POLICY BRIEF

Micromobility Services

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Project Description

This project reviews and summarizes empirical evidence for a selection of transportation and land use policies, infrastructure investments, demand management programs, and pricing policies for reducing vehicle miles traveled (VMT) and greenhouse gas (GHG) emissions. The project explicitly considers social equity (fairness that accounts for differences in opportunity) and justice (equity of social systems) for the strategies and their outcomes. Each brief identifies the best available evidence in the peer-reviewed academic literature and has detailed discussions of study selection and methodological issues.

VMT and GHG emissions reduction is shown by effect size, defined as the amount of change in VMT (or other measures of travel behavior) per unit of the strategy, e.g., a unit increase in density. Effect sizes can be used to predict the outcome of a proposed policy or strategy. They can be in absolute terms (e.g., VMT reduced), but are more commonly in relative terms (e.g., percent VMT reduced). Relative effect sizes are often reported as the percent change in the outcome divided by the percent change in the strategy, also called an elasticity.

Summary

Strategy Description

Micromobility services include the one-way rental of bicycles, e-bicycles, and e-scooters. Docked forms of the service include permanent fixed parking, locking, and sometimes charging locations, while dockless (free floating) services have no such fixed infrastructure but have varying rules about parking.

Behavioral Effect Size

VMT reduction from an average micromobility trip is estimated to be about half a mile (with a range of 0.08 and 0.85 miles), varying widely by city, vehicle type, and service type, but also likely by study design.

Strategy Extent

Micromobility services operate primarily in dense and mixed use areas where destination accessibility is within a few miles. Rural and suburban areas have not found success from micromobility services. Access to micromobility is generally inequitable with fewer vehicles available in low-income communities of color even though many cities have rules and goals to increase equity through micromobility services. Micromobility services continue to grow in terms of trips made in the US at a rapid rate, although that rate is slowing (27% increase from 2022 to 2023 (NABSA, 2023), 16% increase from 2023 to 2024 (NACTO, 2024)). This growth in trip making is occurring despite the declining number of cities served by micromobility services (USDOT, 2024).

Strategy Synergy

Because micromobility services are usually used for short trips, land use strategies that densify and mix uses in urban areas would expand the effective area for micromobility services to

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operate. Most research on micromobility services has focused on urban areas with little available evidence in rural and suburban contexts. Additionally, integrating micromobility services with existing public transportation systems has the potential to increase the VMT reduction of such services.

Equity Effects

Most micromobility services have at least one equity goal or operational requirement. Evidence is mixed about which service type provides greater access to underserved neighborhoods. Geofencing technology, which is used for safety and parking enforcement, also has the potential to exacerbate existing inequities in micromobility access if used to halt the use of vehicles in low-income communities of color. Beyond access to the services, more research is needed to understand the degree to which any micromobility service has resulted in meaningful change in structural transportation inequities. Not specific to micromobility services, but a related concern, is the lack of investment in safe and comfortable infrastructure for walking, bicycling and scooting, especially in low-income and communities of color.

Strategy Description

In this brief we consider the effects of rental services of bikes, electric bikes (e-bikes), and electric scooters (e-scooters) in both docked and dockless forms on car use and equity. Micromobility services in the US are predominantly one-way services where users rent a vehicle for a specific trip through a smartphone application or kiosk. Services that allow longer rental periods (one day or more) are not considered in this brief because of both their lack of prevalence and lack of research on them. We also exclude any specific VMT reduction from first and last mile transit connections from micromobility services which are reported in transit focused briefs. Finally, personally-owned micromobility vehicles which are likely to have different effects on vehicle miles traveled (VMT) and equity are also not included in this brief.

Micromobility services have the potential to reduce VMT by substituting for car trips (i.e., people use the service instead of driving or ridehailing). They also have the potential to change travel patterns more generally and may have further-reaching VMT effects such as users leaving a car at home at the beginning of the day and increasing access to public transport.

However, micromobility services also lead to some increases in VMT and greenhouse gases (GHGs) when micromobility services are substituted for more sustainable modes of travel such as walking and some public transit due to micromobility service operations. Most micromobility service operations VMT is by vans for maintaining, recharging, and rebalancing micromobility vehicles (redistributing to meet demand).

Many micromobility services have equity goals such as minimum numbers of vehicles in defined equity zones of the operational boundary and reduced fare programs.

Strategy Effects

Behavioral Effect Size

For users of micromobility services, evidence suggests that an average micromobility service trip reduces VMT by between 0.08 and 0.85 depending on the city, vehicle type, and service type (Table 1). In most cases, these estimates ignore operational VMT and therefore are likely upward biased, but in the two extreme estimates (0.08 by Fishman et al. (2014), and 0.85 by Fukushige et al. (2023)) operational VMT was considered. These results suggest that VMT reduction effects are more dependent on the context of the city and study, and less dependent on estimates of operational VMT.

Like the consensus that micromobility services reduce VMT, there is also consensus that this reduction in VMT corresponds to total GHG reduction (Table 2, end of document). In only a select number of cities has there been evidence for increases in GHGs from micromobility services (Krause et al., 2022; Sun et al., 2022). Only Sun et al., (2022) found evidence for increased GHGs from dockless (free-floating) micromobility services, mostly based on data points from Chinese cities, with some from North American cities (e.g., Seattle, Washington and Washington, DC).

Most of the VMT and GHG reduction estimates hinge on a key measure of mode substitution. Mode substitution is either assumed based on existing data of mode shares (e.g., Kou et al., 2020), but more commonly and with greater validity measured through surveys of users (Table 3). Studies across the US have shown that micromobility mode substitution has wide variation at the city level and at the same time a consistent sizable share of car substitution (13-60%) (Table 3).

Strategy Extent

Scale of Application:

In 2023, at least 421 North American cities had micromobility services, totaling more than 172 million trips (130 in the US alone) from more than 280 thousand vehicles (North American Bikeshare Association [NABSA], 2024).

Efficiency or Cost:

Micromobility services in the private industry have been consolidating since the early 2020s in attempts to be profitable. In most cases, user revenues make up only a fraction of the costs to operate. Because most services have a revenue shortfall, the National Association of City Transportation Officials (NACTO) recommends that public agencies invest public money into micromobility service, consider owning the systems, eliminate sales taxes for use, and build the needed infrastructure to support safe and comfortable trip making by bike and scooter (NACTO, 2024).

Time / Speed of Change:

Compared to infrastructure projects, many micromobility services are quick to achieve benefits. Dockless services are particularly fast since the installation of docks is not needed. Growth in the industry is also telling of latent demand, with NABSA reporting a 27% increase in ridership between 2022 and 2023 (North American Bikeshare Association, 2024).

Location within the Region:

Micromobility services typically only serve dense urban areas. However, the VMT reduction potential may be greater in slightly less dense areas where travel distances are slightly longer making car substitution more common (Fukushige et al., 2023).

Differences between Regions:

Many studies report differences in VMT reduction, GHG reduction, and mode substitution between cities (Tables 1, 2, and 3).

Equity Effects

Although the studies reported in this brief do not cover the equity effects of micromobility services, there is a growing literature on the subject that is mixed. Some studies show that micromobility service access is inequitable (Jin and Sui, 2024; Aman et al., 2021). This may be one reason why more than half of micromobility services in the US have equity requirements and goals (Brown and Howell, 2024), and several best practices documents exist for making micromobility services a catalyst for social change (see Brown, 2024 and Transportation for America, n.d.). But whether these requirements and goals lead to improved equity has been difficult to measure. Also, when micromobility services are operated by for-profit companies, attracting demand is the primary goal. At least one study suggests there can be synergy between increasing bike-share demand and providing equity, but the relationship is complex (Mohiuddin et al., 2023).

Besides equitable access, many services focus on reduced rates and cash payment compatibility to improve equity (Brown and Howell, 2024). Some programs even provide free access to income qualifying users (e.g., City of Denver, CO). Many docked bike-share systems have more intentional community engagement about planning, and have subscriptions that reduce fares for residents, although docks have been shown to be inequitably placed in many cities (Meng and Brown, 2021). In addition, dockless programs have shown better access by some metrics (Qian et al., 2020), although other results suggest a hybrid service might be best (Jin and Sui, 2024).

Lack of investment in bike and pedestrian infrastructure (e.g., bike lanes, sidewalks, safe crossings) that supports the safe and comfortable use of micromobility services in low-income communities of color and disproportionate policing in black and Latino neighborhoods (Barajas, 2021) also inherently limit the ability of micromobility services to help achieve equity goals.

The complexity of measuring equity with respect to micromobility services and the lack of investment in infrastructure in low-income communities of color highlight the need for more integrated investments and more research on the experiences of people with limited access to transportation. Such investment and research are key to making micromobility more equitable and a lever for social justice.

Strategy Synergy

Because micromobility services are usually used for short trips, land use strategies that densify and mix land use would expand the area for micromobility services to operate. Additionally, integrating micromobility services with existing public transportation systems has the potential to greatly increase the VMT reduction of such services. While all the evidence in this brief assumes a trip-level mode substitution, if micromobility services act as a first-last mile leg of a transit trip that substitutes for driving, the VMT reduction from synergistic micromobility and transit use is much greater. This synergy is not included in the estimated micromobility effects in this brief, but it suggests that planning micromobility services in concert with bus and train stops could have much larger VMT reduction effects. However, if infrastructure and service for public transit are inadequate, it must be improved along with and integrated with micromobility services to achieve VMT and equity benefits.

Confidence

Evidence Quality

The evidence in this brief comes primarily from travel surveys that are cross-sectional. The studies that survey people about their mode substitution (see Table 3) offer a more direct connection to VMT reduction at the person level, even if the survey question is a retrospective counter-factual assessment (see Wang et al. 2022 for discussion of the methods for capturing mode substitution).

The evidence that is based on assumptions of mode substitution from a general travel survey mode share has a greater potential to report biased VMT reduction effects (e.g., Kou et al., 2020).

Only one study included in this brief took a longitudinal approach to measuring VMT effects from micromobility (Choi, et al., 2023). The benefit of the longitudinal approach is the inclusion of time order to improve the likelihood of measuring a causal link between micromobility use and VMT reduction. However, that same study was done in the aggregate (city-level), which means while it benefits from time order, it is limited in what can be inferred about individuals who are using micromobility since other factors might be contributing to the reductions in per capita VMT observed in those cities. Nonetheless, both types of studies reviewed show VMT reductions.

Caveats

Some of the studies measuring the effects of micromobility occurred at a time where the industry was undergoing rapid change in terms of operations, technology, and regulation. This may have an impact on the generalizability of the effects of micromobility on VMT and equity in the future, although it is not certain how. Additionally, several barriers to micromobility have been noted such as safety concerns, blocked sidewalks and curb ramps from parked micromobility vehicles, city-imposed taxes, public resistance, etc.

Technical & Background Information

Study Selection

The number of studies measuring the influence of micromobility on VMT and GHG reduction including studies of modal substitution (the key measure of both VMT and GHG effects) were numerous. We selected the studies, and parts of studies (city selections), that were most likely applicable to California and that had the strongest internal and external validity. Generally, we found that the studies that directly measured or modeled VMT reduction were few but consistent (see Table 1). Three of the four studies estimated VMT reduction by multiplying average trip length by mode substitution, while one study modeled VMT reduction through multivariable statistical models that accounted for other factors likely to influence VMT reduction and variation in the VMT reduction based on trip distance.

The studies that estimated GHG reduction had greater variation than the VMT reduction studies. This may be due to the fact that many made assumptions about VMT reduction instead of estimating it directly (see Table 2). The studies that assumed mode substitutions lack the same accuracy as the studies that measure it through surveys, although with all the GHG reduction studies, the number of assumptions and their potential errors are not in the scope of this brief and so it is possible that other analysis decisions outweigh the decision of how to handle mode substitution making them less reliable overall. Finally, the studies that only provided modal substitution (see Table 3) provide secondary support for estimating the impact of micromobility services on VMT reduction. Modal substitution is one of the most important factors in determining VMT reduction from micromobility.

Methodological Considerations

Calculating VMT reduction

The product of average trip length and car mode substitution is a common method used to estimate VMT reduction. While it may give a decent general estimate, it has several flaws. First, mode substitution varies, in some cases quite dramatically, by trip distance (Fukushige et al., 2023). This means that the simple approach underestimates VMT reduction because car substitution is more common for longer trips. Also, taxi and ridehailing have additional VMT beyond the micromobility trip level. Only one study in one city estimated that additional VMT (Fukushige et al., 2023).

Several other factors could also influence VMT reduction. For example, if micromobility connects to public transit, VMT reduction could be much greater. For people who consider micromobility services as a common and reliable mode of transportation, leaving a car at home at the start of the day could lead to even more VMT reduction than simply the reduction from the specific micromobility trips if it leads to public transit use or walking, or other modes of travel that would have been made by car if a car was used from home. More research is needed to understand how large these “secondary” effects of micromobility services are on VMT reduction.

Location

The wide range of effect sizes in Tables 1-3 suggest that location, particularly the transportation and land use contexts that make up each city, has a strong moderating effect on the relationship between micromobility services and car use reduction. One key variable may be the availability of public transit in the study location. Cities that have comprehensive public transit may see more transit substitution instead of car substitution and could have less VMT reduction (a common result in European cities not included in this brief). Alternatively, cities with good public transit may allow the connection between micromobility services and transit such that when substituting for car use, the total distance is larger thus leading to greater VMT reduction. In reality, both are likely, and yet the magnitude of both potential moderating effects are largely unknown and in need of future study.

Beyond transit availability, several other variables such as land use mix, compactness, or general accessibility are likely necessary to make micromobility successful. In the GHG reduction studies, one key parameter for GHG reduction was the utilization rate of micromobility vehicles (the frequency of trips for each vehicle) (e.g., Sun et al., 2022). Finding ways to increase the utilization rate and increase the car substitution within the city context are likely to be key to reducing VMT.

Vehicle Types

In this brief we cover conventional bike share, electric bike-share, and electric scooter share. Evidence from Tables 1-3 suggests that the vehicle type matters. In general, e-bikes are used for longer trips compared to e-scooters and conventional bikes. In general, car substitution is more common for longer trips, so that makes e-bikes likely to reduce VMT more. However, e-bikes have a larger life-cycle GHG impact due to their increased carbon intensity of production and maintenance compared to e-scooters, making the overall GHG impact uncertain. The reported GHG reduction rates per distance or trip are unclear as to which mode is more sustainable in current services.

Service Type

While there is uncertainty about the overall impact of vehicle type, docked bike shares seem to have more potential GHG reduction compared to dockless services. This is likely due to longer trip lengths being made by bike-share users, and more regular use per vehicle in the system. Service type may have an important impact on equity as well. There is some evidence that dockless systems increase access to micromobility, although evidence is mixed on the equity outcomes of different service types. Dockless systems are also primarily run by for-profit companies and result in larger per trip costs to the user. Given cost is a primary equity concern, and cost covaries with service type, more research is needed to disentangle the factors that contribute to demand and equity of micromobility services.

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Table 1: Micromobility VMT Reduction

Study	Study Location	Study Year	Sample Size	Micromobility Type	VMT Variable	Effect Size
Fishman, et al., 2014	Washington, DC	2012	5,287 persons	Docked bike share programs (only regular bikes)	VMT reduced per micromobility trip	0.14 (except trips <2 minutes or >3 hours). 0.08 after subtracting operational VMT.
	Twin Cities region, Minnesota		685 persons			0.41 (except trips <2 minutes or >3 hours). 0.21 after subtracting operational VMT.
Meroux, et al., 2022	San Francisco, CA	2020	1,996 trips	E-scooter	VMT reduced per micromobility trip	0.58
	Portland, Oregon	2020	2,636 trips	E-scooter		0.66
	Tampa, Florida	2020	2,027 trips	E-scooter		0.68
	Washington, DC	2020	5,312 trips	E-scooter		0.54
Choi, et al., 2023	USA	2012-2019	353 cities	All types of bike share	Daily VMT reduced per capita	-1.465 (0.597)
				E-scooter		-0.855 (0.566)
				E-scooter and bike share		-1.49 (0.636)
Fukushige, et al., 2023	Sacramento, West Sacramento, and Davis, CA	2018	142,936 trips	Dock-less e-bike share	VMT reduced per micromobility trip	0.85 on weekdays. 0.79 after subtracting operational VMT. 0.76 on weekend days

Table 2: GHG Reduction

Study	Study Location	Study Year	Sample Size	Micromobility Type	GHG Variable	Effect Size
Chen, et al., 2021	New York City, NY	2014-2017	48.2 million trips	Docked conventional bike share program	GHGs reduced (grams CO2/trip)[1]	623
Kou, et al., 2020[2]	Los Angeles, CA	2016	184,345 trips	Docked bike share systems	GHGs reduced without round trips (grams CO2-eq/trip)	282.5
	San Francisco Bay Area, CA		193,506 trips			357.1
Hollingsworth, et al., 2019	Raleigh, NC	2019	Battery state-of-charge: 800 scooters User survey: 61 people	E-scooters	GHGs reduced (grams CO2-eq/passenger mile)	202
Sun, et al., 2022[3]	Seattle, Washington, DC	2011–2020	Unknown	Station-based bike sharing (SBBS)	GHGs reduced (grams CO2-eq/passenger km)	Seattle ~ -75 Wash, , ~-100
				Free-floating bike sharing (FFBS)		Seattle ~ -150 Wash. DC ~ 20
Krauss, et al., 2022	Global	2022	4,167 responses	Shared e-scooters	GHGs reduced (grams CO2-eq/passenger km)	Berlin: 14.8 Dusseldorf: 22.1 Melbourne: 42.4 Paris: 20.7 Seattle: 37.7 Stockholm: 20.7
				Shared e-bikes		Berlin: -13 Dusseldorf: 20.4 Melbourne: 13.7 Paris: 15.4 Seattle: 15.2 Stockholm: N/A

[1] Calculated from (30,070 tons/48.23 million trips)*1e+6 grams/ton = 623 grams/trip.
[2] Selected California cities only.
[3] Selected US cities only. Estimates were approximated by authors based on Figure 4 of the source document.

Table 3: Car Modal Substitution

Study	Study Location	Study Year	Sample Size	Vehicle Type	Effect Type	Effect Size
Fishman, et al., 2014	Washington, DC	2012	5,287 responses	Bike	Modal Substitution of Trips	7% private car substitution, 6% ride-hailing
	Twin Cities, Minnesota		685 responses			19% private car substitution
NABSA, 2019	North America	2019	12 cities	E-scooter	Modal Substitution of Trips	15% replaced auto driver & passenger, 26% replaced ride-hailing
				Bike		11% replaced auto driver & passenger, 18% replaced ride-hailing
NABSA, 2023	North America	2020-2023	22 cities	Both bikes and e-scooters	Modal Substitution of Trips	25% replaced auto driver & passenger, 12% replaced ride-hailing
Wang, et al., 2022[4]	Los Angeles, CA	2016-2021	7,067 responses	E-scooters	Modal Substitution of Trips	11% replaced driving, 22% replaced ride-hailing
	Oakland, CA		864 responses			14% replaced driving, 25% replaced ride-hailing
	San Francisco, CA (Lime 2018)		617 responses			9% replaced driving, 51% replaced ride-hailing
	San Francisco, CA (SFMTA 2019)		2,256 responses			5% replaced driving, 36% replaced ride-hailing
	Santa Monica, CA		4,260 responses			N/A replaced driving, 49% replaced ride-hailing
Meroux, et al., 2022	San Francisco, CA	2020	1,996 trips	E-scooters	Modal Substitution of Trips	30% replaced driving or ride-hailing
	Portland, Oregon		2,636 trips			33% replaced driving or ride-hailing
	Tampa, Florida		2,027 trips			33% replaced driving or ride-hailing
	Washington, DC		5,312 trips			32% replaced driving or ride-hailing

[4] Selected California cities only.