



# RECENT INNOVATIONS IN TRAVEL MODELING

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**Transportation & Mapping Solutions**  
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# RECENT INNOVATIONS

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- Two recent projects
- FHWA's Freight Analysis Framework (FAF) v.5
  - Truck route choice assignment
- NC Research Triangle Regional Model (TRM), Gen 2
  - Decision trees for trip productions
  - Nested destination choice

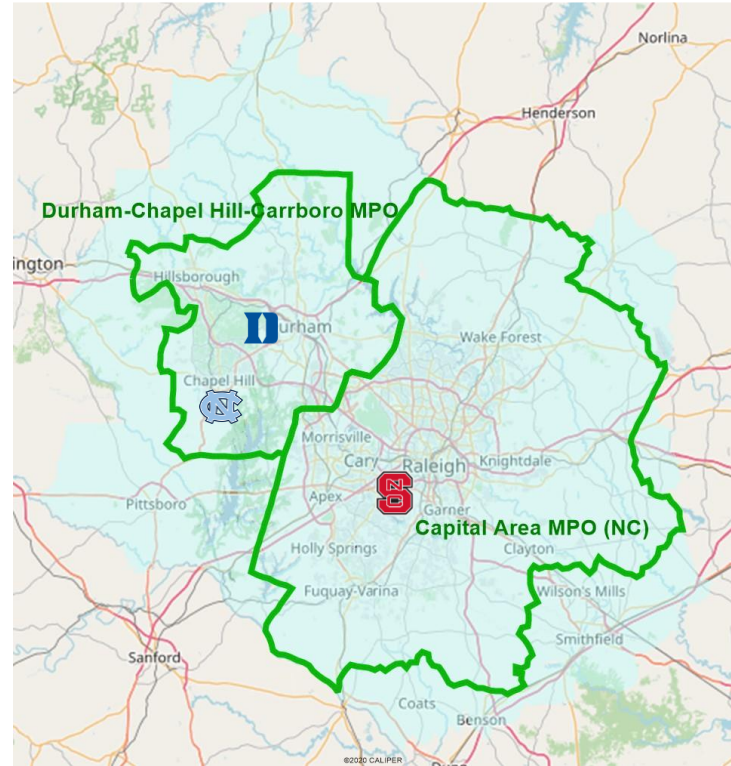
# TRM G2

KY-4



# THE NC RESEARCH TRIANGLE

- Raleigh-Durham Metro
  - Very multi-nucleated
  - Chapel Hill, Cary, Wake Forest
  - Major Research Institutions
  - Tech Industry
  - Affluent
- 1.9 Million People
- 2 MPOs – 1 Model



# A HYBRID TRIP-BASED MODEL

- Disaggregate front end, aggregate back end
- Trips, but segmented by tour type
- Advanced component models
  - Machine Learning, Destination Choice
- Linkage of Home-based & Non-home-based trips

Population Synthesis

Trip Generation

Non-Motorized  
Models

HB Destination  
Choice

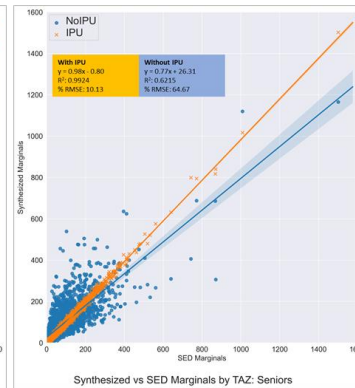
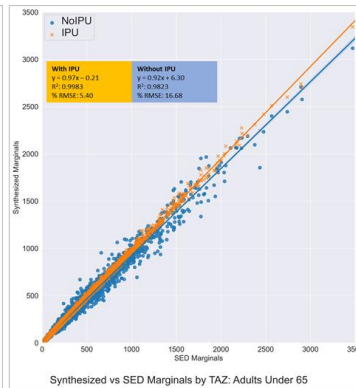
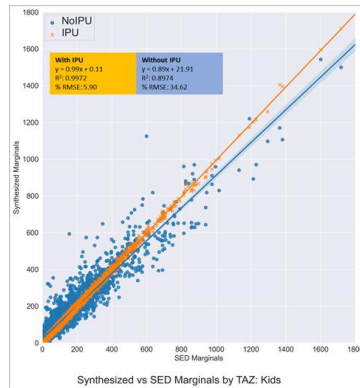
Home-based Mode  
Choice

Non-Home-based  
Models

Parking Model

# POPULATION SYNTHESIS

- TransCAD's Iterative Proportional Updating (IPU)
  - Household and Person level controls
  - Support for controls at multiple levels of geography
  - Extremely fast, ~ 2 minutes – run during model run
- Person level attributes show benefit of IPU over IPF



# POPULATION SYNTHESIS

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Population Synthesis

Trip Generation

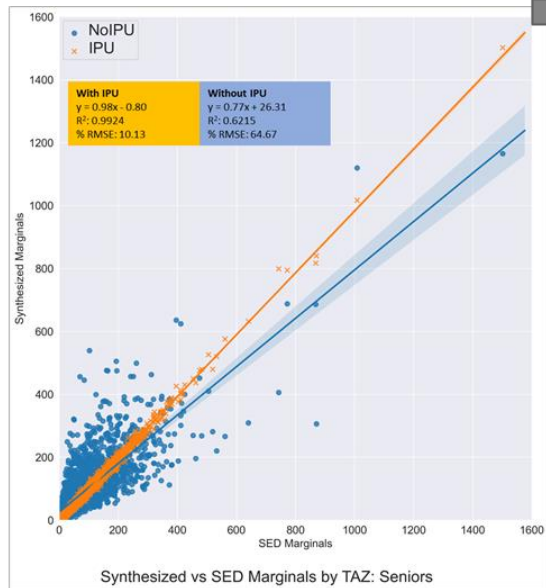
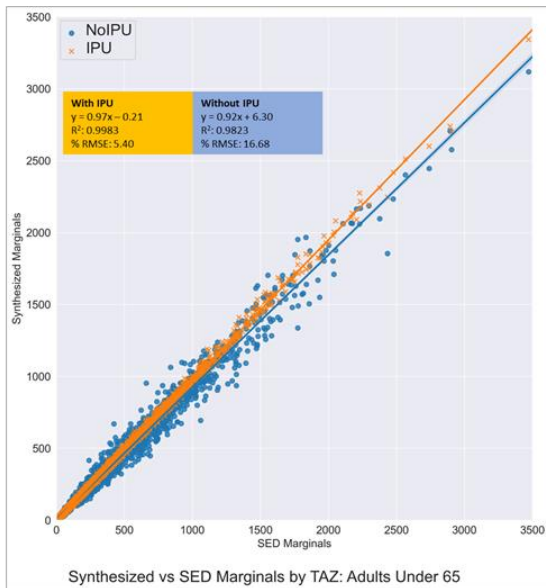
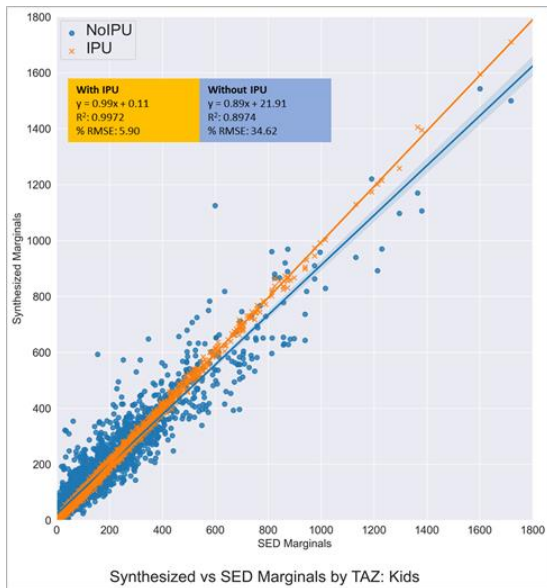
Non-Motorized Models

HB Destination Choice

Home-based Mode Choice

Non-Home-based Models

Parking Model



# TRIP TYPES

Population Synthesis
<b>Trip Generation</b>
Non-Motorized Models
HB Destination Choice
Home-based Mode Choice
Non-Home-based Models
Parking Model

## ■ Work Tours (36.2%) ■ Non-Work Tours (63.8%)

### – Home-Based (21.9%)

- Work
- Other
- Escort to School

### – Non-Home-Based (14.2%)

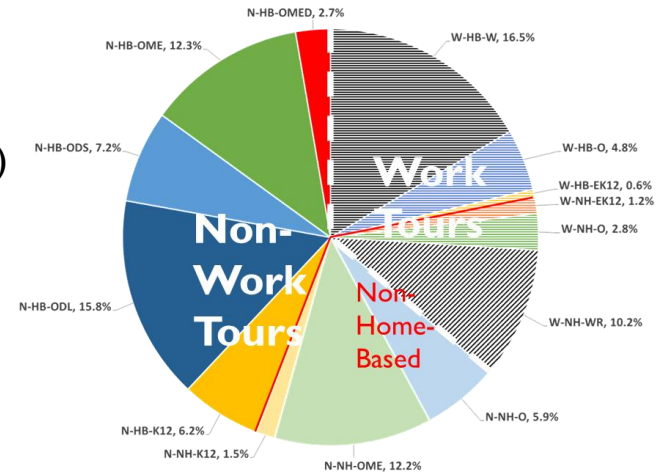
- Escort to School
- Other
- Work Related

### – Home-Based (44.2%)

- School
- Other – Discretionary Long
- Other – Discretionary Short
- Other – Shop / Eat / Errands
- Other – Medical

### – Non-Home-Based (19.6%)

- School
- Other – Maintenance / Eat
- Other – Discretionary





# TRIP GENERATION

- Tested classical stats & plain AI methods
  - Cross-classification
  - GLM (up to and including zero-inflated negative binomial)
  - Logit (ordered logit)
  - Extreme Gradient Boosted Decision Trees (XGBoost) / Random Forests

Example: School Trips

Model Type	Pseudo R <sup>2</sup>
Ordered Logit	0.03
GLM	0.22
Cross-Class	0.33
XGBoost	0.60
XAI ANOVA Decision Tree	<b>0.53</b>

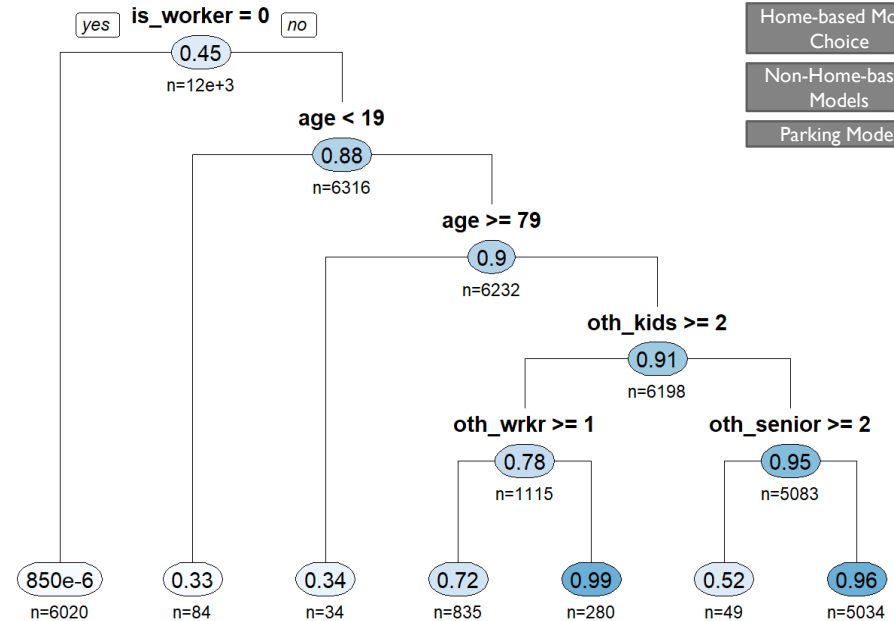
- Chosen approach: **Explainable Artificial Intelligence (XAI)**
  - ANOVA-based Rationalized Decision Trees
  - **Explainable**, reasonable relationships between trip rates and explanatory variables
  - Confidence that the model is not over-fit to the data

# TRIP GENERATION

Population Synthesis
<b>Trip Generation</b>
Non-Motorized Models
HB Destination Choice
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Parking Model

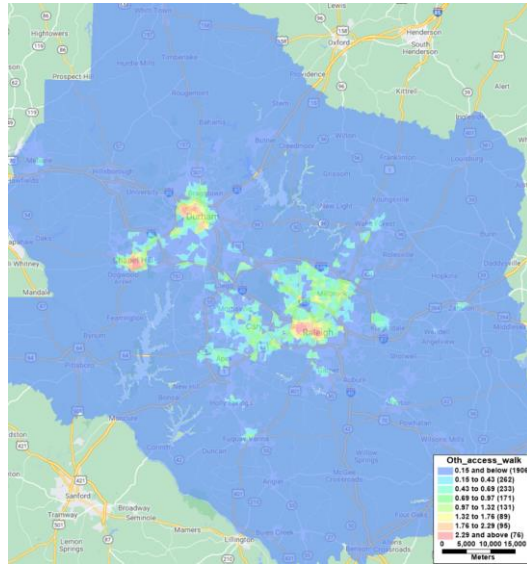
## Advantages of ANOVA-based decision trees

- Sensitivity
  - **Age**
  - **Neighborhood / Accessibility**
  - Income
  - Vehicle ownership
  - Household composition
- Nonlinear effects
- Full survey support
  - No empty cells like with cross-class



# NON-MOTORIZED MODELS

- **All streets network** used for walk, bike, and transit walk access skimming
- **Walk accessibility** drives choice to walk



Population Synthesis

Trip Generation

Non-Motorized Models

HB Destination Choice

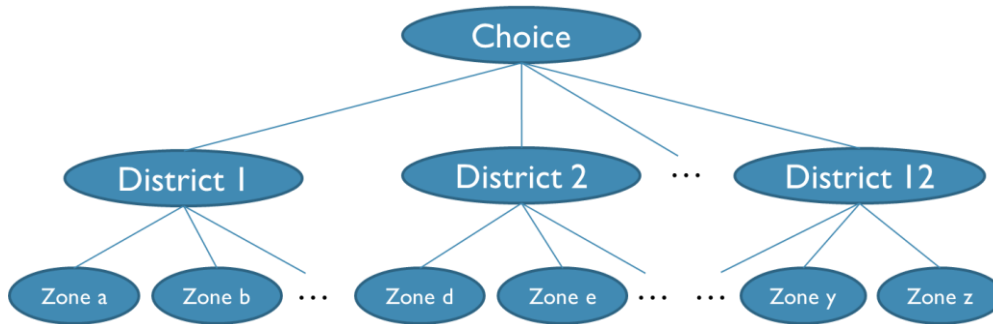
Home-based Mode Choice

Non-Home-based Models

Parking Model

# HIERARCHICAL DESTINATION CHOICE

- **First**, travelers choose a destination district
- **Second**, travelers choose the exact zone
- Significant district level effects
- Allows much better representation of travel in the multinucleated Triangle region

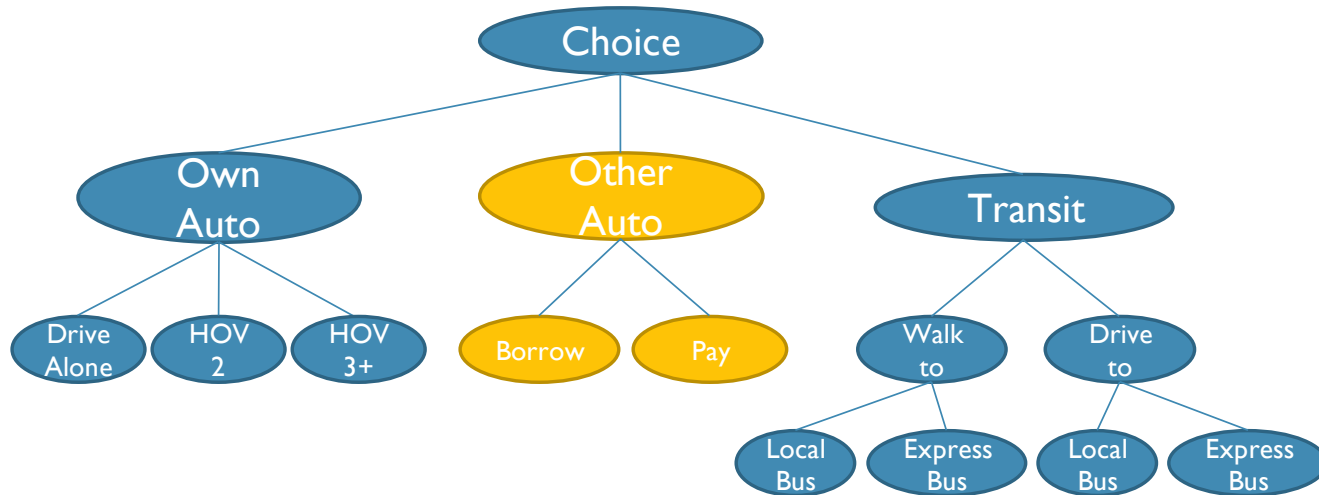


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# NESTED **MODE** CHOICE

- Walk and bike handled earlier
- **Borrowing** someone else's car is prevalent for low-income travelers
- Explicit option to **pay** for **Uber / Lyft / taxi / rental car**

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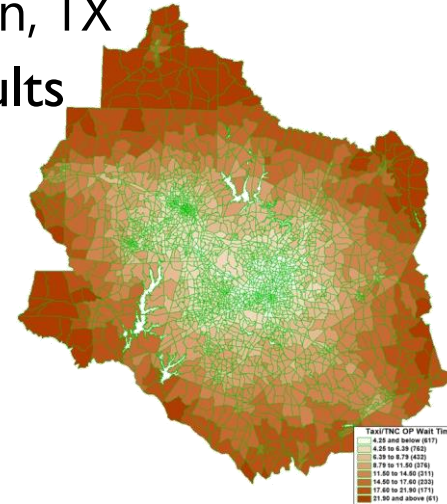




# PAID AUTO MODELS

- **Fare** (\$) = **4.00** + **0.70** \* length (mi) + **0.25** \* time (min)
- Constrained constant and time coefficient
  - Based on the literature
- Estimated cost per mile parameter from local survey

- **Wait Time** =  $45.10 + 3.5 * (\text{Peak}) - 1534.4 / \text{GenAccess} + 13030.36 / \text{GenAccess}^2$
- Estimated model with TRM variables based on published wait time model for Austin, TX
- Produces reasonable results
  - Downtown Raleigh
    - Off Peak: 2.5 min
    - Peak: 6 min
  - Rural Fringe of Model Area : up to 30 min



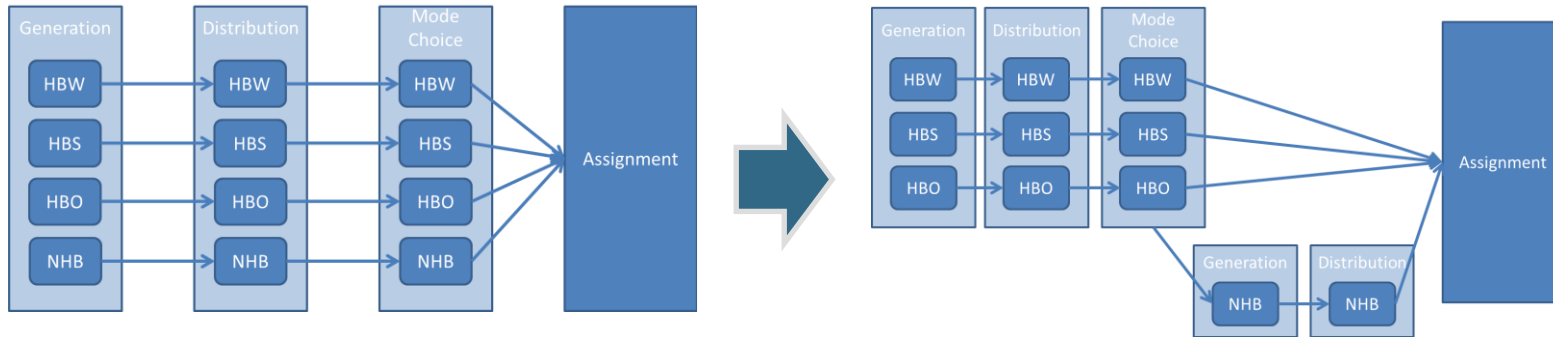
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# NON-HOME-BASED TRIP MODELS (TMIP METHOD)

- After and conditional on HB trip models
  - NHB trips generated separately by mode based on HB trip destinations by mode (~Markov transition probabilities)



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# NHB TRIP GENERATION BY MODE

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Home-based Mode  
Choice

Non-Home-based  
Models

Parking Model

## ■ Example: Nonwork Tour Non-home-based SOV

term	estimated_as	estimate	std.error	statistic	p.value
N_HB_OD_Long_hov	N_HB_OD_All_hov	0.0209	0.0037	5.6162	0
N_HB_OD_Short_hov	N_HB_OD_All_hov	0.0209	0.0037	5.6162	0
N_HB_OD_Long_sov	N_HB_OD_All_sov	0.1034	0.0041	25.021	0
N_HB_OD_Short_sov	N_HB_OD_All_sov	0.1034	0.0041	25.021	0
N_HB_OME_All_hov	N_HB_OME_All_hov	0.0026	0.0034	0.7798	0.4355
N_HB_OMED_All_hov	N_HB_OME_All_hov	0.0026	0.0034	0.7798	0.4355
N_HB_OME_All_sov	N_HB_OME_All_sov	0.0292	0.0044	6.6661	0
N_HB_OMED_All_sov	N_HB_OME_All_sov	0.0292	0.0044	6.6661	0

- All HB trip types (on Nonwork tours) by auto modes generate NHB SOV trips
- No HB trips by non-auto modes generate NHB SOV trips
  - You have to have taken a car with you make a NHB trip by SOV.

# NHB TRIP GENERATION BY MODE

- **Example:**  
 Nonwork Tour  
 Non-home-based  
 Maintenance / Eat  
 WALK

- NHB walk trips can be made by many more modes – because they don't require having a vehicle with you
- Note how likely auto-pay HB trips are to generate NHB walk trips

term	estimated_as	estimate	std.error	statistic	p.value
N_HB_K12_All_t	N_HB_K12_All_t	0.0813	0.0472	1.7235	0.0848
N_HB_OD_Long_auto_pay	N_HB_O_All_auto_pay	0.5896	0.0225	26.237	0
N_HB_OD_Short_auto_pay	N_HB_O_All_auto_pay	0.5896	0.0225	26.237	0
N_HB_OME_All_auto_pay	N_HB_O_All_auto_pay	0.5896	0.0225	26.237	0
N_HB_OMED_All_auto_pay	N_HB_O_All_auto_pay	0.5896	0.0225	26.237	0
N_HB_OD_Long_hov	N_HB_OD_All_hov	0.0062	0.0028	2.238	0.0252
N_HB_OD_Short_hov	N_HB_OD_All_hov	0.0062	0.0028	2.238	0.0252
N_HB_OD_Long_t	N_HB_OD_All_t	0.0681	0.0218	3.1296	0.0018
N_HB_OD_Short_t	N_HB_OD_All_t	0.0681	0.0218	3.1296	0.0018
N_HB_OD_Long_walk	N_HB_OD_Long_walk	0.0398	0.0082	4.831	0
N_HB_OD_Short_sov	N_HB_OD_Short_sov	0.0129	0.0055	2.3628	0.0181
N_HB_OD_Short_walk	N_HB_OD_Short_walk	0.0131	0.004	3.261	0.0011
N_HB_OME_All_bike	N_HB_OME_All_bike	0.1197	0.0477	2.5095	0.0121
N_HB_OME_All_hov	N_HB_OME_All_hov	0.0075	0.0026	2.8264	0.0047
N_HB_OME_All_sov	N_HB_OME_All_sov	0.0251	0.0034	7.3015	0
N_HB_OME_All_t	N_HB_OME_All_t	0.0695	0.0276	2.5216	0.0117
N_HB_OME_All_walk	N_HB_OME_All_walk	0.1767	0.0089	19.884	0
N_HB_OMED_All_walk	N_HB_OME_All_walk	0.1767	0.0089	19.884	0
N_HB_OMED_All_hov	N_HB_OMED_All_hov	0.0168	0.0091	1.8509	0.0642

# BOOSTING TMIP NHB GENERATION MODELS

- We can model NHB trips as function of HB trips **and accessibility**

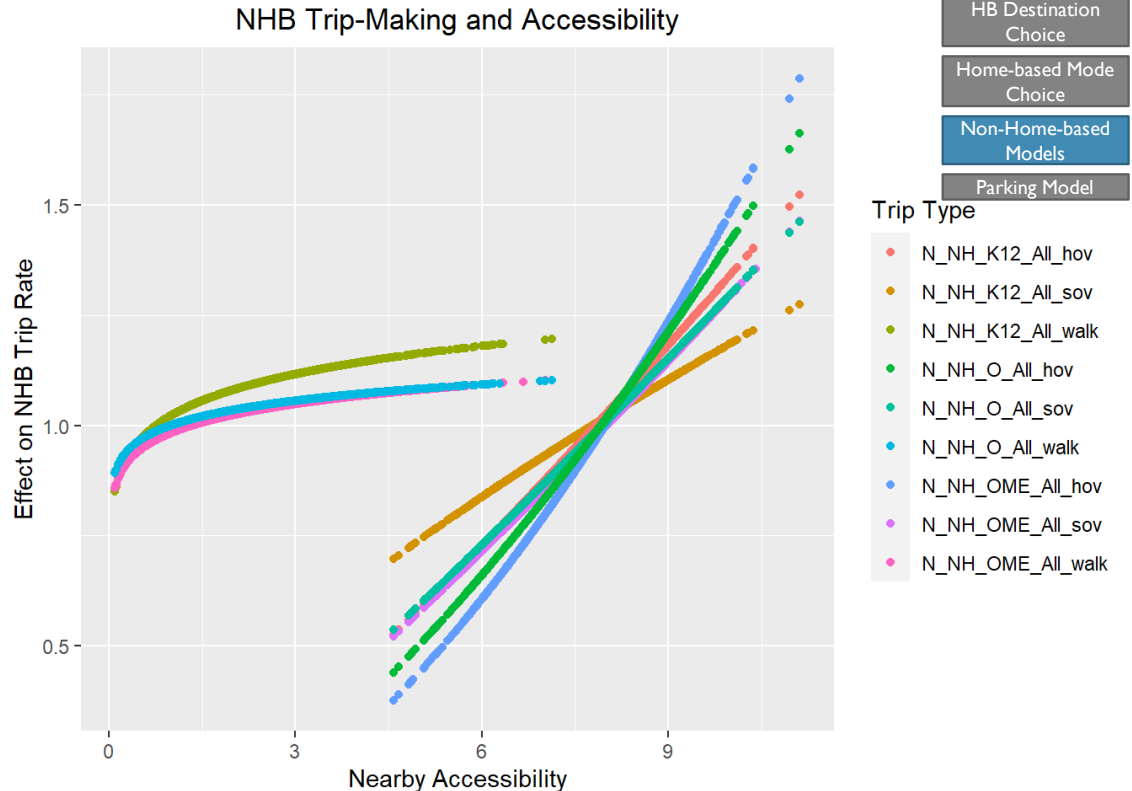
$$Y = \alpha A^\gamma \sum_{t,m} \beta_{t,m} X_{t,m}$$

- Where
  - **A** is a measure of accessibility to nearby destinations
  - $\alpha$  and  $\gamma$  are parameters
- This way, the accessibility term ( $\alpha A^\gamma$ ) scales the productivity of the HB trips



# XAI BOOSTING NHB GENERATION MODELS

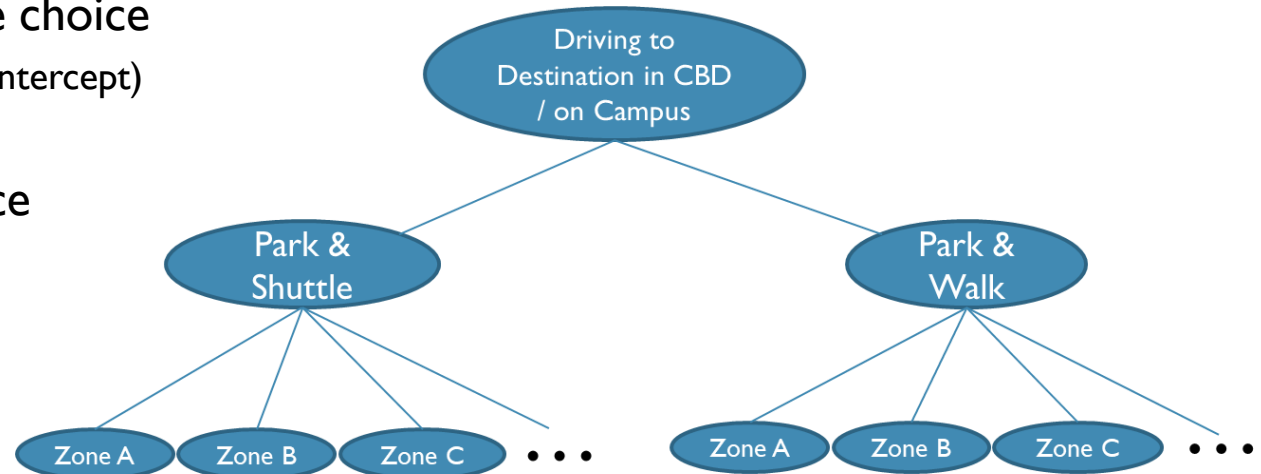
- The NHB trip rate is decreased (~50%) in rural areas
- And the NHB trip rate marginally increases (up to ~+50%) in more accessible areas
- NHB by walk approaches 0 in non-walkable areas



# PARKING MODELS

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Parking Model

- Only for downtown & major campus areas
- Based on 2016 survey
- Nested Mode & Destination Choice Model
  - Lowest level mode choice
    - park & shuttle (auto intercept)
    - park & walk
  - Parking zone choice



# THE NEXT GENERATION TRM

- Trip-making sensitive to **age, neighborhood** type not just household size and income
- Representation of **walk & bike** trips
- Better reflects true **multi-nucleated** travel between communities in the region
- Paid (**Uber/Lyft**) and borrowed car modes
- NHB mode **linked** to HB mode
- Explicit handling of **parking**

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# CONTACTS

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