Dasmalchi, Eric, and Brian D. Taylor. 2022. "Examining Shifts in the Balance of Riders and Bus Service Before and During the Pandemic in Boston, Houston, and Los Angeles." *Findings*, April.

TRANSPORT FINDINGS

Examining Shifts in the Balance of Riders and Bus Service Before and During the Pandemic in Boston, Houston, and Los Angeles

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Keywords: transit ridership, transit service, transit equity, covid-19 pandemic

https://doi.org/10.32866/001c.34216

Findings

The COVID-19 pandemic reduced and shifted transit demand. Bus service also shifted due to shifts in demand and fiscal uncertainties. We examined bus ridership and service in Boston, Houston, and Los Angeles and find: (1) Houston has the most equal match between riders and service in all time periods; (2) In all three cities the distribution of riders and service grew more unequal in April 2020; (3) Boston did the most to shift service to match demand between April and October of 2020; and (4) LA was the only one to increase ridership/service equity in the mid- versus pre-pandemic.

1. Questions

The Covid-19 pandemic reshaped transit ridership patterns, while introducing operational and financial challenges to providing transit service. Given this: How did the distribution of transit ridership and transit service change in 2020 compared with 2019? Did transit agencies shift service delivery to match new patterns of demand across space? Were changes in the relative shares of transit service and ridership due more to changes in passenger demand or changes in service? We examine these three questions with respect to three very different cities: Boston, Houston, and Los Angeles.

2. Methods

To analyze ridership, we obtained stop-level boarding data for bus service from the largest transit agencies in three large, distinct US metropolitan areas: LA Metro (Los Angeles, CA), Houston Metro (Houston, TX), and the Massachusetts Bay Transportation Authority, or MBTA (Boston, MA). We focus on bus service because it can be more easily adjusted to shifting demand than rail service. These data give the average number of weekday boardings at a particular stop for a particular month. We then aggregated these data to census tracts, summing the number of boardings at all stops within a tract.

To analyze service provision, we looked at archived General Transit Feed Specification (GTFS) data. GTFS is a machine-readable format for transit schedule data, published by agencies to power trip planners such as Google Maps. OpenMobilityData archives GTFS feeds for many agencies, including the three that we study. Table 1 shows which GTFS feeds we retrieved for each month. Where service changes occurred within that month, we calculated a weighted average of service levels using the number of weekdays before and after the change.

Table 1. GTFS Feed Dates by Transit Agency and Service Month.

Transit Agency	Service Month	GTFS Feeds Used
MBTA Time 1 (Boston)	April 2019	March 29, 2019
MBTA Time 2 (Boston)	October 2019	October 15, 2019
MBTA Time 3 (Boston)	April 2020	March 24, 2020, April 9, 2020
MBTA Time 4 (Boston)	October 2020	October 15, 2020
Houston Metro Time 1	April 2019	April 3, 2019
Houston Metro Time 2	October 2019	October 13, 2019
Houston Metro Time 3	April 2020	March 11, 2020, April 17, 2020
Houston Metro Time 4	October 2020	October 4, 2020
LA Metro Time 1	April 2019	March 18, 2019
LA Metro Time 2	October 2019	October 4, 2019
LA Metro Time 3	April 2020	January 16, 2020, April 19, 2020
LA Metro Time 4	October 2020	July 30, 2020

To aggregate service provision to census tracts, we used Python and the Partridge library to filter each GTFS feed to a typical weekday within the month of interest. We then estimated vehicle revenue hours by summing the scheduled travel time between stops in each census tract. Where adjacent stops are in different tracts, we assigned the time in proportion to the straight line distance traveled within each. Where routes pass through a tract but do not stop, we did not assign that time to that tract. Instead, we assigned that time to the two nearest tracts that do contain stops, again in proportion to the distance traveled within each of those tracts.

With ridership and service metrics aggregated to the census tract level, we then calculated each tract's percentage of total regional boardings, and percentage of total regional service for each metro and each time period. We then divided each tract's percentage of boardings by its percentage of service to measure how closely service and ridership match. While this metric is not perfect, we think it is a useful indicator of the relative changes in ridership and service during a period of rapid change. Finally, we used this metric to calculate a Gini coefficient to measure the overall equality in the distribution of service and ridership across all tracts served by each operator.

3. Findings

The relative shifts in bus ridership in Boston, Houston, and Los Angeles across our four time periods are shown in Figure 1, and the shifts in bus service provision are shown in Figure 2.

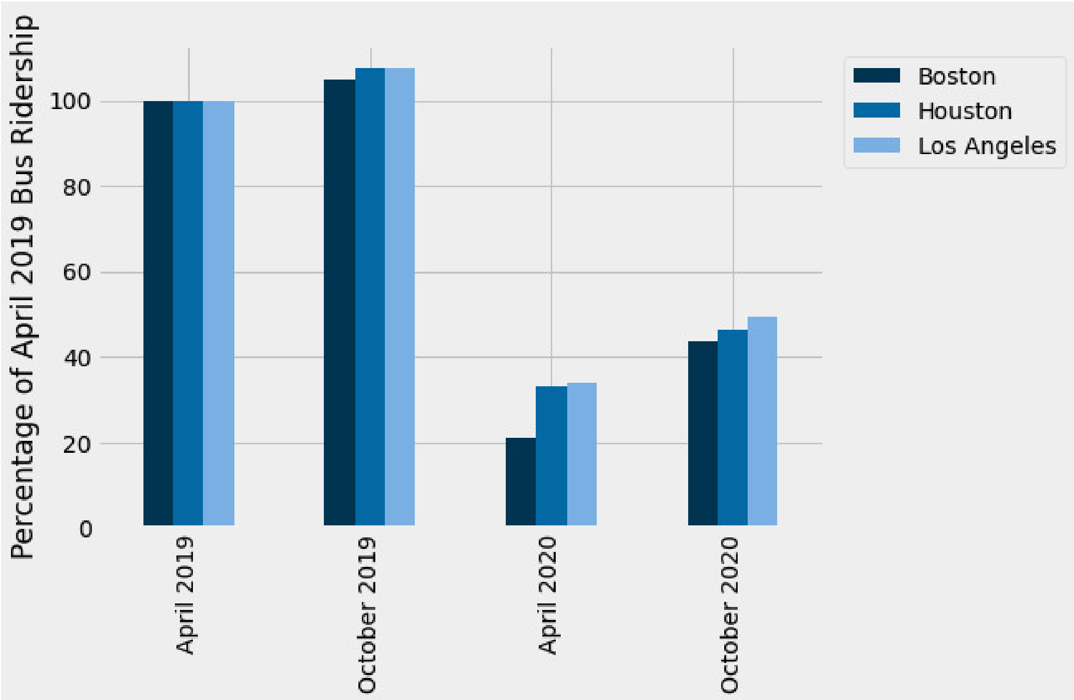

Figure 1. Changes in overall bus ridership before and during the pandemic.

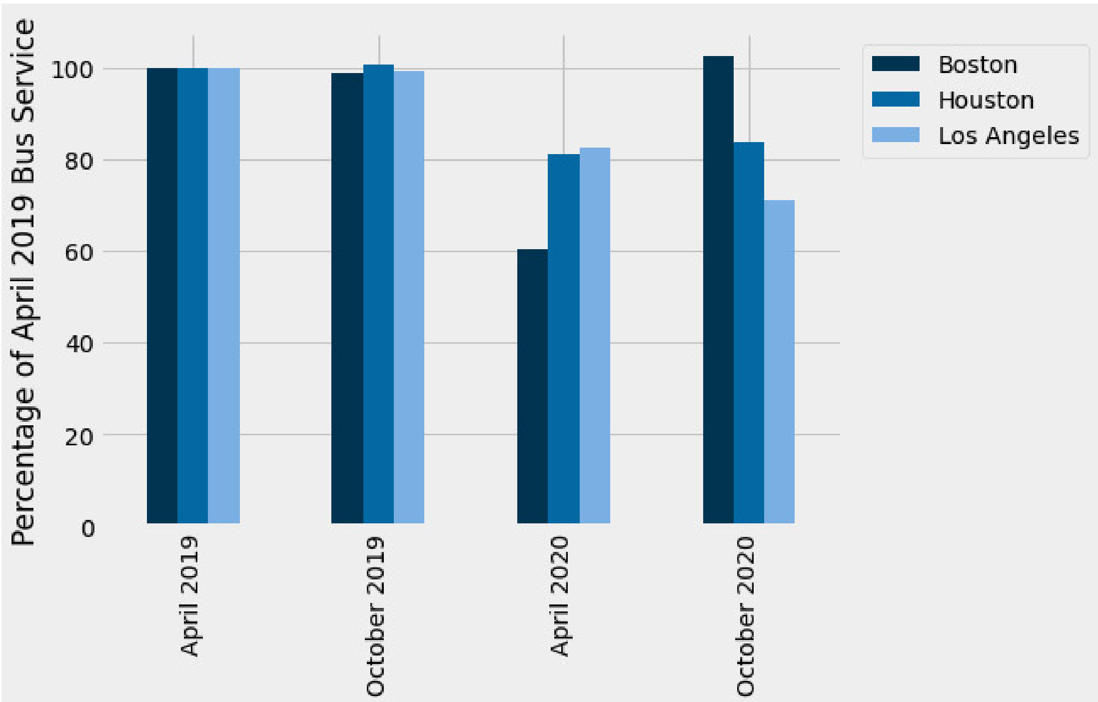

Figure 2. Changes in overall bus service before and during the pandemic.

Table 2. Service-Ridership Match Gini Coefficients.

	Apr '19	Oct '19	Apr '20	Oct '20	Apr '19 to Apr '20	Oct '19 to Apr '20	Oct '19 to Oct '20	Apr '20 to Oct '20
Boston	0.444	0.452	0.491	0.468	+0.047	+0.039	+0.016	-0.023
Houston	0.368	0.369	0.410	0.385	+0.042	+0.041	+0.016	-0.025
LA	0.454	0.453	0.490	0.431	+0.036	+0.037	-0.022	-0.059

Note: The lower the Gini Coefficient, the more equal the relative distribution of service and ridership.

Table 2 shows the bus service-ridership match Gini coefficients for the three cities over the four time periods and reveals several things.[1] First, Houston Metro, which completely restructured its bus service in 2015 to simplify its routes and reduce headways throughout the new network, has a more equal distribution of service and riders than bus service in either Boston or Los Angeles. Second, the relative distribution of service and riders grew more unequal in all three cities amidst the collapse in transit ridership at the outset of the pandemic. Third, the relative distributions of service and ridership grew more equal in all three cities as ridership gradually rebounded by the fall of 2020. And fourth, with overall ridership in October 2020 at roughly half of October 2019 levels in all three cities, the relative distribution of service and riders in Los Angeles had grown more equal, while in Boston and Houston it grew somewhat less equal – though Houston remained the most equally distributed in absolute terms.

What explains these shifts over the course of the pandemic? It may be that transit planners in all three cities responded to the dramatic drops and shifts in transit use observed in April 2020 by shifting service to reflect these new patterns by October 2020. Alternatively, the changes could be primarily due to ridership shifts, regardless of service patterns.

To explore which of these possibilities accounts for the Gini Coefficient changes shown in Table 2 we repeated our Gini Coefficient analysis for a hypothetical scenario: October 2020's patterns of ridership overlaid upon October 2019's service levels. If planners were able to successfully shift service to better match demand, we would expect to see higher Gini Coefficients in this hypothetical scenario, since it evaluates ridership patterns changed by the pandemic on a transit network that remained unchanged. Table 3 shows in all three cities, shifts in service between October 2019 and October 2020 at least partially mitigated the waxing mismatch between service and ridership amidst the pandemic (though in Los Angeles the shifts in ridership demand in October 2020 alone would have increased the balance of service and ridership relative to October 2019). The effect of service changes on the Gini

1 The public health effects of the pandemic varied significantly across the three cities early on. In April 2020, Suffolk County in Boston had by far the highest COVID-19 death rate (2.21/100,000), followed by Los Angeles County (0.36/100,000), and then Harris County in Houston (0.07/100,000). By October 2020, the COVID-19 death rates were much more similar across Suffolk (0.21/100,000), Los Angeles (0.16/100,000), and Harris Counties (0.15/100,000) (Centers for Disease Control and Prevention 2022a, 2022b, 2022c).

Table 3. Gini Coefficient Compositional Analysis.

	Oct '19 Actual	Oct '20 Actual	Actual Shift from Oct '19 to Oct '20	Oct '20 Ridership on Oct '19 Service	Gini shift if no service change from Oct '19 to Oct '20
Boston	0.452	0.468	+0.016	0.491	+0.023
Houston	0.369	0.385	+0.016	0.387	+0.002
LA	0.453	0.431	-0.022	0.441	+0.010

Note: The lower the Gini Coefficient, the more equal the relative distribution of service and ridership.

Coefficients were largest in Boston, less in Los Angeles, and very small in Houston (which, again, had the most equal relative distribution of service and patronage in all four time periods examined).

We thus find that dramatic shifts in transit demand during the COVID-19 pandemic caused the relative distributions of bus service and ridership to grow more unequal in Boston, Houston, and Los Angeles as contracting ridership was increasingly mismatched with bus service configured to meet pre-pandemic demands. However, service changes between April and October of 2020 mitigated these increased ridership/service mismatches in all three cities, but did not eliminate them in Boston or Houston.

Acknowledgements

This research was generously funded as part of the University of California Institute of Transportation Studies 2020 Coronavirus and COVID-19 Response and Recovery Initiative of the Statewide Transportation Research Program. We thank the helpful staff at MBTA, Houston Metro, and LA Metro for generously providing us with the data for this study, and UCLA graduate student Julene Paul and undergraduate student Nathan Sharafian for their contributions to this research.

Submitted: August 13, 2021 AEST, Accepted: April 06, 2022 AEST

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