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Barriers to Reducing the Carbon Footprint of Transportation Part 3: The Impact of the Covid-19 Pandemic on Travel Patterns

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Contents

Abstract

Vehicle travel, measured as vehicle-miles traveled (VMT), dropped precipitously in California following “stay-in-place” orders issued by the state and counties as a response to the Covid-19 pandemic. Although VMT rebounded relatively quickly, the state has an opportunity to leverage other changes in household travel behavior so as to achieve its VMT reduction goals while enhancing transportation equity. This report reviews the available evidence on changes in household travel behavior resulting from the Covid-19 pandemic and provides an overview of potential state, regional, and local-level policies that could help to preserve changes that help to reduce VMT and reverse those that tend to increase VMT. The review focuses on alternatives to driving, specifically telecommuting, public transit, ride-hailing, e-shopping, and active travel and micro-mobility.

TITLE: Barriers to Reducing the Carbon Footprint of Transportation Part 3: The Impact of the Covid-19 Pandemic on Travel Patterns

ISSUE/S: Household vehicle travel, measured as household vehicle-miles traveled (VMT), dropped precipitously in California following “stay-in-place” orders issued by the state and counties as a response to the Covid-19 pandemic in March 2020. Although VMT rebounded relatively quickly, the state has an opportunity to leverage other changes in travel behavior so as to achieve its VMT and greenhouse gas (GHG) emission reduction goals while enhancing transportation equity.

MAIN QUESTION: What potential state, regional, and local-level policies could help to preserve pandemic-related changes in travel behavior that help to reduce VMT and reverse changes that tend to increase VMT?

KEY RESEACH FINDING/S: The Covid-19 pandemic engendered significant changes in travel behavior with respect to telecommuting, public transit, ride-hailing, e-shopping, and active travel and micro-mobility. Some of the changes induced by the Covid pandemic will clearly help in California’s effort to reduce VMT and its associated greenhouse gas emissions, namely the increases in bicycling and use of micromobility services. Other changes, particularly the decline in transit ridership, represent a substantial setback to this effort. The remaining changes – increases in telecommuting, increases in e-shopping, a tempering of the ride-hailing phenomenon – have more ambiguous implications.

CONCLUSION/S: State, regional, and local governments can take advantage of a wide array of policy opportunities to direct post-Covid trends in travel behavior toward reductions in VMT and GHG emissions. The state can facilitate the adoption of VMT reduction strategies by providing financial support and facilitating partnerships across public agencies and between the public and private sectors.

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Executive Summary

Vehicle travel, measured as vehicle-miles traveled (VMT), dropped precipitously in California following "stay-in-place" orders issued by the state and counties as a response to the Covid-19 pandemic. Although VMT rebounded relatively quickly, the state has an opportunity to leverage other changes in household travel behavior so as to achieve its VMT reduction goals while enhancing transportation equity. This report reviews the available evidence on changes in household travel behavior resulting from the Covid-19 pandemic and provides an overview of potential state, regional, and local-level policies that could help to preserve changes that help to reduce VMT and reverse those that tend to increase VMT. The review focuses on alternatives to driving, specifically telecommuting, public transit, ride-hailing, e-shopping, and active travel and micro-mobility, and outlines policy opportunities for each, many of which also offer opportunities for improving transportation equity.

Telecommuting

Telecommuting—also known as telework and remote work— generally refers to paid work conducted mainly at home that substitutes for work conducted in a central workplace, using technology to interact with others as needed to conduct work tasks. Before the Covid pandemic, in 2018, the share of California workers who worked primarily at home was 6%, slightly higher than the national share of 5.3% (from US Census and American Community Survey data, cited in Speroni and Taylor, 2023). With the onset of Covid, telecommuting increased dramatically. Among remote-capable employees (those reporting that their current job can be done remotely from home, constituting about half of the US full-time workforce), as many as 70% worked exclusively from home in May of 2020 (Wigert, 2022). Telecommuting during the pandemic substantially affected transportation patterns.

Hybrid work schedules are expected to be a common arrangement moving forward. As of late 2022, about 55% of remote-capable employees expected to continue a hybrid work schedule indefinitely, based on arrangements made with their employers, and 23% expected to work exclusively remotely (Gallup, 2022). The decline in commute trips does not necessarily mean a decline in VMT, however, for several reasons: 1. Telecommuters tend to commute longer distances (when they do commute) than other workers; 2. Telecommuters tend to make more frequent nonwork trips; 3. Telecommuters may choose to relocate to places that are more car-dependent and farther from the workplace.

Policy opportunities include:

- Implement policies that constrain a rise in non-work travel, including roadway and parking pricing in conjunction with complementary policies to reduce the effects of pricing on low-wage workers.

- Increase support to outlying communities for improving public transit service and active travel facilities, and encourage changes in local land use policies to better support these modes.
- Adopt requirements for employer-based trip reduction programs to reduce commuting by single-occupant vehicles by expanding the availability of alternatives.
- Strengthen parking “cash-out” policies and enforcement of those policies.

Public Transit

Prior to the Covid-19 pandemic, transit ridership had been steadily declining in most metropolitan areas. Ridership fell most noticeably after 2013, first in per capita and then absolute terms (Mallett, 2018), with a decline in overall ridership of 14% to 15% observed nationwide between 2012 and 2018 (Watkins et al., 2022). The pandemic exacerbated these trends. The initial lockdown period caused national transit ridership to drop 79% compared to pre-Covid levels (EBP Inc, 2021). Ridership in San Francisco in April 2020 had dropped 85% and in Los Angeles by 60% (Hughes, 2020). As of January 2021, transit ridership nationally was 35% of pre-pandemic levels (EBP, Inc, 2021). By mid-2022, it had partially recovered but remained about 62% of pre-pandemic levels (Mallett, 2022). Ridership was slower to recover for commuter rail than for bus service, reflecting a higher share of telecommuting among workers commuting by rail than by bus.

Whether and when ridership will fully recover remains uncertain. In order to remain financially solvent in the face of ridership drops, US transit agencies reduced operating costs by reducing service frequencies and cutting some routes altogether. Hybrid work arrangements, which reduce the number of commute trips, reduce the number of transit trips, particularly in areas with high shares of transit commuting among white-collar workers. Additionally, because car ownership increased during the pandemic, fewer people may be dependent on transit, and increased concerns about personal safety and security that arose during the pandemic (but not only because of the pandemic) may continue to suppress transit ridership. Strategies to strengthen transit systems and improve ridership can improve equity outcomes as well. Policy opportunities include:

- Revise service standards and performance metrics and rethink service delivery with respect to coverage, frequency, and hours of operation.
- Prioritize transit in the public right-of-way, including transit priority lanes and transit-signal priority; invest in bus rapid transit systems.
- Encourage higher densities and development types supportive of transit.
- Improve inter-agency coordination, for example, with integrated fare payment systems.

- Encourage partnerships with transportation network companies (TNCs) to improve first/last-mile connections and to provide service in areas where transit service is sparse.

Ride-hailing

Ride-hailing is a service provided by transportation network companies (TNCs) in which users arrange and pay for transportation services using a smartphone app that connects drivers using their personal vehicles with potential passengers. After the founding of the major TNCs (Uber in 2009 and Lyft in 2012), use of ride-hailing services grew dramatically. By 2017, TNCs accounted for more than 0.6% of all trips in urban areas, in comparison to buses and passenger trains at 1.7% and 1.1% of trips (FHWA, 2017).

The pandemic hit TNCs hard. Stay-at-home orders caused demand for ride-hailing services to all but disappear. Uber reported an 80% decline in ride bookings in April 2020 compared to 2019 (Urbanism Next, 2021). TNCs were promptly forced to cut approximately 15% of their workforce in May 2020 (Higgins and Olsen, 2020). To promote social distancing, TNCs canceled shared-ride versions of their services, such as UberPool, further lowering revenues (Siddiqui, 2020). Although ride-hailing trips have partially rebounded, TNCs face other challenges that may limit their growth in the future.

The net impact of ride-hailing on VMT is not certain. Evidence points to a net negative effect of ride-hailing on transit ridership, though ride-hailing can also complement transit as a first/last mile connection. The degree to which ride-hailing trips replace driving trips depends in part on auto ownership. Even when a ride-hailing trip replaces a driving trip, VMT might not decline owing to the “empty” miles driven by TNC operators to reach pick-up locations. Some studies show that ride-hailing has increased VMT and congestion in the cities in which TNCs operate. GHG emissions from ride-hailing are also a concern.

Policy opportunities include:

- Implement congestion management policies such as roadway and parking pricing, plus street redesign that favors transit, as strategies for repressing the substitution of ride-hailing trips for transit trips.
- Support efforts to increase shared rides, with multiple passengers per vehicle, such as implementing lower tax rates and encouraging the designation of drop-off and pick-up zones.
- Encourage partnerships between TNCs and transit agencies.
- Implement policies that require vehicle electrification for TNCs to reduce GHG emissions regardless of impacts on VMT.

E-Shopping

Shopping patterns were changing in fundamental ways even before the pandemic. New devices and interfaces, as well as delivery services, had facilitated and improved the online shopping experience, fostering substantial growth in e-commerce (UPS, 2018). In the US, the e-shopping share of total retail sales had grown from 5% at the end of 2013 to about 11% at the end of 2019 (Statista, 2022). E-shopping increased dramatically when the pandemic hit and statewide and city lockdowns prevented people from leaving their homes. The U.S Census Bureau reported a 43% increase in e-commerce sales in 2020 compared to e-commerce sales in 2019 (Brewster, M. 2022). E-commerce continues to grow, though its growth rate has slowed as the pandemic has eased. Delivery services are likely to remain more popular than before Covid for the foreseeable future.

The impact of e-shopping on VMT and greenhouse gas emissions is uncertain. The flip-side of potential reductions in personal shopping VMT induced by e-commerce is an increase in VMT associated with goods delivery. Some studies show a net decrease in VMT from e-commerce, while others show a net increase. Comparing VMT impacts of in-store and online shopping, Jaller and Pahwa (2020) found that the impact on VMT and emissions is less a question of the choice made between online versus in-store shopping and instead is more dependent on the efficiencies in methods and practices involved in each. This conclusion implies that the behavior of both consumers and delivery firms warrants policy attention to reduce GHG emissions as well as the disproportionate negative impacts of freight on disadvantaged neighborhoods.

Policy opportunities include:

- Encourage consolidation of vehicles and/or parcels, for example through cooperative carrier agreements or creating delivery micro hubs, to reduce VMT.
- Require companies to provide more information about shipping to consumers.
- Develop urban freight plans at state, regional, and local levels that address VMT associated with on-line shopping.
- Set standards for fuel efficiency for freight delivery to reduce GHG emissions irrespective of impacts on VMT.

Active Travel and Micromobility

Prior to the COVID-19 pandemic, active modes represented a small but measurable share of travel in the US. In California, active modes appeared to be declining: from 2012 to 2017, based on data from the 2017 NHTS and the 2012 California Household Travel Survey, both walking and bicycling decreased, walking from 16.2% of trips to 13.0% of trips, and bicycling from 1.5% to 1.3% of trips (Pike and Handy, 2021). Safety has been an on-going concern for pedestrians and bicyclists.

One of the most significant developments in active travel prior to the pandemic was the introduction of shared micro-mobility services that rent bicycles, electric-assist bicycles (e-bikes), and/or electric scooters (e-scooters) on a short-term basis. Bikesharing was the first form to rapidly emerge in the decade before the pandemic. In the US, bikeshare trips increased from 321,000 in 2010 to 32 million in 2017 (NACTO, 2022a). E-scooter trips in the US grew from a negligible number in 2017 to over 80 million by 2019, when well over half of all micromobility trips were taken by e-scooter (NACTO, 2022a).

While stay-at-home orders and accompanying school and workplace closures triggered by the Covid-19 pandemic led to a decrease in travel by all modes, including utilitarian travel by active modes, walking and bicycling served important purposes during the pandemic: as a form of exercise, recreation, and safe socializing for those stuck at home, and as an alternative to transit for those who continued to commute to work. Cities around the country adopted "open streets" programs, in which city streets were partially or fully closed to cars. In US cities, bicycle counts increased by 16% between 2019 and 2020, although most bicycling occurred during afternoons and evenings for non-utilitarian purposes (Buehler and Pucher, 2021). Bicycle sales soared, especially e-bike sales. Micro-mobility service, which was widely suspended at the beginning of the pandemic, bounced back quickly: by 2021, ridership on station-based bike share systems in the US had rebounded to 18% above pre-pandemic levels and e-scooter trips doubled from 2020 to 2021, nearly returning to pre-Covid levels (NACTO, 2022a). These are low-impact, low-cost modes of travel that help the state meet its GHG goals while enhancing transportation equity.

Policy opportunities include:

- Subsidize micromobility services, especially for low-income users.
- Establish transportation "libraries" to loan out bicycles, especially in low-income areas.
- Offer subsidies for the purchase of e-bikes, especially for low-income households.
- Encourage public-private partnerships to provide micromobility services to ensure that such services meet public goals.
- Address the bicycle theft problem.
- Invest in infrastructure for pedestrians, bicyclists, and other active modes.
- Promote a "complete streets" approach to the design and use of public rights-of-way.
- Continue and encourage "open streets" and "slow streets" programs.
- Reduce speed limits, especially on local streets.

Chapter 1. Introduction

Vehicle travel, measured as vehicle-miles traveled (VMT), dropped precipitously in California following “stay-in-place” orders issued by the state and counties as a response to the Covid-19 pandemic in March 2020. The declines far exceed the targets set by the state under SB 375 (Chapter 728, Statutes of 2008) as a part of its overall strategy for reducing greenhouse gas emissions. VMT rebounded relatively quickly, with national totals in April 2021 reaching 93% of national totals in April 2019 (FHWA, 2021). Even so, the state has an opportunity to leverage other changes in travel behavior so as to achieve its long-term VMT reduction goals. The temporary changes in household travel behavior resulting from the stay-in-place orders represent an opportunity to understand how California might create new transportation options beyond personal vehicles to fundamentally change patterns of travel in the state.

This report reviews the available evidence on changes in travel behavior resulting from the Covid-19 pandemic and provides an overview of potential state, regional, and local-level policies that could help to preserve or reinstitute changes that were found during the pandemic to reduce VMT and reverse those that tend to promote VMT. The review focuses on alternatives to driving, specifically telecommuting, public transit, ride-hailing, e-shopping, and active travel and micro-mobility. Numerous surveys conducted by researchers in the past three years provide evidence of changes in the use of these modes during Covid and the likelihood of their persistence in coming years. The policy overview draws on evidence from prior to Covid on the effectiveness of various strategies for promoting the use of these alternatives. The future implications of the documented trends and the adoption of potential policies for the state’s effort to reduce VMT are quantified in a separate study for the California Air Resources Board (Contract No. 20RD005).

Some of the changes induced by the Covid pandemic will clearly help in California’s effort to reduce VMT and its associated greenhouse gas emissions, namely the increases in bicycling and use of micromobility services. Other changes, particularly the decline in transit ridership, represent a substantial setback to this effort. The remaining changes – increases in telecommuting, increases in e-shopping, a tempering of the ride-hailing phenomenon – have more ambiguous implications. Public policy will play an essential role in all cases in determining whether the trends following the initial months of the pandemic help the state meet its ambitious goals for reductions in greenhouse gas emissions while providing a more equitable transportation system.

Chapter 2. Telecommuting

Telecommuting—also known as telework and remote work— generally refers to paid work conducted mainly at home that substitutes for work conducted in a central workplace, using technology to interact with others as needed to conduct work tasks (Speroni and Taylor, 2023). Long hoped-for benefits from telecommuting have included reductions in commute travel, improved productivity, and greater worker satisfaction. This chapter considers whether the increased incidence of teleworking experienced during the Covid pandemic is likely to continue, and if so, whether positive benefits for travel reduction may occur as a result.

Before the pandemic, telecommuting shares in the workforce had been increasing but only slowly, due largely to employers' reluctance to endorse the practice. Then suddenly, in March 2020, with the onset of Covid lockdowns, more than half of US workers began teleworking (Barrero et al., 2021), radically altering workplace practices and introducing a "natural experiment" in how and whether the economy would respond. In the transition to post-pandemic conditions, it appears that increased rates of teleworking will persist, producing substantial impacts on transportation systems associated with changes in spatiotemporal distribution of trips.

This chapter first considers observed impacts of the pandemic on telecommuting, and associated impacts on mode choice, trip-making, and distance traveled, including through the mediating variable of changes in land use patterns associated with teleworking. Expected medium-term and long-term incidence and impacts from telecommuting are then also assessed. The findings indicate that even as increased telecommuting rates are expected to persist, resulting VMT reductions are not likely to be substantial, nor are reductions in congestion. We offer some policy recommendations for addressing travel impacts of telecommuting in that light.

Pre- and post-Covid trends in telecommuting

Before the Covid pandemic, in 2018, the share of California workers who worked primarily at home was 6%, slightly higher than the national share of 5.3%. The work-from-home rate had been growing slowly but steadily, with the share of California's workforce that worked primarily at home rising from just under 2% in 1980 to 6% in 2018, similar to the trajectory nationally, rising from 2.3% in 1980 to 5.3% in 2018 (from US Census and American Community Survey data, cited in Speroni and Taylor, 2023).

Then, with the onset of Covid, telecommuting increased dramatically. Among remote-capable employees (those reporting that their current job can be done remotely from home, constituting about half of the US full-time workforce), as many as 70% worked exclusively from home in May of 2020 (Wigert, March 15, 2022). By November 2022, most remote-capable employees continued to work from home, but many more were doing so part-time, as 52% had a hybrid schedule, and only 26% were working entirely from home (Gallup, November 2022). In 2022, 31% of all paid workdays were being worked from home (Speroni and Taylor, 2023).

Hybrid work schedules are expected to be a prevalent arrangement moving forward. As of late 2022, about 55% of remote-capable employees expected to continue a hybrid work schedule, based on arrangements made with their employers, and 23% expected to work exclusively remotely (Gallup, 2022). These patterns generally matched employee desires, as more than nine in 10 remote-capable employees preferred some degree of remote-work flexibility, with six in 10 specifically preferring hybrid work. The affinity for remote-work flexibility that developed during the pandemic is clearly persisting as an expectation for the future, with the top reason noted by employees for preferring hybrid work being to avoid commuting time (Wigert, 2022).

Nevertheless, while remote flexibility is likely to be an ongoing trend, a fair share of employees will not receive as much flexibility as they desire, with managers indicating they prefer hybrid rather than fully remote work, to a greater extent than employees do (Wigert, 2022). Fully remote work arrangements are expected to continue decreasing, for this reason, but most expert projections concur that a long-term increase in telecommuting is likely relative to pre-pandemic levels (Speroni and Taylor, 2023). Based on surveys of employees and employers, Gallup projects that two in 10 remote-capable employees will work remotely full-time over the long term (Wigert and Agrawal, 2022). Averaging over survey waves from July 2020 to March 2021, Barrero et al (2021) project that 21% of workdays (with a larger share among workers with “remote-capable” jobs) will be done remotely moving forward – about four times the pre-pandemic level. Working from home is feasible for about half of employees, and the typical plan for that half involves two workdays per week at home.

Long-run patterns in working from home are uncertain because the economy is still undergoing a process of accommodating and adjusting to more telecommuting, and it will take time for the economy’s response to stabilize. Firms and workers alike are adjusting their spatiotemporal behaviors. Some scholars contend that current high telecommuting rates may moderate significantly if the economy cools and Covid becomes endemic, and employers re-gain an upper hand in negotiating work arrangements (Speroni and Taylor, 2023). However, other observers contend that even in an economic downturn, telecommuting is likely to persist at fairly high levels because of benefits to employers that include a greater ability to recruit and retain workers from a wider, more diverse, and potentially cheaper labor pool (Constantz, 2022). A recession might even accelerate the telecommuting trend by reinforcing the need to reduce office space.

Transportation impacts of telecommuting

Remote work is not uniformly distributed across groups. Higher-income, white-collar, office workers were traditionally the most likely to work remotely (Matson et al., 2021a, b), and white-collar, highly educated, and higher-income workers have been most likely to telecommute during the pandemic and as it abates (Guyot and Sawhill, 2020; Salon et al., 2022; Soza-Parra et al., 2023). These characteristics of telecommuters have implications for travel behavior, as telecommuters, for example, have historically, lived farther from work on average than other workers (Zhu and Mason, 2014; Zhu et al. 2018).

Telecommuting during the pandemic substantially affected transportation patterns, with various consequences that are likely to persist. Some significant changes relate to commute travel. Travel demand shifted especially for transportation systems designed to accommodate peak period commutes into downtowns and other job centers. While vehicle traffic volumes plummeted during the onset of the pandemic, they rebounded to pre-pandemic levels by 2022 (Alternative Fuels Data Center, 2022, cited in Speroni and Taylor, 2023). Meanwhile, stated desires for owning a car increased during the pandemic, consistent with observed increases in car purchases and mode shifts reflecting concerns about shared modes of travel (Soza-Parra et al., 2023).

During the same period, transit ridership also plummeted, but in contrast to vehicle travel, transit ridership remained low through 2022, as discussed in the next chapter, at less than half of pre-pandemic levels (Federal Transit Administration, 2022, cited in Speroni and Taylor, 2023). This pattern reflects ongoing fears about use of shared-travel modes but also a shift from transit to telecommuting, given that pre-pandemic, commuting accounted for about half of all transit trips (Salon et al., 2021). Rail systems that mainly serve major center city areas have been hit especially hard during the pandemic: white-collar workers were more likely to use rail than bus pre-pandemic (Jin and Wu, 2011) but also more likely to switch to telecommuting, compared to bus users who were more likely to be essential workers (Soza-Parra et al., 2023). given that. For that reason, the drop in bus ridership during Covid has been less extreme than the drop for rail. Based on survey results from 2020, Salon et al (2021) project an ongoing 40% decline in transit commute trips post-pandemic, relative to pre-pandemic, about half of which will be attributable to changes in commuting frequency, another 40% from a net shift among transit commuters toward the private car, and the remaining 10% from shifts to other modes.

Commute patterns are only one aspect of travel behavior that is affected by telecommuting. Non-work travel behavior is important to consider because commute trips account for less than one quarter of all daily trips (FHWA, 2017). While telecommuters might reduce their commute travel, their ability to make more discretionary trips from home could offset the potential reductions in trip frequency and VMT from the elimination of commute trips. Shorter but more frequent nonwork trips made by telecommuters from home could be more difficult to serve with non-auto modes than when such trips were previously made as a stop on the commute to or from work (Soza-Parra et al., 2023; Speroni and Taylor, 2023).

Pre-pandemic research provides insights into these questions. Zhu and co-authors found that US telecommuters (defined as anyone who reported telecommuting at least once per week) had longer commute travel distances than non-telecommuters and also longer distances for their non-commute work trips and their non-work trips; US telecommuters took more frequent trips of all types except direct commute trips (Zhu, 2012; Zhu et al., 2018). The same research found that US telecommuters, on average, traveled about seven more commute miles per day and about five more miles per day for non-work-related trips than non-telecommuters (Zhu, 2012, based on 2009 National Household Travel Survey findings). For all trips, telecommuters averaged 43.8 daily VMT, 17% more than the 37.5 daily VMT for non-telecommuters (Zhu and Mason, 2014).

Speroni and Taylor (2023) assessed findings from multiple pre-pandemic studies on combined work/non-work effects of telecommuting on travel, noting that recent cross-sectional studies (conducted since the mid-2010s) generally found telecommuting to be associated with lower peak period trip-making (especially during the morning peak), but not with lower overall trip-making nor with lower VMT; indeed the studies cited generally found the opposite – more trip-making and VMT among telecommuters compared to non-telecommuters. However, one recent study that aimed to overcome limitations of this previous work found a somewhat different result (Obeid et al., 2022). Using a combination of passively collected data and five waves of panel survey data collected during 2020 and 2021, thereby overcoming the limitations of cross-sectional studies, the authors authors found that telecommuting generates new non-commute trips that offset a significant portion of the reduction in commute trips, but as the additional trips were on average shorter in distance, person miles of travel for telecommuters was lower overall than for non-commuters. In the last wave of the survey, conducted in the period from June to December 2021, telecommuters traveled 3.5 km or about 9% less that commuters on their telecommuting days. According to another study, Although this study did not account for mode, another study found that telecommuters are less likely (by 71%) to make their non-work trips using transit on days they telecommuted, compared to non-work trips made by non-telecommuters (Chakrabarti, 2018)..

Many of the added non-commute trips occur outside of peak hours. Telecommuters especially avoid the evening peak period when making such trips but less so the morning peak period (Lachapelle et al., 2018). Thus, telecommuting induces an increase in off-peak travel, which may produce more leveled use of transportation networks (both roadway networks and transit networks) over time along with a potential rebalancing of trips across local roads versus major highway systems (Soza-Parra et al., 2023).

Potentially the most robust conclusion to draw from these studies is that they are inconclusive about the impacts of telecommuting on VMT and that more research is needed. Adding to the complexity of the assessment is the fact that the energy and environmental effects of telecommuting also depend on energy use at home versus office locations as well as shifts in travel behavior among all members of a telecommuter’s household (see Speroni and Taylor, 2023, for an overview of pertinent research on these topics). Additionally, if telecommuting frees up roadway space during the peak period, that space may be quickly filled by “induced travel” – the shifting of drivers from other routes, times of day, and travel modes. For all these reasons, increased telecommuting should not be viewed as a panacea for reducing VMT and its impacts on the environment and on congestion.

Land use impacts of telecommuting and consequences for travel behavior

Longer commute trips observed among telecommuters compared to non-telecommuters indicate a relationship between telecommuting and land use. The causal arrow here has been speculated to run in both directions: those living farther from work are likely to find remote work more attractive, even as the ability to telecommute may, over time, also induce workers to choose to live farther away from work.

During the pandemic, housing demand decreased in neighborhoods with high population densities and high home values, reflecting at least in part the greater prevalence of telecommuting (Liu and Su, 2021). Bloom and Ramani (2021) determined, using US Postal Service address change data, that most relocations during the first year of the pandemic happened within metropolitan areas rather than between them, with 15% of households and businesses moving from business district zip codes to suburban districts. Considering survey findings across 17 US metropolitan areas conducted both pre-pandemic and during early and later stages of the pandemic, Soza-Parra and co-authors found growing shares of survey respondents indicating an interest in living in a spacious home, even if located farther from public transportation and desired destinations (Soza-Parra et al., 2023). This trend continued even after lockdowns were lifted, suggesting that the pandemic may have at least somewhat cemented these residential location preferences.

Estimating how and whether land use preferences will shift on a longer-term basis and translate into actual changes in residential location is an “active research question” (Soza-Parra et al., 2023). The answer will depend especially on whether employers continue to support remote work arrangements in the future, but also on home prices. Rising home prices were already exerting extreme pressure in coastal metros before the pandemic, suggesting that implications for post-pandemic remote work patterns will include an increase in residential dispersion and increased vehicle travel. However, Soza-Parra et al. (2023) found that while there was a sizable decline in interest in living in central, more mixed-use neighborhoods during the early stages of the pandemic, this pattern receded somewhat during the later stage in late 2020. The long-term trend is uncertain.

The prospect of an ongoing future of hybrid work also begs the question of how firms will define space needs. Central business districts, along with public transit systems, have suffered more than other areas and modes during the pandemic. Many firms are seeking to trim their physical office space, particularly in high-priced major cities (Speroni and Taylor, 2023). One survey of 185 businesses with a physical location in the

US found that just over half of the firms expected to shrink their office square footage by 2025, but about 40% intend to expand (Maurer, 2022).

Speroni and Taylor (2023) delineate various motivations and strategies that may induce firms to alter use of office space. Some companies will look for office space closer to their workers' residences, outside of central business districts. Businesses located in less dense and residential neighborhoods may find their chances for success will improve. Other firms will take advantage of the opportunity to lease the newly available space in the denser urban areas, especially if rents drop. As firms shrink their office footprint, buildings may end up hosting more tenants than before in the same square footage. As workers come to offices less frequently, space use may be reconfigured, perhaps through office-sharing arrangements. This scenario would be advantageous for public transit systems hoping to regain ridership.

Meanwhile, less desirable office space may be converted to other uses (such as warehousing). Another option could be the conversion of unused office space into needed residential space, but this process is difficult and still rare (Speroni and Taylor, 2023). In any case, the process of sorting out how and whether office work returns and is re-configured will take time and is unlikely to settle into a new normal any time soon.

Policy opportunities

A sustained increase in telecommuting does not guarantee a reduction in VMT. The increased interest in owning vehicles observed during Covid combined with greater preference for lower-density suburban living could induce an increase in personal car trips by telecommuters. A reduction in peak period morning congestion stemming from an increase telecommuting could lead to an increase in car trips by non-telecommuters. In the absence of policies to discourage increased car travel, the potential reductions in VMT from telecommuting might prove to be illusory, giving way to even more widespread and frequent use of private vehicles.

This possibility underscores the need for policy interventions, like roadway and parking pricing, that could constrain a rise in non-work travel associated with teleworking. Complementary policies, such as targeted subsidies, can ensure that pricing strategies do not disproportionately harm low-income households. Another helpful strategy would be to provide more direct support to outlying communities for improving public transit and other public transport options, as well as active travel facilities, so as to provide alternatives to driving for non-work trips. This approach would constitute something of a re-orientation from pre-pandemic policymaking for sustainable transport, which focused intensively on denser urban areas, but could be warranted if the Covid trend toward residential and office decentralization persists. The following chapters discuss strategies for expanding the use of alternatives to driving.

Several existing California policies support the goal of expanding alternatives to driving. SB 743, for example, re-oriented CEQA analysis and mitigation of transportation impacts of development from a focus on reducing level of service impacts (on traffic delay) to reducing VMT impacts instead, with the consequence that high-VMT suburban areas must now do more to try to reduce driving. Other critical state policies for constraining low-density development and travel in outlying areas include SB 375, which calls for coordinated transportation-land use planning at the regional scale led by Metropolitan Planning Organizations (MPOs). Recent evaluation reports by CARB on SB 375 progress to-date indicate cause for concern about achieving regional plan goals for reducing VMT and GHGs (CARB, 2018, 2022) and call for bolder action at every level of government to support and ensure implementation of Sustainable Communities Strategies.

Policies to discourage driving for non-work trips can be complemented with policies to discourage driving for commute trips. A promising approach would be to strengthen employer trip reduction programs (EBTRs). EBTRs, either mandated or voluntary, are relatively common in urban areas with significant congestion, air quality problems, or both. Such programs can reduce VMT by up to 6% according to some studies (Boarnet, et al. 2014) through strategies such as subsidized transit passes, carpool incentives, vanpool programs, and bicycle incentives, in addition to telecommuting. The increased provision of alternatives to driving alone would help to increase transportation equity.

A particularly promising component of the EBTR approach is parking "cash-out," which can be done at the state, regional, and/or local levels. In 1992, California enacted AB 2109, the state's parking "cash-out" law, which requires that large employers who rent parking space and offer it free to employees offer an equivalent cash amount to non-driving commuters. A study of effects of the cash-out law at eight sites, conducted five years after the law was adopted, showed that solo driving had fallen 17 percent, carpooling had increased by 64 percent, transit usage had increased by 50 percent, and those walking and biking to work increased by 39 percent (Shoup, 1997). The results confirm that among techniques for managing transportation demand, parking cash out is among the most successful at changing behavior and motivating people to choose options other than driving alone (Singal, 2021).

However, the policy only applies to a small share of employers: companies with 50 or more employees, in regions out of compliance with air quality standards, who lease their parking space, who can calculate the cost of the parking (i.e., the parking is not "bundled" with the building lease), and who can reduce the number of parking spaces they lease without financial penalty (Singal, 2021). Enforcement has been another problem. In 2009, the state's parking cash-out law was strengthened by passage of SB 728, which called for stronger regulatory oversight of implementation (Medina, 2019). The law provided that cities, counties, and air quality management districts could establish and impose fines for failure to comply with parking cash out requirements, but the City of Santa Monica reportedly was the only jurisdiction in the state, at any level of government, that had enforced the law (Singal, 2021). Staff from CARB and the South Coast Air Quality Management District had indicated that neither agency believed the law as written could deliver benefits commensurate with the time and resources required to enforce it.

A new state policy, AB 2206, went into effect on January 1, 2023, significantly strengthening the cash-out law by requiring that employers inform their workers about their right to receive a cash-out benefit and document that they have done so. The new law should make it easier for cities to determine the cost of parking, and thereby ease enforcement. As it stands, only Santa Monica has taken enforcement seriously, having enacted an ordinance to require eligible employers to offer parking cash out (Curry, 2022). Further steps can be taken to extend parking cash-out, for example by expanding its application to more categories of employers. The state could enforce the law more strenuously and provide direct support to localities for enforcement and development of local cash-out policies and programs. Strengthening state and local cash-out law would be an important step for reducing driving for commute purposes.

Chapter 3. Public Transit

Prior to the Covid-19 pandemic, transit ridership had been steadily declining in most metropolitan areas. The pandemic served to exacerbate these trends and to highlight the tension in addressing transit needs as either a necessary social service or a solvent, self-sufficient alternate mode of transportation. A combination of internal and external factors provoked transit ridership declines before and during the pandemic. Internal factors include fare and service changes and safety concerns, while external factors include price attractiveness of other modes, land use policies, and increased teleworking. Policies to reverse the trend of declining ridership will need to target both types of factors, but this chapter focuses primarily on how external factors influence transit ridership, rather than how those factors might be regulated and changed (two factors, telecommuting and TNCs, are addressed in other chapters of this report).

Pre-Covid trends in transit ridership

Transit was considered to have reached a crisis condition even before the Covid pandemic (Mallett, 2018). Transit ridership within the US had been declining in most metropolitan areas during the previous decade, even as transit funding surged (Manville et al., 2018; Mallett, 2018; Watkins et al., 2022). Excluding an increase of more than 20% in ridership (unlinked trips) in the New York City region, national transit ridership decreased by 7% from 2006 to 2016 (Mallett, 2018). Ridership fell most noticeably after 2013, first in per capita and then absolute terms (Mallett, 2018), with a loss of 14% to 15% observed nationwide between 2012 and 2018 (Watkins et al., 2022).

Almost every urban area saw ridership fall, even where ballot measures to increase transit funding were approved (Mallett, 2018). Across US metro areas between 2006 and 2016, ridership declines were particularly severe in the Los Angeles area in spite of significant funding having been provided for transit through local sales tax measures. Between June 2014 and June 2017, ridership losses in the Los Angeles area accounted for 23% of all losses among 41 urban areas with populations of 1 million or more. Meanwhile, urban population and employment rates, both of which are positively associated with high transit ridership, were rising substantially. Buses were the most affected by the ridership losses across US metro areas, reaching their lowest ridership levels since at least the 1970s (Watkins et al., 2022).

As transit ridership declines, agencies lose fare revenue, which often results in reductions in service to meet budgets, resulting in further losses in ridership—thus creating a downward spiral. Findings from an in-depth effort to understand recent transit ridership patterns, the Transit Cooperative Research Program (TCRP) Research Report 209, *Analysis of Recent Public Transit Ridership Trends* (Watkins et al., 2022), point to four main causes that can explain the on-average transit ridership declines in 215 metropolitan statistical areas (MSAs) between 2012 and 2018 (Watkins et al., 2022). The first factor, an external influence, was changes in household characteristics, as higher incomes and more teleworking accounted for a net ridership decline of about 2% during the period for bus and rail. The second and third factors, combining both internal and external influences, produced a shift in the relative costs for transit versus driving. Between 2012 and 2018, costs increased for both bus and rail travel across most metro areas of all sizes, contributing up to a 4% reduction in bus and rail ridership. Meanwhile, average gas prices decreased by about 30% during the same period, contributing another 4% average reduction to transit ridership across MSAs, according to the TCRP report. Manville et al (2018) similarly found, in assessing recent transit ridership declines in Southern California, that fuel prices played a contributing - but not leading – role to declines in transit ridership.

The change in the relative price for driving versus transit use in recent years helps explain why the share of households owning vehicles also increased dramatically during the 2000s in the Los Angeles region, contributing to transit ridership losses especially among traditional transit users such as the foreign-born (Manville et al., 2018). In part, this pattern reflects a policy-driven factor, the passage of a new law allowing undocumented immigrants to obtain drivers' licenses. Between 1990 and 2000, the 6-county Southern California SCAG region had added 0.25 vehicles per new resident, but from 2000 to 2015, 0.95 vehicles were added per new resident (Manville et al., 2018). Statewide in California between 2000 and 2018, 5.6 million vehicles were added, or approximately one for every new resident (Blumenberg and Schouten, 2020). Meanwhile, the share of households that did not own a car dropped from 9.5% to 7%, but those car-less households accounted for approximately 37% of transit trips in the state. This shift in access to personal vehicles would further exacerbate transit ridership losses once the pandemic arrived.

The fourth and biggest factor identified in the TCRP report was the external influence of new modes competing with both bus and rail, in particular ride-hailing services (the effect of bike-sharing and e-scooters was found to be minimal in the study). Researchers found that ride-hailing accounted for a net bus ridership decline of between 10% to 14% during the period, although the effect of ride-hailing on rail ridership in larger metro areas was much smaller (Watkins et al., 2022). Other studies have produced similar findings. A 2017 survey of seven large US cities found a 3% increase in rail ridership and a 6% decrease in bus ridership following the introduction of ride-hailing (Clewlow and Mishra, 2017). A study completed two years later, which analyzed transit ridership before and after ride-hailing arrived in hundreds of US cities, found that ride-hailing presence led to an increase in rail ridership overall and a modest decrease in bus ridership (Babar and Burtch, 2019). In San Francisco, an analysis of 2016 ride-hailing trip data showed that ride-hailing contributed to a 7% growth in light rail ridership and a 10% drop in bus ridership (Mucci, 2017).

Another, more long-term internal factor that may help explain declining transit ridership is the priority given to rail over bus systems in the distribution of transit funding. Transit policies have, for many decades, favored commuter-oriented rail services more than bus services, such that by 2009 total rail subsidies exceeded total bus subsidies (Taylor and Morris, 2015). The politics of public funding for transit and the desire to attract new riders have led to adoption of politically appealing rail transit plans in many regions that may not improve transportation outcomes for the most frequent transit users, namely bus riders, who are more likely to be lower income and members of minority groups, in contrast to rail riders whose incomes and race/ethnicity more closely match users of personal vehicles. Boisjoly et al. (2018) conducted a 14-year longitudinal study on transit ridership patterns, finding that between 2002 and 2007 increased rail operations led to an overall increase in transit ridership, but from 2011 to 2015 a similar increase in rail operations - this time coupled with a decrease in bus operations - led to overall decreased transit ridership.

Transit use during the pandemic

The Covid-19 pandemic worsened the ongoing decline in transit ridership. The transit industry was hit by “what is likely its biggest challenge to date: a global pandemic that uniformly discouraged the close proximity between people on which transit depends to be the most spatially efficient mode” (Watkins et al., 2022).

The initial lockdown period caused national transit ridership to drop 79% compared to pre-Covid levels (EBP Inc, 2021). An analysis of 10 US cities found that transit ridership in the first four months of 2020 ranged from 62% to 87% lower than during the same months in 2019 (Ahangari et al., 2020). Ridership in San Francisco in April 2020 had dropped 85% and in Los Angeles by 60% (Hughes, 2020). As of January 2021, transit ridership nationally remained at 65% less than pre-pandemic levels (EBP, Inc, 2021), while in mid-2022, it was about 62% of pre-pandemic levels (Mallett, 2022). By the second quarter of 2022, commuter rail ridership had been slowest to recover at 52% of pre-pandemic levels; bus ridership the fastest at 66%; and subway ridership in between at 59%.

The causes of plummeting ridership were in some ways new (e.g. increased telecommuting and health concerns due to the inherent public nature of public transit), but the pandemic also brought new rounds of service cuts, reorganizations, and fare shifts that had been affecting the transit industry prior to the pandemic. A national survey conducted mid-pandemic, in August 2020, of people who used transit at least occasionally before the pandemic, probed Covid-induced transit aversion (Parker et al., 2021). Seventy-five percent of respondents reported taking transit less often due to the pandemic, with only 9% saying that they felt comfortable using transit. Eighty-five percent expressed concerns regarding the risk of infection on transit vehicles and said that increased safety measures (masks, distancing, etc.) would encourage their use of transit.

The pandemic changed the distribution of bus and rail trips dramatically. Prior to the pandemic, transit systems carried just 5% of US commuters, but commuting accounted for about half of all transit trips (Salon et al., 2021). The shift to telecommuting thus had a dramatic effect on transit. Because rail systems carried a greater share of office commuters who could shift to telecommuting during the pandemic, rail trips declined more than bus trips. As a result, roadway modes (including bus and demand responsive services) made up 58.1 percent of transit trips taken in 2020, the highest share since 2007 (APTA, 2023). Bus ridership declined by 30.3 percent from 2019 to 2020, heavy rail ridership by 53.1 percent, light rail and streetcar ridership by 30.5 percent, and commuter and hybrid rail ridership by 48.3 percent.

During the pandemic, the differences between rail and bus ridership intersected with increased public visibility of the reliance on transit by “essential workers.” Bus ridership declined less than rail ridership because lower-income and critical workforce populations served by buses were more likely to still be using transit out of necessity. An analysis of 2018 data from the American Community Survey indicated that 36% of all transit commuters worked in essential industries (Transit Center, 2020). Essential workers in that study included those working in health care, grocery, convenience, and pharmacy stores, transit and taxi services, waste management, postal and courier services, social services, and public safety and armed forces. Of those essential workers, the health care segment was by far the largest, at 27% (and 10% of all workers).

With drops in ridership came declines in fare revenues and thus cuts in transit service. In order to remain financially solvent, US transit agencies reduced operating costs by reducing service frequencies and cutting some routes altogether. A June 2020 analysis measured Covid-induced transit service cuts in the 30 largest US cities, finding substantial reductions in 28 of them. Los Angeles and San Diego cut service by 25%, while San Jose and San Francisco cut service by 50% (DeWeese, 2020). These service cuts made for more disjointed transit service, a problem already prevalent in many cities where neighboring transit agencies often do not coordinate schedules or operate under the same fare structures. However, the observed transit service cuts did not disproportionately affect low-income and more vulnerable areas in the cities studied; on the contrary, the analysis revealed that the service cuts were more likely to have been undertaken in areas with higher incomes and considered less vulnerable, especially in San Francisco and San Jose (DeWeese, 2020).

Covid-19-related transit ridership drops were not equal across ridership groups, building as they did upon pre-Covid patterns. Lower-income bus users were far less likely to decrease transit use than higher income rail commuters (Ahangari et al., 2020; He et al, 2021). This disparity underscores the difference in ridership patterns for people using transit as an optional mode of travel versus people for whom it is their only mode of travel. Segments of the population with higher public transit use prior to the pandemic also had higher transit trip counts during the pandemic (He et al., 2021).

Several studies found relationships between income and education with transit ridership during the pandemic in various areas across the United States. A study in Nashville found transit ridership reduction in higher income areas was 19% greater than in low-income areas (Wilbur et al., 2020). Another study in Chicago found larger reductions in transit ridership in parts of town that were more commercial and had a higher proportion of white residents, educated residents, and high-income residents (Hu and Chen, 2021). A study of 10 US cities found that the only factor with a strong relationship to rail ridership drops in April 2020 was unemployment, whereas bus ridership was affected by area demographics including poverty, education, and foreign-born levels, as well as shares of car-less residents dependent on transit to get to work (Ahangari et al., 2020). Another study of transit ridership drops in 20 US cities from February 1, 2020, to January 31, 2021, found that a 1% increase in the population with a BA degree or higher was associated with a 1.06% greater drop in public transit ridership (Qi et al., 2023).

These findings have a variety of explanations. The education impact observed in these studies relates to the job types of workers and their ability to work remotely versus an essential worker who still had to travel to work (Qi et al., 2023). Income disparities also affect access to personal vehicles, which influences transit use. A survey conducted by He et al (2021) in Fall of 2020 of 500 transit riders recruited on-line indicated that transit riders with access to a personal vehicle were more likely to be influenced by fare costs than those without access to a personal vehicle. Hispanic riders who reduced their transit use were less likely to cite a change in travel need and more likely to cite "a move, change in transit service, the cost of riding transit, and concerns about harassment or interactions with police or ICE [Immigration and Customs Enforcement] on transit" as a reason (He et al., 2021).

Concerns about harassment were also cited as a reason for decreased transit use by female riders and transit riders living below twice the poverty level. The concerns about harassment and police and ICE interactions may have been caused by greater feelings of isolation and vulnerability among transit riders due to the decreases in ridership generally that occurred during the pandemic (He et al., 2021). In this sense, the findings by He on the influence of safety concerns related to harassment and police interventions intersect with findings from other studies that specifically assessed health concerns during the pandemic.

During the pandemic, US transit agencies received additional funding to help them remain financially viable. Prior to Covid the federal government had provided about 18%, on average, of capital and operating funds spent by public transportation agencies. Fares and other revenues comprised about 26% of capital and operating funds, state funding another 22%, and local funding about 34% (Mallett, 2018). Federal supplemental appropriations to public transportation agencies in FY2020 and FY2021 totaled $69.5 billion—about five times the pre-pandemic $12 billion in annual federal public transportation support and more than three times the $19 billion from fares and other operating revenue annually (Mallett, 2022). In spite of this assistance, several major transit operators nationally estimate that without additional funding, they will face large and sustained operating deficits in the next few years, in which case these agencies would have to institute some combination of fare increases, service cuts, and layoffs. Reduced and more expensive service could lead to falling ridership, requiring further fare hikes and service cuts.

Some California transit agencies have been hit particularly hard by the Covid pandemic and its aftermath. For example, on the San Francisco Bay Area Rapid Transit (BART) system, a commuter-rail system, ridership fell to just 4% of pre-pandemic levels during the initial pandemic lockdown and hovered around 10% for much of the year (Baker, 2021). The decline in ridership and thus fares severely hampered BART's ability to provide service.

Prior to the pandemic, BART had been one of the most self-sustaining agencies in the US, with a farebox recovery ratio of 60% (Wanek-Libman, M. 2020). This meant that BART was significantly less reliant on public dollars to fund its operations than most other agencies, something that public transit services generally strive for, to support more extensive service. The drop in BART ridership during the pandemic led the agency to run a high deficit, threatening BART's core financial sustainability. Thus, while a high farebox recovery ratio can be a boon during boom times, the opposite may be true during economic downturns and shocks like the pandemic (Mass Transit, 2020). Other public transit agencies more reliant on public subsidies can weather such shocks more easily, if drastic changes to ridership exert less of an impact on their ability to continue day-to-day operations. This situation makes BART an interesting case study in considering how the agency can develop and implement survival strategies, a topic we address later in the chapter.

Although BART was slated to receive $1.3 billion from national recovery supplemental funding by 2022, BART used almost half ($660 million) of the funds by February 2022 (Long, 2022). BART forecasts that ridership and fare revenue will not return to pre-COVID-19 levels for several years, which would deepen operating budget deficits. In March 2023, BART predicted its fiscal cliff will hit as soon as January 2025, in which case the agency would only be able to provide 22% of pre-pandemic service hours in a scenario with slow ridership recovery (Levin, 2023). BART predicted a $78 million deficit in 2025 and an annual deficit of $300 million in each of the following years, totaling a deficit of $1 billion by 2028. This could lead to drastic service cuts such as no weekend service, hourly service during the week, and shuttered stations. BART does not currently have a secure funding source to continue its present operations (Levin, 2023).

Collectively, these research findings indicate that while Covid precipitated dramatic ridership drops, certain agencies suffered more than others, as did certain groups who were less able to stop riding transit. The greater ability of white, wealthier transit users to either switch to other modes or stop commuting altogether built upon patterns that were prevalent before Covid. The decreases in ridership led to service cuts which in turn led to decreases in ridership which worsened safety concerns for some riders. Covid-related safety concerns were widespread, but more demographically concentrated concerns about police or ICE interactions also manifested with decreased ridership and the loss of the feeling of safety in numbers. Safety and perception of safety are important factors for transit agencies to grapple with, to which the pandemic added new dimensions that transit agencies will need to sort out in the coming years to ensure long-term viability and safety for regular riders.

The outlook for transit

By September 2022, transit ridership nationally had rebounded significantly, to 70 percent of pre-pandemic levels, in spite of continuing high shares of workers in many cities still working from home, compared to pre-pandemic conditions (APTA, 2022). While encouraging, this trend still reflected a situation in which many transit agencies were continuing to suffer from ridership losses and associated service cuts, reflecting financial instability. For example, BART ridership is still only at 45 percent of pre-pandemic levels, while Los Angeles's subways are carrying around 65 percent, and San Diego's public bus and trolley system ridership has returned to pre-pandemic levels (Karlamangla, 2023).

While scholars are still seeking to investigate the longer-term impacts of the pandemic on public transit use, and on mobility in general, a few key factors are emerging as likely to have ongoing impacts, according to Watkins et al (2022). These include continuing impacts of telecommuting, as many firms are retaining some telecommuting practices, thereby changing expectations for commuting patterns. Persistent increases in telecommuting can be expected to affect commuter and heavy rail ridership more so than bus ridership, as buses serve more dispersed origins and destinations.

An associated shift may occur in population density, which was already declining pre-Covid, a trend that may be exacerbated by telecommuting, which is associated with residential locations at further distances from work (see previous chapter on telecommuting). While long-term patterns are hard to predict, workers having more flexibility in to work at home also have more flexibility in where they choose to live and may have a need for bigger homes to accommodate home office space.

Other relevant long-term factors include gasoline prices, which have remained generally low (Watkins et al., 2022). Sustained lower travel demand could exert continuing downward pressure on gas prices, making driving a much cheaper option and adversely affecting transit ridership. At the same time, the relative price of transit compared to driving may worsen if agencies are forced to raise fares to recover their financial losses during the pandemic. The key to affordable transit is high ridership on a per vehicle hour basis, and with low ridership per vehicle hour, transit must be subsidized to keep it affordable. The impact of new mobility modes is indeterminate, in particular because ride-hailing services, like transit, also require that users share space.

Going forward, a key question is whether travel mode shifts that occurred during the height of Covid will persist or whether (and how) transit agencies can win back previous riders and draw in new ones. Transit service supply variables—such as service frequency, speed, and reliability; geographic coverage; hours of service; fares; and safety and security—are typically some of the most important factors affecting public transportation ridership (Mallett, 2022). However, as much scholarship has demonstrated, transportation infrastructure and land use patterns have been developed and regulated in the US in a fashion that incentivizes, encourages, and rewards personal vehicle ownership and use (see e.g. Manville et al., 2018). Transit agencies generally have little control over such exogenous forces. An example of a recent policy-related extension of access to car use was the mass success of the driver's license acquisition program in Southern California for undocumented residents (Nelson 2017).

Given this context, Manville et al (2018) contend that transit agencies should focus less on winning back former riders and instead on convincing people who rarely or never use transit to begin riding occasionally, thereby replacing some driving trips with transit. According to a survey conducted in June 2020, the stated likelihood of continuing to use transit post-pandemic was not affected by auto ownership or essential worker status, pointing to an opportunity for transit agencies to attract and recapture ridership among people who have alternate modes of transportation at their disposal (Bradley and Greene 2020).

Policy opportunities

Various specific strategies to address transit challenges have been advanced in recent studies. Taylor and Morris (2015) contend that reducing bus fares, increasing bus frequencies, and expanding center city bus networks are powerful tools demonstrated to be effective for increasing ridership (Taylor and Morris, 2015). A 2018 report written for the Congressional Research Service concludes that bus service can be improved by increasing bus frequency but with fewer stops, and by making travel faster by utilizing dedicated bus lanes and priority for buses at traffic lights, and allowing riders to pay fares before boarding (Mallett, 2018). The report cautions against making transit supply decisions based on assumptions about the cost of ridesharing. TCRP Research Report 209, *Analysis of Recent Public Transit Ridership Trends* (Watkins et al., 2022), a comprehensive effort to understand recent transit ridership trends and possible responses, examined the implementation of specific strategies and related transit ridership effects in case study cities. The authors highlighted five strategies to strengthen transit systems and improve ridership as well as equity outcomes: (1) rethink mission, service standards, metrics, and service delivery; (2) rethink fare policy; (3) give transit priority; (4) consider partnerships with shared-use mobility providers carefully;

and (5) encourage transit-oriented density. The following discussion considers these strategies in more detail.

Internal strategies: Performance metrics, network and service re-design, and fare strategies

The TCRP report contends that, "It is time for the transit industry as a whole to rethink its service standards, service delivery, and performance metrics to ensure that they are reflective of the twin missions of good public transit: to respectfully serve those who rely on transit on a day-to-day basis via greater emphasis on equity of accessibility and service, and to efficiently provide mobility in urban areas" (Watkins et al., 2022). This admonition reflects factors that have come to the fore in recent years, as many transit agencies facing ridership losses for reasons including competition from new modes such as ride-hailing, have sought to evaluate their service levels and network coverage to achieve greater efficiencies in service provided per revenue mile. In turn, the Covid pandemic highlighted the need to serve essential workers and transit-dependent households, underscoring equity considerations that may compete with efficiency strategies aimed only at increasing ridership per revenue mile.

What this means in practice is that transit agencies may need to balance a tension between providing levels of service and network coverage that address mobility needs for essential workers and low-income households (reflecting transit's role as a public service, providing a travel mode "of last resort"), versus undertaking network and service "consolidation" efforts aimed at eliminating low-ridership routes and stops. While these two goals are sometimes mutually supportive, in various cases they are not, requiring decisions to be made about how to balance goals and strategies. Although access to transit—such as distance to a transit stop, hours of service, and service frequency (the time between trains or buses)—is associated with transit use, some efforts to improve use have found the best way to attract riders is to reduce travel times by increasing service frequencies rather than by improving access to stations and stops (Mallett, 2022). The TCRP report, along with other studies, provides examples of cities that have increased transit ridership by "condensing" and re-allocating service through bus network redesigns that eliminate or reduce service on less productive routes enabling service to be added on the most productive routes (Schmitt, 2017; Watkins et al., 2022). This strategy has the potential to increase transit ridership without major budget increases.

The TCRP report found that optimal re-design efforts to maximize equitable transit access could improve ridership, but by considerably less than an optimal re-design meant to maximize efficiency, pointing to some tension between these goals. For this reason, the TCRP report advocates adopting a "wholistic perspective on performance measurement that is human-centric" (Watkins et al., 2022).

These concerns relate to how transit agencies should best design and balance performance metrics. Some transit agencies have started to pay more attention to metrics other than ridership, such as by focusing on increasing accessibility for riders, especially essential workers. Accessibility is a measure of a person's ability to travel to necessary goods, services, and activities. It can be measured in many ways, but one of the most common is the number of jobs that a person is able to reach from their home in a certain timeframe by a certain mode. Transit agencies can increase access to jobs by improving route coverage and frequency from residential areas to nearby job centers (Boisjoly and El-Geneidy, 2017). This can be a difficult balancing act, however, as expanding or adding routes in terms of spatial coverage can come at the expense of temporal frequency. While both coverage and frequency are strong predictors of transit ridership, increased frequency has a slightly larger impact (Lyons, 2017).

The importance of providing job access for essential workers was underscored during the pandemic. As transit agencies re-evaluate performance metrics, they may choose to prioritize transporting essential workers to their jobs more so than transporting white-collar workers who are more able to telecommute. While focusing on access improvements for disadvantaged groups and communities is not necessarily a strategy for maximizing farebox revenues, research has shown that job accessibility is a primary determinant of transit ridership (Ewing and Cervero, 2010; Stevens, 2017). But with ridership revenues generally only covering 20% of the cost of transit in the US, public transit cannot hope to pay for itself in the near future (Schweitzer, 2017). An access-oriented paradigm for transit posits that public transportation's purpose is not to return a profit, but rather to support activities essential to urban life.

California's public agencies generally make good use of accessibility metrics, according to a 2016 study that found the majority of the state's largest metropolitan planning organizations utilize them in their transit system performance reports and future transit plans (Rodier and Isaac, 2016). At the agency level, however, only 10 of 231 California transit agencies were found to employ accessibility metrics.

Several agencies in California, including the San Francisco Metropolitan Transportation Authority (SFMTA), leveraged the Covid disruption to refocus on increasing transit-related accessibility. The SFMTA's Equity Toolkit is a GIS analysis function that utilizes transit routes and schedules along with population and employment data to calculate the overall level of transit access for each census block group of San Francisco. The tool measures how far a person can travel by transit in 30 minutes from each neighborhood, as well as which areas contain the highest numbers of essential workers and vulnerable residents. The program, implemented in 2020, informs transit agencies of potential transit routes that can maximize service for essential workers and vulnerable populations (Maguire, 2021). The tool worked remarkably well, as evidenced by a study of transit service cuts in 30 US cities that found San Francisco to have allocated the most transit service to the highest quantity of vulnerable residents in the city (DeWeese, 2020).

States can encourage transit agencies to prioritize access by implementing funding structures that reward increases in access, instead of basing funding solely on ridership statistics. This would require the establishment of a standard measure of transit access that is applicable in all urban and suburban contexts. This standard metric could come in the form of a comprehensive accessibility score, a number (generally from 1 - 100) that provides a holistic score of how much access is provided by transit to each census block group. This score may be derived from the quantity of jobs, stores, schools, parks, etc. that can be reached from each block group by transit (Pettit, 2015).

A final internal strategy, typically within the control of transit agencies, is to redesign fare policy. Case studies conducted for the TCRP report demonstrated that strategic fare discounts, such as for kids in the summer, seniors, and veterans, could increase transit ridership (Watkins et al., 2022). However, the increase in teleworking and reduction in regular commuting to downtown cores, associated with the pandemic, mean that fare policies may need ongoing review. New patterns of commuting suggest that transit agencies should move away from monthly passes toward fare payment systems that give discounts for frequent but irregular transit use over more flexible time periods. Fare capping, in which riders pay per trip up to a monthly cap, is another promising approach. Pandemic-related changes have created a need for more creativity in transit fare policies.

External-facing strategies: Transit priority, land use policy, and inter-agency cooperation

A strategy that transit agencies can pursue to improve transit ridership substantially without service level increases (without needing to make trade-offs between transit network coverage and service levels provided), is to prioritize transit access and right-of-way in connection to roadway space (Watkins et al., 2022). Prioritizing use of roadway space by transit modes above lower-capacity modes, especially automobiles – such as by giving transit exclusive right-of-way – enables transit to run faster and more reliably, thereby encouraging ridership. Case studies conducted for the TRCP report in Minneapolis–St. Paul, Minnesota, and Cleveland, Ohio, showed that the introduction of high-quality light rail and bus rapid transit improved ridership even with limited service increases.

Various methods can be used to improve transit priority, including physical priority, transit signal priority (TSP), and bus rapid transit. These methods need to be undertaken in cooperation with local government planners and traffic engineers who manage design and operation of streets, while bus rapid transit (BRT) and light rail transit (LRT) systems are by their nature major, complex, and multiyear undertakings (Watkins et al, 2022). Improving transit priority can be a contentious strategy locally, as residents may object to “road diets” that take away roadway space for cars, even if and when those same residents express support for transit on a general basis, such as by supporting tax measures to improve transit (Manville, 2018). To help make it easier for transit agencies, in cooperation with other regional agencies and local governments, to facilitate transit prioritization, the state government could reward such cooperative efforts, such as by establishing a program to direct competitive funds toward them.

Land use policy is another important factor. The relationship between transit use and locally-regulated land use attributes, including permitted development densities and mix of land use types, as well as the provision of transit-supportive pedestrian and bicycle facilities, is well established (Cervero, 2020). High residential and employment density are generally associated with higher transit ridership, and conversely, the long-term growth of low-density suburban and exurban areas in the US has been a major impediment to gaining transit riders.

If transit is to stay competitive in the urban environment, transit agencies need to pursue strategies with regional transportation planning agencies and municipalities to achieve densities and development types that are supportive of transit (Watkins et al., 2022). Various strategies can be pursued, with some California policies and programs providing useful models. For example, AB 2923, adopted in 2018, established a process whereby the Bay Area Rapid Transit (BART) system adopted standards for transit-oriented development (TOD) on BART-owned land within one-half mile of a station, and required that cities and counties with qualifying BART-owned sites adopt those standards into their zoning ordinances by 2020 (BART, n.d.). BART released guidance in 2020 stipulating minimum allowable density at 75 housing units per acre, no minimum parking requirement, and height, floor-area ratio, and parking maximum standards that vary by community type. AB 2923 called for localities to adopt the standards, but BART's guidance serves to indicate the agency's preferences, which must be ironed out with local jurisdictions in terms of how they will apply in specific situations.

A similar policy was adopted in September 2022, by the Metropolitan Transportation Commission (MTC), the federally-required regional transportation planning agency for the San Francisco Bay Area. MTC approved the Transit Oriented Communities (TOC) Policy, intended to help transform how the Bay Area approaches transit-oriented development. Using transportation funds which MTC controls, the policy incentivizes cities and counties in the region to "up-zone" transit-rich areas, making transit, walking, and biking more accessible to the public and maximizing the return on the region's transit investments. To gain access to the discretionary funds available through the program, localities must, in areas located within a half-mile of existing and planned fixed-guideway transit stations, meet requirements for minimum permissible densities for new residential and commercial development, affordable housing production and preservation regulations, parking management, and transit station access and circulation (Metropolitan Transportation Commission, 2022a). To support transit-friendly development, the state government could require that transit agencies and metropolitan planning organizations statewide adopt policies similar to AB 2923 and MTC's TOC policy.

Inter-agency integration is another multi-party strategy that has long been recommended as a means to improve service and ridership. Neighboring transit agencies can coordinate and harmonize their operations by utilizing a single fare payment system, providing contactless payment options, offering coordinated schedules, and providing real-time arrival information. Such integration measures improve rider experience by informing them of wait times and making fare payments easier, and they work to lower agency costs by reducing the need to handle cash payments, ultimately increasing ridership and revenue by making transit easier to use (Cal-ITP, n.d.).

An example of an integration strategy in California Is Seamless Bay Area, a not-for-profit coalition project with the mission of integrating and harmonizing the Bay Area's 27 distinct transit providers into a combined network with a single fare structure. The movement intends to create a system in which transit riders can take advantage of coordinated schedules as they ride city buses, light rail, and heavy commuter rail with a single fare payment (Seamless Bay Area, n.d.). The coalition published a plan in 2020 aimed at boosting Bay Area transit ridership to 135% of pre-pandemic levels through improved inter-agency cooperation (Seamless Bay Area & AECOM, 2020).

Seamless Bay Area was supported by AB 629, a state legislative bill proposed in 2021, which called for the creation of "accumulation passes" for Bay Area transit agencies by 2023 that transit operators would need to accept in at least three adjacent counties. The bill also required inter-agency coordination of fares, wayfinding, signage, and scheduling to be completed within three years of the bill's passage. The bill failed, as did another legislative bill introduced in 2022, SB 917, which also aimed to standardize transit across the Bay Area, by giving riders an easier, one-price trip no matter how many agencies they crossed. However, fears that standardizing fares would result in lower overall revenue led various transit agencies to withhold support initially (Rudick, 2022). An MTC analysis had shown that the proposed cross-subsidization and revenue sharing provisions would lower fares, meaning agencies might face lower revenues (Kamisher, 2022). No-cost transfers between agencies might have led to complicated inter-agency negotiations as to who would get paid at what levels and when. Debate on SB 917 prompted inter-agency negotiations that ultimately resolved many of the concerns, but the bill nevertheless failed in the legislature (Rudick, 2022).

If integration potentially might result in lower revenues, why should BART or other agencies in the region support the effort? By further building ridership (even at a potentially lower revenue point per passenger), BART could build a political case for gaining additional funding from the state and local agencies (Long, 2022). Pre-pandemic, the majority of riders who used more than one agency's service for a trip transferred between BART and another local agency (MTC, 2021). To help rebuild post-pandemic ridership, BART needs to reinvite lost commuters, and fare integration could make the process easier for pandemic-weary commuters (Long, 2022).

This sort of strategy may be especially critical for BART in facing its serious challenges, as the cautious recovery in the Bay Area and the emergence of a remote working regime produces lower farebox revenue and ridership (Long, 2022). Compared to many other transit agencies, BART has far fewer options to manage costs; as a heavy-rail agency only, BART cannot significantly change routing, headways, or scheduling, nor its revenue mix, as significantly increasing prices would be politically opposed (Long, 2022). Therefore, BART must focus on revenue-raising activities, and fare integration provides a strategy to increase overall system ridership while building political capital for non-farebox revenues.

While most integration movements happen on a regional level, the California Integrated Travel Project (Cal-ITP), supported by Caltrans, is a state-level strategy (Cal-ITP, n.d). The program's primary goals are to improve coordination across transit agencies by encouraging contactless payment, more streamlined fare subsidies, and standardized vehicle location and occupancy data sharing techniques to better facilitate trip planning. Cal-ITP has held a series of market-sounding events with transit agency representatives to better understand the feasibility of their goals to improve coordination (Cal-ITP, n.d).

By making transit integration a state-level issue, Cal-ITP can support collaboration and collective problem solving across levels of government, public and private operators, and public research institutions (Cal-ITP & SACOG, 2019). This collaboration can improve rider experience by providing coordinated schedules and payment systems, and increased coordination across neighboring agencies can allow for providing service to a greater number of people. State-sponsored support for inter-agency integration such as Seamless Bay Area and Cal-ITP can leverage funding and policy levers that may not be available at the county or regional level. The slow progress of Seamless Bay Area shows that such support is needed if integration efforts are to succeed.

TNC partnerships

For years, transit agencies have struggled to provide fixed-route transit at appropriate frequencies for people in multiple jurisdictions with varying characteristics. This problem was exacerbated by Covid-related interruptions in many transit services, leaving regular riders with gaps in service. By interrupting the fixed schedules and routes that many transit users had relied upon for mobility, the pandemic indicated that traditional fixed-route transit may not adequately meet transportation demands in a post-Covid future.

In recent years, some transit agencies have started implementing partnerships with transportation network companies (TNCs) as one way to address these concerns. Instead of competing with ride-hailing and other services, these agencies have been proactive in creating formal partnerships with TNCs in order to foster a more synergistic relationship. On-demand microtransit pilot projects have been implemented in Los Angeles, Santa Clara County, and the Alameda-Contra Costa Transit District near San Francisco (Mallett, 2022).

To facilitate mobility outside of their regular routes and schedules, transit agencies can subsidize TNC trips. These subsidized trips can be particularly effective in suburban areas where traditional fixed-route transit is not financially sustainable or effective. Riders benefit from shorter wait times and point-to-point trips, while transit agencies may achieve lower operating costs in serving lower density areas (Sather, 2018). In many contexts, transit-TNC partnerships can be more cost-effective than in-house dial-a-ride style services provided by agency vehicles to mobilize regular riders ("mobility as a service") or disabled people ("paratransit"), because TNCs have the ability to expand and contract vehicle supply in response to demand.

A 2019 review of twenty US transit-TNC pilot programs published by the Transportation Research Board offered a "Partnership Playbook" which reports key findings from transit agencies' beginning attempts at effective TNC partnership (Curtis et al., 2019). The most common target markets for these programs were providing first/last mile access to transit and serving paratransit users, with late night and suburban traveler needs represented as well. Most program designs involved the direct subsidy of TNC trips by transit organizations, with agencies and TNCs collaborating on marketing and customer outreach. Cash payments and over-the-phone reservations were generally available to those without smartphones or credit cards.

Ridership and performance data for transit-TNC partnerships is very sparse, due to the infancy of most pilot programs, and the great hesitancy of TNCs to release any detailed performance data that could be leveraged by competitors (Sather, 2018; Curtis et al., 2019). Coming to a data-sharing agreement was often one of the greatest hurdles in these pilot programs, with TNCs being particularly wary of "sunshine laws" that could require that partnership data be open and available to the public. To ameliorate TNC anxiety regarding data sharing, many transit agencies request coded and anonymized ridership data, and some utilize non-disclosure agreements with TNCs that spell out exactly how shared data will be treated (Curtis et al., 2019).

Transit-TNC partnerships are a concrete policy action that can fill in the holes and gaps of transit services and thereby support transit in a cost-effective manner. However, the potential benefit can easily turn into a harm if the ride substitutes for a trip made by transit. For this reason, maximizing the benefits and lowering the risk that TNCs offer requires delicate preparation and planning (Curtis, et al. 2019). Some studies recommend that to develop effective partnerships, transit agencies should first identify their shortcomings in regard to coverage, and investigate how TNCs might help (Curtis, et al. 2019). Then they should carefully define desired outcomes and measures of success, and carefully design partnership parameters and evaluation processes. Factors that should be considered as fundamental to an effective partnership should include ADA compliance and safety of riders. State-level policymakers can support such partnerships by providing special program funding, and by educating agencies on the best practices for successful partnerships.

Given recent trends, ride-hailing may seem likely to depress overall transit demand in the near future, but that outcome is not a certainty (Mallett, 2022). For much of the last decade, ride-hailing companies and their investors appeared to be subsidizing their services, with one estimate suggesting that the amount riders paid from 2012 through the first half of 2016 may have been 60% of the cost of providing the service (Mallett, 2022). An end to investor subsidization could portend higher prices, along with some other factors such as a possible increase in fuel prices, and challenges to classifying drivers as independent contractors instead of as employees. More costly trips would likely make ride-hailing less attractive as an alternative to public transportation. Given this situation, making decisions about transit service supply on the assumption that TNC service will always be available at a low price might not be prudent.

State assistance

During the pandemic, transit agencies proved their worth and function to the public by providing transportation to essential workers. Transit agencies can leverage this renewed awareness of the value of public transit as a social good (a public service) to advocate for funding and support on this basis. Improving transit access benefits the entire state economy and sustainability goals – transit is a general, not just a localized, public good.

Support from the state government for strategies such as fare integration and supportive land use policies is especially crucial for the future of transit, given internal barriers to coordination and external factors that influence ridership that transit agencies do not control. As the case of Seamless Bay Area shows, state-led efforts such as Cal-ITP may be critical to success of regional policy coordination efforts. The state can also support partnerships between transit agencies and TNCs through funding and incentives as well best practices dissemination.

Transit would also benefit from actions on the part of the state to advance many of the wider strategies that are needed to reduce the relative attractiveness of driving as compared to transit. As this report has demonstrated, many of the factors that explain loss of ridership before and during the pandemic trace to exogenous (external) forces beyond the control of transit agencies. Transit cannot compete with single-occupancy vehicle use when the latter option is substantially cheaper and more flexible. An approach to address this fundamental imbalance would be to price driving in a manner that fully captures its social impacts, such as by imposing road user charges and congestion and parking pricing. The revenues stemming from pricing strategies could in turn be invested in improvements to transit systems, thereby helping to increase ridership while also enhancing transportation equity.

Chapter 4. Ride-Hailing

Transportation Network Companies (TNCs) provide prearranged transportation services for compensation using an online-enabled application or platform (such as smart phone apps) to connect drivers using their personal vehicles with passengers. Uber and Lyft are the largest and best known of the TNCs offering ride-hailing services. These services are often cheaper and more convenient than conventional taxi service. On the other hand, they are more expensive than using transit, though generally faster and more flexible. Ride-hailing services provide an important option for people without cars, thereby helping to enhance transportation equity, but they are also widely used by people who own cars, at least in specific situations.

Pre-Covid trends

After the founding of the major TNCs (Uber in 2009 and Lyft in 2012), use of ride-hailing services grew dramatically. By 2017, TNCs accounted for more than 0.6% of all trips in urban areas, in comparison to buses and passenger trains at 1.7% and 1.1% of trips, respectively (FHWA, 2017). Use of ride-hailing services tripled between 2016 and 2020 (Perri, 2021) with Uber and Lyft reaching 2.6 billion rides in the US as of 2017 (Schaller, 2018). As of 2021, Uber was present in 266 US cities, while Lyft operated in 652 across North America (Uber, 2019; Lyft, 2019), but Uber users outnumbered Lyft users by a factor of more than two (Perri, 2021). The growth of ride-sharing services occurred despite legal battles regarding employee rights, leadership changes, and plenty of bad press surrounding Uber and Lyft, especially for adding to congestion (Isaac, 2017).

TNC use and impacts differ across different groups of users. Pre-pandemic, TNC customers were disproportionately likely to be college-educated, between 18 and 29 years old, and living in dense urban areas (Clewlow and Mishra, 2017). Younger riders took frequent, shorter rides while older riders took sporadic longer trips (Kootie et al., 2017).

Various studies have investigated the impact of TNCs on mode choice and the consequent impacts on vehicle miles traveled (VMT), emissions, and congestion. TNCs can reduce reliance on private car ownership by providing a flexible service for transit riders in case of emergency, and in areas with no or low transit coverage (Hoffman, et al, 2019) while offering a cheaper alternative for vehicle owners for specific trips (Caranza et al., 2016). An important question is whether TNCs complement or substitute for transit, walking, and biking trips. A 2016 survey conducted in San Francisco found that ride-hailing substituted for transit one-third of the time although it also provided first mile/last mile service for some transit users (Shaheen and Chan, 2016). The TNC-transit relationship can depend on many factors, including vehicle ownership, transit system quality, city size, and trip characteristics (Rayle et al., 2016; Young et al., 2020).

Evidence points to a net negative effect of TNC use on transit ridership. Various longitudinal studies have found a negative relationship between TNC intensity and transit ridership. One study estimated that the impact of TNCs on nationwide transit ridership, based on a set of fixed-effect panel models at the MSA level, was a decline in transit ridership of 8.9% after TNCs entered the market (Diao, 2021). Another study indicates that ride-hailing may replace or support transit differently for different trip purposes (Feigon et al., 2018). One study found that bus use decreased while rail use increased as a result of ride-hailing use (Clewlow and Mishra, 2017). An analysis conducted across 209 metropolitan statistical areas (MSAs) found that ride-hailing resulted in 10% to 14% less bus ridership and 2% to 12% less rail ridership in the MSAs studied (Watkins et al., 2022). A study of San Francisco bus ridership between 2010 and 2015 found that TNCs were responsible for a net bus ridership decline of about 10 percent (Erhardt et al., 2021). When TNCs substitute for transit use, overall VMT is likely to rise because TNCs operate at a lower passenger occupancy rate (Fulton et al., 2017; Erhardt et al., 2019).

While these research findings indicate that ride-hailing may contribute to declining transit use, the relationship is still not well understood (Watkins et al., 2022). When ride-hailing enters a market, the effects are not immediate, instead building over time as ride-hailing companies are able to recruit more drivers and serve more passengers. Watkins et al. (2022) found that in the largest MSAs, bus ridership decreased by a net 1.9% per year after ride-hailing enters the market, while for mid-size and smaller MSAs, bus ridership decreased by 3.4% per year. When ride-hailing entered a market, rail ridership in medium-sized MSAs was found to decrease by a net 2.2% for each year after ride-hailing's entry, but rail ridership in MSAs with a larger amount of transit remained resilient. The authors attributed these differences to possible greater transit resilience in bigger, denser cities, where rail systems tend to be older and better integrated into the urban fabric. Ride-hailing may affect rail ridership less than bus ridership also because rail offers a travel-time advantage that bypasses congestion, or because rail tends to serve longer trips that would be more expensive to serve end-to-end with ride-hailing.

If ride-hailing substitutes for private vehicle use, the outcomes could be more beneficial, though the likelihood of that depends on whether customers own cars. A study of three major US markets (San Francisco, Los Angeles, and Washington, D.C.) from 2015 to 2017 found that Lyft and Uber reduced passenger VMT and GHGs overall (Abonour, 2021). Between 6 to 9 percent of survey respondents in each city indicated they would acquire a vehicle if Uber or Lyft should stop their services; however, current vehicle owners were less likely to give up driving because of Uber or Lyft. Another study found that VMT impacts vary depending on vehicle ownership, with VMT reduced for TNC users with driver's licenses and access to household vehicle, but not for users lacking drivers licenses or access to a household vehicle (Wu and MacKenzie, 2021). Ward et al. (2021) estimated that shifting from private vehicles to TNCs can produce a 50−60%

decline in air pollutant emissions of NOx, PM2.5, and VOCs per trip, due to avoided "cold starts" and relatively newer, lower-emitting TNC vehicles.

However, foregone driving by TNC passengers is not the only consideration when assessing overall impacts of TNCs on VMT and emissions: driving by TNC vehicle operators also must be considered. The previously cited study of TNC impacts in San Francisco, Los Angeles, and Washington, D.C. found that VMT from TNC vehicle operators exceeded the estimated reduction in passengers' personal vehicle use, meaning the net effect of TNC use was an increase in VMT. TNCs were similarly estimated to have increased VMT in New York City (Schaller, 2018). The increase in net VMT found in these studies reflects "empty miles" traveled by the TNC operators to reach pick-up locations and then travel away from drop-off locations. TNC vehicle operators also often drive empty miles in search of nearby customers. Empty miles make up 20 to 40% of all TNC VMT (Shaheen et al., 2018).

TNCs have thus been widely blamed for increasing congestion. Erhardt et al. (2019), for example, found that between 2010 and 2016, congestion as measured by vehicle hours of delay, increased by 60% in San Francisco, California, with two-thirds of that increase attributable to ride-hailing. Another study found that average speed declined by 8% from January 2013, to November, 2015, in Shenzhen, China, after TNCs were introduced (Nie, 2017). TNCs were estimated to account for between one percent and three percent of total regional VMT in six US metropolitan regions, including Boston, Chicago, Los Angeles, San Francisco, Seattle, and Washington, D.C., in the month of September 2018; TNC's share of VMT in the central urban areas of these regions was over 13 percent during the same timeframe (Balding et al., 2019).

A pre-Covid strategy employed by TNC firms to quell complaints about congestion impacts and also to improve operation efficiency is ride-pooling, in which customers with nearby origins and destinations are encouraged to share a ride. Lyftline and UberPool, introduced in 2014, provided rides at half the normal price if the ride was shared with another customer. Both companies expended considerable resources pre-pandemic to promote shared rides, achieving mixed results. Challenges included matching algorithms that sometimes struggle to consistently match pooling riders (even in dense urban areas), lower satisfaction rates reported by consumers of shared rides, and reports that many customers (especially women) felt uncomfortable and unsafe sharing vehicles with strangers (Zipper, 2021). Nevertheless, Uber and Lyft indicated that, in 2017, pooled rides made up 20-40% of all trips in cities in which pooling programs were implemented (Shaheen and Cohen, 2019). The service was popular in part because many customers were not matched with other customers, meaning that they ended up with a private trip at a cheaper rate (Zipper, 2021). Both companies suspended their shared services in March 2020.

The net impact of ride-hailing depends on the counter-factual choice: in the absence of ride-hailing, would the trip still have been made, and if so, what mode would have been used? Considering the overall external cost of TNC services, including congestion, emissions, and noise, Ward et al. (2021) estimated that altogether, TNCs increase costs per trip by 30-40%, or about $0.35, per trip, but when TNCs displace transit, walking, or biking, rather than personal vehicles, the increase in externalities was estimated to be about three times larger (+$1.20 per trip).

Ride-hailing during and after the pandemic

The pandemic hit TNCs hard. Stay-at-home orders caused demand for ride-hailing services to all but disappear. Uber reported an 80% decline in ride bookings in April 2020 compared to 2019 (Urbanism Next, 2021). TNCs were promptly forced to cut approximately 15% of their workforce in May 2020 (Higgins and Olsen, 2020). To promote social distancing, TNCs canceled ride-sharing programs such as UberPool, further lowering revenues (Siddiqui, 2020). Consumer preference for shared rides went down, as demonstrated by a before- and during-pandemic survey that reported that TNC customers were less likely to share a ride even if it saved them money (Jabbari and MacKenzie, 2020).

Both Uber and Lyft tried to remain in the market by offering reduced-cost rides, and offering discounted services to healthcare workers, seniors, and families with low incomes and with children; they provided over 10 million rides during the pandemic to essential workers (Urbanism Next, 2021). With a big drop in demand for ride-hailing, the firms worked to increase customer sign-ups for alternative services such as food and grocery delivery, offered at a discounted rate (Urbanism Next, 2021).

Since drivers were not obligated to work for only one company, many decided to switch to delivery services for competitive companies rather than take on the risk of interacting with multiple passengers. The switching between companies favored Uber over Lyft because Uber had introduced delivery services and doubled down with UberEats, which offered drivers passenger-less rides (Siddiqui, 2021). The gross number of bookings for Uber's delivery services doubled from 2020 to 2021 (Uber Investor, 2021).

As pandemic restrictions were lifted region by region, TNC demand began to recuperate. Uber first reported substantial gains in cities like New York City, which bore the brunt of the pandemic. As of June 2021, sales were back to 65% of pre-pandemic levels (Perri, 2021). Nationwide from 2020 to 2021, public transportation made up 5% of lost trips, while Uber gained back 27% (Vigderman, 2023). Uber was able to catch up more easily than Lyft because of its diversification beyond ridesharing into delivery services such as Uber Eats, as well as a freight service for commercial trucking. Meanwhile, Lyft was still struggling to deal with problems such as driver shortages in addition to the pandemic (Siddiqui, 2021).

The most glaring casualty of the pandemic for TNCs may be the shared ride. According to many scholars and policymakers, the concept of sharing is integral to an efficient and sustainable future transportation system (Watkins et al., 2022; Alemi et al., 2018). While they introduced more services and targeted a wider population during the pandemic, TNCs were slow to restart their shared services, with Lyftline returning in July 2021 and Uber's renamed UberX Share returning in 2022. Shared services are essential for the goal of VMT reduction, pointing to the need for policies that aid TNCs in providing pooled rides, a topic addressed further below.

Looking forward, the future of TNCs remain somewhat uncertain. If the firms build on and increase delivery and local commerce services, while also rebuilding mobility services, TNC use and profits may ultimately far exceed pre-pandemic levels. Uber's total revenue grew 13% quarter-over-quarter in the last quarter of 2020 (Uber, 2021), indicating that the firm was quickly catching up on lost business caused by the pandemic. The firm's delivery services grew 224% in 2020 compared to the previous year, while their mobility revenue grew 8% in the last quarter (Uber Investor, 2021). Uber also made new investments during the pandemic such as in local commerce and delivery businesses, and acquiring competitive businesses such as Cornershop and Postmates, as well as lowering their cost base (Uber Investor, 2021).

While these factors suggest that ride-hailing could continue to depress overall demand for transit use, that outcome is not a certainty, as noted in the earlier chapter on transit. For much of the last decade, ride-hailing companies and their investors appeared to be subsidizing their ride-hailing services, with one estimate suggesting that the amount riders paid from 2012 through the first half of 2016 may have been 60% of the cost of providing the service (Mallett, 2022). An end to investor subsidization could portend higher prices going forward, along with other factors such as a possible increase in fuel prices, and challenges to classifying drivers as independent contractors instead of as employees. More costly trips would likely make ride-hailing less attractive as an alternative to public transportation.

To address concerns about the impact of TNCs, some transit agencies have sought to turn TNCs from competitors into partners, as discussed in the chapter on transit. Ideally, ride-hailing complements transit services by providing first/last mile service, similar to other emerging technologies, such as bike sharing and e-scooters, and by providing service outside of transit service hours and areas. Strategies have included partnering with TNCs to provide subsidized rides in these circumstances. However, the transit gap-filling potential of TNCs is not as readily available to neighborhoods with lower income levels, raising equity concerns (Barajas and Brown, 2021).

Policy opportunities

The introduction of ride-hailing services offered by TNCs to the transportation market has significantly affected travel patterns in recent years, with impacts including an increase in VMT, emissions, and road congestion, along with a reduction in transit ridership. Absent policy intervention, and assuming that TNC use returns to and exceeds beyond pre-Covid levels, such negative impacts for transport sustainability are likely to continue to grow.

The state government can play a key role in ensuring that benefits from TNC are supported while dis-benefits are discouraged. Some policies have been adopted in California to address negative impacts of TNCs. The Clean Miles Standard Program (CMS), established through state legislation adopted in 2018, is a joint effort by the California Air Resources Board (CARB) and the California Public Utilities Commission (CPUC) to gradually reduce GHG emissions from passenger ride-hailing services operated by TNCs such as Uber and Lyft. The regulation establishes vehicle electrification and GHG emission reduction targets that TNCs are required to meet on a gradual basis through vehicle electrification, increasing vehicle occupancy, decreasing deadheading, investing in active transportation infrastructure such as sidewalks and bikeways, and/or facilitating connections to transit.[1] Stipulations include that 2% of all TNC trips must be in electric vehicles (EVs) by 2023, ramping up to 13% by 2025, 50% by 2027, and 90% by 2030.

Even with electrification, however, the negative impact of TNCs on VMT and congestion remains problematic. For this reason, congestion management policies, such as roadway and parking pricing and street redesign to favor transit, are additional potential solutions to negative TNC impacts (Abonour, 2021). These strategies are discussed in other chapters.

Policymakers could also take additional action to ensure that TNCs provide pooled rides at lower prices than solo rides. Some California localities, including San Francisco and Berkeley, already have instituted taxes for TNC trips that favor pooled rides. San Francisco imposes a 3.25% tax for trips originating in the city, with a reduced 1.5% rate for pooled rides; rides in electric vehicles, whether pooled or single-passenger, are taxed at 1.5% for five years.[2] Berkeley taxes ride-hailing trips at $0.50 per ride originating in the city, with a reduced rate, $0.25 per ride, for shared rides. Exemptions are also provided for trips paid for by a government healthcare program and wheelchair-accessible trips.

State agencies could support efforts to increase pooled rides starting by identifying groups most likely to use ride pooling and supporting increased usage among them. A 2018 survey conducted in Los Angeles, San Jose, Sacramento, and the San Francisco Bay Area examined the characteristics of those most likely to use TNC ride pooling (Lazarus et al., 2021). The survey found that frequent (at least once per week) users of TNCs were much more likely to use ride pooling. These frequent riders were disproportionately either young, high-income Caucasians or lower-income black people.

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[1] For more information see https://ww2.arb.ca.gov/resources/fact-sheets/tnc-driver-fact-sheet

[2] For more information, see https://www.sfcta.org/funding/tnc-tax

To increase the attractiveness of ride pooling among frequent riders, state agencies could support local strategies such as designating pick-up and drop-off zones in residential and commercial areas so as to make pooled trips timelier and more efficient. Additional strategies include subsidizing pooled rides to make them more economically attractive to potential riders, and providing discounts for any public transit trips that pooled rides connect to, in order to encourage pooling as a first-last mile solution (Lazarus et al., 2021). State governments can assist municipalities in these efforts by providing appropriate funding and best-practices training. Such strategies help to enhance transportation equity.

The state government can also help in supporting partnerships between TNCs and transit agencies to help ensure that TNC use complements, rather than substitutes away from, transit use. As noted in Chapter 3, in recent years, some transit agencies have started implementing transit-TNC partnerships, for example, by subsidizing TNC rides, as a cost-effective way to provide service in areas and at times when fixed-route transit service is inadequate, and to improve first/last mile access to transit. However (as also discussed in Chapter 3), effective partnerships need to be carefully designed and monitored. The state government could assist in such efforts by funding research on what makes partnerships succeed or fail, and in funding partnerships, particularly those that aim to serve lower-income travelers.

Chapter 5. E-shopping

E-shopping patterns before and during the Covid pandemic

Shopping patterns were changing in fundamental ways even before the pandemic. New devices and interfaces, as well as delivery services, had facilitated and improved the online shopping experience, fostering substantial growth in e-commerce (UPS, 2018). By the late 2020s, about 80% of all shopping activities were influenced by e-commerce either in the search process or for final purchase (UPS, 2018). At the macro level, before the pandemic, e-shopping had been growing rapidly (at double digit growth rates year-over-year) for over a decade. In the US, the e-shopping share of total retail sales had grown from 5% at the end of 2013 to about 11% at the end of 2019 (Statista, 2022). Even so, in 2019, the average US resident visited a grocery store 1.6 times per week (Tighe, 2020).

When the pandemic hit in 2020, statewide and city lockdowns prevented people from leaving their homes to stay safe and minimize the spread of the Coronavirus. In 2018, 22% of the U.S. population purchased their groceries online; in March of 2020, 42% did so at least once a week, showing that the pandemic contributed to a near doubling of online grocery sales (Mohsin, 2021). E-shopping peaked at nearly 16% of overall retail sales in the second quarter of 2020 before declining somewhat but still remaining well above the pre-pandemic share US Census Bureau, 2021). The U.S Census Bureau reported a 43% increase in e-commerce sales in 2020 compared to e-commerce sales in 2019 (Brewster, M. (2022). Similarly dramatic increases in e-commerce were observed globally (Feichtinger, 2021; SmartHint, 2021).

The growth in e-commerce has slowed as the pandemic has eased. From 2020 to 2021, e-commerce sales in the US rose by 17.3%, much less rapidly than the previous year, but at a slightly higher rate than all retail sales over the period (US Census Bureau, 2022). The following year, as Covid fears continued to ease, the year-over-year growth rate for e-commerce slowed to 7.7%, the slowest rate since 2009. The slow-down in e-commerce growth reflected the re-opening of many shopping locations and the return of shoppers to stores. Nevertheless, the growth rate was still higher than for total retail sales, which grew by 6.8% (Conley, 2023).

Post-covid projections for e-commerce and implications for travel

In the coming years, e-shopping is expected to continue to grow but at a slower rate. A survey by McKinsey & Co. found that nearly 70% of consumers intended to continue to shop online post-Covid (Torry, 2020). Another study found that about a fifth of Americans intend to visit shopping centers and indoor malls less frequently than they did before the pandemic (Nguyen, 2021). In contrast, a survey by Gekko found that 70% of respondents were planning to visit stores as much or more than pre-pandemic because they were excited to get back in stores (Gekko, 2021). Delivery services are likely to remain more popular than before Covid. In 2020, CommerceHub surveyed US consumers and found that 69% of respondents would be more willing to subscribe to a delivery service following the pandemic (Berthiaume, 2020). Although many factors will affect future trends, e-commerce is projected to increase as a share of all retail sales to 24.5% in 2025 (Chaffey, 2023).

A major question about e-commerce is how it will affect VMT. The growing shift to purchasing goods online rather than in person may allow consumers to make fewer car trips or even go without a car altogether. The flip-side of potential reductions in personal shopping VMT induced by e-commerce is goods delivery VMT, which must also be accounted for. Some studies have sought to examine and compare the role of personal shopping VMT to freight delivery VMT, to get a better handle on net effects of e-shopping. Some of these studies paint an optimistic picture. A study by the firm KPMG, building upon findings from U.S. Bureau of Transportation Statistics and U.S. National Travel Surveys, found that e-commerce may reduce total VMT and carbon emissions because delivery trucks act as a substitute for personal shopping trips and generate 30 times less travel than people driving to stores, thereby reducing traffic congestion (Cortright, 2020). KPMG estimated that the growth of on-line shopping and delivery could reduce shopping trips by 10 to 30 percent in the future which is equal to up to 5 percent of all personal VMT (Cortright, 2020). The fact that multiple deliveries are often consolidated into one trip would also contribute to a reduction in VMT (Cortright, 2020). By some estimates, the rise of e-commerce has already contributed to a 7% decline in greenhouse gas emissions as a result of eliminating single-purpose shopping trips using personal vehicles. This suggests that further reductions in transportation externalities might be possible with even greater market penetration of e-commerce (Jaller and Pahwa, 2020).

On the other hand, a number of studies (Sadik-Khan, 2021; World Economic Forum, 2020; Jaller and Pahwa, 2020) find that e-commerce may not reduce traffic congestion or emissions. These studies project congestion to rise due to more delivery vehicles on the road (Sadik-Khan, 2021). The expected increase in delivery services could mean the total number of delivery vehicles increases by 36% between 2019 and 2030, emitting 6 million tonnes of CO_2, and increasing congestion in cities, in one estimate (World Economic Forum, 2020; NACTO, 2021). The discrepancies between these studies and those suggesting that e-commerce will reduce VMT and GHG emissions points to the need for continued research on this topic as the nature of e-commerce evolves. Comparing VMT impacts of in-store and online shopping, Jaller and Pahwa (2020) found that the impact on VMT and emissions is less a question of the choice made between online versus in-store shopping, and instead is more dependent on the efficiencies in methods and practices involved in each. This conclusion implies that the behavior of both consumers and delivery firms warrants policy attention. Further research is needed to understand the role that different stakeholders, including planners, regulators, the private sector, and consumers, can play in minimizing the negative impacts of online shopping, which is increasingly becoming the norm in everyday life (Jaller and Pahwa, 2020).

Trip consolidation is a key factor in the impact on VMT and emissions for both personal shopping and delivery vehicles. A USDA survey found that in 88% of US households, people drive an average of 4 miles to their preferred store, and if each of these households took at least one trip per week, that would add up to over 42 billion miles driven round-trip each year (USEPA, 2021). If individuals consolidate their shopping trips and buy everything they need in one trip without returning to the store later in the week, emissions would be lower than if individuals shop multiple times per week. The same logic applies to goods delivery. Potential VMT and emissions from delivery services are dependent on many factors including whether companies can flexibly deliver at times that allow them to make multiple deliveries in one trip, and whether customers order multiple items for delivery in one trip rather than multiple trips, and whether or not they choose long delivery windows. As more trucks than ever will be entering cities due to e-commerce, the impacts of rush deliveries, basket size, and purchase consolidation levels become important to consider (Jaller and Pahwa, 2020).

The inevitable growth in goods movement points to the importance of devising means to manage the urban freight system for efficiency, including both delivery services and operations, to foster a more sustainable urban environment (Jaller and Pahwa, 2020). Urban freight transport already makes up a quarter of all traffic in cities, and up to 40% of air and noise emissions (Ch'ng, 2020; Morfoulaki et al., 2016). The "last mile," usually defined in freight logistics as the segment of a parcel's journey from a local distribution center to its final destination, occurs within cities, unlike travel to regional warehouse or distribution centers. The last mile represents over 50% of total shipment costs due to reduced economies of scale, congestion and parking fees, and conflicts over road space in urban areas, resulting in time lost for the carrier (Exon-Smith, 2023; Rodrigue et al., 2017; Dolan, 2023). Heavy delivery vehicles also cause disproportionate wear and tear on roads and contribute to safety incidents and congestion inefficiencies.

The growth of e-commerce has thus called attention to the need for cities to plan for urban freight so as to manage the increasing volume of shipments and where and how they are delivered (Exon-Smith, 2023). Greater competition in the parcel delivery industry has led to rapid innovation, new participants, and new business models entering the marketplace. Three consequent emerging trends present planning and policy challenges and opportunities: changes in the geography, timeframes, and mode of deliveries, the latter based on a rise in crowdsourcing models for covering the last mile (Exon-Smith, 2023).

The first trend is the change in the geography of deliveries stemming from the growth in home deliveries. While business-to-business shipments remain the largest share of delivery trips, the business-to-consumer segment is growing, anchored by home deliveries (Exon-Smith, 2023). This is the default choice for the majority of online shoppers, including three quarters of millennial customers for whom this is the preferred option (Bimschleger et al., 2019). Home deliveries introduce heavy vehicles into residential areas, with accompanying challenges of noise, safety, and emissions (Exon-

Smith, 2023). As last-mile distribution patterns change, carriers must contend with the need to modify networks and location of warehousing and other distribution infrastructure. Freight logistics strategies need to contend with both dense urban and suburban residential areas.

The second trend is the increasingly short timeframes for delivery. The rise of same-day or two-day shipping as standard and free, through subscription services such as Amazon Prime or Walmart+, has normalized into an expectation (Bimschleger et al., 2019; Exon-Smith, 2023). This presents challenges for both shippers and cities. With lead time, shippers can aggregate purchased items into a single truck shipment from a warehouse, but this advantage diminishes when time frames between order and fulfilment are reduced, eliminating economies of scale and potentially any VMT or emissions savings (Jaller and Pahwa, 2020). The increase in grocery delivery that occurred during the pandemic amplified this trend, with services like Amazon Fresh and Prime Now offering two-hour delivery. One way Amazon has been able to meet tight delivery turnaround times is to move its sortation centers closer to urban areas, often using repurposed light industrial sites (Rodrigue, 2020).

More deliveries with shorter lead times contribute to the third major trend, the rise of crowdsourced models for the last mile (Exon-Smith, 2023). While major parcel carriers such as UPS, FedEx, and the postal service still carry the majority of freight, new services have emerged within urban areas, leading to a doubling in the volume of parcels delivered by smaller carriers between 2020 and 2021 (Garland, 2022). Even large companies like Amazon rely on subcontracted delivery service providers such as for the Amazon Flex program. As a result, more delivery drivers and vehicles are on the road than ever before, although they are often unidentifiable as such, presenting a challenge for cities to regulate (Exon-Smith, 2023).

The environmental impacts of e-commerce are further complicated when considering unsold products, product returns, and packaging (Pålsson et al., 2017). Many factors affect the environmental impact of goods movement including population density, packaging, return rate, delivery time, package size, and unsold products (Feichtinger and Gronalt, 2021). E-commerce has the potential to be energy-reducing if personal VMT decreases and delivery services help consolidate package deliveries, but an additional negative externality of ordering online is the amount of plastic included in packages which end up polluting the environment. Approximately 98% of product packaging (e.g. plastic air pillows and bubble wrap) shipped in e-commerce was created for delivery to traditional retail stores, not for online purchases, which has resulted in unnecessary use of plastic (Smithers, 2018). In 2020, Amazon generated nearly 500 million pounds of plastic packaging and more than 22 million pounds ended up in rivers and oceans (Vetter, 2020). Plastic waste causes immense harm to marine environments and entering the food cycle.

Policy opportunities

The growth of e-commerce has called attention to the need to develop comprehensive urban freight plans at multiple levels, to address how the increasing volume of freight shipments should best be delivered from the standpoint of both greenhouse gas emissions as well as the negative impacts of freight on residential neighborhoods (Exon-Smith, 2023). However, even regions and localities with sophisticated and long-established passenger transportation policies have lagged in policymaking for freight (Exon-Smith, 2023). State, regional, and local-level strategies can target logistics infrastructure, firms and drivers, and vehicles themselves to minimize the negative impacts of e-commerce, including GHG emissions, as well as emissions of other pollutants (such as particulates), noise and vibrations, and traffic congestion, which tend to disproportionately affect disadvantaged communities. These strategies can be organized in three categories that match the widely used improve-shift-avoid paradigm for promoting sustainable transportation: first, setting standards for shippers, vehicles, and drivers; second, regulating delivery times and spaces; and third, encouraging consolidation where possible (Exon-Smith, 2023).

Setting standards

Standards for fuel efficiency in freight delivery can address heavy, medium, and light vehicles. Heavy freight vehicles that run on diesel are much less fuel-efficient than cars, averaging 7.5 miles per gallon (Wygonik and Goodchild, 2018). As with passenger vehicles, there has been a push to improve the vehicle and fuel efficiency of freight delivery; however, progress toward electrification has been slower for freight (Exon-Smith, 2023). Without steps to decarbonize freight delivery, an additional six million metric tonnes of carbon dioxide will be released into the world's largest cities in 2030 than were in released in 2019, according to a study by the World Economic Forum (2020).

To promote "green" goods delivery in California, the state adopted SB 671, the Clean Freight Corridor Efficiency Assessment, in 2021 to pursue identification of freight corridors and infrastructure needed to support the deployment of zero-emission medium and heavy-duty vehicles (SB 671 text, 2021). The new law establishes a commission that will advance strategies to reduce emissions and congestion, provide alternative infrastructure for charging and fueling, improve road safety and resiliency, and reduce impacts to neighboring communities (SB 671 text, 2021). The law requires that the commission create the Clean Freight Corridor Efficiency Assessment to identify freight segments of corridors that would be suitable for the development and use of zero-emission medium and heavy-duty vehicles. The priority corridors will be slated for improvements in medium and heavy duty charging and fueling infrastructure, highway improvements needed to accommodate the infrastructure (including parking facilities), and improvements to local or connector streets and areas where micro-grids or similar technologies could be deployed for charging and fueling.

At the local level, many cities, especially in Europe, have instituted low-emission zones (LEZs) to incentivize faster uptake of more fuel-efficient passenger and freight vehicles (Exon-Smith, 2023). These work by prohibiting or charging access to certain zones for all but zero-emission vehicles, pedestrians, and cyclists, and are generally enforced with license-plate camera readers or controlled points of entry (Steimer et al., 2022). LEZs allow cities to pilot urban mobility solutions to tackle air pollution and congestion in designated areas rather than across a whole city (NACTO, 2021). The scope for this policy could be implemented at the neighborhood, city, or regional level, with goals including social equity, road safety, revenue generation, and air pollution reduction. The City of London, a leader in urban freight policies, has enforced an Ultra Low Emission Zone since October 2021, in the same area as its Congestion Charge Zone implemented in 2003. Older and higher-emission vehicles are prohibited from entering the zone or they face fines. An evaluation of the measure six months after implementation found a 31% drop in NOx emissions from road transport (Quarshie et al., 2021).

In California, the City of Santa Monica partnered with the Los Angeles Cleantech Incubator to pilot a zero-emissions delivery zone in 2020 for one to three years. This zone, within which businesses can participate voluntarily, is used to pilot green mobility technologies such as e-cargo bikes and electric delivery vehicles, innovative curbside management practices such as prioritization and digital bookings of curb spots (NACTO, 2021). Santa Monica's pilot allows partners to have the opportunity to learn and participate in zero-emission, last-mile solutions such as e-cargo bike deliveries, zero-emission light and medium duty vehicles, curbside management, and other innovations. The pilot also enables participants to form new partnerships with a variety of stakeholders, and influence what organizers hope will become a blueprint for other cities.

Low-emission zones can be effective measures, but they also can be perceived as aggressive intervention into market behavior, and they require an investment in enforcement from cities (Exon-Smith, 2023). They can be challenging for carriers to comply with and can impose disproportionate impacts on smaller operators with less ability to invest in fuel-efficient upgrades. To aid compliance, some cities offer subsidized access to electric rental vehicles in the designated zones. Cities can also apply vehicle restrictions to smaller areas such as loading zones or curbsides (Exon-Smith, 2023).

Regulating delivery spaces and times

Strategies to regulate delivery spaces and times are a second way to manage freight impacts, with the goal being to shift freight traffic away from busy times of day and other road users, particularly vulnerable ones, through regulation and infrastructure changes (Exon-Smith, 2023). To manage truck traffic in and out of urban areas, cities and metro areas can build truck lanes on major thoroughfares, possibly in combination with High Occupancy Vehicle (HOV) or High Occupancy Toll (HOT) lanes. These lanes can relieve some congestion from trucks sitting in traffic, enabling faster and more reliable travel times, an incentive for carriers (Exon-Smith, 2023). However, HOV and HOT lanes are expensive to create and maintain, particularly with the wear and tear heavy vehicles exert on pavement (Morfoulaki et al., 2016).

Cities and regional agencies can also recommend or enforce specific freight routes for an entire urban area, or down to the neighborhood level, to reduce conflict with other road users and reduce impacts on neighborhoods. This strategy requires enforcement, which might be difficult or expensive for cities to manage (Exon-Smith, 2023).

Another strategy gaining increasing attention is to regulate the curbside at the point of unloading and delivery (Exon-Smith, 2023). Parking and unloading is the most expensive and inefficient part of the delivery for carriers, causing significant congestion and risk of road conflicts. One study from London found that delivery vans are parked 62% of the time, when they can find parking (Corporate Partnership Board, 2018). Parking scholar Donald Shoup reports that, on average, 30% of VMT in urban areas is caused by vehicles circling and searching for parking (Shoup, 2006).

Curbside management can reduce congestion and emissions caused by parking violations and extended cruising times of freight vehicles, as well as help maintain road safety (Exon-Smith, 2023). Tactics include establishing and pricing courier loading zones, easing deliveries during off-peak hours, and regulating vehicles such as by allowing cargo bikes in loading zones (NACTO, 2021). Many curbside management tactics can be implemented simply by creating or amending regulations, such as allowing deliveries in off-peak hours.

Pricing curb spaces can lessen delivery time and provide income for cities (Exon-Smith, 2023; Clewlow, et al., 2020). This policy approach was tested at the District Department of Transportation (DDOT) in Washington, D.C. Initially, delivery companies resisted paying the required curbside fee, but as they began to see the benefits, they became more amenable. Benefits included increased parking reliability and time savings for loading and unloading. The curbside management tactics decreased the number of double-parking violations and non-truck parking in loading zones by more than 50 percent (NACTO, 2021).

Shifting delivery to off-peak hours is another promising strategy. Night deliveries, although sometimes challenging for carriers, can potentially decrease congestion costs and parking challenges significantly, and reduce delivery times (Anderson et al., 2005) The creators of an award-winning off-hours (7 p.m. to 6 a.m.) delivery pilot program in New York City contend that if just 20% of deliveries in the city were shifted to off-peak hours, carriers would save $100-$200 million per year in delay costs, and reduce 200 metric tons of carbon monoxide, 40 metric tons of hydrocarbons, and 12 metric tons of nitrous oxide annually per capita, along with producing fuel savings for carriers (Holguín-Veras et al., 2015).

Competition for the curb reflects a lack of adequate dedicated space for deliveries (Exon-Smith, 2023). Creating dedicated commercial loading zone areas and/or enabling smaller zero-emission delivery vehicles to access the same areas as courier trucks can improve the range of use of commercial loading zones. The City of Toronto created freight staging areas and even temporary loading zones in front of fire hydrants (Lee, 2020). Cities can also incentivize use of smaller vehicles that take up less space, such as cargo bikes or small vans, by prioritizing access by vehicle type, as noted above. Another often optimal choice is to remove loading bays from curbs altogether where possible, onto side streets or other areas with less traffic, a strategy useful to many carriers who often value reliable access to a loading zone more highly than proximity (Lee, 2020).

The San Francisco Municipal Transportation Agency's (SFMTA's) Curb Management Strategy provides a good example of how to approach curbside management to address freight and delivery concerns. With an abundance of new travel modes and on-demand delivery services, San Francisco has experienced more traffic congestion and emissions, and ongoing safety concerns (Curb Management Strategy, 2020). To address these concerns, SFMTA's Curb Management Strategy aims to provide a roadmap for managing and allocating the city's limited curb space that is responsive to and anticipates current and future demands for curb access (SFMTA, 2020). The strategy identifies five key curb functions which are prioritized differently depending on location in town: access for people, access for goods, public space and services, storage for vehicles, and movement. In the most active and dense parts of San Francisco, access for people and access for goods are given top priority while private car parking is lowest priority. After first allocating curb space for the highest priority functions, remaining curb space is then allocated to the lower priority functions (SFMTA, 2020).

For each area Curb Management Strategy applied in different parts of town, six objectives are to be implemented: advance a holistic planning approach; accommodate growing loading needs; increase compliance with parking and loading regulations; improve access to up-to-date data; rationalize policies towards private users of curb space; and promote equity and accessibility (SFMTA, 2020). For every strategy identified, the level of implementation effort necessary is identified, encompassing both financial requirements and human capital needed.

Each objective also identifies specific goals within it. For example, the first objective is to advance a holistic planning approach and the strategies include: supplement the locally-request-based Color Curb Program for allocating curb space; evaluate and revise Color Curb Program charges; simplify hours and days of enforcement of parking regulations, to make them easier to communicate and enforce; and manage parking for city service vehicles (SFMTA, 2020). Strategies for the second objective include implementing loading zone design standards, relocating and combining zones to maximize utility, and extending hours at loading zones to nights and weekends when warranted.

The state could assist localities in developing and adopting similar program approaches to SFMTA's Curb Management Strategy, by providing funding and dissemination of best practices for the purpose.

Encourage consolidation

The third type of strategy identified for addressing urban freight challenges is to encourage consolidation where possible through new infrastructure and demand management (Exon-Smith, 2023). Consolidation, whether of vehicles or parcels, is one of the most effective ways to lessen freight's negative impacts (Beckers et al., 2022). Both strategies recapture economies of scale that can enable e-commerce to be more sustainable than individual shopping excursions (Exon-Smith, 2023). Consolidation through cooperative carrier models has proved successful at reducing trips in central London, Seoul, and Bogotá, using neutrally-branded vehicles for last-mile deliveries when serving the same section of a city. Participating firms reduced vehicle miles traveled by 25-75% (McLeod et al., 2020).

Cities and regions can encourage this kind of consolidation by creating collaborative logistics infrastructure zones, also called delivery micro hubs (NACTO, 2021). Delivery micro hubs are a type of urban consolidation center located between major suburban warehouses and final delivery destination points, which serve a radius appropriate for the density of the area and close enough to allow for packages to be delivered to the consumer within about a 15-20 minute bike or vehicle ride from the hub. The hubs can reduce congestion and freight-related emissions as well as delivery times. The first urban distribution micro hub created in Paris was able to handle 6,500 parcels a day, reducing driving distances by 52 percent, noise from delivery vehicles by 8 percent, and delivery-related CO2 emissions by half (NACTO, 2021).

Micro hubs should be located in accessible buildings in areas with high demand for deliveries from businesses and households - three miles or less distance from the final destinations. Courier companies and businesses should be involved in design and operation, and it is also useful to encourage businesses to develop partnerships with courier companies that use small clean vehicles to complete last-mile deliveries (NACTO, 2021).

Just as with passenger travel, a key part of managing freight is demand management (Exon-Smith, 2023). As discussed above, delivery trip generation is determined not just by carriers but also consumers. Consolidating purchases into one basket rather than separate orders can help to reduce VMT; however, many online storefronts aggregate retailers and obscure freight logistics and true shipping costs. So-called "free" shipping from retailers generally removes price signals about distance or cost (Beckers et al., 2022). While governments may not be able to regulate such practices, they can encourage or require that more information be provided to consumers (Exon-Smith, 2023).

With commercial customers, more options are available for regulating demand. London has experimented with micro-consolidation and micro-distribution at the level of buildings, malls, streets, or Business Improvement Districts (BIDs), in the form of Delivery and Servicing Plans (DSPs) (Exon-Smith, 2023). Deliveries are consolidated by ordering in bulk, synchronous ordering within a building, reducing the number of suppliers, and/or forming collaborative purchasing agreements (Holguín-Veras et al, 2016). The DSP process has been integrated into the Transport Assessment section of new planning permit requests in London, as well as during building construction. In Manhattan, a study based on choice modeling showed a potential reduction in freight traffic of 3.5-11.2% with coordinated receiver consolidation (Holguín-Veras et al, 2016).

A final consideration is how to address the environmental harm of plastic in online packages. A ban on single-use plastics (plastics that are used once and then thrown away) would help mitigate the quantity of plastic used in delivery packages, and the associated environmental consequences. Similarly, regulations on the amount of plastic permitted in a package would reduce the use of unnecessary plastic (Pålsson et al., 2017). Oceana recommends that Amazon scale up existing in-company programs to reduce plastic packaging, as well as broaden the use of reusable containers. Oceana also advised Amazon to improve sustainability transparency around reporting on plastic usage.

Chapter 6. Active Travel and Micromobility

Pre-pandemic trends

Prior to the COVID-19 pandemic, active modes represented a small but measurable share of travel in the US. According to the 2017 National Household Travel Survey (NHTS), walking as a mode of transportation accounted for 10.5% of all trips in the U.S., while bicycling accounted for 1.0% of trips. Because these trips are shorter on average than trips by car or by transit, they represented just 1% of person miles of travel in 2017 (FHWA, 2017).

Evidence on trends in walking and biking pre-pandemic is mixed. Based on NHTS data, 7.2% of all trips in 1990 were by walking compared to 10.5% in 2017 (FHWA, 2018). In California from 2012 to 2017, based on data from the 2017 NHTS and the 2012 California Household Travel Survey, both walking and bicycling decreased, walking from 16.2% of trips to 13.0% of trips, and bicycling from 1.5% to 1.3% of trips (Pike and Handy, 2021).

Several important developments in active transportation underlie the trends. Although the Intermodal Surface Transportation Efficient Act (ISTEA) of 1991 enabled the use of federal transportation funds for bicycle and pedestrian projects for the first time, many state departments of transportation (DOTs) and metropolitan planning organizations (MPOs) were slow to take advantage of the opportunity (Handy and McCann, 2010). Recently, more substantial investments have been made in bicycle and pedestrian infrastructure, such as in protected bike lanes (also known as “cycle tracks”) which increased in extent from just 55 kilometers in the U.S.in 2006 to 684 in 2018 (Furth, 2021). Cities that have invested in bicycle infrastructure have increased their bicycling mode share substantially. Bicycling in New York City, for example, increased from 0.6% of all trips in 1990 to 2.2% of trips in 2017 (Pucher et al., 2021).

Local planning in support of active modes has gained momentum as well. Pedestrian and bicycle master plans had been developed by 48% of US municipalities by 2018 (Peterson et al., 2018). California’s Active Transportation Program, created in 2013, provides funding for the development of community-wide active transportation plans. Another factor is AB 1358 The California Complete Streets Act, signed into law in 2008, which requires all California cities to include complete street designs that safely accommodate roadway users of all modes, speeds, and ages in every future update of their general plans. As of 2023, 81 cities in California have developed a pedestrian plan, 123 cities a bicycle plan, and 53 cities an active transportation plan (SafeTREC, n.d.).

Safety has been an on-going concern. Fatality rates for both pedestrians and bicyclists decreased in the US from 2000-2001 to 2008-2009, with pedestrian fatality rates dropping from 4.4 to 2.9 per 100 million kilometers walked, and bicyclist fatality rates dropping from 5.9 to 4.1 fatalities per 100 million kilometers cycled (Buehler and Pucher, 2017). However, more recent analysis shows that the rates inched up over the next decade and that rates in the US were several times higher than in countries like the U.K., Germany, Denmark, and the Netherlands (Buehler and Pucher, 2021a). Pedestrian fatalities increased by 46% from 2010 to 2019, during which time all other traffic deaths increased by only 5%; Black, Indigenous, and other people of color are struck and killed by drivers while walking at disproportionate rates (Governors Highway Safety Association, 2021). The increase in average vehicle size over this period is widely cited as a causal factor in increasing both pedestrian and bike fatalities.

One of the most significant developments in active travel in recent years has been the introduction of shared micro-mobility services that rent bicycles, electric-assist bicycles (e-bikes), and/or electric scooters (e-scooters) on a short-term basis. Users can pay on a per-trip or per-day basis, or through a monthly fee or annual membership. The majority of micromobility trips are short, averaging 11 to 12 minutes in duration and between 1 and 1.5 miles in distance in 2019 (Teale, 2020). Given that 35% of car trips in the US are less than 2 miles in distance, shifting more trips to bikes and scooters could help ease concerns like congestion, road safety, and emissions.

Bikesharing was the first form to rapidly emerge in the decade before the pandemic. The first bike-share systems were docked systems, meaning that bikes were rented and returned at docking stations; many of the more recent systems are dock-less, meaning that bikes can be left anywhere within the service area, though certain rules may apply. Led by very rapid deployment in China, the number of self-service public-use bicycles grew globally from less than 400,000 in 2010 to 1.2 million in 2015, 10 million in 2017, and almost 18 million in 2020 (ITF/CPB, 2020). In the US, bikeshare trips increased from 321,000 in 2010 to 32 million in 2017 (NACTO, 2022a).

Starting in 2017, e-scooter use began to grow very rapidly, much faster than bikeshare trips (NACTO, 2022a). E-scooter trips in the US grew from a negligible number in 2017 to over 80 million by 2019, when well over half of all micromobility trips were taken by e-scooter (NACTO, 2022a). E-scooter systems so far have been dock-less, leading to concerns over scooter clutter in urban areas, with e-scooters ending up in lakes and oceans, congesting sidewalks, and causing injuries. Nevertheless, e-scooters were becoming a viable last-mile alternative to other transport options.

Active travel and micromobility during the pandemic

While the COVID-19 pandemic upended almost all established mobility patterns, with people taking 81% fewer transit trips and 40% fewer trips by car, people kept walking and riding bikes (NACTO, 2022a). While stay-at-home orders and accompanying school and workplace closures triggered by the Covid-19 pandemic led to a decrease in all types of travel, including the use of active modes as a means of travel, walking and bicycling served two important purposes during the pandemic: as a form of exercise, recreation, and safe socializing for those stuck at home, and as an alternative to transit for those who continued to commute to work.

Covid changed the frequency of and reasons for walking in the US. An analysis of mobility data from over 1.6 million anonymous smartphone users in ten US metropolitan regions illustrated the initial shock and recovery of walking mode share (Hunter et al., 2021). The initial pandemic lockdowns in March 2020 led to a 70% drop in walking trips, which by July 2020 had recovered to 33% below regular levels. Utilitarian walking trips were significantly affected, likely owing to interruptions in work, school, and shopping activities. Leisure walking rates, on the other hand, were not nearly as impacted and in many cases surpassed pre-pandemic levels. Walking rates declined more in socially disadvantaged areas, while higher income areas substituted their utilitarian trips for more leisure walking.

Bicycling rates increased in response to the pandemic. Personal bike ridership increased overall in 2020, compared to the previous year, with some cities such as Houston reporting as much as a 138% increase in bike traffic (NACTO, 2022a). Streetlight reported that bicycling increased 11% from September 2019 to September 2020 across the US, though it declined in some metropolitan areas, including in San Francisco, San Jose, Los Angeles, and San Diego (Streetlight, 2021). In US cities, bicycle counts increased by 16% between 2019 and 2020, although most bicycling occurred during afternoons and evenings for non-utilitarian purposes (Buehler and Pucher, 2021). Data from New York City, collected through the Strava Metro app, showed that bicycling trips increased 80% from July 2019 to July 2020, with increases much higher for women (147%) than men (68%) (Goldbaum, 2020). Also measured through the Strava Metro app, Houston saw a 138% increase and Los Angeles a 93% increase in bicycling trips from May 2019 to May 2020 (Bliss, 2020).

A national survey of people who had taken up cycling during the pandemic found that 4% rode a bike for the first time ever or for the first time in one or more years; primary motivations for biking included stress relief and mental health, exercise and physical fitness, socializing with friends and family, relaxation, and getting outdoors (People for Bikes, 2021). While much of the new bicycling was for purposes other than getting to a destination, bicycling served as an important alternative for those who did need to get somewhere and wanted to avoid transit or faced reduced transit service.

Bicycle sales increased dramatically in the US in 2020, up 62-65% over 2019 (Hawkins, 2020; Fleming, 2021). E-bike sales increased most rapidly, growing by 144-145% from 2019 to 2020 (Hawkins, 2020; Fleming, 2021). In 2020, Americans bought around half a million e-bikes, more than double the number of electric vehicles they bought (Surico, 2021b). E-bike sales then rose 240% in 2021, making e-bikes the third largest cycling category in terms of sales revenue compared to two years earlier (Sorenson, 2021). The surge in demand for bikes created shortages and led to higher prices (Dowell and Hait, 2021) as well as increased reports of bike thefts (de Freytas-Tamura, 2020).

Across 2020 and 2021, people in the US spent $15 billion on personal bicycles and bike accessories, with a major driver being sales of electric bikes (NACTO, 2022a). The e-bike industry promoted e-bikes as an important alternative during the pandemic given the ability to socially distance while riding and the cut-backs in transit service in many areas (E-Ride Solutions, 2020).

Micro-mobility services suffered severe losses in ridership in the early part of the pandemic when many services were suspended at least temporarily. Service was suspended in two-thirds of the dockless systems and half of the station-based systems across the US (NACTO, 2022b). The micro-mobility company Lime pulled out of 95% of its global operations when the pandemic hit, though it was back in operation in 50% of its markets by May, 2020 (Sisson, 2020). Based on iPhone mobility data from the US and Europe, analyzed by the McKinsey Center for Future Mobility, analysts concluded that ridership decreased by 60-70% during the early months of the pandemic (Heineke et al., 2021). Micromobility trips in the US decreased by more than half from 2019 to 2020, from 136 million to 65 million (NACTO, 2022a). Ridership on station-based bike share systems (generally operated in a public-private partnership model) dropped 24% in 2020, compared to a 64% drop in trips on dockless e-scooters and bikes (which had not, until recently, been as closely managed by cities). A consumer survey revealed “risk of infection” as the primary concern steering people away from choosing shared micro-mobility options (Heineke et al., 2021).

Many micro-mobility companies dropped in valuation, halted operations, or laid off large portions of their workforce. But where micro-mobility services remained in service, they were important. One major micro-mobility operator saw a 26% increase in average trip distances nationally during the pandemic, including a 60% spike in Detroit (Heineke et al., 2021). Ridership on station-based bike share systems was particularly stable compared to other modes during the pandemic (NACTO, 2022a). Station-based bike share systems registered only 24% fewer trips in 2020, and in many cities, systems broke monthly ridership records in the latter half of the year (NACTO, 2022a). Strong partnerships between cities and operators ensured consistent availability of devices, and cities continued to invest in station-based systems. The need for healthcare, service, and other essential workers to continue to travel to work drove the continued use of shared bikes and e-scooters (NACTO, 2022a).

Analysts predicted that micro-mobility would bounce back quickly, especially as Covid fears eased, assuming that commuters would see it as less risky than other forms of shared transportation, including ride-hailing and public transit (Sisson, 2020). By 2021, ridership on station-based bike share systems in the US had rebounded to 18% above pre-pandemic levels, with 47 million trips taken from station-based systems (NACTO, 2022a). Meanwhile, e-scooter trips doubled from 2020 to 2021, nearly returning to pre-Covid levels. Shared e-bike use nearly doubled from 2018 to 2021, from 9.5 million to 17 million trips, with the growth attributable to the adoption of e-bikes in station-based systems; by the end of 2021, two-thirds of US station-based bike share systems had e-bikes, and a quarter of the bikes were electric (NACTO, 2022a).

Cities that kept their systems running demonstrated that resilient, well-managed shared micromobility programs are a critical component of the transportation system. Shared micromobility programs stepped up to provide options for essential workers to get around during the pandemic, as operators, partnering with city departments of transportation or local non-profit organizations, offered free or discounted passes for healthcare workers throughout 2020 and 2021 (NACTO, 2022a). For example, in Washington D.C., maintenance issues caused a significant period of reduced transit service on key Metro lines. To help keep the D.C. region moving, Capital Bikeshare offered free 30-day passes. L.A. Metro offered free 30-day passes to essential workers in July 2020 mostly to provide a commuting alternative (Chen, 2020), and in October, 2020, Tucson established Free Ride Thursdays for everyone as a way to get people out bicycling (Davis, 2020). In August 2020 in Chicago, Divvy Bike set a new record high of 612,928 trips in a month and in September 2020 in the greater Boston area, Bluebikes set a record high of 14,403 trips in a single day.

In addition to subsidizing micromobility, cities responded to the demand for active transportation during the pandemic by instituting other policies and programs that prioritized active modes over cars, such as speed limit reductions, pedestrianization of streets, the repurposing of parking areas, and other measures. As of June 2021, researchers at the Pedestrian and Bicycle Information Center (PBIC) had compiled a database of over 650 discrete actions in the US, 133 of them in California (Combs and Pardo, 2021). Open-street programs, in which city streets are partially or fully closed to cars, were among the most impactful and well-documented interventions. Sixteen California cities implemented open streets, most notably Oakland (with 74 street miles closed to cars) and San Francisco (with 47 street miles closed to cars). Some of these programs were meant to provide city residents with space to exercise after long periods of lockdown, while others aimed to boost ailing businesses by increasing foot traffic and providing more space for outdoor dining. As of October 2021, 29% of the open streets programs on commercial streets were still in effect (Andersen, et al., 2023).

Cities moved quickly to implement these programs in the first months of the pandemic, seeing a pressing need. But the quick response came at the expense of traditional planning practices, especially consultation with the community, that might have produced more effective and equitable program. The City of Oakland, whose closure of 74 miles of residential streets was one of the quickest and most widespread programs in the world, was featured in national media as a model for transportation-related pandemic response. A few weeks into the program, however, surveys revealed that while the program was overwhelmingly popular among white, upper-class city residents, marginalized communities reported much less support and lower use (Bliss, 2021a). The initial routing of the open streets did not adequately serve the essential workers of these communities who still needed to commute to work, nor did it provide safe access to important resource centers such as health clinics, testing facilities, and grocery stores. The orange cones and barricades of the program reminded many residents of past instances when their neighborhoods bore the brunt of disruptive transportation infrastructure projects. Marginalized communities expressed concern that the speedy installation of the open streets did not allow for a public input process (Bliss, 2021a). After many tense follow-up meetings with angry community groups, planners went back to the drawing board to improve Oakland's open streets, learning lessons along the way that can inform other cities' open streets programs (Storring, 2020).

Despite open streets programs and other safety efforts on the part of cities, pedestrian deaths increased by 4.8% in 2020 over the prior year, translating to a 21% increase in the rate of pedestrian fatalities per vehicle mile of travel (Governors Highway Safety Association, 2021). Bicyclist injuries and fatalities were down in 2020, but the trend is difficult to interpret given the increase in bicycling coupled with the decline in driving for many months. The National Highway Traffic Safety Administration reported 871 bicyclist fatalities in 2018, the deadliest year since 1990 (Marquis, 2020). In 2020, 675 bicyclists were killed by drivers, according to tracking by Outside magazine (Outside, 2020), though some observers have speculated that bicyclist deaths could have exceeded 2018 levels had driving not declined in 2020 owing to stay-at-home orders (Advocacy Advance, 2021). Data from both the city and county of Los Angeles show a decline in bicycling collisions with cars and in bicyclist fatalities in 2020 over previous years; the number of bicyclists killed in Orange County, however, increased in 2020 (Maison Law, 2021).

Policy opportunities

Evidence indicates that the increased rates of cycling and leisure walking experienced during COVID could persist into the post-Covid era. A national survey found that people who took up bicycling during the pandemic expect to continue to ride, including 75% of those who bicycle commuted and 63% of those who bicycled for other transportation purposes (People for Bicycles, 2021). In the UK Department of Transport's 2020 National Travel Attitude survey, approximately 40% of respondents said that they walked or cycled more often due to the pandemic, 94% of whom also reported that they planned to continue to do so after Covid had passed (UK Department of Transport, 2020). Similar patterns can be expected in the US, especially given the 65% increase in 2020 bicycle sales that put many new bikes in US garages.

The disruption in daily life that the pandemic caused represents an opportunity to encourage a change in travel behavior. Research shows that life events, such as a marriage or the birth of a child, lead to a rethinking of habitual travel choices and may trigger a change in travel behavior, including mode choice (Janke and Handy, 2019). As a vice president of the Taiwanese scooter network Gogoro said in June 2020, "'For the first time in the auto era, people everywhere are simultaneously reevaluating how they get from point A to point B,' he says. 'Recent events have truly created an incredible opportunity.'" (as quoted in Sisson, 2020).

The challenge for local, regional, and state agencies is to take advantage of that opportunity to maintain and even accelerate the growth in active travel that the pandemic produced. Although much of the new activity was for recreational purposes, a new-found appreciation of these activities could generate an openness to considering walking and bicycling as modes of transportation. Agencies can take advantage of this openness by continuing to improve walking and bicycling conditions and by encouraging active travel in a variety of ways. Addressing the upward trend in pedestrian fatalities and the consistently high level of bicycle fatalities will be essential to this effort, particularly given that fatality rates tend to be higher in disadvantaged areas where conditions are often less safe and dependence on active modes is greater.

Although walking and bicycling are often lumped together as forms of "active travel," it is important to consider their differences when devising strategies to support them. Two important ways they differ are with respect to their "people potential" and their "trip potential" (Handy, 2020). Walking, because it does not require special equipment or special training, has more people potential than bicycling in that more people can do it. Bicycling, because it is faster, has more trip potential than walking, in that more destinations can be reached in the same amount of time (and often with less energy expenditure). For the latter reason, bicycling is especially important as mode of transportation, and its importance is enhanced if agencies adopt strategies to increase its people potential. E-scooters are more akin to bicycling than to walking, with comparable speeds and similar people potential, though some data suggests that women may be more willing to use e-scooters than bicycles (Mass Transit, 2021).

Among transport modes, privately-owned bicycles and e-scooters use significantly less energy and emit much fewer GHGs per person-kilometer over their life cycle than cars or even public transit (ITF/CPB, 2020). Buses, mopeds, and metros (rail) are the next most efficient urban modes. Energy use and GHG emissions from shared micromobility (shared e-scooters, bikes, e-bikes and mopeds) are comparable to those of metros and buses. The higher impact of shared micromobility traces to, among other factors, heavier use leading to shorter life-spans of the vehicles, greater incidence of theft and damage, and operations required to move vehicles between station locations.

These findings are pertinent for policymakers to consider, suggesting that programs to incentivize private purchase of micromobility devices might be especially useful for promoting sustainability goals. On the other hand, especially in dense urban areas, shared systems could be especially important to facilitate less car use (such as TNC use) among travelers lacking access to a privately-owned automobile. Shared systems are an important strategy for enhancing transportation equity as well as for reducing care dependence and GHG emissions.

Cities are adopting a variety of strategies for promoting bicycling and micromobility. Open streets and complete streets strategies especially help walking but benefit bicycling and micromobility as well. These strategies complement efforts to increase transit ridership and can help to reduce car use for non-work trips, thereby enhancing the potential benefits of telecommuting. Cities should work closely with residents to ensure that the specific strategies they adopt are consistent with the community's needs and desires, particularly in disadvantaged areas.

Bicycling and micromobility strategies

As a *Bicycling* magazine editorial argued, the pandemic "could be a once-in-a-generation chance to bolster our ranks by sharing the joy of cycling" (Weiss, 2020). As noted above, one way that cities have shared the joy of cycling was by subsidizing rides on bike-share systems during the pandemic. Research shows that experience with shared e-bikes increases awareness of e-bikes in general and may prompt people to consider using e-bikes for commuting (Handy and Fitch, 2020). Continuing to subsidize rides and/or regulate prices could be an important strategy moving forward, because micromobility trip prices have increased substantially since 2018, especially in systems where prices are not regulated by the city (NACTO, 2022a). Trip costs for e-scooters and e-bikes more than doubled from 2018 to 2021, from an average of $3.50 to around $7 for a similar trip (NACTO, 2022a). Prices for non-electric station-based bike share trips also increased, although not as much.

A number of cities have established transportation "libraries" to loan out bicycles especially in low-income areas. Local Motion, a Vermont-based non-profit, has been lending e-bikes since 2017, with programs now spreading to other parts of New England, plus the cities of Denver and Oakland (Bliss, 2021b). The program offers multi-day loans of cargo bikes and other specialized bikes. Almost one-fifth of Local Motion participants later bought their own e-bike. In May 2020, in response to reports that Uber was scrapping thousands of electric bicycles from its Jump bike-share business, after selling the business to Lime, a huge outcry erupted within the bicycle advocacy community. In response, 3000 bikes were saved to create an e-bike library in Buffalo, New York, to loan out bikes to those who need them (Dewey, 2020). In the summer of 2020, the City of Detroit's Mobility Innovation office, in partnership with large employers and a non-profit organization, offered 150 e-scooters and 125 e-bikes to essential workers who needed better ways to get to work (Bigelow, 2020).

Financial incentives for buying e-bikes are proliferating. The popularity of shared e-bikes is predicted to grow in coming years, with e-bike sales currently outpacing sales of electric vehicles. However, while e-bike use has grown, they are often expensive to purchase, reaching prices in the thousands of dollars, making them unaffordable for many, and making shared use an important option. Cash rebates are offered by a utility in Vermont and by Contra Costa County Transportation Authority in California (Bliss, 2021b). California's E-Bike Affordability Program, which will provide $10 million in subsidies, is scheduled to begin sometime in 2023 (Fonesca, 2023). The U.S. Congress is considering an e-bike tax credit to encourage e-bike purchases.

Improving micromobility also requires developing strong public-private partnerships for service delivery. The pandemic demonstrated that strong city-operator partnerships with smart regulatory frameworks could be resilient and support a variety of trip needs, even during the lock-down period (NACTO, 2022b). The majority of station-based bike share trips are concentrated in a small number of cities, which all use public-private partnership frameworks for providing shared micromobility services to the public. More than four-fifths (89%) of station-based bike share trips nationwide in 2021 took place in just six places: the San Francisco Bay Area, Greater Boston, Chicago, Honolulu, New York City, and Washington, DC (NACTO, 2022a). Ridership is more widely distributed among e-scooter share systems, however; about two-fifths (39%) of e-scooter-share trips in 2021 took place in six cities: Atlanta, Austin, Denver, Los Angeles, San Diego, and Washington, DC. Overall, the most popular bikeshare systems share a number of similarities, including a large number of bikes, densely-placed stations or designated pick-up/drop-off areas, and robust rebalancing operations (NACTO, 2022a). These planning and operations characteristics require strong partnership between operators and local governments.

Three trends have emerged recently in regulating shared micromobility: electrification, goal-based operator selection, and expanded regulations to organize devices (NACTO, 2022b). Following the lead of Madison, Wisconsin, the first US bike share system to transition to an all-electric fleet, a number of other cities have transitioned to electric-only systems offering only e-bikes and e-scooters (NACTO, 2022a). Incorporating e-bikes and e-scooters into a shared micromobility fleet adds choice and is an important component of expanding access (NACTO, 2022b).

At the same time, especially in jurisdictions with multiple micromobility operators, cities have been undertaking processes to proactively select operators whose goals better align with the city's own goals (NACTO, 2022b). New regulatory models seek to sustain longer-term (and less volatile) public-private partnerships. Through using pilots and open permits as a temporary regulatory framework, cities are shifting to longer term agreements with fewer operators. The selective permit model leading to single-operator contracts increases city involvement, control, and accountability for outcomes. For effective programs, city planners and officials must connect broader city goals to specific shared micromobility outcomes. For example, a city's safety goals could support investment in promoting safety for bike and e-scooter use, while affordability goals could support regulation or subsidies for micromobility trip prices. Metrics used for public purposes often differ from those used by operators (for example, measuring ridership versus measuring revenue), and overall program goals must align public and private benefit.

Specific program objectives should include ensuring reliability and accessibility – that a device (e.g. bike or e-scooter) can be counted on to be available within short walking distance of where people make trips. Equitable access is essential to prioritize in micromobility programs (NACTO, 2022a,b). In Chicago, the City's Office of Equity and Racial Justice implemented citywide equity targets, which led the city's Department of Transportation to develop an e-scooter permit program against the backdrop of a city vision for equitable transportation. The program ranks permit applicants on criteria including equitable hiring, training, and outreach plans, and operators' ability to provide access for people with disabilities and those facing additional economic, health, or social barriers. Minneapolis has begun requiring operators to distribute a third of their fleet to low-income communities, and to provide a reduced fare option. The city has begun tracking compliance with a public data dashboard, increasing transparency. Other regulatory trends include requiring slow speed zones and slow first rides, establishing designated parking corrals, and lock-to requirements. Cities have also been expanding regulations to organize devices, such as through implementing zonal regulations to ensure that sidewalks, trails, and bike lanes are clear of discarded micromobility devices.

Cities will also need to address the bike theft problem. Bike thefts spiked during first year of the pandemic in response to rising demand coupled with limited supply. Reported bike thefts increased by 27% from September, 2019, to September, 2020, in New York City (de Freytas-Tamura, 2020). The problem is world-wide. The need for safe storage is especially important for e-bikes which are both more expensive and more difficult to bring into buildings (given their greater weight) than conventional bicycles. Bicycle parking is especially challenging for apartment dwellers.

Open streets and complete streets planning

Optimizing pandemic-induced increases in active transport requires holistic planning for mobility and accessibility in cities. Cities can promote active travel by, in consultation with residents, redesigning streets, lowering speeds, and prioritizing bikeway projects that create dedicated space. As active travel networks are expanded, they can be integrated with existing public transportation networks. First- and last-mile travel has long been an issue for public transportation, and micromobility modes, increasingly popular for short-distance travel, can help solve the problem. But that goal can only be achieved if transit, walking, and biking networks provide access in an integrated fashion.

The "complete streets" approach addresses the need for integrating multiple modes and multiple users. California's Complete Streets Act of 2008 requires cities and counties to include complete streets policies as part of their General Plans. Complete streets goals are achieved generally by adding traffic calming and user features to slow down vehicles and makes drivers more aware of their surroundings, particularly of other users such as pedestrian and cyclists (Smart Growth America, n.d). Traffic calming features include larger sidewalks, street trees, median islands, pedestrian refuges, and curb extensions such as bulb outs, while user features include bike lanes or bike share stations for cyclists, transit shelters for transit users, vehicle lanes for drivers, and charging stations for electric vehicles. Some cities have worked to implement a "layered network," building upon Complete Streets principles, by designating modal preferences for each street type, providing continuity for the chosen mode while accommodating others on parallel networks, and using network analysis to target selected treatments for prioritized modes (Fehr & Peers, 2021).

Investing in infrastructure for active modes is an essential part of a complete streets approach. Paris is perhaps the poster child for responding to the pandemic with bicycle infrastructure. The city installed 100 miles of temporary bike lanes early in the pandemic (Druckerman, 2021). It is now working to make the city 100% cyclable by 2024, when it hosts the summer Olympics. The city limited cars in its central areas by 2022. Out of a population of 10 million, 1 million bicycled daily as of 2021 (Alderman, 2021). California's four largest Metropolitan Planning Organizations, in the San Francisco Bay, Los Angeles, San Diego, and Sacramento areas, are currently spending 5% of their total transportation budgets on active transport projects, according to their most recent adopted plans (which do not include local-only funding) (Barbour and Thoron, forthcoming).

Pricing or eliminating parking space is another important strategy for localities to consider. "Free" parking induces driving, and is an inefficient use of space, as cars sit idle and empty 95% of the time (Shoup, 2014, 2016, 2018). Parking is the single biggest land use in most cities, comprising, for example, 14% of land in the City of Los Angeles. With more parking spaces per square mile than any other city on earth, Los Angeles also has the worst traffic congestion in the US. California passed AB 2097 in 2022 to prohibit local governments from mandating minimum parking requirements for housing developments located within a half-mile of public transit, an example of how state-level policies can assist in this endeavor. San Francisco eliminated minimum parking requirements citywide in 2019, and San Diego and Sacramento eliminated parking requirements near transit at the same time.

The "open streets" that popped up across the country during the pandemic may be a sign that cities are ready to reconsider how they utilize valuable urban street space. The hastily-planned, swiftly-installed open streets of 2020 can become permanent features in the community as a strategy for promoting active travel, if communities support permanent implementation. A survey of 130 municipal mayors from 38 states reported that while one-third of respondents planned on making new bike lanes permanent, only four percent intended to maintain open streets programs in the long term (Boston University, 2021). Several large cities, however, announced plans to keep their open streets in place, including New York City, which announced in September 2020 that their "Open Restaurant Streets" would be "permanent and year-round" (Kuntzman, 2020), a policy action supported by a 2020 survey in which 63% of respondents in New York supported the expansion of open streets in their own neighborhood (Transportation Alternatives, 2021).

Cities can make open streets more permanent by indefinitely replacing on-street parking with other uses, and by creating more attractive and effective barricades such as planters or moveable bollards (Surico, 2021a). In California, two cities that have recently made open streets permanent are San Francisco and Los Angeles (Tu, 2022). In San Francisco, JFK Drive (now known as JFK Promenade) had been closed to cars on Sundays since 1967. When the Covid-19 pandemic shut down most of the city, the street was made car-free seven days a week, leading to increased walking and biking, and a space for art and music. In April 2022, the city passed a motion to keep JFK Drive closed to cars, along with providing improvements that would make the park more accessible to disabled people, seniors and others. In Los Angeles, the death of a cyclist led the city to temporarily close a portion of roadway in Griffith Park, a popular spot for hiking and biking. In August 2022, the change was made permanent.

In October 2021, Governor Newsom signed into law AB 773, authorizing "a local authority to adopt a rule or regulation by ordinance to implement a slow streets program, which may include closures to vehicular traffic or through vehicular traffic of neighborhood local streets with connections to citywide bicycle networks, destinations that are within walking distance, or green space" (California Legislature, 2021a). This bill formalizes the process by which cities can make open streets permanent, and clarifies existing policies that make open streets programs less likely to face legal challenges. In addition to such a policy, state governments can encourage effective implementation of open streets by providing training resources that teach best practices for the equitable implementation of open streets. The experience in Oakland points to the importance of working with the affected communities to ensure that the designs and policies of the open streets programs serve the communities' needs.

Europe has been going further than the US to promote active travel in city centers. The Spanish government's proposed Spanish Emergency Plan for Sustainable, Safe and Connected Mobility in Urban and Metropolitan Areas would require the establishment of "low emission zones" that are entirely or partially restricted to vehicle traffic in cities of more than 50,000 people by 2023 (Pechin, 2021). Many other European cities have implemented low-emission zones, as discussed in Chapter 5.

Short of closing streets to vehicle traffic, many cities are reducing speed limits, especially on residential streets. The "slow streets" movement got some help in California with the passage of AB 43 in the Fall of 2021. This bill enables local governments to set speed limits not based on observed vehicle speeds but instead based on the needs of pedestrians, thereby doing away with the traditional "85^{th} percentile rule" (California Legislature, 2021b).

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