# Future Mobility Patterns, Vehicle Ownership and Evolving Travel Behaviors

## December 11, 2018

## Dr. Giovanni Circella
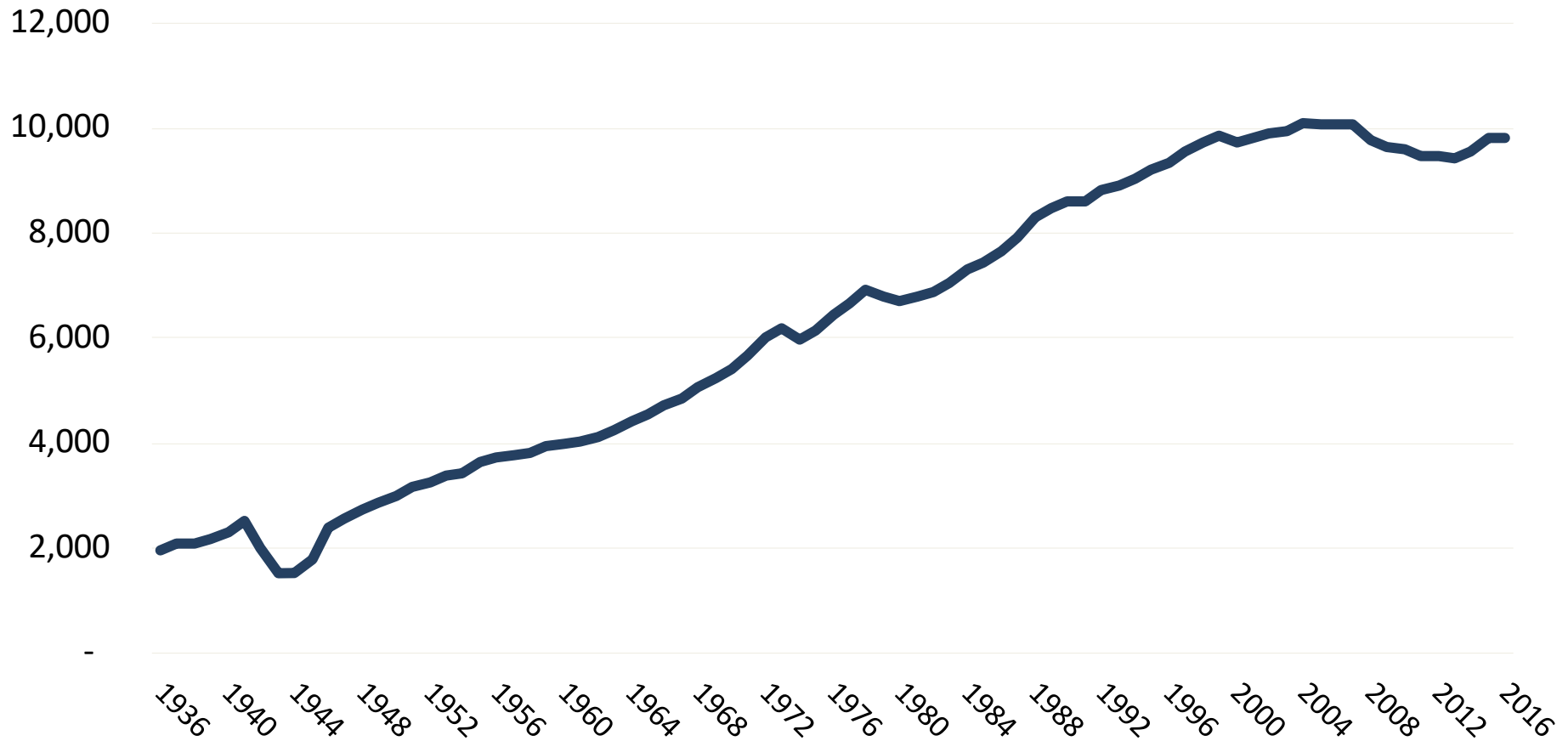
*Director, 3 Revolutions Future Mobility Program*

Institute of Transportation Studies, University of California, Davis

27,476 lane-miles of freeways
24.8 million licensed drivers
27.7 million cars & trucks
38.8 million residents
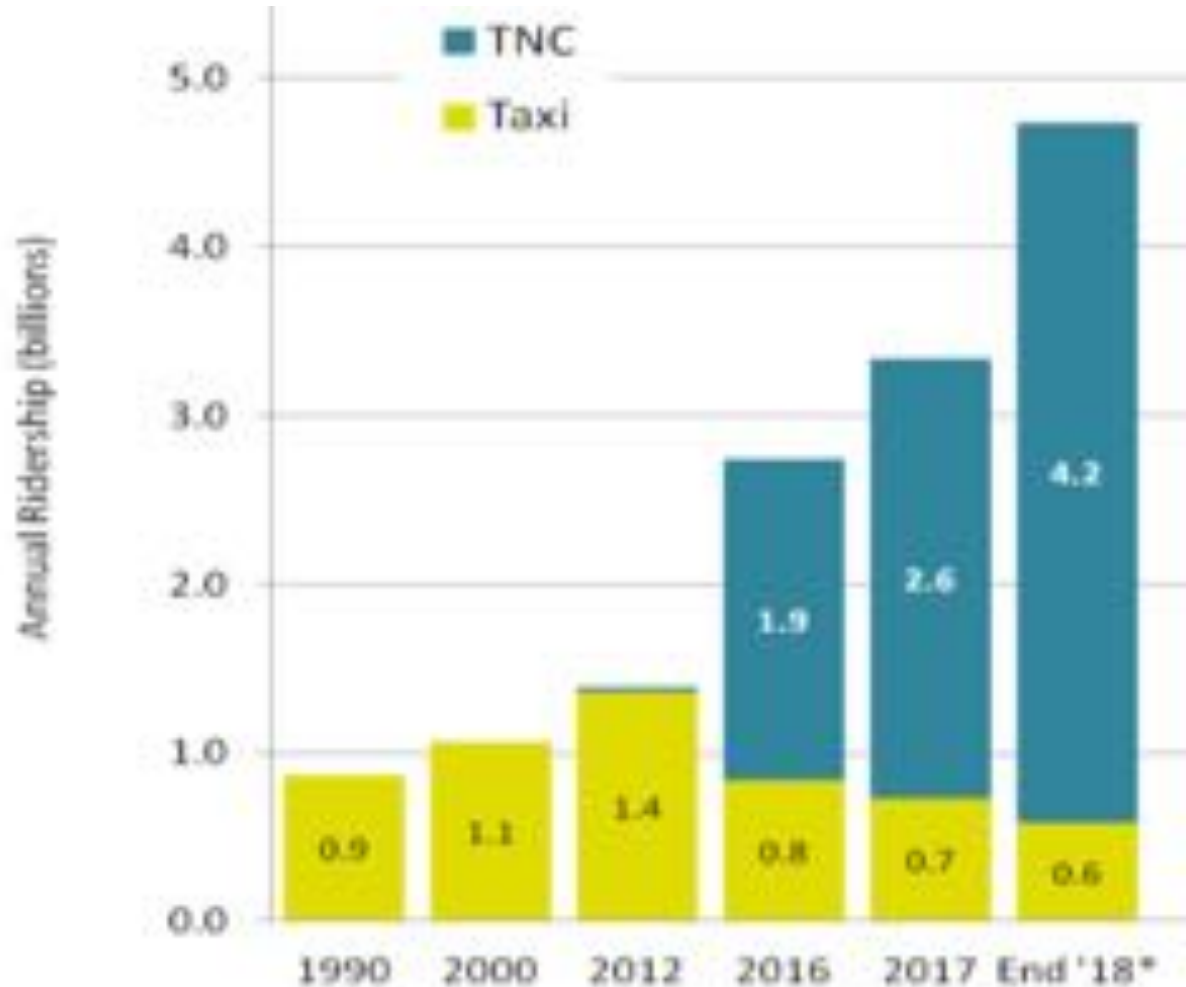
Welcome
to
California

# Annual VMT per Capita in US

- *Research Question:*

How are these transportation "revolutions" affecting vehicle ownership and travel behaviors?

*"People won't have as many vehicles because they'll share one and own one."*

Jim Hackett, Ford CEO
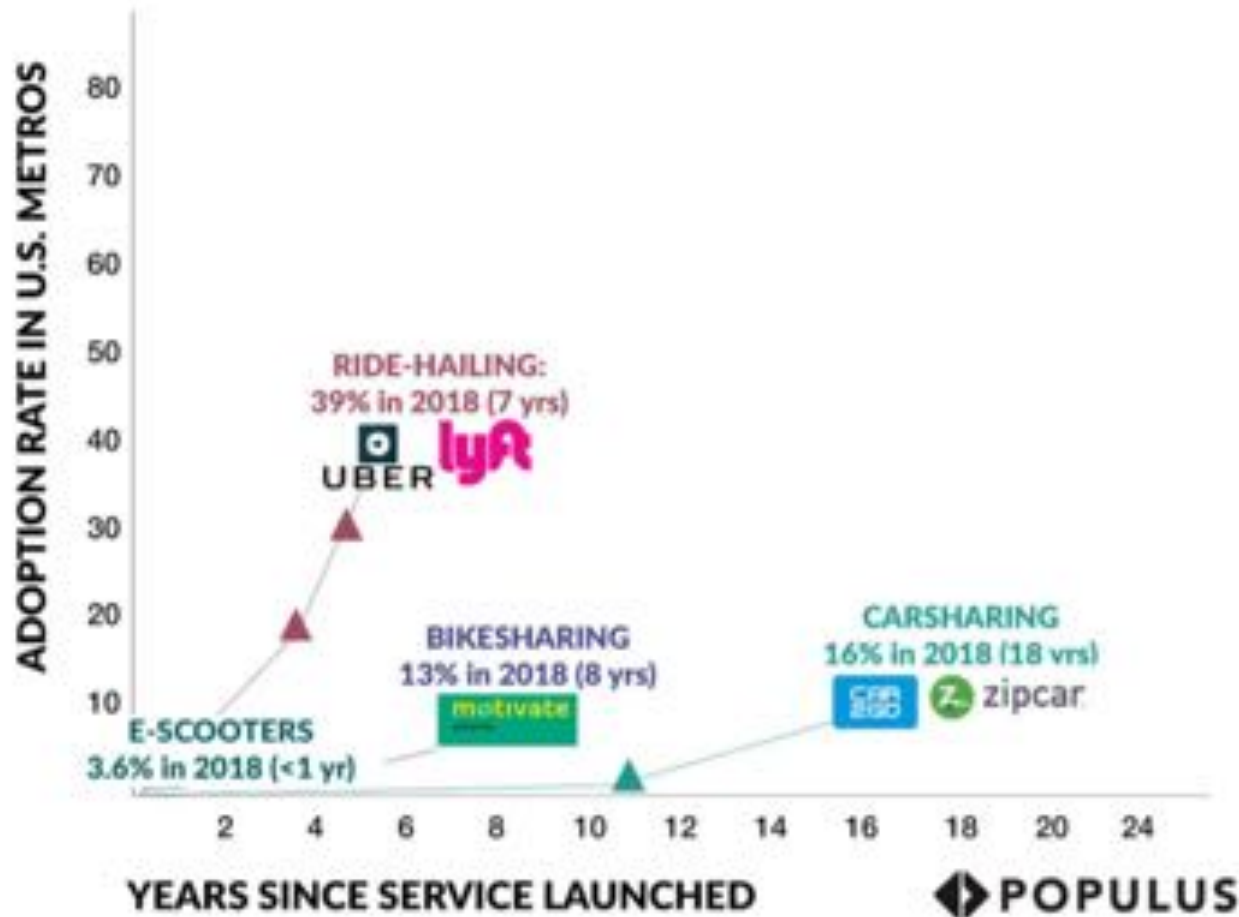
# Uber/Lyft ridership is growing quickly…



2018 Ridership forecasts:
- Taxi/TNC 4.8 billion
- Local bus 4.7 billion
- Urban rail 4.3 billion

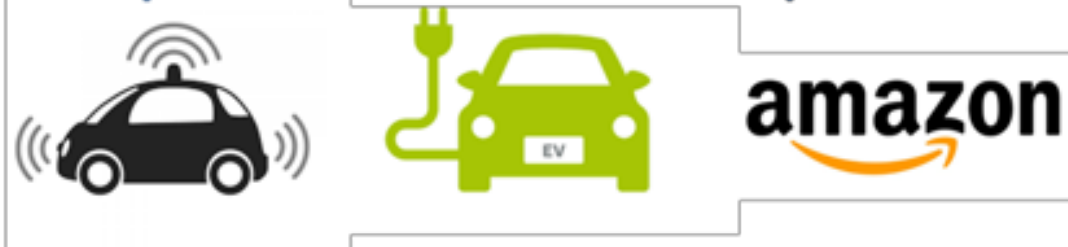*(Annual rate)*

*Source: Schaller (2018)*

# New mobility solutions are quickly being adopted in urban areas



*Source: Populus (2018); Data sources: Populus Groundtruth (2018), Clewlow & Mishra (2017), Clewlow (2016)*

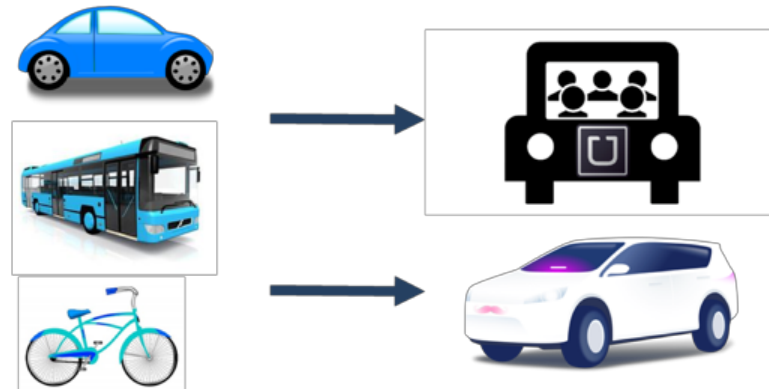# Research Questions

**What are the impacts on vehicle ownership and travel behavior?**



**Car Ownership vs. Shared Mobility?**



**What Replaces What?**

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# 3 Revolutions Future Mobility Program

**Shared mobility**, **electrification** and **autonomous vehicles** are bringing big changes in:

- *Transportation supply*

- *Transportation demand*

Need for rigorous research and impartial policy analysis to understand the impacts of these revolutions, and guide industry investments and government decision-making.

# California Panel Study of Emerging Transportation Trends

- Statewide longitudinal study with *rotating panel*

- 2015 survey: *Millennials* (18-34) and *Generation X* (35-50)

- 2018 survey: *All age groups*

- Quota sampling by *geographic region* and *neighborhood type*

- Focus on changing lifestyles, travel behavior, adoption of shared mobility and propensity to use AVs
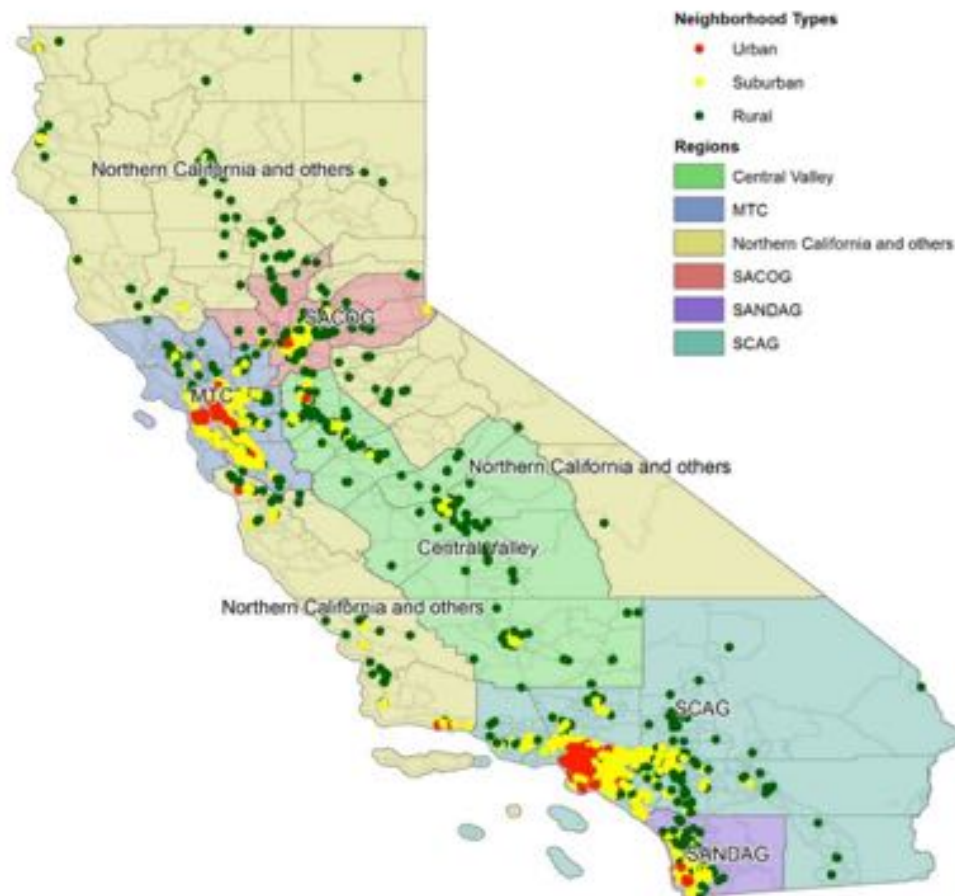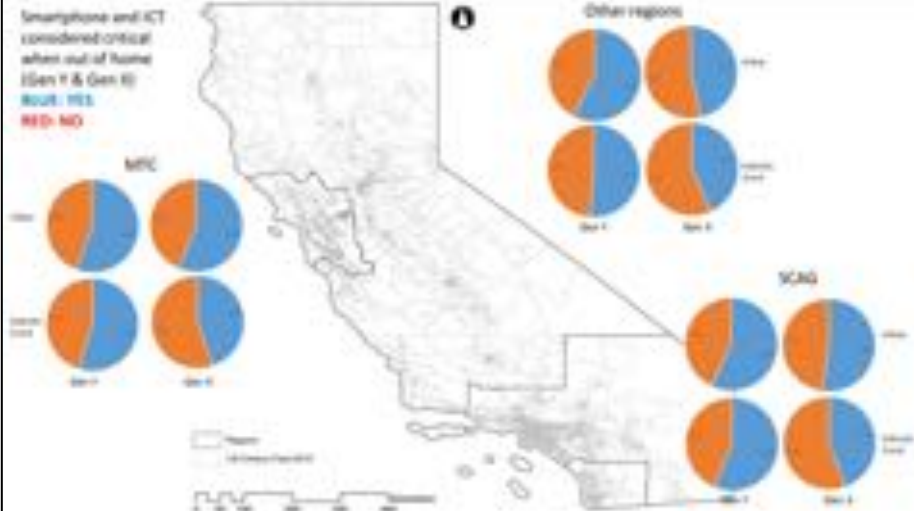
## "Millennials" (or "Generation Y")

- Rapidly changing trends in:
  - Household size
  - Educational attainment
  - Economic influence / consumption

- Very *active segment* of the population

- *Increasing economic power (and still climbing the income ladder)*

- *"Diverse, Expressive and Optimistic"*



MILLENNIALS– BREAKING THE MYTHS

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## Smartphone and ICT



Smartphone and ICT considered critical when out of home (Gen Y & Gen X)
**BLUE: YES**
**RED: NO**

Other regions

MTC

SCAG

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## Research Question

How many millennials match the stereotype of *urbanite/socialite* common in the media?

Cluster or latent class analysis to analyze different profiles of people (socialite/urbanite vs. others)

Stereotype common in the media:
- Live in urban areas
- Have dynamic lifestyles
- Heavy users of social media
- Own zero (or few) cars
- Use public transportation
- Adopt new technologies



How many millennials vs. Gen Xers fit this profile?

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## Shared Mobility Services

| Type of Services | | Ownership and Operational Models |
|---|---|---|
| Carsharing | car2go, zipcar, TURO | • Fleet-based or peer-to-peer<br>• Round trip or one way |
| Bikesharing | BikeShare, Spinlister, citibike | • Fleet-based or peer-to-peer<br>• Dock-based or GPS-based |
| Dynamic Ridesharing | scoop | • Private-public partnership<br>• Carpooling, vanpooling, and dynamic ridesharing |
| On-demand Ride Services | Uber, lyft | • Private (may be subsidized by public in future)<br>• Uber X and Lyft; Uber pool and LyftLine |

# Timeline of the Project

**2015 Survey:**

Opinion panel

*Generation X*
*Millennials*

N = 2,155

**2018 Survey:**

Opinion panel, paper survey

*Baby Boomers (and older)*
*Generation X*
*Millennials*
*Post-Millennials*

N = ~ 4,500
*(Version in Spanish is also offered)*

**Future Surveys**

| 2015 | | 2018 | 2019 | 2020 | 2021 |

*Annual updates…*

# Various Analyses from This Research

MILLENNIALS DRIVE LESS BUT DIFFERENCES IN VMT LARGELY EXPLAINED BY STAGE IN LIFE
**VMT**
**-15%**

HIGHER ADOPTION OF RIDEHAILING AMONG WELL-EDUCATED URBAN MILLENNIALS
**lyft**

MOST PEOPLE COMMUTE BY CAR IN CALIFORNIA. STILL, MILLENNIALS SLIGHTLY MORE LIKELY TO ADOPT OTHER MODES

MILLENNIALS WITH CHILDREN USE PUBLIC TRANSIT MORE THAN OLDER ADULTS WITH CHILDREN. SMARTPHONE USE CORRELATED WITH TRANSIT USE

INDEPENDENT MILLENNIALS CHOOSE MORE CENTRAL, ACCESSIBLE LOCATIONS AND ARE MORE MULTIMODAL

LATENT-CLASS ANALYSIS IDENTIFIES FIVE WELL-DEFINED GROUPS OF TRAVELERS
**HABITUAL DRIVERS: 84.7%**

MANY UBER TRIPS MADE BY MILLENNIALS REDUCE THE AMOUNT OF WALKING AND CYCLING

HIGHER LEVEL OF SATISFACTION WITH TRAVEL AMONG NON-URBAN MILLENNIALS, THOSE THAT RIDE A BIKE AND HAVE ACCESS TO A CAR

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March 2018 Report:
https://ncst.ucdavis.edu/wp-content/uploads/2016/10/NCST-TO-033.1-Circella_Shared-Mobility_Final-Report_MAR-2018.pdf

Travel Behavior and Society (2018) Paper:
https://doi.org/10.1016/j.tbs.2018.06.002

Journal of Choice Modeling (2018) Paper:
https://doi.org/10.1016/j.jocm.2018.08.003

Book Chapter (2018):
*Advances in Transport Policy and Planning, Vol. 1, Elsevier, 2018.*
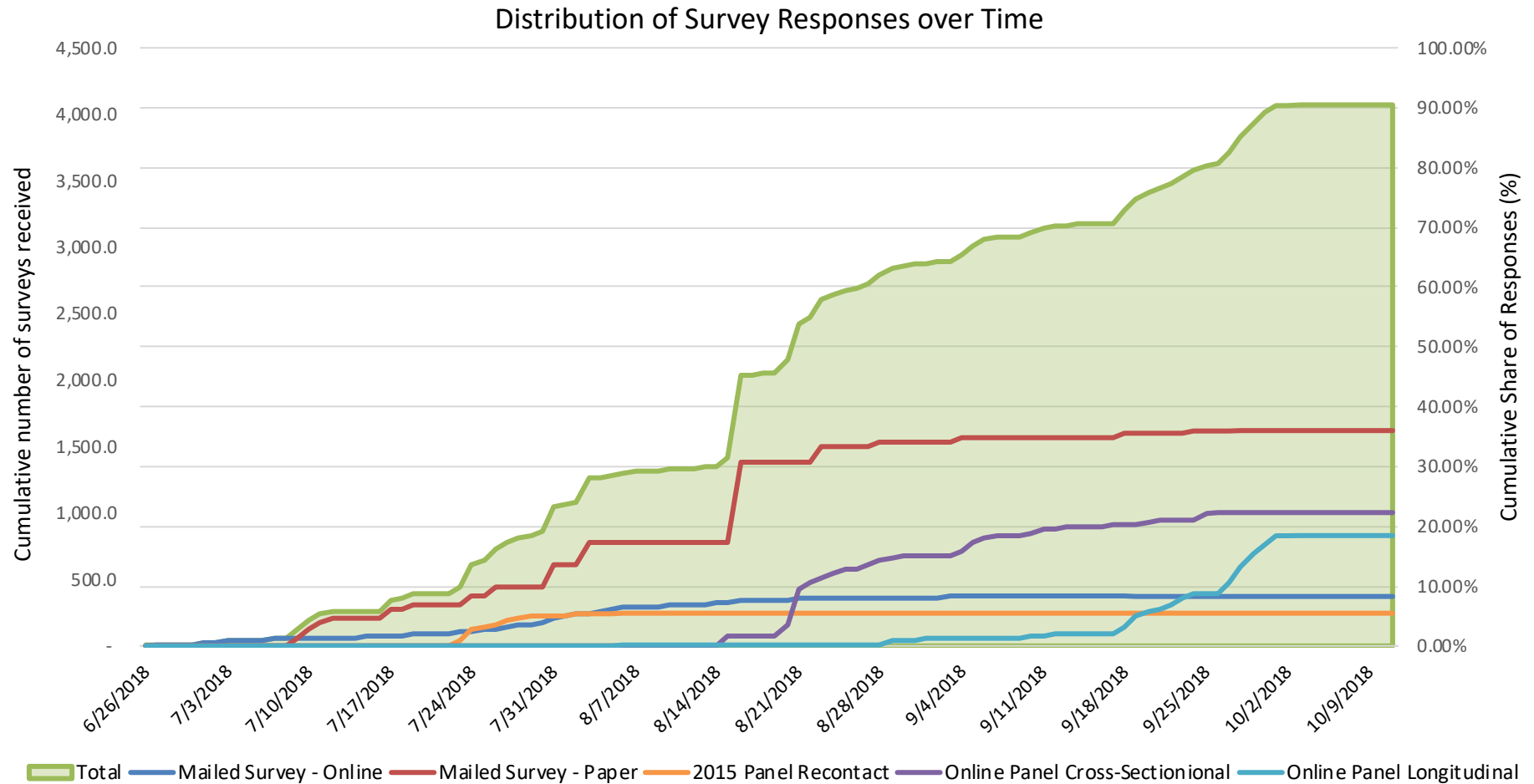https://doi.org/10.1016/bs.atpp.2018.08.001

Report on 2018 Data Collection *(forthcoming)*

*Additional references to papers from this project:*

- Circella, G. F. Alemi, R. Berliner, K. Tiedeman, Y. Lee, L. Fulton, S. Handy and P. Mokhtarian (2017) "Multimodal Behavior of Millennials: Exploring Differences in Travel Choices Between Young Adults and Gen-Xers in California", Presented at the Transportation Research Board 96th Annual Meeting, Washington DC, January 2017, TRB Paper #17-06827; Submitted for publication in the Journal of Transport Geography.

- Tiedeman, K., G. Circella, F. Alemi and R. Berliner (2017) "What Drives Millennials: Comparison of Vehicle Miles Traveled Between Millennials and Generation X in California", Presented at the Transportation Research Board 96th Annual Meeting, Washington DC, January 2017, TRB Paper #17-06044; Submitted for publication in the Journal of Public Transportation.

- Berliner, R. and G. Circella (2017) "Californian Millennials Drive Smaller Cars: Estimating Vehicle Type Choice of Millennials", Presented at the Transportation Research Board 96th Annual Meeting, Washington DC, January 2017, TRB Paper #17-06744.

- Alemi, F., G. Circella, P. Mokhtarian and S. Handy (2018) "On-demand Ride Services in California: Investigating the Factors Affecting the Frequency of Use of Uber/Lyft", Presented at the Transportation Research Board 97th Annual Meeting, Washington DC, January 2018.

- Alemi, F., G. Circella and D. Sperling (2018) "Limitations to the Adoption of Uber and Lyft in California and Impacts on the Use of Other Travel Modes", Presented at the Transportation Research Board 97th Annual Meeting, Washington DC, January 2018, TRB Paper #18-06713.

- Berliner, R., L. Aultman-Hall and G. Circella (2018) "Exploring the Self-reported Long-distance Travel Frequency of Adult Californians", Presented at the Transportation Research Board 97th Annual Meeting, Washington DC, January 2018, TRB Paper #18-05960; Accepted for publication in Transportation Research Record, Journal of the Transportation Research Board (*forthcoming*).

- Circella, G., F. Alemi and P. Mokhtarian (2017) "Exploring the Impact of Shared Mobility on California Millennials and Older Adults' Travel Patterns", Presented at the 2017 International Choice Modeling Conference, Cape Town (South Africa), April 2017.
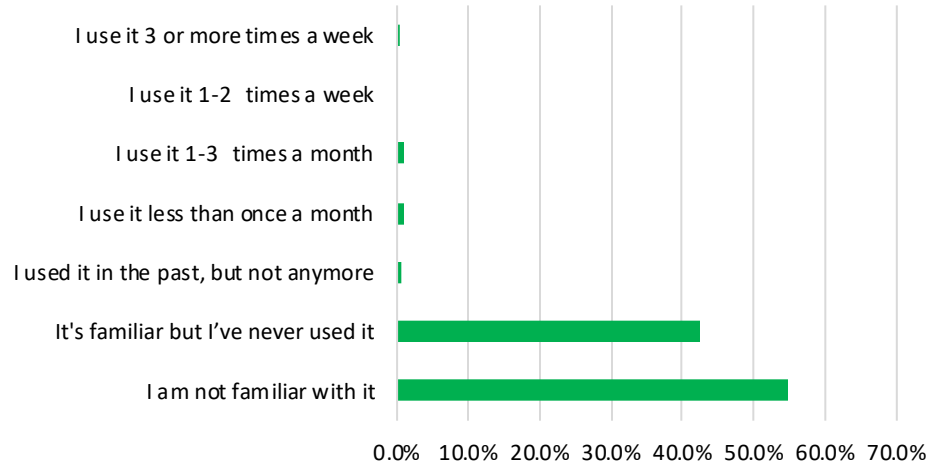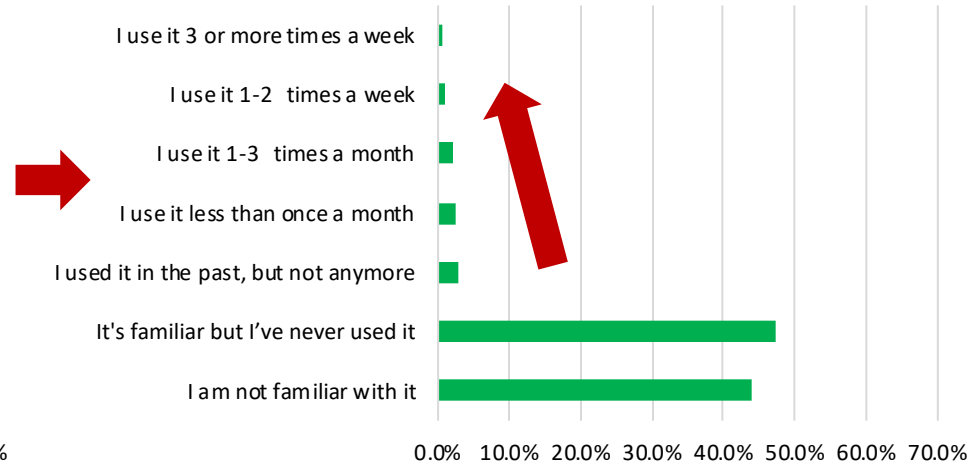
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# 2018 Data Collection



Distribution of Survey Responses over Time

# Adoption of Shared Mobility: 2015-2018



**2015 - Bikesharing**

- I use it 3 or more times a week
- I use it 1-2 times a week
- I use it 1-3 times a month
- I use it less than once a month
- I used it in the past, but not anymore
- It's familiar but I've never used it
- I am not familiar with it

0.0% 10.0% 20.0% 30.0% 40.0% 50.0% 60.0% 70.0%

**2018 - Bikesharing**

- I use it 3 or more times a week
- I use it 1-2 times a week
- I use it 1-3 times a month
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- I used it in the past, but not anymore
- It's familiar but I've never used it
- I am not familiar with it

0.0% 10.0% 20.0% 30.0% 40.0% 50.0% 60.0% 70.0%

**2015 - Carsharing**

- I use it 3 or more times a week
- I use it 1-2 times a week
- I use it 1-3 times a month
- I use it less than once a month
- I used it in the past, but not anymore
- It's familiar but I've never used it
- I am not familiar with it

0.0% 10.0% 20.0% 30.0% 40.0% 50.0% 60.0% 70.0%

**2018 - Carsharing**

- I use it 3 or more times a week
- I use it 1-2 times a week
- I use it 1-3 times a month
- I use it less than once a month
- I used it in the past, but not anymore
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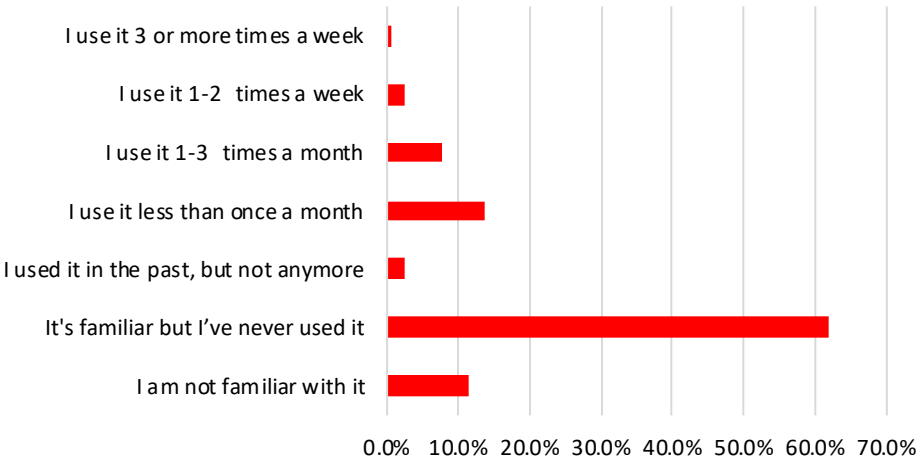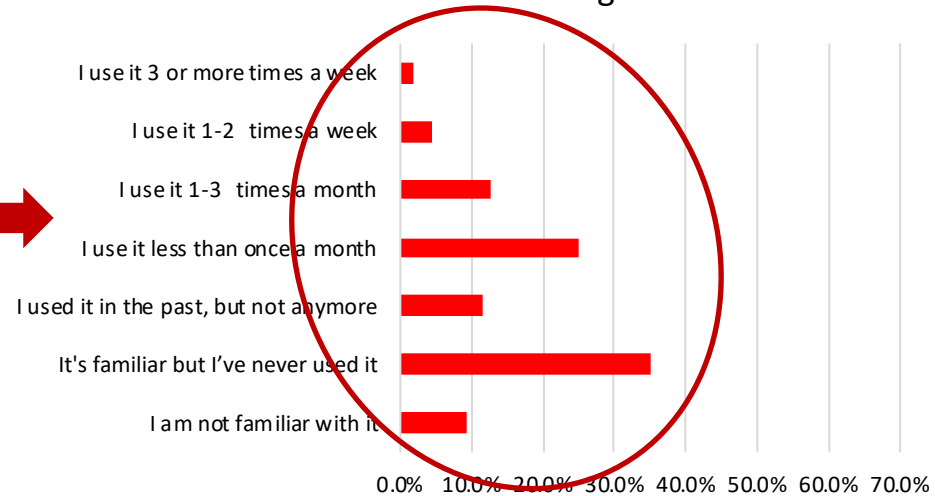INSTITUTE OF TRANSPORTATION STUDIES

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# Adoption of Shared Mobility: 2015-2018 (2)



2015 - Ridehailing

2018 - Ridehailing

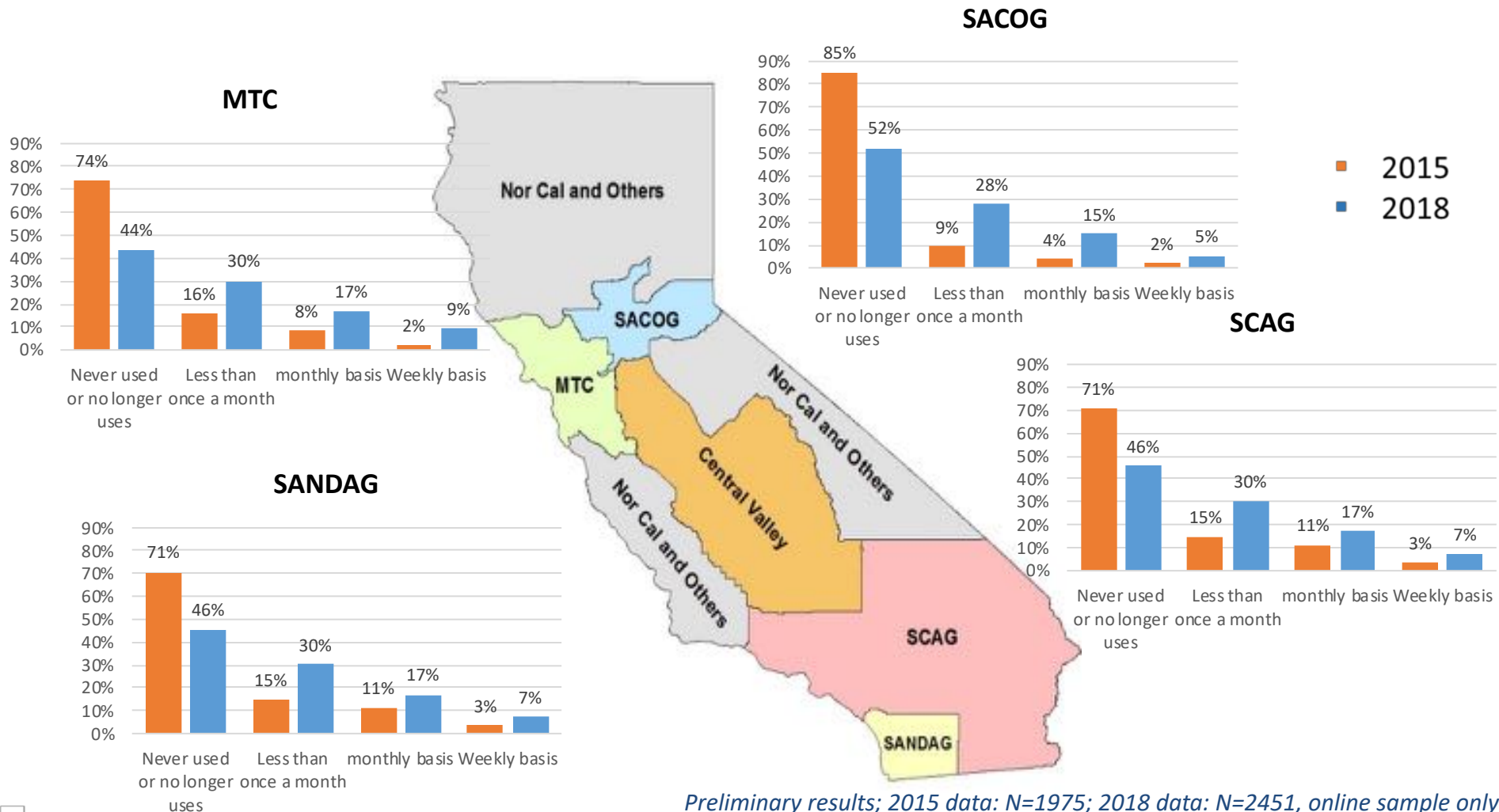2018 - Shared Ridehailing
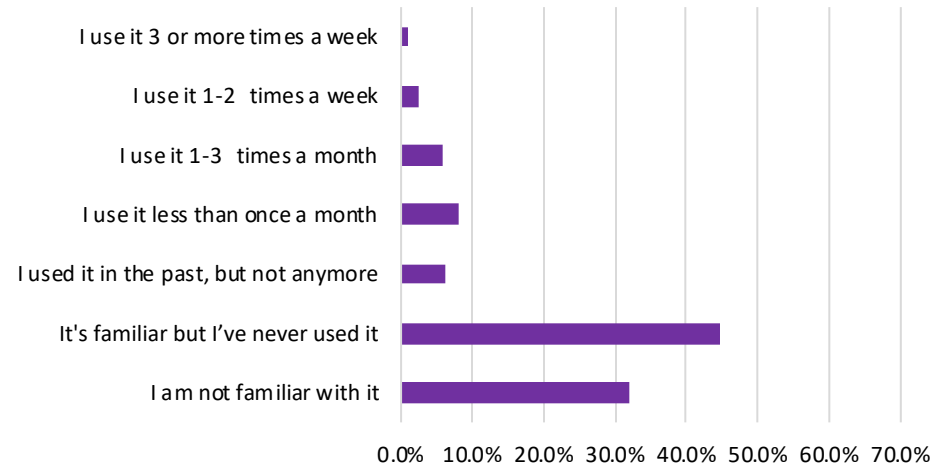
- *Research Question:*

How does the use of ridehailing affect the use of other modes?

# Impact of Ridehailing on Other Travel Modes



Figure 12. Changes in transit use, biking, and walking after adoption of ride-hailing services
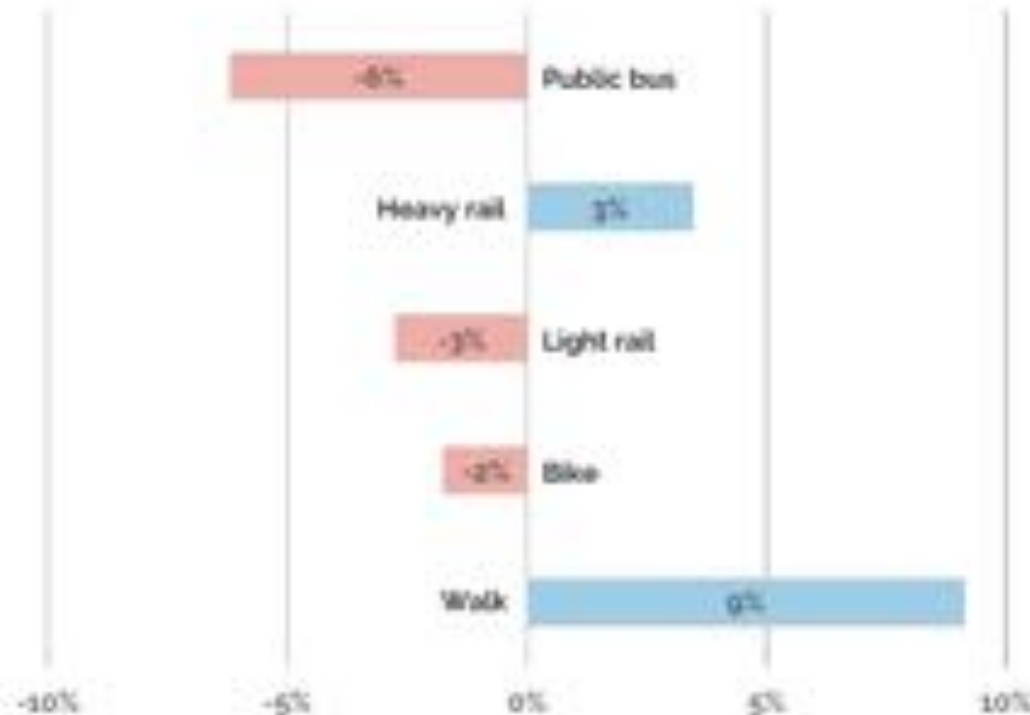
Survey question: "Since you started using on-demand mobility services such as Uber and Lyft, do you find that you use the following transportation options more or less?"

*Source: Clewlow & Mishra (2017)*

- *Research Question:*

What differences in embracing new travel and vehicle ownership behaviors exist across socio-economic and demographic groups?

# Investigating Differences Across Groups of Users

Latent-class adoption model to investigate differences in the use of ridehailing:

**Adoption Rate: 47%**
- *Higher-educated independent millennials* who live *in more central areas* and in households *without kids*
- The adoption rate significantly increases as the *rates of technology adoption* and *frequency of long-distance leisure travel by plane* increase.

**Adoption Rate: 27%**
- *Most affluent* individuals, predominantly *dependent millennials* or *older Gen Xers,* who live with their *families*.
- Technology adoption rate, household income, and frequency of non-car business long-distance trips affect the adoption.

**Adoption Rate: 5%**
- *least affluent* and *less educated* individuals, who live in *rural* neighborhoods and *do not work nor study*.
- Adoption rate is affected by the characteristics of the *built environment*, including *transit accessibility* and *land-use mix*.

For more details:
Alemi, F., G. Circella, S. L. Handy and P. L. Mokhtarian (2018) "Exploring the Latent Constructs behind the Use of Ridehailing in California", *Journal of Choice Modelling*, 29, 47-62.
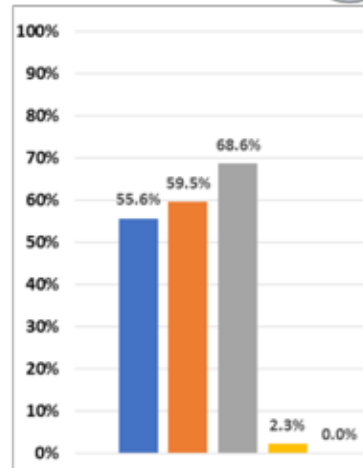
# Investigating Differences Across Groups of Users (2)

Latent-class analysis to investigate the impacts of ridehailing on other travel modes:

## Urban Travelers

- Urban dwellers
- Walkable neighborhoods with good transit access
- Cost and time sensitive
- Least affluent
- Younger/independent Millennials
- Frequent commuters
- Multimodal travelers
- Most frequent users of Uber/Lyft

**Class 1 (size=53%)**

## Car Users

- Suburban Dwellers
- Car-oriented neighborhoods with poor transit access
- High number of vehicles per household drivers
- Frequent commuters
- Monomodal with high VMT
- Pro-suburban
- Materialistic/must own car
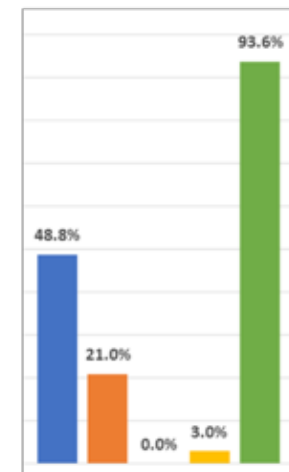- Frequent air travelers
- Medium Uber/Lyft frequency

**Class 2 (size=37%)**

## Transit and TNC

- Suburban Dwellers
- Low transit and walk accessibility
- Not cost and time sensitive
- Older Gen Xers
- Want to come back to urban area
- Non-frequent commuters
- Multimodal when possible
- Like biking
- Pro-environment
- Low frequency users

**Class 3 (size=10%)**

### Urban Travelers chart
- Less Drive: 55.6%
- Less Walk/Bike: 59.5%
- Less Transit: 68.6%
- More Walk/Bike: 2.3%
- More Transit: 0.0%

### Car Users chart
- Less Drive: 99.9%
- Less Walk/Bike: 0.6%
- Less Transit: 1.7%
- More Walk/Bike: 0.5%
- More Transit: 0.1%

### Transit and TNC chart
- Less Drive: 48.8%
- Less Walk/Bike: 21.0%
- Less Transit: 0.0%
- More Walk/Bike: 3.0%
- More Transit: 93.6%

**Legend:** ■ Less Drive  ■ Less Walk/Bike  ■ Less Transit  ■ More Walk/Bike  ■ More Transit

For more details:
*Circella, G. and F. Alemi (2018) "Transport Policy in the Era of Shared Mobility and Other Disruptive Transportation Technologies", in Advances in Transport Policy and Planning, Volume 1, edited by Yoram Shiftan and Maria Kamargianni, Chapter 5, 119-144, Elsevier.*

- *Research Question:*

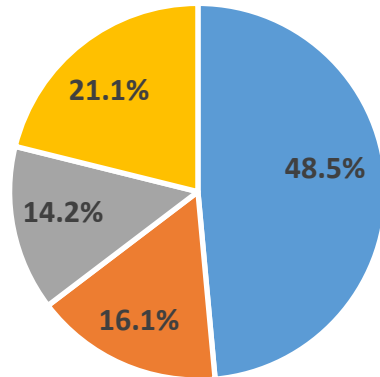What policies can promote public transportation and integrate on-demand mobility?



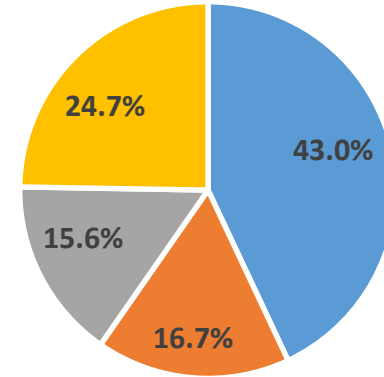*3RFM researchers are partnering with transit agencies to support deployment of microtransit solutions*

Microtransit Solutions

**Microtransit Solutions**

**Principal Investigator: Giovanni Circella**

In this multi-part project, we are conducting a microtransit feasibility and paratransit efficiency assessment for a transit agency operating in California. The Part I of this project, the Microtransit Feasibility Project, includes evaluating the feasibility of a microtransit pilot project in the region and positioning the transit agency to conduct such a pilot. In Part II, the Paratransit Efficiency Study and Strategic Recommendations Project, we evaluate the current efficiency of the local paratransit program and recommend cost-effective strategies for continuing to meet growing demand for service. This project helps the local transit agency and other interested partners identify opportunities for service enhancements or efficiency increases, within the confines of current resources and State and Federal requirements.

# Need for More Detailed Analyses of Trip Patterns:

## Time of day and vehicle occupancy:

### Ridehailing
### (e.g. UberX, Lyft Classic)



- 48.5%
- 21.1%
- 14.2%
- 16.1%

Legend:
- ■ Weekday
- ■ Weeknight
- ■ Weekend daytime
- ■ Weekend night time

### Shared ridehailing
### (e.g. UberPOOL, Lyft Line/Share)



- 43.0%
- 24.7%
- 15.6%
- 16.7%

### Occupancy by time of day



| | Weekday | Weeknight | Weekend daytime | Weekend night time |
|---|---|---|---|---|
| 3+ other riders | 9% | 14% | 14% | 17% |
| 2 other riders | 11% | 15% | 15% | 19% |
| 1 other rider | 20% | 21% | 24% | 30% |
| Alone | 60% | 50% | 46% | 34% |
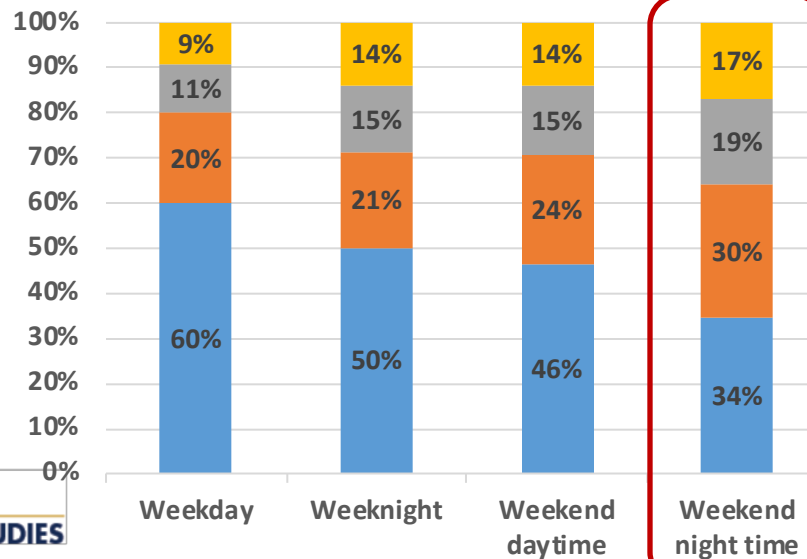
Highest occupancy on weekend nights!

Legend:
- ■ 3+ other riders
- ■ 2 other riders
- ■ 1 other rider
- ■ Alone

*Source: California Mobility Panel Study, 2018 online data, N=1,286*

# What Would You Have Done if Ridehailing Was Not Available?
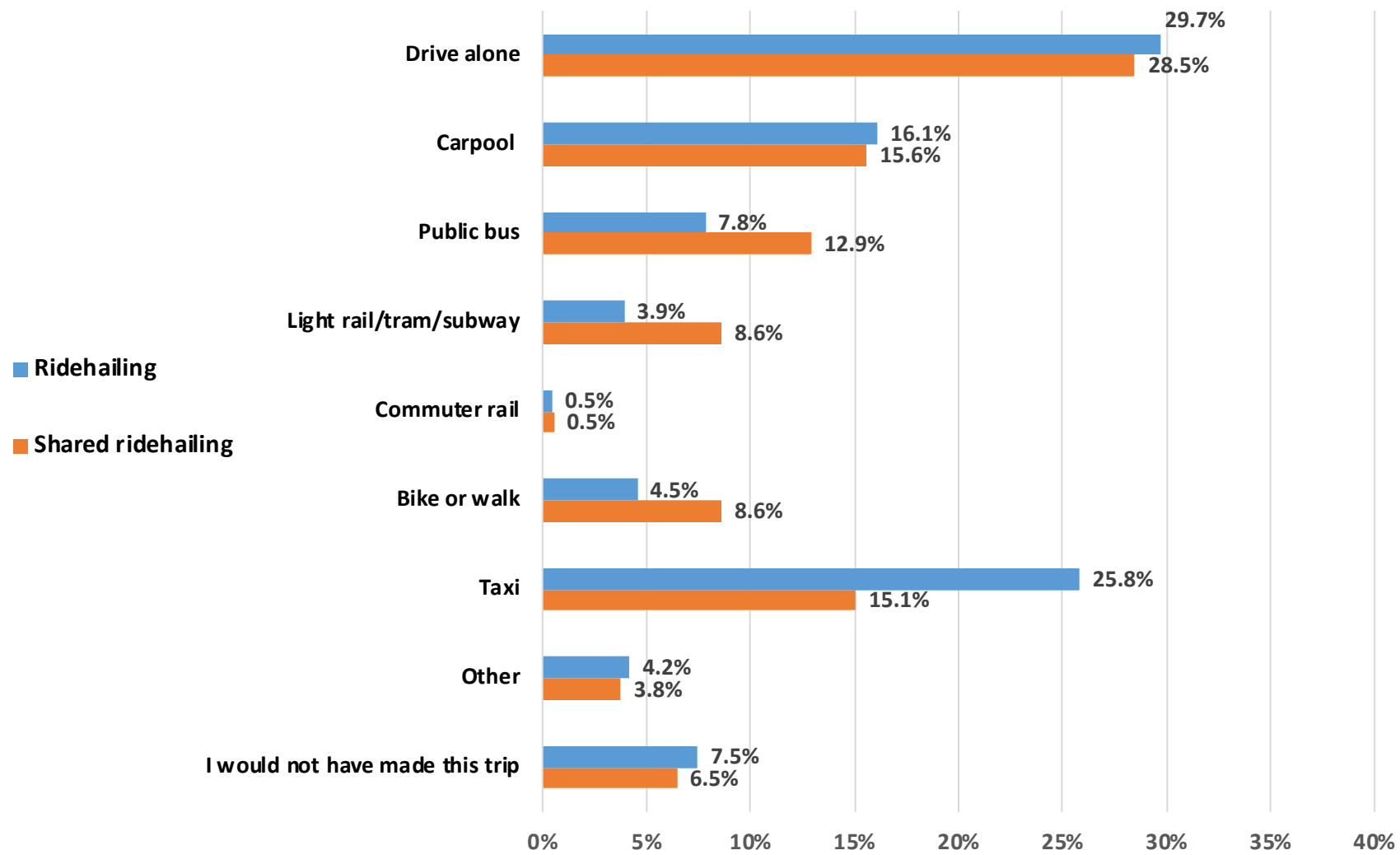


**Ridehailing** (blue) / **Shared ridehailing** (orange)

| Category | Ridehailing | Shared ridehailing |
|---|---|---|
| Drive alone | 29.7% | 28.5% |
| Carpool | 16.1% | 15.6% |
| Public bus | 7.8% | 12.9% |
| Light rail/tram/subway | 3.9% | 8.6% |
| Commuter rail | 0.5% | 0.5% |
| Bike or walk | 4.5% | 8.6% |
| Taxi | 25.8% | 15.1% |
| Other | 4.2% | 3.8% |
| I would not have made this trip | 7.5% | 6.5% |

*Source: California Mobility Panel Study, 2018 online data, N=1,260*

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# What Would You Have Done if Ridehailing Was Not Available? (2)

**Distribution of ridehailing impact by trip duration:**



Legend: 10 min or below, 10 to 15 min, 15 to 25 minutes, 25+ minutes

*Source: California Mobility Panel Study, 2018 online data, N=1,260*

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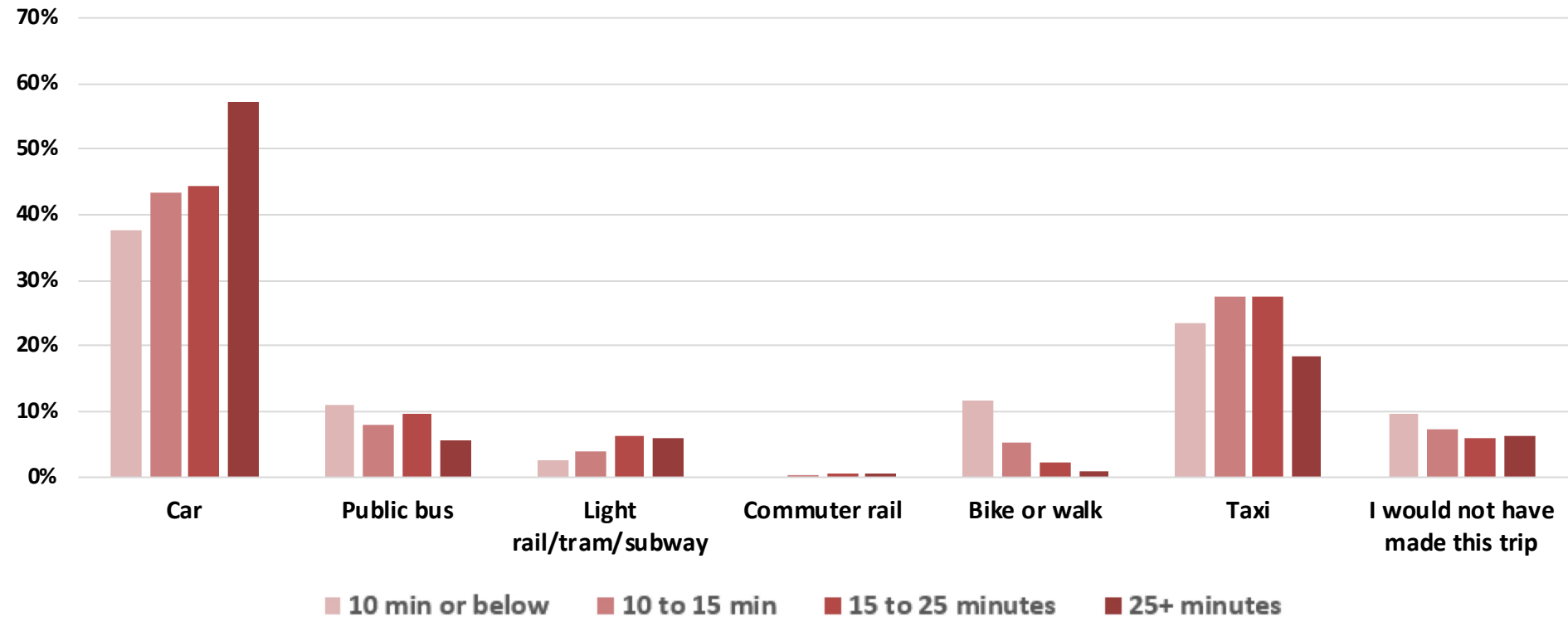
- *Research Question:*

How are micromobility solutions changing travel behaviors in urban areas?

# E-scooters Taking over Bicycling in Cities?

## Comparison of speed ranges by means of travel:

**15th-85th Percentile Speed Comparison**
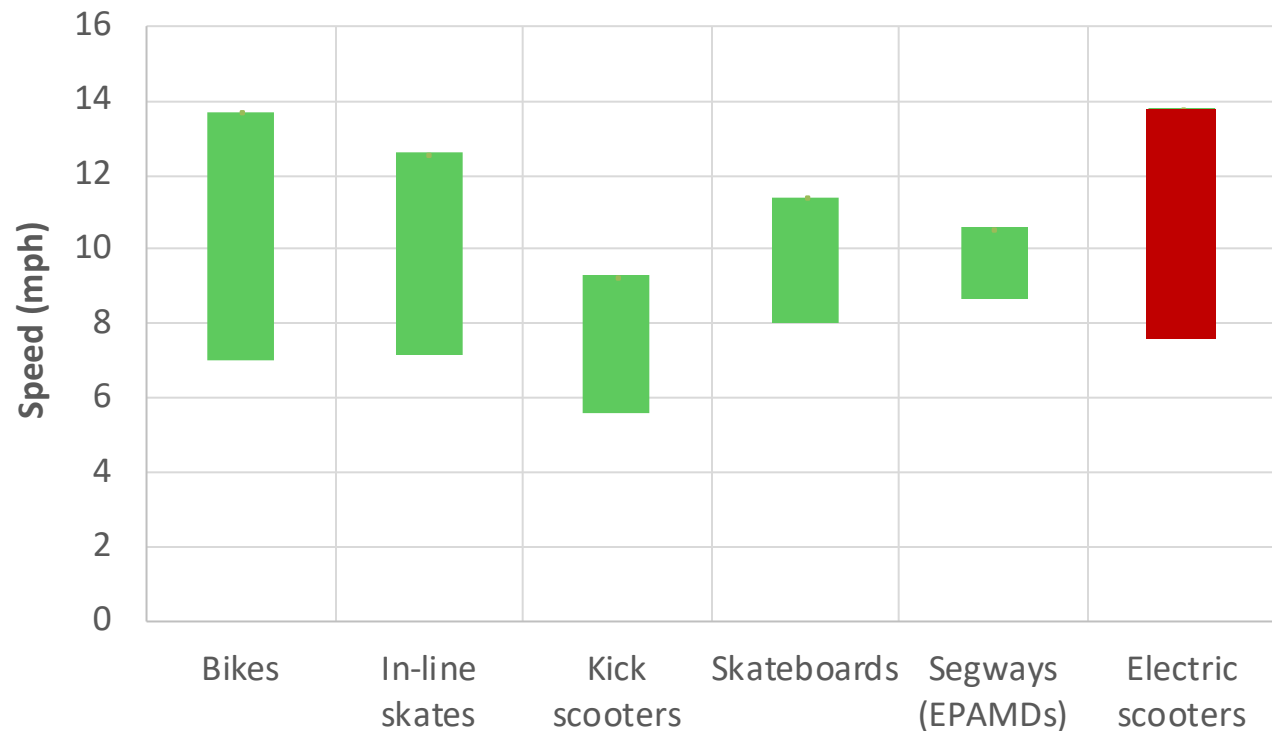


*Source: Pernia, Lu, and Birriel (2000); FHWA (2004); Fang and Handy (2017); Fang (2018)*

# Need for better investigate evolving patterns in urban mobility





2. ANNUAL INVESTIGATION OF NATIONWIDE MOBILITY TRENDS: "THE PULSE OF THE NATION" ON 3R

We plan to launch an annual data collection in selected regions of the US, to investigate the rapid changes in the adoption and frequency of use of shared mobility services, including ridehailing, carsharing, bikesharing, e-scooter sharing and their impacts on the use of other means of transportation, in various parts of the US and among different groups of users. The survey will also include a stated preference component to investigate respondents' preferences towards various subscription plans and the factors affecting individuals' multimodality and the adoption of Mobility as a Service solution, i.e. under what conditions/circumstances individuals are more likely to ditch their own private vehicles and use a combination of non-motorized and motorized modes for various trip purposes. We plan to continuously monitor the changes in attitudes and preferences toward the use of AVs among various population groups, as we get closer to the actual deployment of this transportation technology. This study will shed light on various topics, including the evolving impacts of new shared mobility services on various components of travel behavior and vehicle ownership, the factors affecting the propensity to use MaaS solution packages (i.e. combination of travel modes) instead of driving a private vehicle, and the changes in attitudes toward autonomous vehicles and the use of shared vs. privately-owned AVs.

# WHAT IS MAAS?

- *Research Question:*

How will travel patterns change with vehicle automation?

# Behavioral Experiment to Simulate Life with an Autonomous Vehicle

- FUTURE OF INTEREST:
  a fully autonomous vehicle

- SIMULATION OF FUTURE:
  a personal driver

*Don't have to drive the car ✓*
*Full multitasking ✓*
*No parking worries ✓*
*Can send on errands ✓*

**Results from pilot study**

83% increase in VMT
21% of increase: ghost trips
17% of increase: driving friends/family solo
62% of increase: prime subject traveling
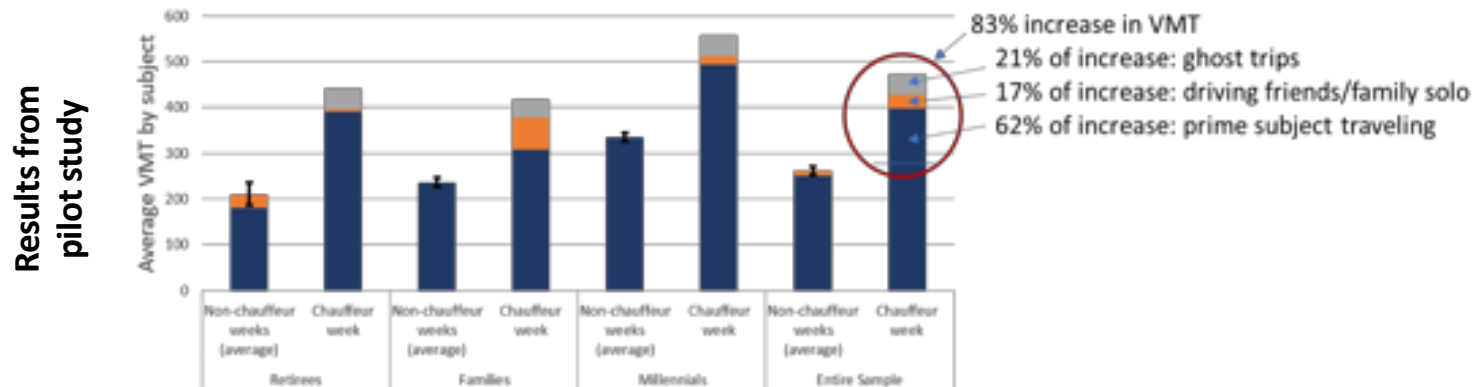
For more details:
*Harb, M., Y. Xiao, G. Circella, P. L. Mokhtarian and J. Walker (2018) "Projecting Travelers into a World of Self-driving Vehicles: Estimating Travel Behavior Implications Via a Naturalistic Experiment", Transportation, 45 (6), 1671–1685.*

- ***Research Question:***

What would be the impact on trip patterns in case of shared AVs (and not privately-owned AVs)?

# Emission Impacts of Connected and Automated Vehicle Deployment in California

- Evaluate future scenarios of C/AV deployment

- Investigate ranges of potential VMT, GHG, and criteria pollutant emission impacts

- Project builds on knowledge from leading research in the field

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*Statewide*
*Travel*
*Demand*
*Model*

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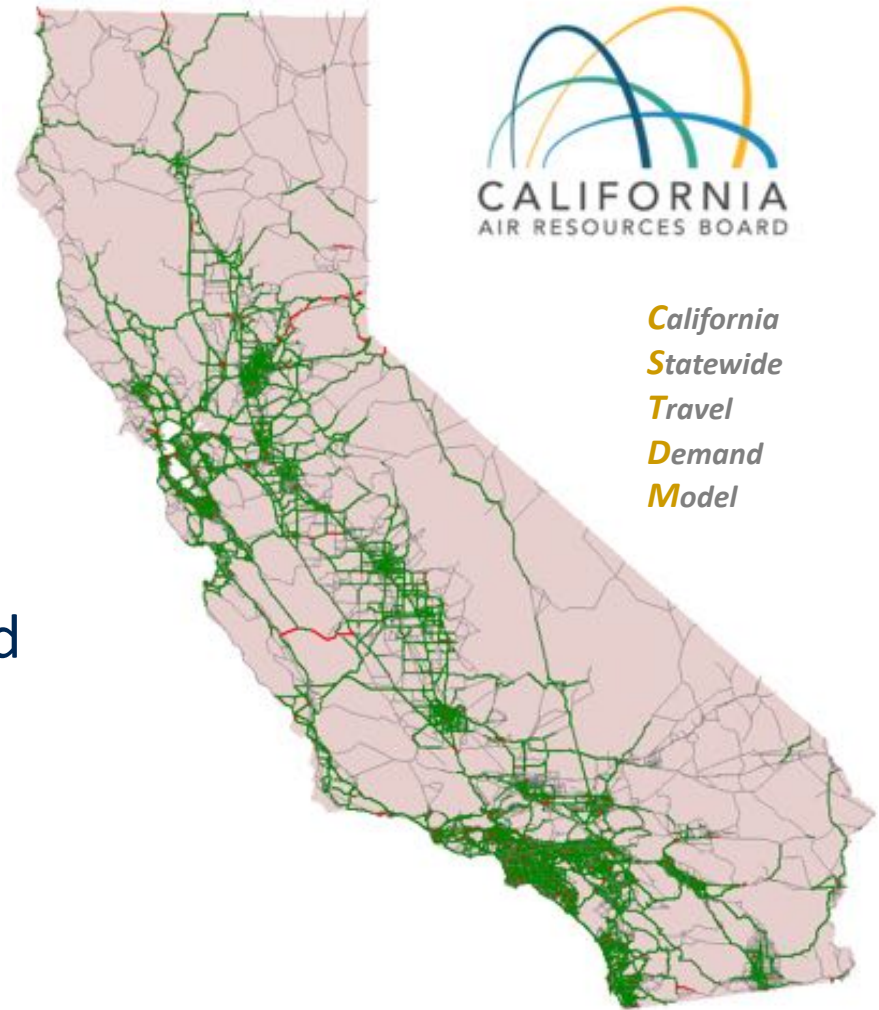
# Car Ownership vs. Shared Mobility?

- *Research Question:*

Under what conditions would individuals prefer to access a vehicles when needed instead of owning one?

# Attitudes Towards Autonomous Vehicles

## Familiarity with Self-driving Vehicles

- I have heard of it and am very familiar with it, 16.3%
- I have never heard of it, 7.0%
- I have heard of it but am not familiar with it, 32.7%
- I have heard of it and am somewhat familiar with it, 44.1%
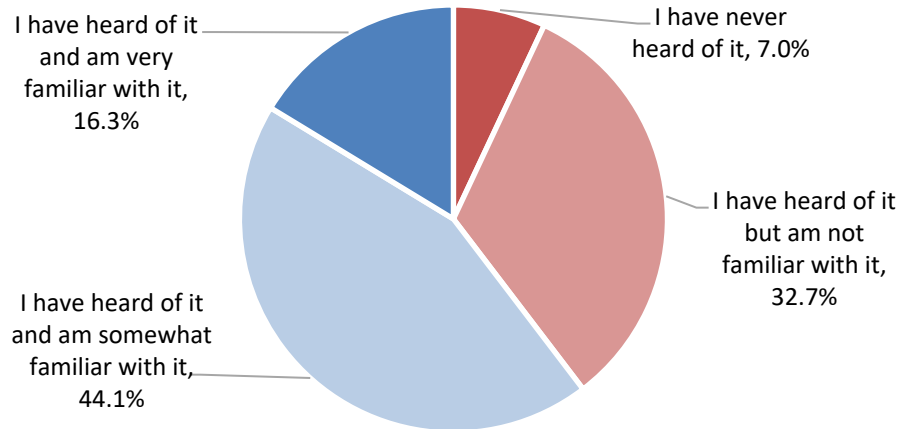
## How many years do you think it will take for cars to be fully self-driving?

- Never, 13.1%
- More than 30 years, 14.4%
- 21-30 years, 20.8%
- 11-20 years, 28.8%
- 10 years or less, 22.8%
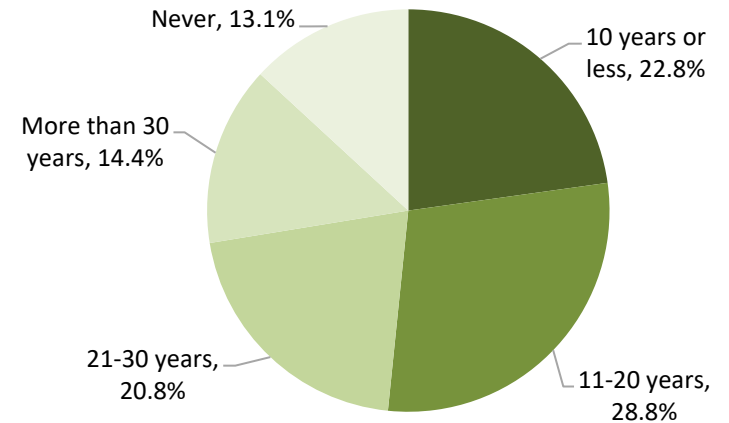
### "Be one of the first people to buy a self-driving vehicle…"
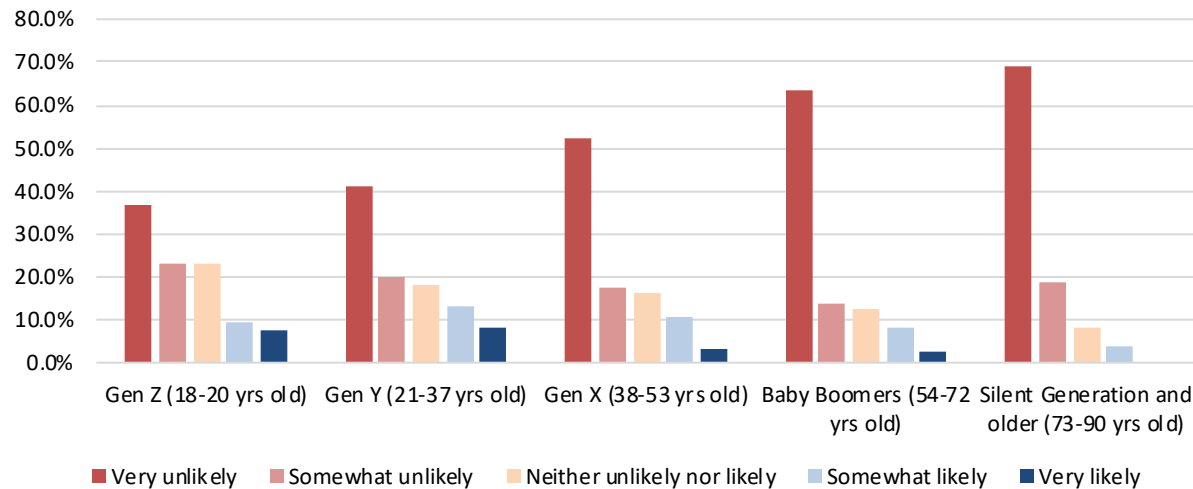
Legend: Very unlikely | Somewhat unlikely | Neither unlikely nor likely | Somewhat likely | Very likely

Categories: Gen Z (18-20 yrs old), Gen Y (21-37 yrs old), Gen X (38-53 yrs old), Baby Boomers (54-72 yrs old), Silent Generation and older (73-90 yrs old)

UC DAVIS
INSTITUTE OF TRANSPORTATION STUDIES

3 REVOLUTIONS
SHARED · AUTOMATED · ELECTRIC

# Attitudes Towards Autonomous Vehicles (2)



Expectations about the Adoption of Autonomous Vehicles and Changes in Vehicle Ownership
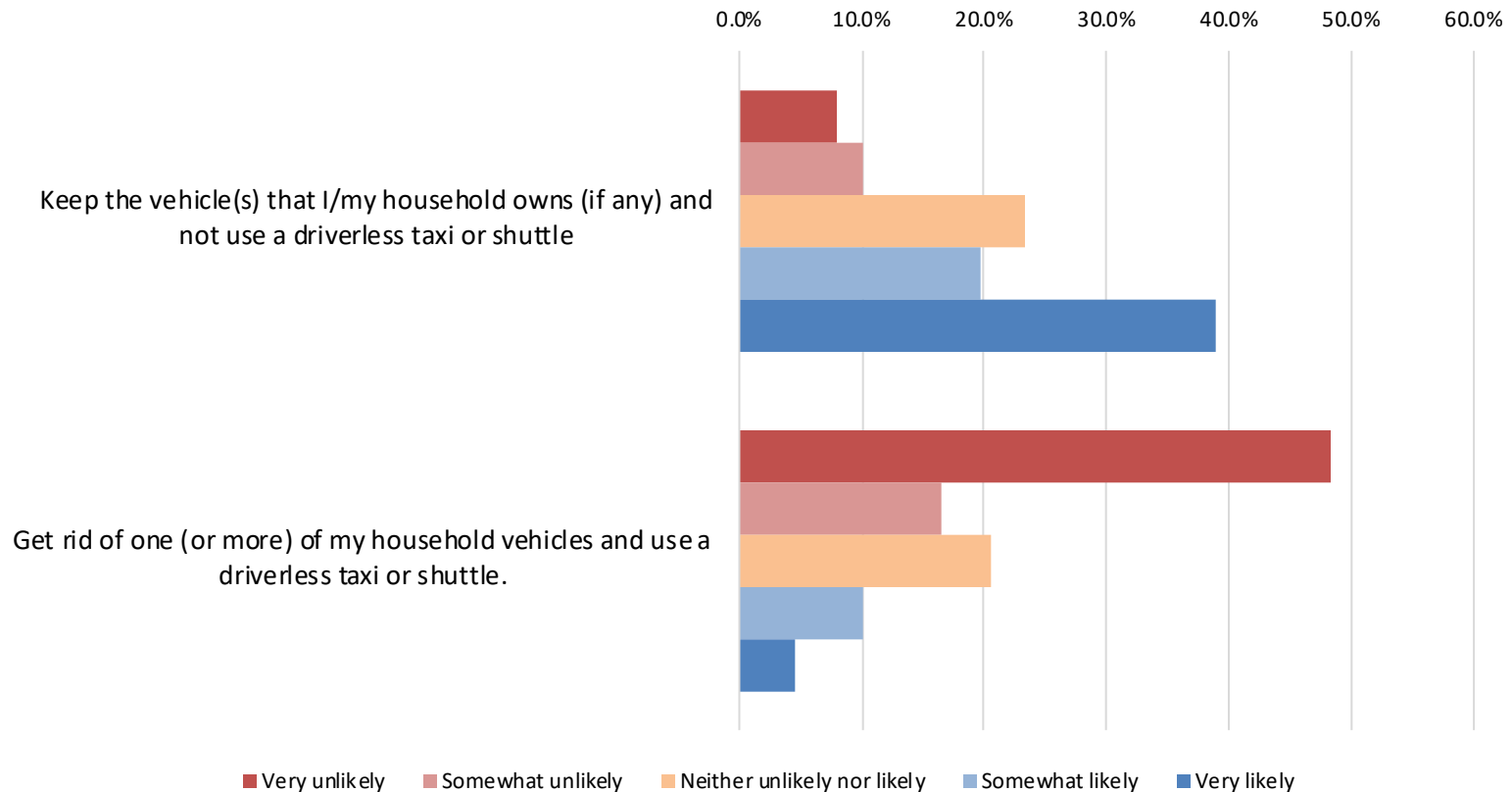
*Source: California Mobility Panel Study, 2018 online data*

- *Research Question – 1:*

How will vehicle design change in the era of vehicle automation and shared mobility?

- *Research Question – 2:*

What factors can encourage travelers to share rides with strangers?

- *Research Question – 1:*

Who will own the future vehicle fleets? Are we moving to an "airline-style" leasing system and what does that mean in terms of fleet composition?

- *Research Question – 2:*

How will vehicles be used and what will the benefits of electrification and alternative fuels be for the various segments of future fleets?

Need for more research on many of these topics…

*STEPS+3RFM*
*Research Program*
*2019-2022*