Complement or compete? The effects of shared electric scooters on bus ridership in Nashville, TN

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Transit Data

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Background

- Shared e-scooter popularity has rapidly increased in recent years in the USA
  - 38.5 million shared e-scooter trips in 2018
  - 88.5 million shared e-scooter trips in 2019
- Transit agencies in the United States are concerned about nationwide transit ridership declines
- Could shared e-scooters contribute to transit ridership declines?

Sources: (NACTO, 2019; NACTO, 2020)

Two Key Research Questions

1. Does the number of ***shared e-scooters available*** within the bus route catchment area affect bus ridership?

2. Does the impact of shared e-scooters on transit ridership vary based on the ***trip purpose***?

Photo Credit: Derek Hagerty

Data (1 of 2)

Category	Variable	Data Source
Dependent variable	Unlinked bus trips	WeGo public transit
Transit variables	Bus vehicle revenue mile (VRM)	
Shared e-scooters	Device availability	Nashville MPO
	Trip summary	
Other variables	Population	1-year American Community Survey Estimates
	Employment	Bureau of Labor Statistics
	Gas price	Energy Information Administration
	Weather Data (Rainfall, and snowfall)	National Oceanic and Atmospheric Administration

Data (2 of 2)

Key Attributes	Shared E-scooter Trip Purpose in Nashville				
	Daytime Short Errand	Morning Work/School	Utilitarian	Social	Entertainment Districts
Time and Location [a]	Weekday daytime downtown and Vanderbilt University short trips on cooler days	Weekday morning downtown and Vanderbilt University	Weekday downtown and urban areas	Weekend evening areas with restaurants	Weekend entertainment district areas like bars or live music venues
% of Total Shared E-scooters Trips	29.0 %	6.9 %	22.1 %	25.8 %	16.2 %
Average Trip Distance (Mile)	0.71	0.68	0.86	0.68	0.67
Average Trip Duration (Min)	17.13	13.07	17.36	16.53	15.07
Average Speed (MPH)	2.76	3.62	3.27	2.75	2.97
Route Directness Ratio [b]	0.49	0.60	0.64	0.52	0.57

[a] Time and location show the typical values. However, a small portion of trips within each purpose might have different characteristics.
[b] Route directness ratio represents the ratio between the Euclidean distance and the actual trip distance

Shah, Guo, Han, Cherry (2023). Why do people take e-scooter *trips? Insights on temporal and spatial usage patterns of detailed trip data, Transportation* Research Part A: Policy and Practice, Volume 173.

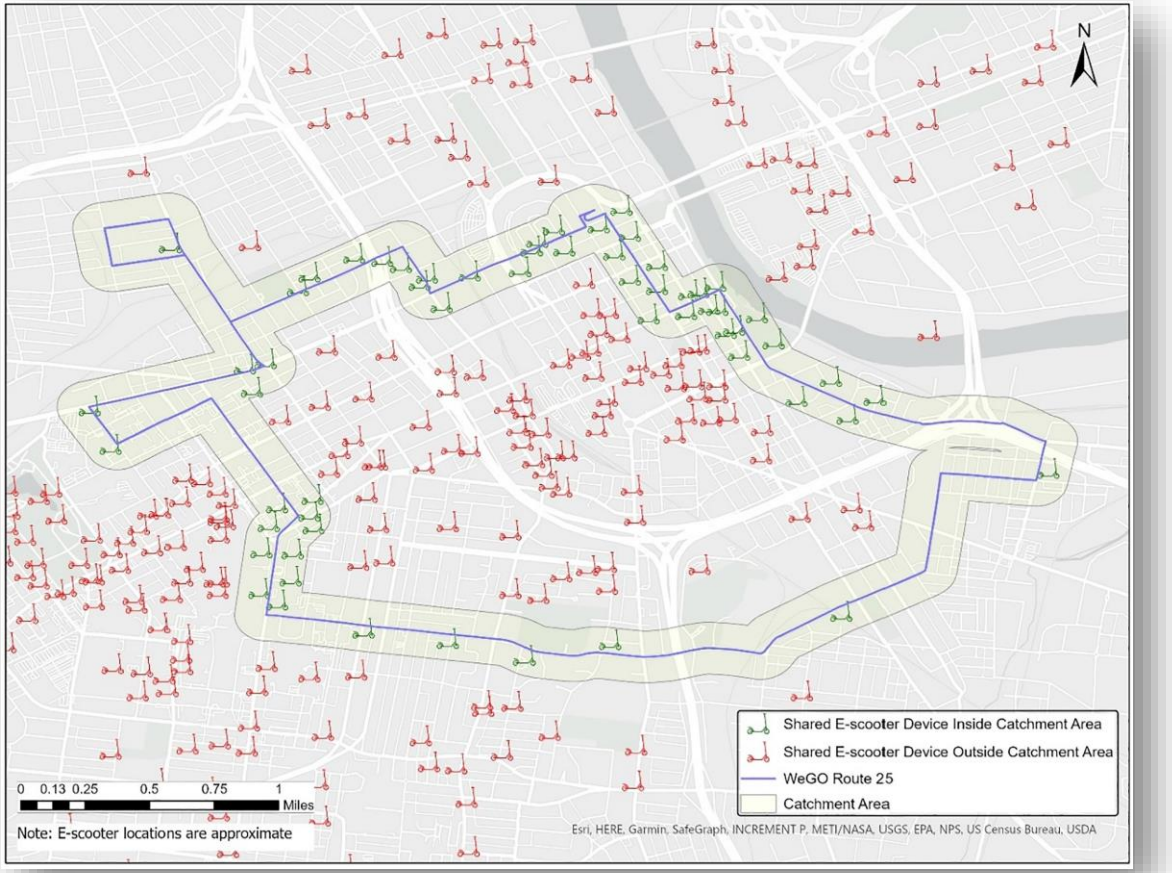
Method

- Fixed effects regression
- Unit of analysis: bus route
- Study timeline: March 2016 to July 2019
- Study location: Nashville, Tennessee
- Why Nashville?
  - Part 1 (e-scooter availability): We had access to archived shared e-scooter device location data
  - Part 2 (e-scooter trip purpose): A parallel study defined different shared e-scooters trip purposes in Nashville (Shah et al.)
    - Daytime Short Errand
    - Morning Work/School
    - Utilitarian
    - Social
    - Entertainment Districts

Shah, Guo, Han, Cherry (2023). Why do people take e-scooter *trips? Insights on temporal and spatial usage patterns of detailed trip data, Transportation* Research Part A: Policy and Practice, Volume 173.

Method Part 1: Scooter Availability

Measure the number of ***shared e-scooters available*** within the bus route catchment area (0.1 mile)



Results Part 1

Does the number of ***shared e-scooters available*** within the bus route catchment area affect bus ridership?

Explanatory Variables	Weekday	Weekend	Monthly
Vehicle revenue miles (VRM)	0.11*** (0.029)	0.14** (0.056)	0.20** (0.094)
Shared e-scooter devices	0.04 (0.058)	0.08 (0.082)	0.07 (0.076)
Population and employment (in 1000s)			35.96 (37.228)
Average temperature (ºF)			-403.86 (370.015)
Snowfall (inch)			-249.58 (185.005)
Route fixed effect		Yes	
Time fixed effect	Day	Day	Month
R Square	0.425	0.163	0.305
Number of observations	29445	8320	1384

- VRM is a significant predictor of bus ridership
- The number of shared e-scooters devices **do not have a significant** impact on bus ridership

Clustered robust standard errors are shown in parenthesis. The cluster variable is bus route
*p<0.10; **p<0.05; ***p<0.01

Method Part 2: Trip Purpose

Measure the number of ***shared e-scooters trips (origin and destination) for each trip purpose*** within the bus route catchment area (0.1 miles)

Results Part 2

Does the impact of shared e-scooter on bus ridership **vary** based on trip **purpose**?

Explanatory Variables	Weekday	Weekend	Monthly
Vehicle revenue miles (VRM)	0.12*** (0.034)	0.14** (0.055)	0.20** (0.093)
Shared e-scooter **utilitarian** trips	-0.93* (0.494)	0.02 (0.928)	-2.49** (1.067)
Shared e-scooter **daytime short errand** trips	0.12 (0.138)	-0.31 (0.369)	-0.93 (0.573)
Shared e-scooter **social** trips	0.30** (0.114)	0.29 (0.229)	1.35** (0.597)
Shared e-scooter **entertainment district** trips	-0.15 (0.133)	-0.02 (0.182)	-0.45** (0.200)
Shared e-scooter **morning work/school** trips	-0.08(0.78)	0.65 (0.694)	3.10 (2.507)
Population and employment			33.67 (37.59)
Snowfall (inch)			-373.30* (196.76)
Average temperature (ºF)			-376.31(332.58)
Route fixed effect		Yes	
Time fixed effect	Day	Day	Month
R Square	0.426	0.169	0.325
Number of observations	34435	9738	1618

VRM is a significant predictor of bus ridership

Utilitarian trips have a **significant negative** impact on bus ridership

Social trips have a **small positive, significant** impact on bus ridership

Clustered robust standard errors are shown in parenthesis. The cluster variable is bus route
*p<0.10; **p<0.05; ***p<0.01

Results Part 2 (continued)

	Estimated Impact on ridership on a typical Weekday (UPT per weekday)		Estimated Impact on a typical Weekday (%)
	Route	Systemwide	Systemwide
# of utilitarian trips	-6.4	-256	-0.94%
# of social trips	5.8	232	0.86%
Net impact	-0.6	-24	-0.08%

The net reduction is equivalent to **0.08%** of the average weekday bus ridership

Conclusions

- Findings
  - Shared e-scooters impacts on bus ridership vary based on trip purpose
  - The net impact of shared e-scooters was minimal in Nashville

- Limitations
  - Count some trips multiple times.
  - This study used trip-based measures to assess trip purpose. The trip-based measures might be impacted by endogeneity.

- Contributions
  - Used infrastructure based measures to study the impact of shared e-scooters
  - Explored shared e-scooter impacts based on e-scooter trip purpose

Thank you
Questions?

CONTACT INFORMATION:

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PAPER:

More details on this research can be found in the following page:

Ziedan, A., Shah, N., Wen, Y., Brakewood, C., Cherry, C., & Cole, J. (2021). Complement or compete? The effects of shared electric scooters on bus ridership. *Transportation Research Part D: Transport and Environment*, 101.

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Fixed Effects Regression Model

- $y_{it} = \beta * x_{it} + \alpha_i EF_i + \rho_t TF_t + \varepsilon_{it}$

Where:

y_{it}: unlinked passenger trips for bus route i during time t (day, week, or month)

x_{it}: explanatory variables for bus route i during time t (e.g., shared e-scooter counts, vehicle revenue miles)

EF_i: Entity fixed effect dummy, equal 1 for bus route i and 0 otherwise

TF_i: Time fixed effect dummy, equal 1 for the t^{th} period and 0 otherwise

ε_{it}: error term