Motivation & Research Question

- Bikesharing is growing.
- How does it impact our existing transit systems?
  - Substitute?
  - Complement?
  - Recreation?
- Does it influence the travel behavior of non-members?

Background: Bikesharing Rollout

- Citi Bike opened in New York in May 2013
- Phased implementation
- Phase 1 stations are located in Manhattan below 60th St and in parts of Brooklyn

Background: Ridership Levels

Daily Bus Ridership in Manhattan & Brooklyn: ~951,000
Daily Bikesharing Ridership: ~26,000

Method: Difference-in-Differences

- Assumes trends would be the same in the treatment and control in the absence of bike-sharing
- Technique to control for omitted variables

Preliminary Evidence
Method: Difference-in-Differences Regression

\[ \ln(\text{BusRiders}_{jt}) = \alpha + \beta_0 \text{BikeOpen}_{jt} \times \text{BikeArea}_{jt} \times \text{Docks}_{jt} + \gamma \text{Date}_{jt} + \delta \text{Route}_{jt} + \lambda \text{Controls}_{jt} + \epsilon_{jt} \]

- \( \text{BusRiders}_{jt} \): bus ridership on day \( t \) on route \( j \)
- \( \text{BikeOpen}_{jt} \): 1 if the date is on or after May 27, 2013
- \( \text{BikeArea}_{jt} \): 1 if any part of bus route is near bike-sharing dock
- \( \text{Docks}_{jt} \): number of bike docks (in thousands) near bus route
- \( \text{Date}_{jt} \): date fixed effects
- \( \text{Route}_{jt} \): route fixed effects
- \( \text{Controls}_{jt} \): vector of area- and time-varying characteristics

Our coefficient of interest \( \beta_0 \), on \( \text{BikeOpen}_{jt} \times \text{BikeArea}_{jt} \times \text{Docks}_{jt} \), identifies routes in the treatment area after the bike-sharing system opened, weighted by the intensity of bike-sharing infrastructure.

Quantifying Treatment Intensity

- M23 Bus Route Example
- Count the number of bike docks at stations falling within ¼ mile of each bus stop

### Treatment Intensity of Docks

<table>
<thead>
<tr>
<th>Per-Treated Route</th>
<th>Manhattan &amp; Brooklyn</th>
<th>Manhattan Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1,359</td>
<td>2,002</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>1,045</td>
<td>1,029</td>
</tr>
<tr>
<td>Min.</td>
<td>66</td>
<td>261</td>
</tr>
<tr>
<td>Max.</td>
<td>4,701</td>
<td>4,701</td>
</tr>
<tr>
<td>Total Docks (all routes)</td>
<td>11,858</td>
<td>9,596</td>
</tr>
</tbody>
</table>

Method: Difference-in-Differences Regression

\[ \ln(\text{BusRiders}_{jt}) = \alpha + \beta_0 \text{BikeOpen}_{jt} \times \text{BikeArea}_{jt} \times \text{Docks}_{jt} + \gamma \text{Date}_{jt} + \delta \text{Route}_{jt} + \lambda \text{Controls}_{jt} + \epsilon_{jt} \]

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Control Variables

- \( \ln(\text{ScheduledRevenueMiles}_{jt}) \): total miles that buses along route \( j \) were scheduled to travel on day \( t \)
- \( \text{BusTime}_{jt} \): 1 if real-time information was available for route \( j \) on day \( t \)
- \( \text{BusExp}_{jt} \): 1 if any part of bus route \( j \) is within the service area on or after August 8, 2013 when expanded street taxi program began
- \( \text{SelectBusService}_{jt} \): 1 if any bus along route \( j \) was operating rapid bus service on day \( t \)

Cycling Infrastructure

- BikeLanes: miles of bike lanes within 0.25mi of the bus route

Image source: http://www.nycbikemaps.com/maps/nyc-bike-map/
Regression Results

<table>
<thead>
<tr>
<th>Manhattan &amp; Brooklyn</th>
<th>Manhattan*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.21</td>
</tr>
<tr>
<td>(1) Main</td>
<td>-0.03</td>
</tr>
<tr>
<td>(2) BikeArea</td>
<td>0.01</td>
</tr>
<tr>
<td>(3) Main x BikeArea</td>
<td>0.00</td>
</tr>
<tr>
<td>(4) BikeDock</td>
<td>0.00</td>
</tr>
<tr>
<td>Std Error</td>
<td>0.15</td>
</tr>
<tr>
<td>R²</td>
<td>0.10</td>
</tr>
<tr>
<td>Adj R²</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Note: The dependent variable is the natural log of daily enlisted bus trips. Bus. are estimated using EKLS method at the route level. This is presented in parentheses.

Interpretation of Results

• Manhattan & Brooklyn
  – Every thousand bikesharing docks along a bus route is associated with a 2.42% reduction in bus trips
  – For a treated route with the mean number of docks, this is equivalent to a 3.3% reduction in trips
  – Or roughly 18,100 fewer bus trips per day

Are the results being driven by something else?

Additional Specifications

1. With a linear time trend by treatment (Date, x BikeArea), the estimated reduction in bus ridership is still significant
   • ~20,800 trips/day in Manhattan & Brooklyn
   • ~14,000 trips/day in Manhattan

2. The results are robust to:
   • most variations of the treatment measure

3. A placebo test using a fictitious start date one year prior to opening passes

4. An alternative way to divide the treatment and control groups (by fare type)

Conclusions and Limitations

Conclusions

• Fall in bus ridership coincides with introduction of a bikesharing system in New York City
• Although this is a small proportion of bus trips, it could mean that either:
  – A large proportion of bikeshare members are substituting bus trips for bikesharing trips
  – Bikesharing may have impacted the travel behavior of non-members

Limitations

• Are there other changes occurring at the same time, in the same area, to the same group of riders that impact bus ridership?

Questions? Email cbrakewo@utk.edu

THANK YOU!
Appendix: Alternate Treatment Group

Is there something unique about the routes in the treatment area?

- Exploit differences in biking across full fare and reduced fare riders. Eligible for reduced fare if:
  1. 65 years of age or older
  2. Have a qualifying disability

1% of trips are taken by age 65+

Appendix: Interpretation of Results for Alternate Treatment by Fare Type

- Manhattan & Brooklyn
  - Every thousand bikesharing docks along a route is associated with a 3.13% reduction in full fare bus trips
  - Taking the mean number of docks, this is equivalent to a 4.2% reduction in full fare trips
  - Or roughly 18,300 fewer full fare bus trips per day

- Additional specifications
  - Controlling for a linear time trend by full fare, it’s roughly 20,200 fewer full fare trips per day
  - A placebo test passes

Appendix: Regression for Treatment by Fare Type

\[ \ln(\text{Riders}_{ijt}) = \alpha + \beta_1(\text{BikeOpen}_i \times \text{FullFare}_j \times \text{Docks}_j) + \delta_1(\text{Dose}_{ijt} + \gamma_1(\text{FullFare}_j \times \text{Route}_{ijt} + \lambda_1(\text{Control}_{ijt}) + \epsilon_{ijt}) \]

Riders\textsubscript{ijt} bus ridership for fare group \textsubscript{i} on day \textsubscript{t} on route \textsubscript{j}

FullFare\textsubscript{i} 1 for full fare, 0 for reduced fare group

Controls\textsubscript{ijt} also includes Access\textsubscript{A}Red\textsubscript{M}, an indicator if qualifying and randomly selected reduced fare passengers were eligible for free transit trips on or after April 15, 2013 when the program began rolling out

Our coefficient of interest, \beta_1, on BikeOpen \times FullFare \times Docks, identifies the treated group of passengers after the bikeshare system opened, weighted by the intensity of bikeshare infrastructure.