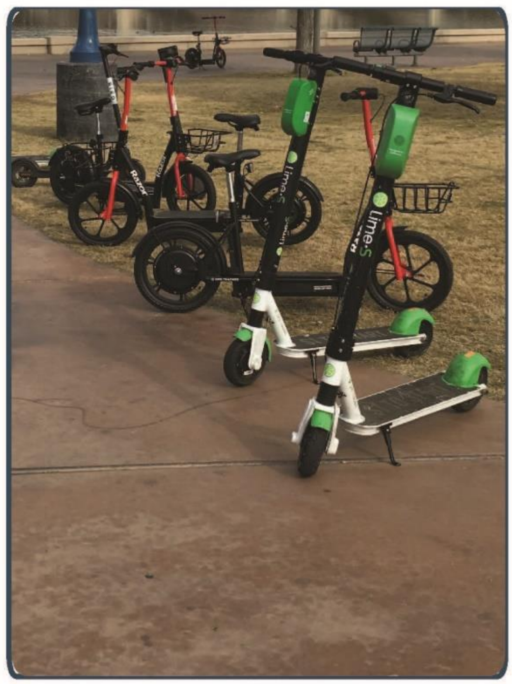
E-SCOOTER MOBILITY

Estimates of the Time-Savings and Accessibility Benefits Achieved via Chicago's 2019 E-Scooter Pilot Program

BY C. SCOTT SMITH, PHD | MARCH 12, 2020



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Introduction

The character of urban transportation and mobility has changed considerably in recent years, in part because of new investments in active transportation and the explosive growth and continuous iteration of shared-use modes (SUM) of travel such as ridesourcing, bikesharing, carsharing and, more recently, electric (e-) scooter-sharing. E-scooters and other novel forms of micro-mobility have the potential not only to offer riders opportunities to experience urban travel at an unconventional pace, but also to leverage more established transportation modes to reduce travel times and enhance accessibility.

With its extensive public transit and shared mobility networks, the city of Chicago proves to be a challenging yet informative setting for exploring the multifold interactions between transportation modes and how specific trip configurations can influence travel times and accessibility. Such analyses are challenging because of the complicated aspects of modeling multimodal trips given that such travel relies on intricate configurations of street networks, public transit system schedules and shared mobility infrastructures that require time-sensitive check ins and check outs and, in some cases, less-restrictive parking requirements (e.g., public bicycle and e-scooter rental).

The mobility benefits of *free-floating* public e-scooter systems can be especially difficult to estimate given that the vehicles have a relatively small footprint and can be made available in more places, and therefore, are less geographically constrained. Furthermore, unlike many cities' docked bikeshare systems, e-scooters are free-standing and do not need to be returned to a designated docking station, producing a spatially variable patterning of micromobility infrastructure over time.

In this study we explore how e-scooter sharing altered the mobility landscape for Chicagoans during last year's pilot program. The analysis builds on the Chaddick Institute's "Day in the Life" study by estimating the potential time savings achieved by e-scooter users for multimodal trips both within and outside the pilot area and how these savings vary by community and time of day due to changes in e-scooter availability and interactions with bus and rail public transit schedules. Similar to the "Day in the Life Study" we use location-specific e-scooter data that were downloaded at regular intervals via real time data streams made available via operators allowing for relatively fine-scale representations of scooted ther locations over time.

This study sets out to explore the following four questions related to the potential mobility benefits achieved via e-scooters made available during Chicago's pilot program.

1. To what extent did e-scooter rentals have the potential to reduce trip travel times either alone or combined with other travel modes (e.g., public transit)?

2. Did e-scooter availability have the potential to reduce travel times for trips both within the pilot area as well as multimodal trips that extended outside the pilt area boundaries?

3. How does the time savings achieved translate into enhanced accessibility to neighborhood and employment destinations?

4. How are the estimated time savings and accessibility benefits distributed across neighborhoods within the pilot area? Did some communities experience greater savings than others? And how did these time savings and accessibility benefits vary by time of day?

Analytical Framework

A simplified representation of the analytical framework used in this study is shown in Figure 1 below. The multimodal network model relied on a collection of open source data and tools. The base street network—including speed limits and pathway categories—was made available via OpenStreetMap. Longitudinal Employer-Household Dynamics (LEHD) and Origin-Destination Employment Statistics (LODES) data made available via the US Census Bureau were used to represent the number and geographic locations of job opportunities for estimating employment accessibility.

Public transit data including schedule travel times, routes, and bus stops and rail stations were drawn from the latest general transit feed or GTFS data made available by the Chicago Transit Authority (CTA) and Metra. Bikeshare stations for the city's Divvy system were downloaded from the city's data portal. Similar to the "Day in the Life Study" the study used location-specific e-scooter data downloaded at regular intervals on Wednesday, July 24, 2019 via real time data streams made available via operator-specific APIs. The data, including a including a unique e-scooter vehicle identifier as well as the time and location (latitude and longitude) of each deployed scooter were collected at two-minute intervals between 7am and 7pm on that day, translating into 3,600 queries yielding 571,124 observations. These data allowed for a relatively fine-scale representation and analysis of scooter use and movement over time.

Once the input data were processed and organized, a series of Python scripts were developed to automate the calculation of trip travel times and accessibility (by trip origin), making use of mode-specific batch trip calculation algorithms available in OpenTripPlanner, an open source application. Estimating trips made by public transit and free-floating e-scooter rental required additional model runs in order to account for spatiotemporal variations in scheduled routes and/or vehicle availability.

FIGURE 1. Multimodal Transportation Accessibility Analytical Framework

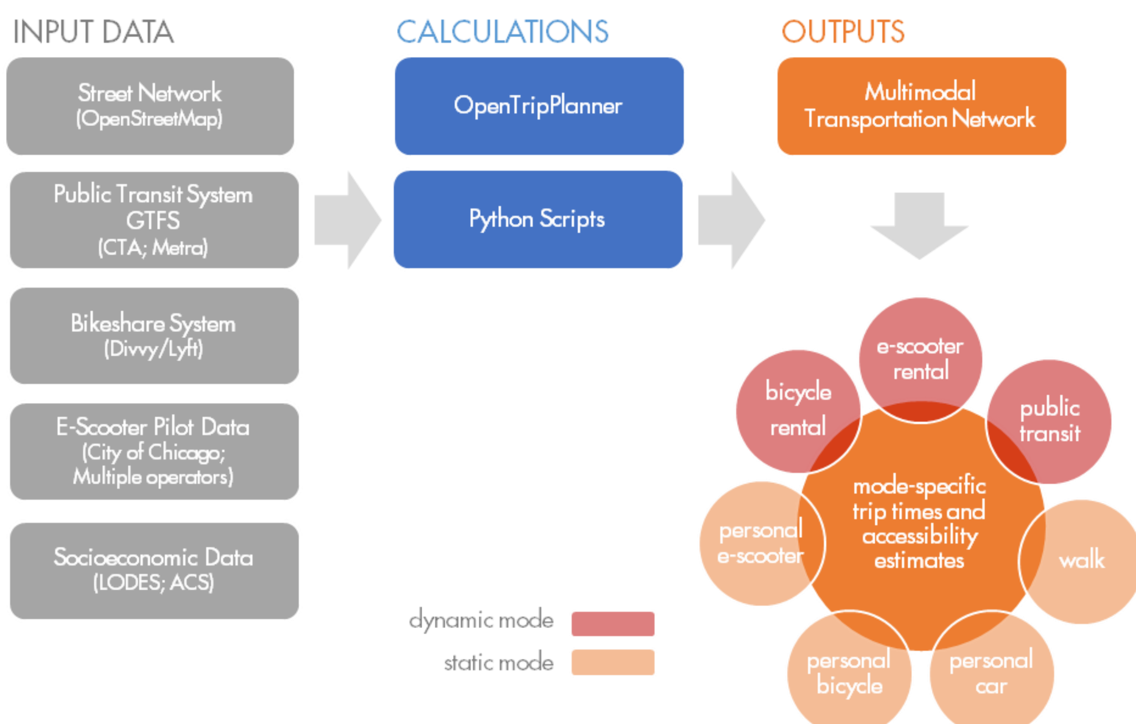
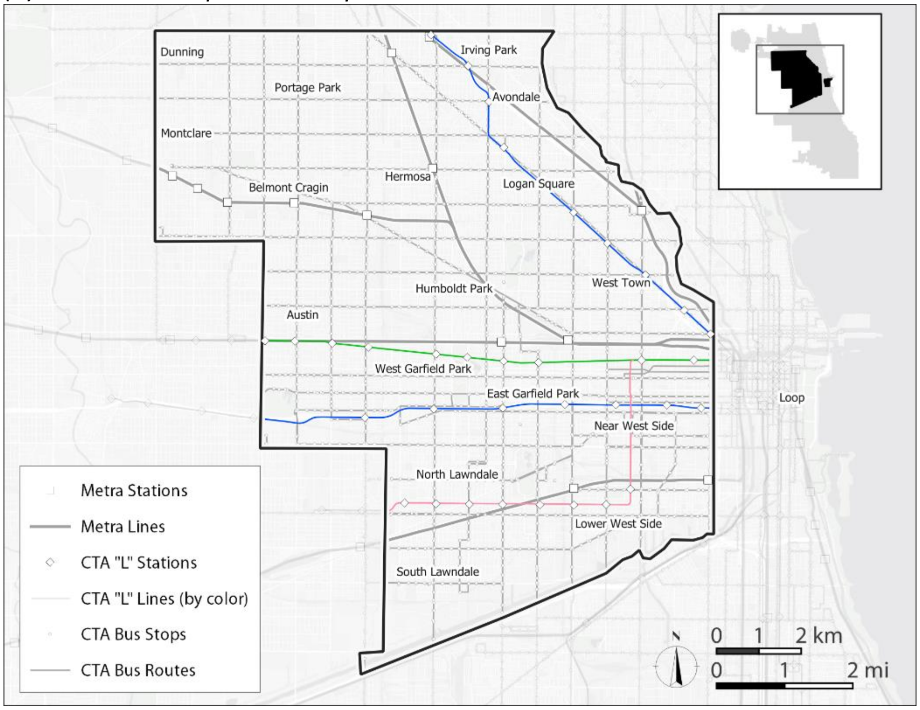
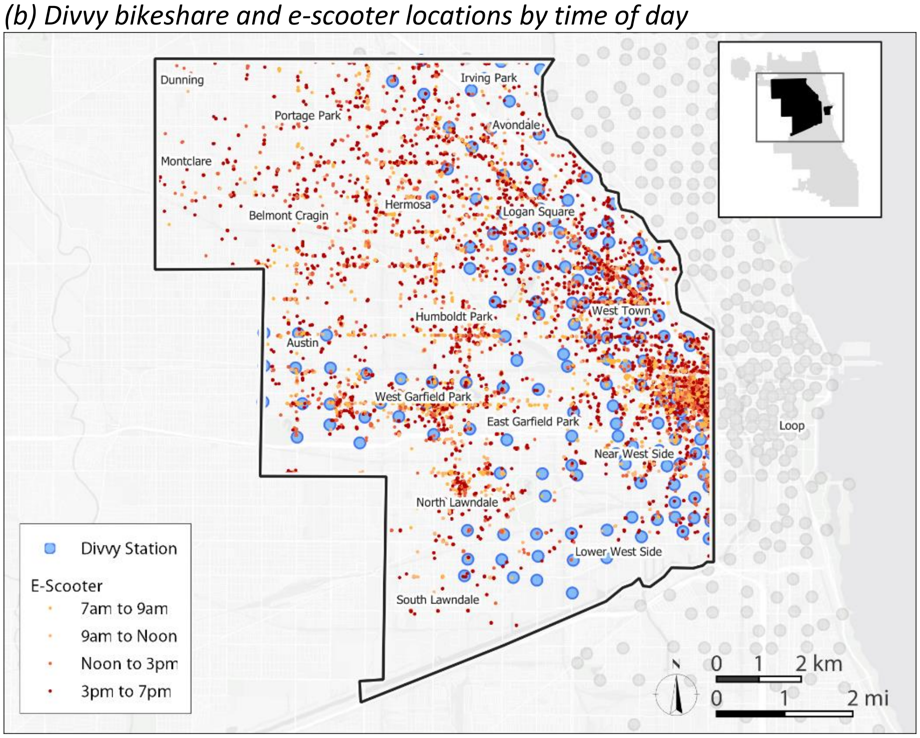


FIGURE 2. Shared Mobility Infrastructure in the E-Scooter Pilot Area

(a) Conventional public transportation



(b) Divvy bikeshare and e-scooter locations by time of day



The above maps show the distribution of (a) conventional public transit including (CTA bus stops/routes, "L" lines/stations and Metra commuter rail lines/stations); and (b) shared use micromobility in the pilot area over the study period including e-scooter locations by time of day.

To improve model accuracy, rather conservative assumptions were made about how each transportation mode functions in terms of velocity, waiting times, and utilization of certain pathways. For example, we assumed that car trips are constrained to posted speed limits and other directional requirements. Public transit trips are sensitive to scheduled pickup and drop-off times. Walking trips were limited to either neighborhood streets or streets with sidewalks. Bicycle rental trips are constrained to the distribution of bike-share stations or e-scooter rental availability. Both bicycle and e-scooter trips were limited to arterial roads and neighborhood streets and banned from limited access highways.

The average speeds for walking, e-scooter and bicycle were set at 3.1mph, 7.5mph and 9.6mph, respectively. Further, all multimodal trips involving walking (e.g., walk+public transit, walk+e-scooter rental) were constrained to a maximum 15-minute walk time which corresponds with approximately a ¾ mile distance when traveling at 3.1mph. In addition, a 30-second transaction penalty was assigned to modeled trips taken by either bicycle- or e-scooter rental. Table 1 summarizes the key characteristics of each mode and their respective network constraints.

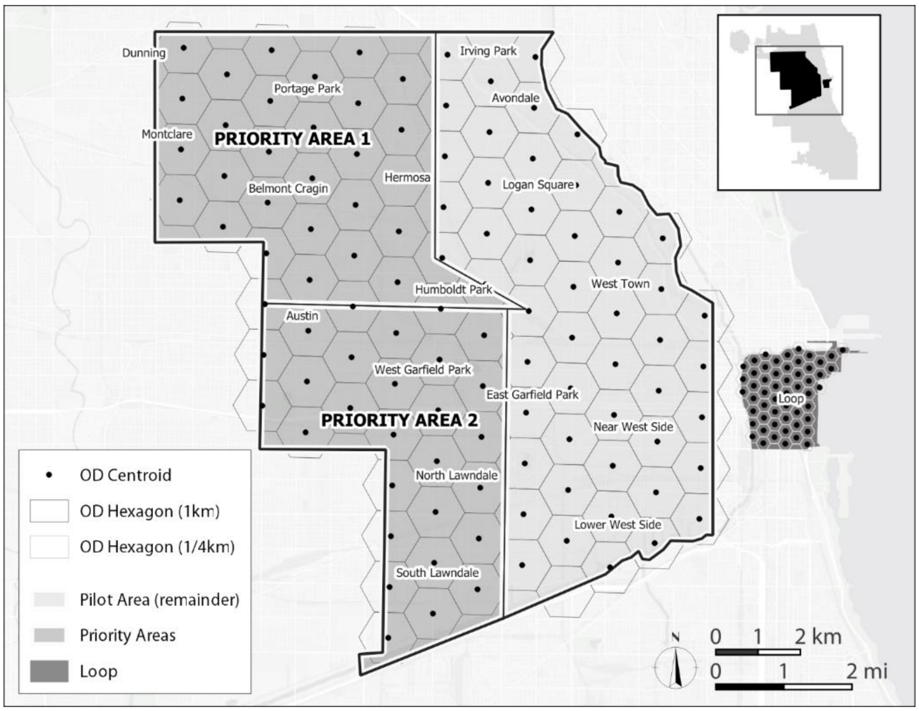
TABLE 1. Transportation Network Model Parameters and Configurations by Travel Mode

Travel Mode(s)	**Average Speed**	**Network/Model Configurations**
(1) walk	3.1mph	banned from discouraged pathways
(2) personal car	posted speed limit	banned from discouraged pathways
(3) personal bicycle	9.6mph	banned from discouraged pathways
(4) personal e-scooter	7.5mph	banned from discouraged pathways
(5) walk+bicycle rental	9.6mph + (1)	banned from discouraged pathways
		30s bike rental pickup penalty
		location-constrained stations
		(1) + max walk time=15 min
		30s e-scooter rental pickup penalty
(6) *walk+e-scooter rental*		banned from discouraged pathways
		30s e-scooter rental pickup penalty
		time/location-constrained e-scooter
		(1) + max walk time=15 min
		30s e-scooter rental pickup penalty
(7) walk+public transit	scheduled routes + (1)	bus stop, rail station, routes
		(1) + max walk time=15 min
(8) walk+public transit+bicycle rental	(7) + (5)	(7) + (5)
(9) walk+public transit+e-scooter rental	(7) + (6)	(7) + (6)

To account for geographic variations in modal performance, we estimated characteristics of trips originating at locations spaced at either 1 km (N=107 within the pilot area) or ¼ km (N=55 within the Loop) intervals on a hexagonal grid. Travel times were estimated for trips both originating and ending in the pilot zone (i.e., pilot area or neighborhood trips) as well as those originating in the pilot zone and terminating in the Loop, the city's central business district. Figure 3 shows the regular hexagonal grid used to derive origins and destinations for modeled trips.

Trips were also estimated across 25 specific departure times in order to account for variability in public transit schedules and e-scooter availability (i.e., dynamic modes). Specifically, a total of 283,550 (107 origin locations x 106 destinations x 25 time periods) mode-specific trips were estimated for travel originating and ending within the pilot zone and 147,125 (107 origin locations x 55 destinations x 25 time periods) trips for travel ending in the Loop. Modeled trip counts vary by vehicle mode combination because personal modes (i.e., walking, private bicycle, private e-scooter and car) were assumed to be time- and system-independent and therefore required only a single estimation of travel time between each origin and destination pair. Possible time-sensitive factors such as traffic congestion were held constant over the study period. In total travel times and other characteristics were estimated for 1,808,835 unique trips as part of this study.

FIGURE 3. Origins and Destinations Used for Estimating Trip Travel Times



Multimodal travel times

Table 2 shows counts and select descriptive statistics for simulated mode-specific trips. The trips range in distance from 0.62 miles to 12.25 miles and are summarized for both Loop- and Pilot-Area destinations with mode combinations ordered with respect to average travel times from slowest (walk only) to fastest (personal car).

The summary statistics show that, on average, personal car (with no considerations made regarding parking or traffic congestion) and personal bicycle travel were the fastest modes. The data also suggest that public e-scooter and bicycle rentals, when combined with transit, tended to outperform trips that rely solely on public transit, bicycle- or e-scooter rentals.

TABLE 2. Descriptive Trip Travel Time Statistics (in minutes) by Transportation Mode (ordered by destination and mean travel time)

Travel Mode by Destination	Modeled Trips	Mean	Median	Std Dev
Loop area destinations (N=55)				
walk	5,885	126.6	126.4	47.4
walk+bicycle rental (divvy)	5,885	59.5	54.9	26.6
walk+e-scooter rental	147,125	57.6	52.4	24.2
personal e-scooter	5,885	50.9	50.7	18.8
walk+transit	147,125	46.6	46.1	13.2
walk+transit+e-scooter rental	147,125	46.4	45.8	13.2
walk+transit+bicycle rental	147,125	46.0	45.4	13.2
personal bike	5,885	42.1	42.0	15.6
personal car	5,885	21.8	20.5	7.6
Pilot area destinations (N=108)				
walk	11,342	95.2	92.2	45.6
walk+bicycle rental (divvy)	11,342	57.2	52.8	26.5
walk+transit	283,550	40.3	39.1	16.3
walk+e-scooter rental	283,550	40.0	38.6	16.7
walk+transit+e-scooter rental	283,550	39.4	38.3	16.0
walk+transit+bicycle rental	283,550	38.7	37.5	15.6
personal e-scooter	11,342	38.1	36.8	18.1
personal bike	11,342	31.5	30.4	15.0
personal car	11,342	20.6	20.1	8.6

Figure 4 compares travel times via modeled trips taken by (a) walking and public transit and (b) walking, e-scooter rental and public transit. It reports both the percentage of total trips enhanced via e-scooters and the average time savings in minutes for these trips. The figure makes evident that trip times can vary dramatically by departure time because of variability in public transit schedules and e-scooter availability. Time savings are also summarized for trips originating in the pilot area and terminating in the Loop (blue) and trips that both originate and end within the pilot area (orange).

FIGURE 4. Trips with Time Savings as a Percentage of Total Trips and Average Time Savings (minutes per trip) by Destination (Loop or Pilot Area) and Departure Time

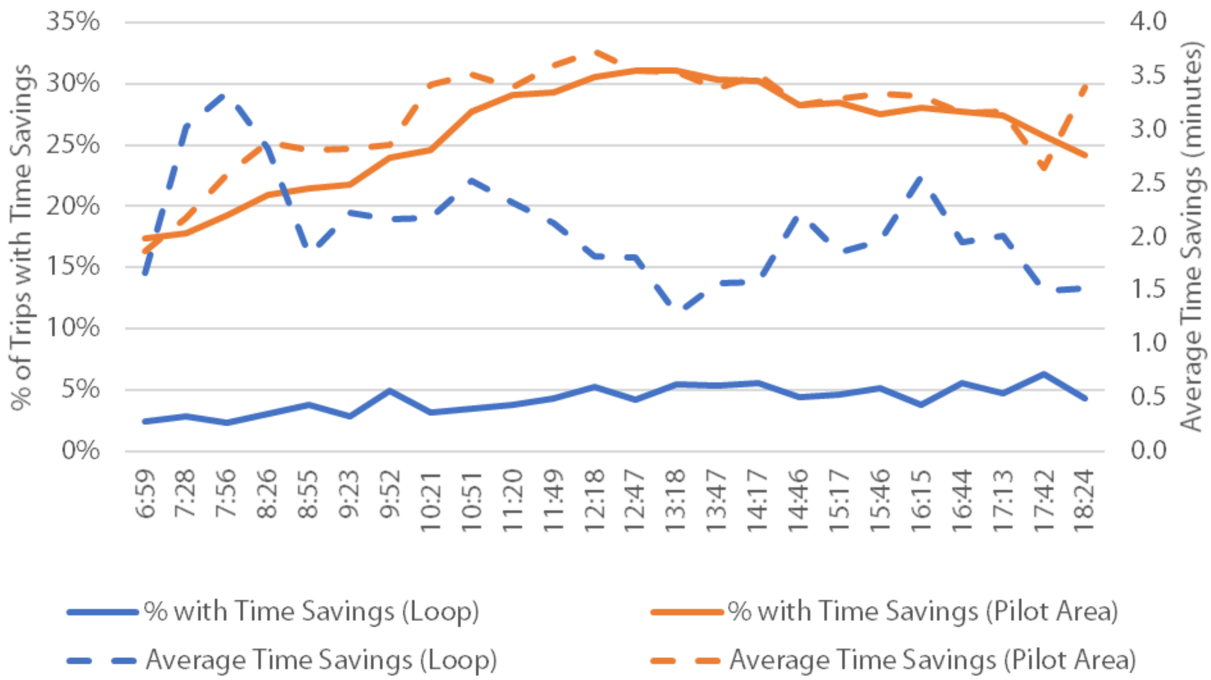
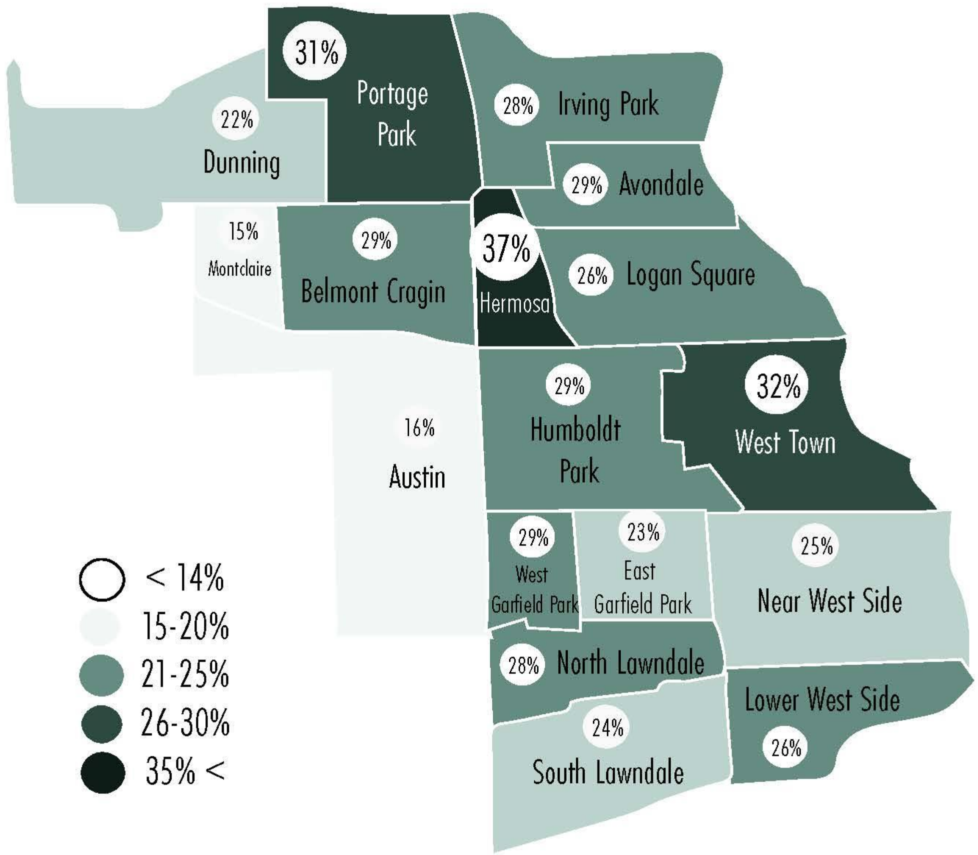


Table 3 compares travel times, job access and total destinations reached via modeled trips taken by (a) walking and public transit and (b) walking, e-scooter rental and public transit. We find that, on average, 25.7% of public transit and/or walking trips within the pilot area were faster when e-scooter rentals were included as a travel option, although this percentage varied by time of day and location. Community areas with limited public transit options such as Hermosa, Portage Park and Belmont Cragin all reported higher rates of potential travel time savings due to the e-scooter availability during the pilot program.

Faster trips can also translate into increased job access and the number of destinations reached within a specified period of time. For work commute trips 30 minutes or less within the pilot area, e-scooters enhanced job across all community areas. E-scooters were estimated to have the greatest impact in South Lawndale where job access improved by 25.3% and overall neighborhood access by 21.6%.

FIGURE 5. Percent of Trips Faster due to Availability of E-scooters Compared to Walking and/or Using Transit Trips between Points within Pilot Area



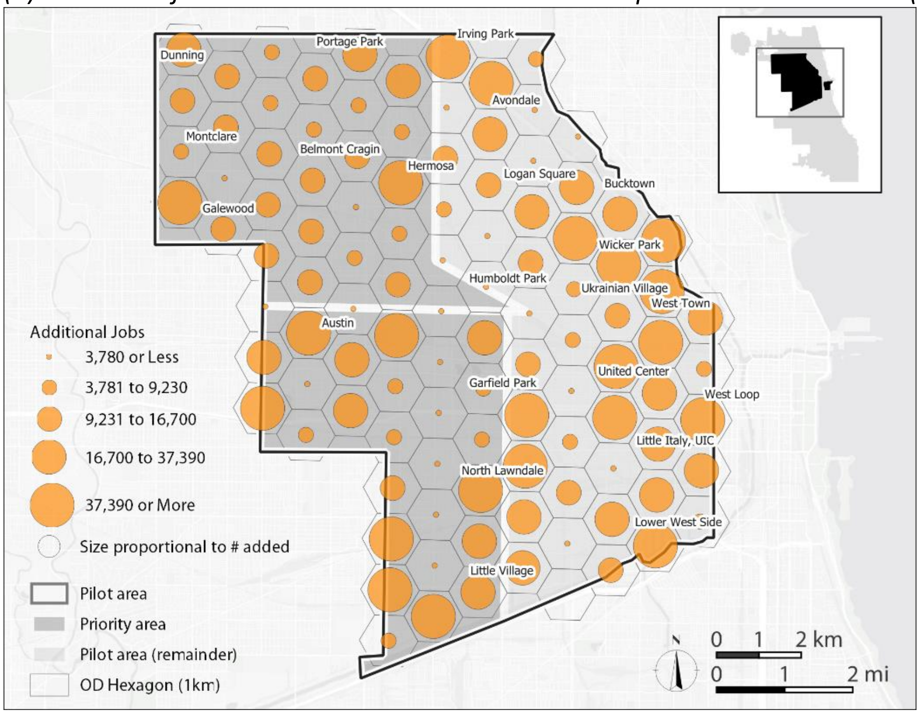
This map shows the share of trips within the pilot zone in which trips are faster due to e-scooters based on conservative assumption about average speed and assuming it takes 30 seconds to activate e-scooter. Some e-scooter trips involve connections with buses and trains while others are e-scooters only (plus walk time to reach the e-scooter). These findings are based on the observed distribution of e-scooters in the pilot zone in five-minute intervals on a randomly selected day during summer 2019.

TABLE 3. Comparisons of Trip Travel Times and Job/Destination Accessiblity between Walk + Transit and Scooter-Enhanced Trips

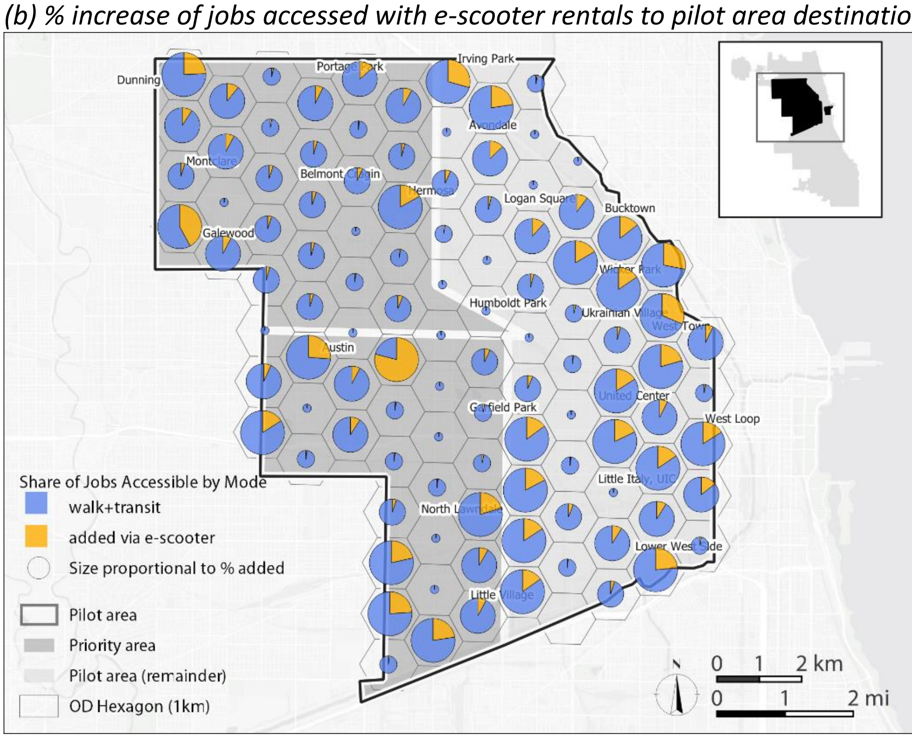
Community Area	% of Trips Faster with E-Scooters	Average Time Savings (minutes)	% Increase in Jobs (<=30-minutes)	% Increase in Destinations (<=30-minutes)
Hermosa	36.8%	3.8	19.3%	18.8%
West Town	32.0%	2.9	22.1%	12.4%
Portage Park	30.8%	1.9	7.9%	4.3%
West Garfield Park	29.3%	3.1	6.4%	9.6%
Avondale	29.0%	2.4	11.2%	7.4%
Belmont Cragin	28.9%	2.8	6.4%	7.7%
Humboldt Park	28.8%	4.8	6.7%	8.1%
North Lawndale	28.0%	2.3	14.1%	14.9%
Irving Park	27.6%	3.2	8.7%	6.0%
Lower West Side	25.8%	1.3	6.8%	7.4%
Logan Square	25.7%	2.7	7.4%	5.8%
Near West Side	25.1%	2.8	13.2%	9.1%
South Lawndale	24.1%	2.8	25.3%	21.6%
East Garfield Park	23.1%	2.3	6.8%	13.3%
Dunning	22.3%	1.7	15.4%	17.6%
Austin	15.6%	2.2	8.7%	9.8%
Montclaire	14.8%	3.2	6.2%	18.2%

FIGURE 6a-b. Average Additional Jobs Accessed when E-Scooter Rentals Added to Public Transit (by trip origin to pilot area destinations for trips <= 60 minutes)

(a) Additional jobs accessed with e-scooter rentals to pilot area destinations (60 minute commute)



(b) % increase of jobs accessed with e-scooter rentals to pilot area destinations (60 minute commute)



The two figures show estimates of the number (averaged over the 25 study periods) of additional destinations (i.e., hexagonal centroids) and jobs (i.e., jobs-weighted hexagonal centroids) accessed by trip origin when e-scooters are added to walk + public transit as a travel options. Based on commute times of 60 minutes or less.

Key Findings

Using a dynamic analytical approach to estimate variations in multimodal trips over time, this study found that:

- **In most neighborhoods within the e-scooter pilot area**, between 24% and 29% of modeled trips were quicker due to the availability e-scooters compared to trips involving walking and public transit alone.

- **Mobility benefits varied widely across neighborhoods**, with trips originating in Hermosa, West Town, Portage Park, and West Garfield Park achieving time savings for the greatest share (29% to 37%) of trips. E-scooter rental availability reduced trip times at a lower rate in the neighborhoods of Dunning, Austin and Montclaire, ranging from 14% to 22% of modeled trips.

- **Estimated average time savings per trip** were highest in the neighborhoods of Humboldt Park (4.8 minutes), Hermosa (3.8 minutes) and Irving Park (3.2 minutes).

- For modeled trips originating and ending within the pilot area, **e-scooters make approximately 12.3% more jobs reachable** within a 30-minute commute time and over 20% within a one-hour commute when compared to trips made by public transit and walking alone.

While the above findings suggest that e-scooters and perhaps other forms of e-micromobility have the potential to provide a welcome niche within multimodal urban transportation systems, our study results should be interpreted cautiously. First, the input data, especially the e-scooter locational information, relied on a single day of observations and therefore have the potential to vary from day to day. Second, the study did not consider the overall supply/capacity constraints of e-scooter rentals. Therefore, in cases where e-scooters are in short supply, the time savings could only be achieved by a limited number of riders. Lastly, and perhaps most importantly, *geographic access* or the relative proximity to e-scooters does not equate to *functional access* or the willingness and/or capacity to use the vehicles.

Previous research has shown that that the geographic availability of bikeshare, public transit and other modes does not always translate directly into usage. Rather, several individual-, socioeconomic-, cultural- and other barriers may exist that limit the use of e-scooters across neighborhoods and riders including, but not limited to barriers concerning: (1) the monetary cost of using e-scooters; (2) lack of access to a credit card or cell phone which are oftentimes required for convenient e-scooter rental; and (3) lack of system awareness or knowledge about how to check in/out and/or operate an e-scooter. One of the key challenges for cities and private operators is to find ways to extend the benefits of both conventional and emerging modes of travel to communities who experience disadvantage.

Author Information

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