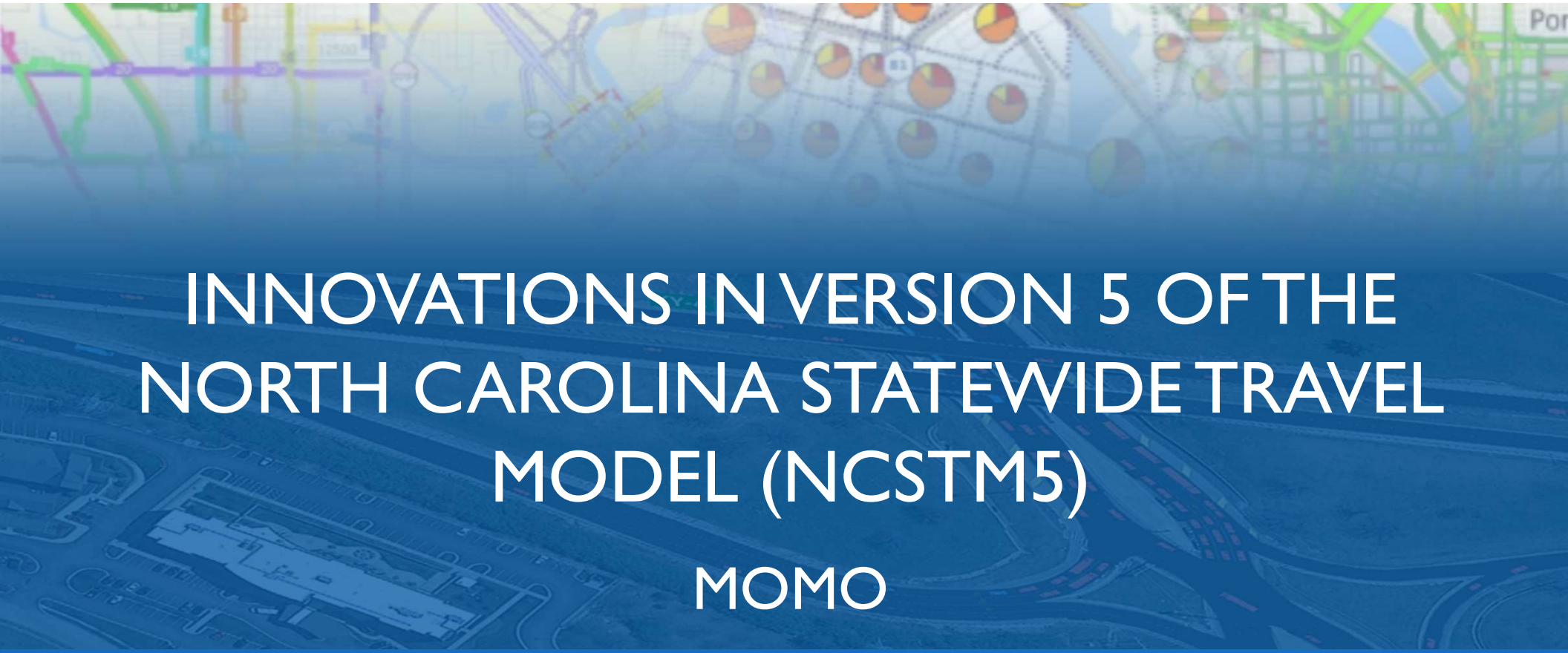


INNOVATIONS IN VERSION 5 OF THE NORTH CAROLINA STATEWIDE TRAVEL MODEL (NCSTM5)

MOMO

Caliper®

Transportation & Mapping Solutions

Maptitude • TransCAD • TransModeler

OVERVIEW OF INNOVATIONS

- Population Synthesis
- New Machine Learning Models
- Handling Remote Work from Home
- Improved Truck Routing
- Nested Destination Choice for Long Distance
- CAV Scenario Testing Functionality

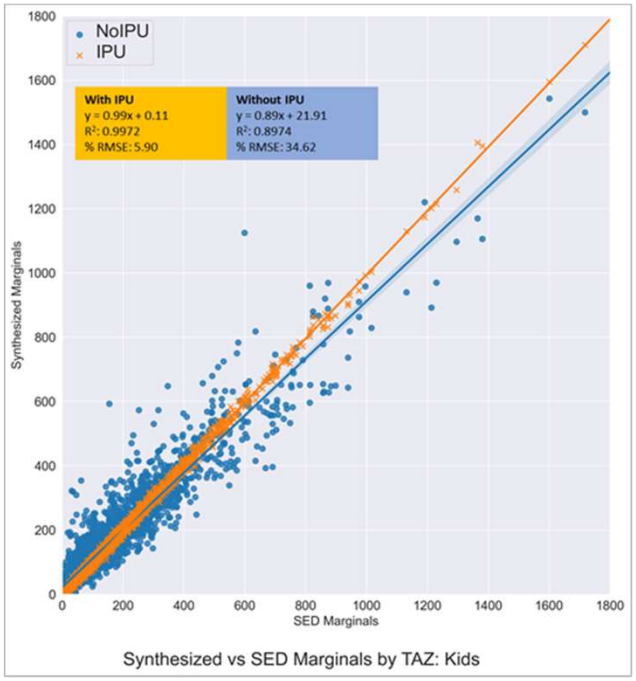
POPULATION SYNTHESIS

POPULATION SYNTHESIS

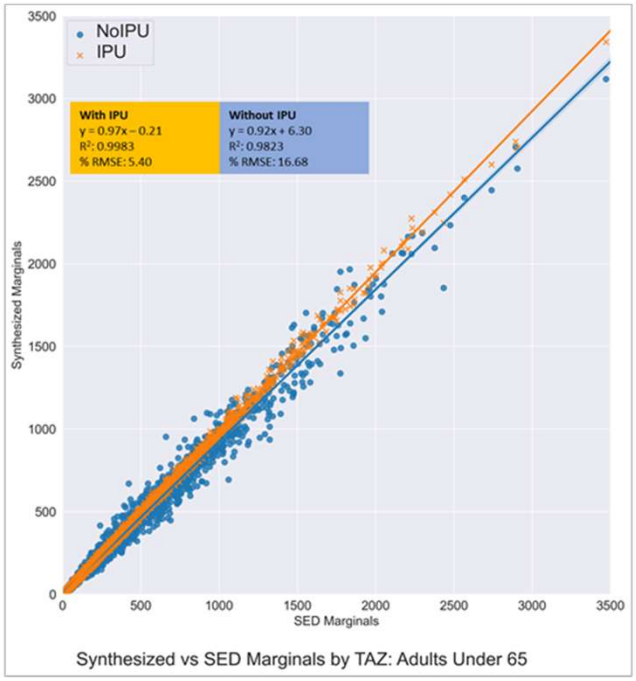
- Common in advanced MPO models (Triangle, Charlotte)
- Generate a list of households, and people in them that have the same characteristics as the real population
- Have been few statewide models with synthetic population due to runtime considerations
- TransCAD's Iterative Proportional Updating (IPU)
  - Extremely fast, ~ 1 minute per million people – runs during model run

POPULATION SYNTHESIS

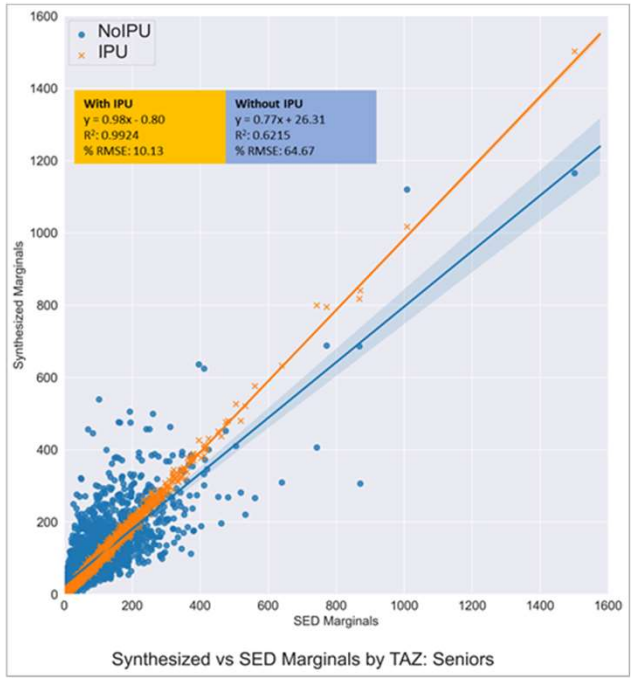
- Person level attributes show benefit of IPU over IPF



Synthesized vs SED Marginals by TAZ: Kids



Synthesized vs SED Marginals by TAZ: Adults Under 65



Synthesized vs SED Marginals by TAZ: Seniors

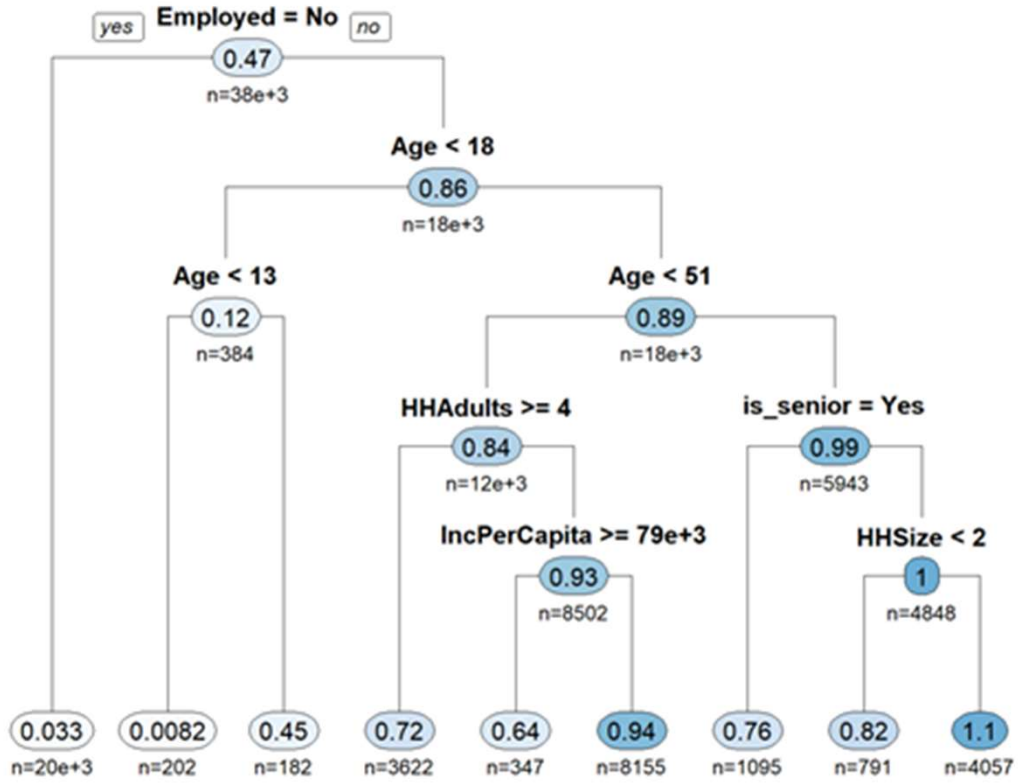
NEW MACHINE LEARNING MODELS

MACHINE LEARNING & AI

- All the rage since ChatGPT
- Can offer improved accuracy
- But need defensibility, ability to explain and justify results
- Some ML/AI methods are simple
- Early application in the Triangle
- FHWA now researching more advanced methods

TRIP GENERATION BY DECISION TREES

- The game of 20 Questions
- Advantages of Decision Trees
  - Sensitivity
    - **Age**
    - **Neighborhood / Accessibility**
    - Income
    - Vehicle ownership
    - Household composition
  - Nonlinear effects
  - Full survey support
    - No empty cells like with cross-class



COMPARISON WITH TRADITIONAL MODELS

- 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)

Example: School Trips

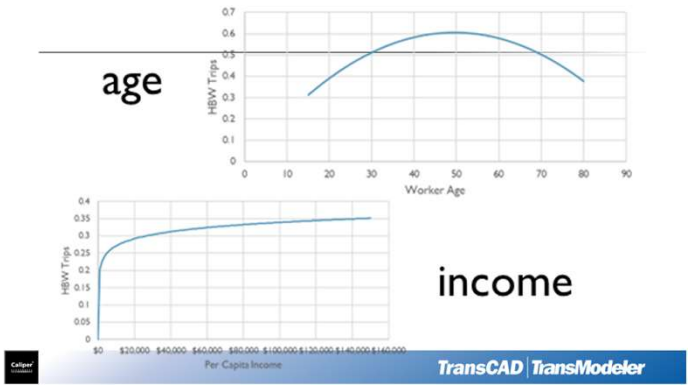
Model Type	Pseudo R^2
Logit	0.03
GLM (Regression)	0.22
Cross-Class	0.33
XGBoost	0.60
XAI ANOVA Decision Tree	**0.53**

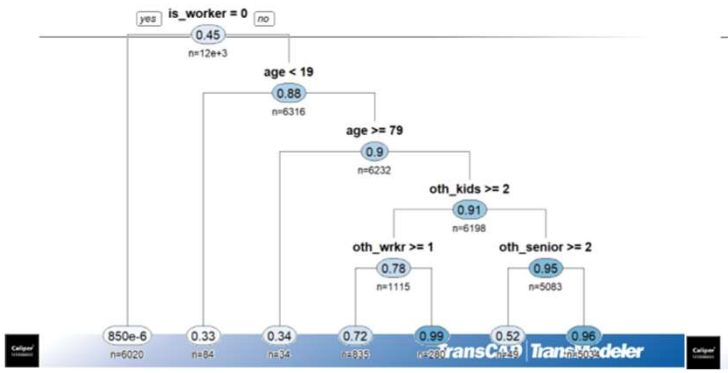
- Chosen approach: **Explainable Artificial Intelligence (XAI)**
  - ANOVA-based Rationalized Decision Trees
  - **Explainable**, reasonable relationships between trip rates and explanatory variables
  - Confidence that the model is not over-fit to the data

BOOSTED DECISION TREES FOR TRIP GENERATION

$$T = \sum_i \beta_i x_i + \alpha + \delta$$

Regression → Decision Tree → Personas



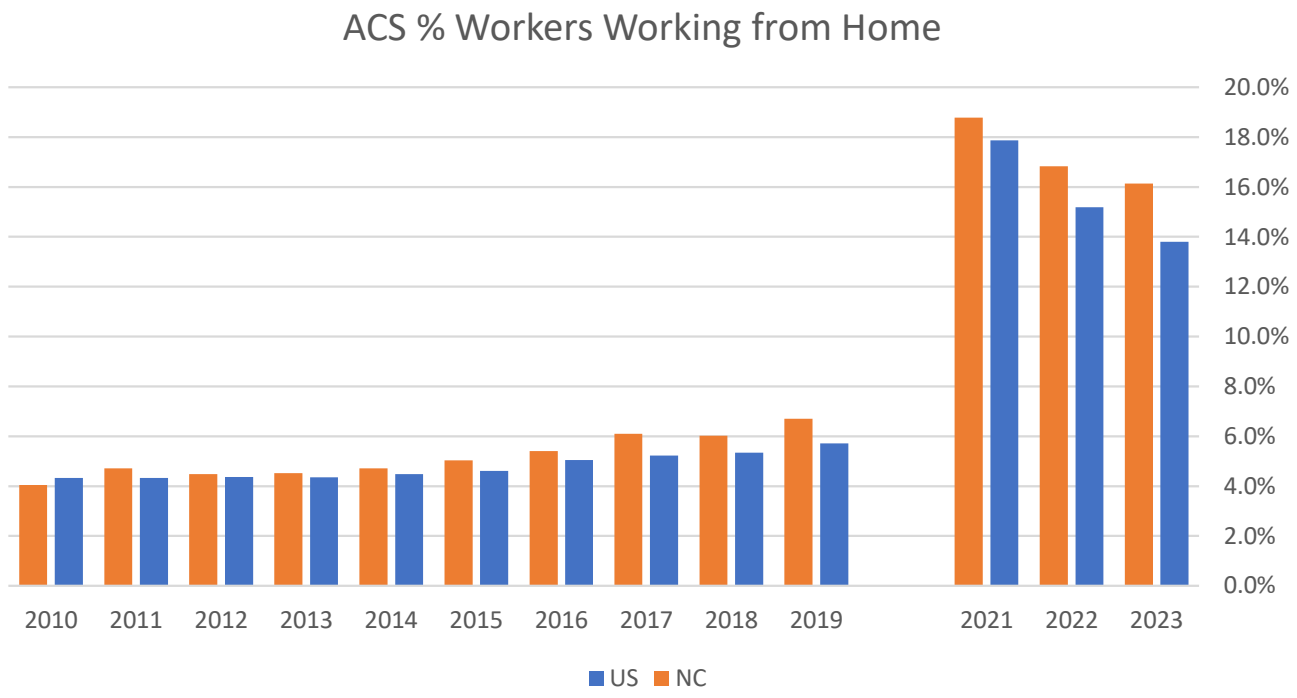


TradFam	Dad	0.073
	Mom	0.098
	Adult Child	0.038
	Child	0.065
Single Parent	Parent	0.033
	Child	-0.055
Senior Parent(s) Adult Child(ren)	Senior Parent	-0.018
	Adult Child	-0.077
Senior Couple	Senior	-0.096
DINK	Worker	0.357
Singles	Worker	0.410
	Non-Worker	-0.081

HANDLING REMOTE WORK FROM HOME

REMOTE WORK FROM HOME

- Has varied considerably over time, future is uncertain
- But has significant impact on peak period traffic



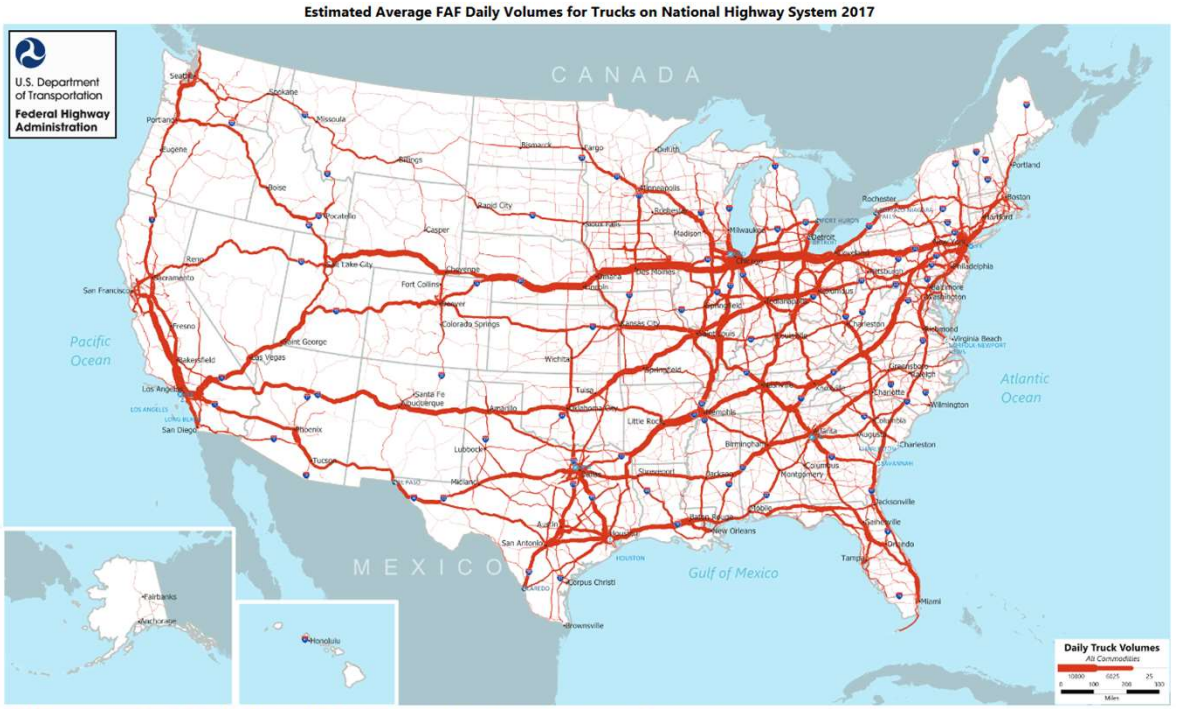
REMOTE WORK FROM HOME

- Disaggregate remote work from home model
- Reflecting how remote workers tend to be higher income and older workers
- Model user will be able to test different assumptions about future work from home rates
  - Slightly decreasing, following recent trend since COVID
  - Hold constant at current rates
  - Slightly increasing like before COVID
  - Increasing significantly in the long run like the long-term trend

IMPROVED TRUCK ROUTING

FAF5 TRUCK FLOWS

- FAF5 used a new method for routing trucks
- In the past, all trucks were routed along the fastest path
- Now, trucks can take several paths



PATH ENUMERATION

- Up to four paths generated for each OD pair
- Example: Charlotte, NC to Apex, NC

ATRI TRUCK GPS DATA

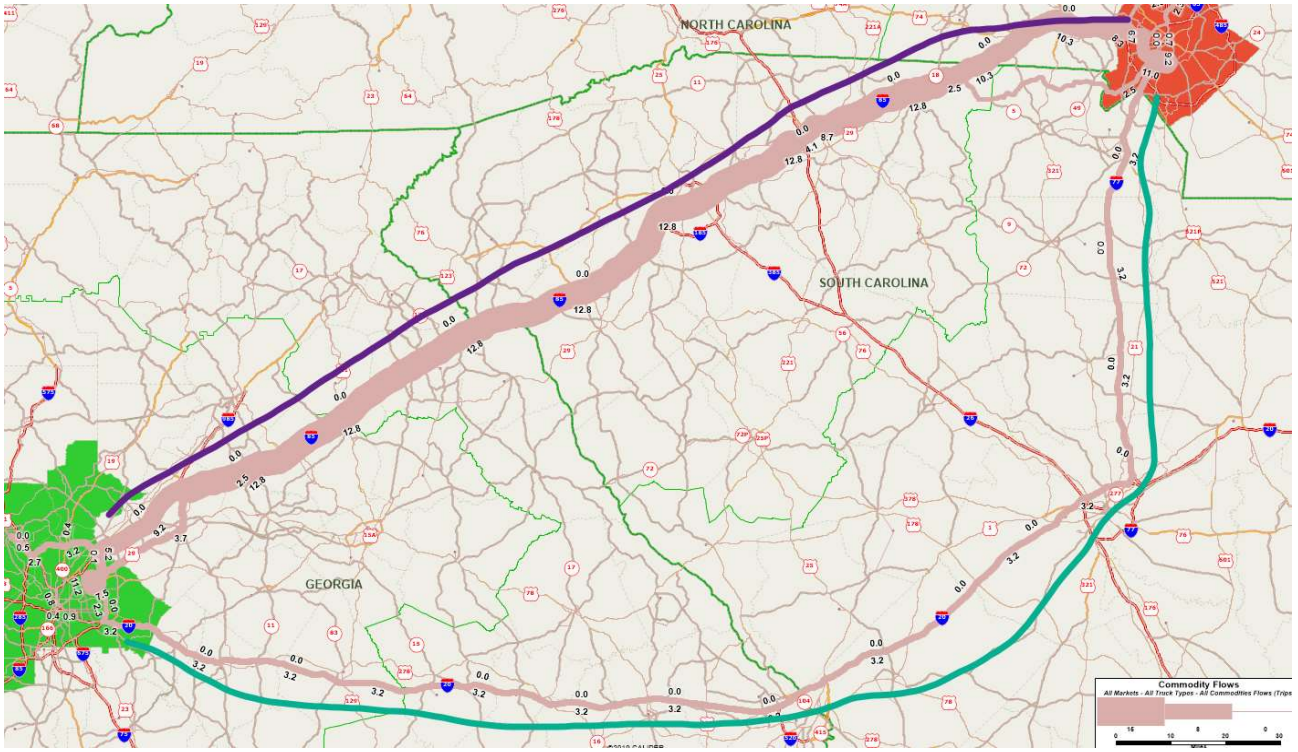
- Over 5 billion sitings
- Over 250,000 individual trucks

EXAMPLE FAF5 TRUCK ROUTING

- Charlotte – Atlanta

Route	ATRI	FAF5
I-85	89%	80%
I-20 / I-77	10%	20%

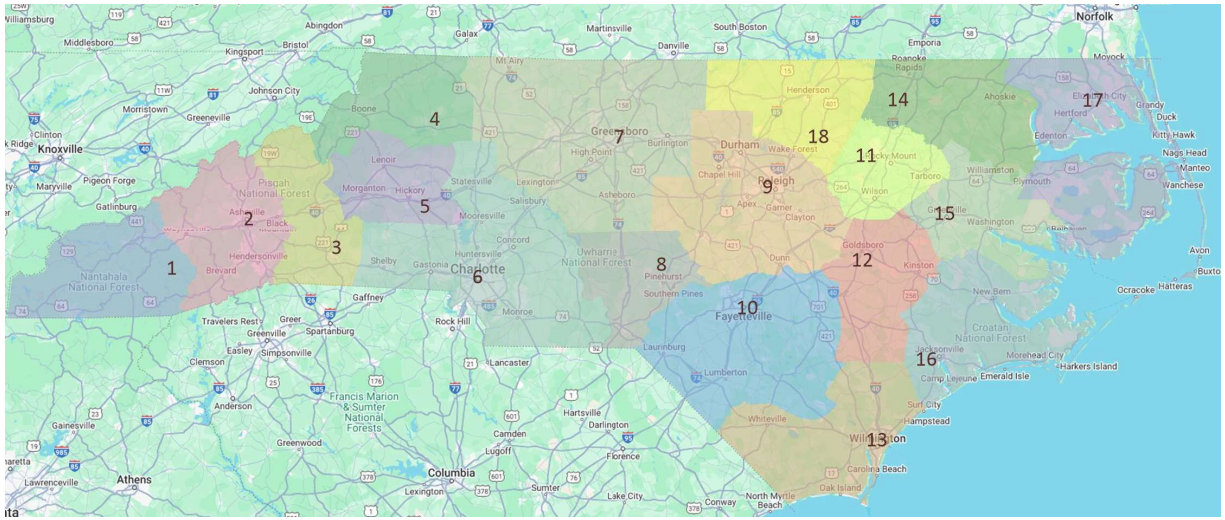
- Some LTLs stop in Augusta & Columbia



NESTED DESTINATION CHOICE FOR LONG DISTANCE TRIPS

THE CHALLENGE

- Long-distance / intercity travel patterns in NC are complex because NC is very multi-nucleated
- New NCSTM5 should do a much better job of reproducing actual intercity travel patterns in NC



CITY TO CITY GOOLE TIME COMPARISONS

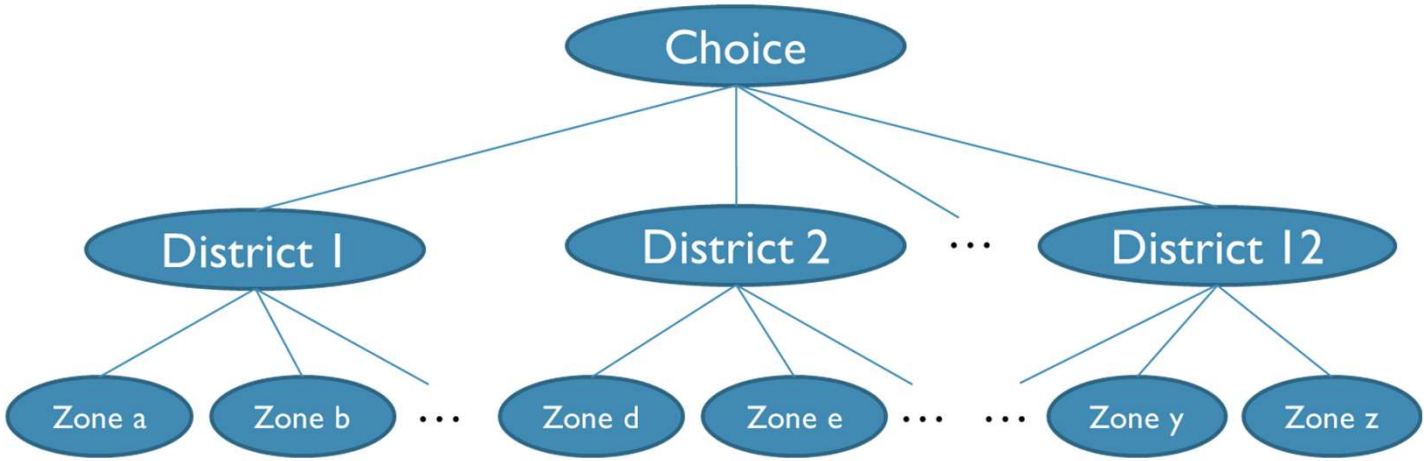
- Used TransCAD's links with Google APIs
- Estimated % difference between TC and Google travel times

	Asheville	Fayetteville	Winston-Salem	Gastonia	Wilmington	Greenville	Charlotte	Greensboro	Durham	Raleigh
Asheville		9.27	-3.18	-0.69	5.20	1.53	0.19	-0.94	-1.31	-1.02
Fayetteville	8.05		14.76	4.07	10.56	3.05	3.90	18.79	-1.38	-3.31
Winston-Salem	-2.34	16.76		2.99	-0.64	6.24	1.50	1.69	0.34	0.77
Gastonia	1.66	4.43	0.09		7.50	3.88	-8.32	0.25	0.38	0.50
Wilmington	4.43	10.59	-1.15	6.62		2.10	7.27	-0.29	-1.51	-2.94
Greenville	0.65	3.06	3.94	2.66	2.91		2.27	5.72	4.74	4.89
Charlotte	2.27	4.64	4.17	-4.17	7.95	4.42		1.11	0.77	0.91
Greensboro	-0.73	17.59	-1.54	0.39	-0.59	6.76	-1.04		-0.72	-0.18
Durham	-1.87	-2.74	-1.32	-0.21	-2.01	6.52	-1.42	-0.03		-6.28
Raleigh	-1.09	-3.25	0.54	0.34	-2.32	6.01	-0.86	1.87	-0.12	

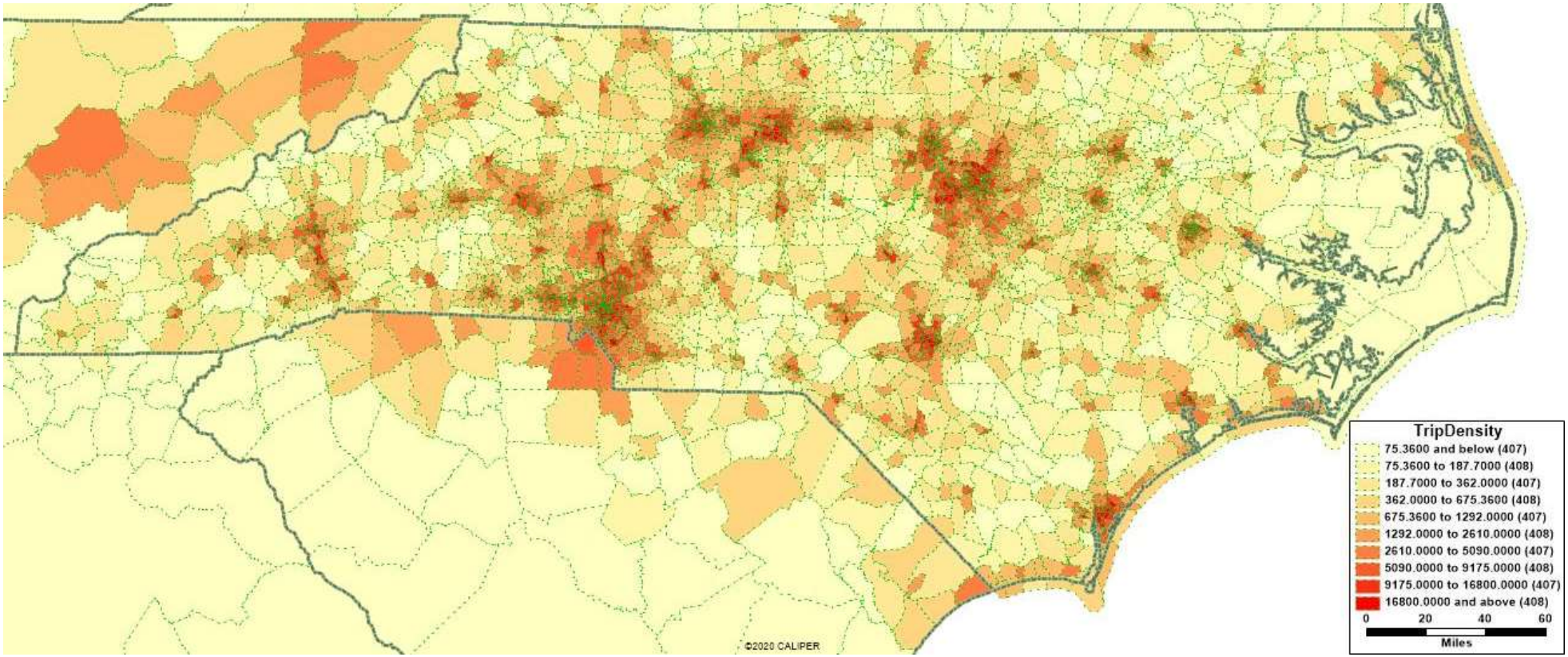
- Updated speeds on NC-87
- Final travel times were 1% different than Google on average

NESTED DESTINATION CHOICE FOR LONG TRIPS

- **First**, travelers choose a destination region
- **Second**, travelers choose the exact zone
- Allows much better representation of travel in multinucleated regions



CALIBRATED TO BIG DATA

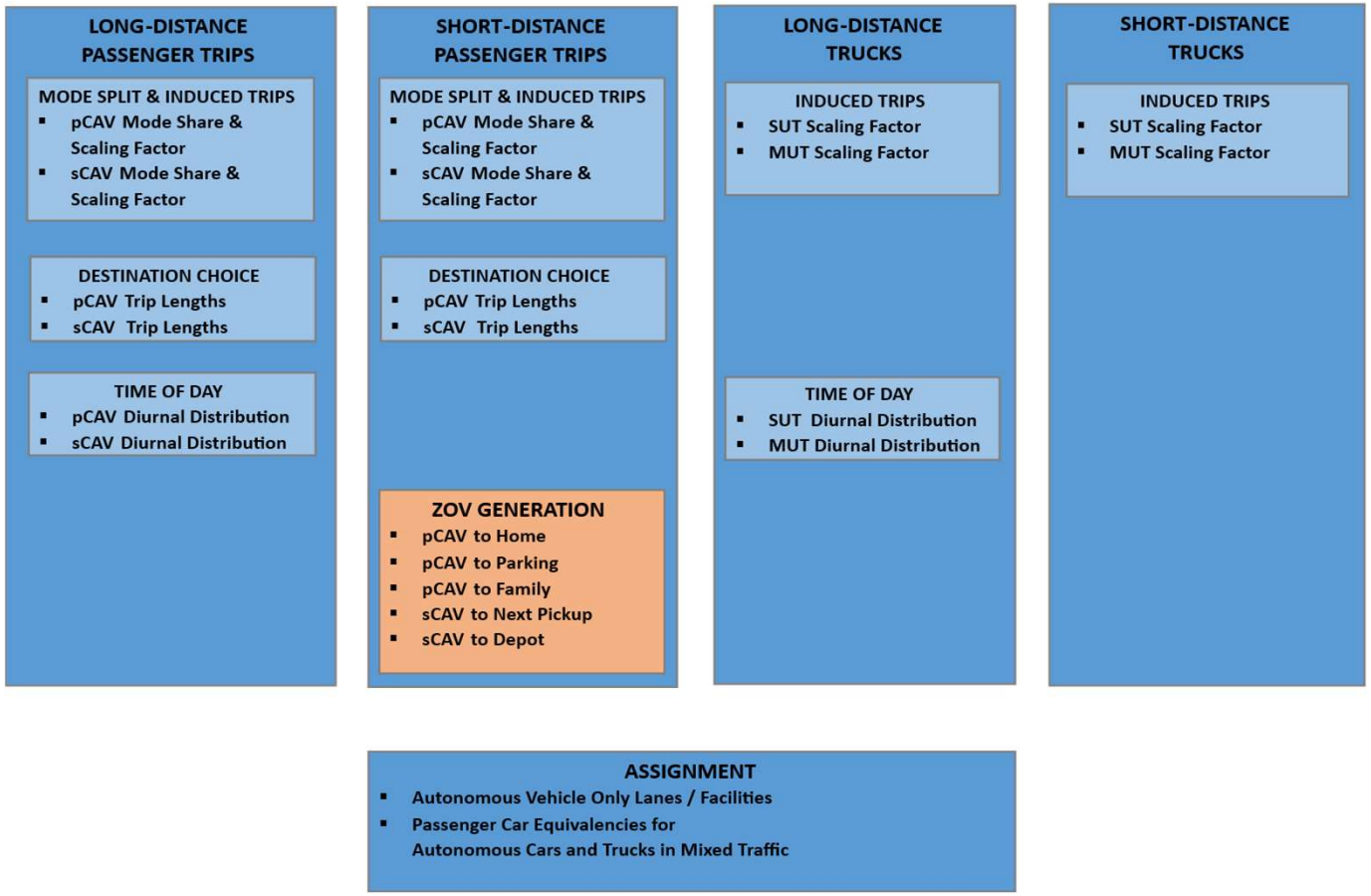


CAV SCENARIO TESTING

ADDING CAV FUNCTIONALITY TO NCSTM

- Support scenario planning
- Adjustment factor "knobs"
  - auto ownership
  - trip generation
  - destination choice
  - time-of-day
  - capacities
- Add module for ZOV trips / deadheading

CAV FUNCTIONALITY



CAV FUNCTIONALITY

- Modified Michigan framework
  - Augmented by NC State's research

- Flexibility to reflect/test
  - Reduced auto ownership
  - Induced trip-making (e.g., by elderly, disabled)
  - Increased trip lengths / reduced time sensitivity
  - Temporal shifts (e.g., long distance to overnight)
  - Zero Occupant Vehicle (ZOV) trips
  - Capacity impacts

Source: driverlesstransportation.com

CONTACTS

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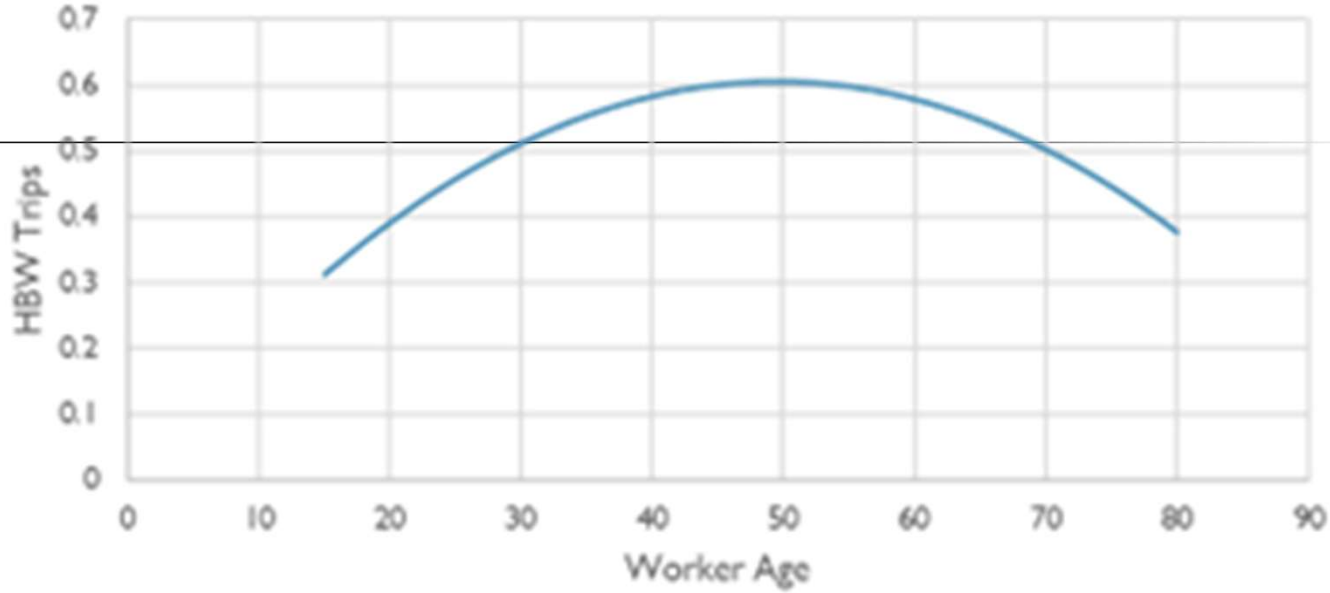
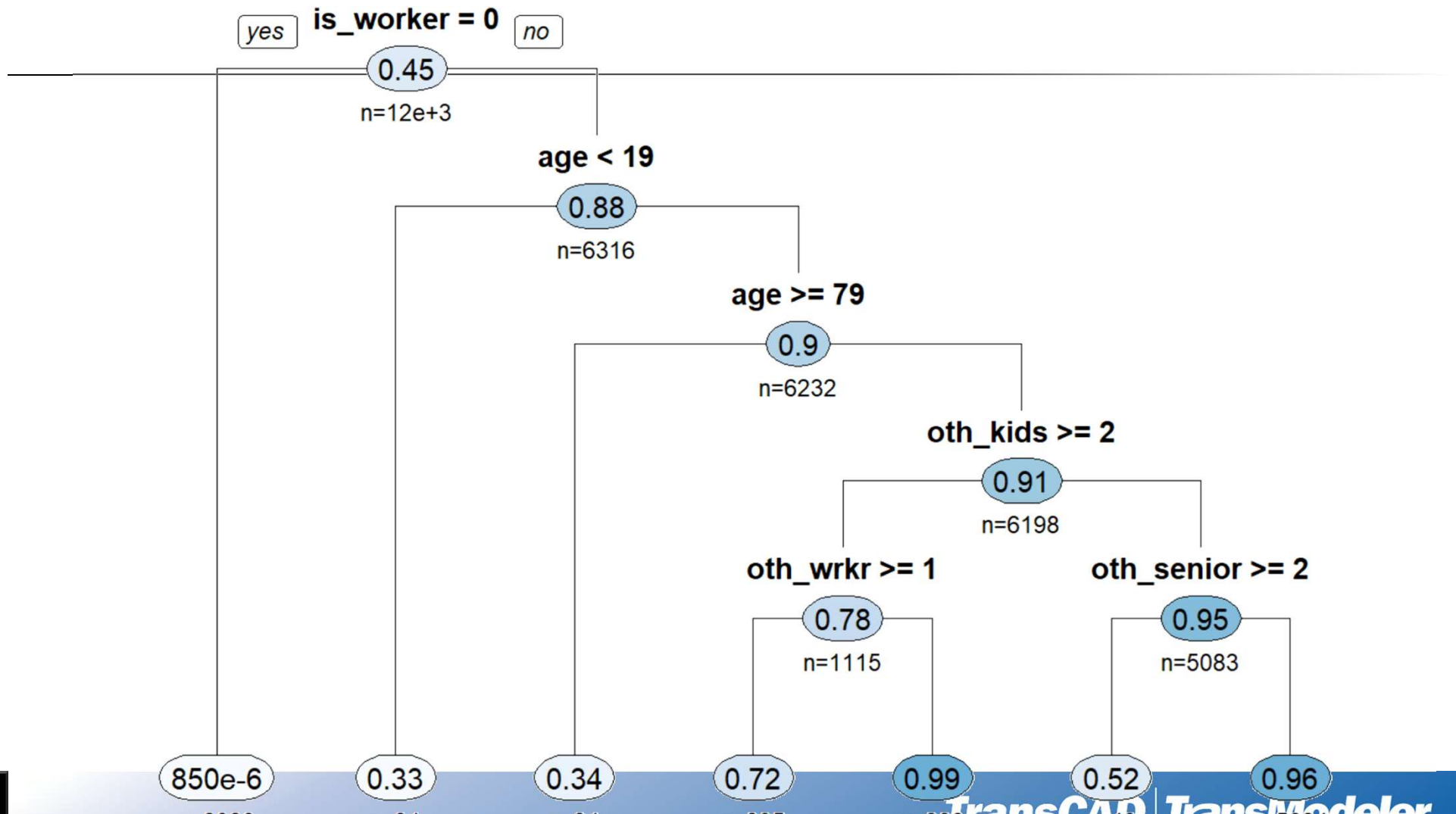

HBW Trips
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
90
Worker Age


HBW Trips
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
$0
$20,000
$40,000
$60,000
$80,000
$100,000
$120,000
$140,000
$160,000
Per Capita Income

income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is_worker = 0
no
0.45
n=12e+3
age < 19
0.88
n=6316
age >= 79
0.9
n=6232
oth_kids >= 2
0.91
n=6198
oth_wrkr >= 1
0.78
n=1115
oth_senior >= 2
0.95
n=5083
850e-6
n=6020
0.33
n=84
0.34
n=34
0.72
n=835
0.99
n=280
0.52
n=49
0.96
n=5034

TradFam	Dad	0.073
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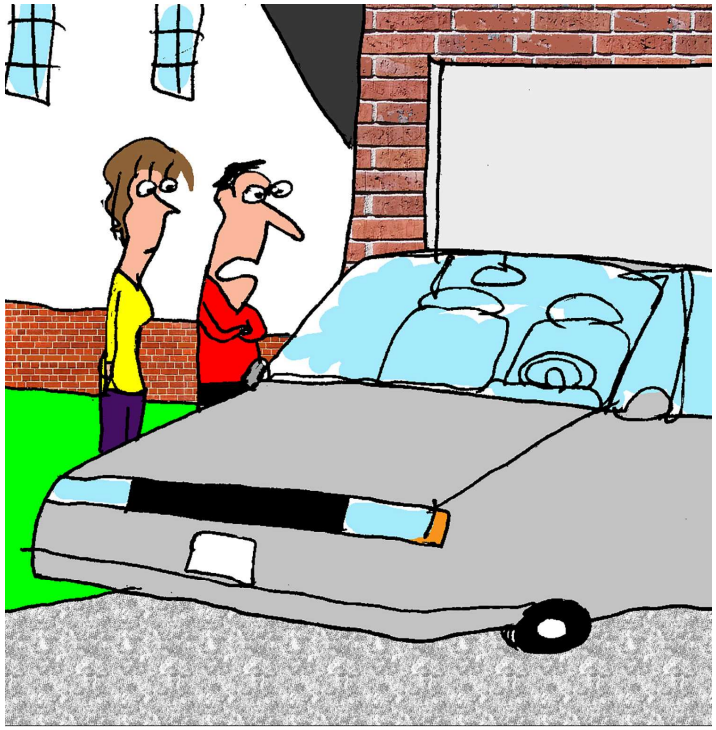
AUTO OWNERSHIP

- Subdivide HH autos into conventional and CAV by income
- Decrease overall ownership



"Maybe I can buy a self driving car, and hire it out to Uber to make the payments."

CartoonStock.com

TRIP GENERATION

- Scale up trips to represent induced demand
- Largest increases to households with:
  - Disabled
  - Seniors
  - Children

Source: Jalopnik.com

- More long distance / external trips from reduced lodging cost?

DESTINATION CHOICE

- Passengers may be willing to travel farther since time in CAVs can be used positively for working, relaxing, sleeping, etc.
- User can factor down traveler sensitivity to travel time / impedance

TIME OF DAY

- Trucks / long distance travelers may shift to nighttime hours to avoid congestion
- Long distance travelers may use sleeping hours to travel

DEADHEADING / ZERO OCCUPANT VEHICLES

- Types of ZOV trips
  - Private CAVs
    - for car sharing among household members
    - to avoid paid parking
      - by parking at home
      - by parking elsewhere
      - by circulating instead of parking
  - Shared CAVs
    - Between passenger drop-off and pick-up

Source: driverlesstransportation.com

ASSIGNMENT

- Separate autonomous and conventional vehicle classes
- User option to have dedicated CAV-only facilities/lanes and assert high capacities and higher speeds
- User option to assert different capacity consumption in mixed traffic (through PCE factor)