Using New Urban Mobility Data in Accessibility Analysis

Executive Summary

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New Urban Mobility alliance

Title picture: *Cairo Bike* station in downtown Cairo, Egypt (11/08/22' TfC – Hazem Fahmy)

Highlights

- There is an observed modal shift towards individual modes of travel, like micromobility, triggered by the COVID-19 pandemic, and expected to continue in the post-pandemic era[1].
- Understanding how micromobility affects accessibility is important to inform policies on the proliferation of New Urban Mobility (NUM) in regional planning frameworks and decarbonizing the transport sector.
- NUM's value in accessibility to jobs has not been studied or compared to car-based mobility using realistic congestion speeds.
- This report provides a largely open-source accessibility analysis framework with relevant mode combinations to investigate and quantify the potential of micromobility services for improving accessibility.
- The approach leverages realistic travel time estimates that account for congestion, a multimodal routing engine that accounts for safety considerations in non-motorized route choice, and a probabilistic approach to account for micromobility service availability.
- Four cities (Cairo, Mexico City, Minneapolis-Saint Paul, and the San Francisco Bay Area) are selected to showcase the workflow and understand the role of micromobility in different urban contexts.
- Overall, in comparison to travel by private cars, micromobility coupled with public transit provides comparable accessibility in shorter trips, i.e., travel time 15-30 minutes.
- Micromobility as a first and last mile solution is only as good as the public transport system it feeds into. Improving public transport services, like higher frequency, will better leverage micromobility's positive effect on accessibility.
- The equity of the beneficiaries of NUM services is calculated for race and income population groups in the US. A surprisingly equitable distribution is found among racial beneficiaries, but a more complex result is found for income groups. The main factor affecting equity is a group's proximity to the city center

Background

Analyzing accessibility to opportunities by New urban Mobility modes is key to integrating them in multimodal transportation planning frameworks. Such integration, including regulation and policymaking, aims ultimately at improving the overall multi and intermodal accessibility of the transportation system. This accessibility analysis exercise is indispensable in cases like the onset of a new emerging mode, the introduction of a disruptive business model, or the start of a remarkable behavioral shift. The transportation market in the past couple of years, particularly in the second half of the past decade, witnessed the emerging wave of shared-mobility services, mobility-on-demand and mobility-as-a-service. Along with this new mobility trend, a decline in transit ridership was observed globally, particularly in North America. After the onset of the COVID-19 pandemic, another behavioral change was observed in the propensity toward user-centric mobility services like micromobility. Therefore, the role of such

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[1] https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/the-future-of-micromobility-ridership-and-revenue-after-a-crisis

services in improving accessibility should be understood and integrated into multimodal transportation planning frameworks.

New Urban Mobility or Micromobility can play a transformative role in getting people out of cars even in cities that exhibit a large degree of urban sprawl. It can also readily integrate with public transit, car rental apps, and other innovative mobility trends like ride-sourcing or ride-sharing. However, to justly evaluate and understand the potential of micromobility service, their contribution to improving accessibility should be analyzed on a realistic basis, especially when compared to car-based modes and collective transport. Their relatively lower speed may mask their real impact on improving the overall accessibility to opportunities in a multimodal transportation system. Therefore, the analysis framework adopted in this report is predicated on two key pillars; (1) capturing the realistic accessibility by cars in congested networks, and (2) focusing on the intermodal role of micromobility coupled with collective transport.

About this Report

This report provides an empirical workflow to evaluate and understand the role of micromobility services in improving the accessibility of people to opportunities, specifically jobs. This workflow comprises the accessibility analysis method, where a Cumulative Opportunities Measure (COM) is used, the multi and intermodal mode combinations; cars only, cycling only, public transit only, and micromobility coupled with transit, and finally the selected geographies for the case studies; Cairo (Egypt), Mexico City (Mexico), Minneapolis and San Francisco (USA) are selected to showcase the workflow implementation and results. The studied geographies are selected deliberately to explore the role of micromobility within distinct urban fabrics, and their underlying multimodal transportation supply and sociodemographic contexts. The limited availability of micromobility vehicle supply, another crucial component in analyzing accessibility by micromobility, is accounted for in this workflow.

Accessibility Gains by Micromobility: Approach and Insights

As a baseline, accessibility by private cars is calculated and compared to three scenario narratives for mode combinations, as shown in Figure 1. In COMs, the overall number of opportunities, e.g. jobs, reachable from each origin within a certain travel time threshold is calculated. To understand the impact of micromobility on accessibility at different trip lengths, we use 60-, 45-, 30-, and 15-minute thresholds to analyze and compare the respective improvement in accessibility, also known as accessibility gain. Each city was divided into hexagonal zones, ranging from 400 m to 2.5 km, to facilitate the computation and comparison between the modes.

Our accessibility framework is powered by an open-source routing engine (r5) that consumes OpenStreetMap (OSM) network data structure. The workflow focuses on the realistic and intermodal interactions of the analyzed modes. Our objective is to avoid using default free flow speed for motorized modes which results in far greater accessibility scores for car-based mobility. Therefore, to model realistic car travel times, the OSM road network is augmented with Uber Movement and Mapbox speed datasets. Figure 2 shows the significance of the congestion on accessibility by cars in San Francisco. Access, egress, and parking cruise time components of car-based trips are also accounted for in this accessibility analysis framework using values from the literature.

For public transport, General Transit Feed Specification (GTFS) data, which includes bus schedules that take into account congestion, are consumed by the routing engine.

To account for user preferences toward choosing user-friendly routes for micromobility and active transport modes, Level of Traffic Stress (LTS) is used to limit routing to OSM segments with low LTS scores, representing the majority of potential cyclists and not just the most confident.

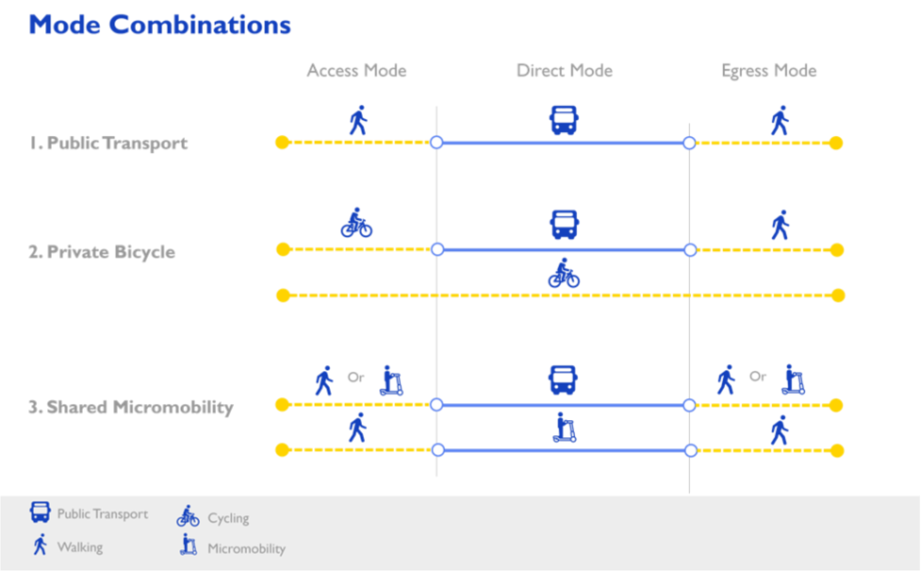

Figure 1: Mode combinations used in analysis

Service or vehicle availability for micromobility is estimated at all origins and destinations for scenario narrative three using a probabilistic approach. The probability distribution of vehicle availability is estimated using Mobility Data Specification (MDS) which shows where the supply of micromobility services is at a given time. This probability of not finding a micromobility vehicle at the origin and destination where micromobility improved accessibility is used to reduce the potential accessibility gain due to micromobility.

The final objective of the project is to analyse the equitable distribution of the beneficiaries of accessibility gain due to micromobility. We calculate the changes in accessibility as experienced by the populations of the zones witnessing these changes. Since the zones' population can be stratified into groups based on race[2] and household income, we calculate the changes in accessibility for each group.

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[2] This is applicable for US cities only. we use census data on racial composition and household income at the US census block level

The elements described above explain how this study tackles the following key questions:

1. How can accessibility by private cars and transit be captured in a realistic way?
2. How can travel by micromobility modes be modelled behaviourally?
3. How can micromobility systems' supply be estimated spatiotemporally?
4. How can equity in the distribution of benefits from micromobility be measured?

The answers to these key questions together allow us to gauge the role of micromobility in improving accessibility to job opportunities in multimodal transportation systems.

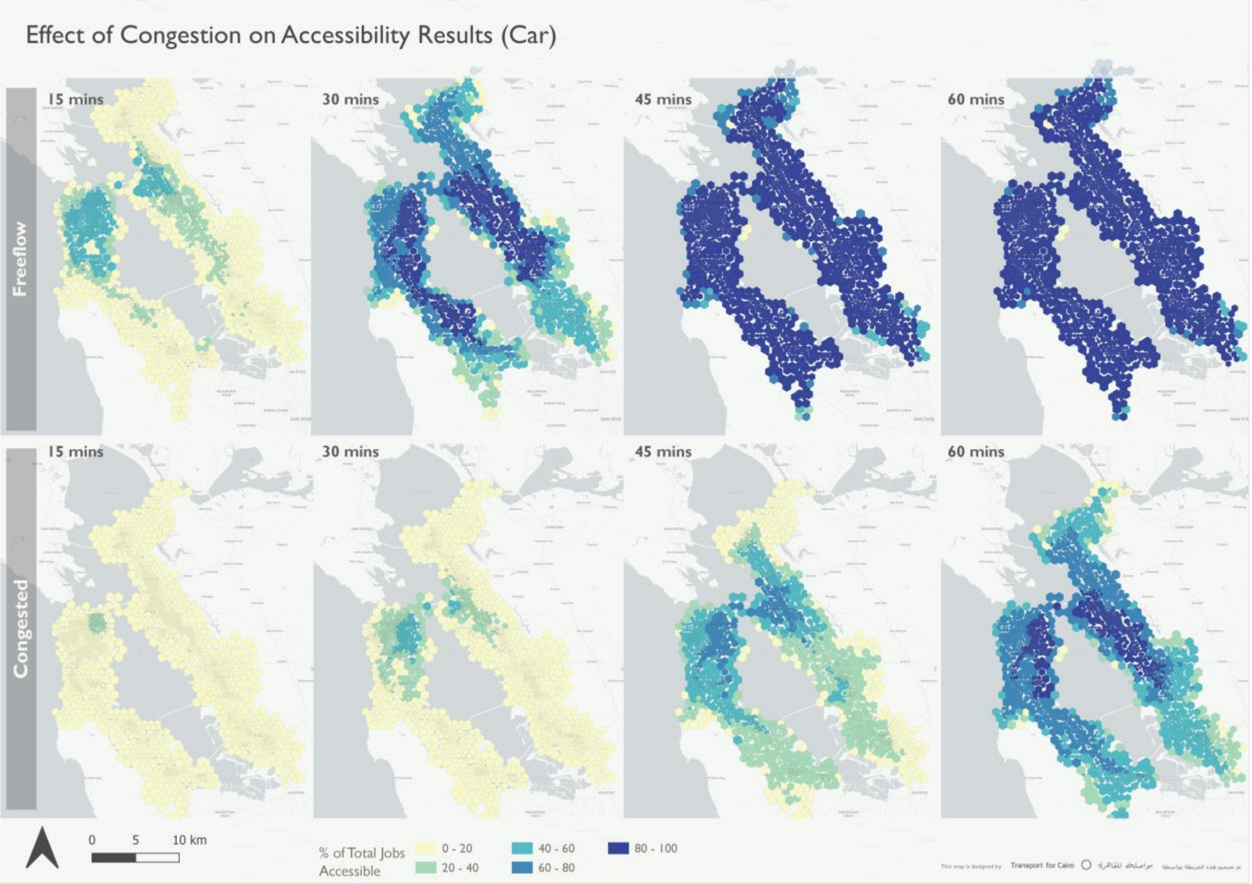

Figure 2: Effect of Congestion on Accessibility Results. (Top Row) Accessibility at Different Time Thresholds under Freeflow Conditions. (Bottom Row) Accessibility at Different Time Thresholds under Congested Conditions – San Francisco

Key Findings and Recommendations

Micromobility service, either docked or dockless, was found to enhance the accessibility of travelers to jobs either as a main mode or as a feeder to public transit. Dockless micromobility has a higher positive effect than its docked counterpart because it does not have the same spatial constraints, as shown in Figure 3. At the zone level, the highest mean improvement occurs at 30 minutes of travel time, or 45 minutes for docked micromobility in San Francisco, with larger maximum improvement but lower overall mean improvement as the time threshold increases. This improvement is most noticeable in areas with high public transit connectivity. For very short trips, micromobility is shown to be a competitive alternative to travel by car, likely because congestion and parking is avoided.

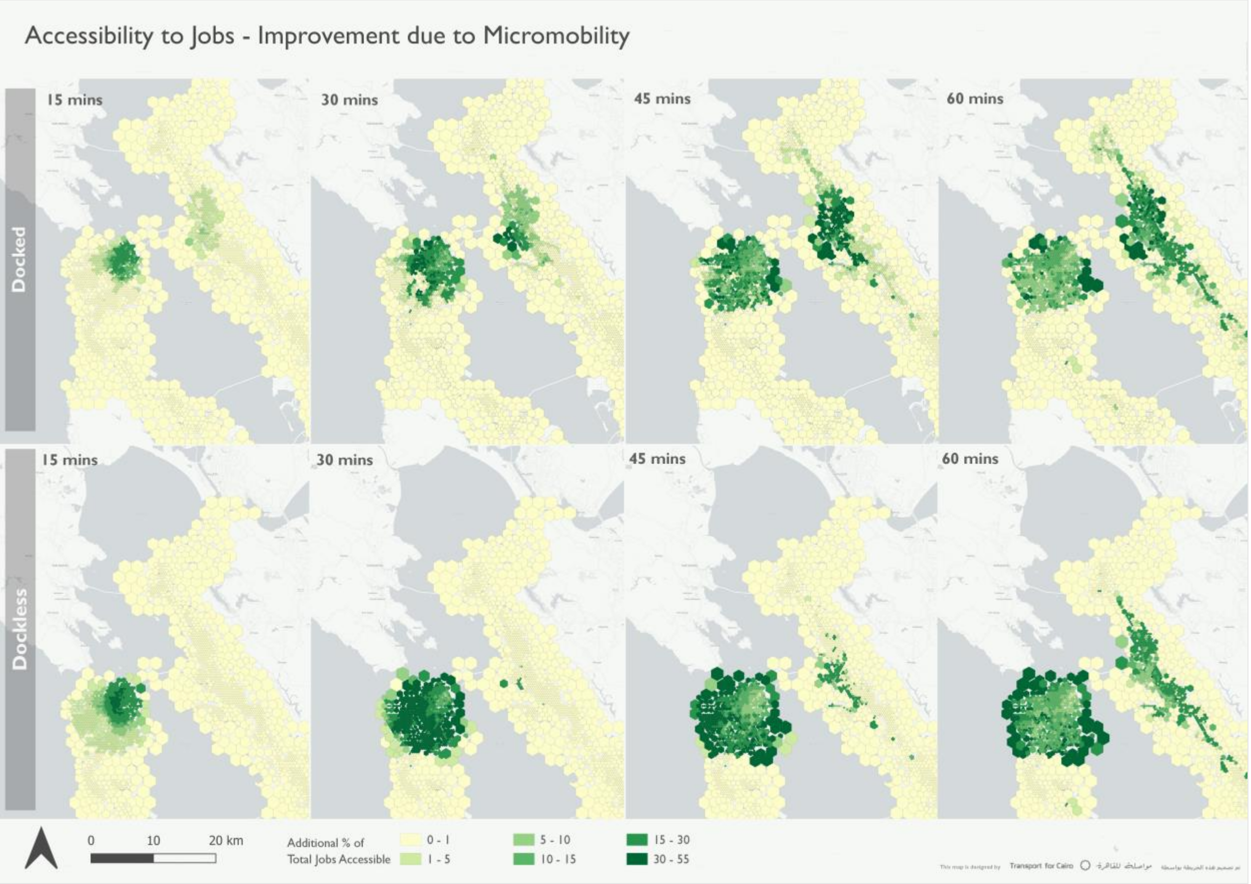

Figure 3: Accessibility gain due to micromobility (San Francisco)

In this analysis, we explored the impact of service availability for dockless services in San Francisco. Most zones in San Francisco witness a reduction in the accessibility gains by micromobility at levels less than 10% and a mean of 8.5%. This reduction is realistic and consistent with the demand profile in the area. The spatial distribution of supply constraints and their effects can be seen in Figure 4.

One important observation on micromobility availability is its relative lack in the outskirts of San Francisco which reduces the potential accessibility gains achievable by its residents. Therefore, the key recommendation that can be drawn from this analysis is to drive policymaking efforts to increase micromobility services in underserved areas. This can be achieved via infrastructure as well as operational improvements.

Equity in the distribution of accessibility gain due to micromobility was measured in San Francisco and Minneapolis-Saint Paul. Micromobility was found to improve the equitable distribution of accessibility among the zones of the city from 3 to 6% on the Gini Coefficient. For most minority race groups except Asian and Hawaiian, Weighted Average Accessibility (WAA) is higher than that of the total population. On the other hand, given San Francisco Bay Area's spatial distribution of income groups where the city proper has extreme wealth and poverty, we found that most middle-income families have WAA scores lower than the average. Micromobility pushes the needle in the right direction, giving more low-income groups better access to jobs in the city.

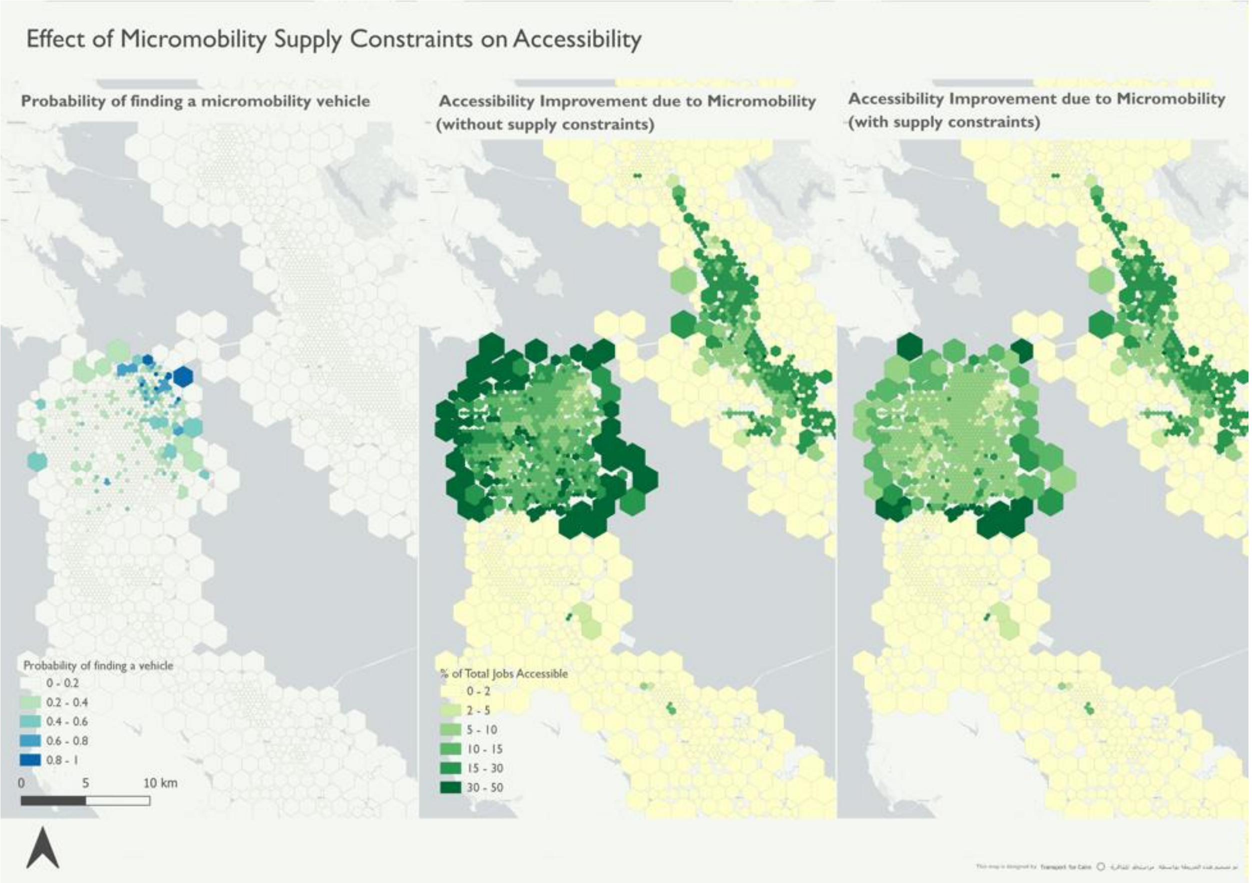

Figure 4. Effect of micromobility supply constraints on accessibility.

Micromobility did not have the same equalizing effect in Minneapolis as it did in the Bay Area. Overall spatial equity in accessibility barely improved due to micromobility, only 0.6% on the Gini Coefficient. This is likely due to the improvement in accessibility limited to the center of the metropolitan area, where minority groups lower income groups can benefit in both first and last mile portions of their commutes. Asian and White residents of the city, who live in the eastern and western outskirts of the city respectively, witness lower than average accessibility gain. In general, population groups that can benefit from micromobility twice, as access and egress, in their trips, see the highest benefit. Since micromobility and high concentrations of jobs are usually found in a metro area's center, the groups residing in that area have the highest accessibility gain due to micromobility.

Equitable access to micromobility services is key to its successful integration within regional multimodal transportation networks. Improvement due to micromobility varied across the different context studied in this report. Since it is a feeder to public transport and uses roadways, it depends heavily on both public transit connectivity and roadway LTS levels. Future work should further explore these dimensions. The service availability modeling technique presented in this paper can also be further refined using edge probabilistic approaches like latent variable probabilistic modeling. This future research direction is of significance to model the supply in such an uncertain and newly emerging market.