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Development of a Multi-modal Travel Demand Module for the Regional Strategic Planning Model

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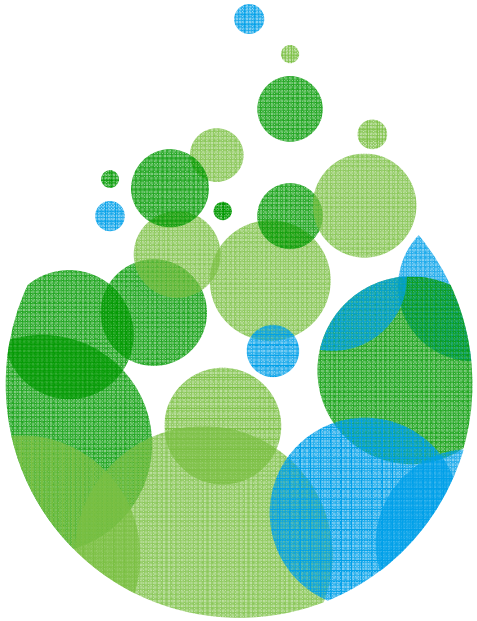

Development of a Multi-modal Travel Demand Module for the Regional Strategic Planning Model

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Friday Transportation Seminar, Jan. 19th

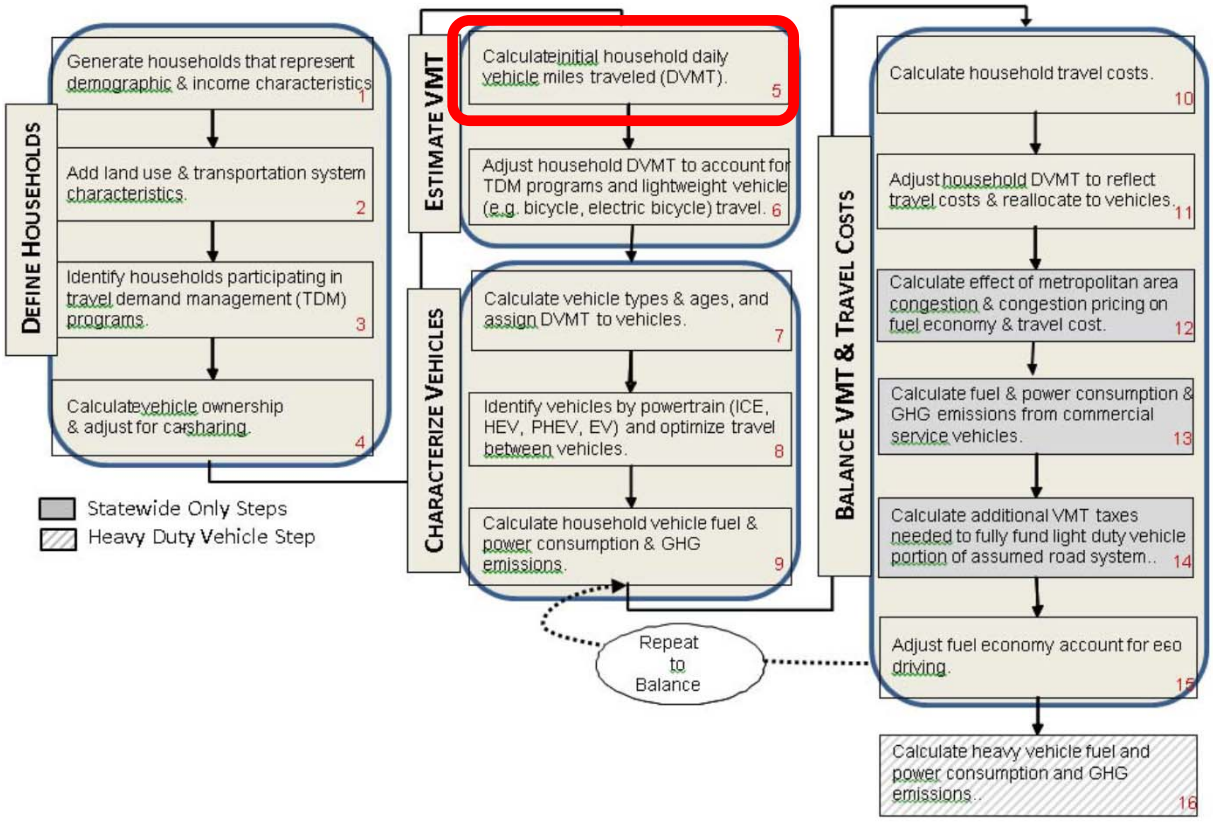
Overview of the RSPM

- A performance-based planning tool
  - GreenSTEP
  - RSPM (Regional Strategic Planning Model)
  - RPAT (Rapid Policy Assessment Tool)
  - EERPAT (Energy and Emissions Reduction Policy Analysis Tool)
- VisionEval: an open source common framework

Overview of the RSPM

Integrated land use and transportation model

- Simple models
  - Speed
  - Interactivity
- Microsimulation
  - Flexibility
  - Realism



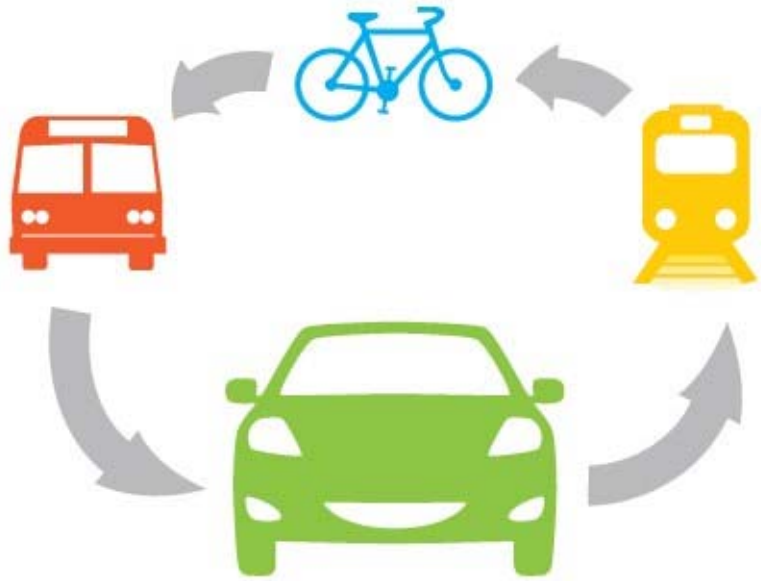
Overview of the RSPM

Deficiency of calculating initial household Daily Vehicle Miles Traveled (DVMT)

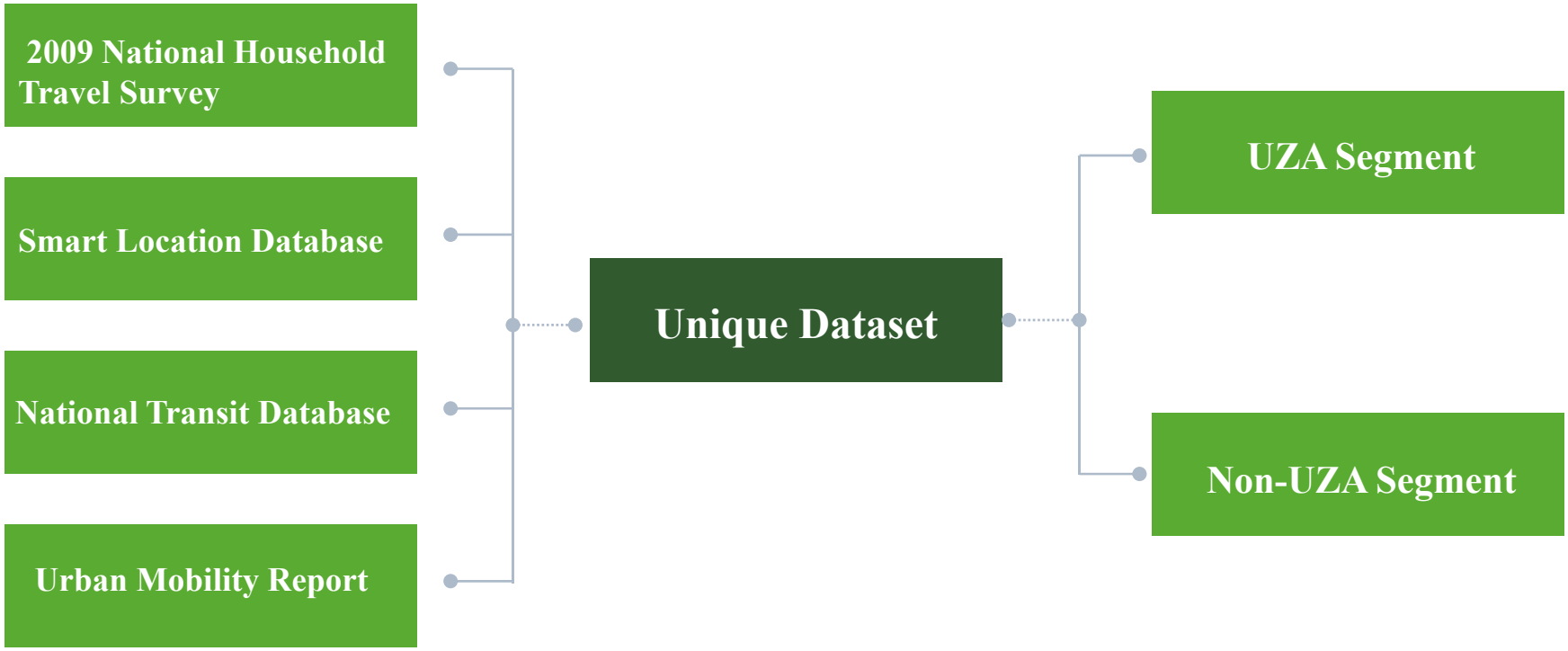
- Synthesize annual DVMT
- Include limited set of built environment variables

Motivation

- Capture the connection between built environment and travel for rapid policy evaluation
- Develop a module for VisionEval that works with existing modules to assess outcomes for a wide range of policy and technology outcomes
- Follow the best practices for model development recommended in the literature.



Data


2009 National Household Travel Survey
Smart Location Database
National Transit Database
Urban Mobility Report
Unique Dataset
UZA Segment
Non-UZA Segment

Data

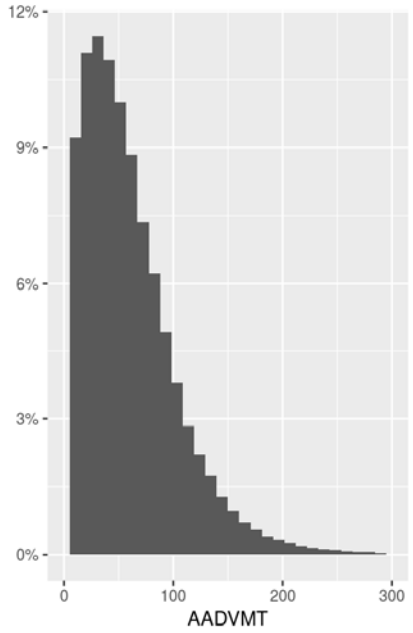
Name	Source	Description	Mean	std dev
AADVMT	NHTS	Annual average daily VMT	60.0134	48.87283
ntrips.Transit	NHTS	Transit trips during the day of survey	0.1686	0.75515
ntrips.Bike	NHTS	Biking trips during the day of survey	0.0656	0.48796
ntrips.Walk	NHTS	Walking trips during the day of survey	0.6987	1.59824
Age0to14	NHTS	Number of household members younger than 14	0.2037	0.57598
Age65Plus	NHTS	Number of household members older than 65	0.5735	0.75125
CENSUS_D	NHTS	Census division classification for home address: New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, or Pacific		
DRVRCNT	NHTS	Number of drivers in household	1.7950	0.77507
HHSIZE	NHTS	Count of household members	2.3390	1.23666
LIF_CYC	NHTS	Household life cycle classification: Single, Couple w/o children, Couple w/ children, or Empty Nester		
LogIncome	NHTS	log total household income	10.7208	0.86801
VehPerDriver	NHTS	Number of vehicles per licensed driver	1.1231	0.57332
WRKCOUNT	NHTS	Number of workers in household	0.9262	0.89044
D1B	SLD	Gross population density (people/acre) on unprotected land	6.1465	16.02445
D2A_EPHHM	SLD	Employment and household entropy	0.4697	0.22547
D2A_WRKEMP	SLD	Household Workers per Job, as compared to the region	10.0460	31.81125
D3bpo4	SLD	Intersection density in terms of pedestrian- oriented intersections having four or more legs per square mile	13.1078	22.98465
D4c	SLD	Aggregate frequency of transit service within 0.25 miles of block group boundary per hour during evening peak period	25.7009	65.43733
D5ar	SLD	Jobs within 45 minutes auto travel time, time- decay (network travel time) weighted	85004.2787	123761.90420
D5cr	SLD	Employment accessibility expressed as a ratio of total MSA accessibility	0.0039	0.00768
TRPOPDEN	SLD	Census tract population density	5.5277	15.04279
EMPTOT_5	SLD	Total employment within 5 miles buffer of block group	31773.3194	95419.99700
Fwylnmicap	TTI UMR	Urbanized area freeway lane-miles per capita	0.0007	0.00038
Tranmilescap	TTI UMR	Urbanized area transit annual vehicle revenue miles per capita	0.0167	0.01189

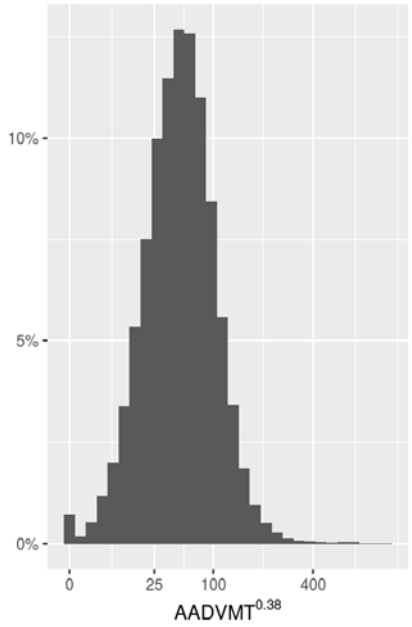
AADVMT Model

- Formula

$$AADVMT_h = f(household\ characteristics, built\ environment, transportation\ supply)$$

- Model structure
  - 2-step model
  - hurdle model
  - power-transformed linear regression model
  - semi-log regression model





AADVMT Model

- Variable selection
  - behavioral validity
  - model goodness-of-fit
  - statistical significance
- Model selection
  - k-fold cross-validation

Results: model selection

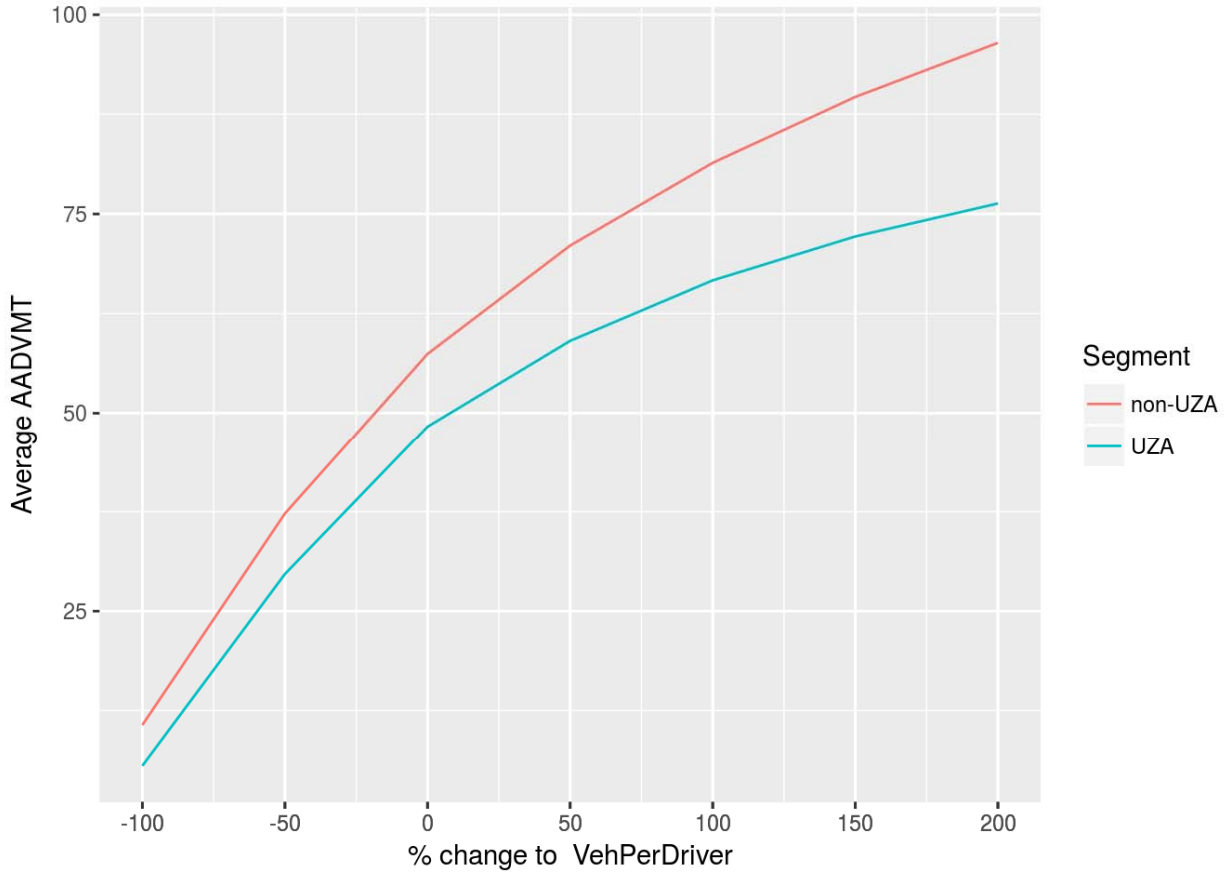
Table the Average K-fold Cross-validation for Model Structures

Model Type	Segment	rmse	R^2	Pseudo-R^2
2 step models	UZA	29.18	0.46	0.59
hurdle model	UZA	30.27		0.33
power-transformed linear regression model	UZA	29.18	0.46	
semi-log regression model	UZA	32.21	0.42	
2 step models	non-UZA	32.93	0.47	0.40
hurdle model	non-UZA	34.22		0.12
power-transformed linear regression model	non-UZA	32.92	0.47	
semi-log regression model	non-UZA	36.33	0.43	

Results

	$AADVMT^{0.38}$	
	UZA	Non-UZA
Constant	−1.780*** (0.123)	−2.230*** (0.088)
DRVRCNT	0.714*** (0.011)	0.759*** (0.009)
HHSIZE	0.003 (0.009)	0.021*** (0.007)
WRKCOUNT	0.182*** (0.008)	0.160*** (0.006)
LogIncome	0.246*** (0.007)	0.292*** (0.005)
Age0to14	0.092*** (0.011)	0.101*** (0.010)
Age65Plus	−0.066*** (0.009)	−0.071*** (0.006)
ns(log1p(VehPerDriver), 3)1	2.740*** (0.050)	2.780*** (0.040)
ns(log1p(VehPerDriver), 3)2	5.960*** (0.205)	5.750*** (0.161)
ns(log1p(VehPerDriver), 3)3	3.020*** (0.224)	3.700*** (0.152)
LIF_CYCCouple w/o children	−0.042** (0.018)	−0.006 (0.015)
LIF_CYCEmpty Nester	−0.264*** (0.021)	−0.199*** (0.017)
LIF_CYCSingle	−0.225*** (0.026)	−0.178*** (0.021)
log1p(TRPOPDEN)	−0.028*** (0.011)	−0.053*** (0.010)
log1p(EMPTOT_5)	−0.059*** (0.006)	−0.043*** (0.003)
CENSUS_DEast South Central	0.105* (0.057)	0.089*** (0.026)
CENSUS_DMiddle Atlantic	−0.085*** (0.029)	−0.136*** (0.019)
CENSUS_DMountain	−0.085*** (0.028)	−0.097*** (0.027)
CENSUS_DNew England	−0.124*** (0.048)	−0.022 (0.026)
CENSUS_DPacific	−0.066*** (0.025)	−0.172*** (0.020)
CENSUS_DSouth Atlantic	0.021 (0.025)	0.041** (0.016)
CENSUS_DWest North Central	−0.061 (0.061)	−0.050** (0.020)
CENSUS_DWest South Central	0.062** (0.026)	0.094*** (0.018)
Fwylnmicap	0.093** (0.041)	
Tranmilescap	−0.002** (0.001)	
D1B	−0.001** (0.0004)	**0.009*** (0.003)**
D2A_WRKEMP	−0.0003** (0.0001)	
D3bpo4	−0.0004* (0.0002)	
D5cr	−51.500*** (9.950)	
Tranmilescap:D4c	**−0.00001** (0.00000)**	
D2A_EPHHM		0.058** (0.023)
I(D5ar/1000)		**0.0003** (0.0001)**
D1B:D2A_EPHHM		**−0.022*** (0.005)**
Observations	41,497	73,899
Adjusted R^2	0.455	0.469

Results

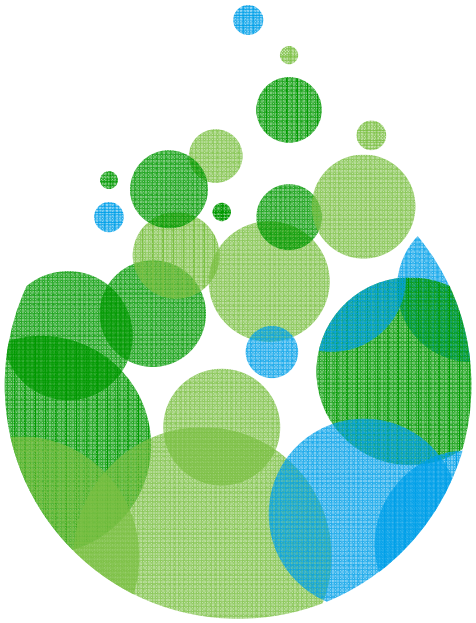

100
75
50
25
Average AADVMT
-100
-50
0
50
100
150
200
% change to VehPerDriver
Segment
non-UZA
UZA

Conclusion

- The power-transformed method is chosen among a handful of model structure options for its simplicity and predicting power.
- The household AADVMT model presented in this paper is the first model utilizing such a nationwide dataset with high resolution built environment variables while controlling for households' socio-demographic characteristics.

Discussion

- Although not included in this presentation, the models for non-auto travel, along with the AADVMT model, made up the multi-modal travel demand module that are implemented for the open source VisionEval software framework.
- The implementation of the the multi-modal travel demand module as an open source R package follows the best practices outlined in the VisionEval development guide and went through a contribution review process (https://github.com/gregorbj/VisionEval/wiki/Meeting-%233-Example-Contribution).
- For large sample size dataset with large number of variables, model selection techniques are helpful only to an extent. Machine learning techniques may be a direction we will explore in our future research.



Acknowledgments

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