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Sustainable mobility in auto-dominated Metro Boston: Challenges and opportunities post-COVID-19

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ABSTRACT

The COVID-19 pandemic has disrupted society as we knew it in a variety of ways, with especially severe impacts on low-income households. Even before COVID-19, Metro Boston was witnessing a rise in private car ownership and decreasing mass transit ridership, further exacerbated by a historical spatial mismatch that made low-income commuters relatively more dependent on mass transit. Accounts of overcrowded buses and trains since early March have heightened psychological dread among regular transit commuters, some of whom have already purchased a private car or intend to do so within the next year. Uncertainty around transit service frequency and erosion of trust in the MBTA are the primary challenges for rebuilding transit rider confidence, which is likely to be a long and slow process. Low transit ridership levels can lead to fiscal challenges on the horizon and consequent service cuts, which necessitate the need for adopting a multi-modal approach to affordable and sustainable urban mobility. A narrow window is available to discourage a further shift to cars that will further cannibalize transit. Given the diversity of mobility services available in Metro Boston, designing a MaaS pilot with close attention to technological integration and cost salience can be crucial in showcasing the value of multi-modal and cross-modal accessibility. Such programs must be synergistic with concurrent transit service improvements and car-commute disincentives, such as in-town parking charges and road-use charges, without impeding access to affordable mobility for low-income and essential workers. Looking at the various agile policy responses of several cities in Metro Boston over the last few months, we are cautiously optimistic that sustainable mobility will become a major theme in urban and regional mobility policies in the post-COVID recovery period.

1. Introduction

COVID-19 has disrupted regular societal patterns and caused significant loss of human lives. Almost 80 million people have been infected by COVID-19 globally, out of which around 1.8 million have died (as of December 25, 2020). The United States is the worst affected country, with around 19 million cases (24% of global) and almost 330,000 deaths (18% of global). Around 20.5 million individuals (13% of the workforce) in the US are still claiming unemployment benefits, compared to only 1.8 million last year. Anecdotal reports of food security and mental health issues add to the woes bequeathing the most marginalized and low-income members of our society, many of whom are now considered “essential workers” in a bid to maintain normalcy in the global supply chain. Not surprisingly, they are also the most dependent on mass transit services, highlighting the role of mass transit as an essential public good. However, mass transit ridership has been hit hard by the pandemic, with current ridership trends pointing to a long and slow recovery period.

Stigma surrounding mass transit and unfavorable views of transit patrons has been a long-standing phenomenon, which has only grown stronger with the availability of social media outlets (Schweitzer, 2014). The “dread hypothesis” from psychology literature has been used to explain drops in usage of particular modes following major incidents (such as terrorist attacks) through three steps: (a) avoidance of ‘risky’
transport modes, (b) substitution with modes that are perceived to be safer but are not over the long-term, and (c) increase in the number of fatalities. Following the 9/11 terrorist attacks in the US, it was found that Americans substituted air travel with increased car usage (Gigerenzer, 2004). An additional 1,500 deaths could be directly attributed to the consequent higher interstate highway travel for a period of one year following the attacks (Gigerenzer, 2006). After the July 7, 2005 terrorist attacks in London, subway ridership decreased by about 12% until December 2005 (Fasolo et al., 2008). However, increased car usage led to significant increases in PM10 and NO2 concentrations (Percoco, 2019), and increased bike usage without adequate supporting infrastructure caused an additional 214 bicyclist road casualties over the following six months (Aytoun et al., 2019).

We hypothesize that COVID-19 has also caused a psychological dread risk effect with regard to shunning mass transit, which might result in increased usage of alternative modes, particularly private cars. Zero-car (or car-free) households may even consider purchasing a car because of its perceived safety relative to mass transit. Primary effects of this dread-induced car favoritism can be increased auto-dependence and pollution, while secondary effects can extend to further loss of life through higher road casualties. We already find preliminary evidence of such trends from city traffic data tracked by TomTom, which shows current peak congestion in Beijing, Shanghai, Wuhan, and Moscow close to or even higher than last year’s levels.4 Workers have expressed concerns over commuting to work using mass transit as businesses start to reopen, both in the US5 and UK.6 Car sales data from China show an increase in car purchases post-lockdown, in contrast to a historically decreasing trend.7 Even the Center for Disease Control and Prevention (CDC) in the US has issued travel guidelines suggesting people drive to work by themselves, where possible, instead of taking mass transit or carpooling.8

Heightened stigma surrounding mass transit, although unfounded,9 would have disastrous consequences for auto-dependent regions like Metro Boston, which has been ranked as the ‘most congested city’ in the US for the second year in a row by mobility consultancy firm INRIX.10 Lower-income households are more susceptible to be forced into auto-dependence, as their usual reliance on mass transit may be affected by lower service frequencies and fear of transmission risk. Using Census data on residential and workplace locations of workers in Metro Boston, we show in Fig. 1a how workplaces are mostly concentrated in the core towns (i.e., Boston, Brookline, Cambridge, Somerville), while housing is spread over the region at a comparatively lower density. Fig. 1b uses data for only low-income workers to highlight the dependence of low-income workers on mass transit, as can be seen by the concentration of residential locations of low-income workers in the core cities. Moreover, these locations also have a significant overlap with the service areas of the currently busiest bus routes, indicating that most low-income workers are still commuting to work and are heavily

dependent on mass transit.

The historical spatial mismatch between residences and workplaces, in addition to the heightened fear of transmission risk on public transit, can contribute to furthering the auto-dependence of Metro Boston. With time stuck in traffic costing Boston’s economy over USD 4 billion annually, the region can ill afford to witness increased car ownership and usage. This dread effect can be particularly high for low-income workers, who still have to commute to work using public transit. Purchasing a car in a time of economic uncertainty can increase the financial burden on already struggling households. Moreover, financial constraints can force them to purchase older, less sustainable vehicles that pollute more and have higher long-term maintenance expenses. Therefore, pushing zero-car low-income households towards auto-dependence may result in seriously inequitable and unsustainable consequences.

Instead of viewing COVID as a blip in the system, we argue in this paper that this disruption can actually be a ‘circuit-breaker’ by providing opportunities to reverse historically increasing car ownership trends and promote sustainable mobility alternatives. The next section describes historical mobility trends in Metro Boston and discusses the effects of COVID-19 on mass transit. We then discuss challenges for promoting sustainable mobility in the region, focusing on crowding risks on buses by analysing ridership data and providing evidence of the hypothesized dread risk effect through increased car purchase intentions among zero-car households. Opportunities for sustainable mobility alternatives, e.g. promoting bikesharing and mass transit in addition to disincentivizing low-occupancy vehicle trips, are discussed following that. Finally, we conclude with highlighting how this is an opportune moment to use new technologies in integrating a wide gamut of already available mobility services, along with providing a supportive ecosystem of land–use and pricing policies.

2. The state of the commonwealth amidst COVID-19

Auto-dependence has been steadily rising in Metro Boston in recent years, as evidenced by the INRIX congestion ranking. Fig. 2a shows that the City of Boston (home to 14% of the Metro Boston population, and covering 11% of the area) has witnessed a growth of 25% in the total number of households since 2005, while the growth in households with two or more vehicles stands disproportionately higher at 64%. Moreover, the share of households with zero cars, i.e., car-free households, has largely remained constant over the last 5 years at the same value as 2005. This has led to the overall vehicle ownership rate jumping from 70% to 76% in just the City of Boston, whereas the vehicle ownership rate in Metro Boston currently stands at an overwhelmingly 91.5%.

Along with the aforementioned spatial mismatch between housing and jobs, another reason for increasing auto-dependence may be the low reliability of the bus services provided by the Massachusetts Bay Transportation Authority (MBTA). While both the subway (i.e., rapid transit, often colloquially referred to as the ‘T’) and the commuter rail are perceived to be reliable over 90% of the time, bus services are rated only 73% in terms of reliability.11 Although Metro Boston is among the few metropolitan areas in the US to boast of a relatively well-connected and high-use public transit system with over 1.1 million trips on an average weekday (pre-COVID), the MBTA has been struggling to maintain adequate revenue streams in recent years. Compared to January 2002, commuter rail and light rail services have experienced steady declines in monthly ridership, especially since 2014. Ridership gains in heavy rail (or subway) services up to 2014 had been decreasing slowly since then, not unlike other public transit systems in the US. However, the lockdown measures imposed due to the COVID-19 pandemic have wiped out these gains entirely to the point that public transit ridership on all services

\[4\] Live traffic data are provided by TomTom for a few select cities, in addition to comparisons of current traffic congestion levels with those pre-COVID. Interested readers can refer to https://www.tomtom.com/covid-19/.

\[5\] https://www.us.jll.com/en/views/workplace-experience-survey.

\[6\] https://www.citylab.com/transportation/2020/06/coronavirus-risk-transit-france-japan-trains-subway-buses/612841/.

\[7\] https://www.scmp.com/economy/china-economy/article/3083797/coronavirus-china-car-sales-mark-first-gain-almost-two-years.

\[8\] https://www.cnbc.com/2020/06/04/cdc-guidance-against-mass-transit-sparks-fears-of-congestion-emissions.html.

\[9\] Public health data from Japan and France suggest that recent clusters of new COVID cases did not occur on mass transit, where passengers are following safety guidelines. Interested readers can refer to https://www.citylab.com/transportation/2020/06/coronavirus-risk-transit-france-japan-trains-subway-buses/612841/.

\[10\] https://www.bostonherald.com/2020/03/09/boston-still-has-worst-traffic-in-the-country/.

\[11\] Statistics were obtained from the MBTA Performance Dashboard, available at https://mbtabackontrack.com/performance/ #/home.
languish between 70% and 95% lower than the January 2002 reference (see Fig. 2b).

Using aggregated data from a popular transit navigation and routing app, we show in Fig. 3 how major events (such as announcements by public officials) influenced transit ridership at the system level. The Biogen conference in Boston, held in late February, is regarded as the spark behind the Massachusetts outbreak and may have even played a notable role in the early spread of COVID-19 within the US. Transit ridership started dropping as soon as news spread of the conference attendees being tested positive for COVID-19. Emergency declarations by Governor Charlie Baker (Governor of Massachusetts) and Mayor Marty Walsh (Mayor of Boston) accompanied sharp declines of 20–30 percentage points each. By then, the outbreak in Massachusetts had forced the MBTA’s hand in announcing reduced services with additional precautionary measures, such as conducting only back-door boardings, suspending fare payments, and encouraging passengers to wear masks and physically distance within the vehicle. The ridership decline started stabilizing around the end of March and remained constant at 85% lower than the expected usage until mid-May. Around that time, the state had passed the first ‘peak’ of the COVID-19 transmission curve and reopening plans were being announced at multiple administrative levels. With more workplaces and establishments opening up, transit ridership went up slowly but steadily since then by around 20 percent age points. Ridership remained constant at 60–65% lower than expected throughout the summer despite the commencement of Phase 3 reopening. Since September, we find that ridership remained well below expected, perhaps because of several schools, colleges, and universities in the region actively pursuing online instruction policies, leading to fewer student trips. The trend seems to be slowly declining over the last three months, indicating a widening gap between observed and expected transit usage. In summary, the system ridership data highlights that transit ridership recovery may occur, but will likely be quite slow and take much longer than expected.

The Transit app (https://transitapp.com/) is quite popular across North America and is endorsed by several mass transit agencies, including the MBTA. 

https://www.bostonherald.com/2020/05/02/biogen-conference-in-boston-recognized-by-top-cdc-official-as-major-coronavirus-event/.

Fig. 1. Spatial mismatch between residential and workplace locations in Metro Boston. (a) All workers; (b) Low-income workers (earning less than $1,250 per month).

Data on residential and workplace locations were obtained for all workers and low-income workers (defined as earning less than $1,250 per month) at the Census block group level from the 2017 Longitudinal Employer-Household Dynamics (LEHD) Origin-Destination Employment Statistics (LODES). Network distances were calculated from the CBD (Boston City Hall) to the centroid of each block group using the ‘drive’ street network from OSMnx. Manual classification schemes are used to symbolize the maps based on the data distributions.
While the system-level ridership analysis provides an adequate understanding of the aggregate trend, transit demand is distributed heterogeneously across routes, especially more so when most office workers are advised to ‘work from home’, i.e., telecommute. Therefore, we examine route-level ridership level in a comparative analysis to examine where the currently busiest routes fit in ‘usually’. Using April as the reference month (since transit demand was at its lowest point - 85% below expected - during April), we find that the top 10 busiest routes this year are within the top 20 busiest routes from last year (see Fig. 4). Bus route ‘1’, the busiest during pre-COVID times, connects Harvard, MIT, BSO, and the Berklee School of Music along Mass Ave and dropped off the list during 2020 after most universities and theaters closed and/or went online. Additionally, the top 10 busiest routes from last year contain 6 of the top 10 busiest routes this year. Thus, we see how the currently busiest routes are also ‘usually’ busy, albeit with different magnitudes and rankings. Even at the reduced ridership levels, some of these routes (such as 23 and 111) were reported to be overcrowded during the AM peak.\footnote{https://www.bostonglobe.com/2020/03/18/metro/mbta-passengers-complain-about-crowded-trains-buses-amid-coronavirus-outbreak/}

The route-level analysis points to the possibility of some of these currently busy routes facing crowding risks as non-essential workers start to return to regular commuting patterns, which would further endanger the low-income transit-dependent essential workers currently using these routes. In an effort to better inform potential riders of crowded buses, the MBTA launched the provision of real-time crowding information for currently busy bus routes,\footnote{https://www.mbta.com/projects/crowding-information-riders.} several of which are corroborated by our analysis. The MBTA is also experimenting with flexible bus scheduling, wherein service is concentrated on about 80% of
bus routes and 30% of the bus fleet is reserved to be deployed where there is increased demand for service.

More recently, the MBTA released a ‘Forging Ahead’ proposal to revise transit services in light of the new ridership patterns and internal budgetary concerns. News of these proposed service cuts have been met with strong disapproval and opposition from transit riders and local politicians. While these strategies may be partially effective during an extremely reduced demand scenario, prioritizing routes during a relatively ‘normal’ demand scenario may result in inequitable outcomes by further marginalizing transit-dependent individuals along low-demand routes that are cut off. The MBTA had placed an order for 60 new buses that are expected to arrive in early 2021, which can be utilized for the flexible scheduling strategy. As evidenced by these efforts, the MBTA is clearly adopting a proactive approach in ensuring the safety of its riders along with providing services at pre-COVID quality. However, negative perceptions of mass transit can manifest themselves through several challenges that threaten sustainable mobility planning in Metro Boston.

3. Challenges for sustainable mobility

The primary challenge for sustainable mobility in Metro Boston during the COVID-19 recovery phase is to adequately address concerns over overcrowded buses on busy routes and re-instil confidence in mass transit, while continuing to provide services at reasonable frequencies to low-income and essential workers. COVID-19 has accentuated the stigma surrounding mass transit as ‘unclean and crowded’, which reinforces negative perceptions of transit and may even increase the intention to purchase and use a private car among households that are currently car-free. If the decline in mass transit ridership cannot be fully recovered, increasing auto-dependence will make the most congested region in the US even more congested. Moreover, in the long-term, lower ridership levels will further hurt the fiscal health of the MBTA, thus diminishing the frequency and quality of services provided, which in

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16 https://www.mbta.com/news/2020-06-10/bus-schedule-changes-summer-2020.
17 https://www.bostonglobe.com/2020/12/07/metro/mayor-walsh-blasts-proposed-mbta-service-cuts-warns-they-would-hurt-workers/.
18 https://www.bostonglobe.com/2020/12/07/metro/mayor-walsh-blasts-proposed-mbta-service-cuts-warns-they-would-hurt-workers/.
Although the MBTA has started experimenting with this strategy, social buses in mid-May. The vehicle load threshold was reduced from 56 to 20 route average basis, but undoubtedly not for the busier segments of the MBTA and trust of riders. In summary, we find that initial crowding incidents can spread like wildfire and severely damage the reputation of media has been abuzz with pictures of crowded buses (particularly the 111 and SL5), which has raised concerns among potential riders. Such fears pose a serious challenge to mass transit usage in Metro Boston, as some critics put it, must be reversed.

3.1. Crowding risk on busy bus routes

In an effort to allow riders to effectively maintain physical distancing protocols on buses, the MBTA announced reduced capacity levels on all buses in mid-May. The vehicle load threshold was reduced from 56 to 20 passengers for 40 foot buses (which is the standard MBTA bus) and from 80 to 31 passengers for 60 foot buses, thereby reducing acceptable crowding to 36% and 39% of the usual AM peak load.19 These revised service delivery standards were proposed so that passengers could maintain a minimum distance of 3 feet (or 1 meter) between themselves. Using various demand levels and two types of supply schedules, we evaluate how the currently busiest bus routes face crowding risks during the COVID recovery phase in Fig. 5.

Due to the significantly reduced demand, the MBTA was operating on their Saturday schedule in April, which allows buses to run with longer headways. Fig. 5a shows that two routes (111 and 116) exceeded the revised crowding threshold for 40 foot buses during the weekday AM peak despite the reduced demand in April. Moreover, three additional routes (28, 23, and 66) were quite close to the threshold. As establishing metrics start to reopen, the demand and consequently the AM peak load are expected to increase. Acknowledging the uncertainty in demand estimates during the long and slow transit recovery phase, we use four stages of ‘normal’ demand levels - 25%, 50%, 75%, and 100% - to further understand crowding risks. We find that all of the top 10 busiest routes will exceed the crowding threshold for 40 foot buses at only 50% normal demand. Even with 60 foot buses, all routes will be crowded at 75% normal demand, which highlights that the Saturday schedule cannot be a viable long-term strategy for the MBTA.

The MBTA has, since July 21, introduced weekday schedules for buses on selected high-demand routes, such as 1, 22, 23, 28, and 111.20 Fig. 5b shows that the weekday schedule can effectively manage crowding on the top 10 busiest routes at the current demand level. However, at 50% normal demand levels, 5 of the top 10 routes will remain at risk of exceeding the revised crowding threshold. Therefore, even the weekday schedule may not be sufficient to manage crowding risks on high-demand routes with large weekday AM peak loads. Flexible scheduling that allows for reduced services on low-demand routes while redirecting buses for more frequent service provision on high-demand routes can be key to ensuring the safety of bus passengers. Although the MBTA has started experimenting with this strategy, social media has been abuzz with pictures of crowded buses (particularly the 111 and SL5), which has raised concerns among potential riders. Such incidents can spread like wildfire and severely damage the reputation of the MBTA and trust of riders. In summary, we find that initial crowding risks with the Saturday schedule could possibly be addressed on a full-route average basis, but undoubtedly not for the busier segments of some routes (such as the congested segment traversing the Mystic River Bridge from Chelsea into Boston). Such experiences have led to significant erosion of public confidence in mass transit. Although the current demand levels are managed well using weekday schedules on high-demand routes, fears remain that even that may not be enough during the recovery phase when demand levels will start to increase. These fears pose a serious challenge to mass transit usage in Metro Boston, especially among those households that are currently car-free and transit-dependent.

3.2. Perceptions of mobility options

While ridership data and crowding risk analysis can help us evaluate system performance, a separate survey had to be conducted to better understand individual perceptions and future plans. A web-based survey was administered through the market research firm Qualtrics, with around 2,200 responses from Metro Boston collected from April to October. The sample was found to be generally representative of the Metro Boston population, with the usual shortcomings of online samples (i.e., some under-representations of extremely low-income households and minorities). For example, we find that 73% of workers in our sample are car commuters, compared to 78% reported by the 5-year ACS estimates for 2014–18. We generated household-level sampling weights using household income, residential tenure status, and the number of children as household marginals. Similarly, individual-level sampling weights were generated using age, gender, race, and ethnicity as marginals. All summary statistics reported henceforth are computed using the weighted sample.

We asked several statements related to perceptions of private cars, mass transit, and taxis/TNCs, and asked respondents to evaluate them on a 5-point Likert scale. We found significant differences in these responses based on the pre-COVID commute mode of respondents, as shown in Fig. 6. Car commuters, who form 73% of workers in the sample, are found to be quite confident about the possibility of reduced transmission risk in a private car (77% agreement). However, non-car commuters (27% of workers in the sample) display significantly lower confidence about the value of a car with 69% agreeing with the same statement. Moreover, car commuters are found to be much more critical of mass transit than non-car commuters, with an 11 percentage point difference in agreement levels with regard to transit being unsafe. These trends point to the possibility of the nay-saying around mass transit being mostly driven by car commuters, who may not be using transit frequently but have significantly negative perceptions of transit.

Both groups reach somewhat similar levels of agreement in judging taxis/TNCs to be unsafe, as vehicles are shared between multiple people over the course of the day and the close proximity between driver and passenger(s) may not allow for effective physical distancing. They also share agreement on transit recovery, with 60% of each group expressing confidence that people will go back to using transit. This is a surprising finding, as we would have expected non-car commuters to perhaps indicate a higher level of agreement than car commuters. This may point to the possibility of some non-car commuters currently contemplating trading their transit commute for a perceivably safer option, such as a private car. To understand more about their expectations in the near future, we asked specific questions on perceptions about reductions in vehicle costs and increase in private vehicle ownership. Car commuters display significantly higher confidence in the anticipated reduction of vehicle prices with a difference of 11 percentage points over non-car commuters. However, both groups have similar levels of agreement about private car ownership increasing due to COVID-19, with non-car commuters being marginally less confident. These findings point to the differences in perceptions of mobility options and post-COVID mobility trends based on pre-COVID commute modes, wherein car commuters are much more confident about the value of car ownership but less so about mass transit. Additionally, we find that there is a strong possibility of some non-car commuters departing from transit via private car ownership, possibly taking advantage of the anticipated reduction in vehicle prices.

3.3. Car purchase intentions of zero-car households

Modal shifts occur when risk perceptions for a particular mode are reduced (Noland, 1995). These potential risk-compensating effects may manifest themselves through currently zero-car households...
contemplating purchasing a private car in the near future due to COVID-19. To test the validity of this hypothesis, we asked currently zero-car households to indicate their level of agreement with COVID-19 having enhanced their intention to purchase a car. Fig. 7a shows that one in every five zero-car households agree with this statement. While some transit commuters are more likely to experience enhanced car purchase intentions, there are also staunch transit loyalists who indicate disagreement at a higher than average rate. Most active transport commuters seem to be on the fence, and may be evaluating the costs of private car ownership against the benefits of added convenience and accessibility that a car allows for. Taxi/TNC commuters indicate the highest level of disagreement, possibly because they anticipate working from home on account of being higher-income workers in white-collar occupations.

We term those zero-car households that do not disagree with the above statement as zero-car households with enhanced car purchase intentions, and ask a follow-up question about the anticipated timeline of their intended car purchase (see Fig. 7b). We find that, on average, 13% of such households anticipate purchasing a car within the next six months, while over 25% anticipate doing so within the next year. About 40% of zero-car households with enhanced car purchase intentions are possibly waiting to see how the COVID-19 recovery plays out, and anticipate purchasing a car within the next one to two years. If the COVID-19 recovery plan can successfully instill confidence in these households about safe non-car mobility options, policy-makers may be able to avert a large increase in car ownership among currently zero-car households and limit the damage to the immediate car purchasers.

We also find that low-income households are more likely than average to purchase a car within the next six months, thereby supporting our earlier premonition of forced auto-dependence and perhaps an increasing strain on financial resources. While one in every four regular transit commuter household with enhanced car purchase intentions anticipate purchasing a car within the next year, almost half of such households are willing to wait and watch developments over the next year. Active transport commuters are more likely than average to purchase cars within the next year, which can lead to significant lifestyle changes (including decreasing health benefits from reduced exercise) stemming from increased auto-dependence. Since the survey was conducted over a six-month period, we had the opportunity to follow up with some households that had anticipated buying a car within six months of the survey response. We interviewed ten households that had purchased a car subsequently, and found that the major reasons for their decisions were:

- uncertainty around transit service frequency ("I have to wait ages for the next bus, and it’s just easier to plan trips when you have your own car.");
- lack of trust in safety measures by the MBTA ("You know, I saw those pictures of overcrowded buses, and I’m like, I don’t want to be on one of them. I can’t risk it, I live with my mom who’s 86."); and
- fear of other passengers not adhering to the safety guidelines ("I wear a mask and try to physically distance on the bus, but what can I do if the person sitting next to me doesn’t wear a mask?").

3.4. Ride-hailing services

Although our sample currently perceives ride-hailing services (or TNCs) negatively due to the increased risk of infection from shared vehicles, we believe that the general usage of ride-hailing services in Metro Boston was not heading in a sustainable direction pre-COVID. We fear their current (pre-COVID) service and fare structures pose a significant challenge to sustainable mobility planning for the region, especially if their usage patterns go back to ‘normal’ post-COVID. An intercept survey of 1,000 ride-hailing passengers was conducted in Fall 2017 by the...
Metropolitan Area Planning Council (MAPC), which is the regional planning agency for Metro Boston. Gehrke et al. (2019) caution policy-makers against being overly optimistic about the prospect of ride-hailing services reducing private vehicle ownership and use, which is often hailed as a beneficial side-effect by TNC advocates. The study found that almost 60% of ride-hailing trips are adding a new vehicle on the road. Moreover, only 20% of passengers used the pooled or shared service. This is consistent with findings from other American cities, such as Brown (2020) reporting that only about a third of all Lyft trips in Los Angeles are shared. In agreement with a vast literature on adopters of ride-hailing services (e.g. see Alemi et al. (2018), among others), Gehrke et al. (2019) also find that ride-hailing users are relatively younger and more educated than the regional population. Residents of compact neighborhoods with mass transit access were reported to be more likely to generate new car trips, as their trips would otherwise have been taken by mass transit or active transportation. Therefore, it seems clear that the pre-COVID usage patterns of ride-hailing services in Metro Boston posed significant challenges to sustainable mobility efforts. Despite the current negative perceptions surrounding TNCs, we suggest that this is likely a short-lived phenomenon and caution against allowing for a post-COVID return to the pre-COVID status quo.

4. Opportunities for sustainable mobility

Sustainable mobility futures are challenging to envision and even more so to realize, given the pervasive nature of automobiles in modern society despite their ecological unsustainability. Such futures are dependent on high-quality implementation of innovative schemes, and the need to gain public confidence and acceptability to support these measures through active involvement and action (Banister, 2008). The transition to sustainable mobility can only be successful when urban planning is well integrated with transportation investments, as acknowledging and understanding the links between transport, land use, and socio-cultural contexts are key to developing effective mobility management campaigns (Hickman et al., 2013).

4.1. Mass transit

Mass transit has historically been a primary driver of metropolitan development, perhaps the most famous examples of which are the “Finger Plan” of Copenhagen, Denmark and the “Planetary Cluster Plan” of Stockholm, Sweden. As the oldest subway system in North America, mass transit in Metro Boston continues to have long-term impacts in shaping metro development and travel behavior, even when rail infrastructure has ceased to exist. This ‘hysteresis effect’ of past access to rail continues to reverberate in current residential location and travel behaviour (Block-Schachter, 2012). Moreover, mass transit currently serves 35% of all commuters in the inner core towns, while low-income commuters are even more dependent on mass transit (see Fig. 8). Therefore, from both ecological and equitable perspectives, we suggest that sustainable mobility efforts in Metro Boston need to be centered around mass transit.

Our earlier analyses show that regaining and maintaining public trust in the safety of mass transit will be a primary challenge of the COVID recovery period and the post-COVID era. However, the MBTA has been undertaking a variety of measures to address these concerns. Real-time crowding information is being provided to riders on busy routes through the MBTA website, e-ink digital signs at bus stops, and on the MBTA-endorsed Transit app.‡ This is expected to provide a much needed confidence boost to riders who can choose to adjust their travel plans based on the available information and enjoy an improved travel experience, as demonstrated by Drabicki et al. (2020). Contactless payments are already possible through Charlie Cards, which are reusable cards that can be loaded with cash value orpasses at the MBTA website or station kiosks to pay transit fares.\‡

The MBTA has also instituted evolving practices to ensure the safety of transit riders. While rear-door boardings and reduced crowding thresholds can be effective in allowing for appropriate in-vehicle physical distancing, there is no fare collection from those boarding from the rear. Another challenge during the COVID recovery phase will be the enforcement of wearing masks. This has become a major point of criticism with riders taking to social media to criticize the MBTA over its lack of enforcement, despite Governor Baker’s executive order in May mandating face coverings on the T for both riders and employees.\‡ Acknowledging that refusing to let riders on without masks is a delicate stance, we suggest that other measures that allow for more confidence in the safety of MBTA services start being considered. Providing sanitizers at bus stops and T stations, more frequent cleaning of trains and buses, and checking temperatures at T entrances may be useful strategies to increase the perceived safety of the MBTA. Additionally, we also suggest that a more active media (including social media) presence by the T in promoting its efforts on safety measures can increase awareness and dispel unfounded biased stigmas surrounding mass transit.

Along with the safety of riders, maintaining adequate quality of mass transit services will also be key to the long-term prospects of the MBTA. Our analyses highlight that low reliability of MBTA bus services can be severely detrimental to post-COVID ridership. We found that only 37% of bus riders were using the Transit app, which provides real-time updates on bus schedules and in-vehicle crowding information. Therefore,
has identified 14 corridor miles for investing in bus priority infrastructure such as dedicated bus lanes and transit signal priority. In conjunction with the Better Bus Project, the MBTA can considerably improve quality of service by decreasing transit commute times. Lower-capacity vehicles, such as the EZRide shuttles, can be operated on low-demand routes, without substituting services on certain routes. With the addition of the anticipated 60 new buses to their fleet, the MBTA would have the resources to make flexible scheduling more than a temporary strategy for regular weekday and Saturday schedules. With the addition of the anticipated 60 new buses to their fleet, the MBTA would have the resources to make flexible scheduling more than a temporary strategy for regular weekday and Saturday schedules. With the addition of the anticipated 60 new buses to their fleet, the MBTA would have the resources to make flexible scheduling more than a temporary strategy for regular weekday and Saturday schedules.

In addition to providing more frequent service, bus transit priority can considerably improve quality of service by decreasing transit commute times. In conjunction with the Better Bus Project, the MBTA has identified 14 corridor miles for investing in bus priority infrastructure such as dedicated bus lanes and transit signal priority. In early July, new dedicated bus lanes were opened along Washington Street and are expected to save 12 minutes of commute time for more than 24,000 weekday riders from historically low-income Roxbury (where the median household income is USD 26,000, compared to the Boston median of USD 56,000) to downtown Boston. The City of Everett is actively pursuing a rush hour dedicated bus lane on Broadway, the city’s main thoroughfare into Boston, for speeding up commutes for 10,000 riders through the Everett BRT pilot. Early pilots of tactical interventions, such as trial morning peak dedicated lanes and temporary boarding platforms, conducted by the Institute for Transportation & Development Policy (ITDP) have dropped average travel times from Everett Square to downtown Boston by more than 20%. Therefore, it seems clear that the MBTA is quite proactive in attempting to improve its infrastructure and services, despite financial constraints and decreasing fare box revenues. In the post-COVID era, we suggest that the top priorities for encouraging mass transit ridership be placed on increasing perceptions of safety through awareness campaigns, and enhancing service reliability by improving frequencies, commute times, and the ease with which riders can obtain real-time information.

4.2. Biking and bikesharing

Biking (and active travel, in general) can have substantial benefits, such as improved fitness levels, lower obesity rates, and reductions in pollution and greenhouse gas emissions. One study reported that if every Londoner walked or cycled for 20 min every day, reductions in diseases associated with physical inactivity (such as type 2 diabetes, cardiovascular diseases, and dementia, among others) would lead to savings of roughly GBP 17 billion for the National Health Service over a 20-year period (Jarrett et al., 2012). For a European driver who switches to biking for a daily commute of 5 kms, the health benefits from the physical activity are worth about €1,300 annually (Rabl and De Nazelle, 2012). As a shared mobility service, bikesharing can enable more individuals to engage in biking without worrying about the challenges that accompany ownership, such as a high one-time purchase cost, regular maintenance costs, and parking. Using a quasi-experimental design, a recent study in Metro Boston found that bikesharing has the potential to reduce long-term auto-dependence in the densely populated inner core; the reported decrease in vehicle ownership per household is around 2% per quarter, while vehicle miles traveled and greenhouse gas emissions per individual have decreased by over 3% per quarter (Basu and Ferreira, 2021). A significant finding of this study is that the estimated decrease in auto-dependence measures is almost 10% (more than thrice as high as average) when bikeshare connections to mass transit stations are less than 1 km long. Similar observations about the impact of bikesharing on reducing auto-dependence have been reported in other metro areas as well (Fishman et al., 2014; Rojas-Rueda et al., 2012).

Following the 2005 terrorist attacks in London, biking activity increased significantly at the expense of mass transit ridership (Ayton et al., 2019). Similarly, in the wake of COVID-19, we are witnessing a similar phenomenon in most major cities across the globe. In particular, bike shops in the Boston area are witnessing a boom in sales as people turn to cycling for exercise (given the short summers and impending

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24 https://www.mbta.com/news/2020-08-27/mbta-and-cities-boston-somerville-everett-chelsea-rapidly-construct-14-miles-bus.
25 https://www.bostonherald.com/2020/07/06/dedicated-bus-lanes-shave-12-minutes-off-commute-from-roxbury-to-downtown-boston.
26 https://www.masstransitmag.com/home/press-release/12420865/boston-brt-everett-becomes-first-local-city-to-speed-bus-commute-with-raised-plat-forms.
harsh winters in New England), perceiving lower accident risk due to fewer cars on the roads. Unfortunately, without appropriate bike-friendly infrastructure (such as marked bike lanes), this increased biking activity can result in significantly higher casualties, a pattern we saw in the six months following the terrorist attacks in London that is currently being repeated in New York City. While such infrastructure is necessary in encouraging more biking activity, it is necessary to highlight that infrastructure improvements may predominantly benefit socioeconomically advantaged groups. Recent analysis by the MAPC found that exposure to pollutants, as measured by proximity to major roadways, is unequally distributed across racial groups in Greater Boston. 45% of Black residents and 54% of Latino residents live in the most polluted areas, compared to only 29% of White residents. Strong correlations between high exposure to air pollutants and increased risk of heart and lung diseases are especially important in the current circumstances, as they are also linked to higher death rates among COVID-19 patients.

Metro Boston was one of the early movers in embracing bikesharing in 2011, as only the second major metropolitan area in the US after Washington, DC in 2010. Since then, the Bluebikes (previously known as Hubway) bikesharing program has expanded its bikeshare station network to five cities (Boston, Brookline, Cambridge, Everett, and Somerville) in the inner core, and recorded a major milestone of 10 million trips in 2019. Over the summer of 2020, Bluebikes expanded its network by opening 30 new stations in five new municipalities (Arlington, Chelsea, Newton, Revere, and Watertown) in an effort to further facilitate cross-municipality trips in the inner core. The state Department of Transportation (MassDOT) released a draft of the “Massachusetts Bicycle Transportation Plan” in 2019, that aims to support the growth of biking activity in the region over the last decade (primarily driven by bikesharing) through installation of safety and comfort measures for cyclists. These would be welcome and necessary efforts since our analysis of Census data shows that 32% of commute trips in the inner core of Metro Boston are less than 4 kms (2.5 miles) long, but biking accounts for only 2% of commute trips in the inner core (see Fig. 8).

While the current surge in walking and biking activities may be short-lived, cities are taking proactive measures to lock in such sustainable travel behavior. Since the 2005 attack, London has completed several major bike infrastructure projects, such as dedicated biking ‘super highways’ and bike-hire programs, that have helped increase biking activity significantly. Bogotá, which has experience with car-free Sunday experiments, plans on opening 80 kms of roads to cyclists, while Lima aims to construct 300 kms of bike lanes. Paris, whose mayor was committed to building 650 kms of cycleways, connecting the downtown core with the suburbs. In the US, Oakland has converted about 10% of its street network into ‘slow streets’ that will remain closed to motor traffic. New York City has expanded the number of temporary protected bike lanes as part of its “Open Streets” initiative to add 100 miles of dedicated bike lanes. In the same vein, Boston has also launched a “Healthy Streets” initiative that aims to provide dedicated bike lanes along busy corridors that enable improved biking access to Boston’s job centers. While these are laudable efforts, cities should strive to convert temporary infrastructure into more permanent structures that can enable continuation of sustainable travel behavior in the future. Along with infrastructure provision, regulatory instruments can also be crucial to supporting sustainable travel behavior. Auto speed limits and more rigorous overtaking laws can improve safety perceptions of cyclists, by challenging the ‘might is right’ road culture currently prevalent among auto drivers (Aldred, 2016). Brussels has already reduced speed limits to 20 kmph in the city center. Thus, we recommend that Metro Boston focus on reducing the large gap between short commute trip share (32%) and biking commute mode share (2%) in the post-COVID era through a mix of encouraging bikeshare network expansion (especially in low-income neighborhoods), increased provision of protected bike lanes, and traffic regulation policies that enhance perceptions of safety among cyclists. In light of the aforementioned findings by Basu and Ferreira (2021), we also recommend that regional mobility planning efforts view bikesharing in conjunction with mass transit, to fully realize its potential to decrease auto-dependence and increase health and economic benefits.

4.3. Mobility-as-a-service

Mobility-as-a-Service (MaaS) has received widespread attention over the last few years, but both conceptual clarity and robust scientific evidence of practical impacts remain lacking. At its heart, MaaS attempts to overcome market segmentation by offering mobility services tailored to individual needs through shared mobility and cross-modal integration. MaaS can be used as a mobility management tool to introduce more travelers to shared modes, which they may not have used before (Matyas and Kamargianni, 2019). Simulation studies, which allow for analysis at large spatial scales, predict MaaS impacts to be promising. A case study for Zurich found that transport-related energy consumption could be reduced by 25%, accompanied by an increase in transport system energy efficiency by 7% (Becker et al., 2020). Stated preference surveys are another approach to understand how people respond to different MaaS strategies and calculate willingness-to-pay for such services (Ho et al., 2018a). Despite the suite of available research methods, practical applications are few and far between, possibly due to the significant expenses and complex coordination between public and private transport service providers associated with conducting pilots. Only a few pilot studies have been conducted with very limited sample sizes in European cities, e.g. N = 195 in Gothenburg, Sweden (Sochor et al., 2015) and N = 100 in Ghent, Belgium (Storme et al., 2020). The literature converges in recommending that the service delivery model drives the success of the program. In particular, the price (or subsidy) of different mobility services and modal efficiency are crucial factors that impact the uptake of shared modes.

The COVID recovery period provides a timely opportunity to leverage well-established shared mobility in the region (e.g. bikesharing and mobility-on-demand) and synergistic mass transit improvements (e.g. dedicated bus lanes and new bus fleets) to highlight how cross-modal integration can improve modal efficiency. Two major challenges that are likely to affect the success of this experiment are technological integration and cost salience. Fig. 9a shows an example of cross-modal integration, wherein a few identified busy bus routes in Boston overlap with a branch of the commuter rail (i.e., the Fairmount Line). Since MBTA services can be accessed with a single card (i.e., the Charlie Card), the technology makes it possible to divert a sizeable portion of commuters along these bus routes onto the Fairmount Line during the COVID recovery period in an effort to reduce crowding. As a result of being early movers in embracing shared mobility, consumers in Metro Boston are quite aware of and familiar with these services that keep growing in popularity. Moreover, the vendor of the Transit app is already experimenting with adding software support for one-stop shopping of mobility services (i.e., an integrated mobility marketplace). Along with real-time crowding information provision, they already have the functionality to book TNC rides and Bluebikes, and expect to add shuttle services (such as EZRide and Via) soon. With these features, commuters can easily use bikesharing in conjunction with mass transit.
improved health and overall well-being) have been found to increase co-benefits of sustainable mobility (such as better air quality, and... important meeting, etc.).

(e.g. taking kids to school/an important activity, being late for an... higher-cost TNC/taxi trips in emergency or time-sensitive situations).

Since the technology to implement MaaS programs in Metro Boston will be available soon, we expect cost salience, which leads individuals to perceive the cost of immediate effort to be larger than the cost of future effort, to be the clincher in determining the success of these programs. It is known that people tend to under-estimate the total costs of car ownership by about 50%; provision of this information can increase willingness-to-pay for mass transit by 22% with a projected decrease in car ownership of up to 37% (Andor et al., 2020). Car owners tend to view cars as a favorable mobility option since the marginal cost of car usage is almost negligible compared to the initial and relatively steep sunk cost of car ownership (Ho et al., 2018b). This contributes to non-car modes being perceived as more expensive on a marginal basis, which can affect the success of MaaS programs. For example, a study in Finland found that relative willingness-to-pay for MaaS was only 64% of respondents’ current mobility costs, despite around 43% of the sample being willing to adopt MaaS (Liljamo et al., 2020). Recent research on TNC perceptions among Metro Boston residents has reinforced that such services are mostly used for non-mandatory trips and act as mass transit substitutes within the inner core (Gehrke et al., 2019). All of these behavioral inclinations point to the necessity of a multi-pronged MaaS implementation strategy, wherein incentivizing MaaS use must be accompanied by disincentivizing car use and ownership (including TNCs) and promoting mass transit as the backbone of MaaS. Mobility bundles (provided through multi-modal MaaS programs) can also compete with car ownership/use in an additional way, by making it easier to use transit routinely while reserving a few dollars for occasional high-cost TNC/taxi trips in emergency or time-sensitive situations (e.g. taking kids to school/an important activity, being late for an important meeting, etc.).

Along with managing cost salience and providing the technology to enable cross-modal integration, another crucial element in MaaS programs (or mobility management programs, more generally) is the design of campaigns. Careful user-centric design of campaigns that stress the co-benefits of sustainable mobility (such as better air quality, and improved health and overall well-being) have been found to increase campaign efficacy (Cruz and Katz-Gerro, 2016). Although mobility management campaigns can contribute to enabling changes in mobility cultures, they have rarely been integrated into strategic transport policies. Such campaigns are found to be most effective when the focus is on social motivation and normalization of sustainable transport behavior (Hiselius and Rosqvist, 2016). We believe that focusing on reducing car use as a primary goal would yield better results, rather than demonizing car ownership, given the auto-dependent land-use and undeniable benefits of car ownership in the US. To aid governments and policy-makers in these endeavours, large employers (such as universities or businesses in downtown) can engage in employer-provided sustainable mobility benefits. For example, employers in Belgium provide mobility allowances (i.e., a monthly cash amount as compensation for car trade-in) or mobility budgets (i.e., an annual budget equaling the total cost of car ownership to be used on alternative and sustainable transport options) to reduce dependence of employees on company cars. Although company cars are not as prevalent in the US as in Europe, we believe that such programs could make a meaningful difference to the 10% of respondents (in the aforementioned survey) who use company cars in Metro Boston. In summary, we are hopeful that the technology to implement large-scale MaaS experiments will soon be available in post-COVID Metro Boston, and recommend that cost salience control and mobility management campaigns are adequately utilized through a multi-stakeholder framework that involves large employers.

4.4. Parking and congestion pricing

It has become imperative to restrict car ownership and use through pricing policies, as accessibility improvements on their own (such as new mass transit stations or bikesharing stations) may result in the influx of higher-income car-owning households who can out-purchase lower-income car-less households (Basu and Ferreira, 2020a). Employer-provided subsidized (or free) parking has been found to significantly increase solo driving in the US (Willson and Shoup, 1990). This is a major concern for Metro Boston in particular, where over 90% of car commute trips are made using single-occupancy vehicles based on ACS 2014-18 estimates. We find from our recent survey (discussed earlier) that 94% of respondents receive some form of subsidized parking at their workplace, among which 66% reported not having to pay for parking at all. Employer-provided free parking statistics in Metro...
Boston do not seem to have changed since 2005, when a study by Shoup (2005) reported the rate to be 93%. A recent investigation by the Spotlight team of the Boston Globe found that the vast majority of 21 surveyed major employers in the region offer commuter benefit policies that show little preference for whether employees drive or take mass transit. In the post-COVID recovery period, we believe that large employers have the potential to play an important role in reducing single-occupancy car commutes, especially as employees start returning to offices and businesses. For example, MIT eliminated annual parking permits in 2016 in favor of a daily pay-as-you-park program while also providing most of their 13,000 employees with a subsidized mass transit pass. The program was found to successfully decrease parking demand by 8% in the first year, alongside a 10% increase in mass transit ridership by MIT employees (Rosenfield, 2018). Similar parking cash-out programs, which allow employees the option to choose cash in lieu of parking subsidies, have been found to successfully reduce solo-drive employee commutes by 17% in California (Shoup, 1997a).

Parking policies can also affect sustainable mobility prospects through the mediating influence of housing. Minimum parking requirements have been critiqued for playing a role in inflating parking demand by reducing the market price of parking (Manville et al., 2010). When considered as an impact fee, minimum parking requirements can increase development costs by more than 10 times the impact fees for all other public purposes combined (Shoup, 1997b). This transport cost burden can account for an additional 17% of a housing unit’s rent, and can impose a steep cost on car-less renters (often extremely low-income households) who are forced to pay for parking that they do not need or want (Gabbe and Pierce, 2017). This can be a particularly acute problem in Metro Boston, where four in five of our survey respondents report having access to free parking at their residences. A recent study by the MAPC found that nearly 30% of off-street parking spaces at multi-family developments (accounting for over 41 acres of pavement and almost $95 million in construction costs) in the inner core of Metro Boston sit empty during peak demand hours.35

Eliminating minimum parking requirements have the potential to reduce the cost of urban development and auto-dependency. Cities like Hartford, Connecticut and Edmonton, Canada have removed city-wide minimum parking restrictions, while Buffalo, New York City, Minneapolis, and Portland have focused on doing away with these restrictions for certain types of developments, such as affordable housing or developments near transit. Reducing parking requirements may cause spillover parking problems, which could be addressed through creation of ‘Parking Benefit Districts’ where revenues from market-priced curb parking can be used for funding neighborhood public services (Shoup, 1995). The ‘Perfect Fit Parking’ report released by the MAPC provides strong evidence to support more informed decision-making when setting minimum parking requirements (instead of uniform municipality-wide requirements) by better understanding how parking demand varies based on proximity to transit, development type, and cost.36 While parking policies can be implemented relatively quickly, they need to be complemented with longer-term ‘car-lite’ strategies that encourage reducing the need for private car ownership and use (Basu, 2019). Such strategies usually focus on designing particular neighborhoods to become more ‘car-lite’ by improving non-car accessibility through mixed land use, transit-oriented development (TOD), shared mobility, and sustainable urban design (Basu and Ferreira, 2020).

In addition to deterring car use through parking and land use policies, congestion pricing is another regulatory instrument that can also generate revenue for communities to invest in sustainable mobility efforts. While express toll lanes are better suited to highways and expressways (as witnessed in California), cordon charges are more likely to be adopted within metro regions (Santos, 2005; Croci, 2016). Currently, New York City is the only city in the US to have a congestion pricing plan. Although not implemented yet, the plan is expected to charge around $12 for cars and $25 for trucks. The city already has a congestion charge of $2.75 for taxis and TNCs in Manhattan. Similar to NYC, Boston has also adopted congestion charges, but only for taxis and TNCs. The current charge of 20 cents per ride resulted in $4.2 million in revenue in 2018 for the City of Boston. While other cities in Metro Boston have also collected sizeable revenues, policy-makers have postulated that the current 20-cent fee is not adequate. Governor Baker’s 2021 budget proposes to raise the fee to $1 per ride, under which 70 cents would go to the state (to increase the MBTA’s operating budget, among other projects) and 30 cents would go to the city where the ride originated. Mayor Walsh has proposed two bills that would place a 6.25% charge on each ride, same as the state’s sales tax, which would be reduced to 3% if the ride is shared, in addition to a 20-cent fee for each mile of deadheading (i.e., empty cruising without a passenger). While these policies are necessary, the administration has not shown as much enthusiasm in establishing ‘traditional’ congestion pricing strategies that penalize low-occupancy private vehicles. Although cordon-based charges still remain a distant dream for Metro Boston, cities like Singapore (who have a long and successful history of congestion pricing policies) are moving away from cordon-based charges in favor of road usage charges within congested areas that are becoming increasingly practical to implement with modern ICTs (Cavallaro et al., 2018).

5. Discussion & conclusion

The COVID-19 pandemic has disrupted society as we knew it in a variety of ways. Long-term urban choices and medium-term travel behavior choices have been affected, in addition to possible changes in lifestyles and attitudes. These effects may be particularly acute for low-income households, whose hardships have been amplified by loss of employment and risky work environments. Metro Boston, which has a spatial mismatch history that is unfavorable to low-income workers, is no stranger to these trends. Even before COVID-19, the region was witnessing a decrease in mass transit ridership, while private car ownership and TNC services continued growing in popularity. Therefore, it came as no surprise when Boston was ranked in 2019 as the most congested city in the US for the second year in a row. What COVID-19 has highlighted is the brittleness of non-car mobility choices, while reinforcing how sticky car-oriented travel behavior can be (unless we properly internalize transport externalities).

COVID-19 presents a tipping point regarding transit demand. Within a week after the onset of the pandemic in Metro Boston, mass transit ridership dropped to 85% below expected levels. Although transit ridership has picked up since then, it currently stands at 75% lower than expected, implying a long and slow recovery to pre-COVID levels. Potential riders continue to remain nervous about transit safety, especially about the possibility of other passengers not adhering to safety measures already instituted. These measures come at a steep price for mass transit agencies such as the MBTA - physical distancing implies fewer passengers and lower revenues, while additional cleaning of vehicles and provision of safety equipment to employees place further demands on an already strained operating budget. Without funding support from the federal and state administrations, most transit agencies are going to struggle financially during the post-COVID recovery period. The cracks have already begun to show, as exemplified by the MBTA recently proposing service cuts to adapt to the ‘new’ ridership patterns.

Enhanced expectations of psychological dread risk have already alienated some transit commuters. Our survey found that one in five currently car-less households intend to purchase a car because of COVID-19. The convenience and safety of a personal car commute can indeed seem alluring, especially because of low traffic levels and
inherent physical distancing. Due to currently low parking demand in inner cities, the allure of low parking expenses also play a role in increasing the attractiveness of car commutes. However, we believe that these are only short-term trends, and are likely to be undone as more employees start going back to work in the recovery period. Left to the devices of the market, the net effects of COVID-19 would be reduced transit demand and increasing car commuting. These outcomes can prove to be particularly challenging to manage in areas where return to ‘normal’ work patterns cannot be handled due to already existing high congestion levels. At the broader level, these trends do not portend well for climate change-related sustainability concerns, and taking steps later rather than sooner will be much more painful. We believe that there is a window of opportunity in the next couple of years to move towards sustainable mobility outcomes rather than away, as we recover from the impacts of COVID-19.

ICT-enabled improvements in urban mobility have led to the emergence of a wide gamut of mobility services, and can play an important role in enabling a movement towards safe and sustainable mobility. Metro Boston plays host to mobility-on-demand services (e.g. TNCs like Uber and Lyft), bikesharing (e.g. Bluebikes/Hubway), shuttle services (e.g. EZRide and Via), in addition to mass transit. Multi-modal coordination, which is expected to be key in enabling a shift away from cars, is currently left in the hands of the consumer. Recent features introduced by the Transit app may start making a difference in alleviating this burden. For example, real-time crowding information on buses, in addition to transit passes, are available through the app. We posit that the ingredients for a multi-modal regional mobility strategy are in place, that could possibly be combined to provide the first Mobility-as-a-Service (MaaS) program in the world at a regional scale. Disincentivizing car commuting through congestion pricing or market-rate parking policies are going to be key in ensuring the success of a MaaS program, but consumers need to have the flexibility to choose cars for special circumstances (e.g. taking kids to activities, running late for work, crowded buses, etc.). The essence of a MaaS pilot should be centered around mass transit, with a complementary focus on penalizing car use rather than car ownership (since historic land-use policies in the US make car ownership necessary, rather than optional).

However, the incentives for MaaS to succeed as a ‘system’ solution are not yet in place. Each of the mobility services we described earlier are provided by different suppliers, and there is no easy way to have them share budgets and commitments to a larger sustainable mobility vision. For example, mass transit agencies are often nervous about TNCs cannibalizing their ridership, while TNCs are more focused on providing point-to-point (or direct) trips instead of first/last-mile connections to transit. As we move away from the inner core, car ownership becomes increasingly necessary due to low density of suburban development (requiring higher times to travel to activity locations) and higher distances to transit stations. The increasing cost of car travel affects low-income and essential workers disproportionately, who are already experiencing inordinate hardships due to COVID-19. For these individuals, mobility costs form a necessary and significant share of their monthly budgets, and being pushed into auto-dependence can be equivalent to pushing them into poverty. Thus, providing better mobility alternatives to the car need to be accompanied by meaningful and targeted reductions in mobility costs.

‘Car-lite’ policies may aid the regional MaaS program in becoming equitable, on top of being sustainable, by reducing the need for private vehicle ownership. A frequent example is by increasing the demand for parking in inner towns has the potential to act as a major deterrent for car commutes, but employers might want to consider the possibility of providing subsidized parking to low-income workers and late-night workers, especially at large institutions like universities or hospitals. Local policy-makers might wish to consider partnering with TNC and shuttle operators to provide subsidies for first/last-mile connection trips and pooled trips, with the fare difference being high enough to motivate behavioral change. While already low, transit fares can be further revised with an eye towards reducing transfer costs and provide of subsidized-fare passes for low-income transit commuters. These nearer-term mobility management policies need to be complemented by longer-term land use strategies that provide improved accessibility within ‘car-lite’ neighborhoods. As shown in New Zealand recently, strong political will can alter historic land-use policies that are geared around planning for automobiles, e.g. reducing parking requirements in building codes of inner cities.

Metro Boston, in particular, is going through a few changes in its mobility ecosystem. Will the new buses that are coming in this year be added to existing routes, or will they be part of the flexible demand management strategy? Will the real-time crowding information provision be coupled with a broader supply strategy to handle crowded or bad-weather days? After the success of the recent BRT pilots in Everett, can MassDOT be more assertive in providing a dedicated bus lane on the Tobin Bridge that connects Everett to downtown Boston (and is on the high-demand 113 bus route)? Can we re-envision mass transit stations to become mobility hubs, where bike-share networks converge and TNCs are provided priority pick-up/drop-off points (like in Singapore)? These questions, while exceedingly important for a long-term sustainable mobility strategy, cannot be addressed through academic analysis alone at this point.

As we discussed earlier, bills to increase the tax on TNCs and support transit are in legislature, but the political will to tax in-town parking and low-occupancy TNCs is still lacking. As more workers shift towards car commutes and traffic moves back to normal, the pain of shifting incentives will impact more people. As we recover from COVID-19, there will be many debts to pay and raising car costs (through higher parking costs and other car-commute disincentives) will become even more politically challenging. Therefore, we feel that regions like Metro Boston that could imagine more transit use and fewer single-occupancy car commuters are at a tipping point. How do we choose to recover from the COVID-19 crisis will set the stage for the next couple of decades. Will we continue to look the other way while car ownership and usage increase further? Will we take steps now that can reduce the pain later, or take the path of least resistance now and squander the current opportunity? Unlike COVID-19, climate change-related disruptions may not offer the time or opportunity to draft a recovery plan. In closing, we hope that our analyses and suggestions will prove helpful to academics and policy-makers who envision a sustainable mobility future for Metro Boston, and other metropolitan regions struggling to break free from the clutches of auto-dependence (e.g. Los Angeles), without diminishing the mobility of essential and low-income workers.

CRediT authorship contribution statement

Rounaq Basu: Conceptualization, Methodology, Data curation, Formal analysis, Visualization, Writing - original draft, Writing - review & editing. Joseph Ferreira: Conceptualization, Writing - review & editing, Supervision, Funding acquisition.

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