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TRAVEL-TIME USE AND VALUE WITH MOBILITY SERVICES

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OVERVIEW:

Time Use and Value in Mobility Services: Seeking Insights from Carsharing & Ridehailing Mode Choices for Value of Travel Time in AVs

- **Timeline:**
  - Start Jan 2019
  - End Mar 2020
  - 100% complete

- **Budget:**
  - Funding for FY19: $75K (100% DOE)
  - Funding for FY20: $0

- **Barriers:**
  - *Determining the value and productivity* derived from new mobility technologies
  - Difficulty in sourcing *empirical real-world data* applicable to new mobility technologies such as connectivity and automation
  - Complex role of the human decision-making process in mobility systems

- **Partners:**
  - University of Washington (D. MacKenzie) collaboration, subcontract
  - Migo (mobility service aggregator), data
  - Argonne National Laboratory (J. Auld), interactions

RELEVANCE: TRAVEL TIME VALUE IS CRITICAL FOR ASSESSING BEHAVIOR AND BENEFITS OF NEW MOBILITY TECHS

Central to modeling vehicle automation and ride hailing/pooling

- The monetary value (cost) of time spent traveling ("Value of Travel Time" or VoTT) is a ***major*** determinant of travel behavior, single largest travel cost
  - Affects extent of travel (trip frequency and distance) and mode choice
  - VoTT estimates/ savings are the principal component of cost-benefit analysis of transportation infrastructure investments [U.S. DOT 2016]
- Impact of automation on VoTT is *highly uncertain*
  - Known to be *one of the most important single parameters* of in assessing benefits, demand response, and impacts of new mobility technologies
  - Essential input for goal of "accurately modeling and simulating large-scale transportation systems"
- Paucity of real-world data on time-value in automated vehicles requires either
  - Stated-preference surveys
  - Inference from analog trips in proxy travel modes

RELEVANCE: ESTIMATE AV TIME VALUE FROM UNIQUE, REAL WORLD, DATA

Dataset uniquely observes paired-choice between car driving & riding

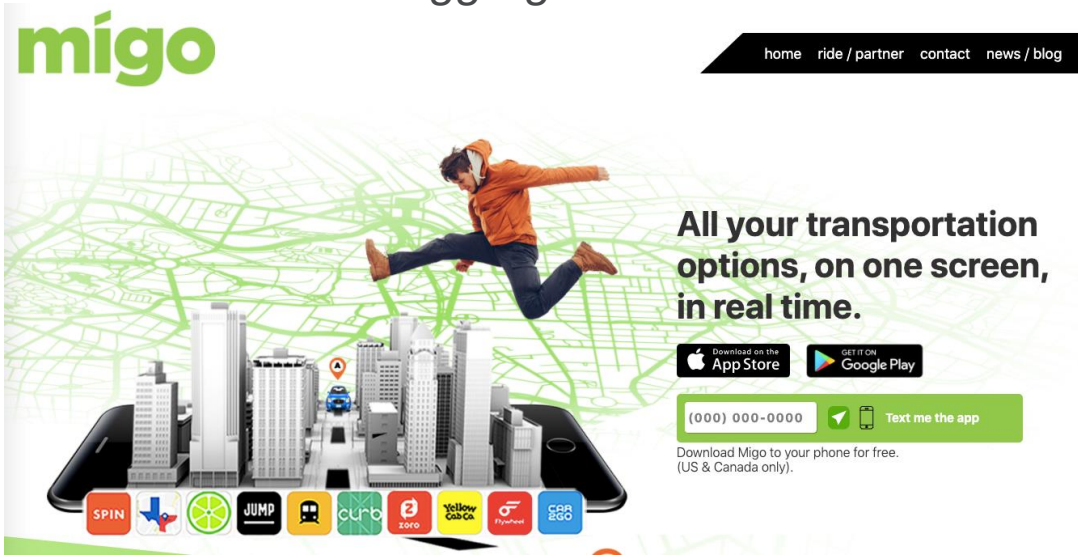
- Riding in a ridehailing service or an AV, vs driving, is expected to reduce mental burden and ultimately allow travelers freedom to engage in other activities
  - may result in decreased disutility/cost of time spent traveling
- Prior "stated preference/choice" methods are based on survey responses to *hypothetical trip* choices
  - limitations to this approach are well established, partic. for novel choices
- Prior studies based on *actual proxy trips* consider modes dissimilar to AVs (trains or transit), or not definitively paired to a driving alternative (taxi/TNC)
- ***This study:*** Based on *actual car trip choices* develops quantitative estimates of how the value of travel time (VoTT) may change when time spent *driving* is replaced by time spent *riding in a car*.

APPROACH

Analyze actual data on travelers' choices between simultaneous carsharing (driving) and ridehailing options, considering cost & time

- Revealed preference analysis of actual mode choices using a novel dataset from a mobility-as-a-service aggregator App.
- As in Gao et al. (2018), we treat the in-vehicle experience in a ridehailing vehicle today as a proxy for riding in a future fully automated vehicle
- Our team worked with Migo staff to clean the data.

Data for this project provided by Migo, a Seattle-based mobility-as-a-service (MaaS) aggregator



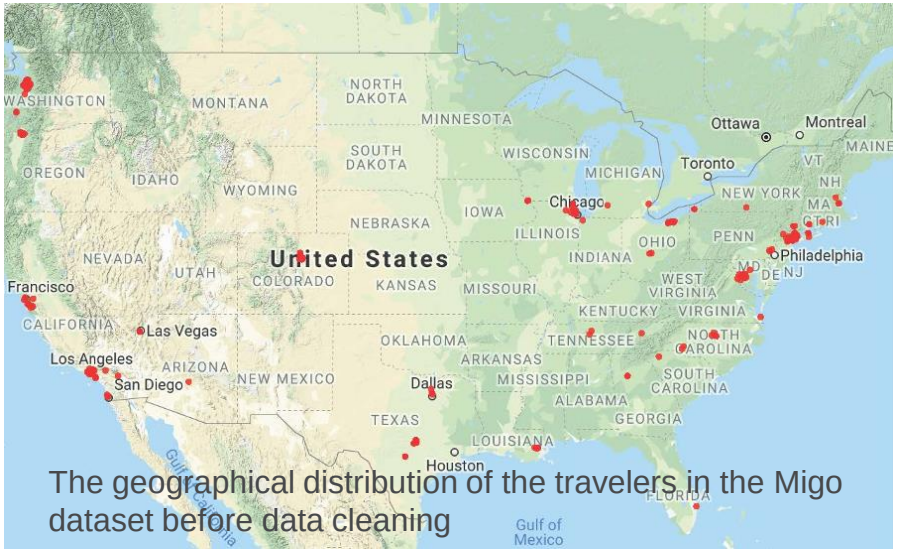
APPROACH – USE DATA FROM APP USERS ON TRIP ALTERNATIVES AND THEIR CHOICES

Variables:

- Traveler ID (anonymized)
- Traveler location, trip origin & destination (blurred to within 100 meters)
- Actual trip OD distance
- Walking time, in-vehicle time and price for car-share Car2go
- Waiting time, in-vehicle time, and price for TNCs Uber and Lyft
- Whether traveler tapped to see more details
- Whether traveler booked Uber, Lyft, or car2go in the Migo app, or linked out to the booking page

Data range:

- July 2018 to February 2019
- 168 travelers and 2082 sessions
- After filtering (incomplete cases, those without bookings or linkouts, unreasonable times/prices): 103 travelers and 863 sessions



The geographical distribution of the travelers in the Migo dataset before data cleaning

APPROACH – DATA SUMMARY

Data: Chosen modes by number of observations and number of unique users		
Chosen Mode	**Number of Observations**	**Number of Users**
Car2go	98	52
Uber	457	60
Lyft	308	51

Data: Summary statistics of variables						
Variable	**Minimum**	**1st quantile**	**Median**	**Mean**	**3rd quantile**	**Maximum**
Car2go walk time (min)	1	3	5	6.88	9	32
Uber wait time (min)	1	2	3	3.15	4	14
Lyft wait time (min)	1	1	2	2.33	3	15
IVTT	1.53	8.89	11.78	13.31	16.19	123.27

ACCOMPLISHMENTS – DEVELOPED SUITABLE ESTIMATION MODELS

Use modern discrete-choice models (Multinomial Logit & Mixed Logit with Error Components)

1. Account for In-Vehicle Travel Time (IVTT) and trip cost
2. Account for differences between walking and waiting times across alternatives
3. Because data do not show different In-vehicle travel times across alternatives for the same trip, treat IVTT as situation-specific (trip-specific) attribute, rather than an alternative-specific attribute.
4. Account for other alternative-specific (Car2go vs TNC) effects in ASC term.

$$V_{car2go} = \beta_1 * Price_{car2go} + \beta_2 * WalkTime_{car2go}$$

$$V_{uber} = ASC_{uber} + \beta_1 * Price_{uber} + \beta_3 * IVTT_{uber} + \beta_5 * WaitTime_{uber}$$

$$V_{lyft} = ASC_{lyft} + \beta_1 * Price_{lyft} + \beta_3 * IVTT_{lyft} + \beta_5 * WaitTime_{lyft}$$

RESULTS FROM ESTIMATION: MIXED LOGIT WITH ERROR COMPONENTS

Parameters	Value	Standard error	t-test	p-value
Alternative specific constants				
Car2go (base)	-	-	-	-
Uber	0.84	1.28	0.66	0.51
Lyft	0.61	1.25	0.49	0.63
Cost	**-0.32****	0.09	-3.56	0.00
In-vehicle travel time				
Car2go (base)	-	-	-	-
Uber/Lyft	**0.12****	0.06	1.99	0.05
Wait time (Uber/Lyft)	0.06	0.08	-0.78	0.44
Walk time (Car2go)	**-0.41****	0.15	-2.71	0.01
Error component (accounts for variability in non-time aspects of ridehailing vs. Car2go)				
Ridehailing	-6.69	2.37	-2.82	0.00
Initial log likelihood: -1065.758		Akaike Info. Criterion: 1307.240		
Final log likelihood: -646.620		Bayesian Info. Criterion: 1340.563		Rho-square: 0.387

ACCOMPLISHMENTS: VOTT RESULTS FROM TWO ESTIMATION METHODS

Both suggest a $16-$23/hr reduction in travel time cost from not driving

- The positive coefficient of In-Vehicle Travel Time represents the greater utility (lower travel time cost) of ridehailing modes (riding) relative to car2go (driving).
- Can estimate VoTT change with estimated coefficients for travel time and cost

$$\Delta \text{ VoTT} = \frac{\beta_{time}}{\beta_{cost}} * 60 = \$/hr$$

- Based on Multinomial Logit model (simpler/more restrictive):

$$\Delta \text{VoTT} = \frac{0.035}{-0.134} * 60 = \sim -16 \ \$/hr$$

- Based on Mixed Logit (the least restrictive in terms of structuring the choice):

$$\Delta \text{VoTT} = \frac{0.12}{-0.32} * 60 = \sim -23 \ \$/hr$$

ACCOMPLISHMENTS - DISCUSSION

Comparison with other results and Context

- Results here indicate that the *reduction* in VoTT for using ridehailing services vs. carsharing (riding vs. driving) is about $23/for Migo users in the US
- This number may seem high, considering prior literature studying similar concepts and reporting a range of 13-40% VoTT reduction
  - Those are relative to driving a personally owned vehicle
  - And principally from stated-preference studies
- Furthermore, unique data in this study applies to its sample of users, who are likely higher-income
  - VoTT is known related to opportunity cost of time and wage (as well as being trip and situation-dependent)
  - Migo users examined are from cities with higher-than-average median
  - NHTS also shows nationally car-share and ride-hail users are above-average income
    - 50% of all carsharing/ridehailing users income exceeds $100k (vs U.S. median $61k)

COLLABORATIONS AND COORDINATIONS

- University of Washington
  - Parastoo Jabbari (PhD candidate)
  - Andisheh Ranjbari (Research Engineer)
  - Borna Arabkhedri (MS student)
  - Don MacKenzie (Assoc. Prof., PI for subcontract)
- Oak Ridge National Laboratory
  - Paul Leiby (PI)
- MIGO - kindly shared data
- Argonne National Laboratory (J. Auld) coordination

PROPOSED FUTURE WORK

- Strengthen and extend estimates:
  - Follow up with expanded data set, given further collaboration from Migo, others
  - Seek some controls/proxies for rider characteristics like income
  - Obtain data better-differentiating travel time for alternatives on same trip, and refining time estimate.

•Any proposed future work is subject to change based on funding levels.

SUMMARY – NEW ESTIMATES WITH REAL-WORLD CAR TRIP CHOICE DATA SUGGEST LARGE TIME COST SAVINGS FROM RIDING VS DRIVING IN THESE SETTINGS

Informative result, relevant for VoTT in AVs, but still partial answer

- Unique behavioral dataset allows estimation of VoTT by “revealed preference”
  - **Directly addresses** relative change in **VoTT for same trip, riding vs. driving**
- Estimated mean travel time cost reductions $16- $20/hr, for frequent urban users
  - Suggests large benefits for full AVs & ridehail, and possible strong VMT response
- Result robust to two alternative estimation methodologies
  - Control for walking and waiting time, and for non-time aspects of alternatives
- SOME CAVEATS
  - Limited size of dataset, other limitations of data
    - Trips are urban, short-to-medium distance, and for a higher-income sample
  - Unclear if Car-share driving more or less convenient than conventional private car
    - (if less, our estimated VoTT reductions from not driving would be on high side)
  - VoTT is known to vary significantly with trip purpose, urgency, and driver income