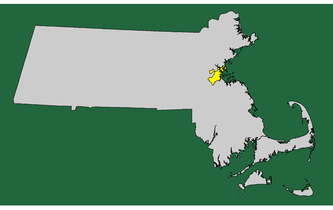
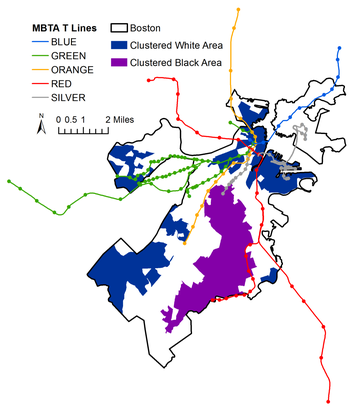
Towards a More Equitable Public Transportation System

An Exploratory Spatial Analysis of Boston's Bus Routes



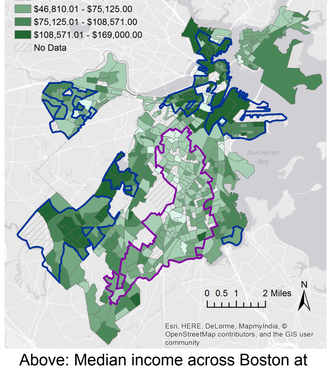
Introduction

Previous research has shown that expansions in public transportation have significant impacts on the spatial distribution of the activities of communities of color across an urban space[1]. It has also been shown that concentration of different types of public transportation influences neighborhood median income[2]. Housing value is also significantly influenced by access to public transit[2]. Most previous efforts to study disparities across the various spatial relationships of transit in Boston and other metropolitan areas have focused on rapid transit.



However, there is much less insight existing on these relationship as it regards bus routes. Existing literature on bus routes has often focused on impacts of service levels on ridership[3]. This preliminary exploratory analysis aims to gain a better understanding of the relationship between residential segregation and bus routes in Boston, MA. This is warranted considering the lack of access to MBTA T lines for areas of the city with a high proportion of black residents, as evidenced in the map to the left.

Methods

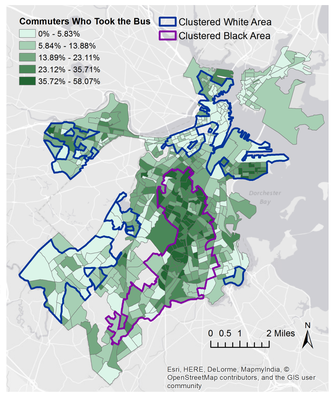


Above: Median income across Boston at the block group level

For this exploratory analysis, two Ordinary Least Squares regression models were run. Demographic data on race and receipt of food assistance, downloaded from the American Community Survey 2015 5-year estimates, were selected as potential explanatory factors for the fraction of commuters in each block group in Boston who commuted to work by bus. A second OLS regression was run using demographic data — including the fraction of commuters who took the bus — as potential explanatory factors for the fraction of commuters in each block group who spent 45 minutes or more in transit.

An analysis of clustering by race across block groups in Boston was performed using Moran's I. New polygon layers were created from the High-High clustered areas of both white alone populations and black alone populations. These polygons were combined with line shapefiles of MBTA bus routes and stops downloaded from MassGIS. A new layer of bus routes was created after performing an attribute query for those routes that intersected the clustered black area. This layer was then selected for those routes which also entered the white clustered area.

Additionally, the Network Analyst tool was used to create a .25 mile service area walkshed around all bus stops along the routes that the MBTA has identified as "key bus routes." Two new polygon layers were created from the block groups within the High-High clustered areas that fell completely outside the .25 mile service area walkshed layer. Select attributes of these two layers (one consisting of white clustered block groups and the other of black) were summarized in order to compare transit habits across these two groups.



Above: Fraction of total commuters in each Boston block group who commuted by bus

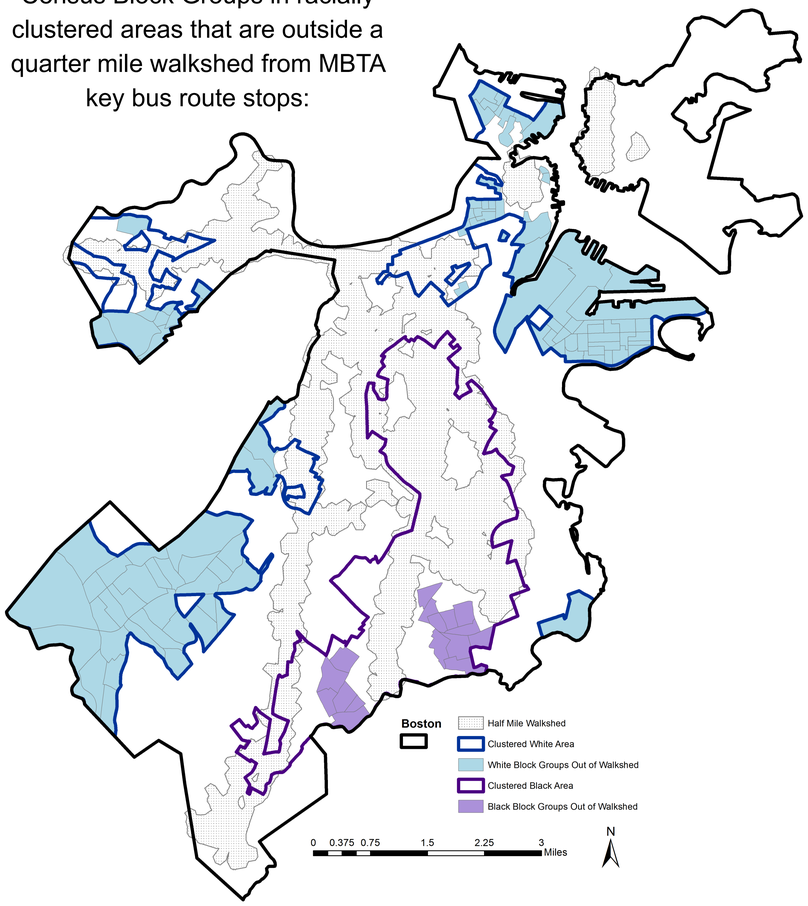
References:

1) Holzer, H. J., Quigley, J. M., & Raphael, S. (2002). Public Transit and the Spatial Distribution of Minority Employment: Evidence from a Natural Experiment. *Journal of Policy Analysis and Management, 22*(3), 415-441.

2) Barton, M. S. , & Gibbons, J. (2015). A stop too far: How does public transportation concentration influence neighbourhood median income? *Urban Studies, 54*(2), 538 -554.

3) Currie, G., & Delbosc, A. (2011). Understanding bus rapid transit route ridership drivers: An empirical study of Australian BRT systems. *Transport Policy, 18*, 755-764.

Census Block Groups in racially clustered areas that are outside a quarter mile walkshed from MBTA key bus route stops:



Comparison of average commute habits between Block Groups in racially clustered areas that are outside of a quarter mile walkshed from MBTA key bus route stops:

Cluster	Over 45 Min in Transit	Walked or Biked	Drove by Car	Took Public Transit	Took the Subway	Took the Bus
White	19.04%	18.05%	55.23%	26.72%	52.84%	37.13%
Black	36.73%	2.07%	64.16%	33.76%	52.77%	47.22%

OLS Regressions

Dependent Variable: Fraction of commuters/block group who took the bus
Adjusted R^2: 0.290016

Independent Variable	Coefficient	Standard Error	P-Value	Significance
Black Alone Population	0.195443	0.0297726	0	Yes
Received Food Assistance	0.135416	0.0190141	0	Yes

Dependent Variable: Fraction of commuters/block group who travelled ≥45 min
Adjusted R^2: 0.195062

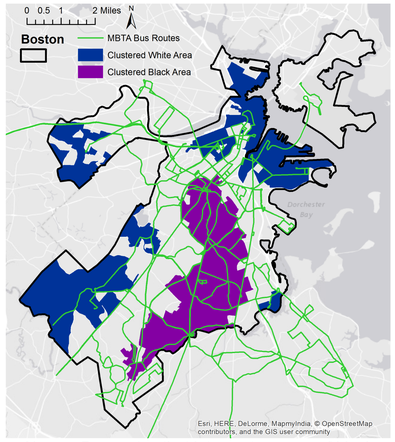
Independent Variable	Coefficient	Standard Error	P-Value	Significance
Black Alone Population	0.125923	0.020364	0	Yes
Commuters Took the Bus	0.0961139	0.046533	0.03935	Yes
Median Housing Value	-5.61E-08	2.27E-08	0.01378	Yes
Foreign Born Population	0.145973	0.0367803	0.00008	Yes

Results

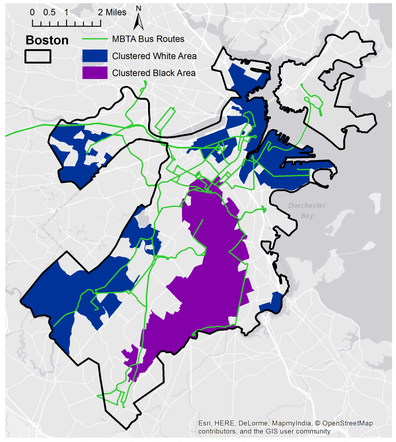
The value of the global Moran's I for the fraction of each block group that is black alone was 0.842284, and the value for white alone clustering was 0.760052. Not surprisingly, these values indicate significant clustering of black and white residents in Boston. The two maps to the right were the first to be produced. They reveal a disparity in the number of bus routes that can be accessed from the area of High-High clustered black alone population block groups and the number of these bus routes that subsequently connect directly into High-High clustered areas of white alone populations. This suggests a potential relationship between bus connectivity and residential segregation.

The Network Analysis reveals further inequity between these two areas of clustering. The clustered black area is much more covered by the .25 mile walkshed for MBTA key bus route stops, but it can be hypothesized that this is because this area is less served by T access (as shown in the map of MBTA T lines). And despite neither groups falling within the .25 mile walkshed, the block groups in the black clustered area are still 10 percentage points more likely to take the bus as their mode of commute. Also striking, these block groups are 17 percentage points more likely to spend 45 minutes or more in transit than those in the white clustered area.

The results of the OLS regressions show that several demographic variables are significant in predicting commuters who take the bus as well as those who spent 45 minutes or more in transit. The fraction of the population that is black alone is the most significant variable across both cases. As this value increases across block groups, bus ridership increases as well. The adjusted R^2 indicates that this and the fraction of the population who received food assistance predict almost 30% of the difference across commuters per block group who took the bus.



Above: Bus routes that intersect an area of block groups clustered by high proportions of the population that is black alone



Above: Bus routes that intersect areas of clustered high black population block groups and areas of clustered high white population block groups

Conclusion

In an ideal world, everyone would have equitable access to rapid transit. But rapid transit requires massive monetary and time investments in order to expand its infrastructure. The addition and enhancement of bus routes can serve as a much less intensive means to creating a more equitable city. This analysis has highlighted some of the ways that the current MBTA bus system is failing to provide equitable access to the city and potentially contributing to residential segregation. It was limited by the comparison of only two racial groups. Thus a more nuanced analysis of the relationships shown here that accounts for differences across race and ethnicity is warranted. Further research is needed to better clarify how race and other demographic factors relate to transit access and habits, and how transit has shaped these factors across time and space.

Katherine Stiegemeyer
GIS102 Advanced GIS
May 10, 2017

Tufts UNIVERSITY

Data Sources: American Community Survey 2015 5-year estimates, TIGER/Line Shapefile 2015, MassGIS 2016 Bus Routes Shapefiles

Projection: Lambert Conformal Conic

Coordinate System: NAD_1983_StatePlane_Massachusetts_Mainland_FIPS_2001