Behavioral Considerations for Integrated Modeling in an Era of Disruptive Emerging Transportation Technologies

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What is Going On With Travel Demand?

Disruption due to Socio-demographic shifts, attitudinal shifts, e-commerce, and IoT
Frequency of Internet Use

NHTS 2001 – Generation X
N=3849

NHTS 2017 – Millennials
N=8328

Framework

SOV + HOV drive VMT

Geographical effects

Period effects

Age effects (Controlled 26-30 years)

Cohort (generational) effects

Unexplained effects

Socio-economic effects
Summary and Conclusions

Vehicle Miles Traveled is lower for Millennials, but the size of the generation (cohort) effect is tiny (less than 0.3%). VMT differences are largely due to socio-economic and demographic characteristics. The period effect is actually greater than the generation effect.

Huge UNEXPLAINED portion of person VMT variance!
The Future of Mobility

- Connected vehicles
  - V2V and V2I configurations
- Automated vehicles
  - Various degrees of automation
- Autonomous vehicles
  - Truly driverless
- (Shared/Hailed) Mobility Services (TNCs)
  - On-demand
- Electrification
- No Travel – Virtual and Delivered!
Technology Adoption

https://www.visualcapitalist.com/rising-speed-technological-adoption/

125 Year Span!

Technology Adoption

https://www.visualcapitalist.com/rising-speed-technological-adoption/

65 Year Span!
Waymo Now Giving Self-Driving Car Rides to the Public in Phoenix
Average Joes are about to get a crack at riding in the company's autonomous minivans.


AV adoption

Slight majority of Americans would not want to ride in a driverless vehicle if given the chance; safety concerns, lack of trust lead their list of concerns

% of U.S. adults who say they would/would not want to ride in a driverless vehicle

44% Yes, would want to ride in a driverless vehicle

56% No, would not want to ride in a driverless vehicle

Among those who say yes, % who give these as the main reasons

- Just for the experience/think it would be cool: 37%
- Would be safer: 17%
- Can do other things while driving: 15%
- Less stressful than driving: 13%
- Greater independence: 4%
- Convenience: 4%
- Good for long trips: 2%
- Other: 9%

Among those who say no, % who give these as the main reasons

- Don't trust it/warned about giving up control: 42%
- Safety concerns: 30%
- Enjoy driving: 9%
- Feel technology is not ready: 3%
- Potential for hacking: 2%
- Other: 8%

How a Self-Driving Uber Killed a Pedestrian in Arizona

By TROY GRIGGS and DAISUKI WAKABAYASHI

A woman was struck and killed on Sunday night by an autonomous car operated by Uber in Tempe, Ariz. It was believed to be the first pedestrian death associated with self-driving technology.

What We Know About the Accident

fear about riding in a fully autonomous vehicle

78% → 63% → 73%

early 2017  early 2018  may 2018

Survey taken few weeks after the Uber fatal accident in Tempe, AZ

Sources:
Consumers not ready for full autonomy


Consumers not ready for full autonomy

Question: How do we control a system in which the most important agent doesn’t wish to be controlled?

Evolution of Ride-hailing Frequency: Age 18-34 years

Observed Heterogeneity in Evolution – Puget Sound Regional Travel Survey
Evolution of Ride-hailing Frequency: Age (65 to 74 and ≥ 85)

Observed Heterogeneity in Evolution – Puget Sound Regional Travel Survey

65 - 74 years

85 years and above

Modeling Approaches

1 Electrification
2 Sharing
3 Automation
4 Deliveries

Scenarios & Parameters ➔ Models & Simulations ➔ Fake Forecasts

So little is known about the future

Behaviors Defined by Attitudes, Perceptions, Preferences, Values, and Evolutionary Dynamics
# How Will Emerging Technologies Impact VMT?

## Vehicle Ownership and So Much More!

### Pros
- May replace a drive-alone trip with Uber + transit, or other combo (solves transit’s first- and last-mile problem)
- May eliminate a personally-owned car (separately good), reducing unnecessary trips

### Neutral
- May replace a kiss-and-ride or PNR trip
- Or replace some other drive-alone trip

### Cons
- May displace a transit trip (not only increasing VMT, but undermining transit)
- May replace one carpool trip with multiple single-rider AV trips
- Makes travel easier, cheaper → may generate new trips
- Time saved (e.g., for parents using Shuddle for their children) may be used to generate new trips
- On-demand vehicles cruising, deadheading

Source: Patricia L. Mokhtarian, Georgia Tech

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## The “I” Era in Transportation

- Information (real-time, predictive, and personalized)
  - A focus on information provision and data collection
- Individual
  - A focus on individual agents
- Integrated
  - Addressing the built environment – travel demand – network supply nexus
- Intelligent
  - A user responsive, adaptive, and flexible multimodal transportation system
- Innovative
  - Big data to monitor and optimize complex adaptive system performance
App-Empowered Connected Travelers

Connected, Shared, and Autonomous Agents

- Connectivity:
  - Among vehicles of all types
  - Among vehicles and a variety of roadway infrastructures
  - Among vehicles, infrastructure, and wireless consumer devices

- Enables **real-time activity/trip planning** (across spectrum of choices)

- Integrated models for era of connectivity and real-time information
A Consumer Adoption Modeling Framework

- Consideration of factors which significantly affect consumers’ preferences (Technological factors, Non-technological factors)
- Reflecting heterogeneous consumers’ preferences

Estimation of consumers’ preference and willingness to pay for advanced technologies and alternative fuel types

Multiple discrete-continuous probit (MDCP) model with MACML

- Strategic management of advanced vehicle Technology options and fuel types
- Implications depending on consumer group

Success of new products

MMNP Model of Smart Vehicle Options

- Marginal willingness-to-pay (MWTP) computed for each attribute
  - Amount of money required to maintain a consumer’s current level of utility when one unit of an attribute is changed
- Also compute relative importance (RI) of option based on worth of each attribute
- Assuming deterministic portion of utility ($V_{nj}$) may be divided into price-dependent component and non-price dependent component:

$$MWTP_{x_{jk}} = -\frac{\partial U_{nj}}{\partial x_{jk}} = -\frac{\beta_k}{\beta_{price}}$$

$$RI_k = \frac{\text{part} - \text{worth}_k}{\sum_k \text{part} - \text{worth}_k} \times 100$$
Level 0 Model Integration - Classic Sequential Paradigm

- Activity-Travel Model
  - Trip Information
  - Dynamic Traffic Assignment Model
    - Update O-D Travel Times
    - Update Time-Dependent Shortest Path
  - Convergence?
    - NO
    - YES

End

Level 4 Model Integration: Pre-trip + Enroute Traveler Choices

- Activity-Travel Demand Model
  - Trip Record 1
    - Origin O
    - Destination D
    - Mode M
    - Person(s) reached destination and pursue activity
  - Dynamic Traffic Assignment Model
    - Person(s) received traffic congestion information
    - Trip Record 2
      - Origin O
      - Destination D
      - Mode M
      - Vehicle Information

- Person(s) reached destination and pursue activity

Trips in distress
Trips that arrived at their destination

6 second interval

1440 minutes

A portion of trips on the network are checked on every N minutes (N = 3 mins in this figure)
Need Data on Behavioral Adaption

Collect revealed preference data during events in the real world

I-85 Bridge Collapse, Atlanta 2017

Realizing Behavioral Change That LASTS

• The Spitsmijden reward-based travel demand management strategy
  • Assess the effectiveness of incentives in reducing morning peak period vehicular traffic volumes
• October 2006: 7:30 – 9:30 AM commuters on Dutch A12 motorway
• 14 week experiment
  • 2 weeks “pre-reward” period
  • 10 weeks “reward” period
  • 2 weeks “post-reward” period
• 340 participants
  • 232 selected monetary reward (€3 - €7 per day)
  • 108 selected Yeti smartphone (earn credits to keep smartphone at end of experiment)
Realizing Behavioral Change That LASTS... is proving elusive!

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Total (%)</th>
<th>Prereward Period (%)</th>
<th>Reward Period (%)</th>
<th>Postreward Period (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driving before peak hour (base)</td>
<td>34.2</td>
<td>23.4</td>
<td>37.2</td>
<td>24.9</td>
</tr>
<tr>
<td>Driving during peak hour</td>
<td>25.9</td>
<td>46.8</td>
<td>20.0</td>
<td>45.7</td>
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<tr>
<td>Driving after peak hour</td>
<td>17.5</td>
<td>13.3</td>
<td>18.7</td>
<td>13.9</td>
</tr>
<tr>
<td>Using carpool or carshare with family or friends</td>
<td>5.3</td>
<td>4.4</td>
<td>5.5</td>
<td>4.4</td>
</tr>
<tr>
<td>Avoiding peak hour by using public transportation</td>
<td>10.3</td>
<td>4.7</td>
<td>11.7</td>
<td>6.6</td>
</tr>
<tr>
<td>Avoiding peak hour by using bike</td>
<td>3.0</td>
<td>4.5</td>
<td>2.9</td>
<td>1.5</td>
</tr>
<tr>
<td>Working from home</td>
<td>3.8</td>
<td>2.9</td>
<td>4.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Transport Controls and Behavior

- Let’s collect the data we need to understand
  - attitudes, behaviors, adoption and adaptation, and evolutionary dynamics…
- Take advantage of live experiments in the real-world
- Reflect behavioral evidence in transport models
- Acknowledge and accommodate high degree of uncertainty

It’s all about the human!
Thank you

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