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Enhancing Equity and Access in Dockless Micromobility Services

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POLICY BRIEF

BACKGROUND AND OBJECTIVES

Shared micromobility services can help communities reduce their dependence to private vehicles, encourage physical activity, drive technological innovations, and foster economic growth. Naturally, there are also potential costs and concerns associated with shared micromobility. Chief among the concerns is the prospect that disadvantaged communities will not have equitable access to micromobility travel alternatives. Given that the study of travel patterns can inform the enactment of effective policy, the first objective of our research project was to present a case study of the dockless e-scooter rental service (MDES) in Mayagüez, Puerto Rico. The case study examined characteristics of users and nonusers of MDES, the sociodemographic and land-use factors associated with the demand for the service, the spatiotemporal patterns of e-scooters trips in the city, and the spatial access to and equity of the service. This analysis motivated the development of new methods that can be used in practice to quantify spatial access in the context of dockless micromobility systems.

Equity concerns can also be addressed by ensuring that micromobility operations are guided by decision support systems that account for equity objectives. For this reason, the second objective of this project was to develop an optimization-based approach to guide vehicle rebalancing operations according to efficiency and equity objectives.

METHODOLOGY

Two sets of methodological approaches were used to achieve the two main objectives of the project. For the case study, an online survey was conducted to explore the characteristics of MDES users and nonusers. The data collected though the survey was analyzed using standard exploratory data analysis techniques and logistic regression. In addition, e-scooter trips transaction data was obtained from the service operator, and it was analyzed to understand the spatiotemporal patterns of e-scooter trips. These data were examined using geographic information system (GIS) tools and regression techniques. The GIS outputs enabled the analysis of the spatial access levels in MDES. A network-based approach was developed to quantify spatial access measures. For this analysis, e-scooter locations were mapped to transportation network nodes for each day and each period of the day (5-minute periods were used to discretize time in a day). Spatial access indicators were computed for each day, each period, and each node of interest to reflect that, in the context of dockless micromobility services, a neighborhood's spatial access to the service varies as vehicles are used during the day. For each location of interest, the following spatial access indicators were computed: the average distance to the K closest e-scoters, the area under the scaled cumulative relative frequency curve of the distance to each e-scooter in the fleet, and the node-level number of e-scooters per person. Finally, Atkinson inequality index values were computed using the spatial access measures determined for all buildings in the service area. The inequality index values serve as proxy measures of the spatial equity-in-access of MDES.

For the second objective, a two-step framework was proposed that can be used coordinate the rebalancing operations of dockless micromobility vehicles according to efficiency and equity objectives. In the first step, an optimization model is used to determine target vehicle distributions that maximize system performance metrics for a given time horizon. Examples of efficiency objectives are the maximization of the number of micromobility trips or the congestion reduction potential of the micromobility service. The spatial access indicators previously discussed are examples of metrics that can be used to formulate the equity objective. This first step presumes the existence of models that can be used to forecast the performance of the system according to the selected metrics. The project explored the used of machine learning algorithms to train the forecasting models. In the second step, a multi-objective vehicle pickup and delivery problem is used to generate the rebalancing plan (i.e., the micromobility vehicle pickup and delivery locations and quantities). This optimization problem attempts to minimize the deviations from the target distributions related to an efficiency and an equity objective, as well as the transportation cost of the rebalancing operations.

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RESEARCH FINDINGS

The main findings from the analysis of survey responses were:

- Female respondents were 1.7 times less likely to use MDES than males.
- Respondents in the 18-to-26 age group were at least two times more likely to be e-scooter users than people in older age groups.
- Costs, inadequate pavement conditions, lack of dedicated space for on-street riding, and safety concerns were identified by survey respondents as the main reasons for not using the service or not using it as much as desired.
- Traffic congestion and lack of parking spaces were identified among the main reasons for using MDES, which suggest that the service could have reduced auto trips in the service area.

The main findings from the analysis of the e-scooter trip record data were:

- Trips were concentrated in and around a university's campus. Approximately 78% of e-scooter trips started or ended at the University of Puerto Rico at Mayagüez. Outside the university, trips primarily concentrated in neighborhoods with large student populations.
- During periods of low university activity (e.g., weekends or holidays), the demand for the service was relatively very low.
- There were differences in spatial access among neighborhoods. This observation could be explained by the spatial distribution of the main system users (university students), the sociodemographic characteristics of the population in Mayagüez (generally low-income and older), and the rebalancing operations being aimed at satisfying user demand.
- Regression analyses suggest that income levels, mixed land use, and university locations are positively associated with e-scooter trip demand.

The results from simulation tests conducted with the rebalancing optimization model suggest that, relative to efficiency-focused rebalancing, there are scenarios in which equity-focused rebalancing operations could result in minor reductions in total trips and significant improvements in spatial access to micromobility services. However, given that the simulations were based on MDES characteristics and on assumed behavioral parameters, additional studies are needed to reach generalizable conclusions on the likely effects of equity-focused rebalancing operations on the overall performance of dockless micromobility services.

POLICY AND PRACTICE RECOMMENDATIONS

The study findings suggest that micromobility services could help reduce short auto trips, particularly in cities that lack effective public transportation services. However, the magnitude of this effect and its ultimate impact on traffic congestion remains to be determined, at least in the case of MDES. The study also provides further evidence of the importance of investing in infrastructure that creates safe road spaces for users of bicycles, e-scooters, and other shared micromobility modes. Creating safer road spaces for all users could not only increase the demand for cleaner modes of transportation, but it could also help close the participation gaps of groups that are consistently underrepresented among shared micromobility users (e.g., older population groups) and expand their travel options.

The methods developed in this project offer transportation planners a disaggregate approach to evaluate spatial access and equity-in-access of dockless micromobility services. The proposed network-based approach can be applied to measure spatial access at the level of specific locations. This circumvents the need for defining zonal systems and it directly focuses the analysis to the spaces in which people perform their activities. In turn, the network-based methodology allows for a more detailed analysis of spatial access across time.

More detailed measurements of spatial access can be used to develop more complete policies and models aimed at improving the equity-in-access of dockless micromobility. In particular, the rebalancing operations of dockless micromobility services could be enhanced if models like the ones presented in this project were implemented to balance the often-conflicting objectives of maximizing profit and ensuring equitable access. For example, in the e-scooter pilot program of the city of Chicago, service operators were required to redistribute a set percentage of the e-scooter fleet within two priority areas in the city. The models developed in this project could be used within a decision support system that not only specifies the number of e-scooters that should be located within priority areas, but they could also be used to specify the locations that would result in the greatest spatial access benefit. Considerable work has been completed on algorithms and systems that enable transportation network companies to make real-time decisions to improve the efficiency of their services. The tools used to maximize efficiency objectives could be easily extended to create a future in which equity-conscious objectives are also proactively pursued with the assistance of smart decision systems.

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