From Trend Spotting to Trend Setting: Behavioral Analysis to Guide Transformative Mobility

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Outline

- Motivation
- Travel Behavior Modeling Framework & Gaps
- Modality Style Models
  - Concept and Formulation
  - Findings
- Nudging Modality Styles
- Conclusions

Sustainability Needs

- CO_2 emission targets
  - By 2050 be 80% below 1990 levels (CA, Japan, EU, …)
- US 25% of CO_2 from transport 15% from passenger cars
  Japan 18% " 5% "
- How to meet GHG reduction goals for transportation?
  - Technology
  - Behavior
- Even most optimistic *technology* scenarios for 2050 are insufficient
  (Sager et al., 2011; Dray et al., 2012)

Transformative Mobility

- Clean *
- App-driven
- Shared
- Connected
- Autonomous
- Virtual mobility **

* *JAFOE 2016*
Energy Storage theme

** *JAFOE 2016*
3D Printing theme

Will a World of Driverless Cars Be Heaven or Hell?

The answer depends in large part on whether we own autonomous vehicles or share them.

ROBIN CHASE | @rmchase | Apr 3, 2014 | 179 Comments

459 Shares | Share on Facebook | Tweet

Shutterstock

“Hang on—I’ll Uber us a school bus.”

New Yorker, May 2016

Transformative Time for Travel Behavior Analysis

Critical need

New travel paradigms here and on horizon

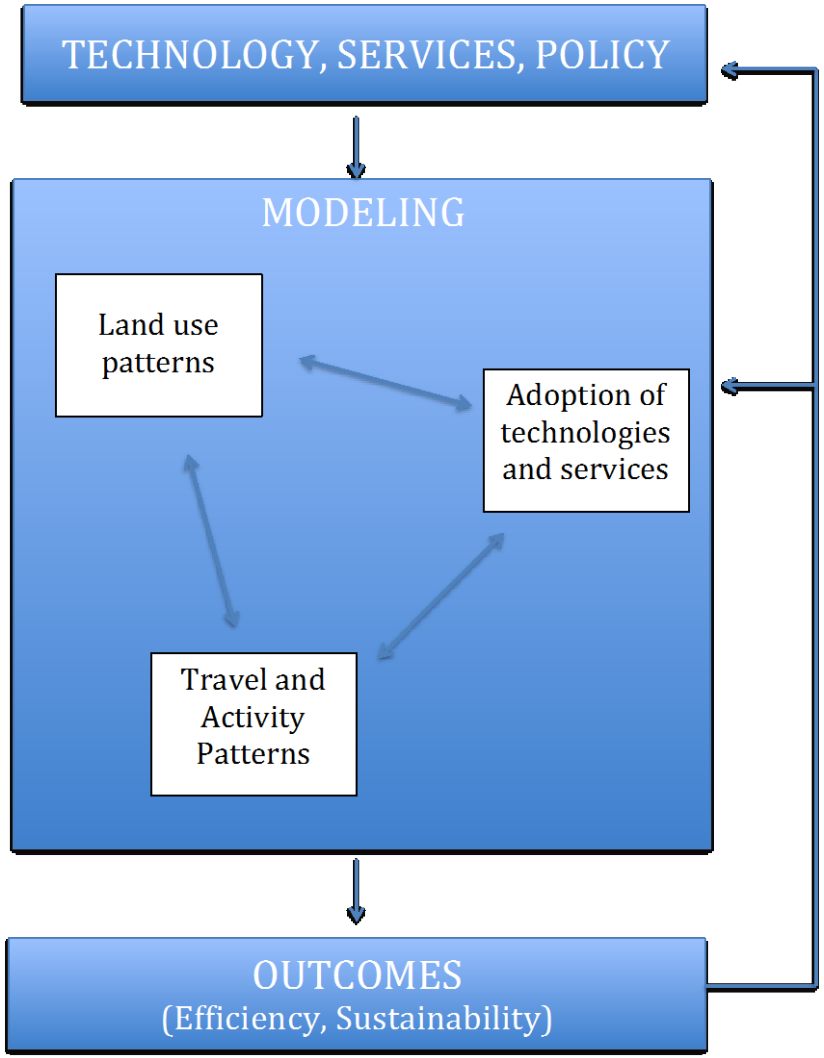
Tremendous potential from data goldmine*

RESEARCH OBJECTIVE

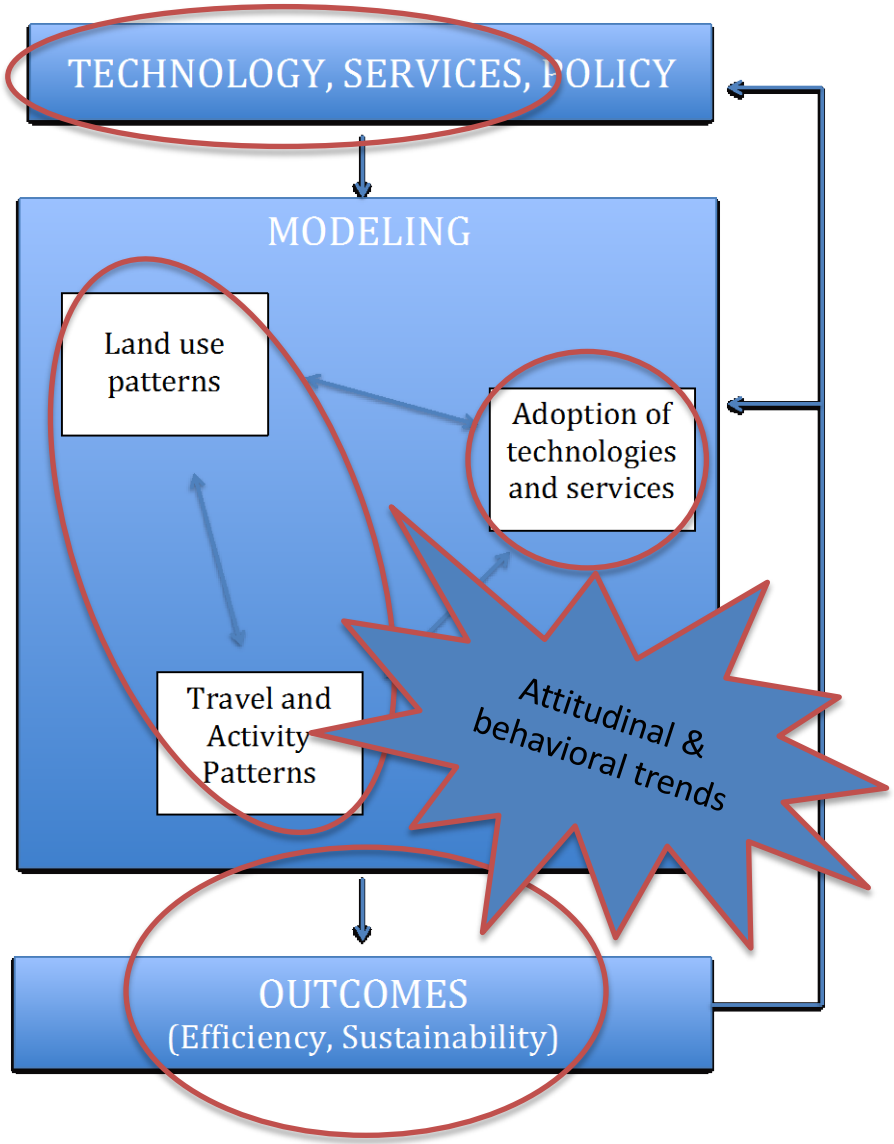
To develop behavioral analysis tools
that focus on modeling and influencing
trends of travel behavior
to guide transformative mobility towards a more sustainable, efficient, and equitable system.

*JAFOE 2016 Big Data theme

Modeling Framework



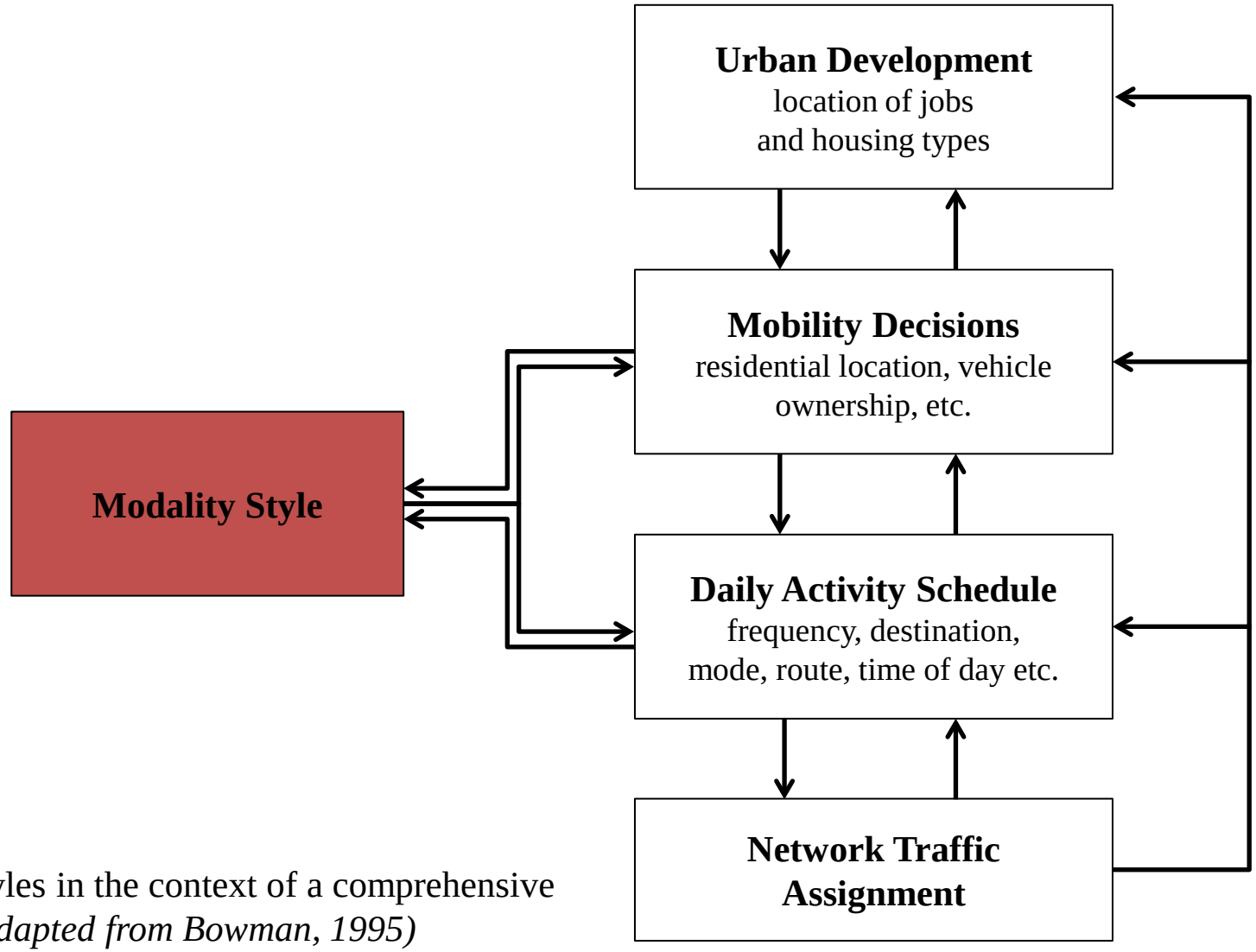
Modeling Framework



Gaps in Behavioral Modeling

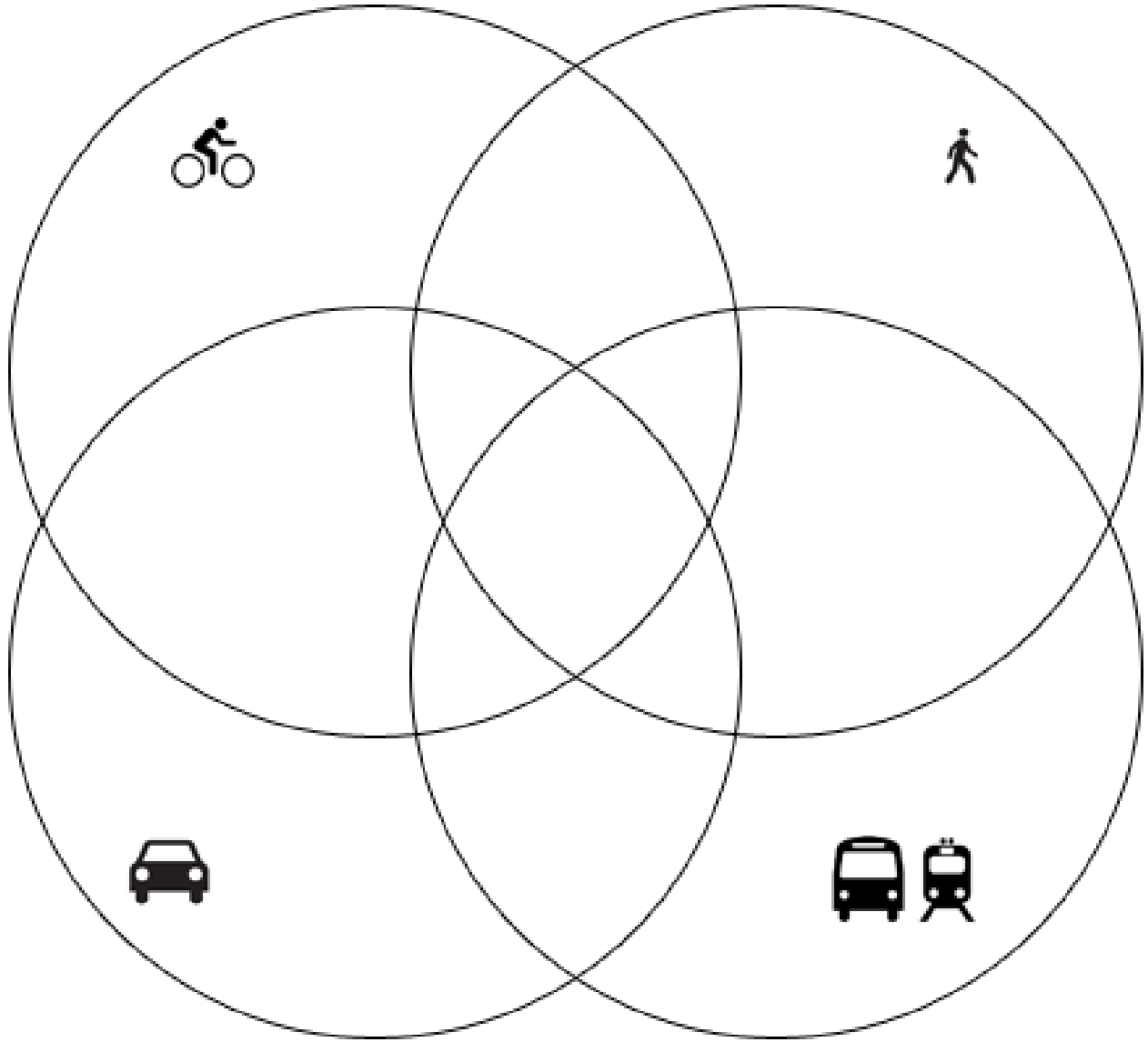
1. Flexibility around uncertainty of future technologies and services
2. Diffusion of new technologies and services
3. Location, travel, and activity behavior conditional on adoption
4. Effective nudges/policies to achieve desired outcomes
5. Attitudinal and behavioral trends

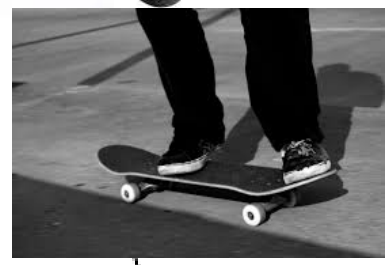
Vital Decision Missing in Modeling Framework



The influence of modality styles in the context of a comprehensive forecasting model system *(adapted from Bowman, 1995)*

Vij, Waddell, Walker (2015)





zipcar

UBER

lyft

Models of Travel Behavior

Traditional Models

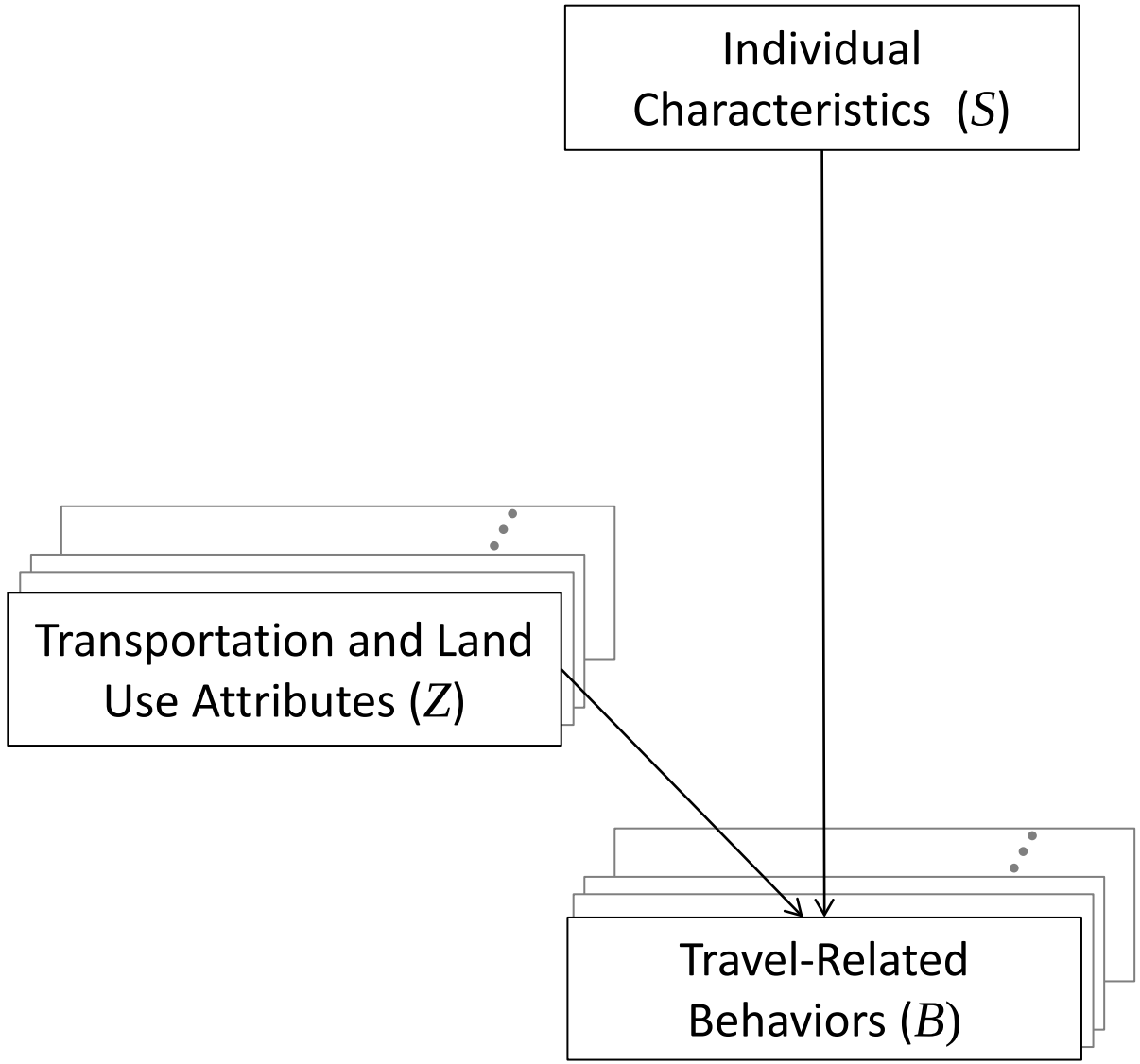
- Trip-based decision
  - Consider all transportation alternatives
  - Evaluate time and cost (and other)
  - Make rational decision
- Limited heterogeneity

Modality style Model

- Higher-level decision
  - Lifestyles built around particular travel modes

Vij, Carrel, Walker (2013)

Latent Modality Style Formulation



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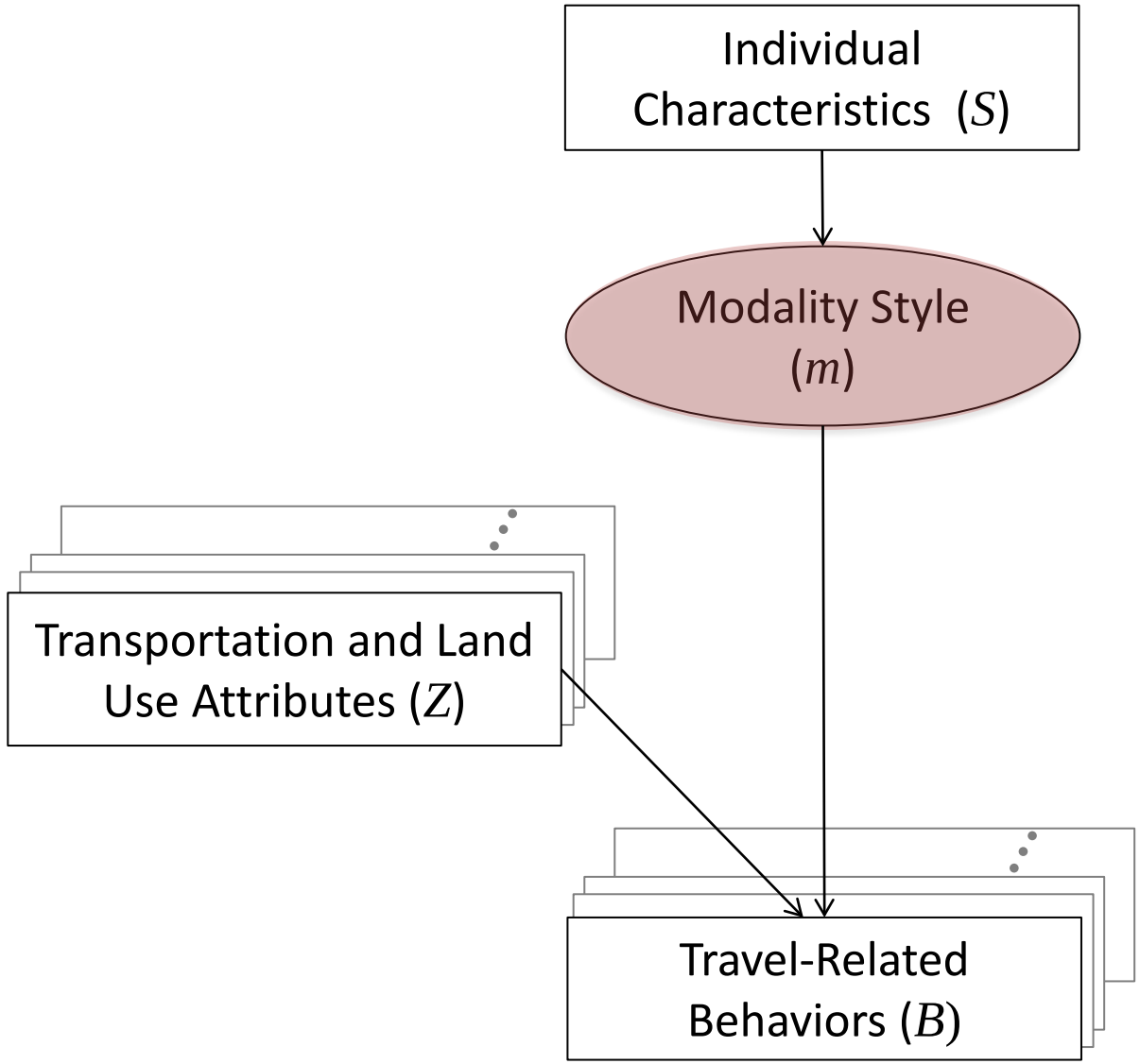


Latent Modality Style Formulation

- Latent Modality Style Segments;
  each segment ($m=1, \ldots, M$) has its own people and behavior
  - Set of transportation alternatives considered
  - Willingness to pay and attitudes
  - Demographic distributions
- Data mining of travel diary data determines
  - Number of segments M
  - Behavior of each segment $P(B \mid Z, m) \quad for \;\; m=1, \ldots, M$
  - Demographics of each segment $P(m \mid S)$

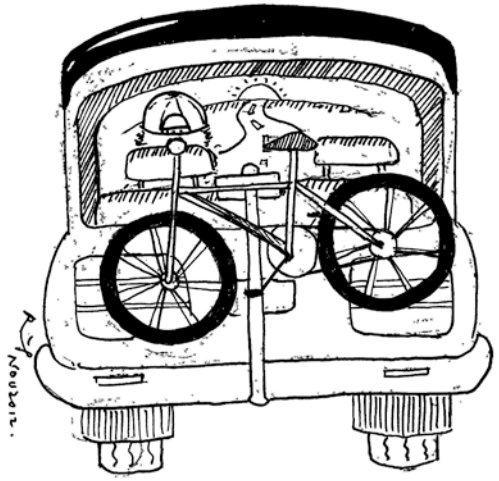
1. Produces Meaningful Segments

1. Inveterate Drivers

2. Car Commuters

3. Moms in Cars

4. Transit Takers



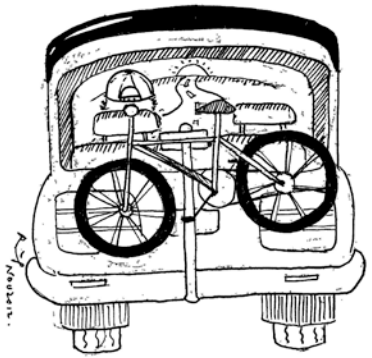
5. Multimodals

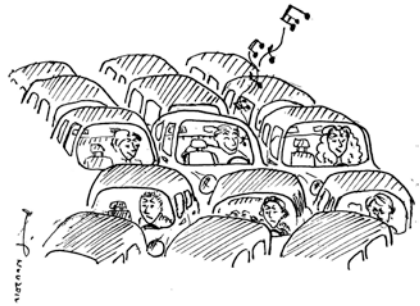
6. Empty Nesters

Vij (2013)

2. Explains Interdependencies of Decisions

Variation in SOCIO-DEMOGRAPHICS





1. Young Urbanists

4% of the sample population.

Most likely to be
young unemployed individuals,
often students,
with low household incomes.

2. Multimodals

6% of the sample population.

Most likely to be
single employed individuals
in households with no kids,
living in rented apartments,
with a carshare membership.

3. Nonworking Suburbanites

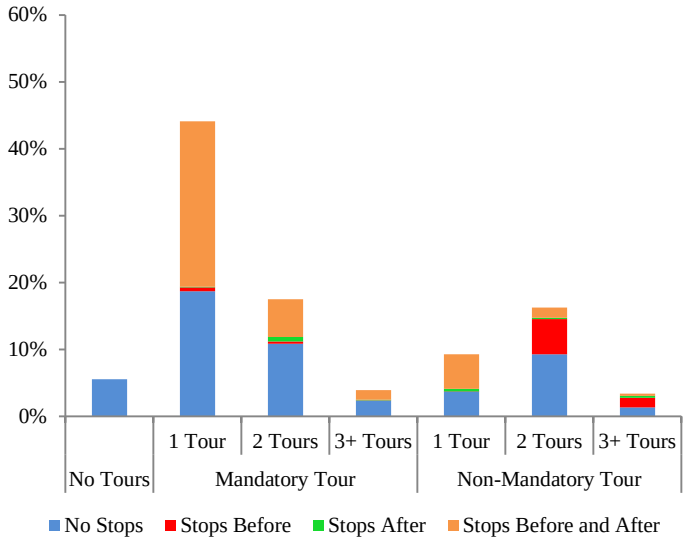
14% of the sample population

Most likely to be
high income hhs with kids,
live in single-family homes,
have on average 2.5 cars,
and unemployed or retired.

Vij, Waddell, Walker (2015)

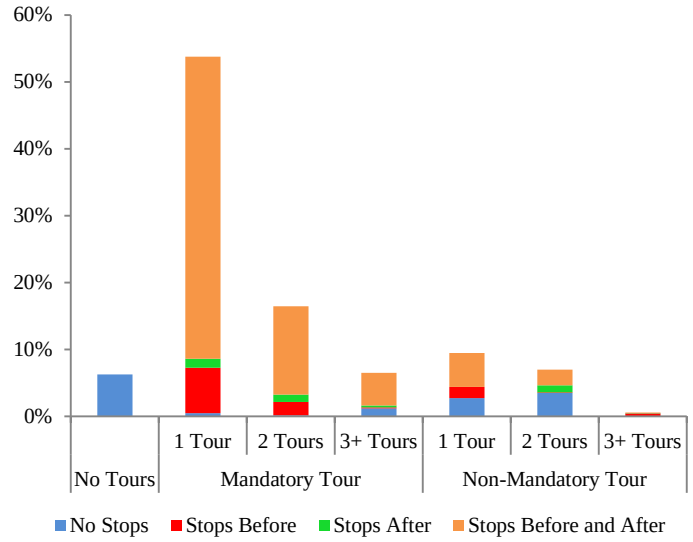
2. Explains Interdependencies of Decisions

Variation in TRIP-CHAINING and TRIP PURPOSES



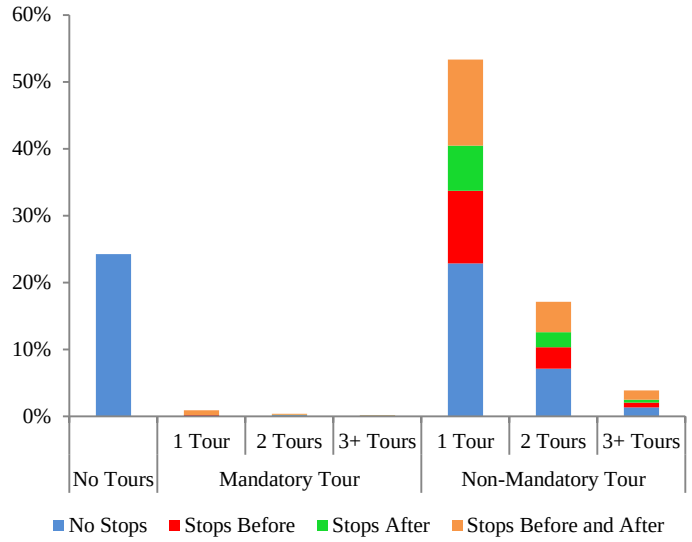
1. Young Urbanists

66% individuals make a mandatory tour;
equally likely to trip chain or not.



2. Multimodals

77% individuals make a mandatory tour;
strongly inclined to trip chain.

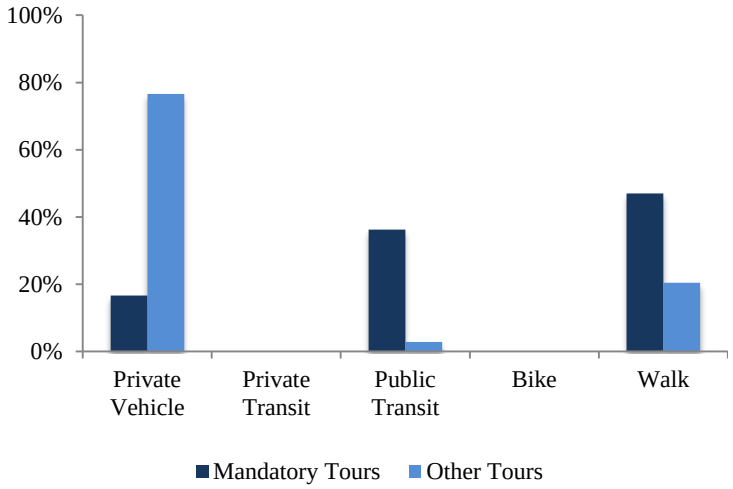


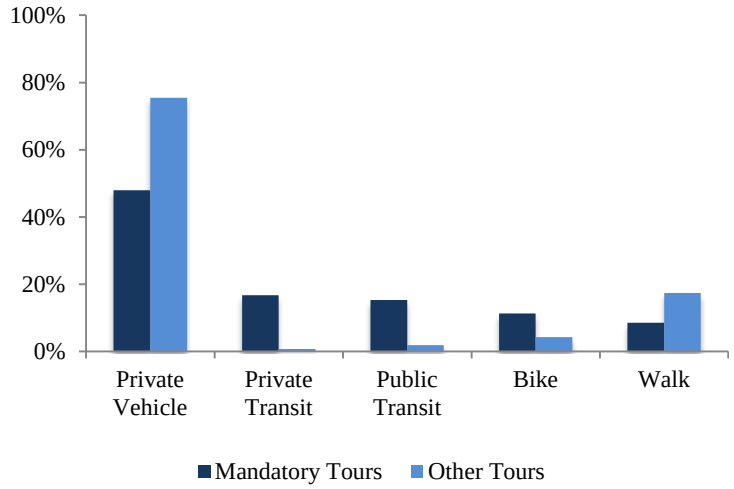
3. Nonworking Suburbanites

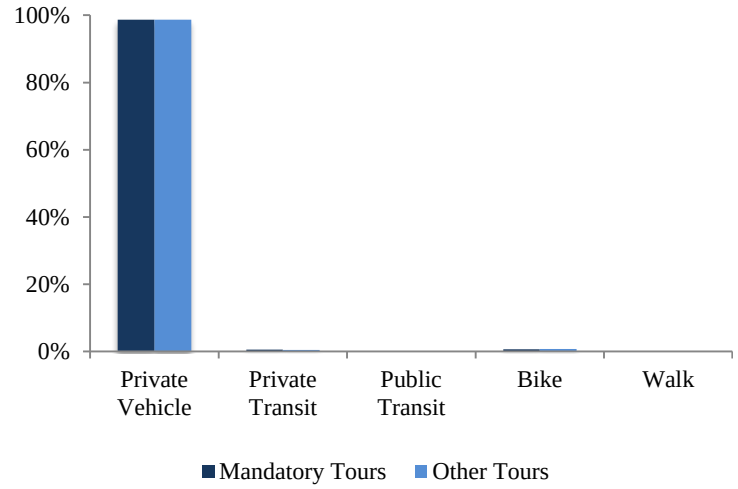
Only 1% individuals make a mandatory tour;
equally likely to trip chain.

2. Explains Interdependencies of Decisions

Variation in MODE CHOICES







1. Young Urbanists

Strong preference for walking: half of their mandatory tours and a fifth of their non-mandatory tours are made on foot.

2. Multimodals

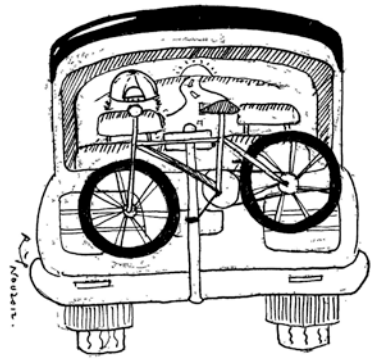
Drive for half of their tours.

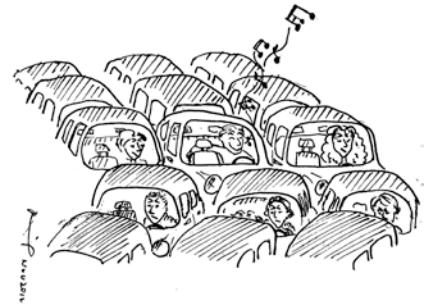
3. Nonworking Suburbanites

Drive everywhere.

2. Explains Interdependencies of Decisions

Variation in DESTINATIONS





1. Young Urbanists

Attracted to places with **higher** mixed use and **better** walkability.

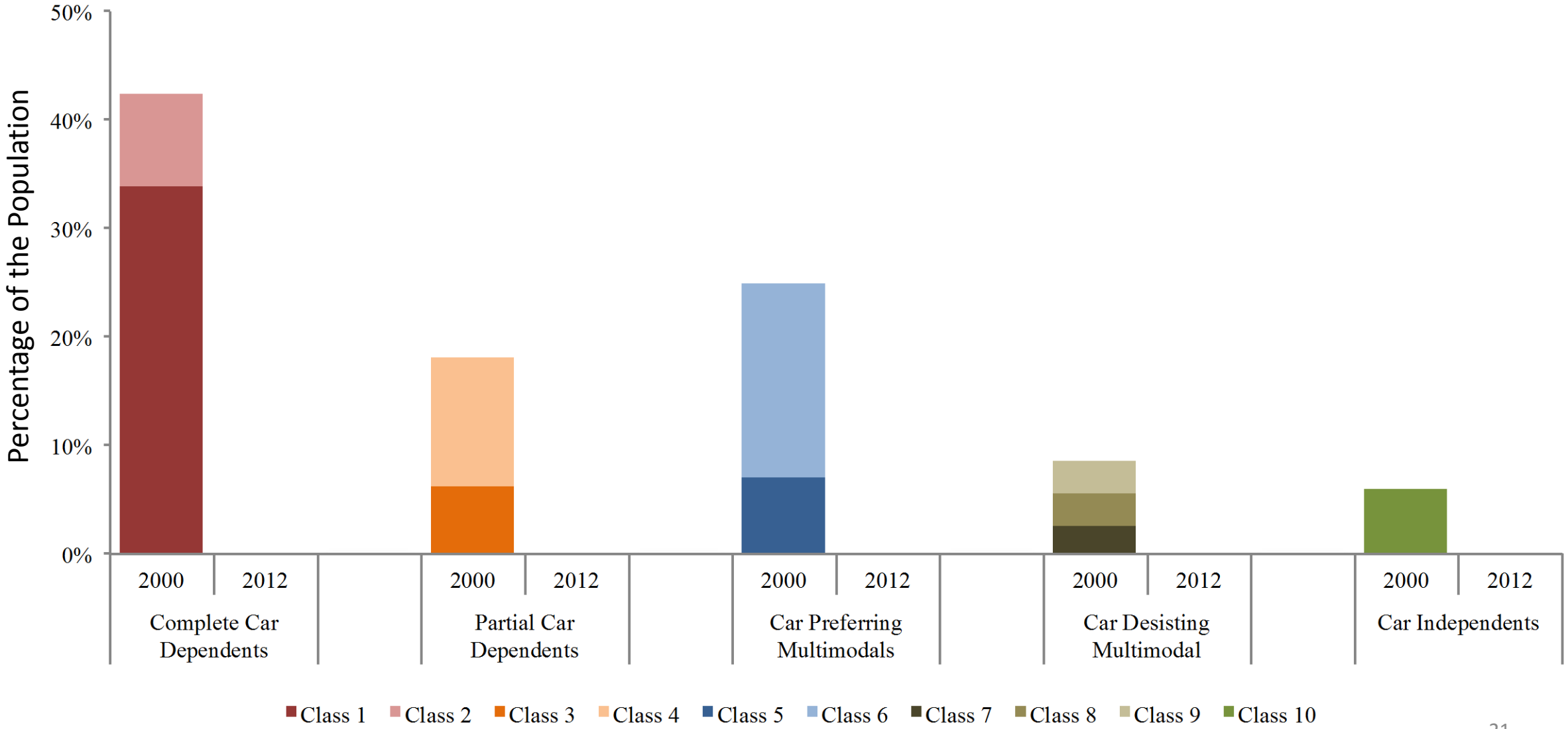
2. Multimodals

Attracted to places with **higher** mixed use and **less** walkability.

3. Nonworking Suburbanites

Attracted to places with **lower** mixed use and **less** walkability.

3. Provides Insights Regarding Behavioral Trends



Vij, Gorripaty, Walker (2015)

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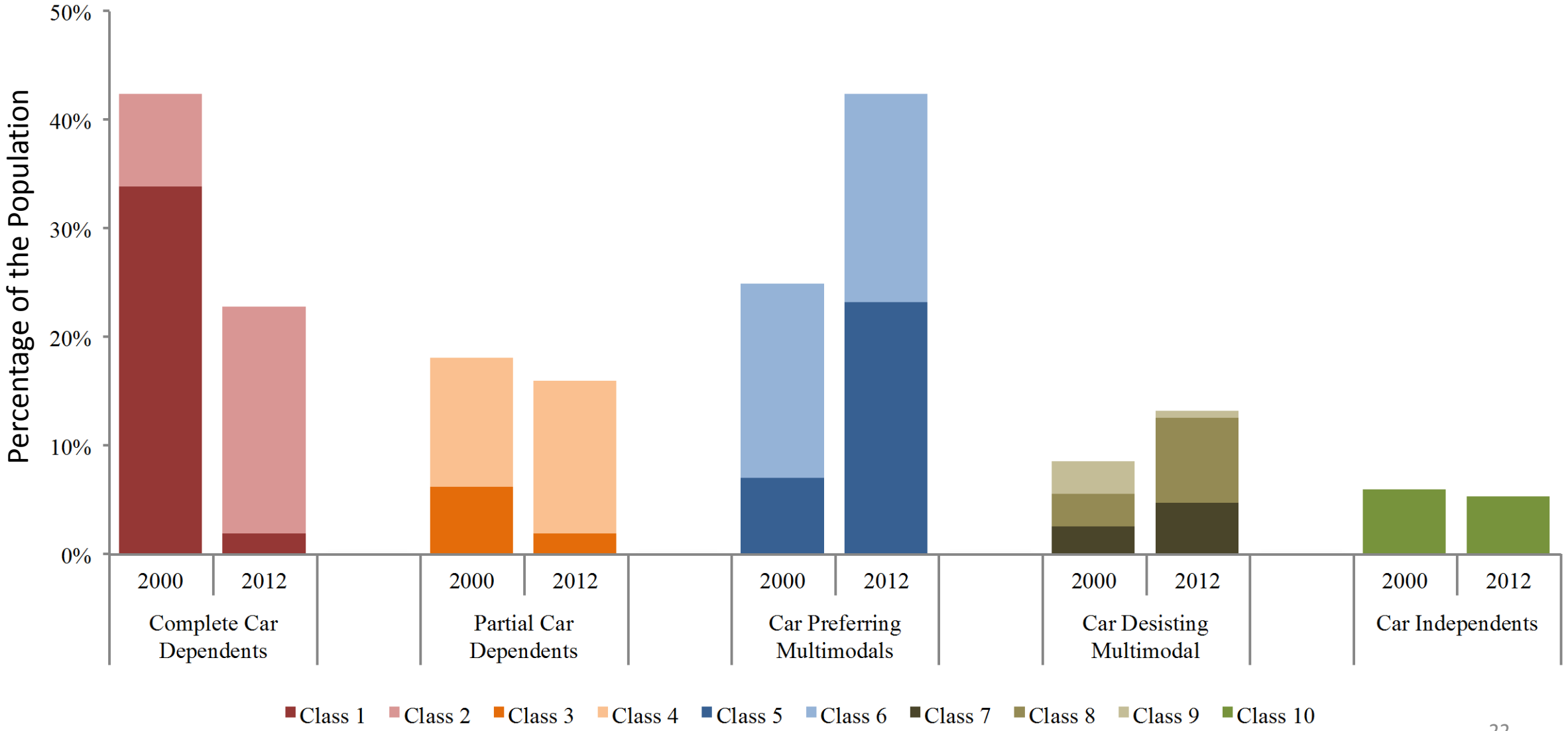
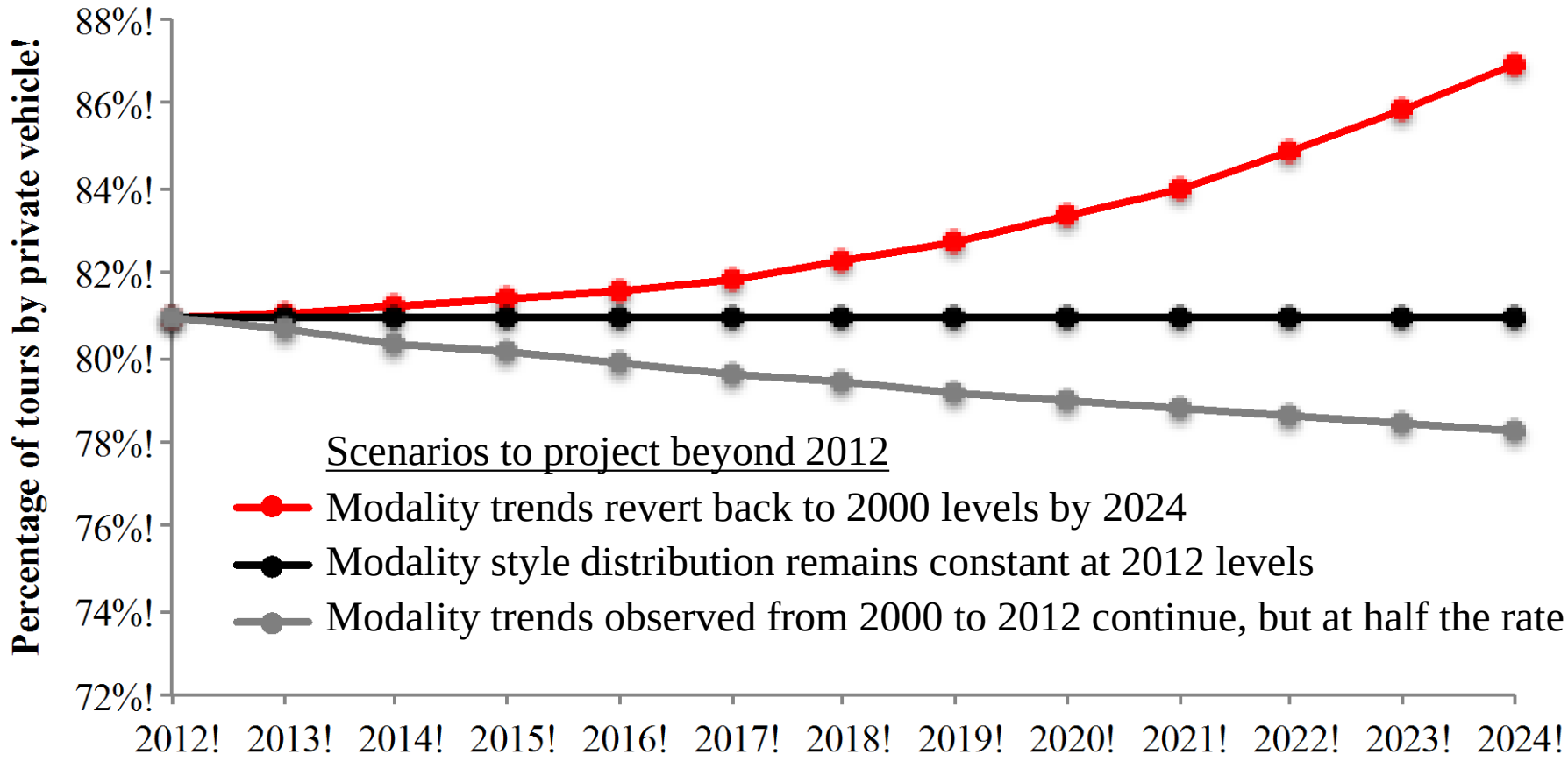


Vij, Gorripaty, Walker (2015)

4. Critically Impacts Forecasts



Vij, Gorripaty, Walker (2015)

5. Predicts Trends via Integration with HMM

El Zarwi, Vij, Walker (2016)

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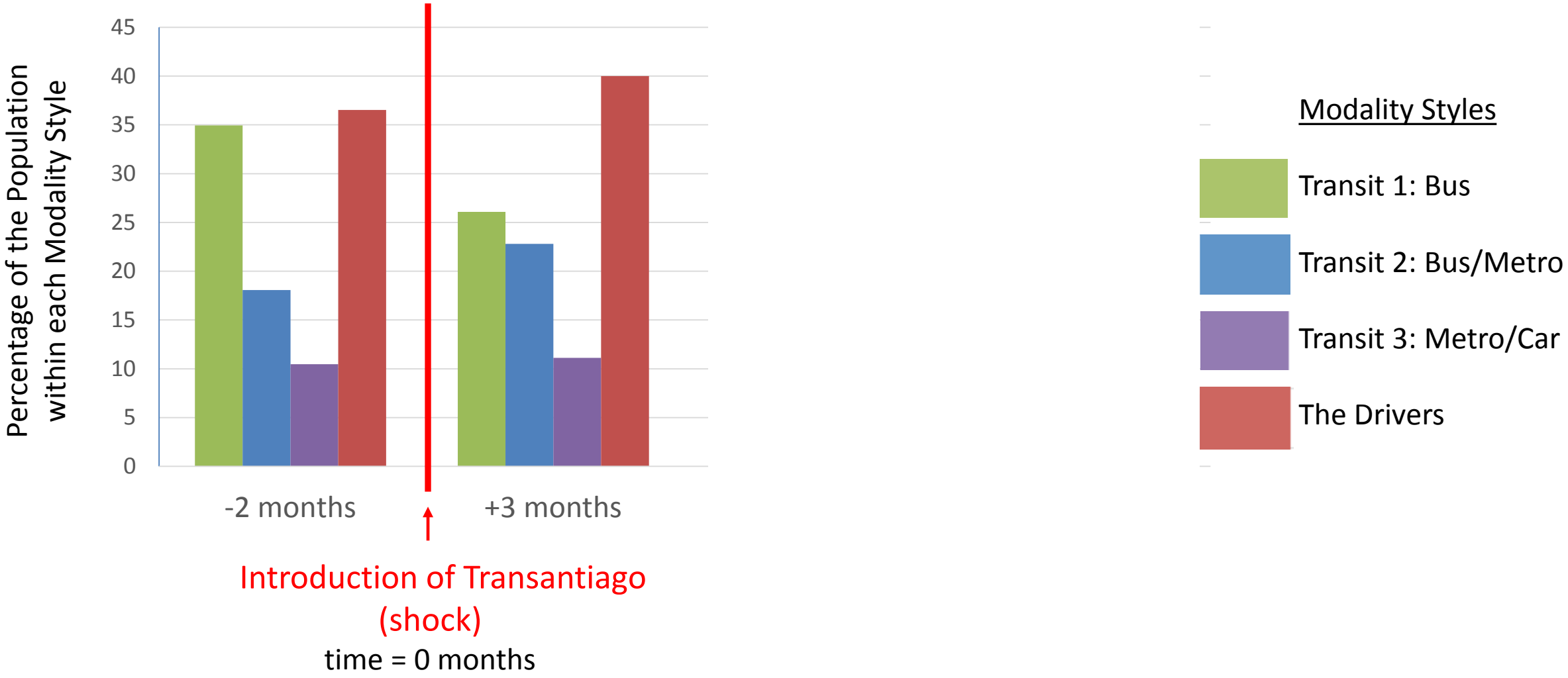

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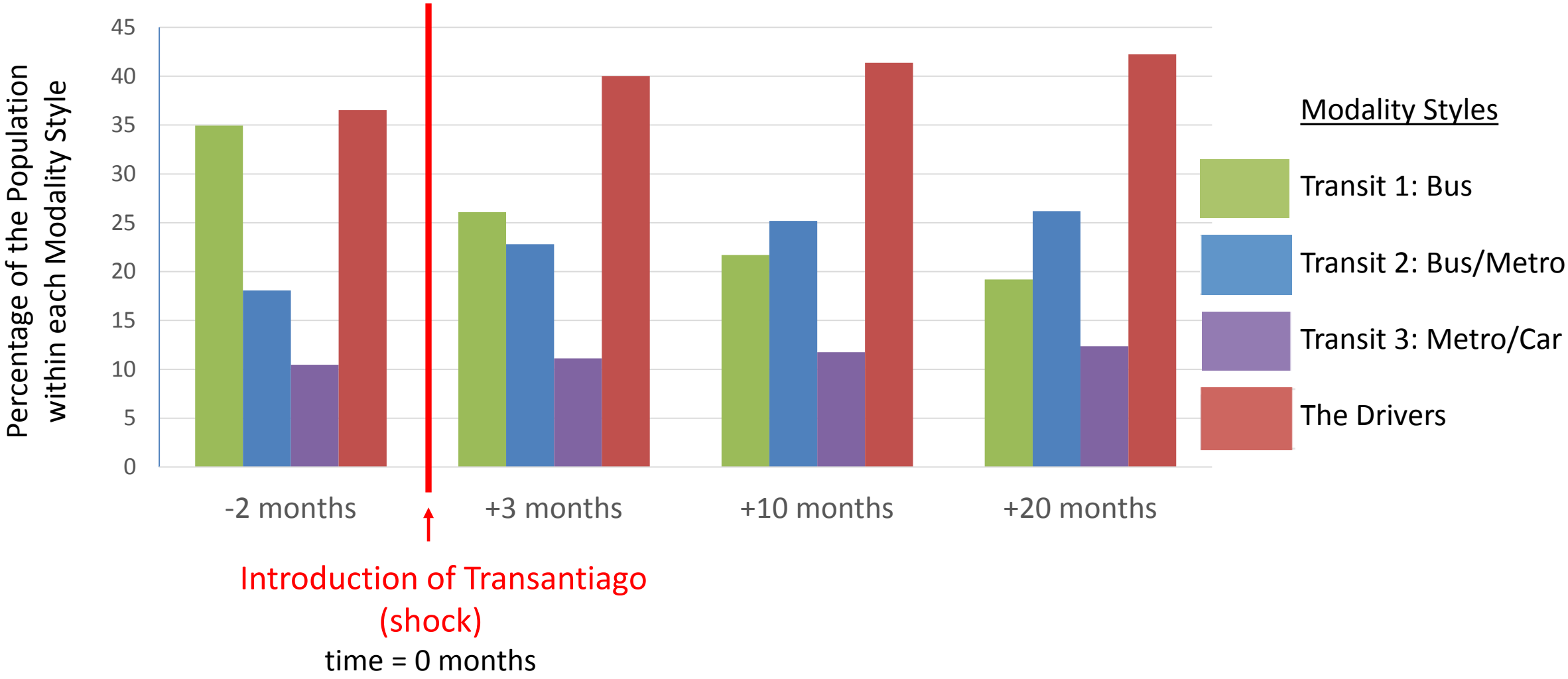


El Zarwi, Vij, Walker (2016)

Transformative Mobility

- Clean
- App-driven
- Shared
- Connecte
- Autonomou

To Change Behavior, Need to Change Modality Styles

Changing Modality Styles:
From Trend Spotting to Trend Setting

- Quantified Traveler — *Jariyasunant et al. (2015)*
  - Creating a more mindful traveler
- San Francisco Bay Area Travel Quality Study — *Carrel et al. (2015)*
  - Importance of personal experience
- Intervening on Residential Choice — *Bhattacharyya et al. (2015)*
  - Using psychological theories to shift habits
- New App-based, Shared Services (Uber, Lyft, Zipcar) — *Schade et al. (current)*
  - Shedding private cars versus shedding transit
- Adoption of new technologies and services — *El Zarwi et al. (2016), Nafisi et al. (current)*
  - Impact of design, policies, social influences, personalized info
- Future technologies (Automation) — *Walker et al. (current)*
  - Infer from present-day analogies

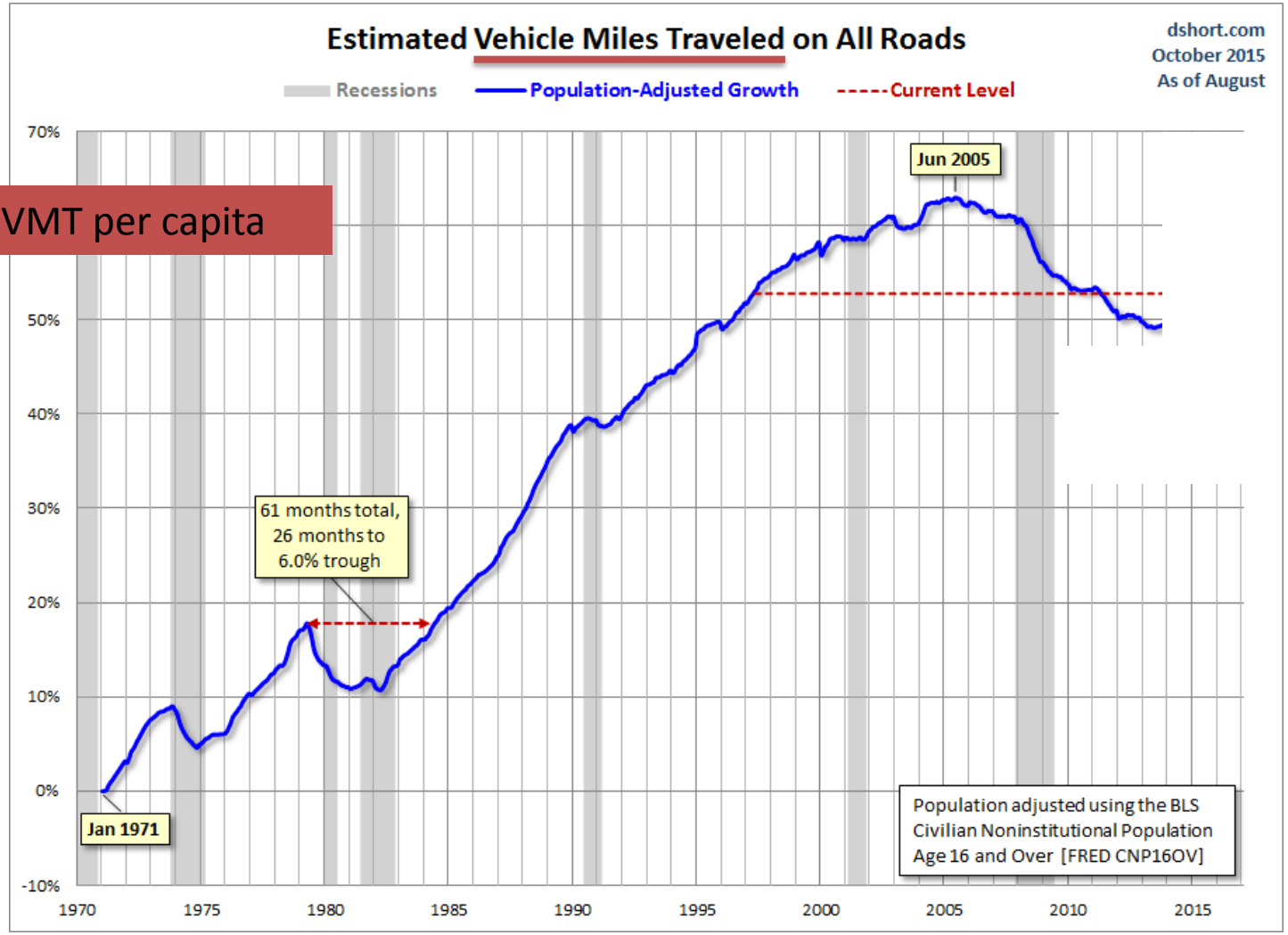
Conclusions

- Developing behavioral analysis tools to guide transformative mobility
- Must concern ourselves with potential heaven or hell outcomes today
  - Key is to model and influence trends
- Modality style concept is essential
  - Key driver of aggregate travel outcomes
  - Provides ability to model attitudes and trends in travel behavior
  - Behavior change efforts must focus on changing modality styles
- Ongoing work
  - Studying influence of Uber, Lyft, Zipcar, etc. on modality styles
  - Using present-day analogies to model future technologies (e.g., automation)
  - Experiments nudging towards sustainable modality styles, residential locations
  - Collecting more and better dynamic behavioral data from mobile devices

APPENDIX

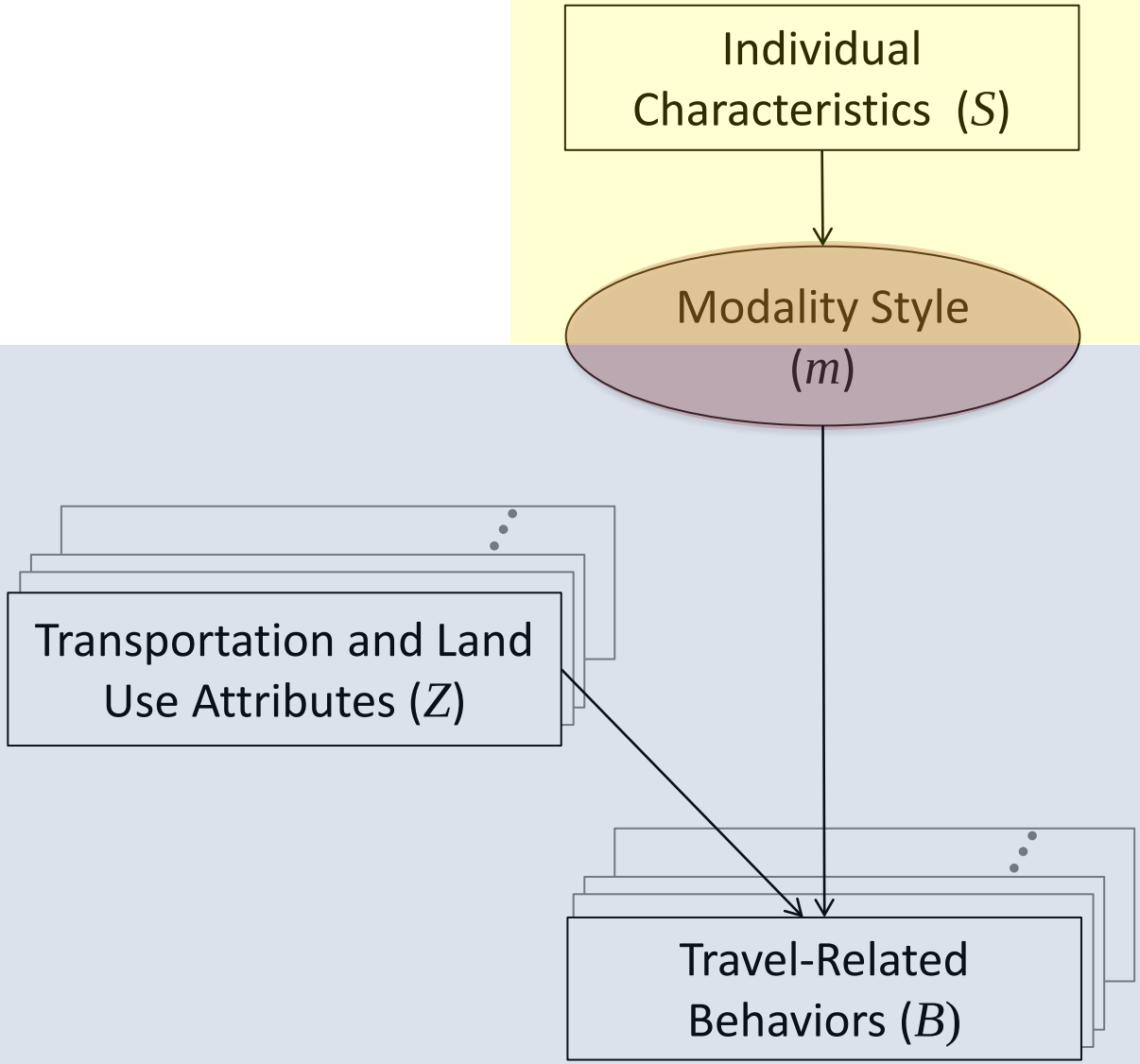
VMT Trends in the US… peak auto?

VMT per capita



Total VMT

Latent Modality Style Formulation



Class-Membership Probability

$$P(m \mid S)$$

that the individual has modality style m conditional on characteristics of the individual S

Class-specific Choice Probability

$$P(B \mid Z, m)$$

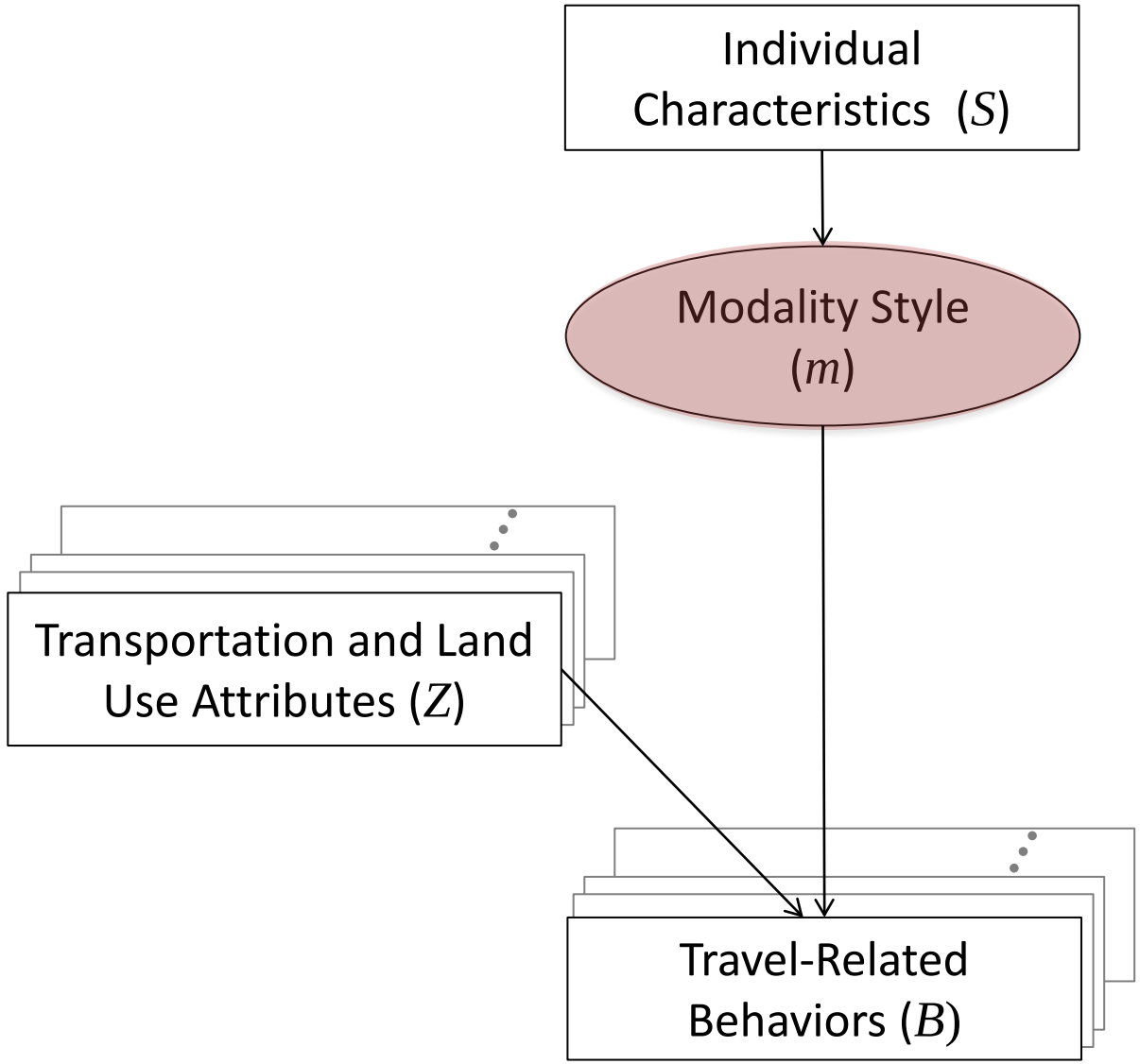
that individual chooses behaviors B conditional on alternative attributes Z and modality style of the individual m

Marginal Choice Probability

$$P(B \mid S, Z) = \sum_{m=1}^{M} P(B \mid Z, m) P(m \mid S)$$

unconditional on modality style m

Latent Modality Style Formulation



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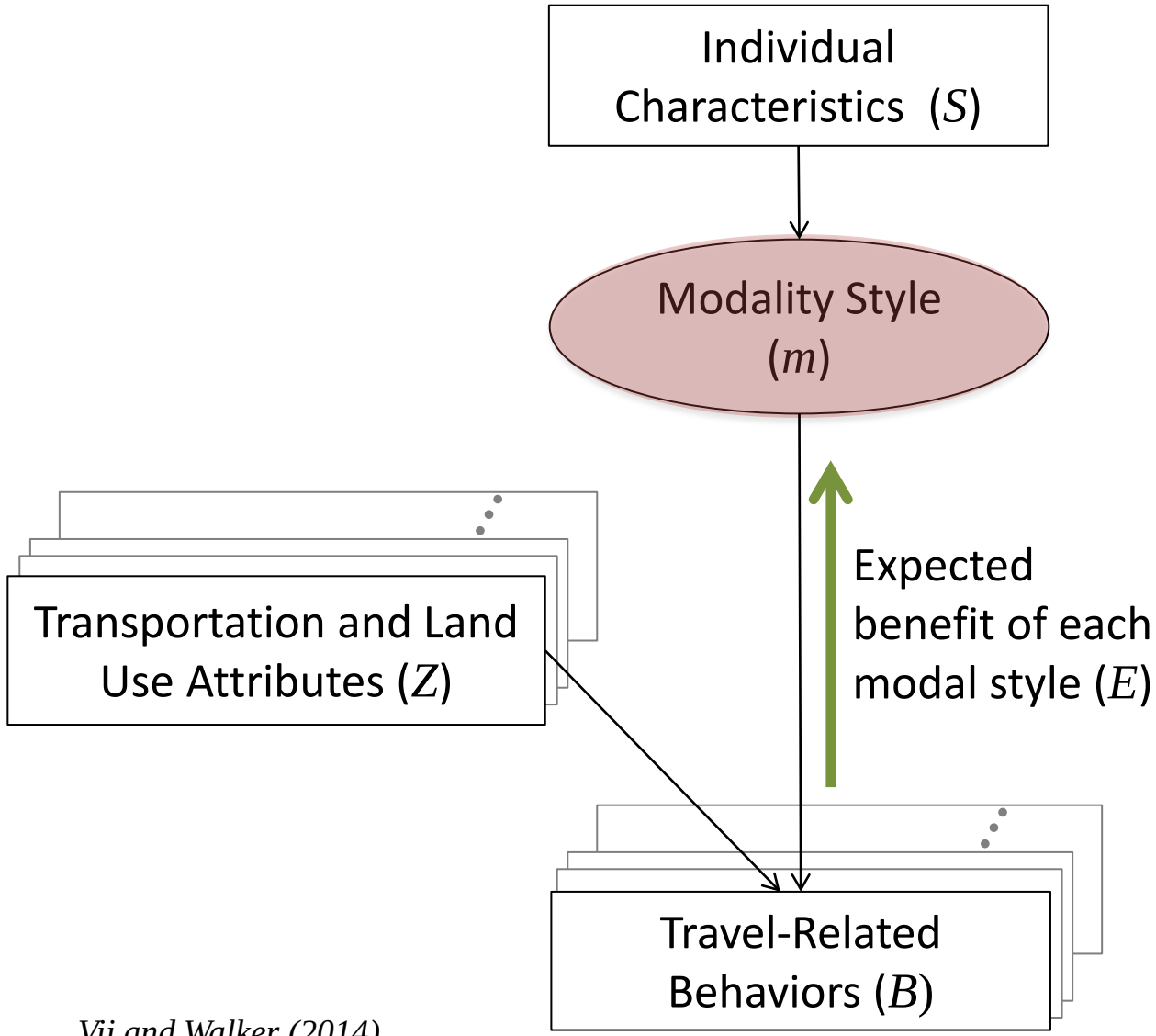

Vij and Walker (2014)

Class-Membership Probability

$$P(m \mid S, E(Z))$$

that the individual has modality style m conditional on characteristics of the individual S and expected benefit of each modality style E

Class-specific Choice Probability

$$P(B \mid Z, m)$$

that individual chooses behaviors B conditional on alternative attributes Z and modality style of the individual m

Marginal Choice Probability

$$P(B \mid S, Z) = \sum_{m=1}^{M} P(B \mid Z, m) P(m \mid S, E(Z))$$

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