Bikesharing Effect on Transit Ridership: A Time Series Analysis of the Capital Bikeshare Program CaBi

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Shared-use Vehicle Services and Transit Relationship
Capital Bikeshare and Metrorail

DC – 194 Stations
Arlington – 70 Stations
Alexandria – 8 Stations
Montgomery County – 41 Stations

Source: https://www.capitalbikeshare.com/stations
Questions we ask

• Is there a relationship between spatial pattern of bikeshare trips and rail station locations?
• Does spatial pattern of bikeshare trips change over time/by season?

➡ Spatial analysis

• Does bikeshare program affect transit ridership, if so, how?

➡ Econometric analysis
Spatial analysis
Origin – Destination (O - D) analysis
  • by year
  • by season

Econometric analysis
OLS regression analysis
  • Bikeshare program characteristics
  • Transit service characteristics
  • Built environment
  • Socio-demographics
Capital Bikeshare (CaBi) of D.C.

• Established in September 2010
• 321 stations, 2,500 bicycles, 22,200 members (as of July 2014)
• User profile:
  – Young (63% under 35)
  – Slightly gender skewed (57% male)
  – Predominantly white (80%)
  – Highly educated (95% with four-year college degree)

(source: 2013 Capital Bikeshare Member Survey Report)
Capital Bikeshare Installation Year

- 2010
- 2011
- 2012
- 2013

M Metrorail Stations

Quarter Mile Buffer
Origin-Destination (O-D) Analysis by Year

Number of trips by O-D pair

- 100 - 500
- 501 - 1,000
- 1,000 +

Metrorail Stations
From 2011 to 2013, program expended, number of trips increased
CaBi stations with highest ridership share similar built environment characteristics (except Tidal Basin)
- Woodley Park-Zoo
- Dupont Circle
- Union Station
- Eastern Market
- Crystal City
- Court House
- Tidal Basin

Co-location of CaBi and metro rail stations
Most commuting trips are shorter than other modes
2\textsuperscript{nd} and 3\textsuperscript{rd} quarter have the highest ridership
  – Tourist
  – Outdoor activities

Despite the seasonal change, two stations have the highest ridership throughout the year:
  – Dupont Circle
  – Capitol Hill Area (Eastern Market, Union Sta)

Some exceptions:
  – Students
Capital Bikeshare Installation Year

- 2010
- 2011
- 2012
- 2013

M Metrorail Stations
Quarter Mile Buffer
## Variables and Data Sources

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Variables</th>
<th>Description</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit ridership</td>
<td>Average Daily weekday boardings of Metrorail station, walk or bike as egress and access modes</td>
<td>WMATA, 2013</td>
<td></td>
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<table>
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<tr>
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<tr>
<td></td>
<td>Bicycle sharing program</td>
<td>CaBi station number</td>
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<td></td>
<td>Existence of CaBi station</td>
<td>1 for transit station with CaBi station within ¼ mile distance</td>
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<td>Transit service</td>
<td>Park &amp; Ride</td>
<td>1 for transit station with Park &amp; Ride facility</td>
<td>WMATA, 2013</td>
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<td>Parking usage</td>
<td>1 for WMATA-owned parking facilities</td>
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<td>Bus stops</td>
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<td>GTFS, 2014</td>
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<td>AM peak frequency</td>
<td>Number of trains in both directions in AM peak (7am - 10 am)</td>
<td>WMATA, 2013</td>
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<td></td>
<td>Terminal</td>
<td>1 for terminal station</td>
<td>WMATA, 2011</td>
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<td></td>
<td></td>
<td>Connectivity</td>
<td>Composite index including transit routes, coverage, speed, capacity, urban form, and etc.</td>
<td>NCSG, 2010</td>
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## Variables and Data Sources (cont’d)

<table>
<thead>
<tr>
<th>Built environment</th>
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<td><strong>Housing density</strong></td>
<td>Gross residential density (HU/acre) on unprotected land</td>
<td>SLD, 2012</td>
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<tr>
<td><strong>Population density</strong></td>
<td>Gross population density (people/acre) on unprotected land</td>
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<td><strong>Employment density</strong></td>
<td>Gross employment density (jobs/acre) on unprotected land</td>
<td>SLD, 2012</td>
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<td><strong>Employment mix</strong></td>
<td>8-tier Entropy employment mixture index</td>
<td>SLD, 2012</td>
<td></td>
</tr>
<tr>
<td><strong>Street network connectivity</strong></td>
<td>Number of intersections in transit station catchment areas</td>
<td>OSM, 2013</td>
<td></td>
</tr>
<tr>
<td><strong>Centrality</strong></td>
<td>Index of block group working age population accessibility relative to max CBSA accessibility</td>
<td>SLD, 2012</td>
<td></td>
</tr>
<tr>
<td><strong>Regional job accessibility (auto)</strong></td>
<td>Number of jobs that can be accessed within 30 minutes by auto</td>
<td>NCSG, 2012</td>
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### Dependent variable
- **Transit ridership**
  - Average Daily weekday boardings of Metrorail station, walk or bike as egress and access modes
  - WMATA, 2013

### Independent variables
- **Bicycle sharing program**
  - CaBi station number
    - The number of CaBi docking stations within a ¼ mile distance of Metrorail station
    - DDOT, 2013
  - CaBi ridership
    - The total ridership of all CaBi stations within a ¼ mile distance of Metrorail station
    - CaBi and DDOT, 2013
  - Existence of CaBi station
    - 1 for transit station with CaBi station within ¼ mile distance
    - DDOT, 2013
- **Transit service**
  - Park & Ride
    - 1 for transit station with Park & Ride facility
    - WMATA, 2013
  - Parking use
    - 1 for WMATA-owned parking facilities
    - WMATA, 2013
  - Bus stops
    - The number of bus stops within a ¼ mile distance of Metrorail station
    - GTFS, 2014
- **AM peak frequency**
  - Number of trains in both directions in AM peak (7 am - 10 am)
  - WMATA, 2013
- **Terminal**
  - 1 for terminal station
  - WMATA, 2011
- **Connectivity**
  - Composite index including transit routes, coverage, speed, capacity, urban form, etc.
  - NCSG, 2010

### Built environment
- **Housing density**
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- **Population density**
  - Gross population density (people/acre) on unprotected land
- **Employment density**
  - Gross employment density (jobs/acre) on unprotected land
- **Employment mix**
  - 8-tier Entropy employment mixture index
- **Street network connectivity**
  - Number of intersections in transit station catchment areas
- **Centrality**
  - Index of block group working age population accessibility relative to max CBSA accessibility
- **Regional job accessibility (auto)**
  - Number of jobs that can be accessed within 30 minutes by auto
  - NCSG, 2012
## OLS Regression Analysis

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<th>Model 1: full model</th>
<th>Model 2: Parsimonious model</th>
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<tr>
<td>Constant</td>
<td>4.39</td>
<td>1.0</td>
</tr>
<tr>
<td>log(CaBi ridership)</td>
<td>0.28</td>
<td>0.06</td>
</tr>
<tr>
<td>Log(transit connectivity)</td>
<td>0.04</td>
<td>0.09</td>
</tr>
<tr>
<td>log(AM peak frequency)</td>
<td>0.49</td>
<td>0.20</td>
</tr>
<tr>
<td>Log(housing density)</td>
<td>0.03</td>
<td>0.08</td>
</tr>
<tr>
<td>Log(employment density)</td>
<td>0.14</td>
<td>0.06</td>
</tr>
<tr>
<td>Log(bus stops)</td>
<td>0.21</td>
<td>0.12</td>
</tr>
<tr>
<td>log(street network connectivity)</td>
<td>-0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>Log(median household income)</td>
<td>0.04</td>
<td>0.01</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.81</td>
<td>-</td>
</tr>
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</table>
• 10% increase in bikesharing ridership will lead to 2.6% increase in transit ridership
• Employment concentration at the transit station areas has stronger impacts on transit ridership than residential concentration
• 10% increase in transit frequency will lead to 4.9% increase in transit boarding
• Bus connection are also important to provide egress and access connection
Remarks

• Spatial patterns of bikeshare stations in both urban and suburban areas
  – Denser, mixed land use, vibrant historic districts
  – Closer to rail transit
  – Varies by season, by location (urban vs. suburban, special OD e.g. university, tourist attraction)

• The close interactions between bikeshare program and rail
  – Higher bike ridership → higher transit ridership
Limitations & Future Research

- Time-series analysis on bikesharing and transit
- Magnitude of effects, transit vs. bike
- Only 40% CaBi trips are commute trips, trip purpose data is missing
- Unobserved characteristics e.g. short trips due to free first 30 min
- Impacts of transit on bikesharing?
- Improving model, e.g. time-series, additional variables e.g. bike lanes
Thanks!

Q&A