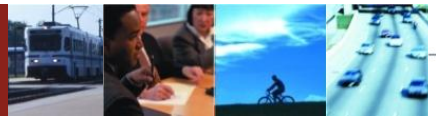
Empirical Results for Work Tours

- Models were internally validated against observed departure, duration and arrival patterns across many different segmentations of the data
- Strong effects were found related to
  - Person & household characteristics
  - Trip & tour characteristics
  - Accessibility to the primary destination
  - Individual Daily Activity Pattern and scheduling pressures
- Most of the estimated effects are very similar for the data sets from Columbus, Atlanta, Sacramento, San-Diego, Bay Area, and others

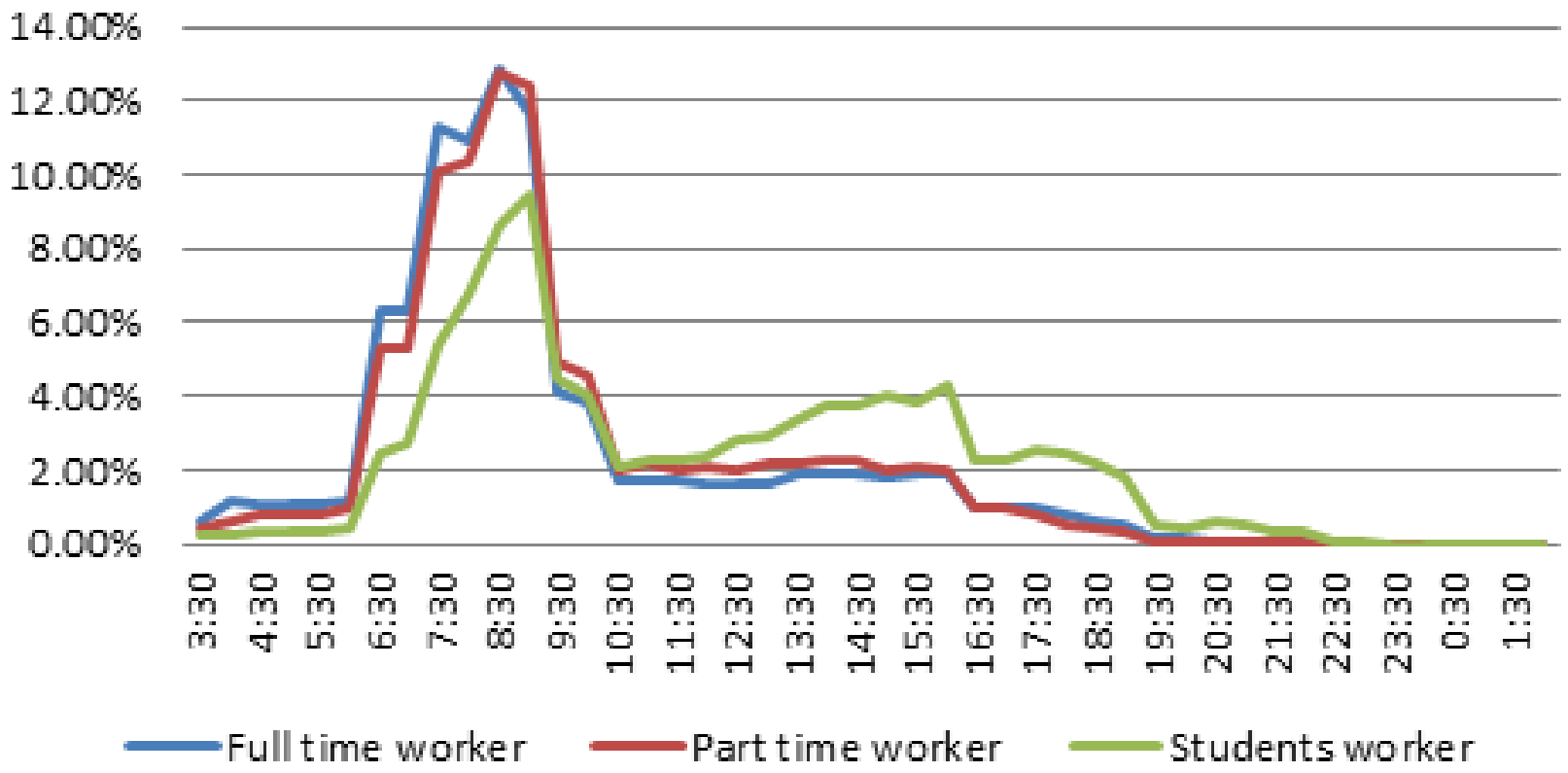


Impact of Person & Household Characteristics

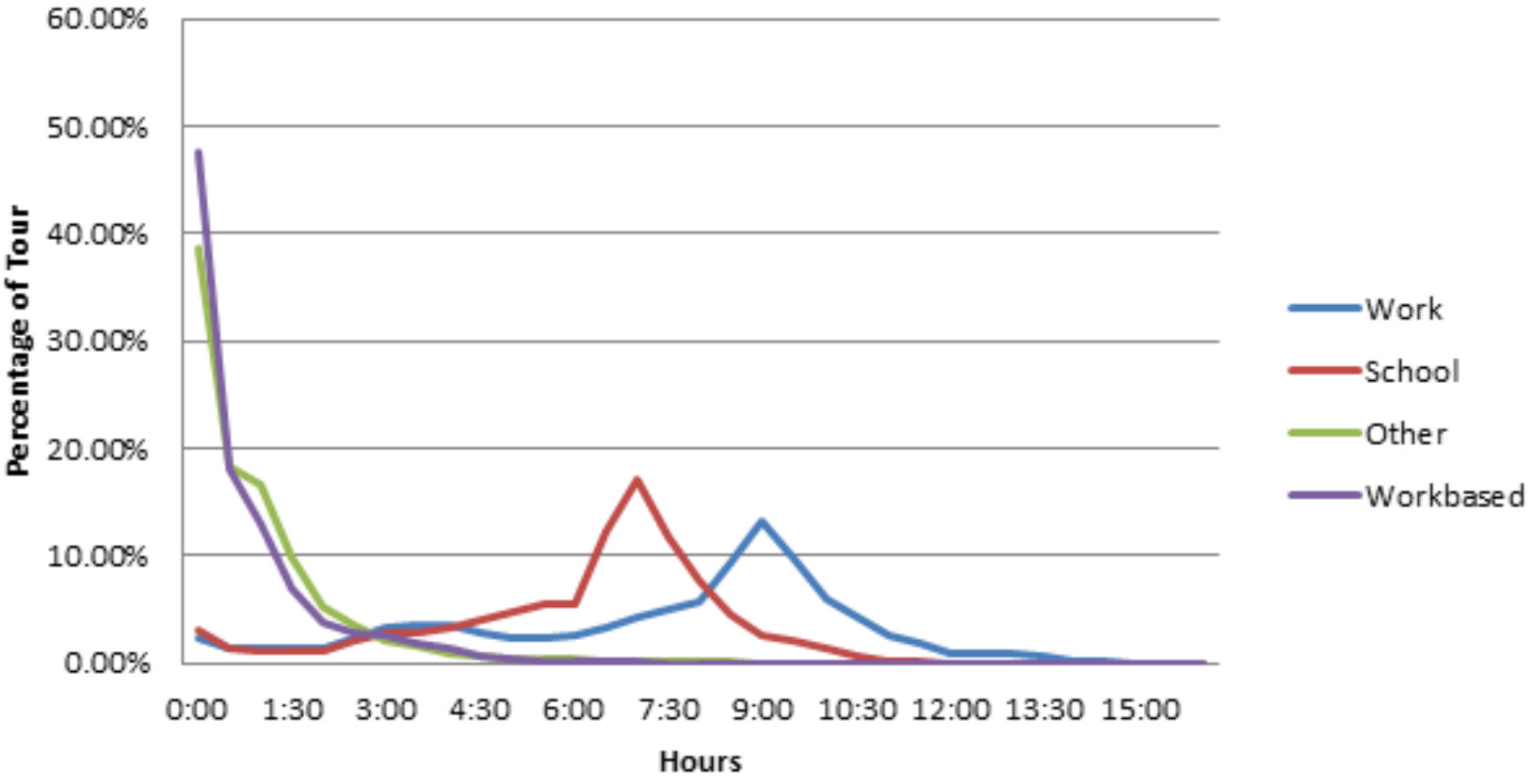
- Very different TOD patterns for full-time and part-time workers
- Higher income workers tend to work longer hours, but can avoid working extremely late or early.
- Female workers with young children avoid very early and late hours
- Younger workers have shorter work durations
- Carpoolers to work have more conventional schedules and avoid very early and late hours
- Workers with flexible schedules depart to work late more frequently



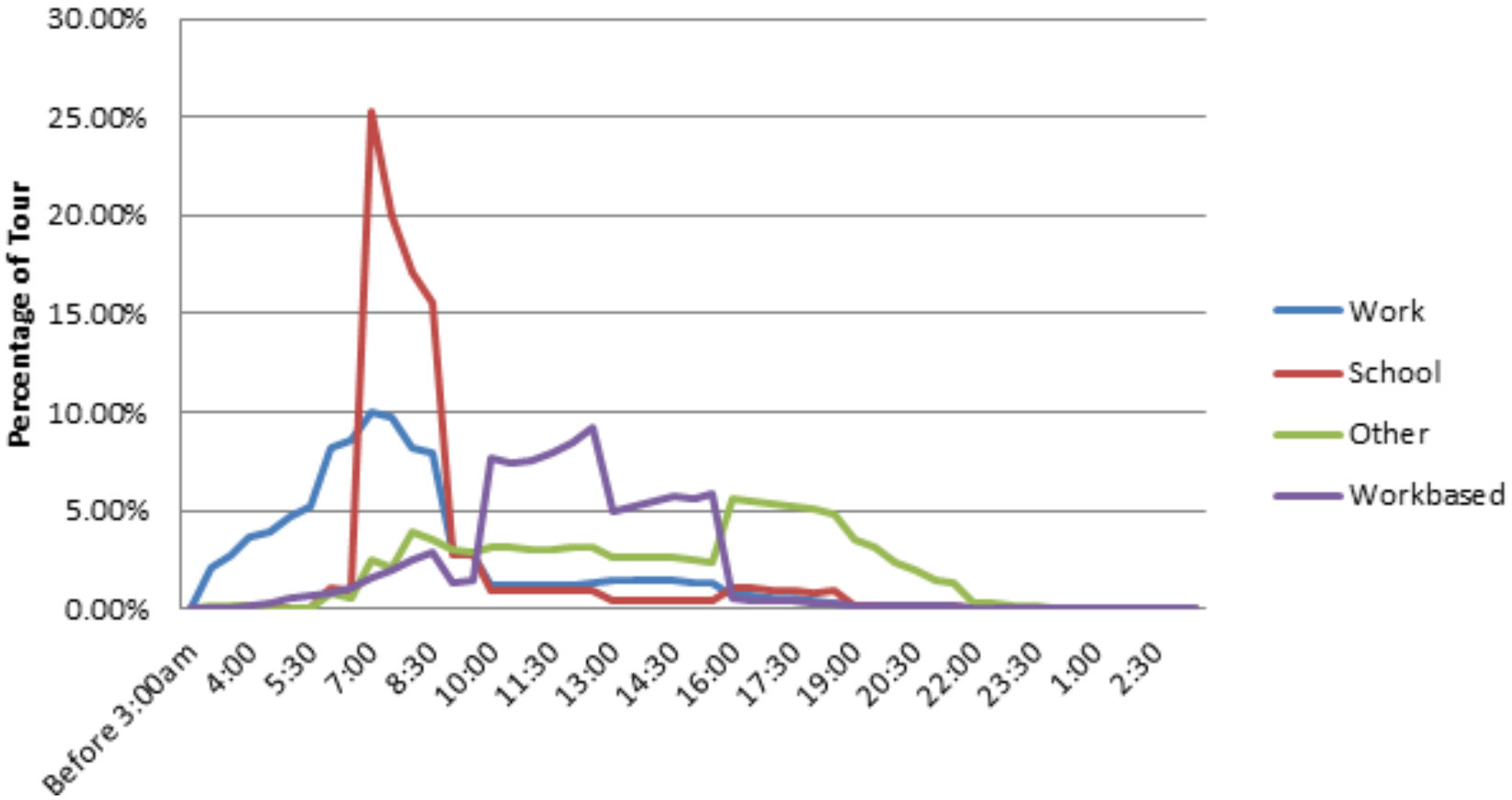
Example of Work Tour Arrival Times by Person Type (San Joaquin Valley ABM)



Example of Activity Duration by Purpose (San Joaquin Valley ABM)

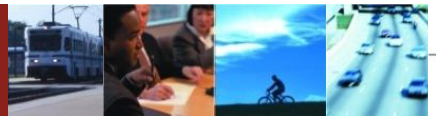


Example of Arrival Times by Purpose (San Joaquin Valley ABM)



Location & Accessibility Effects

- Longer travel time in general
  - Extends duration of work tour
  - Shifts departure from home to earlier hour
  - Shifts arrival back home to later hour
- Congestion effect: higher travel time impedance in peak periods shifts trips to and from work to other hours
- Stops on the way to or from the destination extend the tour duration in both directions (except for escort stops)
- Tours to CBD tend to be of longer duration and later in the day (occupation effect)
- Work tours that include sub-tours are of longer duration



Activity Pattern & Schedule Pressure

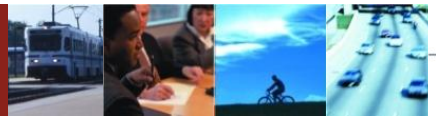
- The more tours to schedule in the day, the shorter the duration of each tour
- Higher number of tours tends to shift work and school tours earlier, other tours later
- People generally tend to schedule tours shortly after previous tours to leave a larger amount of continuous free time for later

Summary of TOD Effects for Non-Work Tours

- School tours
  - Very different TOD patterns for full- and part-time workers, and for students at various levels of school
  - Children stay at school longer when all adults in the household are working
- Shopping, maintenance, and discretionary tours
  - Likelihood of staying out late in the evening varies a great deal by age group
  - Shopping and maintenance tours tend to be short duration and restricted to retail hours
  - Maintenance and discretionary tours implemented jointly by several household members tend to be longer

Modeling Complete Individual Daily Schedule

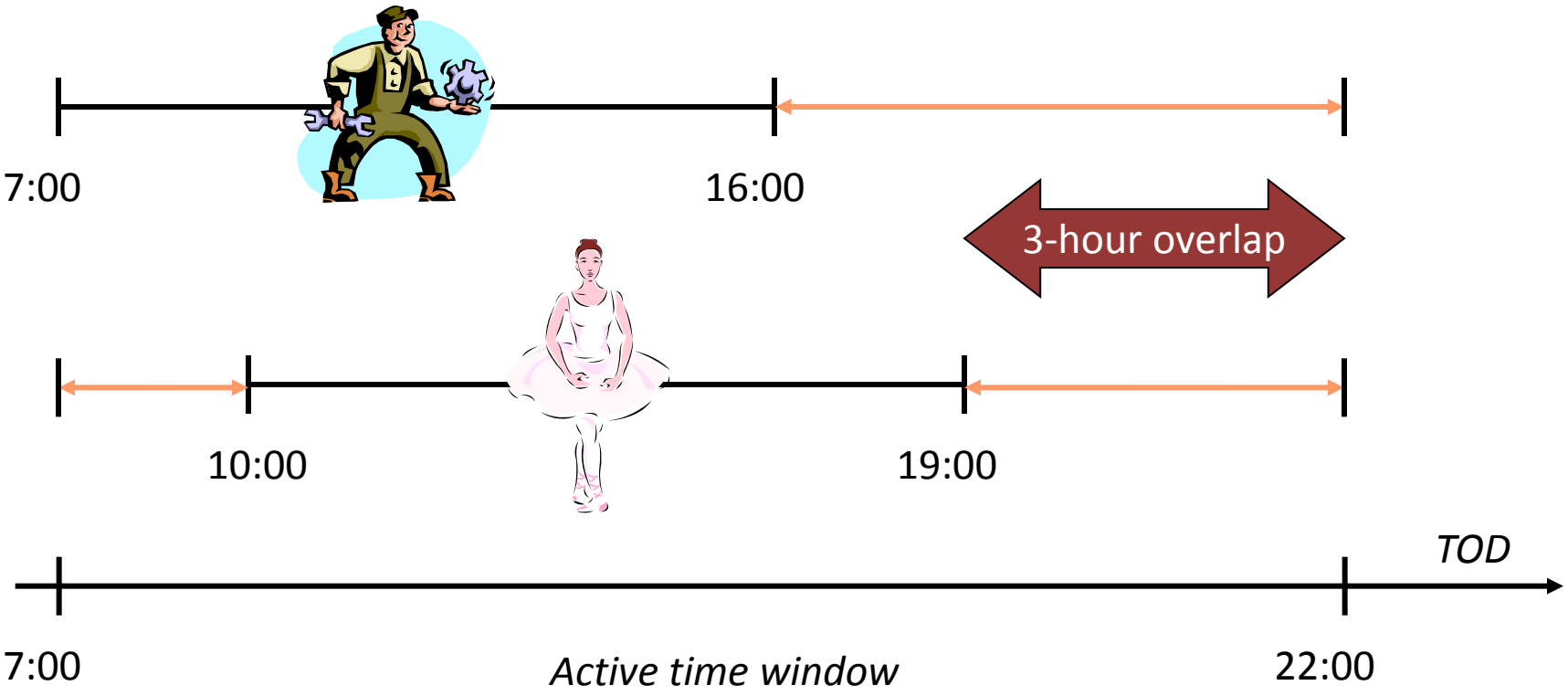
- Basic daily schedule consistency for each person
  - No overlaps between tours allowed
  - Tours scheduled sequentially by priority with dynamically updated residual time windows
  - Essential for evaluation of congestion & pricing effects that can be outside the congestion pricing period
- Advanced model features (CEMDAP, FAMOS, CT-RAMP, DaySim)
  - Residual time windows used also for generation of lower- priority activities & tours (TOD intertwined with DAP)
  - Time-space constraints affect destination choices (TOD intertwined with DC)
  - Activity duration is controlled along with entire-tour duration



Treatment of Joint Activities & Travel (CT-RAMP)

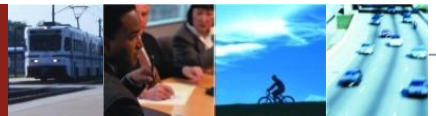
- Joint tours by several household members
  - Require intra-household schedule consolidation
  - Higher scheduling priority than individual tours
  - Fully joint tours for shared shopping maintenance & discretionary activities discussed in current presentation
  - Escorting and other partially joint tours require more complex sub-models beyond current presentation
- For fully joint tours, available time window is calculated as overlap of time windows for all participants

Time Window Overlap

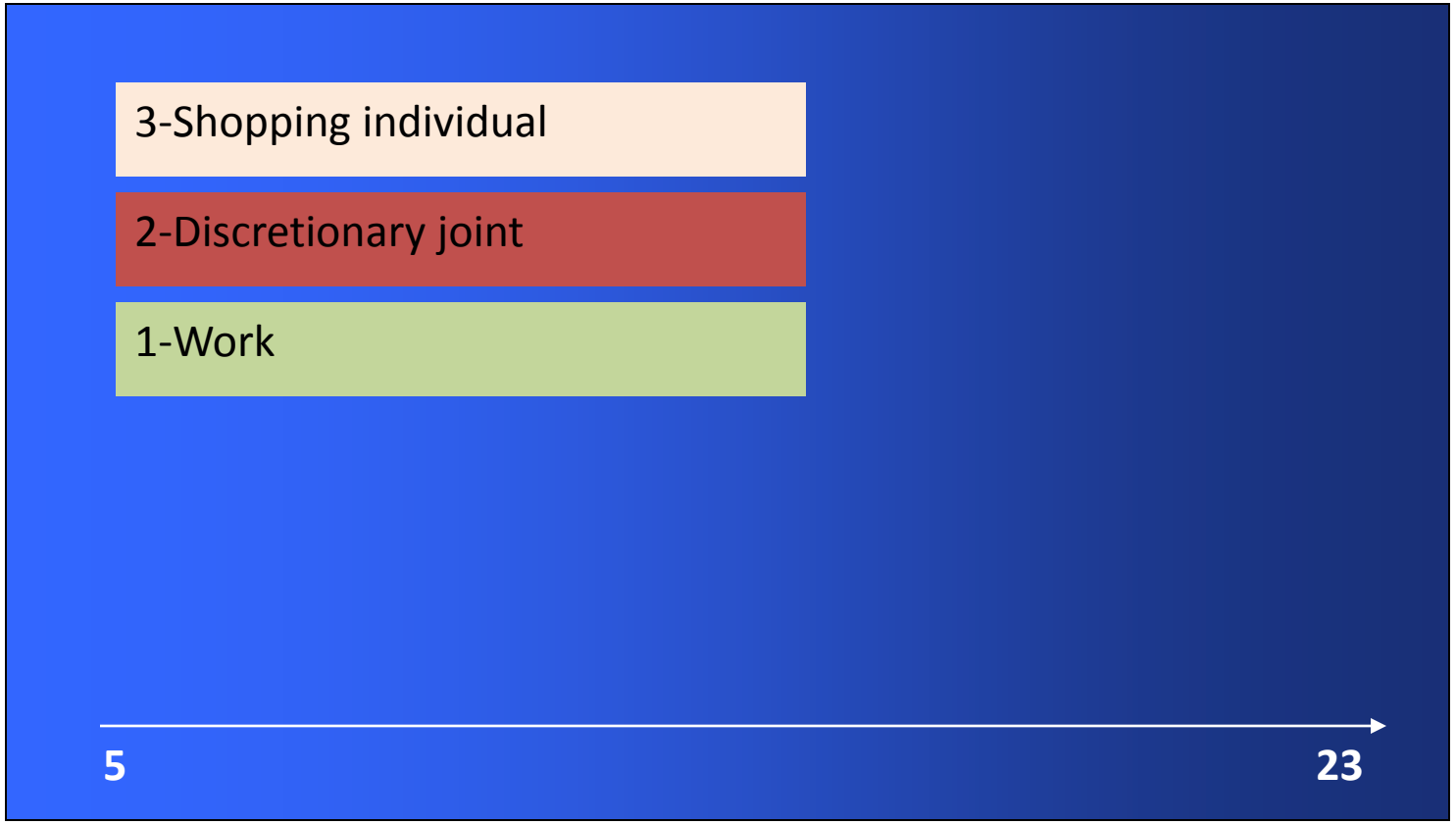


Tour Hierarchy for Scheduling

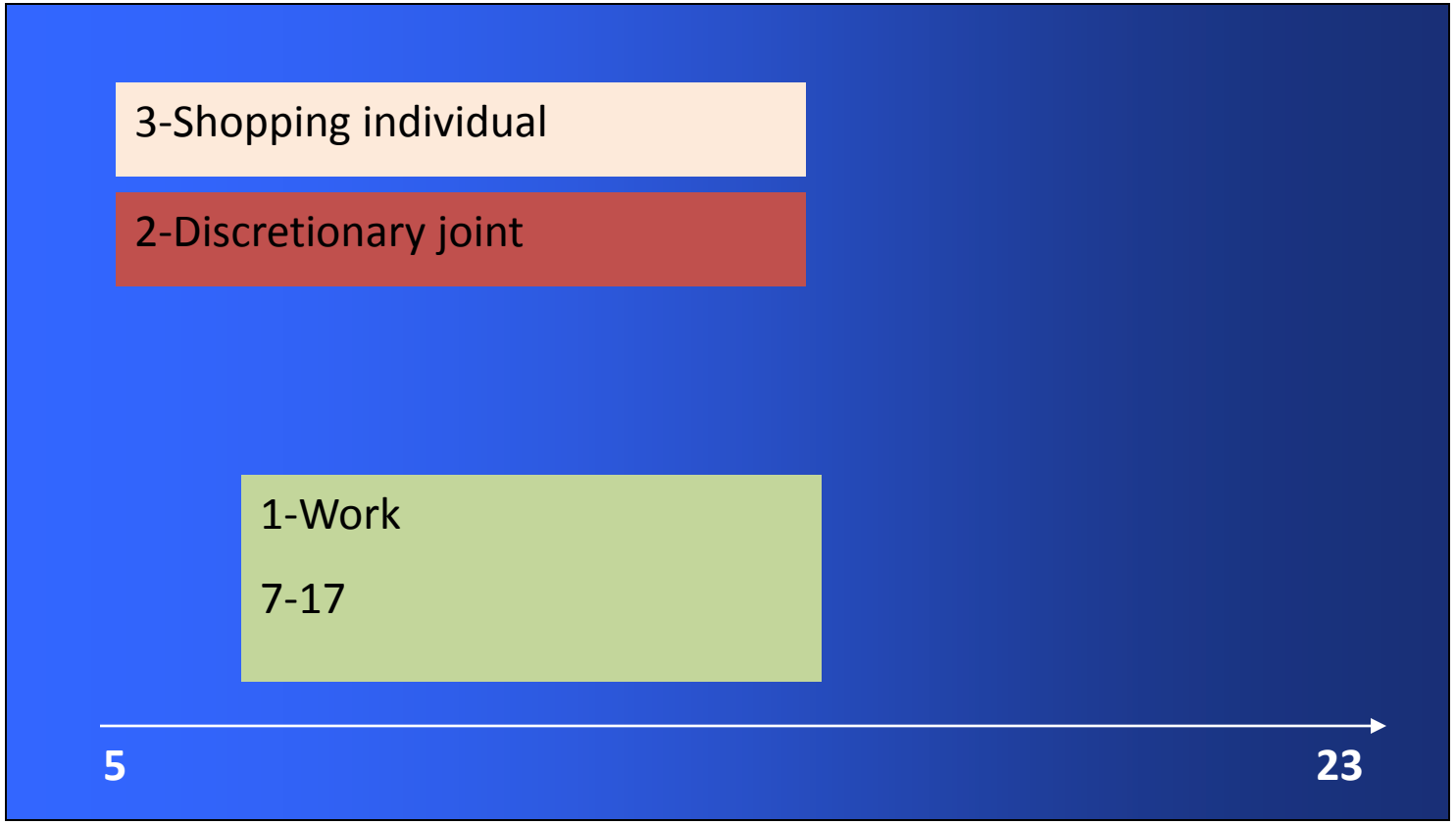
Priority	Workers / Non-workers	University students / School children
1	Work	University / School
2	University	Work
3	Maintenance joint	
4	Shopping joint	
5	Discretionary joint	
6	Eating-out joint	
7	Escorting	
8	Shopping individual	
9	Maintenance individual	
10	Discretionary individual	
11	Eating-out individual	



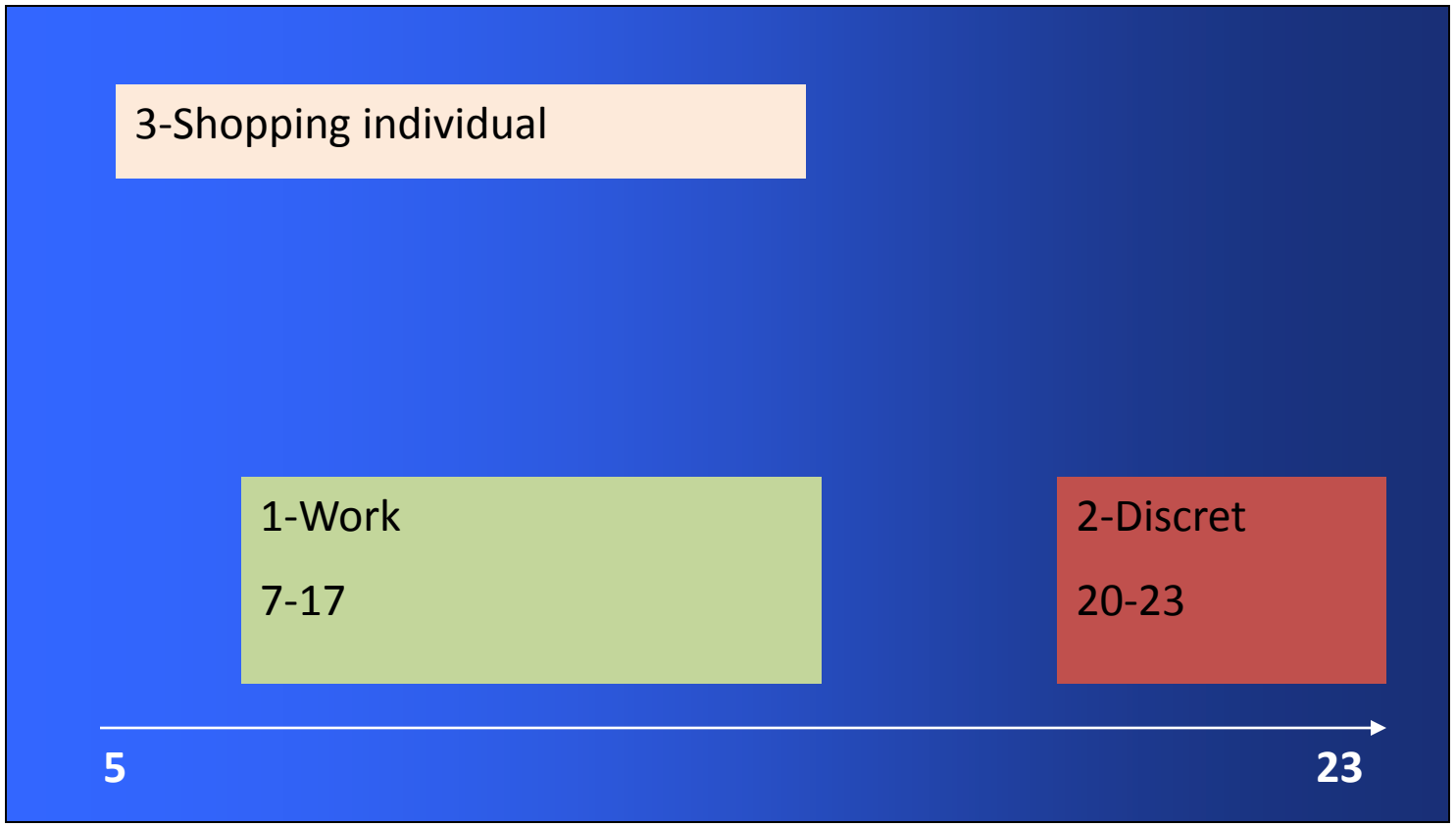
Sequential Processing of Tours



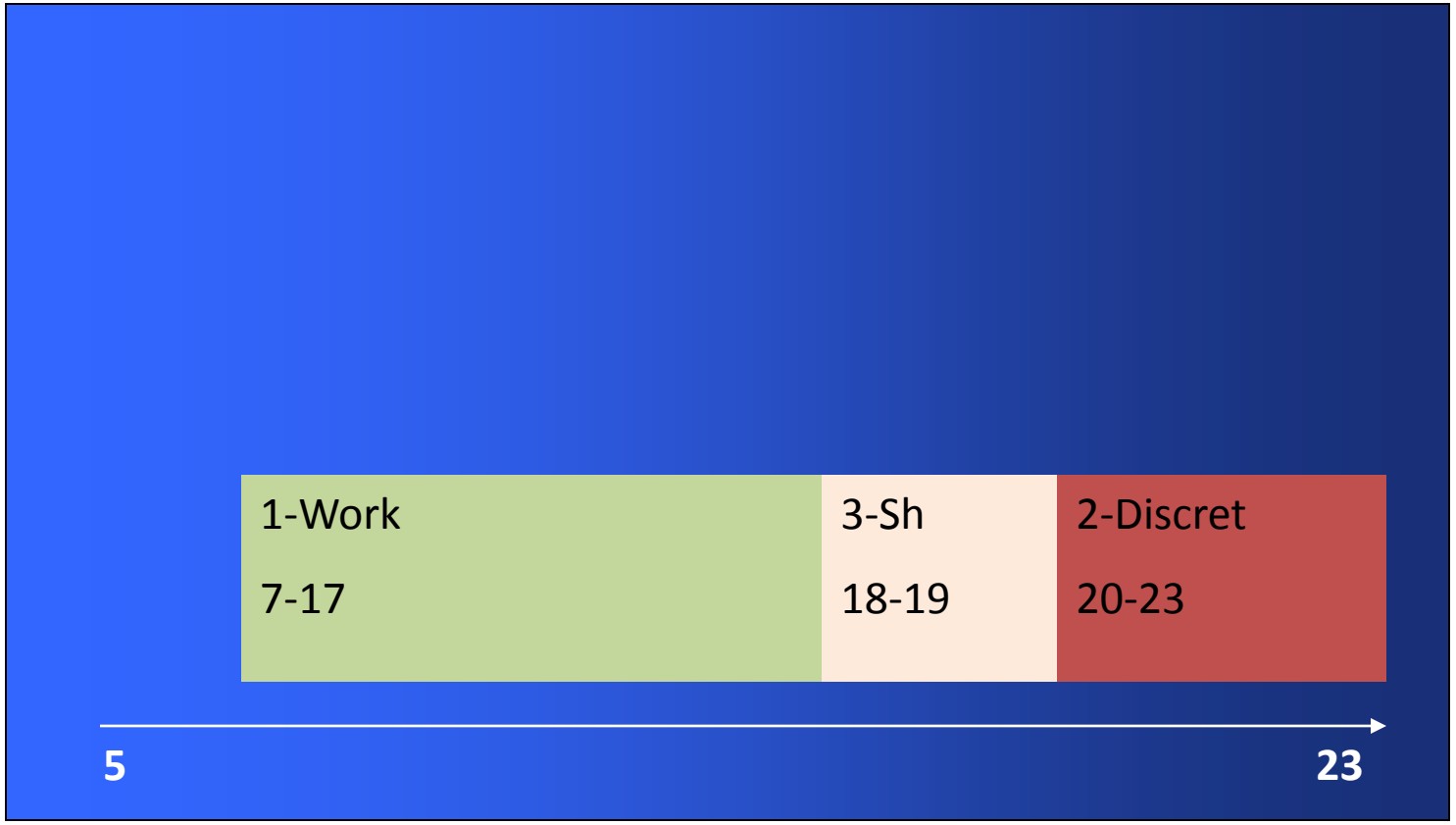
Sequential Processing of Tours



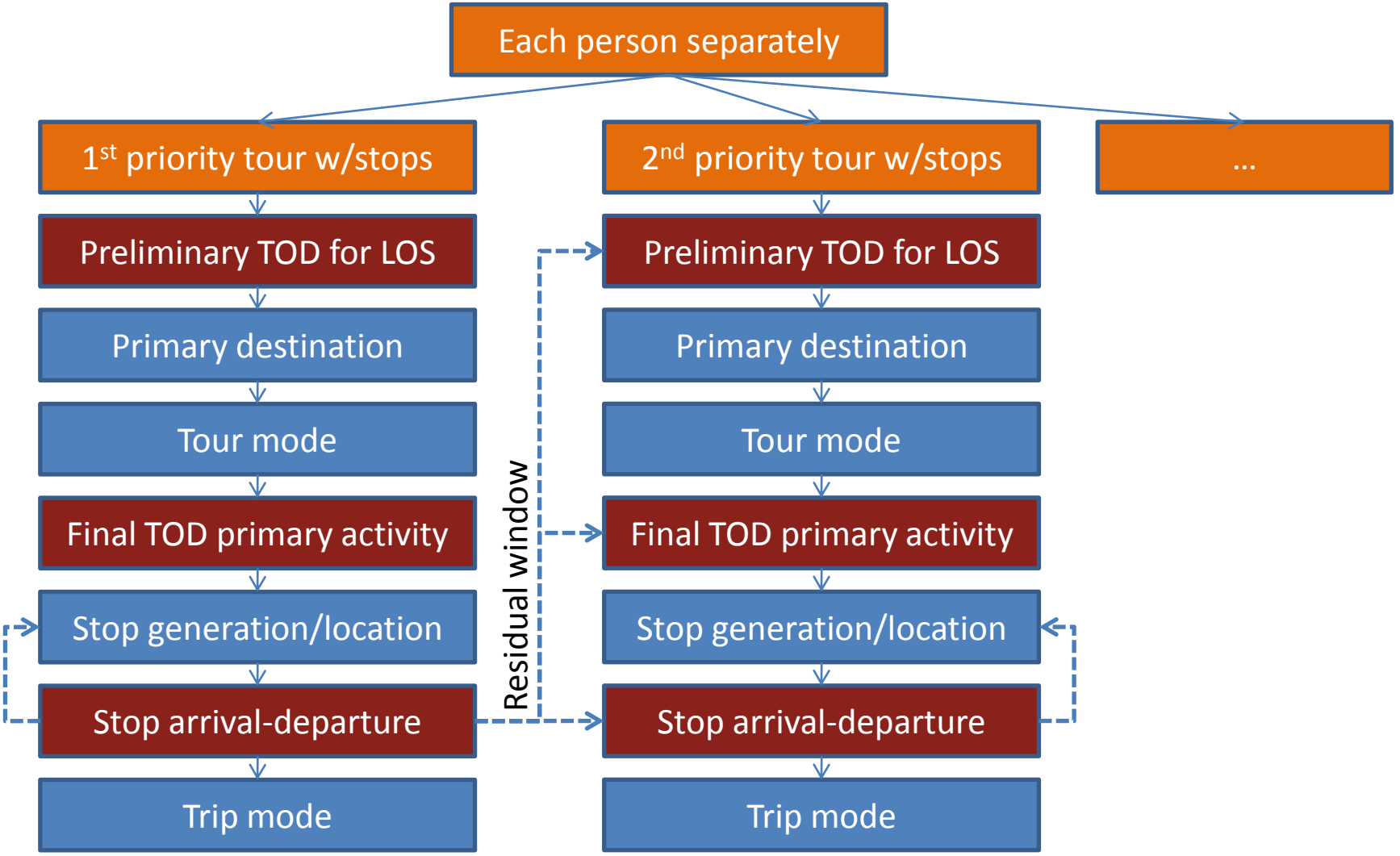
Sequential Processing of Tours



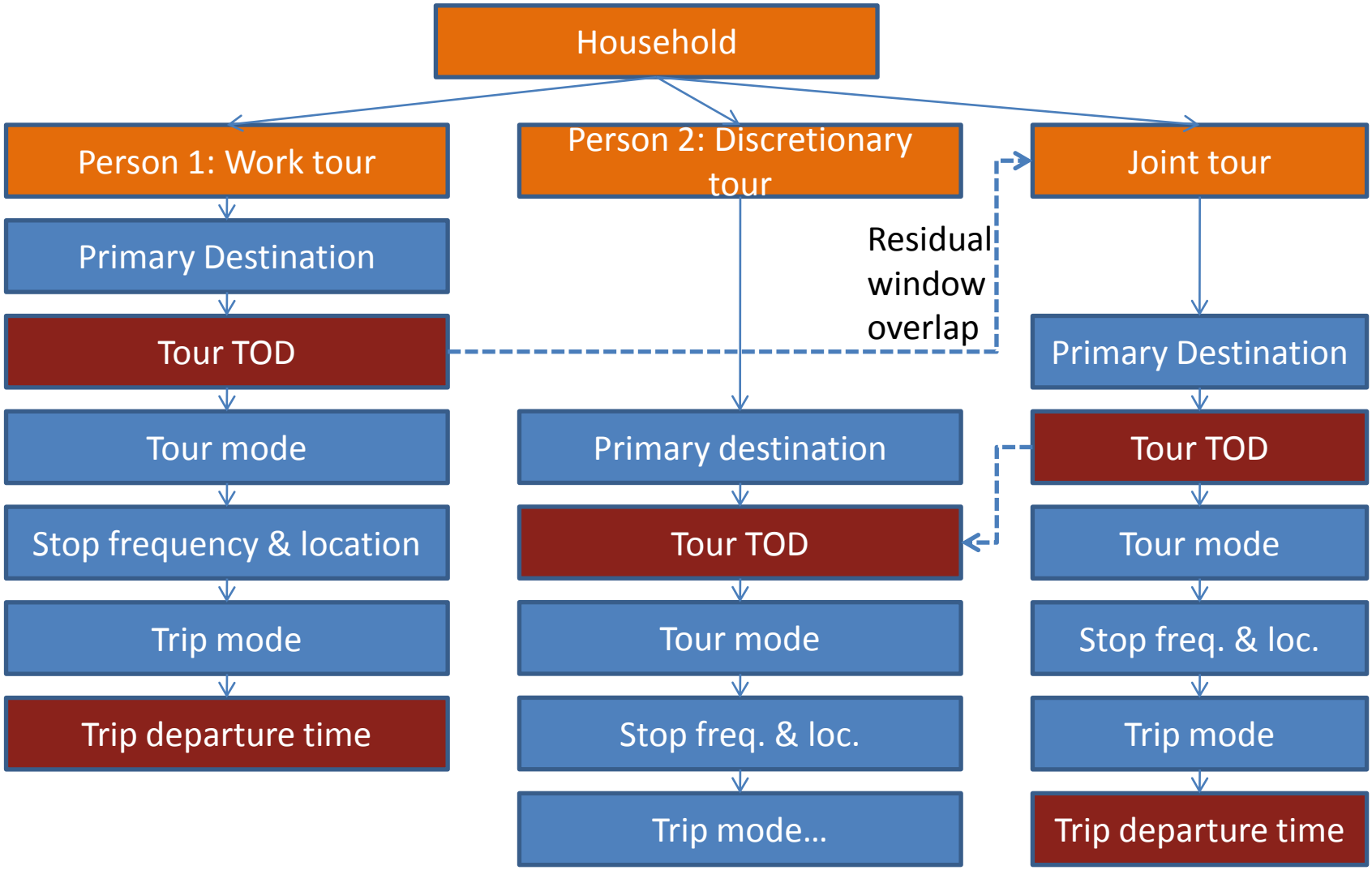
Sequential Processing of Tours



TOD Choice in ABM System (DaySim)

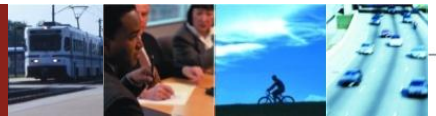


TOD Choice in ABM System (CT-RAMP)

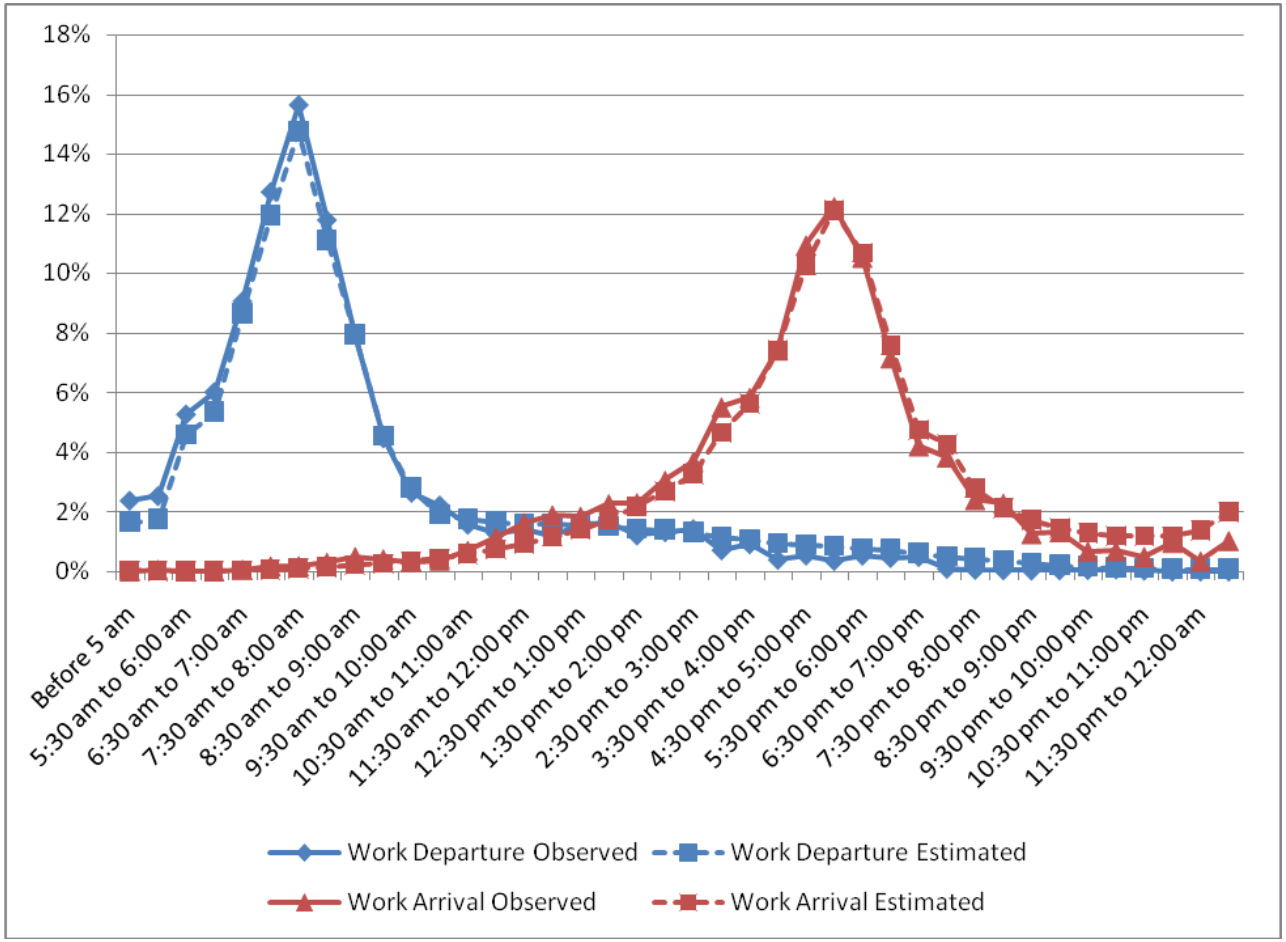


TOD Model Validation & Calibration

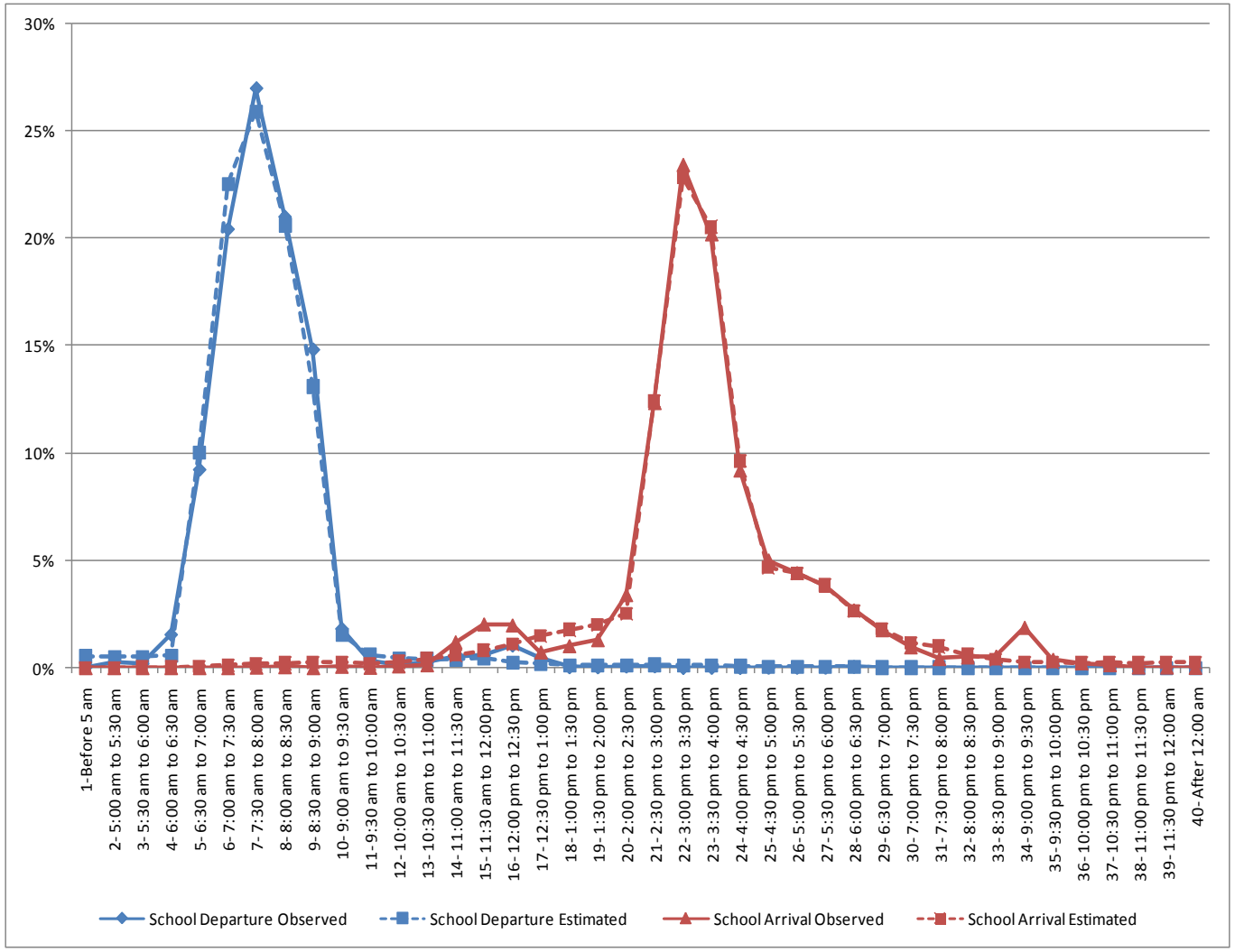
- Validation process
  - ABM system is applied w/TOD for full synthetic population
  - TOD model is intertwined with other sub-models
  - Aggregate outcomes are compared to expanded HTS
  - Ideally, validation against hourly traffic counts if available
- Highlights
  - Remarkably good match for Work and School tours with higher scheduling priority
  - Reasonable match for Shopping, Maintenance, and Discretionary activities with lower scheduling priority
  - Either no or very minor calibration is required



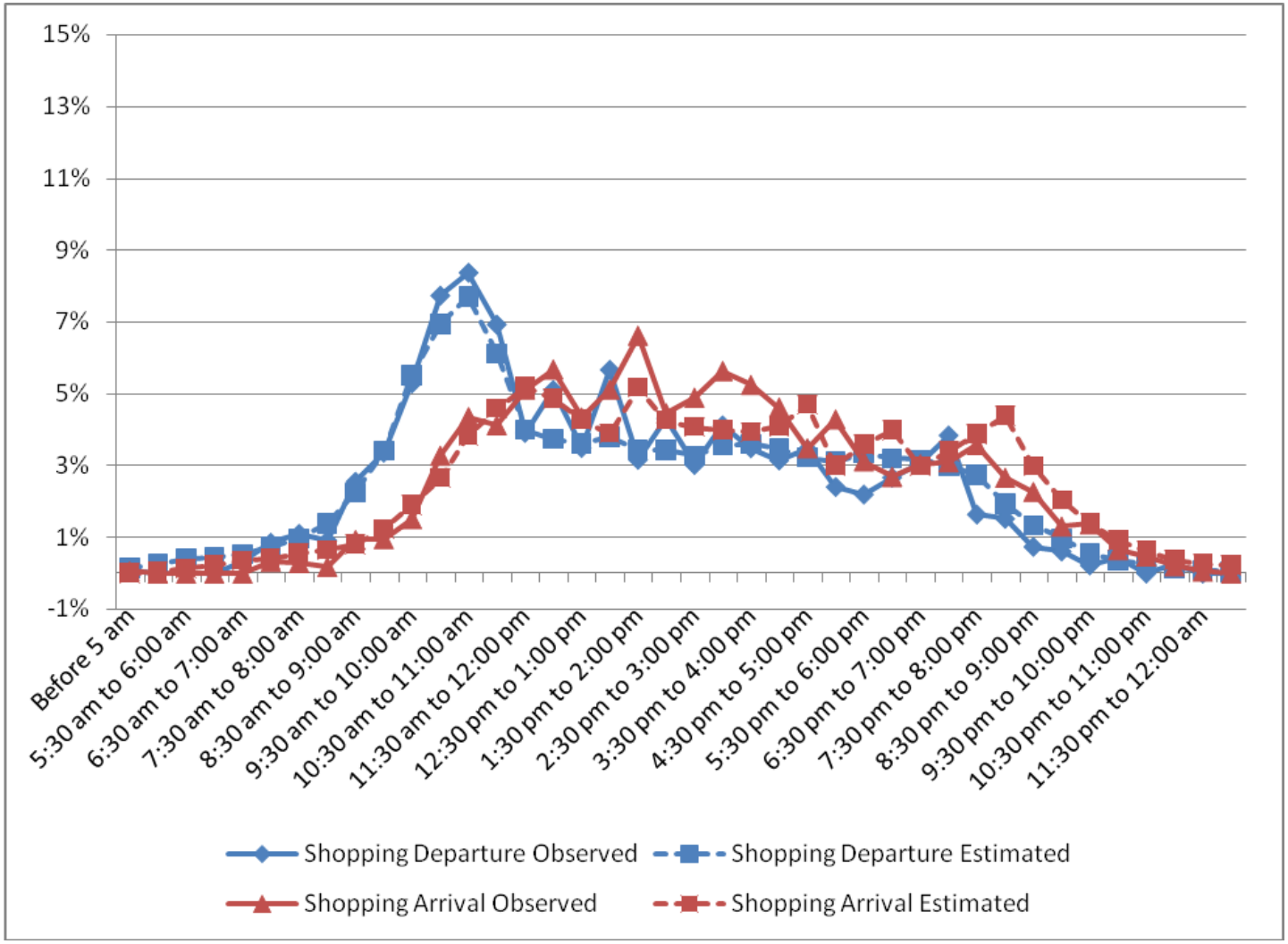
TOD Model Validation: Work Tour Arrival and Departure from Home



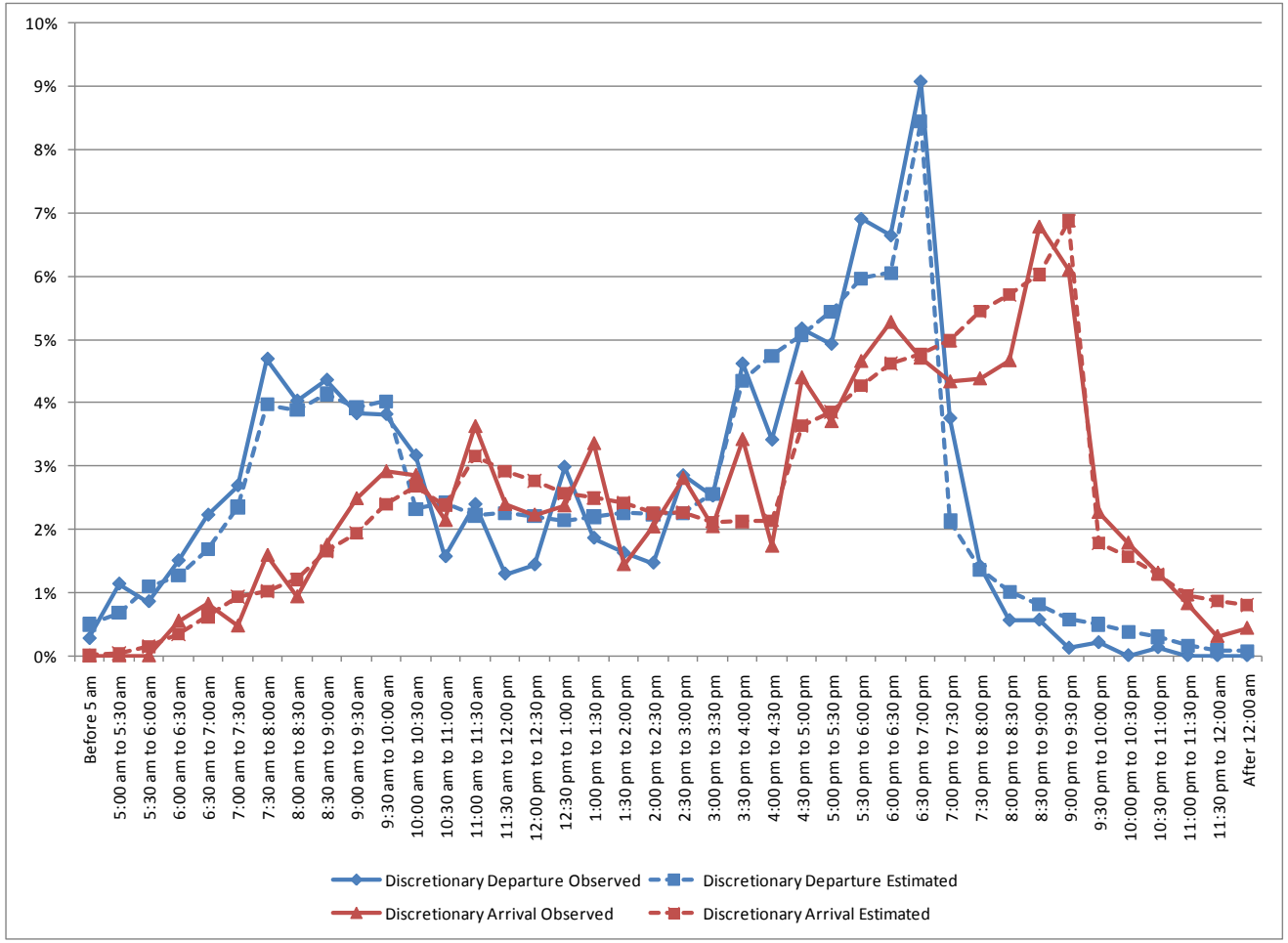
TOD Model Validation: School Departure and Arrival



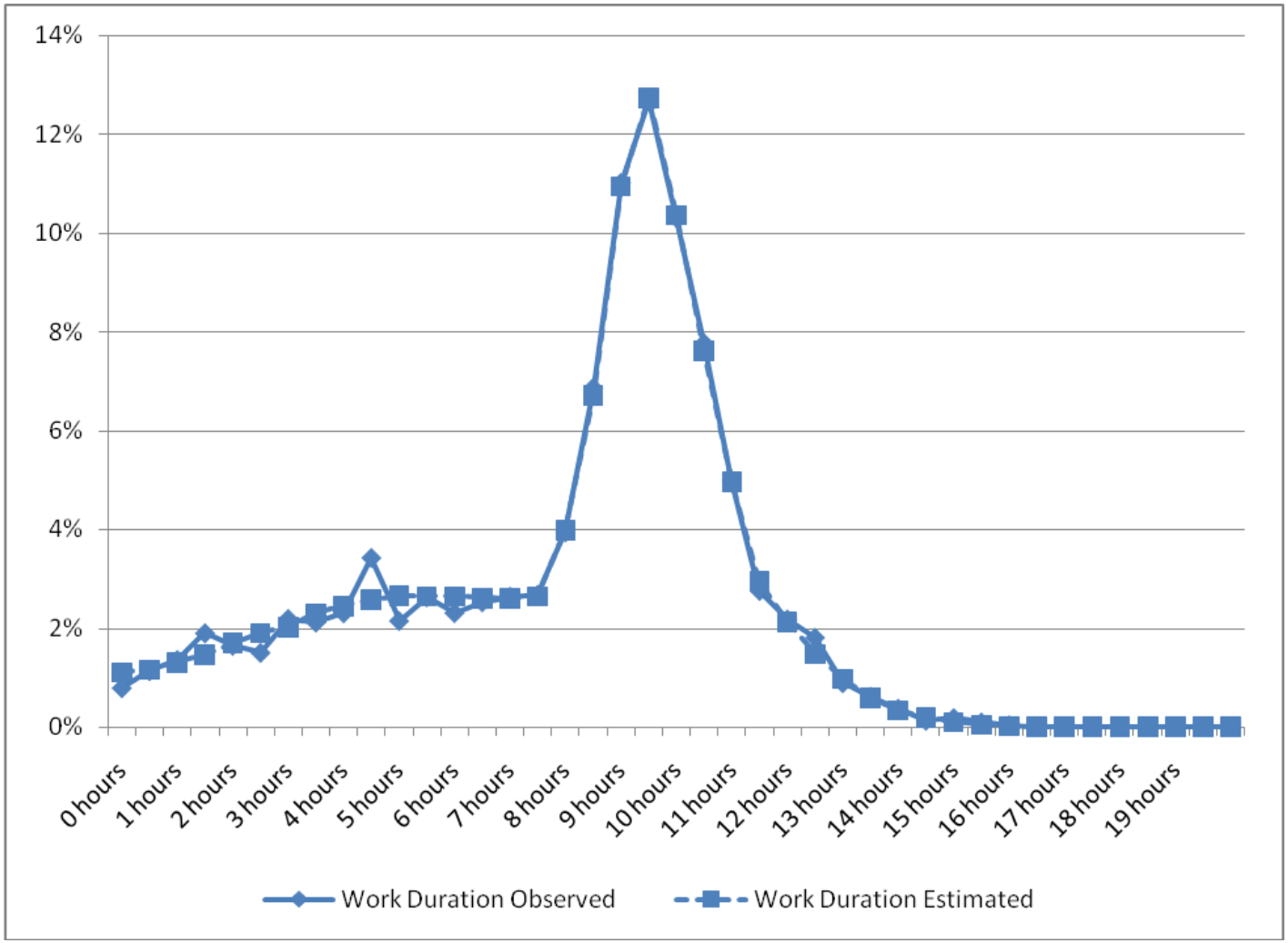
TOD Model Validation: Shopping Departure Time



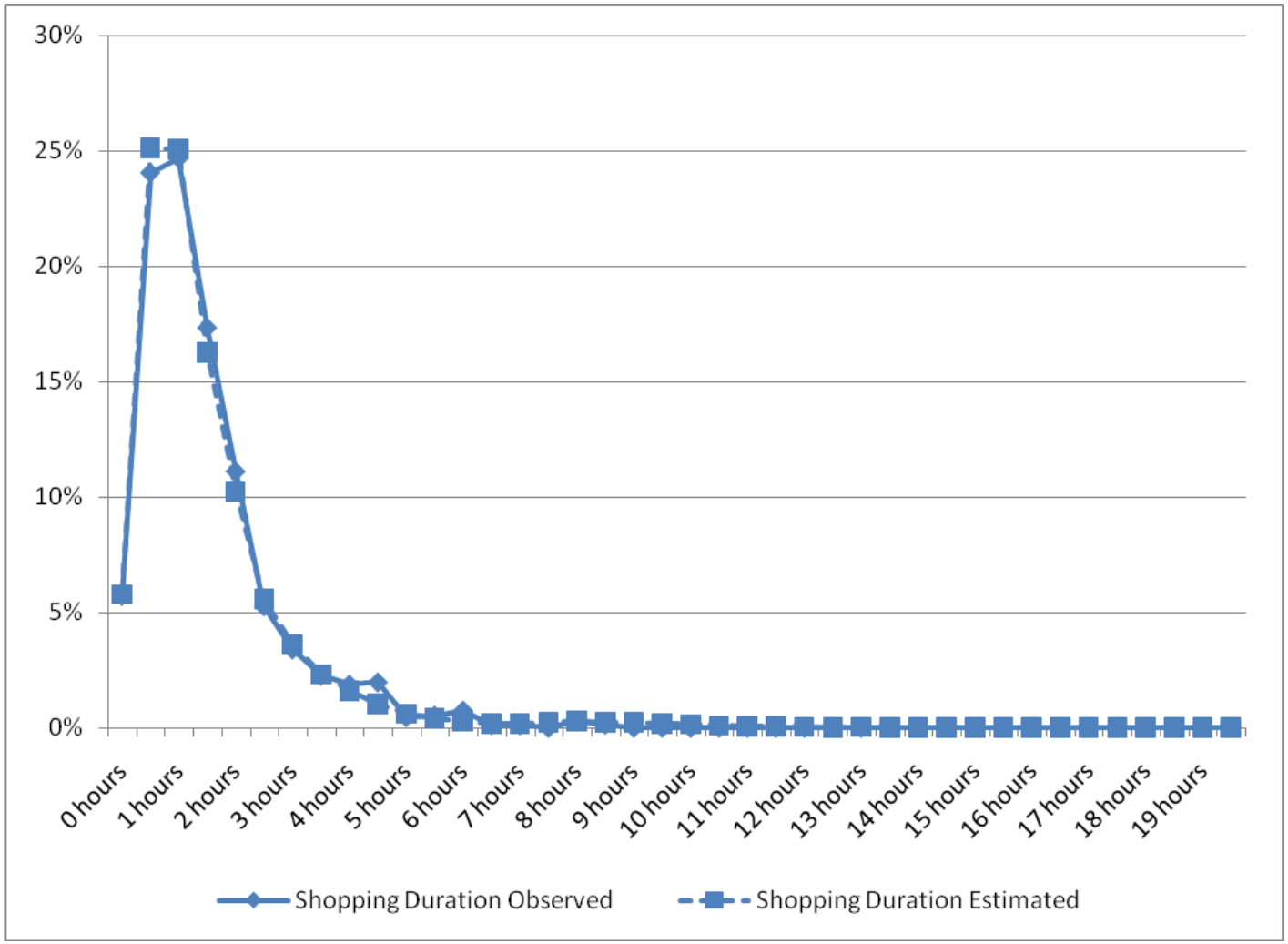
TOD Model Validation: Discretionary Tour Departure and Arrival Times



TOD Model Validation: Work Tour Duration

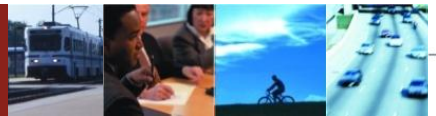


TOD Model Validation: Shopping Duration



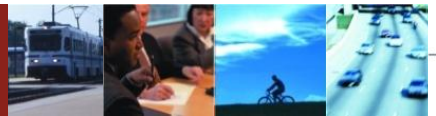
Why it is Better for Work and School

- Validation results looks perfect for mandatory (work & school tours)
- Validation results look reasonable but less perfect for non-work tours
- What is the reason and possible improvements?
  - Work and school activities have clear schedules and it is easier to relate them to person characteristics
  - Work and school tours are modeled first in the scheduling chain; non-work activities are subject to compounding of small errors
  - Improvements in entire-schedule conditionality and sequence of scheduling steps are on the way



Additional Validation against Traffic Counts

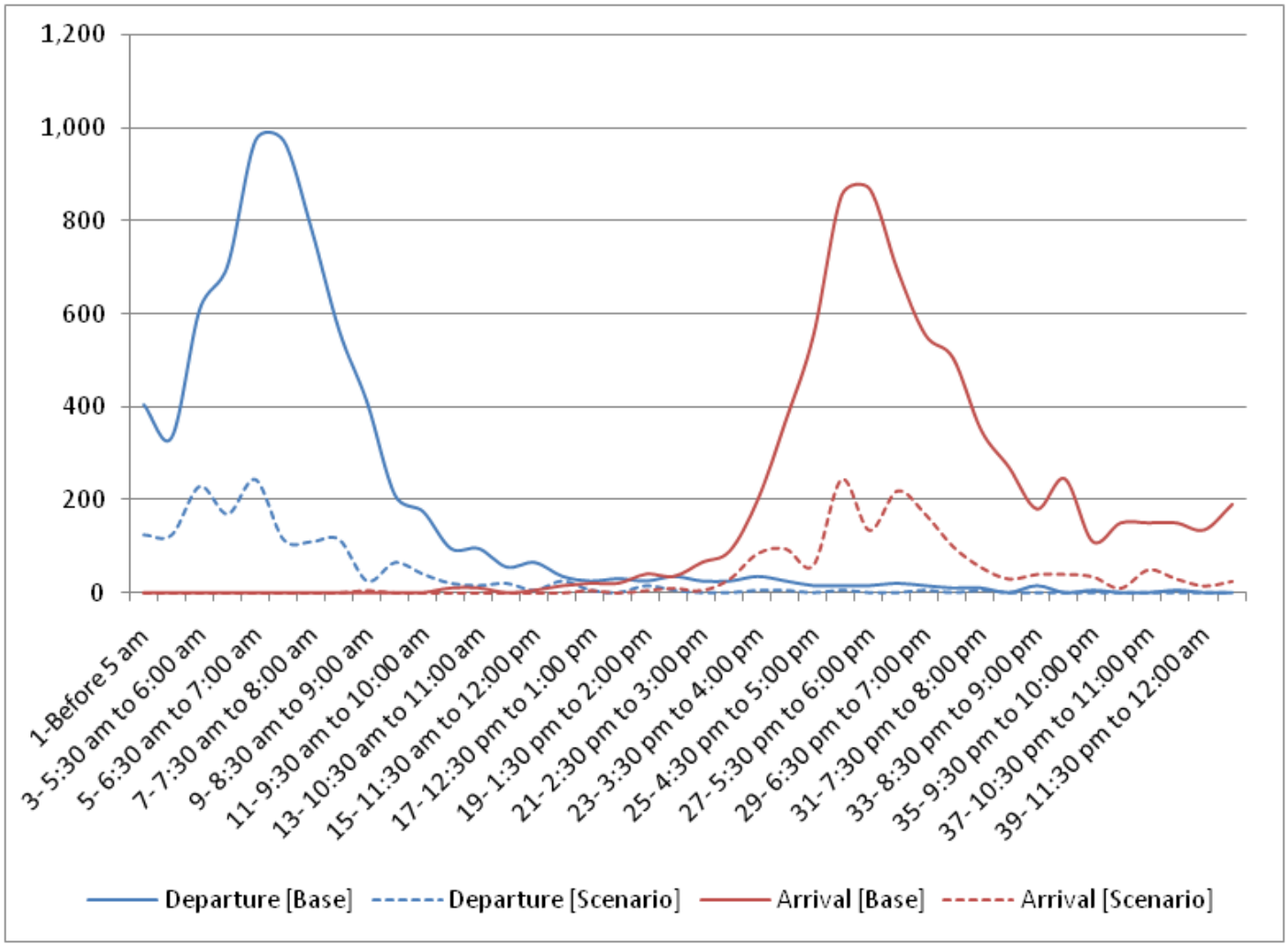
- In practice there can be significant differences between the traffic count validation at the hour/half-hour level and the household survey
  - Household survey expansion becomes "lumpy" at fine origin-destination level
  - Trip duration comes into play
- Additional validation is desired and calibration effort might be needed
  - Origin-destination specific adjustments can be introduced in TOD choice



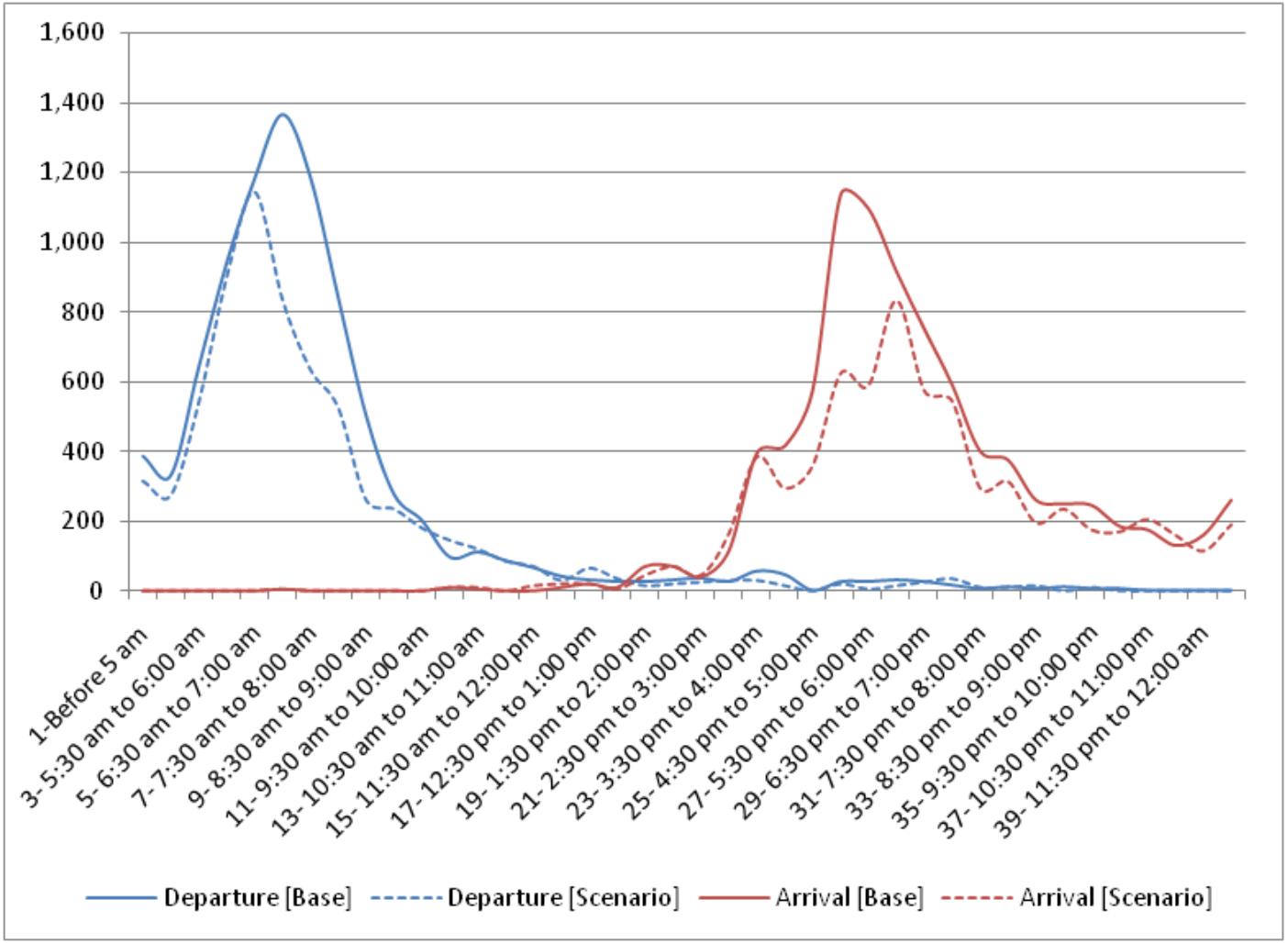
Pricing Policy Evaluation (Chicago ABM)

- 2 pricing scenarios
  - ("Global") Tolls×5 on all toll facilities during the entire day
  - ("Congestion") Tolls×5 on all toll facilities for peak periods only (7am-9am and 4pm-6pm)
- We present results
  - ("Global") Absolute number of toll users vs. the base
  - ("Congestion") Absolute number of toll users vs. the base
  - ("Congestion") TOD distribution of toll users vs. the base (peak spreading effect)

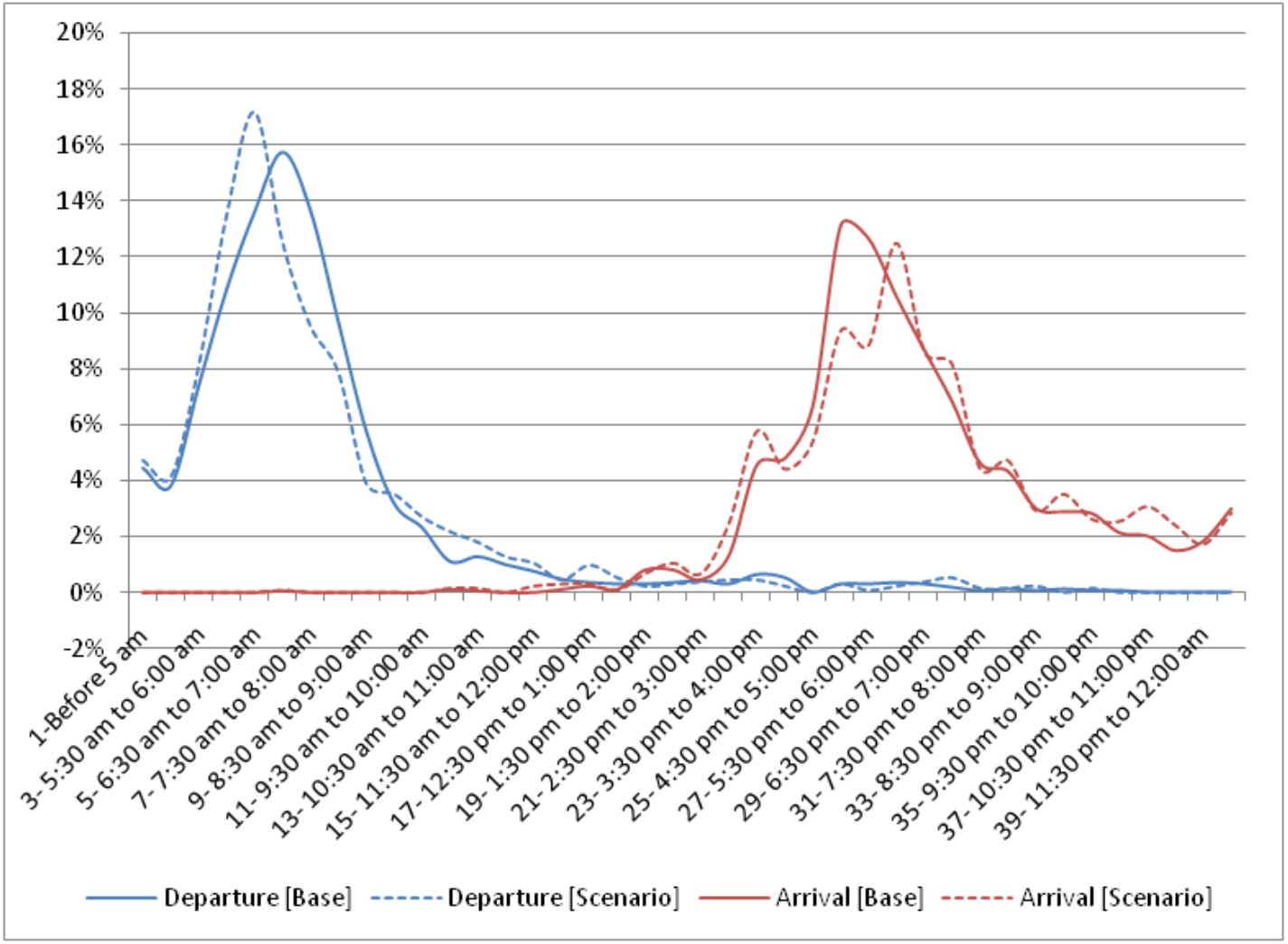
Impact of "Global" Pricing



Impact of "Congestion" Pricing

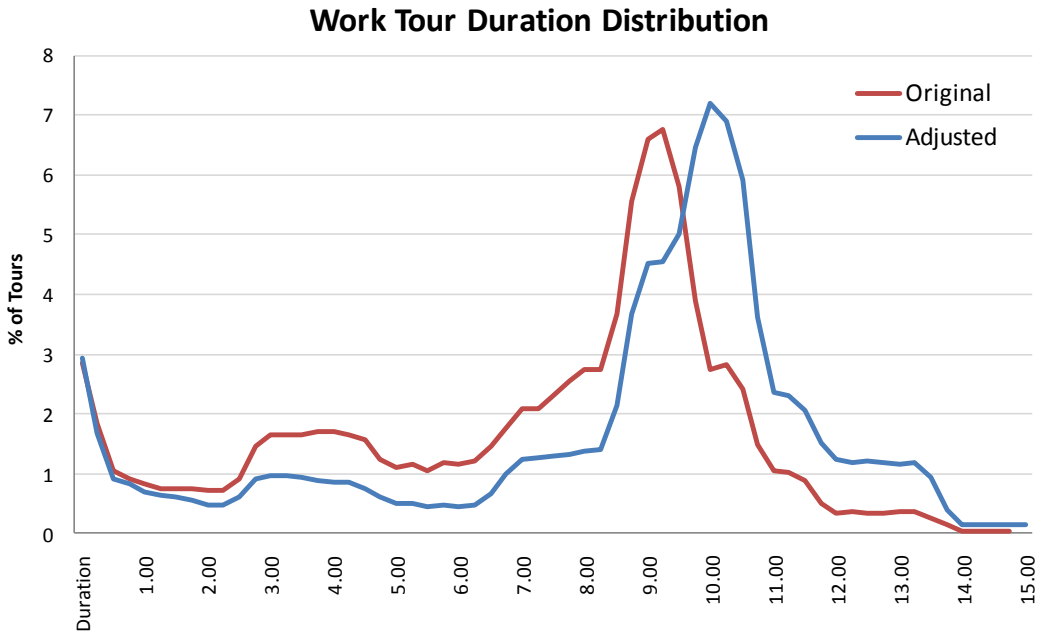


Peak-Spreading Effect



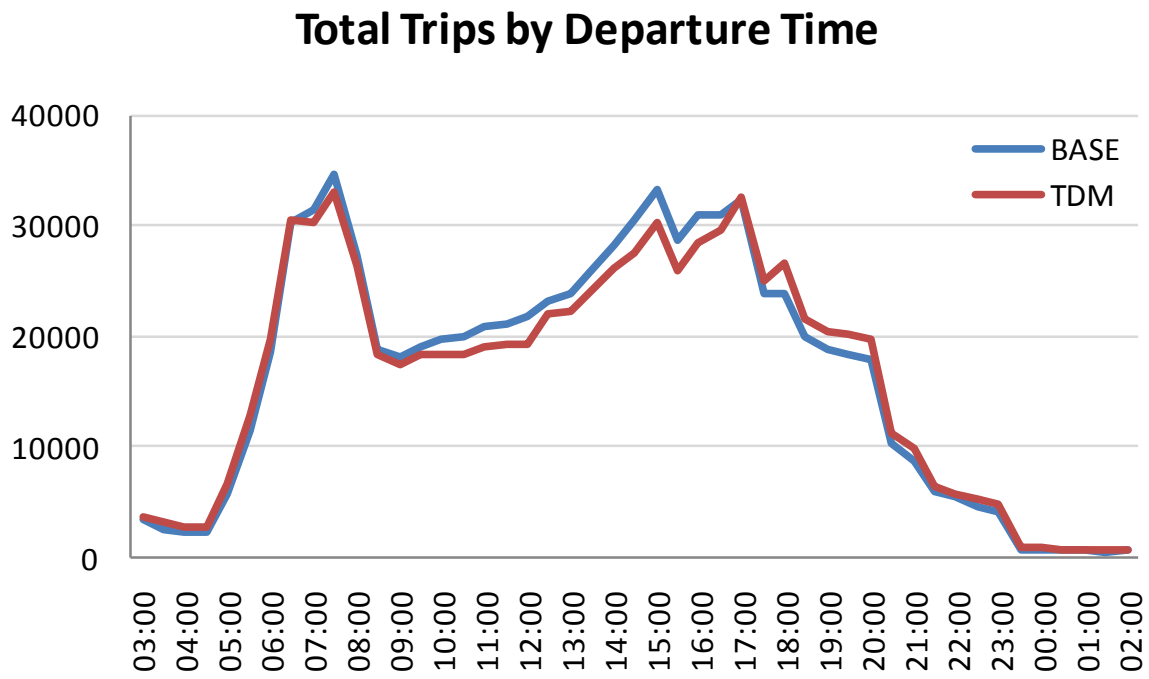
Travel Demand Management Evaluation (Burlington ABM)

- "Flexible Schedule" scenario
- Asserted assumptions about
  - Fewer individual work activities
  - Longer individual work durations
  - Aggregate work durations constant
- Target: Fulltime Workers



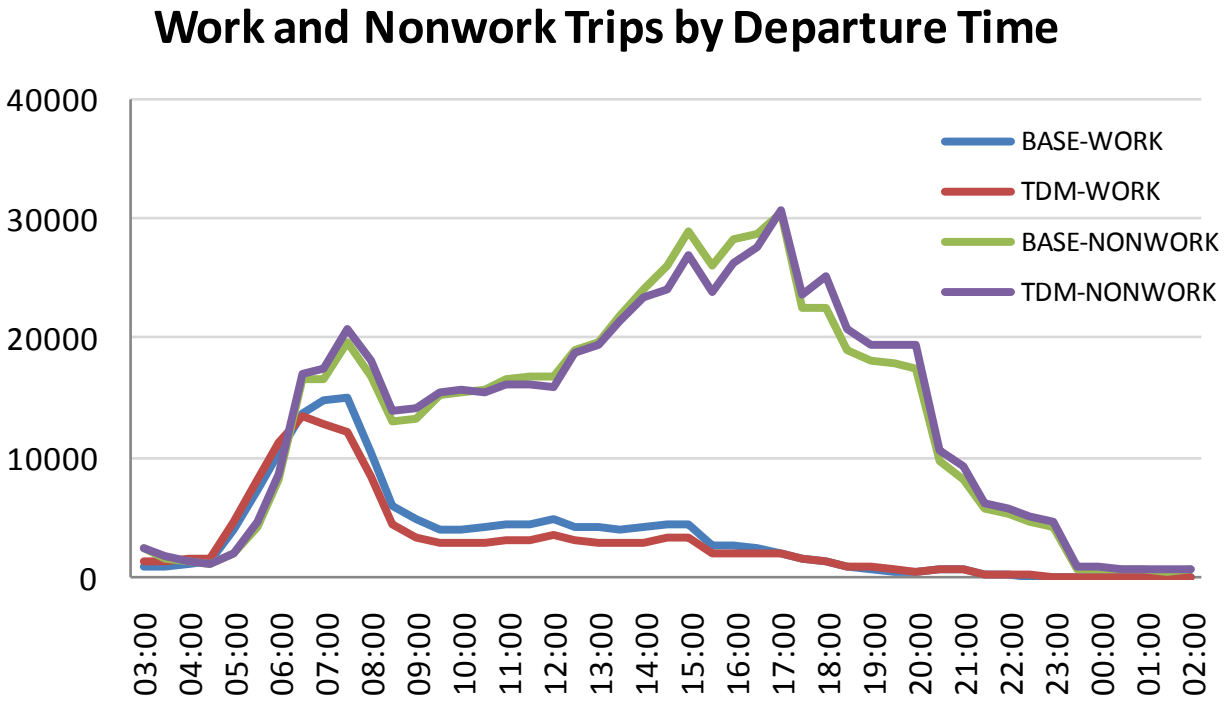
TDM Total Trip Impacts

- Reduced peak period and midday travel
- Slightly more early AM travel
- Significantly more evening travel



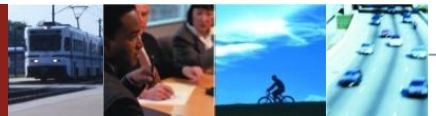
TDM Trips by Purpose

- Fewer, and earlier, work trips
- More non-work trips in morning and evening with fewer in midday



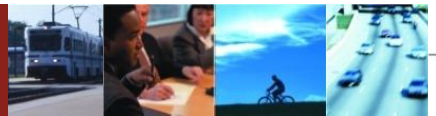
Ongoing Research: Core Tour & Trip TOD

- Flexible correlation patterns
  - Nesting across similar departures, arrivals, and/or durations [Lemp et al, 2011; Hess et al, 2007]
  - Differential shifts from peak periods to shoulders vs. other [Small, 1987 (Ordered GEV)]
- Functional form of the utility
  - Non-linear shift-type variables and profiles
  - Exogenous activity supply-side variables (workday, opening hours) [SCAG ABM]
- TOD joint with other choice dimensions
  - Joint mode and TOD choice [Hess et al, 2007]
  - Joint destination and TOD choice [de Jong et al, 2003]
  - Car allocation within household and TOD choice [Vovsha & Petersen, 2005]



Ongoing Research: Daily Schedule and Beyond

- Moving toward continuous representation of time (FAMOS, CEMDAP, DASH)
- ABM-DTA integration with enhanced temporal resolution (SHRP 2 C10 and L04 Projects)
- Integrated activity generation and scheduling procedures
  - Multiple Discrete Continuous Extreme Value (MDCEV) models (SCAG ABM; Bhat et al, 2010)
  - Real-time activity re-planning during the day (ADAPTS)
- Multi-day scheduling framework (ALBATROSS)
- Multi-stage scheduling procedures
  - Relaxation and consolidation rules [TASHA]



Extending TOD Choice Framework: ALBATROSS

- Fundamental behavioral observation
  - People do not schedule and implement activities in one day
  - Some activities (special events) are scheduled many days in advance and come into daily schedule as pre-fixed
  - Some activities (shopping) occur periodically and can be shifted between days
  - Some activities (work, school) occur daily
- Modeling schedules requires longer time horizon (at least week)
  - Fixed events scheduled first
  - Daily activities are scheduled initially to assess time availability
  - Periodic activities are scheduled on certain days based on the "need" frequency function
  - Daily activities are adjusted if needed to accommodate periodic activities

Summary: TOD Model Structure

- TOD choice
  - Key component of ABM
  - Closely intertwined with tour generation, destination choice, and mode choice
- Temporal resolution improving
  - From aggregate TOD periods to 30 min and eventually to continuous time
- Tour-level TOD is joint choice of
  - Departure from home (or arrival at primary destination)
  - Arrival back home (or departure from primary destination)
  - Tour duration (or activity duration)
- Trip-level TOD choice conditional upon tour TOD
  - Trip departure time

Summary: TOD Model Application

- Described TOD modeling framework
  - Incorporates wide variety of variables and effects including person, household, travel and other variables
  - Generates consistent individual daily schedules w/o gaps or overlaps
  - Realistically sensitive to congestion, pricing, and other policies (compressed work weeks)
  - Successfully applied in many ABMs in practice and tested for many projects

Questions and Answers

The Travel Model Improvement Program

Next Webinar

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 Framework	April 5
Population Synthesis and Household Evolution	April 26
Accessibility and Treatment of Space	May 17
Long-Term and Medium Term Mobility 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