Imperial College London

**The Use of Activity-Based Accessibility Measures in Land Use and Other Long Term Life Style Models**

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**Abstract**
This paper presents the extension and integration of the general activity-based travel demand model framework to present the complex relationship between various long term individual decisions regarding residential and work location, auto ownership and other lifestyle decisions and his or her daily activity and travel behaviour. This produces an improved methodological framework for analyzing various land use and transport policies that affect both types of decisions. The paper first develops a theoretical model framework that broadens the activity-based framework to include long term choices and land-use policies in particular, and to improve the two way interrelationships between long and short term activity and travel behaviour. In particular, we develop activity-based accessibility measures that take the information from the activity-based model of the person's access to various activities in order to study how it affects longer-term decisions such as auto ownership and residential choice. This brings the activity-based models, to a level relevant for analyzing various policies affecting individual long-term choices and in particular the effect of land-use policies on people`s residence choice, activity patterns and travel behaviour. The paper then presents a case study using such activity-based accessibility measures in the auto ownership model of the Tel Aviv metropolitan area. While the decision on car ownership significantly affects activity and travel patterns, it is also highly influenced by the need and desire to participate in various activities in space and by the accessibility that the transportation system provides to these activities. Many auto ownership models include some variables of accessibility reflecting the performance of the transportation system on auto ownership such as the number of work places reached within an hour of travel. However, such variables do not reflect the individual`s need to participate in activities. It is the activity-based accessibility (ABA) measure that can take the information from the activity-based model of the person`s access to various activities in order to study how it affects longer-term decisions such as auto ownership. The paper discusses the trade-off between the model computation complexity which such measures bring and behavioural realism, and suggests and demonstrates the use of various simplified activity-based measures in the car availability model developed for the Tel-Aviv. Various model structures were tested for the car availability model including multinomial logit, nested logit ordered logit, and mix logit including these two types of accessibility variables. The estimated model is used to explore how the inclusion of these accessibility variables affects car availability under different policy scenarios considered for the Tel-Aviv metropolitan area including congestion pricing, parking policies and new planned mass transit system. These case studies provide insight on the role of the accessibility measures on car availability and better understanding of the effect of different policy measures on car availability and travel behaviour under such policy scenarios.

**Biography**
Prof. Yoram Shiftan is the Head of the Transportation and Geo-Information Department in the Faculty of Civil and Environmental Engineering at the Technion, the Israel Institute of Technology. Prof Shiftan teaches and

conducts research in travel behavior with a focus on activity-based modeling and response to policies, the complex relationships between transport, the environment and land use, transport economics and project evaluation, and has over 25 years of experience in these areas, both in academia and in the practice. Prof. Shiftan is the editor of Transport Policy and the secretary/treasurer of the International Association of Travel Behavior Research (IATBR). He is a member of the Transportation Research Board (TRB) Committee on Travel Behavior and Values, the co-chair of the Network on European Communications and Transport Activities Research (NECTAR) cluster on Environment and Policy, member of the World Conference Transportation Research (WCTR) scientific committee, and chair of its Transport Security Special Interest Group. Prof. Shiftan received his Ph.D. from MIT and since then has published dozens of papers and co-edited the book "Transportation Planning" in the series of Classics in Planning, as well as the forthcoming book "Transition towards Sustainable Mobility, The Role of Instruments, Individuals and Institutions." He has been a guest editor of special issues of two publications (Evaluation and Program Planning and the Journal of Choice Modeling) and he is a member of the editorial board of five journals: Transport Policy, Transportation Letters, Journal of Choice Modeling, Journal of Environmental Protection, and Open Transportation Journal. In Israel Prof. Shiftan was the president of the Israel Association of Transportation Research and chaired two of its annual conferences.

# The Use of Activity-Based Accessibility Measures in Land Use and Other Long Term Life Style Models

**Yoram Shiftan, Technion**
**Imperial College, October 2011**

# Outline

- Daily activity travel behavior and longer term decisions
- Activity Base Accessibility Measures
- Behavioral realism vs. computational complexity
- Tel-Aviv Metropolitan Model Structure
- Car Availability Model
- Simplification of Car Availability Model
- Main results

# Land Use Policies

- Mixed land use
- Concentration schemes
- Urban design
- New urbanism and smart growth

- Assuming residents of “New Urbanism” drive less
- Will lead to less congestion and air pollution

# Land Use Effects on Travel Behavior

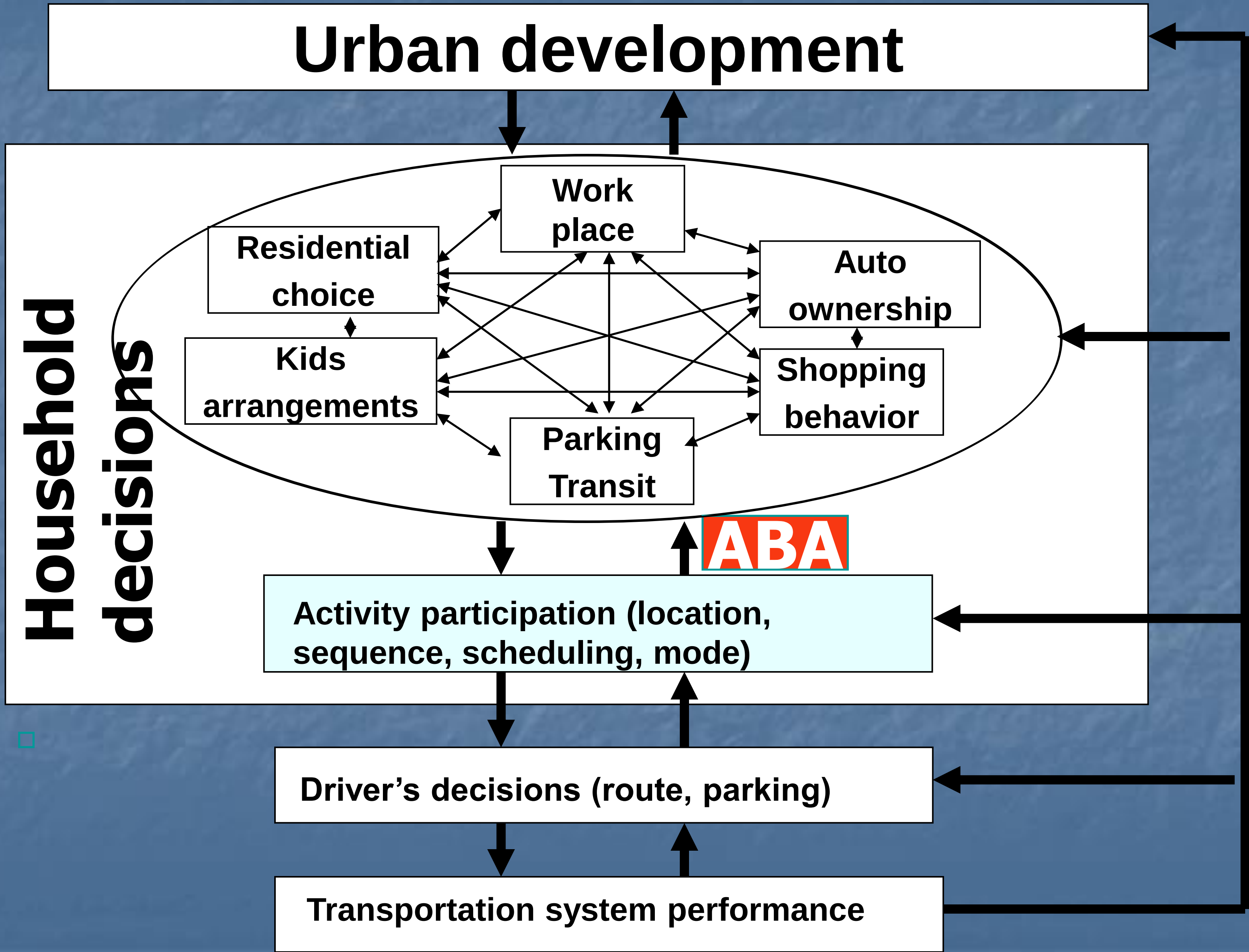
- The research of the build environment on travel behavior is non-conclusive (selectivity bias)
- The effect of improved accessibility: shorter travel time and more access to activities, may induce more travel
- Mixed results in the literature
- Not much can be said about the effectiveness of urban design and land use planning in reducing traffic.

# Exogenous Activity Based Accessibility Measures

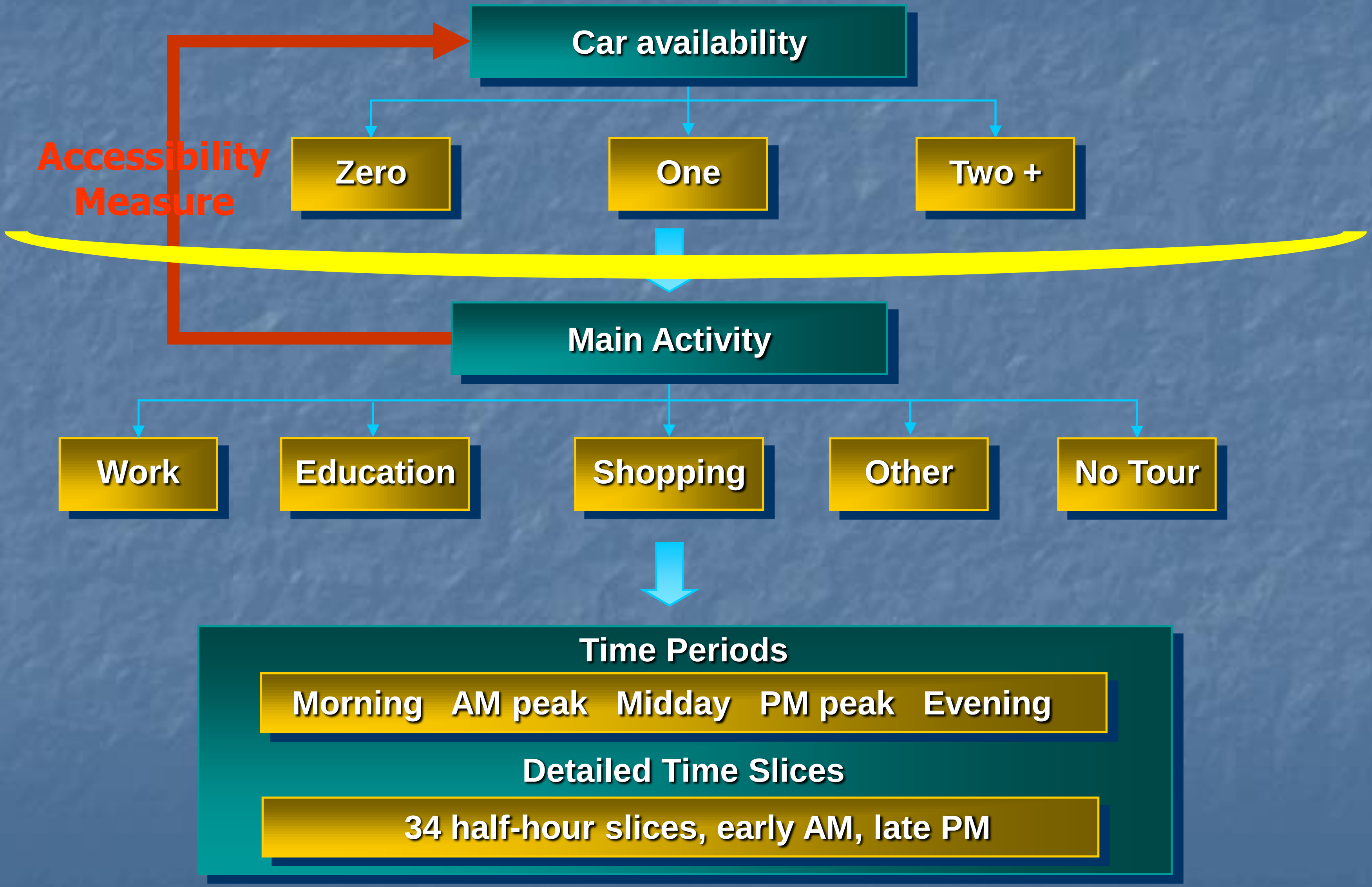
- Accessibility as space-time feasibility to better understand individual's accessibility experience (Miller, 1991/2, Kwan, 1998/9)

- However, they treat important attributes of the activity pattern as exogenous, the measures of accessibility depending on the activity opportunities that can be attained.

# Overall Framework



# Tel-Aviv Metropolitan Model



# Accessibility Measure

- Logsum variables represent the expected utility value from lower level models

- Calculated As:

$$Logsum = \ln\left(\sum_d \exp(V_d)\right)$$

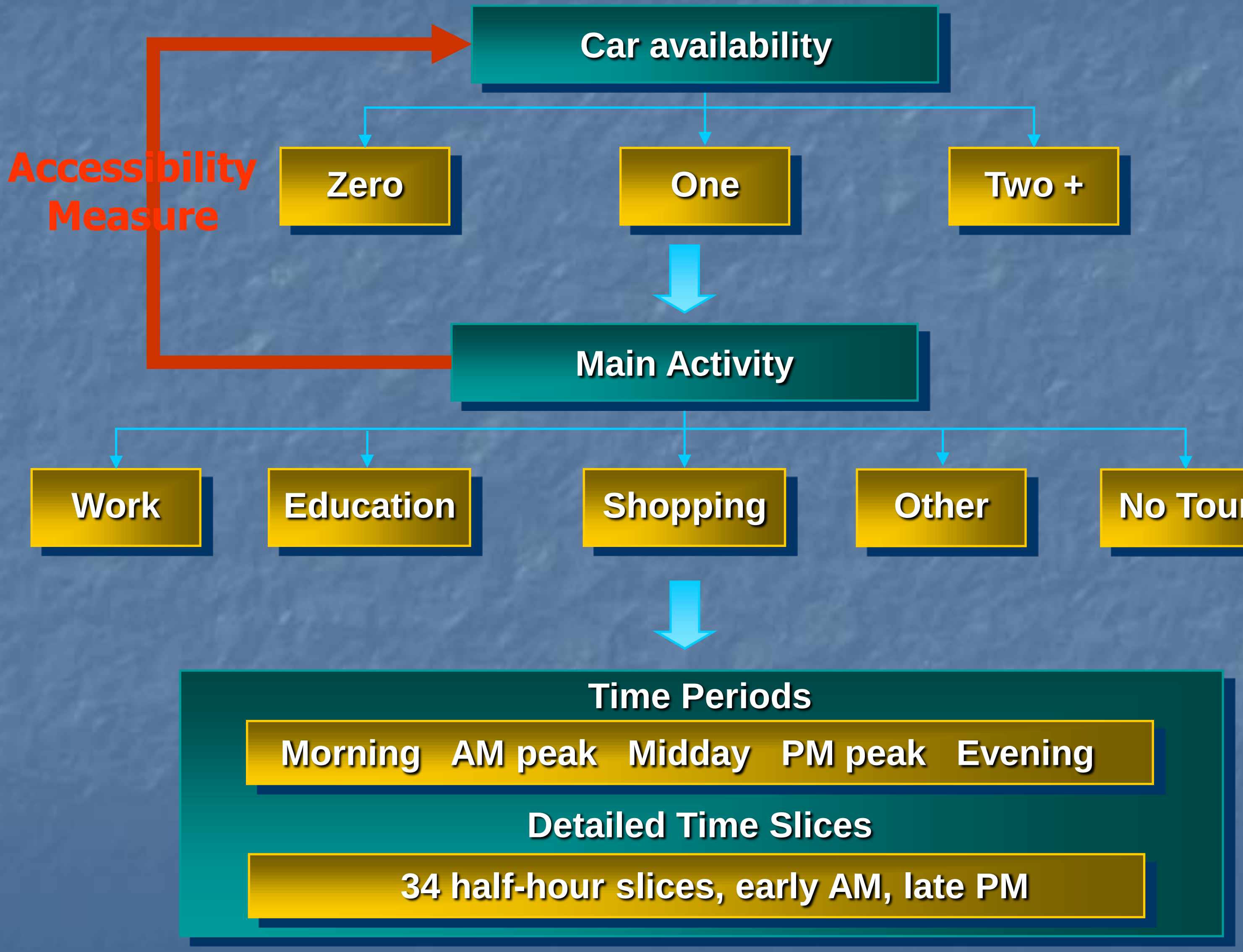
- Activity Logsum Case:

$$Logsum = \ln\left[\left(V_{NO\ TRIP}\right) + \alpha \times \ln\left(V_{WORK} + V_{EDUCATION} + V_{SHOPPING} + V_{OTHER}\right)\right]$$

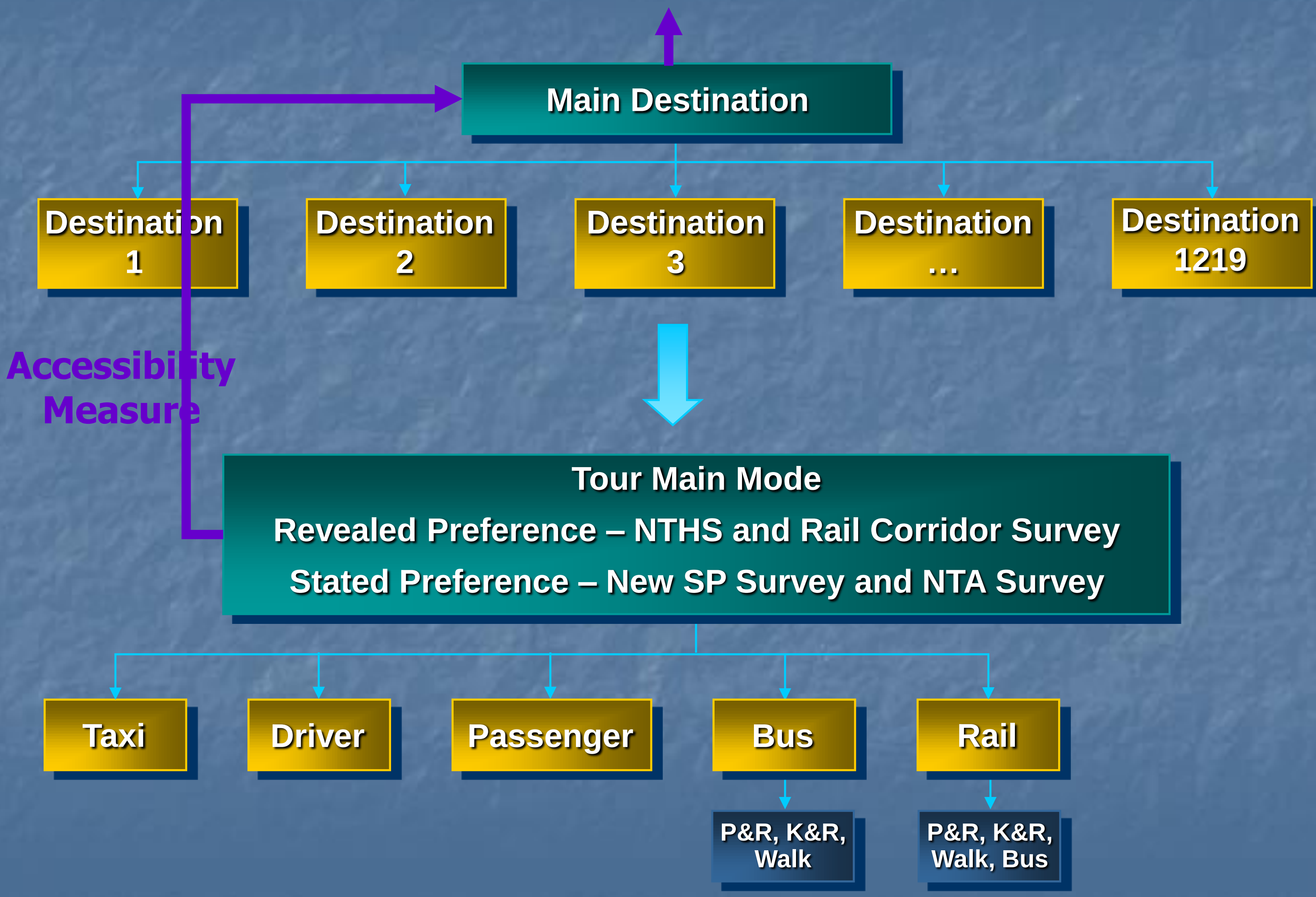
# Activity Based Accessibility Measures

- Ben-Akiva and Bowman (1998) - accessibility as the expected value of the individual maximum utility among the activity schedule available.
- Allow one residential location to have different accessibilities for different people
- Can take the information from the activity-based model of person's access to various activities in order to study how its affect long-term decisions.
- Can reflects  travel time and costs of all travel modes to all destination from all trips during the day.
- The ABA treats activities endogenously through a micro-economic approach based on specifying utilities of activity participation.
- Dong et al (2006) used it to analyze various policies.
- Ben-Akiva and Bowman estimate residential choice model

# Tel-Aviv Metropolitan Model



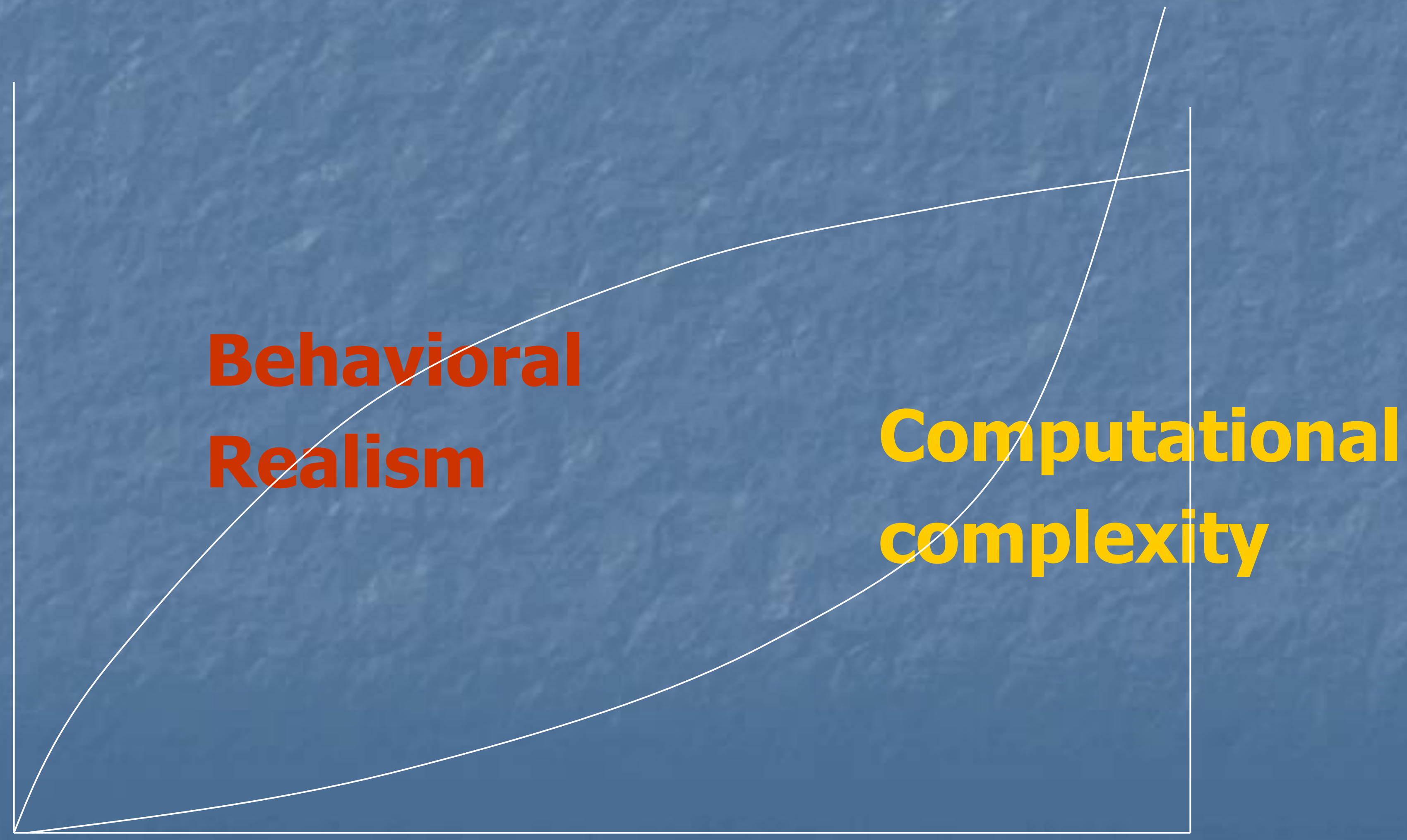
# Tel-Aviv Metropolitan Model



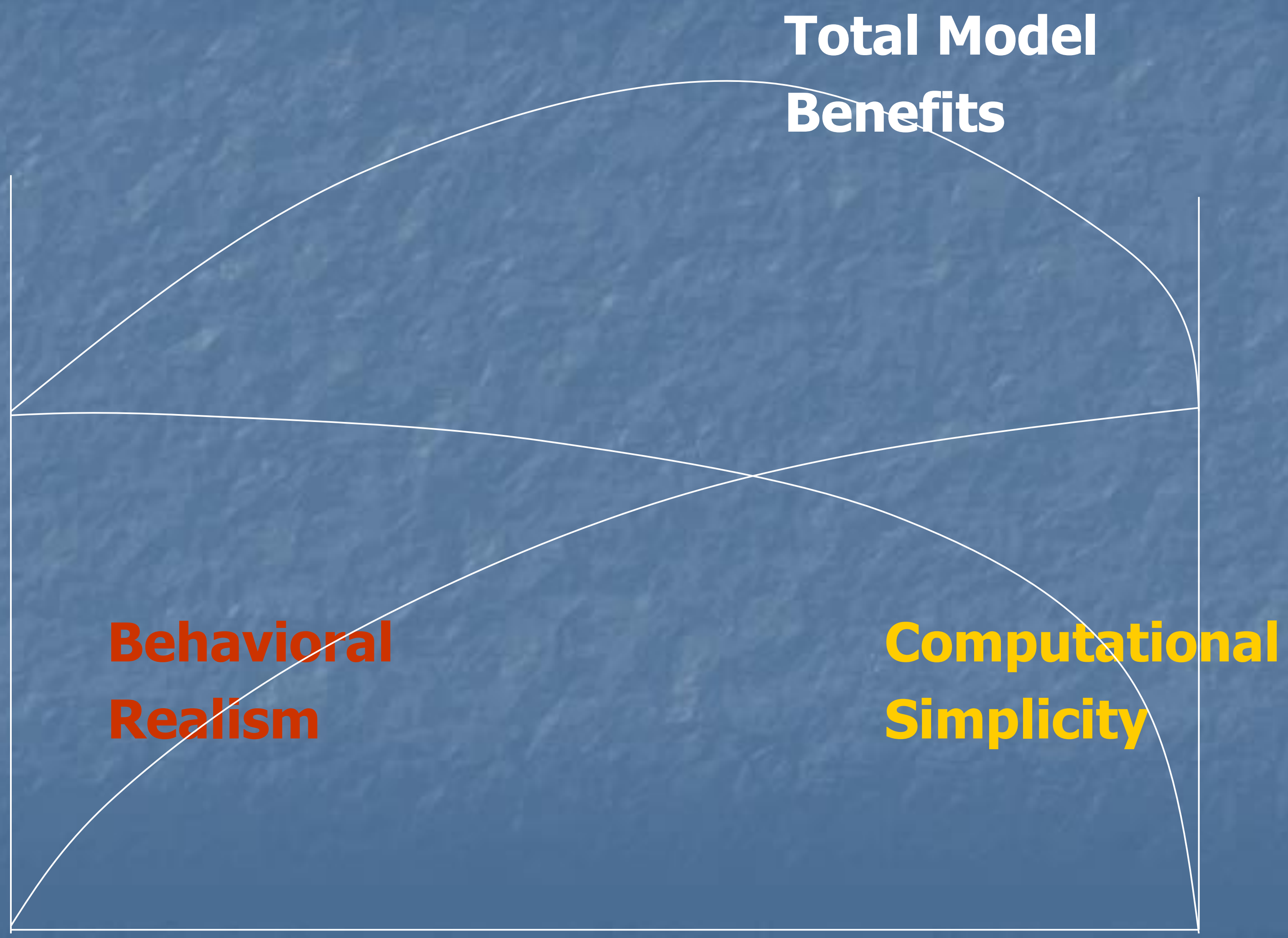
# ABA Measures are complicated
# They add significant running time in applying ABM

- The need to calculate the utility of every combination of the many alternatives
- Can be in the scale of millions for an entire AB model
- Start from the bottom of the model structure going up the tree and then calculating probabilities back down the tree structure

# Behavioral Realism and Computational Complexity



# Benefits from Behavioural Realism and Computational Simplicity



# Simplifications/Short Cuts in ABA measures:

- Capture the most important accessibility effects
- Approximate the expected utility logsum:
  - Aggregate logsums – ignoring some differences among individuals
  - Use logsums for a carefully chosen subset or aggregation of the available alternatives
  - Simulate a conditional outcome using a probability weighted Monte Carlo draw

# Examples

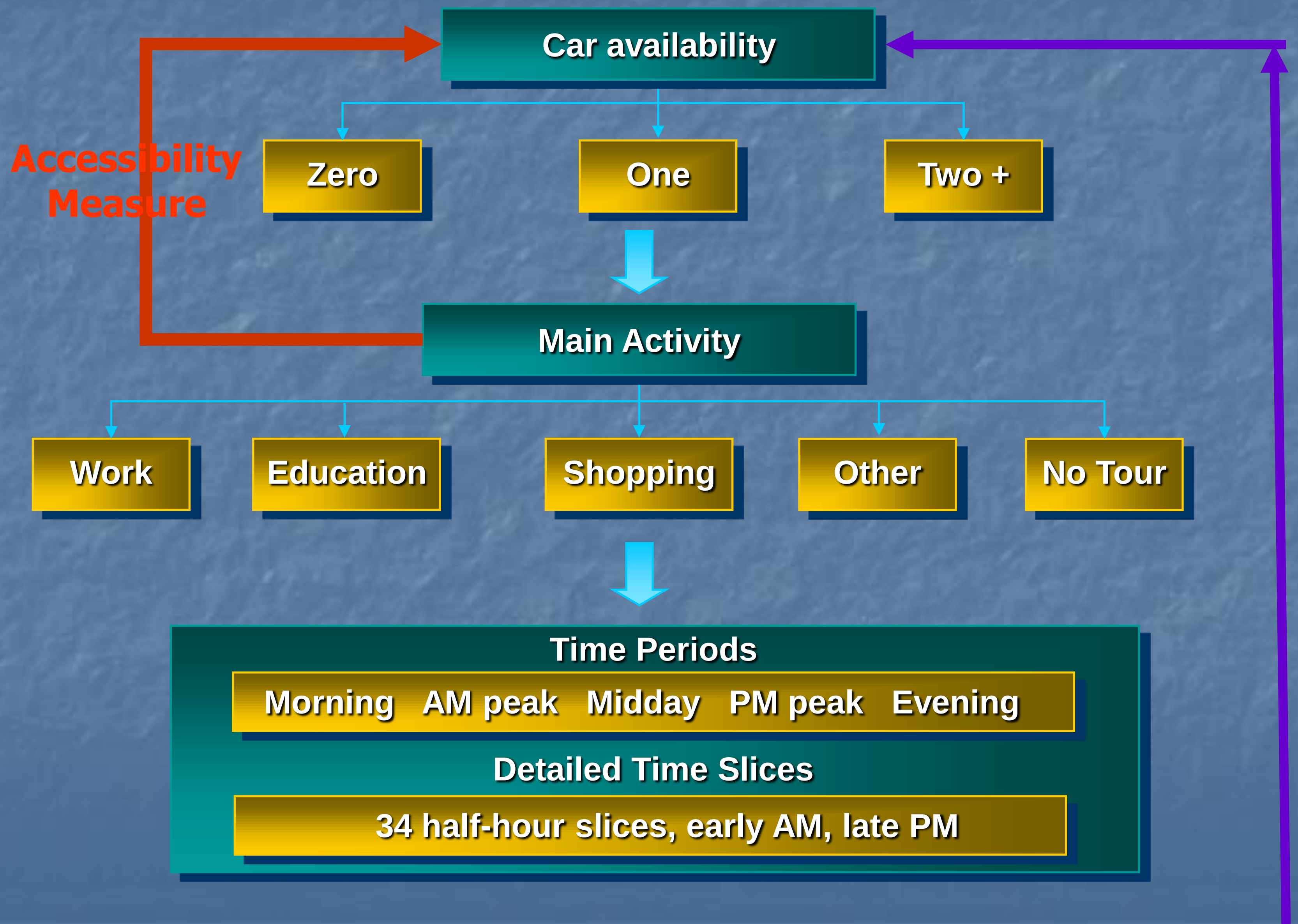
- San Francisco
  - Work mode choice accessibility logusms (to be fed into work location model) are calculated assuming AM Peak - PM Peak tour with no intermediate stops
- Sacramento
  - The assumed conditional outcome is selected by Monte Carlo draw using approximate probabilities
  - Aggregate logsums
- However, these simplifications results in unknown biases

# Accessibility Measures in the Tel Aviv Car Availability Model

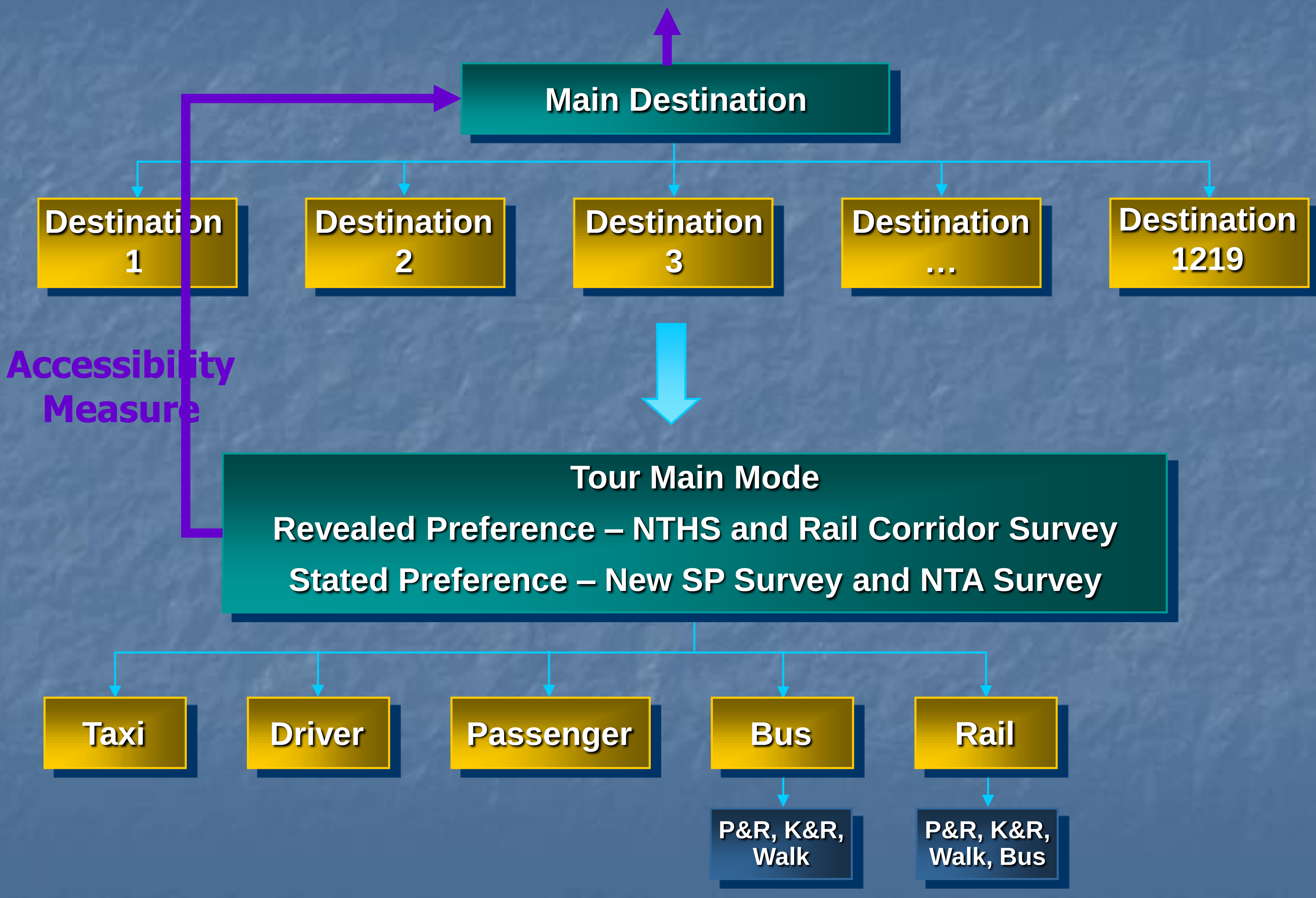
- **Two Accessibility Measures:**

  - Main Activity Accessibility Measure
  - Main Mode-Destination Accessibility Measure

# Tel-Aviv Metropolitan Model



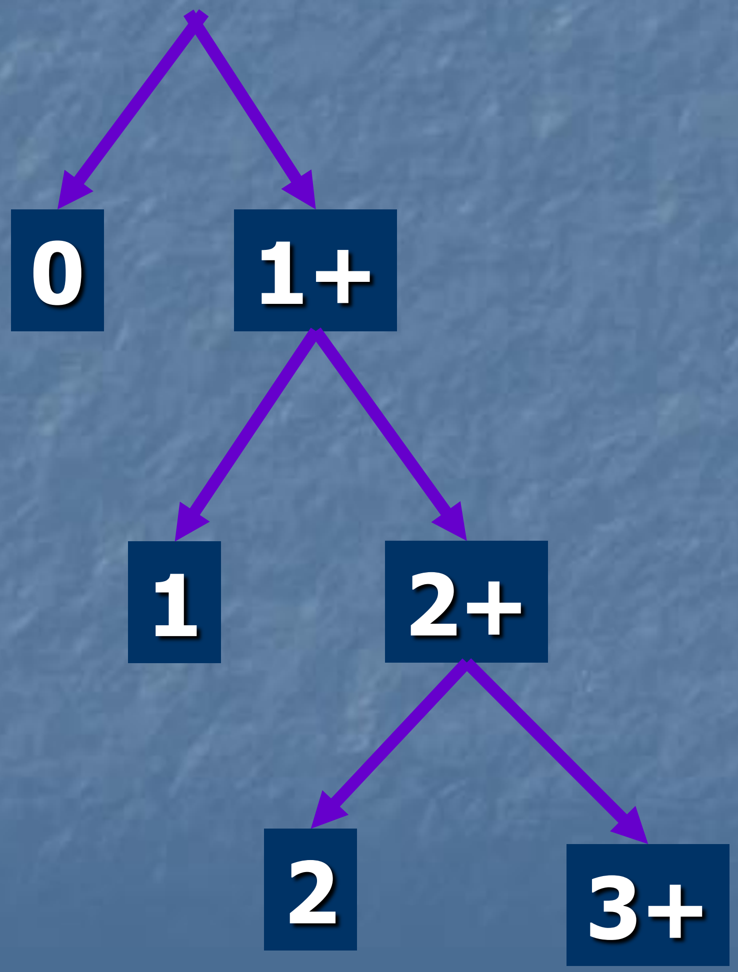
# Tel-Aviv Metropolitan Model



# Accessibility Measures Simplifications

- Main Activity logsum with no feedback from lower models
- Mode-Destination logsum was incorporated directly.
  - only for work purpose at the AM peak period
  - The mode choice logsums are varied only by time variables and aggregated for individual characteristics
- 6 Times longer to run the model with the simplified Logsum

# Car Availability Model Structure



# Full Model Estimation

| *Variable* | *Utility 1 Car* | *Utility 2 Cars* | *Utility 3 Cars* | *Utility 0 Cars* |
|---|---|---|---|---|
| Activity Logsum for CarY- Activity Logsum for CAR N | | 1.170 *[2.00]* | | |
| Constant | -2.380 *[-8.26]* | -4.430 *[-8.59]* | -6.040 *[-7.13]* | |
| Destination Logsum for 1 Car | 0.542 *[4.170]* | | | |
| Destination Logsum for 2 Car | | 0.682 *[4.450]* | | |
| Destination Logsum for 3 Car | | | 0.740 *[4.440]* | |
| Destination Logsum for 0 Car | | | | 0.479 *[3.950]* |
| Educated Dummy (1 of Person has 15 or more years of study) | 0.367 *[5.880]* | 0.625 *[8.810]* | | |
| Number of Fulltime Workers in a Household | 0.075 *[2.200]* | 0.177 *[4.153]* | 0.213 *[4.392]* | |

# Full Model Estimation

| *Variable* | *Utility 1 Car* | *Utility 2 Cars* | *Utility 3 Cars* | *Utility 0 Cars* |
|---|---|---|---|---|
| **Number of Part time Workers in a Household** | 0.051<br>*[0.970]* | 0.177<br>*[2.810]* | | |
| **Number of Men havig license in a Household** | 2.004<br>*[33.690]* | 2.296<br>*[39.110]* | 2.537<br>*[27.510]* | |
| **Population Density (Population/Area in km2)** | -0.0000089560<br>*[-3.410]* | -0.0000306836<br>*[-6.590]* | -0.0000390280<br>*[-6.090]* | |
| **Number of Women havig license in a Household** | 1.495<br>*[26.420]* | 1.866<br>*[30.230]* | 2.075<br>*[21.57]* | |
| | ***Estimator*** | ***t-test0*** | ***t-test1*** | |
| NESTA | 0.478 | 5.08 | 2.65 | |
| NESTB | 0.335 | 4.12 | 2.74 | |
| ***Onservation Number*** | ***15866*** | | | |
| ***Init log-likelihood*** | ***-21994.9*** | | | |
| ***Final log-likelihood*** | ***-13723.4*** | | | |
| ***Rho-square*** | ***0.376066*** | | | |

# Estimation Results

## Choice Between 0 and 1+ Vehicles

| 0 CARS VS. 1 CAR | | |
|---|---|---|
| *Variable* | *Utility 1 Car* | *Utility 0 Cars* |
| Constant | -2.770 *[-9.75]* | |
| Destination Logsum for 1 Car | 1.340 *[12.36]* | |
| Destination Logsum for 0 Car | | 1.17 *[11.53]* |
| Educated Dummy (1 of Person has 15 or more years of study) | 0.395 *[6.61]* | |
| Number of Workers in a Household ( Full time +Part Time ) | 0.143 *[5.07]* | |
| Number of Men havig license in a Household | 1.950 *[38.31]* | |
| Number of Women havig license in a Household | 1.500 *[32.78]* | |
| Population Density (Population/Area in km2) | | -1.32E-05 [-5.11] |
| | ***Estimator*** | |
| ***Onservation Number*** | ***15866*** | |
| ***Init log-likelihood*** | ***-10997.473*** | |
| ***Final log-likelihood*** | ***-5540.853*** | |
| ***Rho-square*** | ***0.496*** | |

# Estimation Results

## Choice Between 1 and 2+ Vehicles

| *Variable* | *Utility 2 Car* | *Utility 1 Cars* |
|---|---|---|
| **Constant** | -4.910<br>*[-17.24]* | |
| **Destination Logsum for 2 Car** | 1.470<br>*[11.36]* | |
| **Destination Logsum for 1 Car** | | 1.12<br>*[8.37]* |
| **Educated Dummy (1 of Person has 15 or more years of study)** | 0.557<br>*[11.36]* | |
| **Number of  Workers in a Household ( Full time +Part Time )** | 0.256<br>*[9.64]* | |
| **Number of Men and Women havig license in a Household** | 0.784<br>*[28.96]* | |
| **Population Density (Population/Area in km2)** | | -4.90E-05<br>[-18.34] |
| | ***Estimator*** | |
| ***Onservation Number*** | ***11465*** | |
| ***Init log-likelihood*** | ***-7946.932*** | |
| ***Final log-likelihood*** | ***-6308.727*** | |
| ***Rho-square*** | ***0.206*** | |

# Estimation Results

## Choice Between 2 and 3+ Vehicles

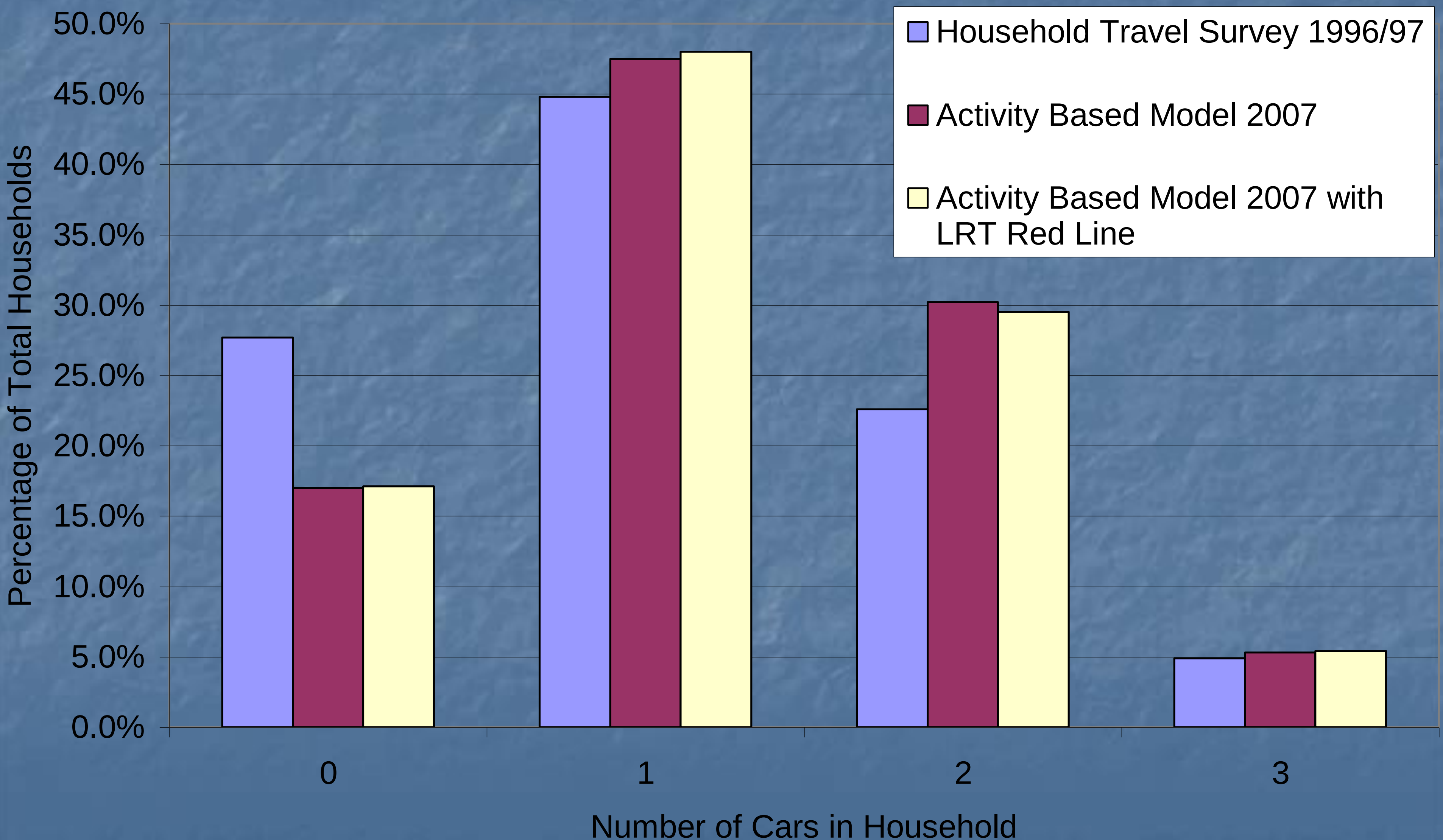
| *Variable* | *Utility 2 Car* | *Utility 1 Cars* |
|---|---|---|
| **Constant** | -3.950<br>*[-25.79]* | |
| **Number of Workers in a Household ( Full time +Part Time )** | 0.044<br>*[2.89]* | |
| **Number of Men and Women havig license in a Household** | 0.825<br>*[17.59]* | |
| **Population Density (Population/Area in km2)** | | -1.93E-05<br>*[-3.9]* |

| | ***Estimator*** |
|---|---|
| ***Onservation Number*** | ***4359*** |
| ***Init log-likelihood*** | ***-3021.429*** |
| ***Final log-likelihood*** | ***-1775.78*** |
| ***Rho-square*** | ***0.412*** |

# Summary of Main Model Results

- Driver license by gender has the most explanatory power
- Number of full time and part time workers in the household
- Population density
- Education
- Activity logsum was significant only in the full model estimation
- Mode-Destination logsum was significant

# LR Alternative



# Other Hypothetical Scenarios

| Scenario | Motorization Rate (Cars/1000 Residents) | |
|---|---|---|
| | Metropolitan | Tel Aviv Only |
| *Basic Scenario 2007* | 295 | 505 |
| *Triple the Parking Cost for Tel-Aviv Only* | 295 | 508 |
| *Triple the Parking Cost for Tel-Aviv Metropolitan* | 295 | 510 |
| *Double the Parking Cost and Walk Time for Tel-Aviv Only* | 297 | 511 |
| *Triple the Parking Cost and Walk Time for Tel-Aviv Only* | 296 | 508 |
| *With 20% increase in transit speeds* | 296 | 509 |
| *Basic Scenario 2007 with Light Rail Line* | 296 | 507 |

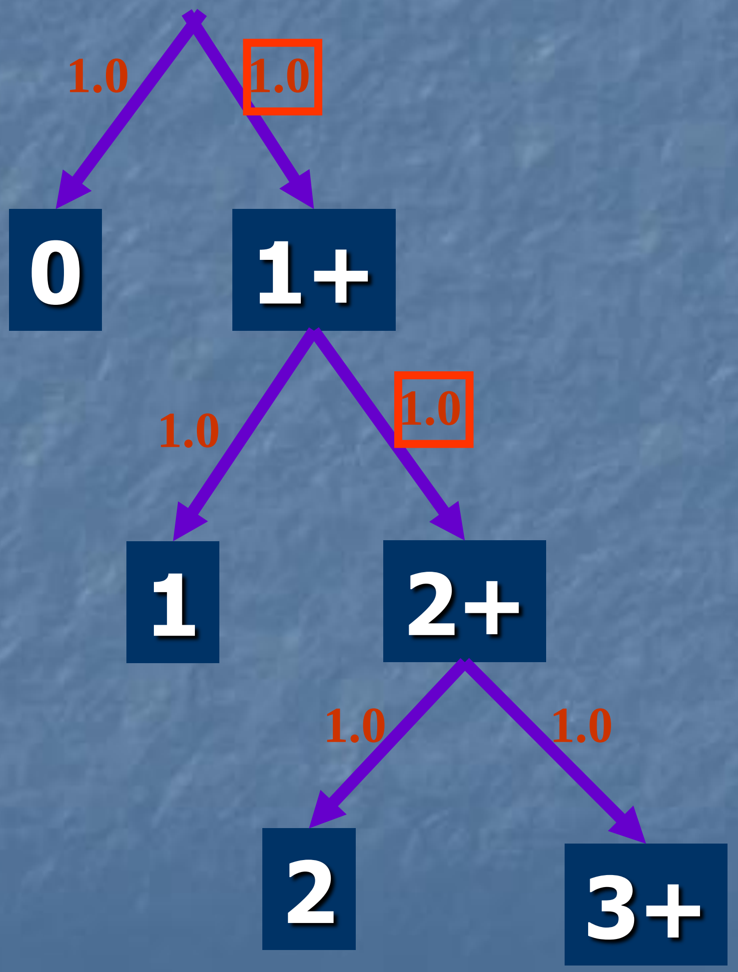
# Conclusions

- ABA measures are important elements in integrating short-term and long-term choices
- Need to carefully consider behavioral realism vs. computational complexity
- Low impact of accessibility on auto ownership in our case
- More work is needed to improve computational issues and to identify the best estimates of ABA measures

Thanks you for your attention

# Model Simplification

- **Destination Logsum Only**



# Other Scenarios

- **Basic Scenario 2007**
- **Triple Parking Cost for Tel Aviv Only**
- **Triple Parking Cost for Tel Aviv Metropolitan**
- **Double Parking Cost & Walk time (TA only)**
- **Triple Parking Cost & Walk time (TA only)**
- **Enhanced Public Transit (Increase Speeds by 20%**
- **Run with Light Rail Transit in TA**

# The Tel Aviv Auto Ownership/Activity Based Model

- Based on the NTHS data
- Additional data include:

# Mode Destination Accessibility Coefficients

| | |
|---|---|
| 0 cars: | 0.479 |
| 1 car: | 0.542 |
| 2 cars: | 0.662 |
| 3+ cars: | 0.740 |