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2025 Modeling Mobility Conference

Uncovering the Built Environment & Demographic Drivers of Shared Micromobility Usage in Denver

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Agenda

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- Background
- Research Gap & Contribution

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- Study Area
- Explanatory Variables
- Model Specification

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Summary

- Summary
- Limitation and Future Research

Background

Ridership recovery & growth

- Shared micromobility rebounds Strongly After COVID-19
- In 2023: **157 million trips nationwide** (+20% compared to 2022)

Rising safety risks

- Micromobility injuries ↑ **21% in 2022 vs. 2021**
- E-scooter injuries ↑ **22% in 2022**
- ERs seeing increasing **e-scooter cases**

Background

Managing micromobility growth through trip mapping

- Identify high-use corridors
- Highlight underserved neighborhoods
- Detect crash-prone areas
- Guide infrastructure investments

Research Gap & Contribution

1. Comparative approach: one of the first comparative studies of e-bike & e-scooter usage at the CBG level in Denver

2. Methodological contribution: Applies Truncated Negative Binomial (TNB) model to micromobility research

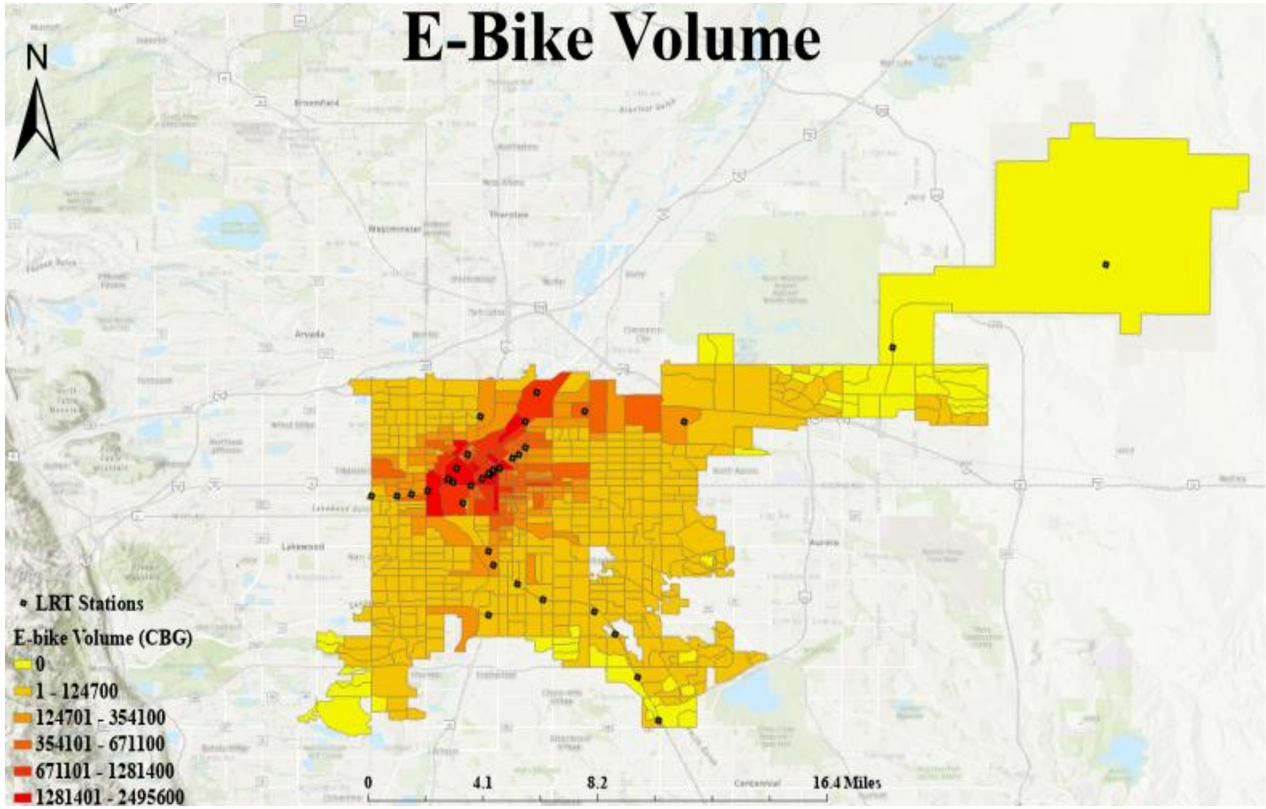
3. Policy relevance: Provides an interpretable alternative to black-box ML and complex spatial regressions, while still capturing spatial patterns (CBD proximity, land-use diversity)

Method - Study Area

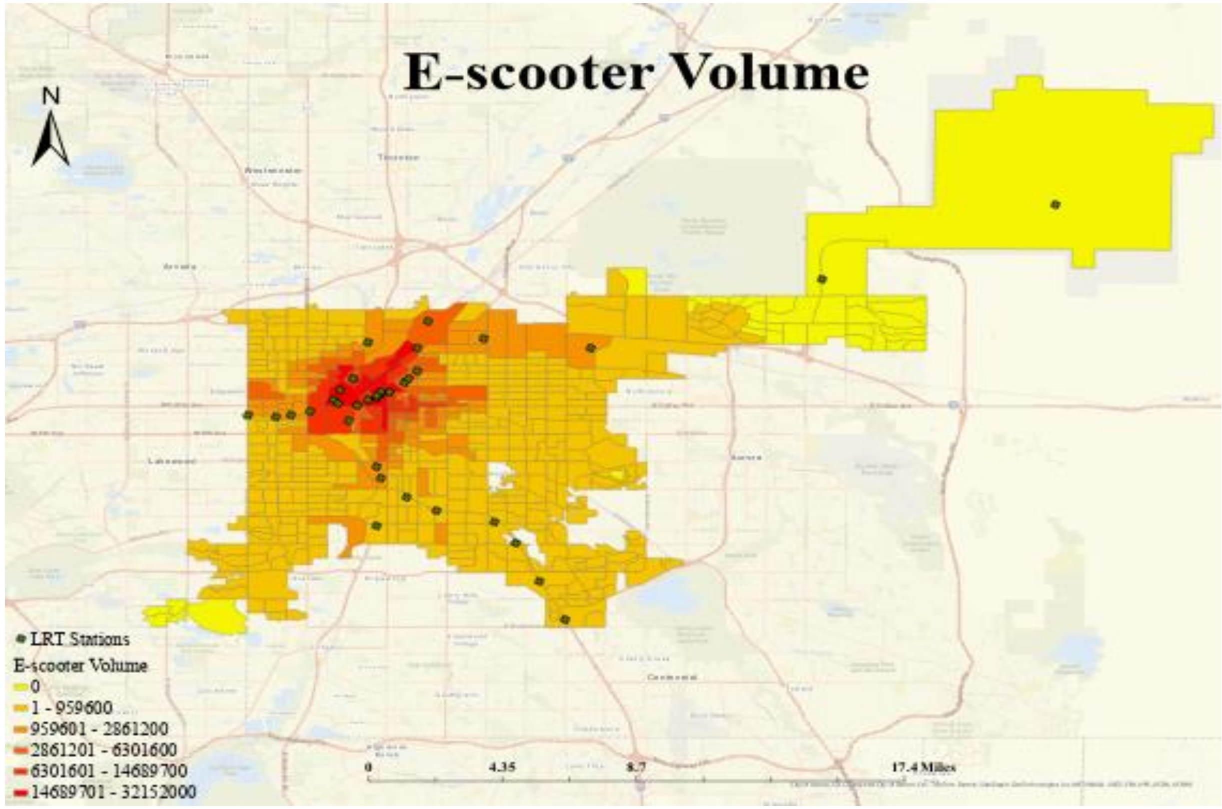
Why Denver?

- High micromobility usage & national leader in adoption
- Strong infrastructure investments & policy support
- Reliable, publicly available trip data

Distribution of Shared E-bike and E-scooter Volumes at CBG Level in Denver



E-bike Trip Volume per CBG in Denver, October 2018 to March 2025 (Data Source: Ride Report)



E-scooter Trip Volume per CBG in Denver, October 2018 to March 2025 (Data Source: Ride Report)

Explanatory Variables

Socio-economic and Demographic (SED) :

- % Male
- % Aged 18–34
- %White
- Median household income
- %Households with 2+ cars
- % with bachelor’s or higher

Land use and built environment (LU&BE):

- Population density
- Job per household
- Employment and household entropy
- Employment entropy
- Regional diversity
- Multi modal intersection density
- Aggregate frequency of transit service
- Number of bus stations in each CBG

Proximity Indicators (PI):

- Distance from CBG center to the nearest LRT station
- Distance from CBG center to CBD

Model Specification

Truncated negative binomial model

$$\mathbf{P}(\mathbf{Y}=\mathbf{y})=\frac{\Gamma(\mathbf{y}+1/\boldsymbol{\alpha})}{\Gamma(1/\boldsymbol{\alpha})\mathbf{y}!}\left(\frac{1}{1+\boldsymbol{\alpha\mu}}\right)^{1/\alpha}\left(\frac{\boldsymbol{\alpha\mu}}{1+\boldsymbol{\alpha\mu}}\right)^{\mathbf{y}}, \qquad \mathbf{y}=0,1,2,\ldots$$

$$\mathbf{P}^{*}(\mathbf{Y}=\mathbf{y}|\mathbf{Y}>0)=\frac{\mathbf{P}(\mathbf{Y}=\mathbf{y})}{1-\mathbf{P}(\mathbf{Y}=\mathbf{y})}, \qquad \mathbf{y}=1,2,3,\ldots$$

$$\mathbf{P}(\mathbf{Y}=0)=\left(\frac{1}{1+\boldsymbol{\alpha\mu}}\right)^{1/\alpha}$$

$$\mathbf{P}^{*}(\mathbf{Y}=\mathbf{y})=\frac{\frac{\Gamma(\mathbf{y}+1/\boldsymbol{\alpha})}{\Gamma(1/\boldsymbol{\alpha})\mathbf{y}!}\left(\frac{1}{1+\boldsymbol{\alpha\mu}}\right)^{1/\alpha}\left(\frac{\boldsymbol{\alpha\mu}}{1+\boldsymbol{\alpha\mu}}\right)^{\mathbf{y}}}{1-\left(\frac{1}{1+\boldsymbol{\alpha\mu}}\right)^{1/\alpha}}, \qquad \mathbf{y}=1,2,3,\ldots$$

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Estimation Findings

Variables	E-bike Estimate	E-bike Std. Error	E-bike P-Value	E-scooter Estimate	E-scooter Std. Error	E-scooter P-Value
(Intercept)	**10.93**	**0.04**	**0.00**	**13.00**	**0.03**	**0.00**
% aged 18–34	**0.08**	**0.05**	**0.07**	**0.13**	**0.04**	**0.00**
% Female	-0.06	0.04	0.10	-0.03	0.03	0.3
%Households with 2+ cars	**-0.13**	**0.04**	**0.00**	**-0.14**	**0.04**	**0.00**
Jobs per household	**0.10**	**0.04**	**0.02**	**0.10**	**0.04**	**0.01**
Employment and Household entropy	**0.14**	**0.05**	**0.01**	-	-	-
Employment entropy	-	-	-	**0.09**	**0.03**	**0.01**
Regional Diversity	**0.10**	**0.05**	**0.06**	**0.19**	**0.03**	**0.00**
Intersection density in terms of multi-modal intersections	0.06	0.04	0.11	**0.07**	**0.03**	**0.04**
Number of bus stations	**0.24**	**0.05**	**0.00**	**0.21**	**0.04**	**0.00**
Aggregate frequency of transit service within 0.25	-	-	-	**0.13**	**0.04**	**0.00**
Distance to the nearest LRT	**-0.34**	**0.06**	**0.00**	**-0.30**	**0.04**	**0.00**
Distance to CBD	**-1.12**	**0.04**	**0.00**	**-1.27**	**0.04**	**0.00**
LL(B)		-5822.2			- 6962.3	
AIC		11668.4			13950.6	
BIC		11718.7			14005.4	
pseudo_ rho sq		0.065			0.074	
Number of Observations		490			502	

Key Takeaways

Socio-Economic & Demographic (SED)

- Young adults (18–34):
    - +8% e-bike trips (marginal)
    - +14% e-scooter trips (strong, significant)
- Multi-car households (2+ vehicles):
    - –12% e-bike trips (significant)
    - –13% e-scooter trips (significant)
- Female residents (%):
    - Slight negative effect (not significant)

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Key Takeaways

Proximity Indicators

Distance to CBD

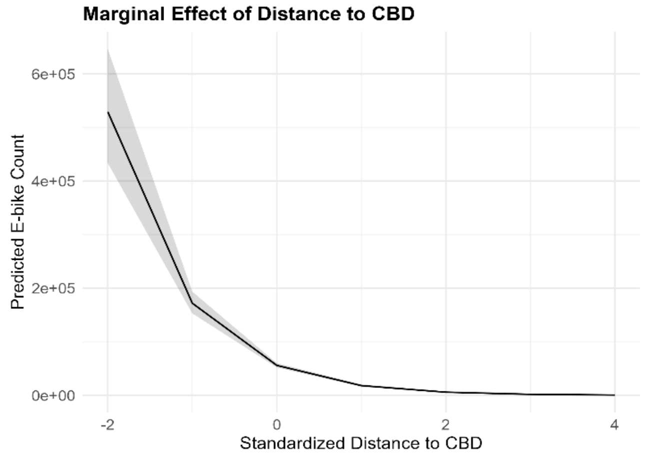
- e-bikes: –67% trips (coef. –1.12, $p < 0.001$)
- e-scooters: –72% trips (coef. –1.27, $p < 0.001$)

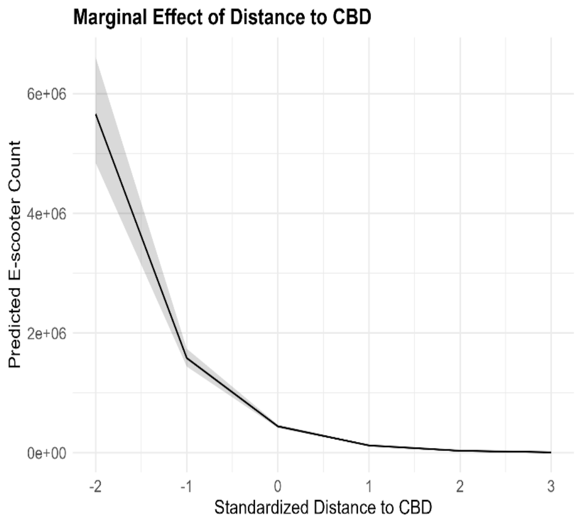
Closer to CBD → much higher usage

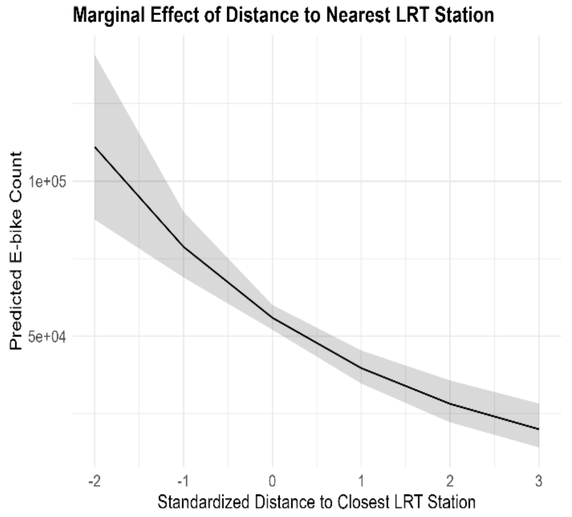
Distance to Light Rail

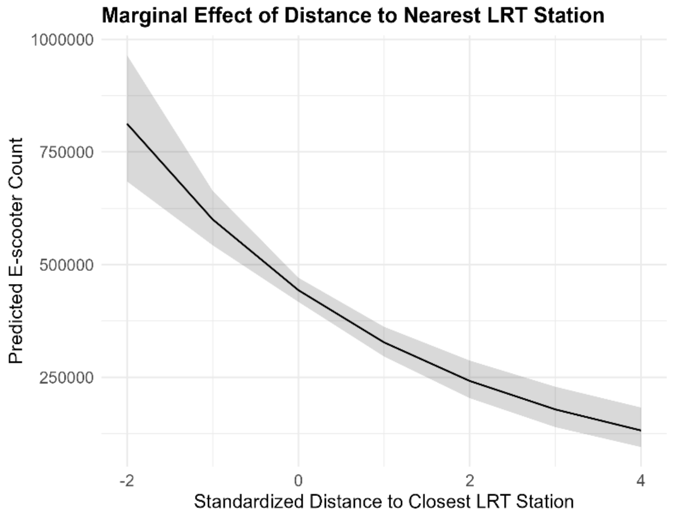
- e-bikes: –29% trips (coef. –0.34, $p < 0.001$)
- e-scooters: –26% trips (coef. –0.30, $p < 0.001$)

Closer to transit → higher usage









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Key Takeaways

Land Use & Built Environment:

Jobs-per-household

- E-bike: coef. = 0.10 ($p = 0.02$), +10% trips
- E-scooter: coef. = 0.10 ($p = 0.01$), +10% trips

Regional diversity

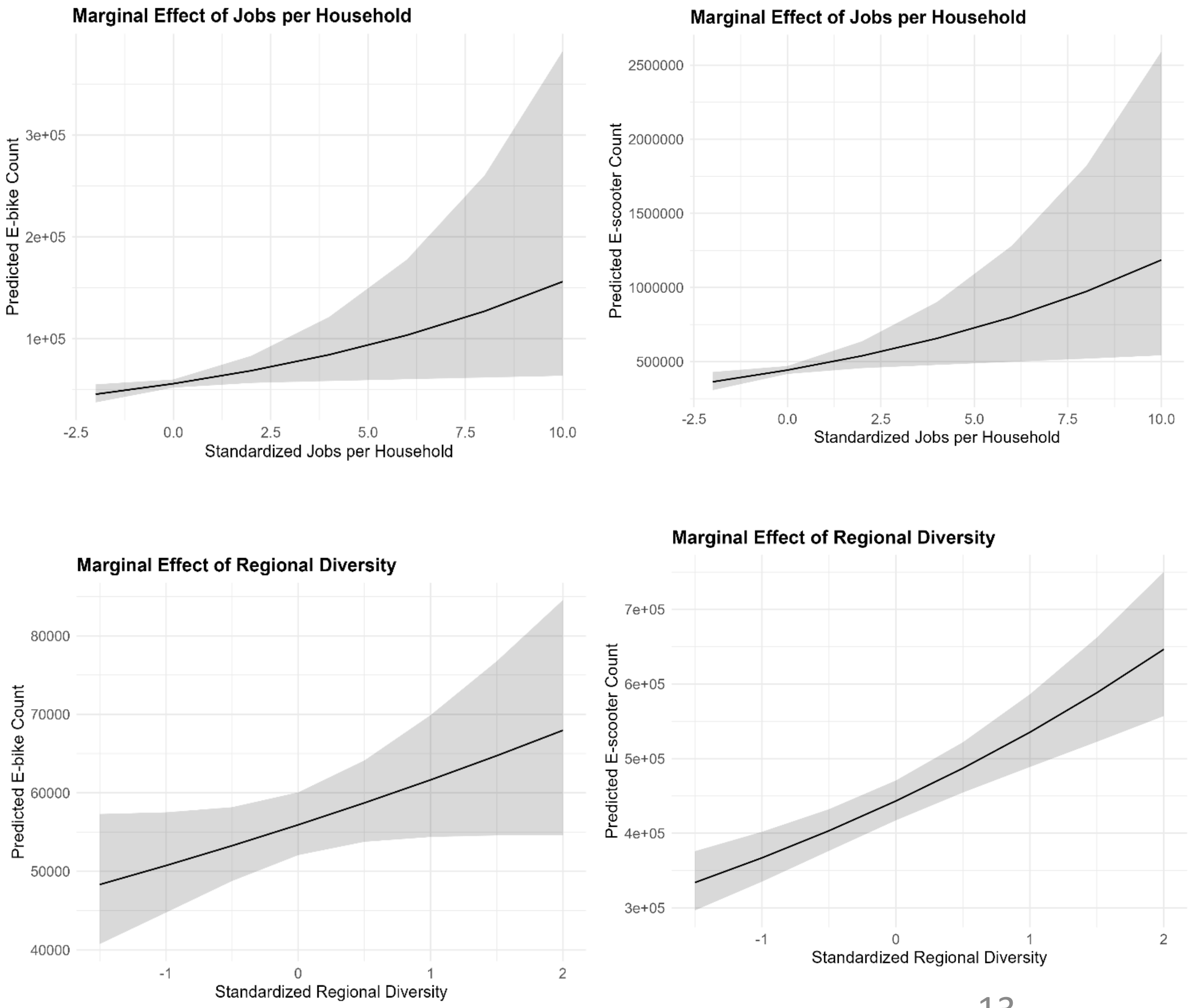
- E-bike: coef. = 0.10 ($p = 0.06$), +10% trips (marginal)
- E-scooter: coef. = 0.19 ($p < 0.001$), +20% trips

Employment and household entropy index

- E-bike: coef. = 0.14 ($p = 0.01$), +15% trips

Employment entropy index

- E-scooter: coef. = 0.09 ($p = 0.01$), +9% trips



Key Takeaways

Multi-modal intersections

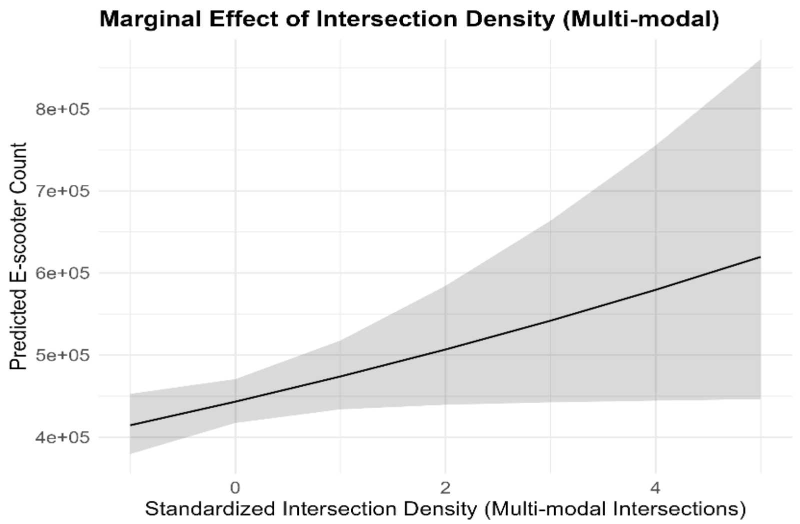
- E-scooter: coef. = 0.07 ($p = 0.04$), +7% trips

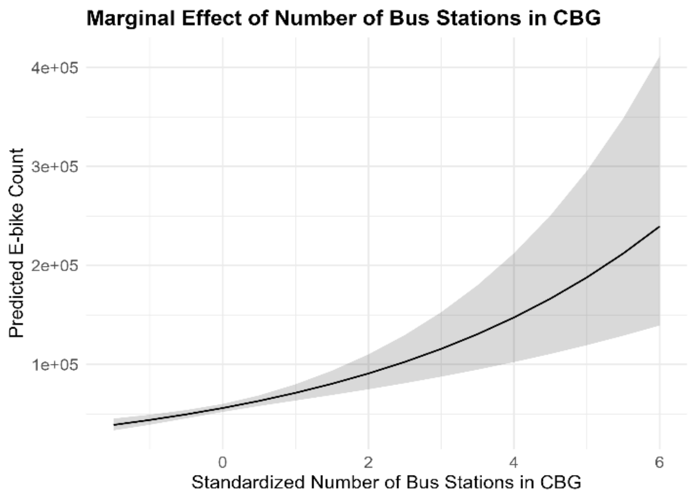
Bus stops

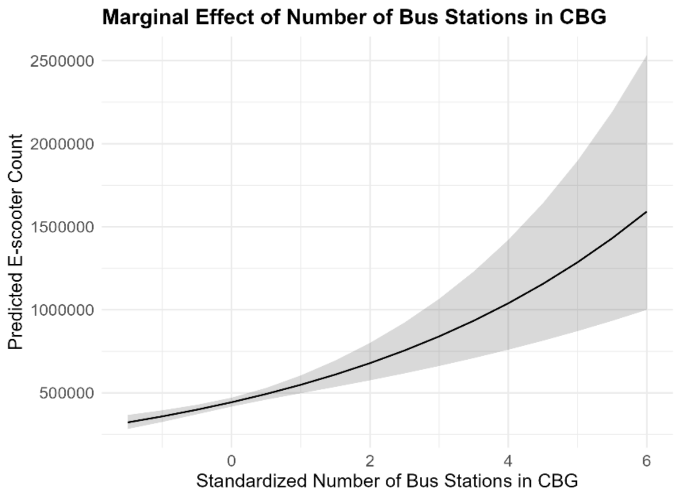
- E-bike: coef. = 0.24 ($p < 0.001$), +27% trips
- E-scooter: coef. = 0.21 ($p < 0.001$), +23% trips

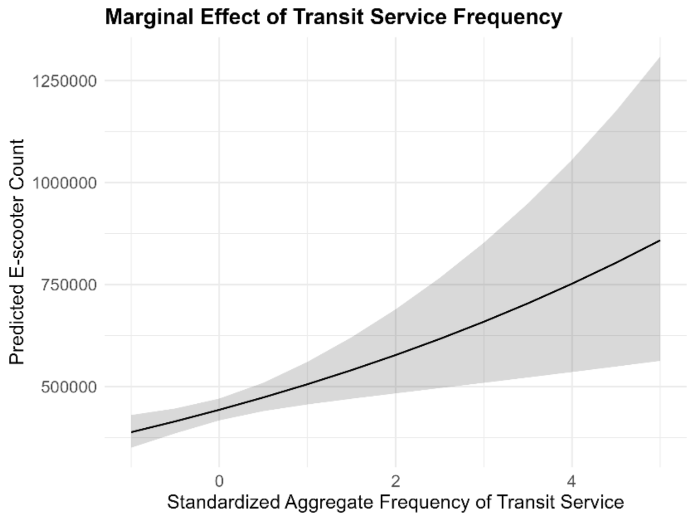
Transit service frequency

- E-scooter: coef. = 0.13 ($p < 0.001$), +14% trips









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Summary

Younger populations drive demand

- Young adults are early adopters of micromobility
- E-scooters especially popular with 18–34 due to affordability & app-based access

Car ownership suppresses micromobility

- Multi-car households show reduced e-bike & e-scooter use
- Reinforces car-dependence as a barrier to shared mobility adoption

Centrality matters most

- Strongest predictor: proximity to CBD

Micromobility complements transit

- Higher usage near light rail, bus stops, and frequent service areas
- Supports role of e-bikes and e-scooters as first-/last-mile solutions
- Built environment shapes usage differently

Limitations & Future Research

Data Limitation

- No **origin–destination data** → limits ability to estimate true demand at the CBG level

Future Research Directions

- Incorporate **OD data** to better inform planning
- Examine **individual user preferences** for routes & infrastructure
- Use **link-level infrastructure data** (e.g., bike lanes) to design stronger **safety interventions**

Thank you

Any Question?

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