What travel modes do shared e-scooters displace? A review of recent research findings

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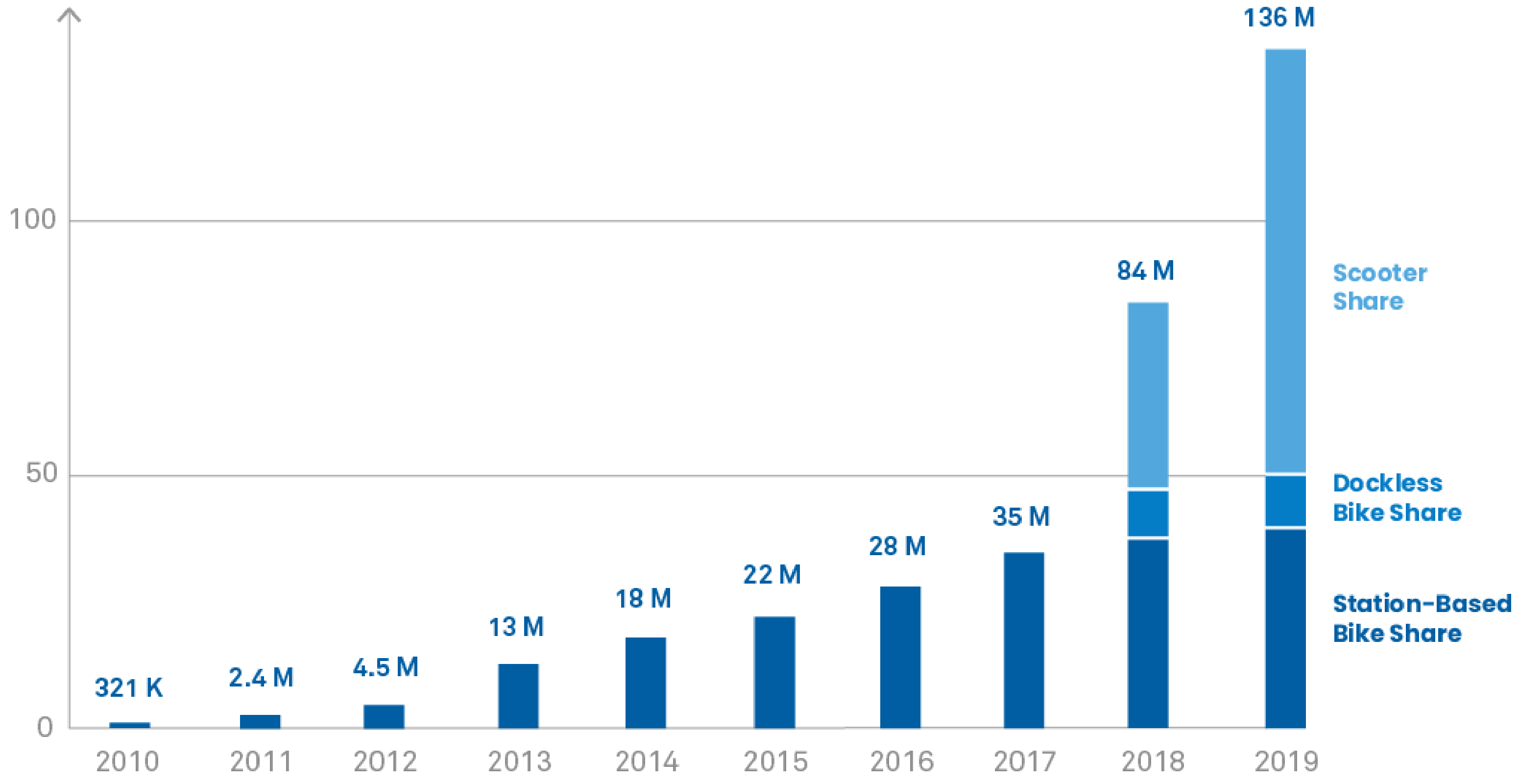
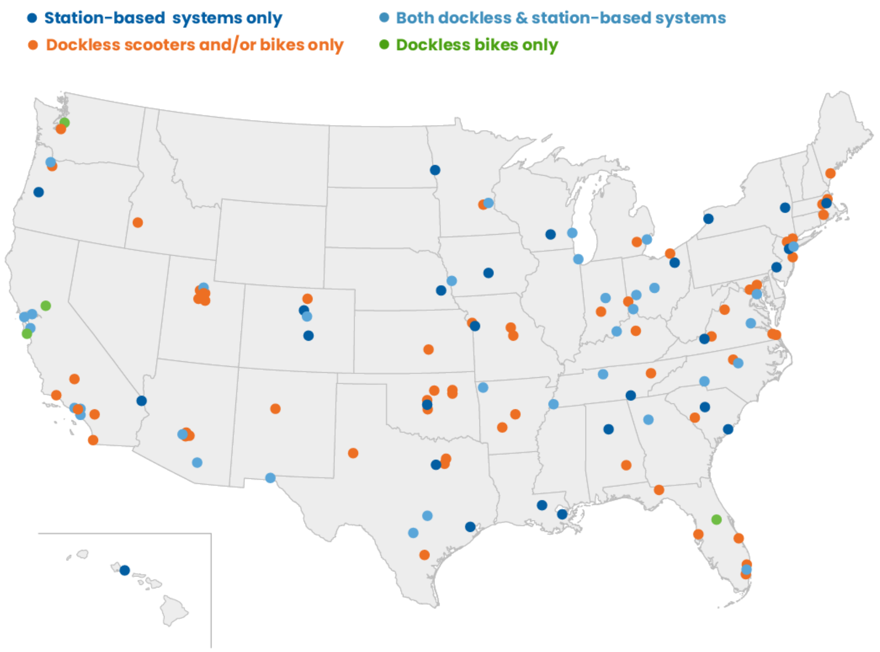
Trends in micromobility services

SHARED MICROMOBILITY RIDERSHIP GROWTH FROM 2010–2019,
IN MILLIONS OF TRIPS

Source: NACTO





Source: Shared Micromobility in the U.S.: 2019, National Association of City Transportation Officials (NACTO), https://nacto.org/shared-micromobility-2019/

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Trends in micromobility services

- Expected benefits of shared e-scooters
  - Commuting times; first/last-mile solutions
  - Small physical footprint; land use planning
  - GHG emissions; car culture shifts
  - Public health goals

- **Depends on modal shift from other modes…**
  - Driving alone? Taxi/TNC? Ridesharing? Public Transit? Bicycling? Walking?

Outlines

1. Shared e-scooters as a complement or substitution
2. User segments of shared e-scooters
3. The interactions between shared e-scooters and other modes
4. Analysis of recently collected survey data
5. Research findings, future directions, and conclusion

Flow chart of the search process

Google Scholar

ScienceDirect

TRID
the TRIS and ITRD database

"electric scooters", "e-scooters", "shared e-scooters", and "e-scooter sharing"

1. Define Search Period
2. Conduct Search
3. Identify Relevant Publications
4. Screen Articles

85 in total

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Outlines

Shared e-scooters as a complement or substitution

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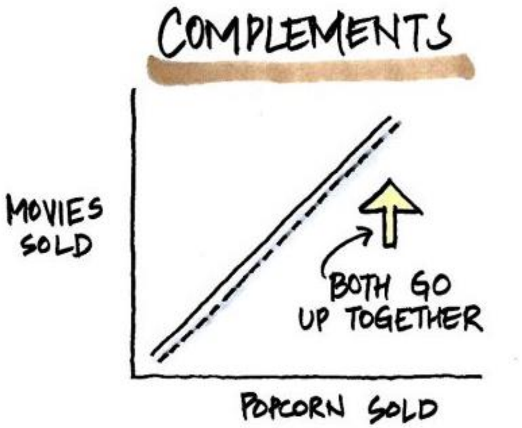
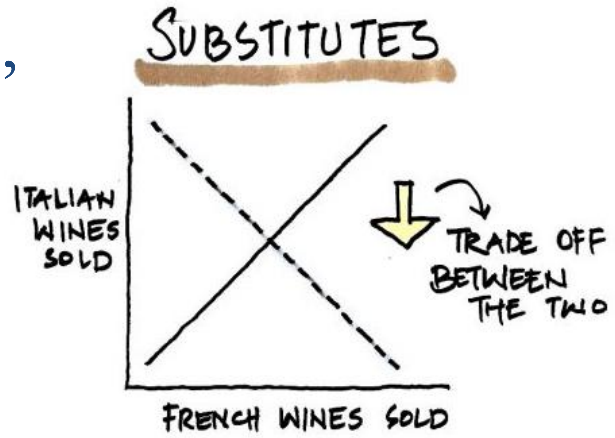
Shared e-scooters as a complement or substitution

- Have both effects/It's challenging to measure the effects in direct ways…
- Current measurements of **COMPLEMENTS**
  1) "Still thinking of your most recent e-scooter trip, how did you get to the e-scooter that you rode?"
  2) "How often do you ride e-scooters?"
  3) "How often do you ride a dockless vehicle in connection with transit (bus or light/commuter rail)?"
  4) "How has the use of shared e-scooters affected your frequency of use of [list of travel modes]?"





Shared e-scooters as a complement or substitution

- Current measurements of **SUBSTITUTES**
  1) "If an e-scooter had not been available for your last trip, how would you have made that trip?"
  2) "If you have used a scooter, what form of transportation has your scooter ride most often replaced?"
  3) "Since first using shared e-scooters, how has your use of the following options changed?"
  4) "How would your use of other modes change if e-scooter sharing services were to shut down?"
- The validity and reliability with observed behavioral data.

Retrospective Counterfactuals

Outlines

User segments of shared e-scooters

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User segments of shared e-scooters

- **Demographic Traits**
  - The profile of is similar to that of station-based and dockless bikeshare programs.
  - Low-income groups adopt shared e-scooters more than shared bicycles.
- **Geographic Features**
  - Distance to the city center, distance to transit stops, density, street connectivity, bicycle infrastructure, etc.…
- **Psychographic Variables**
  - "Pleasant/fun mode", attracting more people involved in active travel
  - Feeling unsafe is a barrier to adoption/interactions with other road users
- **Behavioral Factors**
  - Trip purposes, temporal patterns, trip distance and duration, etc.…

Outlines

The interactions between shared e-scooters and other modes

Reported modes replaced by the use of shared e-scooters

	Study area	Driving alone[3]	Taxi or TNC	Public transport	Walk	Micro-mobility[2]	Sample size[4]	City-specific data[5]: Population density (# of persons per square mile)	City-specific data[5]: % of commuters who take public transit
	North America								
(1)	Tempe city, Arizona (ASU's campus)		25%		57%	8%	406	4522.6	4.5%
(2)	Tucson city, Arizona	24%	14%	3%	36%	8%	2,704	2393.5	3.4%
(3)	Los Angeles city, California	11%	22%	9%	48%	5%	7,067	8318.7	9.0%
(4)	Oakland city, California	14%	25%	9%	42%	12%	864	7898.3	23.5%
(5)	San Francisco city, California (Lime, 2018)	9%	51%	34%	61%	20%	617	18646.6	34.8%
(6)	San Francisco city, California (SFMTA, 2019)	5%	36%	11%	31%	9%	2,256	18646.6	34.8%
(7)	Santa Monica city, California		49%	4%	39%	7%	4,260	11067.3	4.1%
(8)	Denver city, Colorado	10%	22%	7%	43%	14%	2,084	4676.6	6.5%
(9)	Tampa city, Florida	21%	27%	1%	38%	6%	585	3394.4	2.2%
(10)	Atlanta, Georgia		42%	2%	48%	4%	2,640	3745.5	10.4%
(11)	Bloomington, Indiana	25%	16%	7%	54%		124	3418.3	6.7%
(12)	Chicago city, Illinois	11%	32%	14%	30%	8%	12,446	12065.1	28.2%
(13)	St. Louis Park city, Minnesota	34%	37%		5%	8%	38	4700.2	5.5%
(14)	Hoboken city, New Jersey	11%	37%	13%	51%	13%	1,391	47202.3	61.1%
(15)	Raleigh, North Carolina		34%	11%		49%	61	3272.7	2.0%
(16)	Portland city, Oregon (in 2018)	19%	15%	10%	37%	5%	3,444	4890.2	12.9%
(17)	Portland city, Oregon (in 2019)	19%	23%	11%	39%	8%	1589	4890.2	12.9%
	Portland city, Oregon (in 2020)	14%	23%	10%	41%	5%	531		
(18)	Alexandria, Virginia	46%	41%	18%	50%	13%	982	10609.9	19.9%
(19)	Arlington County, Virginia	13%	19%	5%	37%	4%	1,066	9189.2	27.4%
(20)	Arlington County, Virginia (Rosslyn area)	7%	39%	7%	33%	12%	181	9189.2	27.4%
(21)	Blacksburg, Virginia (Virginia Tech's campus)		6%	7%	77%		12,014	2253.7	9.7%
(22)	Milwaukee city, Wisconsin	23%	22%	7%	40%	7%	7,658	6005.2	7.3%
(23)	Calgary, Canada	21%	12%	6%	56%	5%	6,285		

(*Continued*)

Reported modes replaced by the use of shared e-scooters

	Study area	Driving alone[3]	Taxi or TNC	Public transport	Walk	Micro-mobility[2]	Sample size[4]	City-specific data[5]: Population density (# of persons per square mile)	City-specific data[5]: % of commuters who take public transit
(24)	Toronto, Canada		44%	53%	57%	36%	334		
	Europe								
(25)	Paris, France (face-to-face road interviews in May-June, 2019)	4%	6%	37%	35%	7%	459		
(26)	Paris, France (online questionnaire in Sept.-Oct., 2019)	5%	8%	36%	37%	12%	1,350		
(27)	Paris, Lyon, Marseille, France (online questionnaire in Apr., 2019)	3%	6%	30%	44%	12%	4,382		
(28)	Munich, Germany		24%	59%	80%	59%	167		
(29)	Thessaloniki, Greece		17%	33%	44%	7%	271		
(30)	Oslo, Norway	3%	5%	23%	60%	6%	549		
(31)	Zurich, Switzerland		10%	24%	52%	14%	121		
	New Zealand								
(32)	Auckland, New Zealand		21%	7%	53%	6%	1,000		
(33)	Christchurch, New Zealand	14%	9%	5%	52%	6%	380		

Notes

1. The references are listed in Appendix A.
2. Most existing studies discuss mode complementarity, mode substitution, and mode integration within the geospatial context. The trip-level information they collected does not directly indicate the interactions between shared e-scooters and other modes of transport, though. Exploring their underlying assumptions is beyond the scope of this study. Thereby, we do not report these studies in our table.
3. Drive alone includes carsharing and carpooling, and Micro-mobility excludes shared e-scooters.
4. Some surveys allowed multiple responses (therefore, percentages do not add up to 100%). Some studies did not report replacement rates for all modes.
5. This study adopts 2019 American Community Survey 1-Year Estimates for all US cities.

Shared e-scooters and active travel

- **Walking as the most common travel mode substituted**
  - Ranging between 30 and 60% of trips
- **Reasons for scooter trips are replacing walking trips**
  - Speed and fun
  - Jiao and Bai (2020) argued that the e-scooter traveling is a means of transportation between walking and bicycling. It fills the travel demand gap when a trip is too long to walk, but also too short to ride a bicycle.
- **The sidewalk is the least preferred space for riding e-scooters**
  - potentially causing traffic safety risks and increasing the likelihood of collisions
  - New road facilities and proper regulations → cohabit with other vulnerable road users

Shared e-scooters and active travel

- **Bicycling and bikesharing is rarely a common substitution mode reported**
  - The majority of studies showing less than 10% substitution
  - E.g., a study conducted during 2017-2019 in Santa Monica, California revealed that the counts of bicycles declined by 6% due to the operation of e-scooter sharing program; however, the total count of bicycles and e-scooters is 37% higher than bicycles alone.
  - E.g., a survey study conducted in three major cities in France found that 12% of local residents who used shared e-scooters would have otherwise made bikeshare trips (9%) or ridden their own bikes (3%).

Both substitution and complementary effects on micromobility behavior

Shared e-scooters and public transit

- **Public transit trips are not very likely to be replaced**
  - Ranging between 3 and 18% of trips in most studies – differences in trip features
- **Shared e-scooters are particularly suited to intermodal trips that can benefit mass transit substantially**
  - In fact, existing studies (both behavioral surveys and spatial data explorations) suggest proximity to public transit nodes and public transit ridership are not closely related to shared e-scooter rides.
- **E-scooter rides bring in new transit trips due to providing first/last-mile connections**
  - Investigating social-psychological factors
  - Cost-effective alternative?
    Improving the compatibility through financial incentives such as MaaS.

Shared e-scooters and automobility

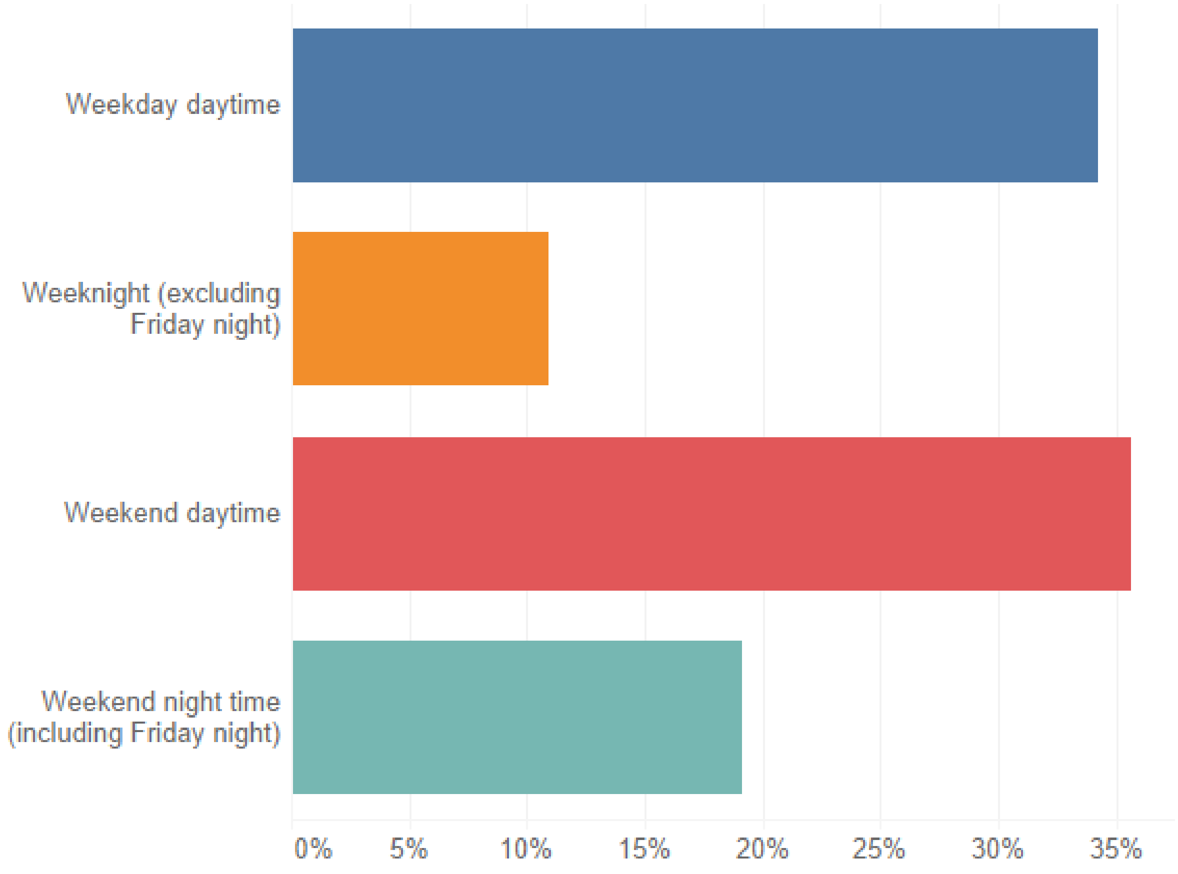
- **The substitution rate is within the range of 25-40% in most cases**
  - Including driving alone and ridesharing
- **Relatively few studies have sought to quantify the impacts of shared e-scooters on VMT reduction at the system level**
  - Portland's pilot program lasted 120 days from July to November 2018. This study estimates that e-scooters replaced approximately 423,000 miles of walking, biking, and transit, and more than 300,000 vehicle miles → avoided about 120 metric tons of CO_2
  - The San Francisco report estimates that bikesharing and shared e-scooters can reduce about 1,000,000 miles and 250,000 miles per year, respectively.
- **The total impacts on traffic congestion may be mixed**
  - Add complexity to vehicle interactions, distracting motor vehicle drivers and potentially leading to increased injuries

Outlines

Analysis of recently collected survey data

Evidence from the *Atlanta Survey*

Trip time



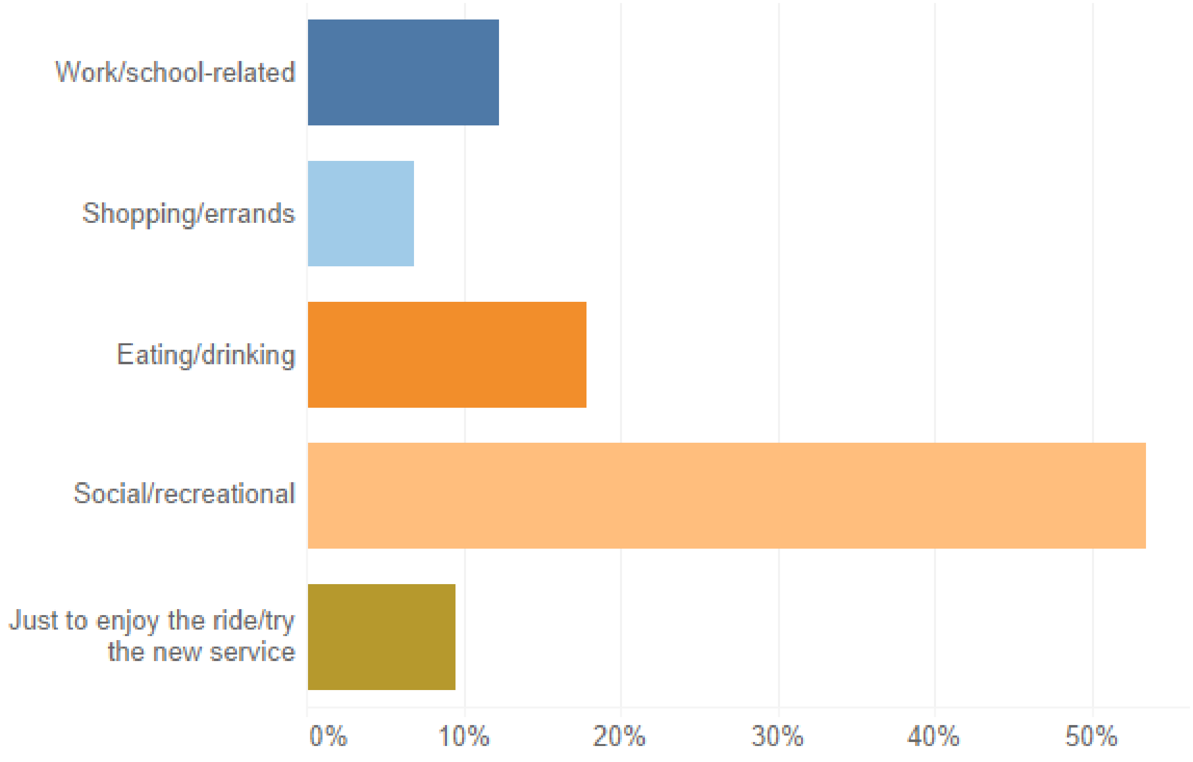
Trip length

Alternative mode	Less than a mile	1-2 miles	3-4 miles	5 miles or more
Drive private vehicle, alone		8	1	
Drive private vehicle, with others		3		1
Ride in private vehicle, with others		1		
Ride the light rail			1	
Use Uber/Lyft	3	7		1
Use my own bike or scooter	2			
Walk	13	27		
I would not have made this trip	2	3		

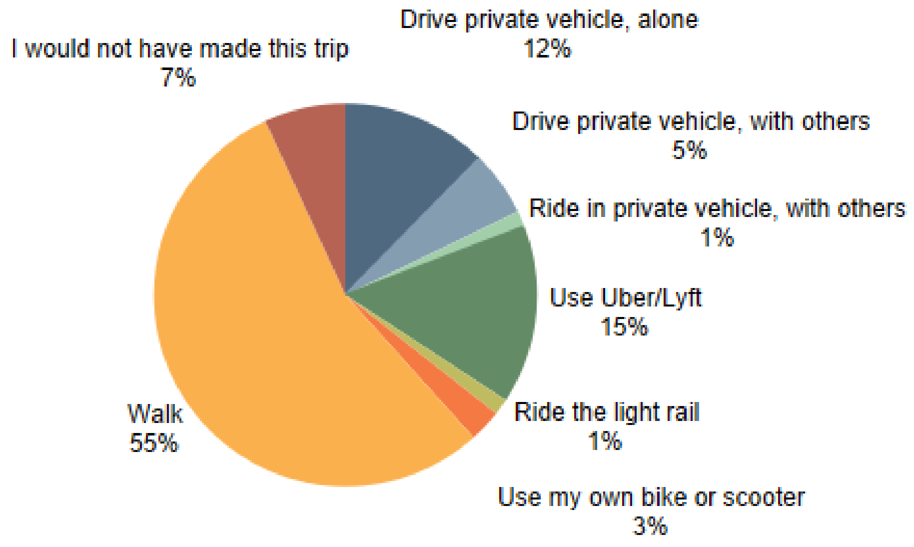
Trip attributes of the last trip with shared e-scooters (n=73)

Evidence from the *Atlanta Survey*

Purpose

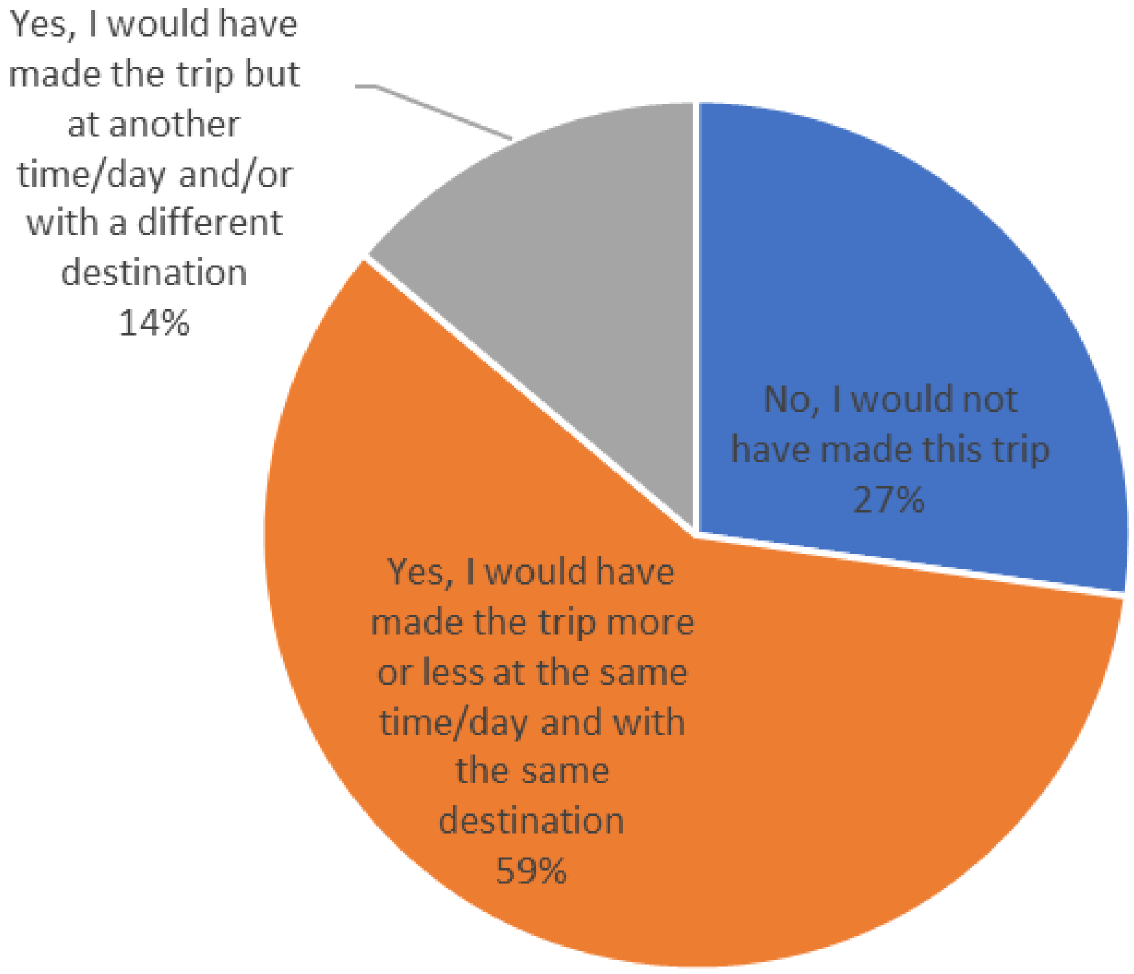


Alternative mode

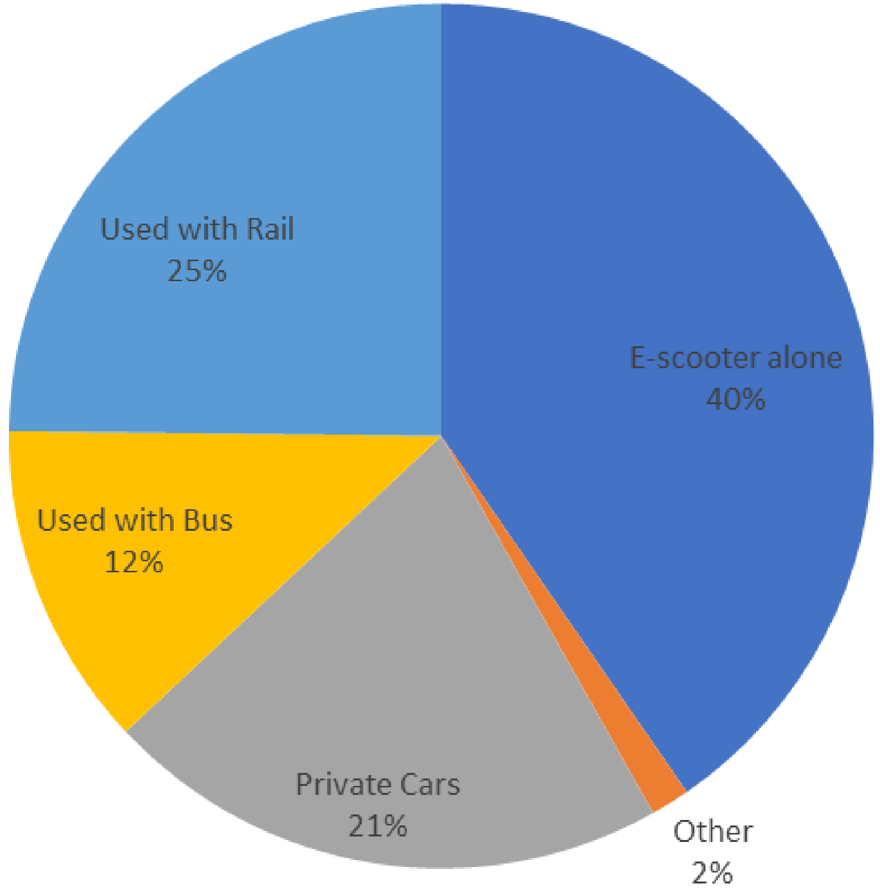


Trip attributes of the last trip with shared e-scooters (n=73)

Evidence from the *"8 Cities" Survey*



Effects of shared e-scooters on daily activities (n=411)



Modes used in combination with shared e-scooters (n=411)

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Outlines

Research findings, future directions, and conclusion

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Conclusions

- **Share e-scooters do exert a positive impact on shifting car culture**
  - Still, shared e-scooters are more likely to replace those trips that are originally made by active transport modes.
  - Differences in results from European and U.S. studies.
- **Surveying both trip-level counterfactual questions and general travel patterns**
- **How to validate the current prospective and retrospective counterfactual surveys?**
  - Before and after designs at the individual level
  - Longitudinal panel surveys during “natural” changes in micromobility services.
  - Combine tests for reliability of current measures,
    and to conduct small targeted validations using the above discussed methods.

Conclusions

- **Adopted by males, relatively young, well-educated individuals, and local residents.**
  - Low incomes prefer shared e-scooters over station-based and dockless bikesharing
- **Spatial and temporal distribution: Does not exhibit a two-peak pattern**
  - Riding for other purposes than daily commuting; have taken place in urban areas
  - Risk perception may be different from bicycling
- **Displacement: walking (30%-60%) > automobiles (25%-40%) > public transit (3%-18%)**
  - Trip features: 1) trip length, 2) the share of public transport in most U.S. cities is low.
  - Mobility packages, such as MaaS
  - Modified supply of transportation services,
reduced "willingness to share" in the era of post COVID-19

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Thank you!

Any questions?

Please feel free to contact me via

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