

Article

A Spatiotemporal Study and Location-Specific Trip Pattern Categorization of Shared E-Scooter Usage

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Abstract: This study analyzes the temporally resolved location and trip data of shared e-scooters over nine months in Berlin from one of Europe's most widespread operators. We apply time, distance, and energy consumption filters on approximately 1.25 million trips for outlier detection and trip categorization. Using temporally and spatially resolved trip pattern analyses, we investigate how the built environment and land use affect e-scooter trips. Further, we apply a density-based clustering algorithm to examine point of interest-specific patterns in trip generation. Our results suggest that e-scooter usage has point of interest related characteristics. Temporal peaks in e-scooter usage differ by point of interest category and indicate work-related trips at public transport stations. We prove these characteristic patterns with the statistical metric of cosine similarity. Considering average cluster velocities, we observe limited time-saving potential of e-scooter trips in congested areas near the city center.

Keywords: e-scooter; micro-mobility; shared-mobility; land use analysis; spatiotemporal analysis; spatial allocation; HDBSCAN; big data



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1. Introduction

The *National Association of City Transportation Officials* recorded 96 million dockless micro-mobility related trips in the United States (US) in 2019. Almost 90% of these trips were made with shared electric scooters (e-scooters) in 109 US cities. The concept of shared micro-mobility refers to shared-use fleets of fully or partially human-powered, low-speed vehicles such as bikes and scooters [1,2]. In the fall of 2017, shared e-scooters represented a new mode of micro-mobility that emerged on the streets of multiple US cities. Since then, the number of micro-mobility users has multiplied in the American market. Beyond that, e-scooters are now also widely spread in European cities. These developments are reflected in Schellong et al. [3]'s predictions which assume rapid growth to as much as \$50 billion in global market volume in 2025.

This publicly available, on-demand, and easy-to-use concept combined with electronic payment is the foundation for the rapidly increasing dissemination of e-scooters. As Bai and Jiao [4] outlined, short distance trips cannot be covered due to an insufficient number of short-distance travel alternatives. Besides bike-sharing and electric motorbike services, shared e-scooters present a promising solution to address the first- and last-mile problem. These services can contribute to improved mobility, reduction of congestion and fuel use, and reduced emissions [1].

Regarding the European market, Madrid, Paris, and Berlin are the top three cities, considering fleet size and usage frequency. *Tier Mobility* is the overall leading provider in Europe in terms of regional coverage, with e-scooters in 54 cities [5]. Because of intoxicated drivers, vandalism, and badly parked e-scooters (e.g., [6]) in large cities, the influx of e-scooters polarizes the opinions of residents, users, planners, and other groups involved [7]. Despite these negative aspects, the rapid growth of e-scooter providers cannot be ignored.