Chapter 6
Shared Micro-mobility: A Panacea or a Patch for Our Urban Transport Problems?

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Abstract Shared micro-mobility, including station-based bike-sharing and dock-less bike-/scooter-sharing, experienced phenomenal growth in the past decade in cities across the globe. It is low traffic impact, eco-friendly, and associated with a healthy lifestyle. Cities see it as a viable solution to solve issues related to congested, polluted, and auto-centric urban transport. In this chapter, I overview the history of shared micro-mobility. I then broadly summarize the existing research on shared micro-mobility systems around the world and explore how shared micro-mobility has transformed urban transport for its users. Using an empirical case from the city of Brisbane, Australia, I demonstrate the usage and limitations associated with shared micro-mobility trip big data. Lastly, I narrate two possible scenarios of the shared micro-mobility future. I conclude the chapter with a call for collaborations between cities, vendors, and researchers to make shared micro-mobility work for our future urban transport.

Keywords Shared mobility · Micro-mobility · e-scooters · Clustering analysis · Data analytics

6.1 Shared Micro-mobility: The New Kid on the Block

Open the app, search for an available vehicle nearby, walk to it, scan the QR code on the app, unlock the vehicle, start a trip, travel, park at the destination, and end a trip. I just walked you through a standard shared micro-mobility trip—no muss, no fuss. Micro-mobility, supported by light-weighted, low-speed (<25 km/h or 15 mph), human-/electric-powered fleets (e.g., bike, scooter, self-balancing board, and segway), has become an emerging and popular mode of mobility for short-distance travel (<5 km) in the urban environment (Oeschger et al. 2020; Orozco-Fontalvo et al. 2022). Shared micro-mobility, as the name suggests, is a shared mobility system for micro-mobility. A contemporary shared mobility system can be characterized by its

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reliance on online platforms (i.e., mobility vendors), mobility as a service (MaaS), and an on-demand marketplace that matches demand with supply in real time. Ride-hailing services provided by transportation network companies (TNCs) like Uber or DiDi, car-sharing services provided by car rental companies, and shared micro-mobility services provided by cities and private vendors are all broadly umbrellaed under the shared mobility concept. The global micro-mobility market surpassed $100 billion in 2021 with a 10 percent non-ownership market share (Lang et al., 2022). In particular, the shared micro-mobility market is projected to grow 10–30% over this decade (Lang et al., 2022). As the new kid on the block of urban transport, shared micro-mobility is reviving a niche mobility option in a heavily auto-oriented urban world.

6.1.1 The Three Generations of Shared Micro-mobility

Shared micro-mobility systems around the world went through a three-stage evolution based on the significant advancements in technology and popularity/influence:

The 1960s—early 2000s (ad hoc, city-operated bike-sharing) While the first verifiable bicycle—*draisine*—was introduced to the world back in the 1810s in Germany (Herlihy, 2004), the first public bike-sharing system—*Witte Fietsenplan* ("white bike plan")—only emerged 150 years later in Amsterdam, The Netherlands, out of an idealistic mission to take the street back from "the gaudiness and filth of the authoritarian car" (van der Zee, 2016). Ahead of its time, the system was merely a grassroots response to the urban transport crisis. However, the idea eventually incubated a global micro-mobility initiative decades later. In the 1970s, public bike-sharing systems were established in several European cities, such as *vélo* in La Rochelle, France, was developed as an institutional solution to address urban sprawl and auto-dependency (Hure & Passalacqua, 2017). In 1995, the Danes launched the world's first large-scale bike-sharing system, *Bycykler København*, with 1,100 bicycles locked and placed all over Copenhagen. Of course, this system predated smartphone apps such that a coin-deposit system was utilized for payment.

In addition, a docking-station model was adopted for fleet rental and return (Shaheen et al., 2010). This became a prototype for the contemporary station-based bike-sharing (SBBS) systems. The drawback of a SBBS system is obvious: fleets are subject to vandalism and theft. Moreover, coin-deposit payment is not user-friendly. In the early 2000s, smart technologies (e.g., mag-stripe cards) for check-out and check-in of a bike, payment, and theft deterrents were integrated into bike-sharing systems (Abduljabbar et al. 2021)—a critical upgrade towards the modern bike-sharing system. Nevertheless, it is reasonable to state that before the 2010s, bike-sharing was a niche in the urban transport market.

The late 2000s—early 2010s (app-based, station-based, city-led bike-sharing programs). As smartphones have become ubiquitous to the average person and an ecosystem of smartphone apps has been built to facilitate every aspect of our daily life since the late 2000s, it was only a matter of time before shared micro-mobility evolved into the 2nd generation. In this stage, many existing public bike-sharing programs were upgraded to be readily run via a smartphone app. The major advantage of an app-based system is the integration of searching, booking, navigation, and payment, all under one platform instead of having isolated platforms each perform a single function.

Consequently, bike-sharing systems quickly diffused into major cities around the world. In Europe, a significant number of SBBS schemes were launched between 2007 and 2012 (Parkes et al., 2013). In North America, the bike-sharing movement finally caught up: BIXI Montréal was the first large-scale public bike-sharing system launched in 2009. In the U.S., public bike-sharing expanded from four programs in 2010 to 55 programs in 2016 with annual trips growing 9-folded from 0.3 million to 2.8 million in the same time frame (NACTO, 2017). In Australia, Brisbane's CityCycle and Melbourne's Bike Share debuted in 2010. Asia by and large missed the opportunity to embrace shared micro-mobility in this stage, despite several countries that have a strong bike culture traditionally, such as China, Japan, and Vietnam.

Another key feature of bike-sharing systems in this generation is the use of a docking station for rental and return. The semi-flexible docking-station model has advantages and drawbacks: It allows for more orderly fleet dispatching and rebalancing, but the geographical coverage of stations is limited due to the non-trivial construction cost, land use impact, and capacity limit of a docking station (Chen et al., 2020). Lastly, the bike-sharing programs in this stage were mostly launched and operated by cities with some partnerships with private vendors (Shaheen et al., 2010). While the city-led model worked well in the early-day diffusion of shared micro-mobility, its limited ability to grow with the market was magnified when cities hesitated to invest a significant amount of budget to expand their bike-sharing program.

The late 2010s—present (platform-mediated, dock-less, shared micro-mobility programs). In 2016, a number of Chinese dock-less bike-sharing (DBS) start-ups (e.g., Mobike and Ofo) rolled out their product both domestically and internationally and achieved a visible expansion backed by venture capital investment (Zou et al., 2020). It marked the beginning of a new generation of shared micro-mobility. The dock-less eco-system further cannibalized the previous generation's market share when a new player—e-scooters—was added to the shared micro-mobility family. In the U.S., e-scooter sharing became the predominant mode of shared micro-mobility, as compared to SBBS and DBS, in 2019 (NACTO, 2020). In Canada, Australia, New Zealand, Europe, and Asia (e.g., Singapore), dock-less e-scooter sharing emerged around the same time and proliferated at an impressive speed as well.

The dock-less operation model relaxes both the geographical confinement and the fleet capacity limit of a docking station. More importantly, a private-public partnership business model between cities and vendors significantly motivates capital to invest in shared micro-mobility (Zou, 2021). Shared micro-mobility vendors bring in operational and economic efficiency that helps accelerate the mass deployment of thousands of e-bikes and e-scooters on city streets. Although shared micro-mobility took its toll during the Covid-19 pandemic, industry statistics from North America suggest that the market has quickly recovered—even surpassing its pre-pandemic level (North America Bikeshare & Scootershare Association (NABSA), 2022). At this stage, cities and the transport industry are taking a serious look at this new kid on the block: Is shared micro-mobility going to take over a substantial share of the urban transport market? What does a shared micro-mobility vision look like for cities?

6.1.2 Contribution and Disruption to Cities

The numbers do not lie: Shared micro-mobility's popularity is quickly rising. Cities are gearing up to deploy more bikes and scooters in the street, build more docking stations, and permit more service vendors. They must see the desirability of shared micro-mobility to potentially remedy the wicked problems in urban transport, such as congestion and the steady decline in public transport ridership. In Brisbane—the city where I live and work, micro-mobility is heavily promoted by the Brisbane City Council. The Council highlights that micro-mobility brings an array of benefits, including an affordable mobility option, convenience to tourists and residents, promoting sustainability in urban transport, spurring economic growth through job creation and local business visitations, and creating a safer, pedestrian-/cyclist-friendly built environment (the Brisbane City Council, 2020). Because the fleets are associated with a healthy, green, low-traffic-impact image a generally favorable sentiment towards shared micro-mobility is found in qualitative evidence across global cities (Mitra & Hess, 2021; Bakker, 2018).

On the other hand, the shared micro-mobility vision is overshadowed by a few outstanding issues. In its early days, the issue of dock-less fleets cluttering streets/sidewalks was pervasive (Burtina et al., 2020). If the war of who owns sidewalks and curbsides reflects spatial mismanagement, then a system-wide mismanagement of fleet supply could cause an even more undesirable consequence: For instance, China's bike-sharing mania in 2017–2018 resulted in thousands of damaged and abandoned bikes piling up and rotten in the so-called 'bike graveyard'. Production and supply of fleets, pumped by ill-considered investors rushing into this emerging market, dramatically outpaced the actual demand for shared micro-mobility in multiple Chinese cities. Eventually, it led to huge piles of fleet debris (Taylor, 2018). Additionally, shared micro-mobility was, and still is, scrutinized for safety issues. Particularly, e-scooters can travel at a comparable speed to cars in low-speed (~20 mph) city streets. When e-scooter riders share the roadway with drivers, traverse congested intersections, or ride on poorly lit roads at night, they run into the risk of a crash incidence that may result in an injury to a varied degree of severity. On the other hand, shared micro-mobility riders may also become a safety hazard/ nuisance to pedestrians and residents (Aman and Smith-Colin 2021). Moreover, researchers question whether shared e-scooters generate any environmental benefit based on simulation outcomes, suggesting that their environmental impact is highly sensitive to the emission from charging and the actual private car travel distance being replaced over the life cycle of an e-scooter (Hollingsworth et al. 2019). In a case where e-scooters have a short life span (less than one year) and an insufficient number of auto trips are being replaced the emission level could be higher than a baseline without any shared e-scooter.

This chapter focuses on two important questions: What impacts shared micro-mobility has had and may have on our urban transport? As micro-mobility vendors continue upgrading the hardware (e.g., battery life, durability, maneuverability, safety, and anti-theft features of an e-bike/e-scooter) and the software (e.g., GPS accuracy, geo-fencing accuracy, and facial recognition of a user), we can foresee that cities will either continue expanding their shared micro-mobility program or jump on the bandwagon if they do not have one currently. However, how big a promise can shared micro-mobility fulfill in terms of building a more efficient, equitable, and eco-friendly urban transport future?

To answer the questions, the rest of this chapter is centered around three activities: In Sect. 6.2, I summarize the existing research evidence on how shared micro-mobility has transformed/ is transforming our cities; In Sect. 6.3, I use big shared micro-mobility trip data to empirically demonstrate what the data does and doesn't tell about the usage of this novel mobility in our urban environment; In Sect. 6.4, I create two qualitative narratives on dichotomous micro-mobility futures; In Sect. 6.5, I conclude the chapter by discussing what cities, vendors, and researchers should jointly work on to achieve a sustainable micro-mobility future that we have been envisioning since the idea was born half a century ago.

6.2 Shared Micro-mobility Transforming Cities: The Research Landscape

With public shared micro-mobility programs being implemented in cities around the world since the 2010s, research that characterizes shared micro-mobility business, operation, travel pattern, and user profiles have also taken off across different disciplines. In this section, I pay attention to studies that try to empirically understand, uncover, and underpin the extent to which shared micro-mobility has reshaped our urban economy, sustainability, accessibility, and lifestyle. By no means is this review exhaustive or systematic as (1) innovations in technology, business, and operation of shared micro-mobility continue to improve this new product, and (2) localized knowledge dominates general knowledge in this emerging research area as each local market offers unique practices and perspectives.

6.2.1 Shared Micro-mobility Transforming the Urban Economy

Transport is the backbone and vessel of the urban economy. Shared micro-mobility transforms the urban economy in the digital, location-based direction. It benefits the urban economy by improving transport efficiency. As many cities are faced with severe peak-hour congestion, shared micro-mobility (e-bikes and e-scooters) offers a faster urban mobility solution compared to driving for short-distance commutes (McKenzie, 2020). In addition, empirical studies (Ma et al. (2015) for SBBS and Yang et al. (2019) for DBS) suggest that bike-sharing can be integrated with public transport in a first-/last-mile setting and boost transit ridership. It is yet to be empirically concretized that e-scooter sharing complements public transit, although conceptually it is plausible (Zuniga-Garcia et al., 2022).

The economic efficiency argument is not without limitations. In terms of replacing car travel, survey evidence points to divergent possibilities of either a substitutional (especially for short-distance trips of <2 miles) or an insignificant relationship (due to auto-dependency) between cars and e-scooter sharing (Wang et al. 2022). Public bike-sharing trips may also replace short or unlinked transit trips, which may adversely affect transit ridership (Campbell and Brakewood 2017), especially during the Covid-19 pandemic (Teixeira and Lopes 2020).

Besides improving transport efficiency, shared micro-mobility and its associated infrastructure (e.g., docking stations) are seen as part of the millennial economy, just like craft-beer shops and corner cafés, that reshapes the local economy and uplifts previously unattractive neighborhoods (Hyra 2016). Indeed, cluttered sidewalks may be seen as an eyesore, but a well-balanced docking station/parking corral with bright-colored, fresh-looking e-bikes and e-scooters is place-making in itself (Buehler & Hamre, 2016). The flip side of the aesthetic appeal of shared micro-mobility is the potential gentrification of an affordable community (Leszczynski and Kong 2022).

6.2.2 Shared Micro-mobility Transforming Urban Sustainability

It was the congested, auto-oriented urban transport system that impregnated the original idea of shared micro-mobility. Naturally, shared micro-mobility is seen as a solution to reduce auto-dependency and mobile source emission. Empirical studies using American and Chinese public bike-sharing cases have demonstrated its environmental benefits. Hamilton & Wichman (2018) identified a causal, positive impact of public bike-sharing in Washington D.C. on congestion reduction (by as much as 4%). He et al. (2020) demonstrated that bike-sharing usage in four U.S. cities is highly sensitive to fuel costs for driving, indicating that micro-mobility can substitute short-distance & short-duration driving trips. Consequently, a small but significant reduction in vehicle distance traveled is translated into a small reduction in CO_2 emission. In another case from Shanghai, China, Zhang and Mi (2018) quantified emission reduction as a result of the proliferation of bike-sharing.

On the other hand, whether shared micro-mobility can realize its promises of sustainability largely depends on (1) the lifecycle emission, especially for e-bikes and e-scooters, and (2) the level of substitution between shared micro-mobility and auto travel. Luo et al. (2019) compared the life-cycle emission of DBS and SBBS systems: The former's emission level is 82% higher than the latter in a life cycle. Hollingworth et al. (2019) suggest that a short lifespan or a low battery efficiency of a scooter would significantly limit its environmental benefit. Furthermore, mixed results on the substitution between shared micro-mobility and car travel were identified across different countries/systems (Fishman et al. 2014). To accurately assess the environmental benefit of shared micro-mobility, we need to consider both the emission reduction through the vehicle travel distance being substituted and the emission accumulated throughout a fleet's life cycle (fleet production, the battery recharges, rebalancing, and recycling).

6.2.3 Shared Micro-mobility Transforming Urban Accessibility

Shared micro-mobility is seen as a convenient mobility option to improve people's accessibility to various opportunities and amenities. Public transport operates on fixed routes with a fixed timetable, which means there are blind spots when and where it is unavailable to serve those who lack mobility. Public bike-sharing can readily cover such blind spots, providing the transit-dependent population with a first-/last-mile solution or directly substituting short transit trips (Kong et al., 2020). In addition, many cities designate equity priority areas, where many low-income and low-mobility households are guaranteed to have a fair share of micro-mobility fleets and infrastructure (Zou, 2021). Cities also implement financial assistance programs to make shared micro-mobility either affordable or free for the most economically disadvantaged individuals (Riggs et al., 2021).

One limitation of spatial access is that it does not directly translate into usage. Membership subscription amongst socially disadvantaged residents tends to be lower than others, although they are inclined to use the service more often upon joining membership (Qian & Jaller, 2020). Furthermore, even if the spatial coverage of fleets may be adequate in low-income neighborhoods, significantly fewer trips tend to be generated in such areas, suggesting a disparity in the actual usage (Frias-Martinez et al. 2021).

6.2.4 Shared Micro-mobility Transforming Urban Lifestyles

Finally, shared micro-mobility promotes an active, healthy lifestyle that is aligned with the public health mission for cities. The health benefit associated with bike-sharing, such as lowering the obesity rate, substantially outweighs the risk of a higher morbidity/mortality rate associated with traffic accidents (Woodcock et al. 2014). Empirical evidence suggests that bike-sharing is associated with more physical activity and lower rates of obesity (Xu, 2019; Stahley et al. 2022). However, there lacks sufficient evidence to prove the health benefit of e-scooter sharing due to its novelty and the fact that riding an e-scooter requires little physical effort.

The image associated with shared micro-mobility—high-tech, green, affordable, and active—softens disputes and controversies caused by its early-day oversupply, mismanagement, and safety concerns. Policymakers and governments see the potential of shared micro-mobility to transform the urban environment. Nonetheless, there exist significant knowledge and information gaps between a pilot shared micro-mobility program and mass adoption—where the high-demand areas and corridors are, how to balance demand and supply, who uses or refuses shared micro-mobility, what the traffic impacts are, etc. Such knowledge must be gained through evidence-based research specific to a local shared micro-mobility program. In the next section, I will showcase an empirical work that explains what typical shared micro-mobility data can and cannot inform decision-makers about the travel and operation patterns of shared micro-mobility.

6.3 What Does and Doesn't The Data Tell? An Empirical Demonstration

In the age of mobility big data, trip data is arguably the most available data source for shared micro-mobility. Through web-scraping techniques and partnerships with private vendors, researchers can either self-collect trip data or receive data from service providers. Combining spatial and temporary trip information with secondary data (e.g., weather, points of interest, population statistics), researchers can make reasonable inferences about the shared micro-mobility users' travel behavior. In my case, I will interpret trip patterns in Brisbane, Australia, using data-driven empirical techniques.

6.3.1 Study Area

Brisbane serves dual functionalities: a business city and a tourism city. As the capital city of the State of Queensland, Brisbane has a 1.3 million population in the labor force (Australian Bureau of Statistics (ABS), 2022), which generates sizeable commuting trips. The city also possesses enormous tourism resources: Brisbane is known for its proximity to world-class beaches on the Gold Coast and the Sunshine Coast, as well as its tourist attractions in the central business district (CBD) and along the Brisbane River. In terms of urban form, Brisbane is a classic monocentric city with a predominant employment/activity center in the CBD. Population density and building density quickly decay outside of a 3km buffer from the CBD, resulting in auto-oriented suburbs.

Demographic-wise, Brisbane has a diverse immigrant population (31.7% oversea born population in 2021(ABS, 2022) with a strong presence of the Asian community. Climate-wise, Brisbane has a year-round subtropical warm and humid weather, which favors cycling activities.

6.3.2 Data

I processed shared micro-mobility trip data received from a Singaporean-based vendor—Neuron, who entered the Brisbane market in 2019. For demonstration purposes, I analyzed trips between August 30 and September 26, 2020—the State of Queensland had its borders (interstate and international) closed against the spread of the Covid-19 Delta variant at the time. Essentially, the micro-mobility trips were taken by Queenslanders, if not Brisbane locals, during the demonstration period. A total number of 64,353 trips were included in the analysis.

I spatially joined trip origins and destinations with the following spatial features: points of interest (POIs), including educational institutes, financial services, healthcare facilities, hotels, parks, public buildings, stores and shopping centers, sports venues, sightseeing spots, restaurants and bars, and churches, from OpenStreetMap; transport infrastructure locations, including bus hubs, train stations, and ferry terminals, from general transit feed specification (GTFS) data provided by the regional transit authority; and roadway classification (major roadways, minor roadways, and bikeways) from OpenStreetMap. A 50m buffer for various (POIs) and a 10m buffer for the street network were drawn. Then, the number of spatial features within which a trip's origin and destination fell inside was counted.

In addition, I merged 0.5-hourly archived Brisbane weather data (temperature, humidity, wind speed, and precipitation) from Weather Underground (https://www.wunderground.com/) with trip data by a trip's starting timestamp. Lastly, trip characteristics themselves were considered in the analysis, such as time of day, day of week, distance, duration, and loop trip—where its origin-destination distance is shorter than 200m and 1/3 of its network distance.

6.3.3 Building a Typology of Shared Micro-mobility Trips

With rich information from multiple data sources, I was able to explore what big trip data can tell us about travel behavior. I applied the same analytical framework from my previous work (Zou, 2021), where I built a typology of e-scooter trips using a K-means clustering technique in Washington, D.C. based on the spatiotemporal features of an e-scooter trip. Methodologically, building a 'typology' of shared e-scooter trips draws inspiration from the transit user segmentation studies (e.g., Grise and El-Geneidy, 2018) and bike-sharing spatiotemporal trip characterization studies (e.g., Zhou, 2015). Based on the qualitative description of natural and built environment factors that distinguish trips within one cluster from other clusters, I can make inferences about unique/common travel behavior associated with shared e-scooters in Brisbane.

A flow chart conceptualizing the empirical framework is provided as follows in Fig. 6.1.

Notice that ideally user data should be accompanied for a better understanding of individual users' travel behavior. However, such information is not available in the dataset (Hence the dashed box of 'User data' in Fig. 6.1). Empirically, the following bullet points summarize key processes of building the trip typology:

- The following features were run into the clustering analysis: 16 spatial features related to trip origin, 16 spatial features related to the trip destination, 10 features related to a trip's temporal information, 2 features related to trip distance and duration, as well as 4 features related to the weather conditions at the time when a trip was taken
- An elbow test was run to determine the optimal number of clusters, which is 15
- 9 out of the 15 clusters have a decent size (>2,000 out of 64,353 trips): a qualitative summary of the distinct characteristics of each cluster was created

For demonstration, the qualitative summary for Cluster 11—'weekend riverside recreational trips' (n = 5,316) is presented in Fig. 6.2: Out of the 48 spatiotemporal features, only the features with a significantly higher cluster mean statistic (the blue series) than the sample mean statistic (the gray series) are visualized. The number of point of interest (POI) buffered areas (typically 50 meters) an average shared e-scooter trip's origin/destination falls inside, an average trip's weekday/weekend status, whether a trip is a loop trip or long duration trip are significant factors that differentiate trips within Cluster 11 and the entire sample. As illustrated in Fig. 6.2, on average, trips in Cluster 11 were more likely to start and end near public buildings (e.g., library and city hall), sightseeing locations, etc. In addition, these trips were also more likely to be long, loop trips taken on a weekend day along bikeways, hinting at recreational rather than utilitarian usage.

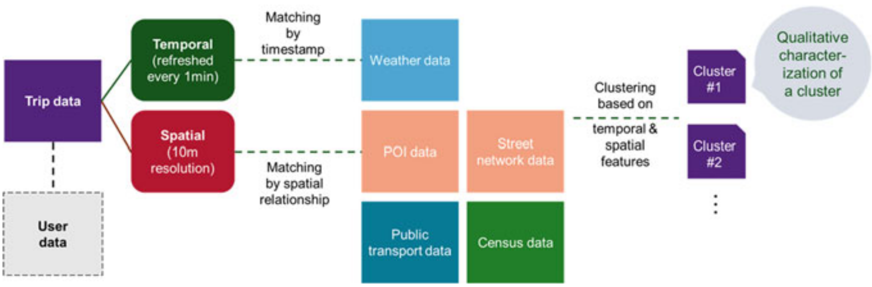

Fig. 6.1 The flow chart of the empirical framework

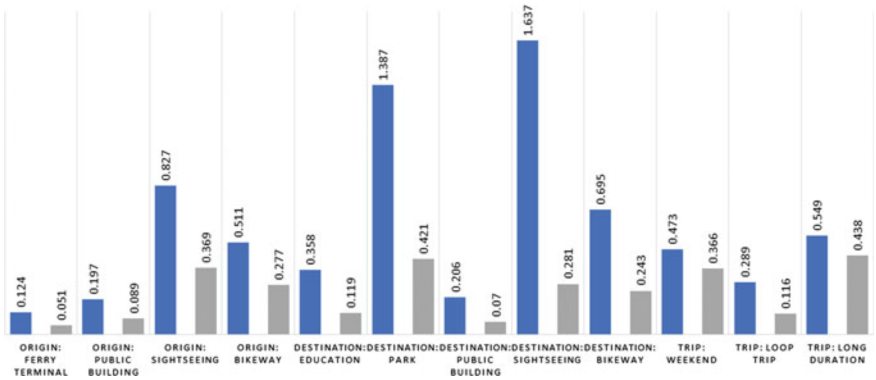

Fig. 6.2 Summary of the distinct characteristics for Cluster 11 (the blue series: cluster mean statistics; the gray series: sample mean statistics)

Figure 6.3 maps trip origins (top) and destinations (bottom) for Cluster 11. The spatial distributions of origins and destinations confirm the distinct spatial characteristics summa: A significant number of trips started and ended along the Brisbane River in the CBD and South Bank with proximity to various POIs and on riverfront bike trails.

Clustering is a powerful data analytic tool to recognize shared micro-mobility trips of similar spatiotemporal dynamics. Taking advantage of real-time big data with a range of features, we can distinguish and explain heterogeneous mobility patterns. The geospatial and temporal clusters of micro-mobility trips can then inform stakeholders (vendors, transport authorities, city planners, and policymakers) about the points of interest that generate high trip demand, the corridors that could benefit from new/improved bike infrastructure, and the specific hours in a day in a week to manage micro-mobility traffic.

6.3.4 People: The Missing Puzzle

Nonetheless, a major factor is missing from the analysis: the people—specifically, the riders who rode e-bikes and e-scooters. Are they visitors or residents? How often do they bike/scoot? Is a certain trip type (as indicated by 'clusters') attached to certain user demographics?

In the research space, it is not an uncommon practice to anonymize user information in passive trip data due to privacy concerns (Cottrill 2020). Particularly in the age of big data, researchers hope to capitalize on the geographic and temporal granularity of big trip data and explore travel behavior at a fine-grained scale. Had we possessed a range of user information (e.g., membership status, user ID, and basic sociodemographic characteristics), we should be able to fully characterize (1) shared micro-mobility user behavior, (2) the existing market penetration amongst different

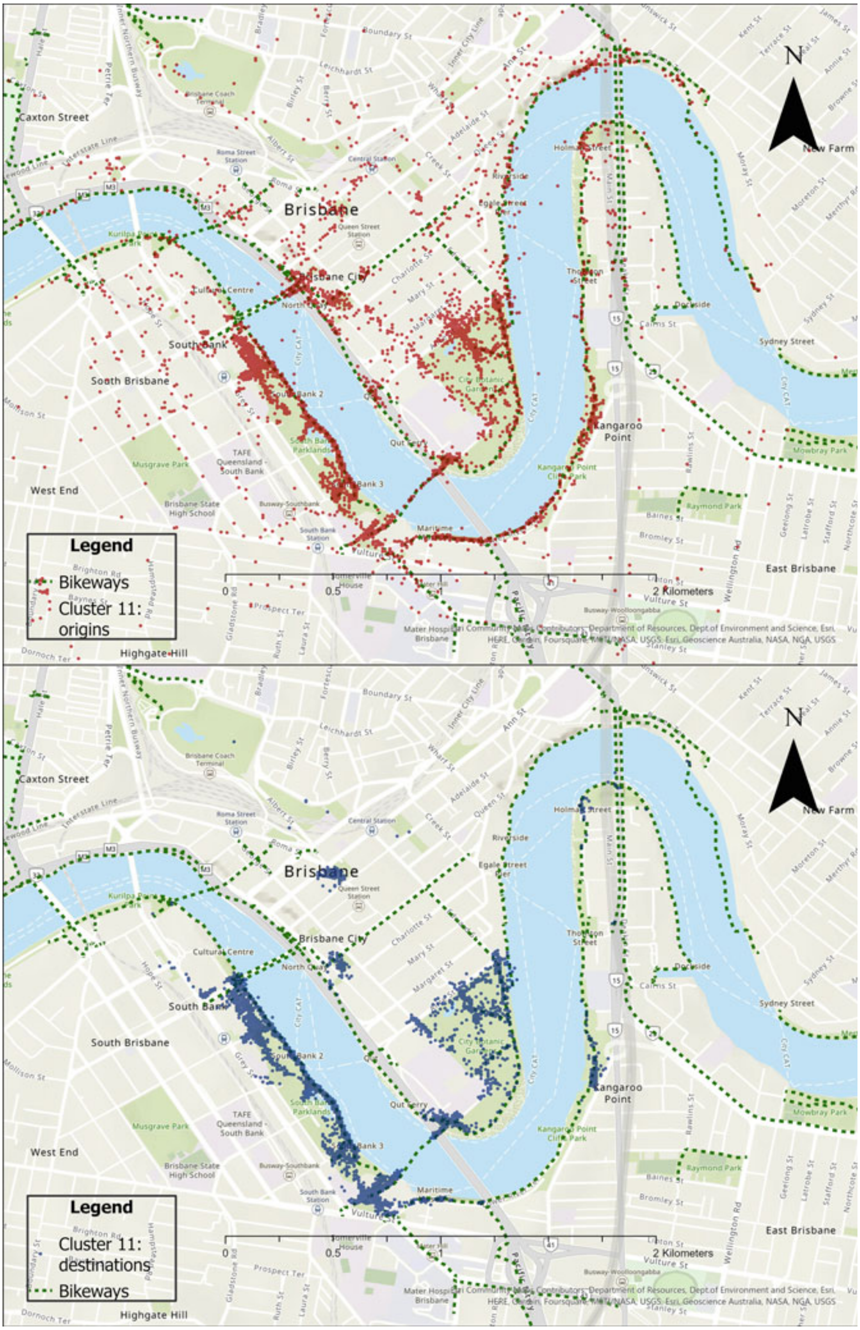

Fig. 6.3 The spatial distributions for trip origins (top) and destinations (bottom) for Cluster 11: Weekend riverside recreational trips

sub-population groups, and (3) differentiation between casual and membership users. On the other hand, we still need to collect data on people to understand why they use or refuse to use shared micro-mobility occasionally and/or frequently.

The empirical work makes the case that data is a powerful friend which informs high-level decisions to manage or expand a shared micro-mobility program, such as the system-wide fleet quota, effective and equitable spatial deployment of fleets, critical corridors to add new bikeways, intersections to accommodate multimodality, and major activity areas in need for parking management (e.g., geofencing/parking corrals). Significant data gaps when it comes to 'people' should also be acknowledged. A trustworthy partnership among the city, private and public vendors, and researchers need to be established to start incorporating the user (and non-user) dimension into analyses on shared micro-mobility travel behavior whilst mindfully protecting user data privacy. Anonymity and aggregation are viable solutions, but consultation is necessary to achieve a balance between meaningful analyses and the non-disclosure of personal information.

6.4 Two Scenarios of Shared Micro-mobility: A Panacea or a Patch for Urban Transport Problems?

Cities champion shared micro-mobility. Vendors expand the shared micro-mobility market. Researchers facilitate these two decision-makers with data-driven, evidence-based studies. Do the inputs from all three converge and point to a shared micro-mobility vision? If so, what does it possibly look like, and what it means to our problematic urban transport? While I do not have an answer, I could imagine two scenarios of the future shared micro-mobility:

6.4.1 Scenario 1: A Shared Micro-mobility Paradise

This scenario sketches a fresh blueprint of an urban transport ecosystem centered around micro-mobility as opposed to a minor increment from the status quo. For this scenario to happen, several factors need to work together:

Firstly, we need a thriving shared micro-mobility market. On the *supply* side, many vendors, not just a few start-ups, will enter the shared micro-mobility market. They provide adequate services on varieties of products and a tiered pricing scheme that suits user groups of varied mobility needs and income levels. On the *demand* side, shared micro-mobility can meet most of our travel demands, including daily commuting, recreation, shopping, social and nightlife, as well as out-of-town visits. For longer-distance trips, micro-mobility can provide first-/last-mile connectivity to public transit.

The *built environment* must strongly favor micro-mobility in this paradise. On the *infrastructure* side, Bike-friendly infrastructure is installed in major activity centers, corridors, and transit hubs, such as bike superhighways, off-street bike trails, on-street protected bike lanes, bike/scooter corrals, and fast-charge stations. A high-density, mixed-use, job-housing-balanced, polycentric *urban form* is desirable in this scenario. Commuting trips and non-commuting trips can be accomplished within 30 minutes and 15 minutes, respectively.

Public policy also plays a critical role in promoting micro-mobility. Cities permit vendors to operate on a generous fleet quota. Car-free zones are designated for pedestrians and micro-mobility riders in activity centers. Auto traffic speed is capped at 25mph on local and minor arteries to protect micro-mobility riders' safety. Periodical data sharing between cities, vendors, and researchers is arranged using a standard, anonymous format.

Suppose all the prerequisites are met, then we shall see a significant mode shift from private vehicles to (1) shared micro-mobility for short- & middle-distance trips, and (2) a 'shared micro-mobility + public transport' hybrid mode for long-distance trips. In the long run, this shared micro-mobility heaven will have significantly less traffic congestion, less pollution, better traffic safety, a more active lifestyle, and improved health outcomes for all citizens.

6.4.2 Scenario 2: When the Hype is Over

If Scenario 1 portrays an ideal world for shared micro-mobility, then Scenario 2 depicts a much drearier shared micro-mobility future, where cities no longer expand their program and the other factors are not much different from the status quo:

The shared micro-mobility market remains a niche in this scenario. On the *supply* side, only a limited number of vendors and fleets are permitted to operate in the core urban areas. On the *demand* side, residents and visitors of certain demographic and socioeconomic characteristics would use shared micro-mobility services, such as young, physically active, high-income, and car-less tourists and residents who live in the urban core.

The built environment favors private cars, instead of pedestrians and cyclists. On the *infrastructure* side, a marginal expansion/improvement of bike infrastructure is implemented. In terms of *urban form*, cities remain monocentric, sprawling in the periphery, and auto-centric.

Lukewarm promotion of shared micro-mobility is enacted by cities. In addition, cities offer minimal incentives for vendors to enter the market or for residents and visitors to try out micro-mobility services. Limited collaboration between cities and researchers is achieved to understand travel demand and travel behavior associated with new mobility.

We would expect a negligible mode shift from private vehicles to shared micro-mobility in this scenario. What is worse, with ongoing population growth and suburbanization auto-dependency may further aggravate. In this scenario, only a fringe user group benefits from shared micro-mobility. However, the well-being of the general public either remains unchanged or worsens from the status quo.

Of course, transport technologies advance beyond our prediction and imagination. Emerging mobility options, such as electric and autonomous vehicles, and alternative travel methods, such as teleworking and online delivery, may fundamentally alter our future urban transport system. Shared micro-mobility may not be a solution but a transition. While our society should keep up with technological advancement, we should keep in mind that efficiency is not the sole metric that matters. Green, active, and affordable micro-mobility offers multitudes of broader social benefits beyond economic efficiency.

6.5 Conclusion: Making Shared Micro-mobility Work for Cities

In this chapter, I walked through the origin and evolution of shared micro-mobility. I broadly introduced the current research findings on how shared micro-mobility is transforming cities. I also empirically demonstrated the power of big data associated with shared micro-mobility, along with its limitations where the human factor is missing. Finally, I described two possible shared micro-mobility futures moving forward. Although researchers deliver mixed messages, vendors sometimes mismanage, and cities see it as both a friend and a foe, we can reach a consensus that shared micro-mobility does more good than harm to cities.

Furthermore, a shared micro-mobility paradise is not a delusion – do you know it has the nickname 'Copenhagen'? If car-oriented cities around the world scrap their lukewarm bike and pedestrians master plans and follow the playbook of building a micro-mobility heaven (inspired by the Danes!), then our cities will be much greener, safer, more pleasant places to live in.

As a researcher in shared micro-mobility myself, I believe we need to make our research outcomes visible to cities and vendors. In return, they will seek collaboration with us by providing much-needed data and funding capacities. Together, we can ally to re-draw the blueprint of urban transport—with a little help from shared micro-mobility!

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