

Washington, DC, Bikeshare Equity Analysis

Technical Appendix

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This appendix documents the technical steps that support our analysis of Washington, DC's Capital Bikeshare trip-level data in 2010 and 2017.

Data Sources

Capital Bikeshare Trip History Data

We relied on Capital Bikeshare's trip history data from 2010 and 2017 to investigate where and when people set out to ride in Washington, DC. Downloadable files are generated for each quarter in the year and include the following information about each trip:

- duration
- start date and time
- end date and time
- start and end stations
- ID number of bike used for the trip
- whether the rider was a "registered" member (Annual, 30-Day, or Day Key Member)

The dataset contains over 3 million trips in 2017 and fewer than 200,000 trips in 2010.

American Community Survey (ACS) Data

ACS 5-year estimates were the primary data source to measure socioeconomic characteristics in small geographies within DC. We used ACS 2006–10 and ACS 2012–16 samples to support analysis of trip history data from Capital Bikeshare in 2010 and 2017. The 2013–17 ACS 5-year estimates were not available in time to include them in our publication. For each census tract, we extracted and computed the following data:

- share of residents by race and ethnicity
- rate of violent crime per 1,000 people
- unemployment rate
- homeownership rate
- share of workers with annual earnings over \$75,000 and share of households with annual income over \$75,000
- share of workers ages 16 and older who did not work from home, with a commute of fewer than 45 minutes

Linking Bikeshare Trips to Neighborhood and Physical Transport Structure

Bike trip history data from Capital Bikeshare are identified using station names. To map stations and perform spatial analysis, we retrieved location attributes of Capital Bikeshare stations in the Washington, DC, metropolitan area from the Open Data DC catalog.

The Capital Bike Share Locations dataset, part of the DC Geographic Information System, marks whether stations are within the boundaries of Washington, DC. As part of our analysis, we considered only stations located within the city of Washington, DC, and we assigned each station to the census tract where it is located. Each bike station in the city, therefore, inherits its assigned tract's socioeconomic characteristics from the ACS data.

Similarly, we accessed locations of Metro stations and dedicated bicycle lanes from the Open Data DC catalog to measure transport infrastructure and its impact on usage of Capital Bikeshare.

Deriving Equity Insights

Public Transport Access

For simplicity of analysis, we defined access to public transportation as the distance between each Bikeshare station and the nearest Metro station and [designated bike lane](#), defined by the Department

of Transportation. Straight line distance was calculated as a proxy for a bike station’s adjacency to a Metro stop. In the case of a bike lane, straight line distance stands for the shortest perpendicular distance between a bike station and all bike lanes. No actual route or transportation preference was incorporated in the calculation because of limitations in data and scope of work.

As of October 2018, the database of bike lanes in DC documented the lengths, locations, and types of 1,370 lanes in shapefiles, including dedicated bike lanes, cycle tracks, and shared lanes. This database is the best source for identifying bike-friendly infrastructure in the city, but it may underestimate the space where bikes could be operated, as riders may choose to use roads or paths dedicated to pedestrians or vehicles.

Trip Weighted Characteristics

We quantify the socioeconomic characteristics of trip destinations to conduct equity analysis in our second blog post. We look at the destinations of trips from each starting neighborhood and aggregate the socioeconomic measurements of destination neighborhoods with the number of trips to any one of those destinations. The weighted average values represent, on average, which kinds of destinations riders are exploring on bike trips. Findings from comparing each neighborhood and their aggregated destinations are presented in our second blog post.

The following formula summarizes this approach:

$$C^S = \frac{\sum_{i=1}^{N^S} C_i + T_i^S}{\sum_{i=1}^{N^S} T_i^S}$$

where C^S , the weighted destination characteristics for a starting neighborhood S , is the sum of the product of characteristics for each destination neighborhood i and the volume of trips T between neighborhoods S and i , divided by the sum of all trips from neighborhood S , N^S is the number of destination neighborhoods from a given neighborhood, and the number of destinations varies by each neighborhood in DC. When examining the weighted origin neighborhood characteristics for a given destination, the formula is modified:

$$C^E = \frac{\sum_{i=1}^{N^E} C_i + T_i^E}{\sum_{i=1}^{N^E} T_i^E}$$

where C^E , the weighted starting neighborhood characteristics for a destination neighborhood E , is the sum of the product of characteristics for each starting neighborhood i and the volume of trips T between neighborhoods E and i , divided by the sum of all trips from neighborhood E , N^E is the number of destination neighborhoods from a given neighborhood.

Travel Patterns for Different Types of Users

Users may adopt Bikeshare to travel for different purposes. Capital Bikeshare’s trip history data allows for roughly distinguishing regular trips conducted for daily commutes (Bikeshare membership riders who travel 7:00–10:00 a.m. and 5:00–7:00 p.m.) from trips of potential leisure users and tourists (riders without membership) or DC residents who use Bikeshare to explore other parts of the city for a variety of purposes (membership riders who travel outside previously mentioned morning and evening rush hours). In our research, we focused on riders with membership traveling during or outside rush hours, where appropriate, to establish relatively reliable travel patterns; yet this approximation is imperfect and cannot speak to a rider’s real motivation for using Capital Bikeshare.

Outliers

A few census tracts from ACS surveys are recorded to have very small numbers of households and may have extreme average levels of neighborhood characteristics. These include Anacostia Park and Kingman Island, the Potomac Parks and National Mall, and the neighborhoods that contain George Washington University and Georgetown University. We approach these areas with care, and when values of characteristics are extreme and unreasonable we choose not to present results on maps or graphs for these census tracts. For instance, the DC maps in our first blog post did not present income or ethnicity information for census tract 006202 (the Potomac Parks and National Mall) because of extreme values.

Limitations

- Since individual-level route data are not available, we assume all trips begin and end in the census tract of the bike station, though we are aware that riders’ journeys may begin or end outside these tracts. There is a possibility that riders use Bikeshare as a tool in the first or last mile of their journey, to complement existing public transport modes such as the Metro. Individual-level data with a more comprehensive account of journey history would be necessary to clarify the role of Bikeshare in the broader transportation ecosystem.
- Bikeshare data may be affected by the introduction of other shared mobility tools, such as dockless bikes and scooters. In recent years, DC has experimented with dockless bikes and scooters, which for many people may be substitutes for the Capital Bikeshare system. Although it’s likely these new transit modes are operating on a much smaller scale, as they expand we believe the data should be made publicly available to study their effects.
- Bikeshare stations are not necessarily representative of the tract to which they are assigned. In cases where a bike station is at the boundary of several census tracts, for example, the nearby census tract to which the station was not assigned may contain an equal number of riders.

Accounting for station exposure by distance, as opposed to census tract assignment, would be a more detailed approach but was unfortunately out of the scope of this analysis.

- We do not have information on actual routes traveled. Our research examines start and end stations but does not investigate the trips of users. However, the trips may have equity implications in no small part because of the urban spaces users are exposed to throughout their bike journeys.

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