Shared micromobility as a last-mile transit solution? Insights from a novel dataset

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Background

- Micromobility is a great first-/last-mile connectivity option to transit.
- Existing data sources on first-/last-mile shared micromobility trips have significant limitations.
- Survey data which typically ask questions such as "Have you used shared e-scooters to connect with transit?" suffers from problems including small sampling size, inaccurate percentages, and no spatiotemporal information about the trip.
- Researchers also infer first-/last-mile trips from large-scale shared micromobility trip data based on a **buffer-zone approach**. However, trips happening close to a transit stop often are often **not** first-/last-mile trips.
- We have access to a unique dataset: Spin post-ride 3-question survey, which contains information on trip start/end time & location, trip time/distance, and **if transit-connecting** collected from **May to September 2021**.

Research Objectives

We used this unique dataset to address two research objectives:

- Examining **spatiotemporal patterns** of Spin e-scooter trips serving as a first-or last-mile connection to transit in Washington DC.
- **Validate** if and to what extent the commonly applied buffer-zone approach can infer FM/LM micromobility trips accurately.

Analytical Framework

We developed a validation framework as shown in Figure 1 below. We applied a set of statistical tests to examine if the inferred FM/LM trips and the reported FM/LM trips have different **spatial** and **temporal** patterns and if their **trip attributes** (i.e., trip distance and duration) are different. If no statistical differences are found, we can conclude that the buffer-based FM/LM micromobility trip inference approach will generate results that can reflect actual FM/LM micromobility trips' spatiotemporal patterns and trip characteristics. The approach used here resembles methods applied in McKenzie (2019).

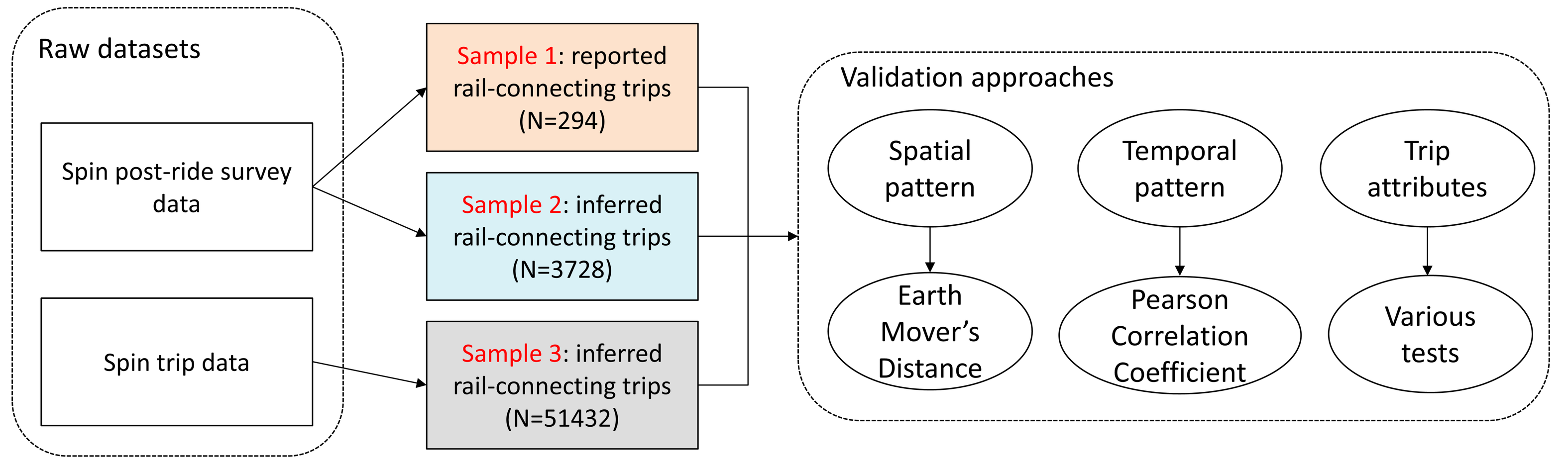

Figure 1. Validation framework

The Spin post-ride survey data were the main data source used for the validation. To address the potential survey bias, we incorporated into the validation procedure a second dataset for comparison, i.e., the Spin trip data. The dataset includes all Spin trip records that occurred during the two months of the study period.

Analysis and Results

For temporal patterns, we aggregated the reported FM/LM e-scooter trips by hour of day based on the trip start time. When it comes to spatial patterns, we aggregated their trip origins and trip destinations at the census block group level.

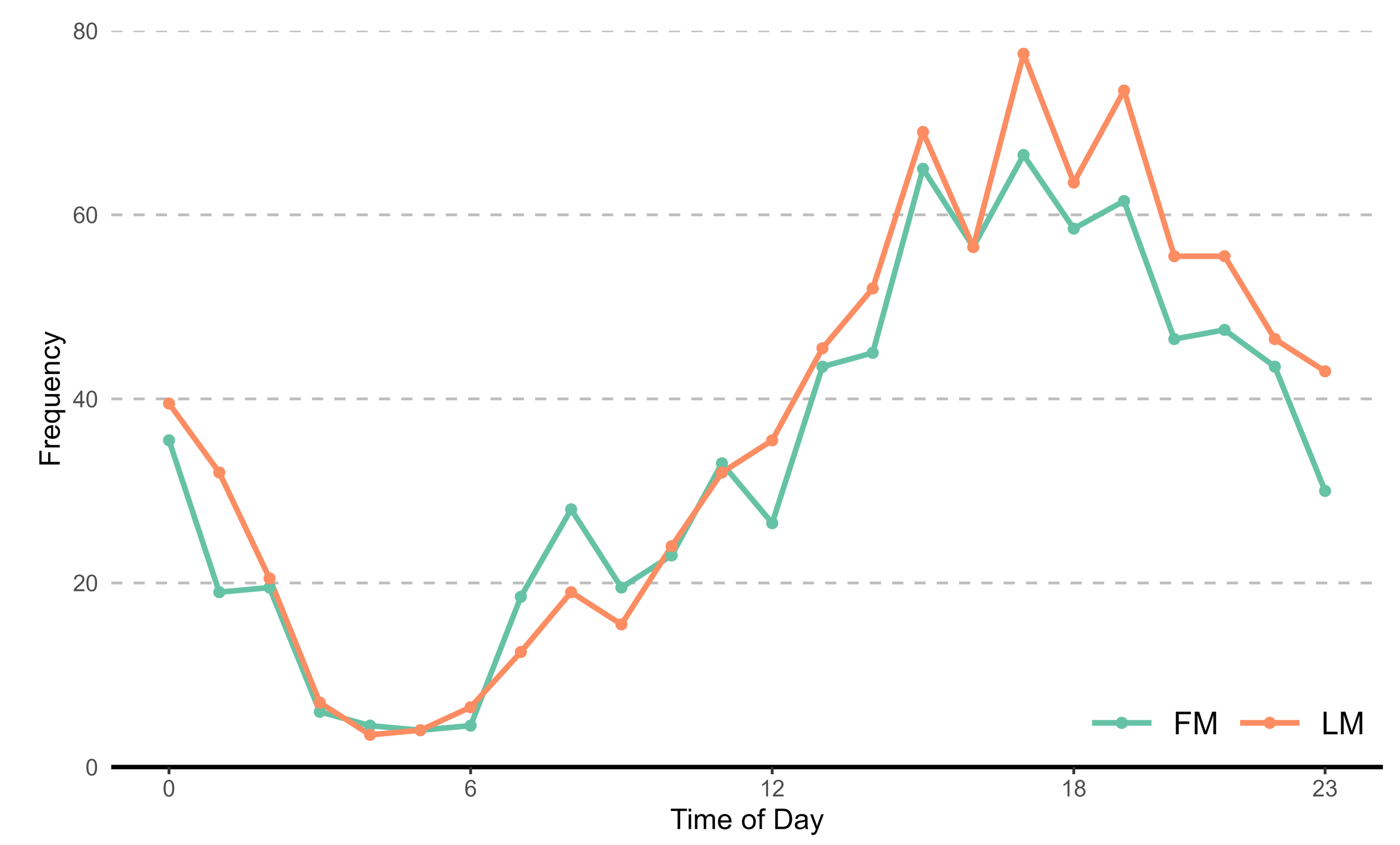

Figure 2. Reported FM/LM trip frequency by hour of day in Washington DC

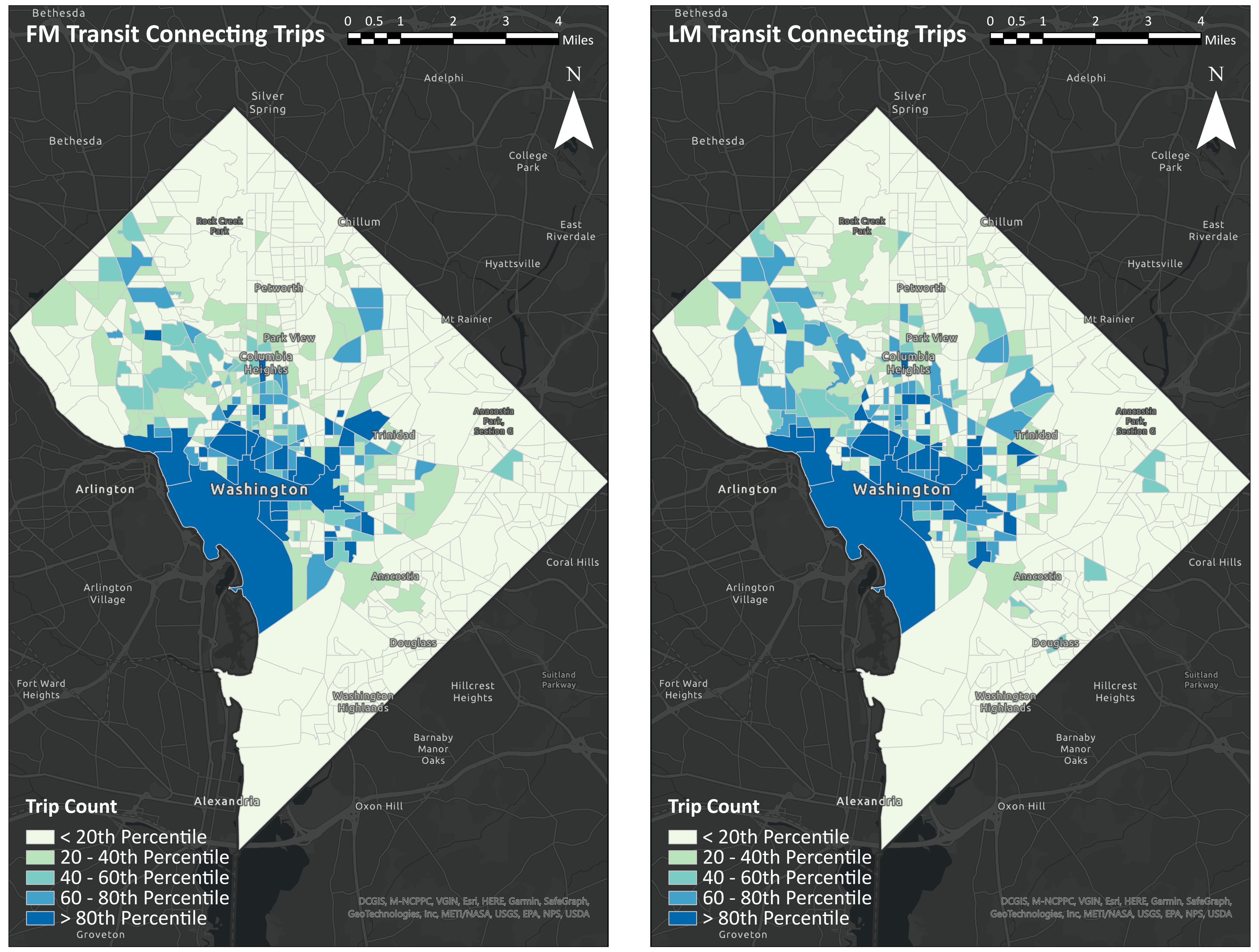

Figure 3. Spatial pattern of reported FM/LM trips in Washington DC

Table 1 presents some key trip attributes of the reported FM and LM transit-connecting trips. It is also worth noting that Sample 1, reported FM/LM trips from the Spin post-ride survey data, in Table 2 is the **ground truth** in our validation framework.

Table 1. Descriptive statistics and test results of FM/LM transit-connecting e-scooter trips

Data Category	*n*	Distance (miles) Median	Distance (miles) Mean	Duration (minutes) Median	Duration (minutes) Mean	%morning peak	%afternoon peak
Reported FM/LM Transit-connecting trips	1,695	1.0	1.5	10.3	20	7.3%	30.3%
FM trips	806	0.9	1.5	9.5	19.7	8.8%	30.2%
LM trips	889	1.1	1.6	11.1	20.3	6.0%	30.5%
FM trips vs LM trips		Mood's median test (Two-sided)		Two-sample t-test (One-sided)		Two-proportions Z-test (One-sided)	
p-value		0.002	0.019	0.273	0.512	0.001	0.440

Table 2. Test results for spatiotemporal patterns and characteristics

Temporal Pattern	Pearson Correlation Coefficient			% FM/LM Trips at 15-minute interval	
		Sample 1[1] vs Sample 2[2]		0.833	
		Sample 1 vs Sample 3[3]		0.781	
		Sample 2 vs Sample 3		0.931	
Spatial Pattern	Earth Mover's Distance			Weighting Variable % FM/LM Trips	
		Sample 1 vs Sample 2		1618.597	
		Sample 1 vs Sample 3		1029.708	
		Sample 2 vs Sample 3		835.210	
Trip Attributes Sample 1 vs Sample 2		Trip Distance (meters)		Trip Duration (seconds)	
		Test Statistics	*p-value*	Test Statistics	*p-value*
	Mood's Median Test	0.485	0.628	0.363	0.716
	Wilcoxon Rank Sum Test	529883	0.344	539742	0.666
	Fligner-Killeen Test	1.171	0.279	1.396	0.237
	Kolmogorov-Smirnov Tests	0.056	0.357	0.036	0.881

Notes: 1. Reported FM/LM trips from the Spin post-ride survey data 2. Inferred FM/LM trips from the Spin post-ride survey data 3. Inferred FM/LM trips from the Spin trip data

Main Findings

- The temporal pattern of FM trips' and LM trips' usage patterns are **quite similar**, with two pronounced peaks: one in the morning and one in the afternoon.
- The spatial distribution of reported FM/LM trips, which shows that the spatial patterns of FM and LM trips were **largely consistent**. The highest density of shared e-scooter trips was found near the National Mall, the central business district, and the Potomac River, suggesting that e-scooters were often used for **recreational purposes**.
- In terms of trip attributes, compared to LM trips, FM transit-connecting trips were **slightly shorter** and disproportionately happened during the **morning peak**.
- Inferred FM/LM trips have **different spatial and temporal distributions** compared actual FM/LM trips reported by Spin users.
- Trip attributes are **not significantly different** between Sample 1 and Sample 2.

Policy Implications

- We need better data sources to understand transit & micromobility integration.
- Surveys are inadequate, and FM/LM trips inferred from big data are biased.
- We need more initiatives such as the Spin post-ride survey.
- Specific policy efforts (e.g., price bundling, integrated payment options, improved availability and cycling infrastructure) are needed to promote shared micromobility-transit integration.