An Analysis of New York City's Citi Bike System as a Substitute for Subway Travel During Service Disruptions

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Project Goal

Determine whether subway shutdowns have any significant effect on ridership patterns

Business/Policy Relevance

- Free shuttles are often provided during subway shutdowns

  → Cities could evaluate whether more shuttles or more bikes are needed during shutdowns

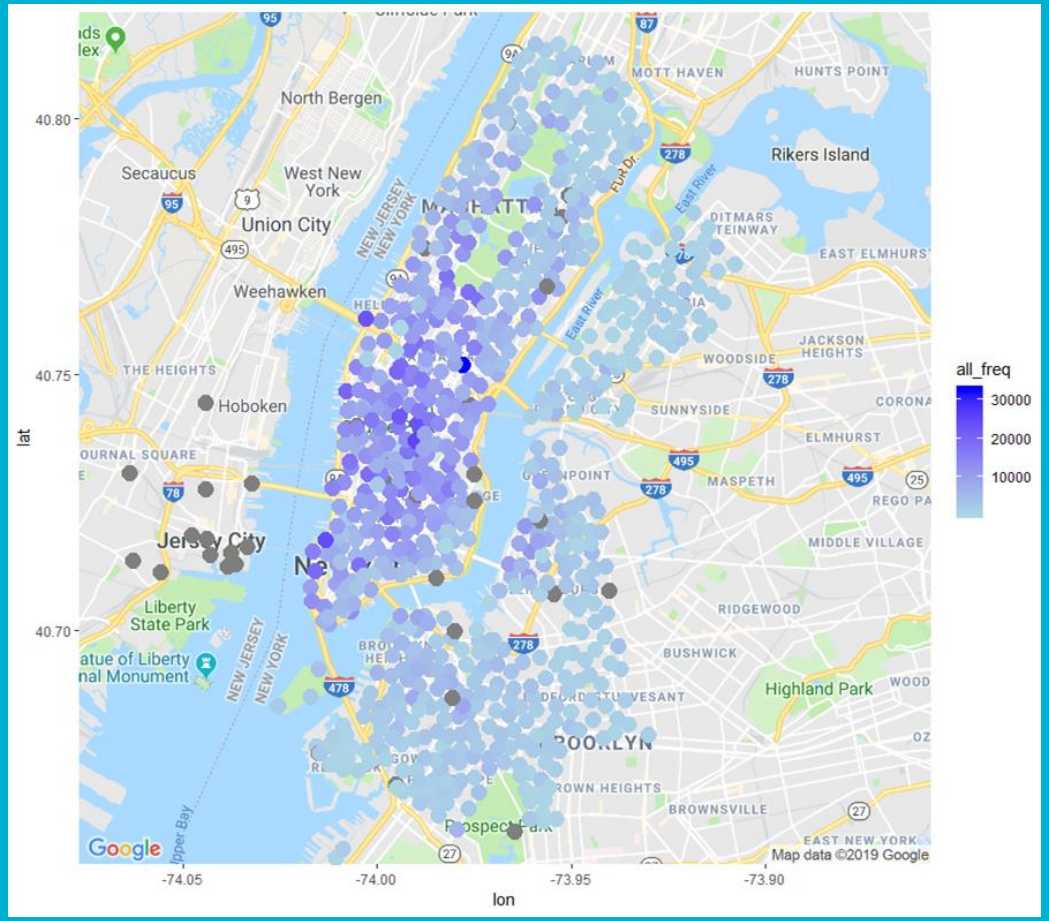
- Could be used to determine whether to expand bike stations and where to expand bike stations to plan for major construction events

Background & Context

- Allows users to borrow and return bikes at any station
- Largest bike sharing system in the United States
- Monthly ridership data free & available to the public (June 2013-present)
- Model each bike station as a node in a network
- Two stations share a directed edge if a person rides from one station to another

Background & Context Continued

- CitiBike station usage frequency in August 2018.
- Stations with high usage rate are in midtown.



Previous Literature- Relevant Findings

- Bike sharing systems help extend the reach of public transit networks
  - Bike station proximity to subway stations is associated with greater use
    - Noland et. al, 2016 -- NYC CitiBike Data
    - Ma et. al, 2015-- Washington D.C. Capital Bikeshare
- Bike sharing systems sometimes serve as substitutes to public transit
  - Used in place of the bus (less desirable form of transit)
    - Campbell & Brakewood, 2017-- NYC CitiBike
  - Used during metro/subway service disruptions
    - (Saberi et. al, 2018)-- London Tube Strike
    - (Kaviti et. al, 2018)-- Capital Bikeshare during SafeTrack construction

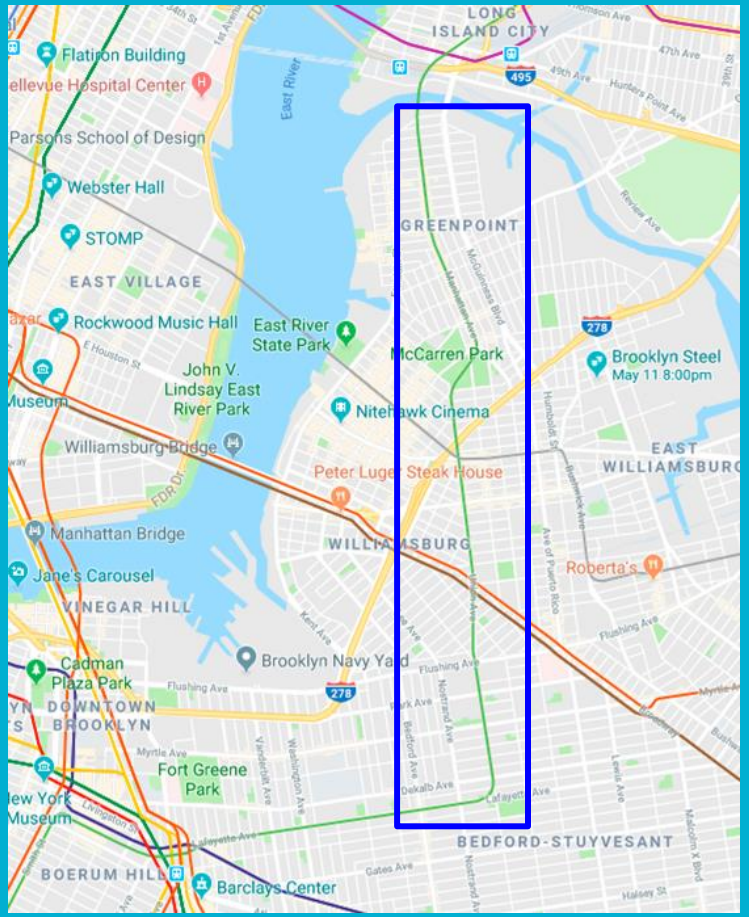
General Methodology

1. Choose subway shutdown incident from the news in an area where there are few transit substitutes
2. Model CitiBike ridership networks in the same geographic area as the shutdown locations
3. Build Test groups & Control groups to compare networks during shutdowns and during similar/comparable times

Incident I : No G train on weekends during September 2018

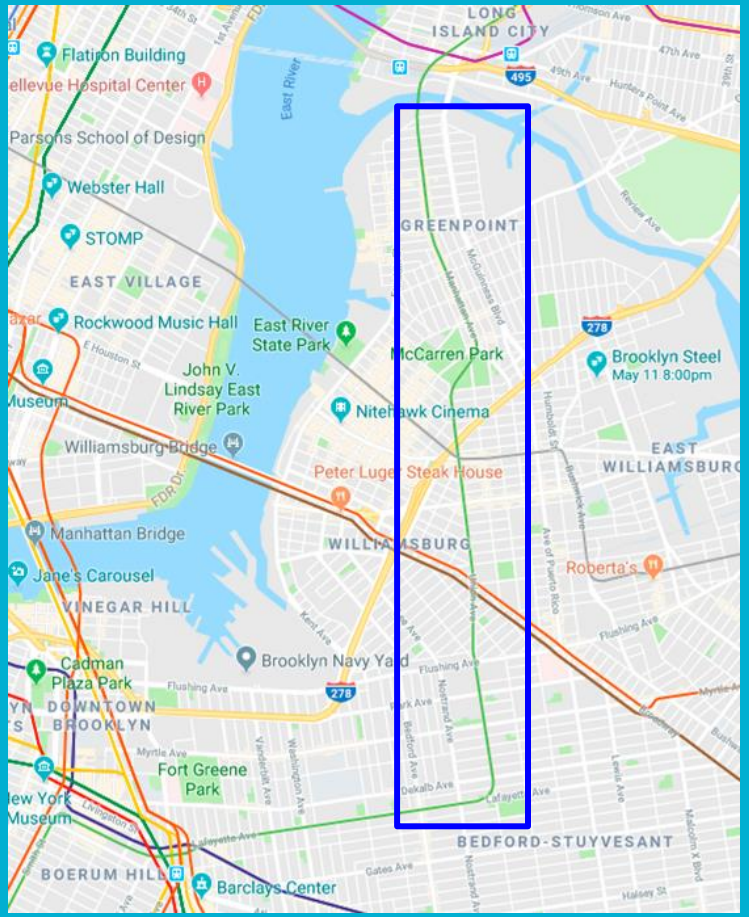
Methodology:

1. Filter for rides that occurred within blue box
2. Define node size= # rides to and from a particular station
3. Compare visualizations of weekend rides with no shutdown for August 2018 and September 2018

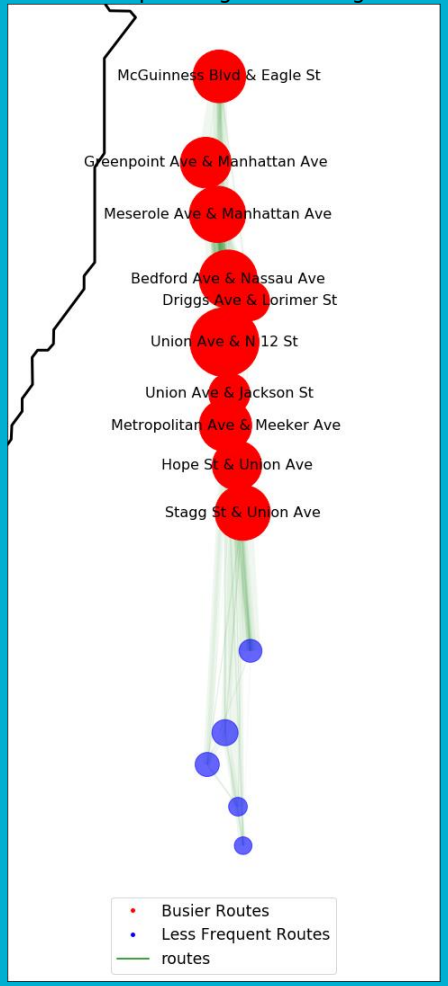


Continued

- Chose 8 weekend days in months prior rather than September 2017 for better comparison
- No rainy days in either dataset
- Compared total number of rides within area of interest between the two groups



CitiBike Ridership During Functioning Weekends

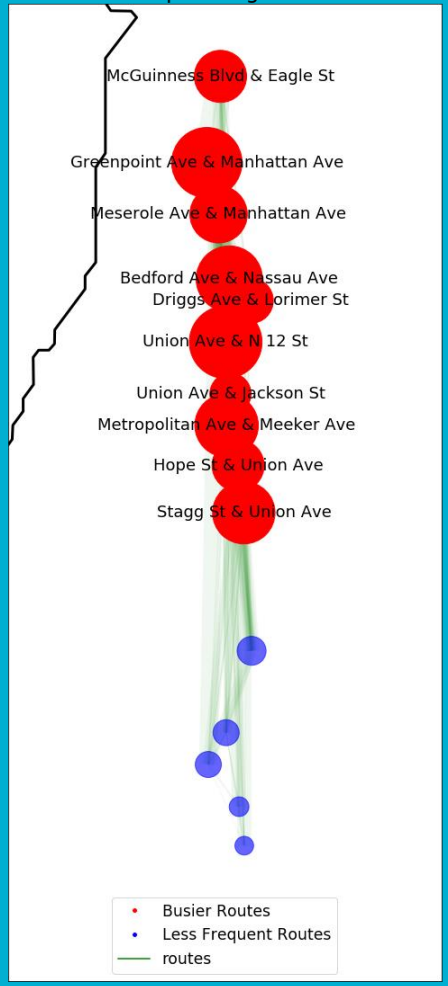


Results

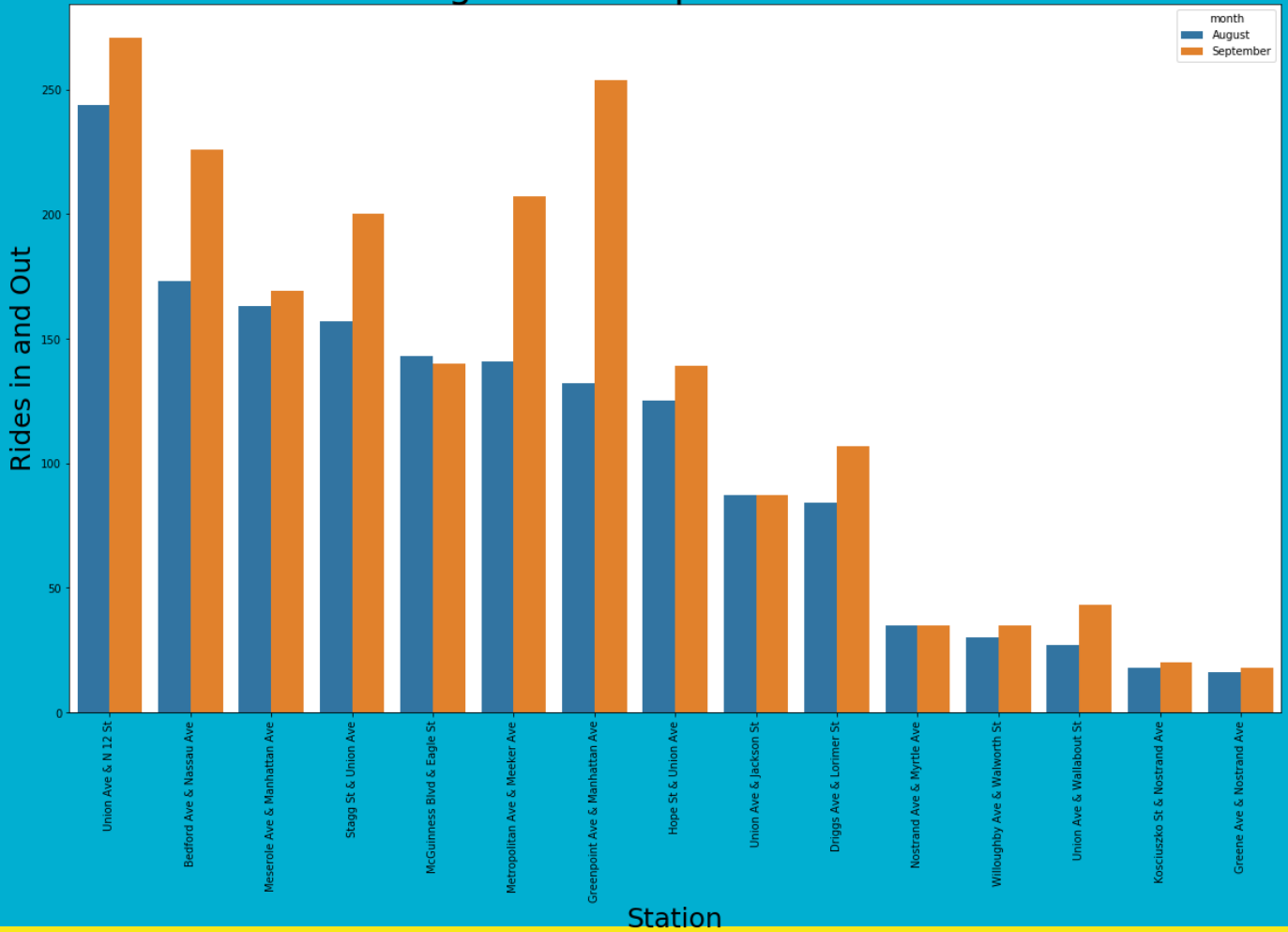
There is a slight increase in September rides (shown again on next slide), but the results are inconclusive for the following reasons:

- Higher number of rides could be a product of random chance or some unobservable reason
- September would have had more pleasant temperatures
- Wouldn't make sense to compare September 2017 and September 2018 due to growth of CitiBike service
- Relatively small amount of data-- methodology would have to be repeated over many instances

CitiBike Ridership During G Train Shutdown



August and September Rides



Incident II

March 15, 2018, Thursday

4 PM: G trains are running with delays because of signal problems at Bergen St

6 PM: G train service was suspended

9 PM: Shuttle bus service is provided for part of G train service

Focus on bike trips 4:00 pm - 9:00 pm

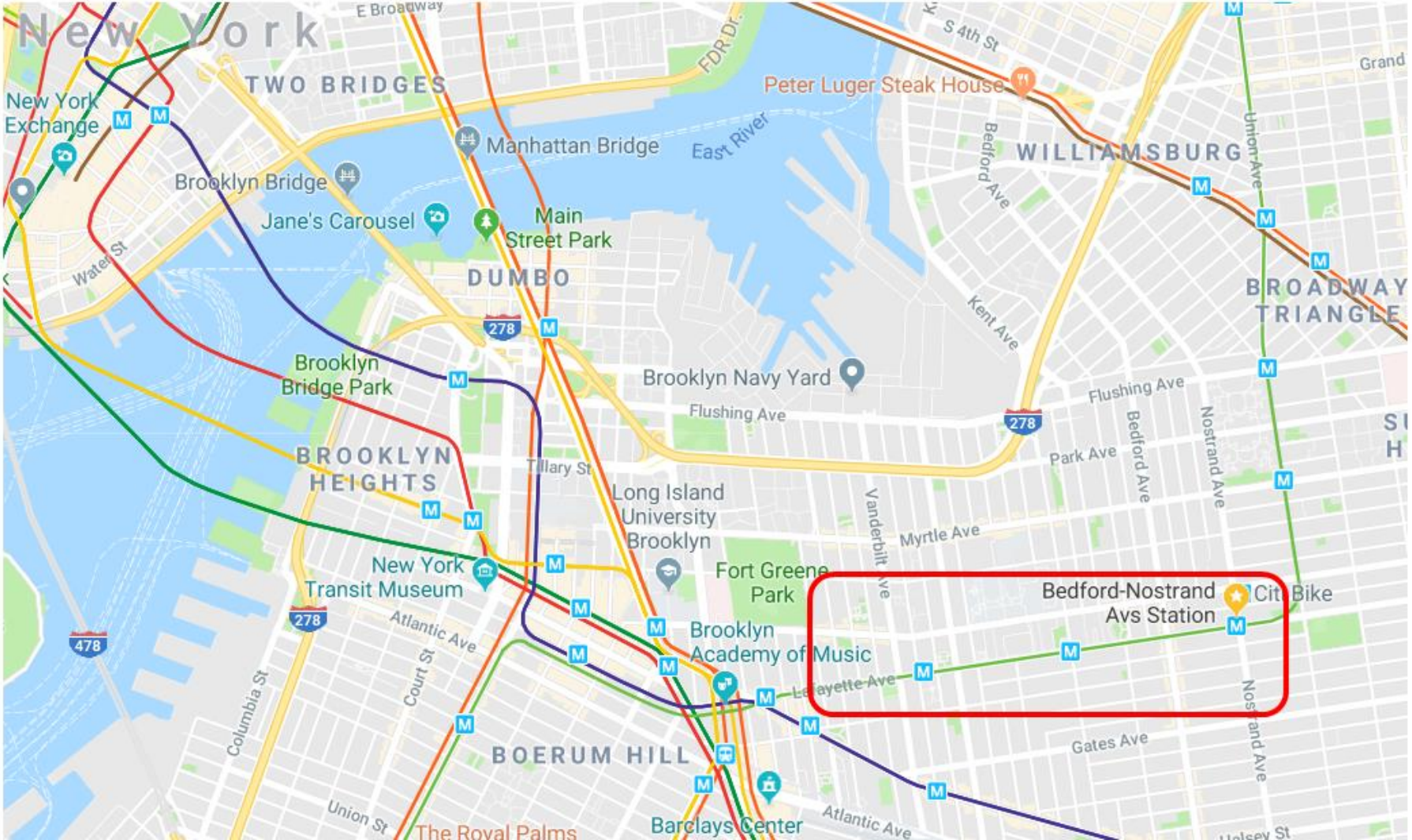
Metro Stations Selected

Three Metro Stations Selected:

- Clinton-Washington Ave
- Classon Ave
- Bedford-Nostrand Ave

Reason:

- Separated from other Metro Lines
- Within the suspended G line area

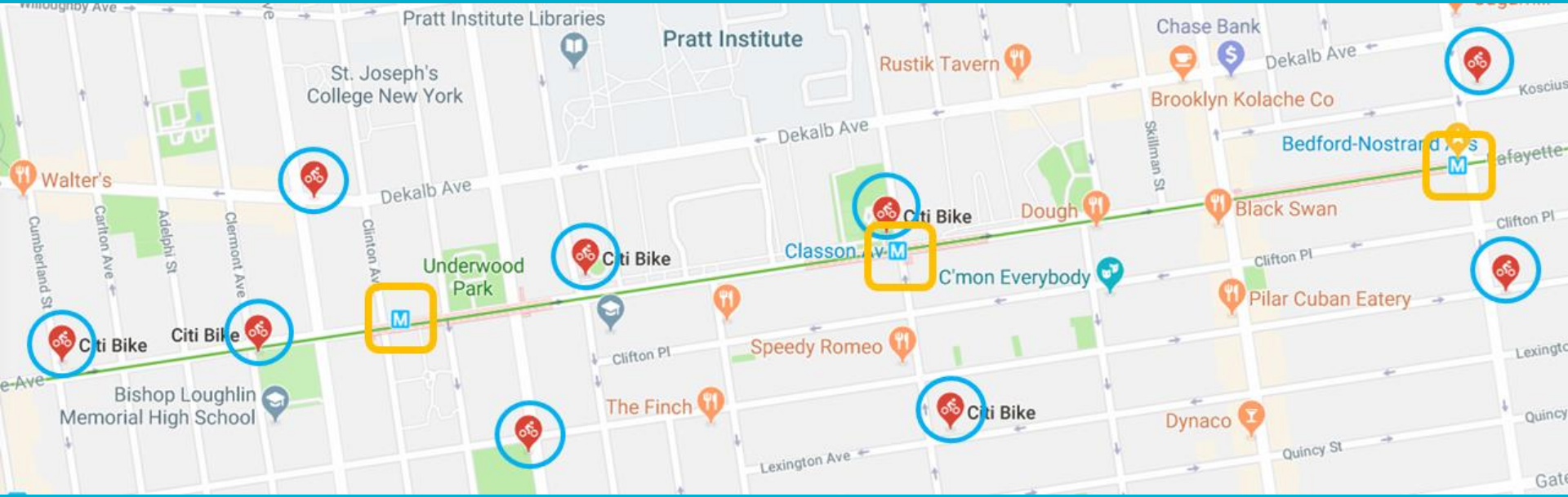

New York
TWO BRIDGES
New York Exchange
Manhattan Bridge
Brooklyn Bridge
Jane's Carousel
Main Street Park
DUMBO
Peter Luger Steak House
WILLIAMSBURG
BROADWAY TRIANGLE
Brooklyn Bridge Park
Brooklyn Navy Yard
BROOKLYN HEIGHTS
Long Island University Brooklyn
New York Transit Museum
Fort Greene Park
Bedford-Nostrand Avs Station
Brooklyn Academy of Music
BOERUM HILL
Barclays Center
The Royal Palms
E Broadway
S 4th St
FDR Dr
East River
Water St
Bedford Ave
Union Ave
Kent Ave
Flushing Ave
Park Ave
Nostrand Ave
Tillary St
Vanderbilt Ave
Myrtle Ave
Atlantic Ave
Court St
Columbia St
Lafayette Ave
Gates Ave
Union St
278
478

CitiBike Stations Selected

9 CitiBike Stations within 3 blocks of G Line Metro Stations selected:

- Cumberland St & Lafayette Ave
- Clermont Ave & Lafayette Ave
- DeKalb Ave & Vanderbilt Ave
- Washington Ave & Greene Ave
- Lafayette Ave & St James Pl
- Lafayette Ave & Classon Ave
- Lexington Ave & Classon Ave
- Greene Ave & Nostrand Ave
- Kosciuszko St & Nostrand Ave

Analyze number of bike trips From and To each 9 stations


Pratt Institute Libraries
Pratt Institute
St. Joseph's College New York
Chase Bank
Rustik Tavern
Dekalb Ave
Brooklyn Kolache Co
Bedford-Nostrand Avs
Walter's
Dekalb Ave
Citi Bike
Dough
Black Swan
Underwood Park
Citi Bike
Classon Av
C'mon Everybody
Clifton Pl
Pilar Cuban Eatery
Citi Bike
Citi Bike
Speedy Romeo
Bishop Loughlin Memorial High School
The Finch
Citi Bike
Dynaco
Lexington Ave
Quincy St
Cumberland St
Carlton Ave
Adelphi St
Clermont Ave
Clinton Ave
Skillman St

Dates Selected for Analysis

March 8, 2018	Thursday	One **week before** the incident day
March 14, 2018	Wednesday	One **day before** the incident day
March 15, 2018	Thursday	Incident Day
March 16, 2018	Friday	One **day after** the incident day
March 22, 2018	Thursday	One **week after** the incident day

Control for Weather Condition

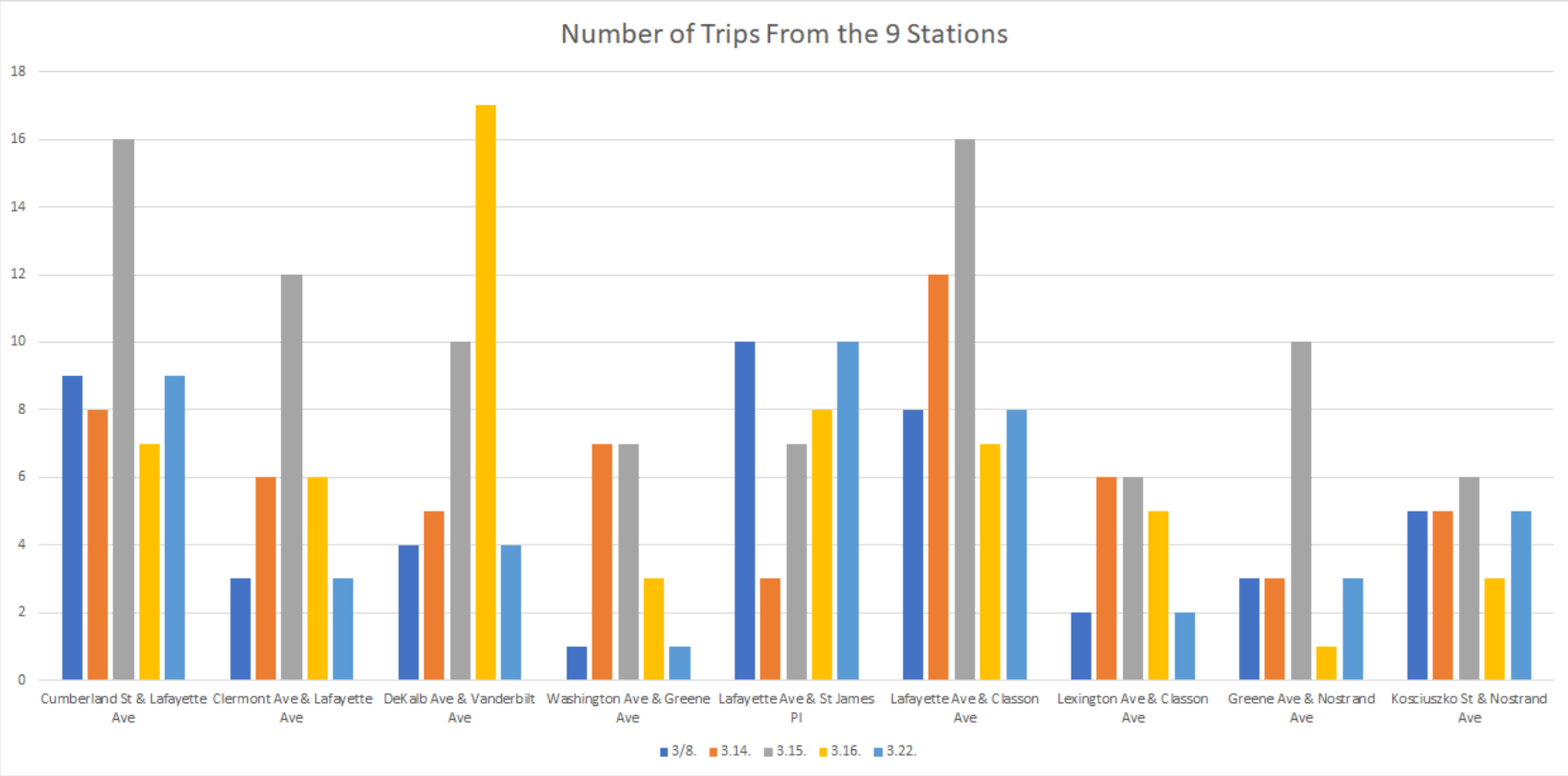
Date	Precip	Snow	Avg. HI / LO
THU 3/8	0 in	0 in	47°/33°
WED 3/14	0.01 in	0 in	49°/34°
THU 3/15	0 in	0 in	49°/35°
FRI 3/16	0 in	0 in	50°/35°
THU 3/22	0.06 in	0.2 in	52°/37°

Results

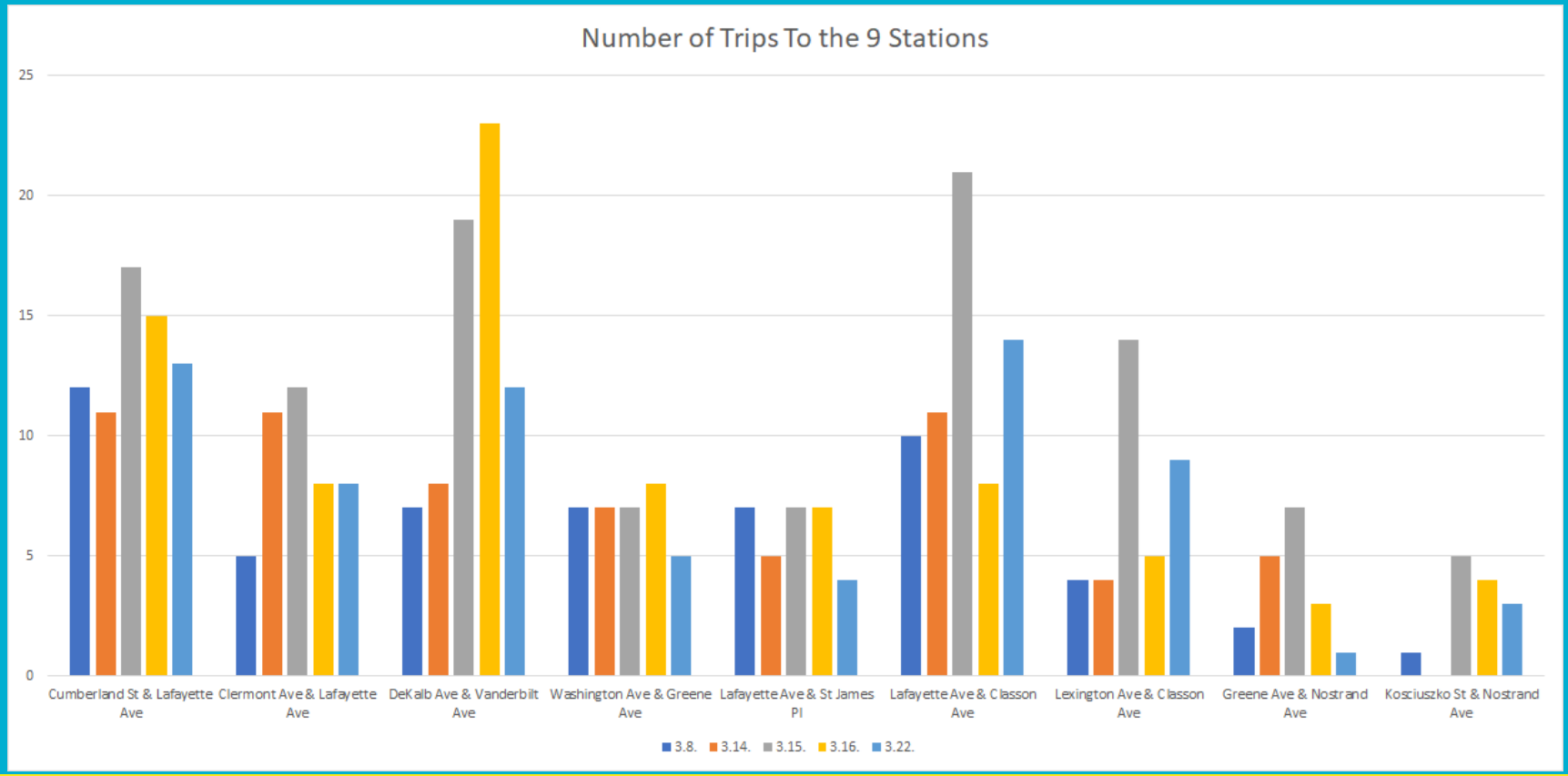
The number of trips on the incident day (3.15) is much higher than other days.

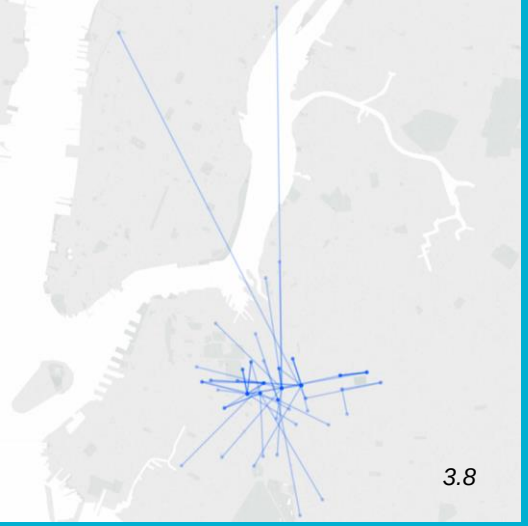
	From					To				
Citi Bike stations	3/8.	3.14.	3.15.	3.16.	3.22.	3.8.	3.14.	3.15.	3.16.	3.22.
Cumberland St & Lafayette Ave	9	8	16	7	9	12	11	17	15	13
Clermont Ave & Lafayette Ave	3	6	12	6	3	5	11	12	8	8
DeKalb Ave & Vanderbilt Ave	4	5	10	17	4	7	8	19	23	12
Washington Ave & Greene Ave	1	7	7	3	1	7	7	7	8	5
Lafayette Ave & St James Pl	10	3	7	8	10	7	5	7	7	4
Lafayette Ave & Classon Ave	8	12	16	7	8	10	11	21	8	14
Lexington Ave & Classon Ave	2	6	6	5	2	4	4	14	5	9
Greene Ave & Nostrand Ave	3	3	10	1	3	2	5	7	3	1
Kosciuszko St & Nostrand Ave	5	5	6	3	5	1	0	5	4	3
	45	55	90	57	45	55	62	109	81	69

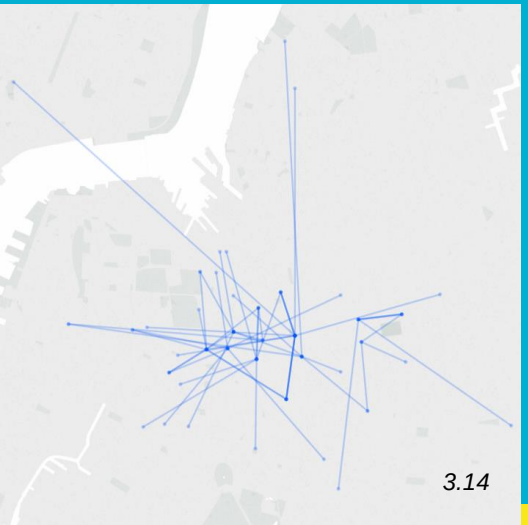
Results

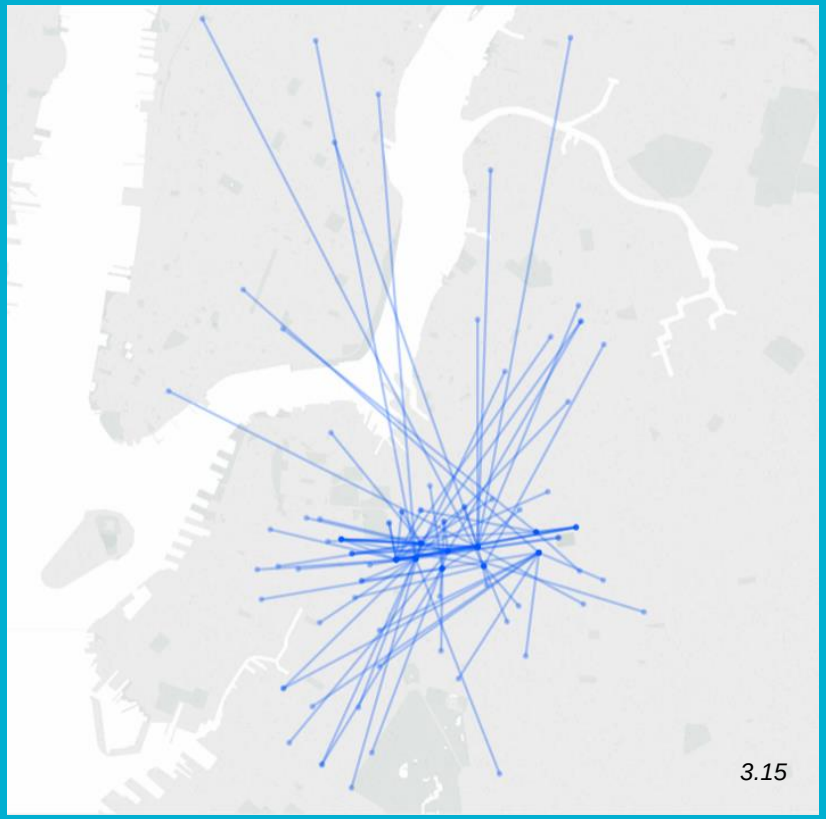

Number of Trips From the 9 Stations
18
16
14
12
10
8
6
4
2
0
Cumberland St & Lafayette Ave
Clermont Ave & Lafayette Ave
DeKalb Ave & Vanderbilt Ave
Washington Ave & Greene Ave
Lafayette Ave & St James Pl
Lafayette Ave & Classon Ave
Lexington Ave & Classon Ave
Greene Ave & Nostrand Ave
Kosciuszko St & Nostrand Ave
3/8.
3.14.
3.15.
3.16.
3.22.

Results

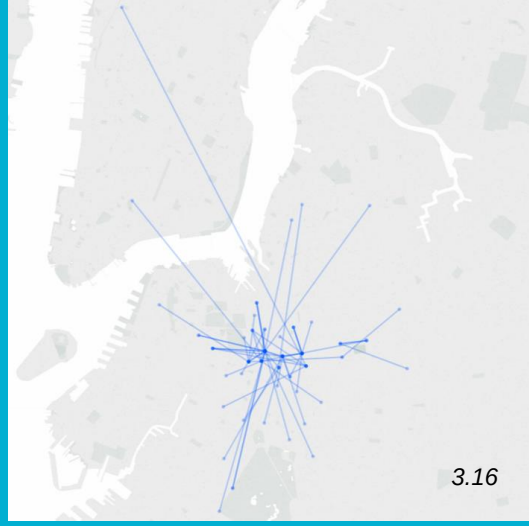

Number of Trips To the 9 Stations
25
20
15
10
5
0
Cumberland St & Lafayette Ave
Clermont Ave & Lafayette Ave
DeKalb Ave & Vanderbilt Ave
Washington Ave & Greene Ave
Lafayette Ave & St James Pl
Lafayette Ave & Classon Ave
Lexington Ave & Classon Ave
Greene Ave & Nostrand Ave
Kosciuszko St & Nostrand Ave
3.8.
3.14.
3.15.
3.16.
3.22.

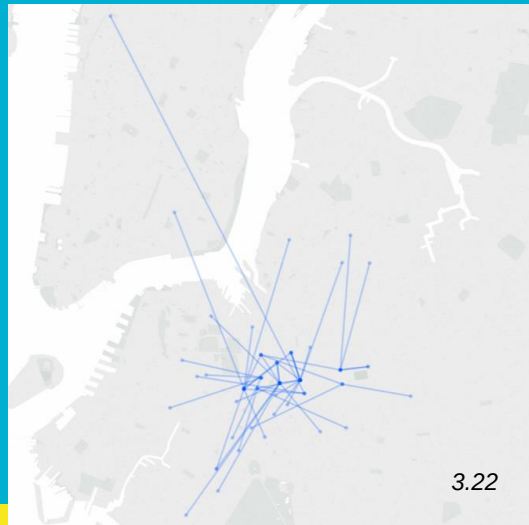


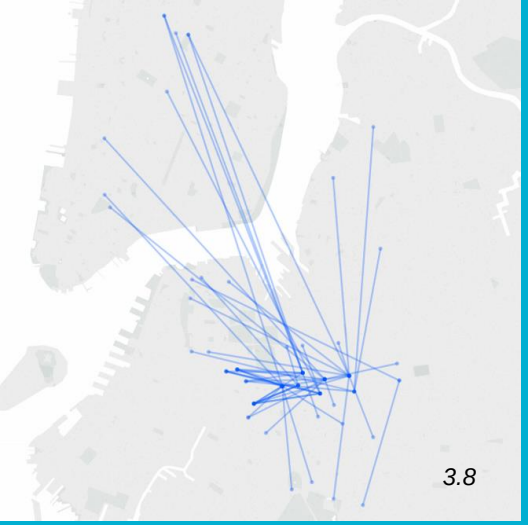


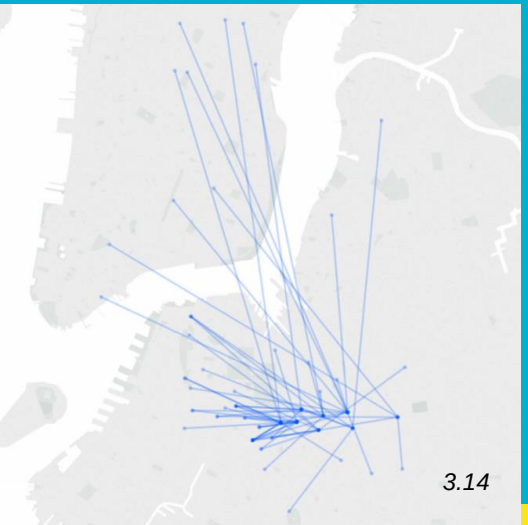


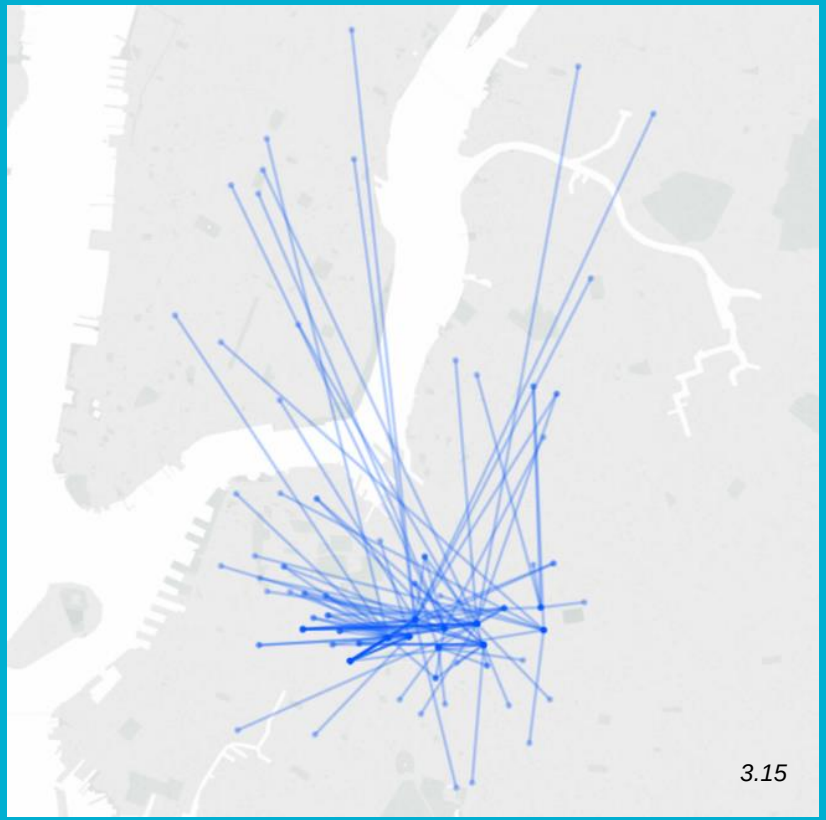
*Bike trips **from** the 9 stations to other stations.*



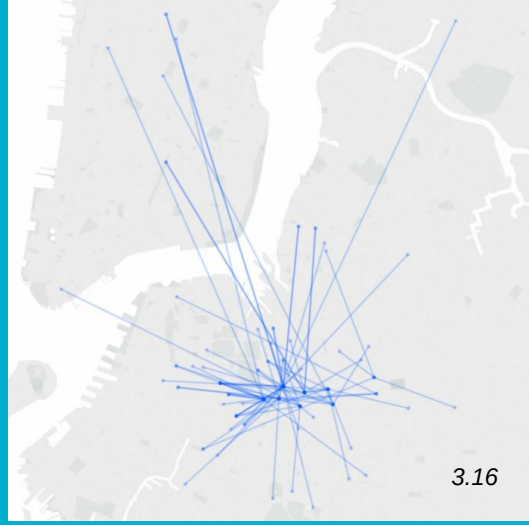


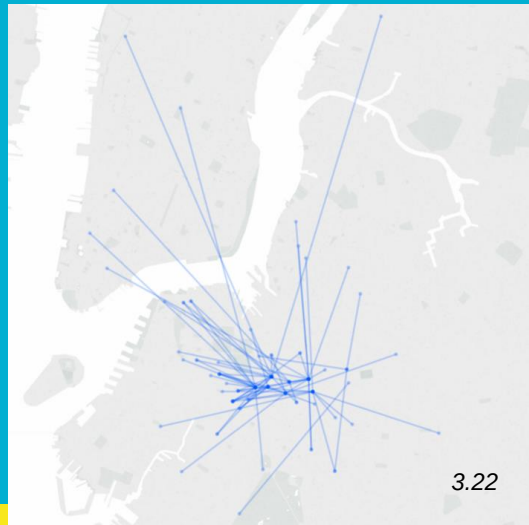






*Bike trips from other stations **to** the 9 stations.*





Results

For this incidents:

- More bike trips during incident time overall
- More bike trips along G line route during service disruptions
- More trips from Manhattan to the 9 stations during 4-9 pm
- Number of trips may be affected by day of week (Friday) and whether the station is near college/church
- The increasing ridership did not last after the incident

Incident III: Green Line shut down from Aug 18 to 19 (whole weekend)

Hypothesis: Given G line stations (Clinton-Washington Avenues to Flushing Avenues) are far away to another line's stations, support people will change to ride the CitiBike between stations closer to each other.

Method: Analysis the data structure to see Citi Bike ridership frequency on weekend or workdays, and compare with the weather to look for what reasons make CitiBike using rate.

Affected Stations

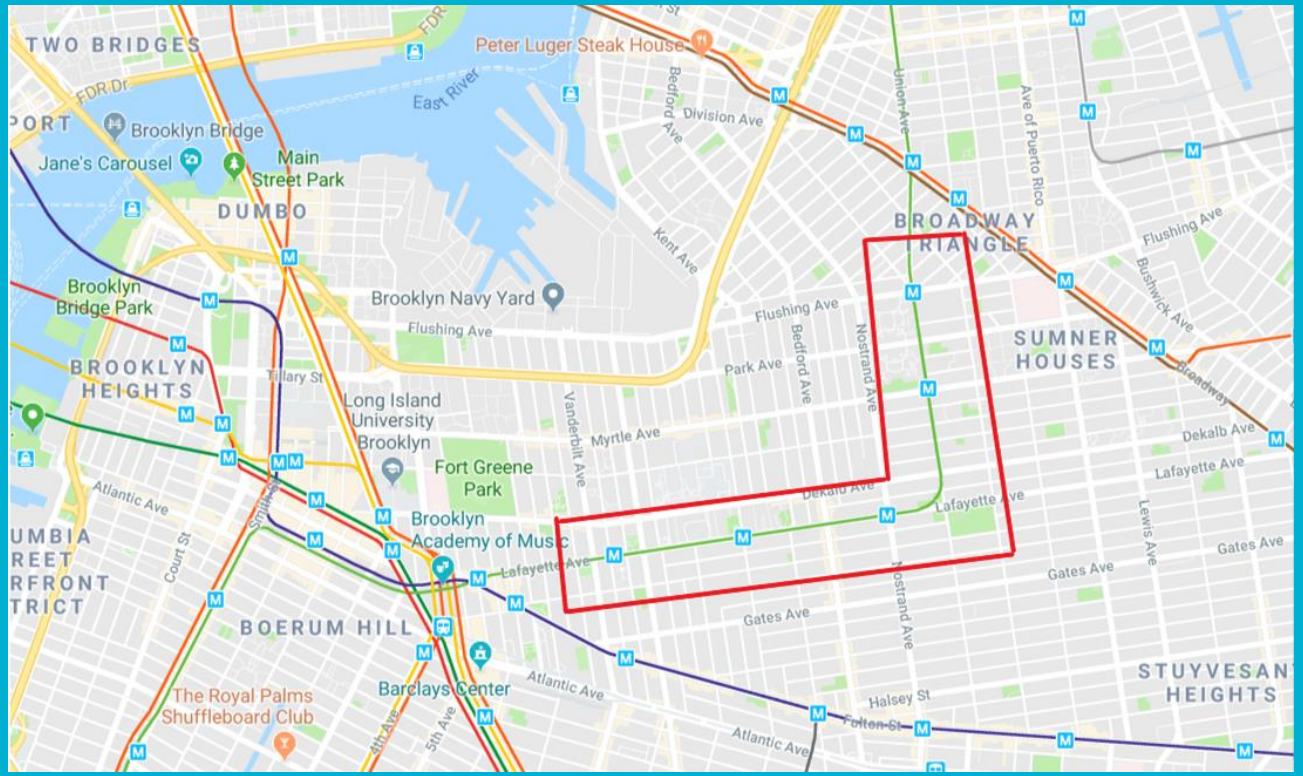
Clinton-Washington Ave

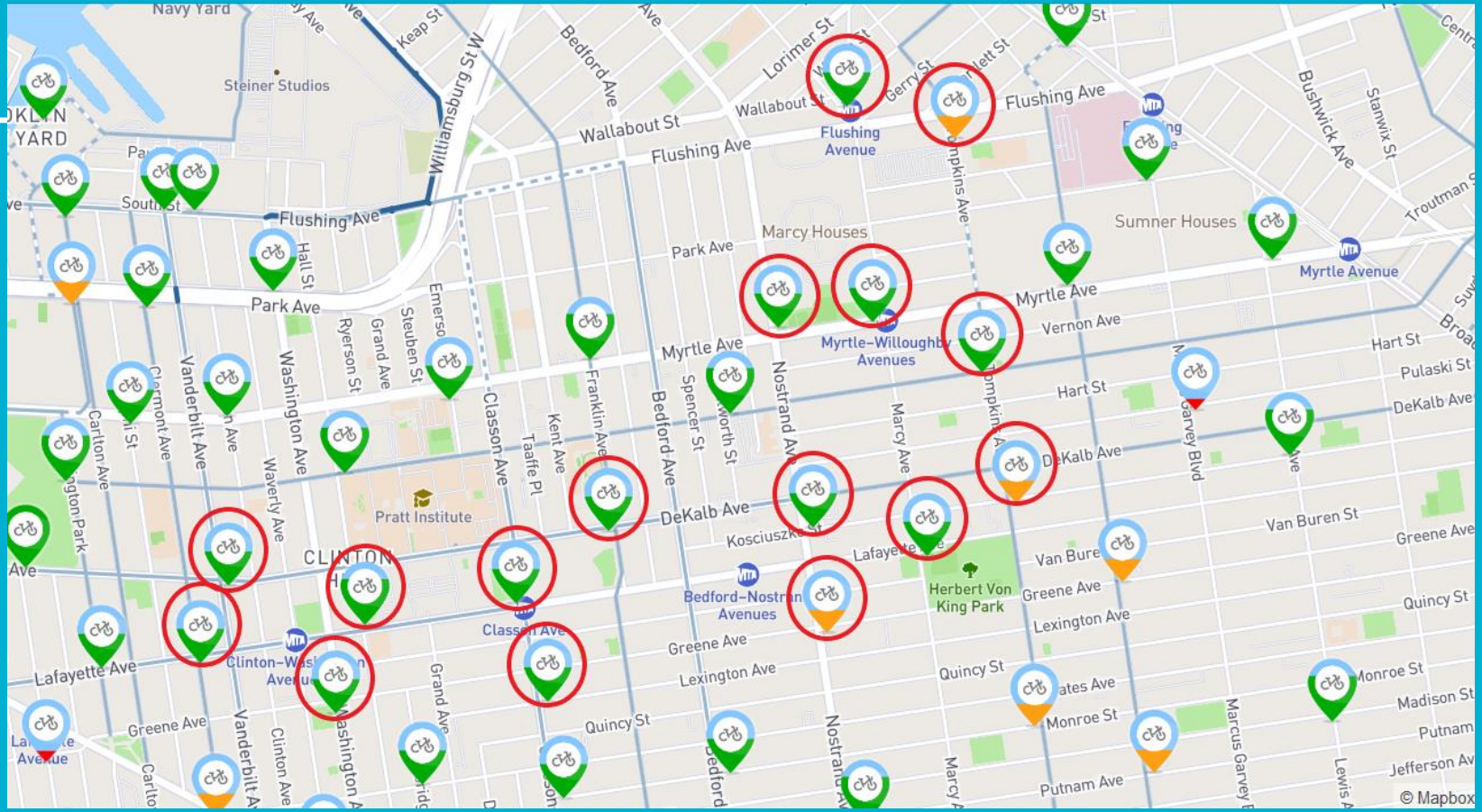
Classon Ave

Bedford-Nostrand Ave

Myrtle - Willoughby Ave

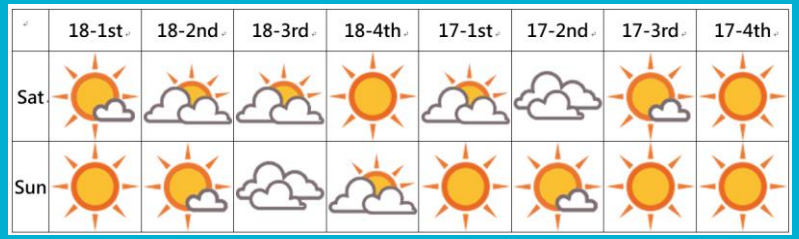
Flushing Ave

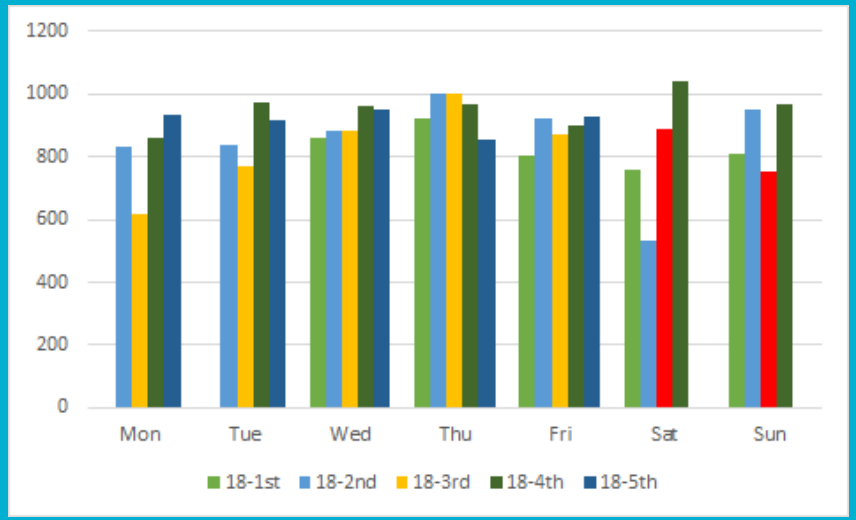


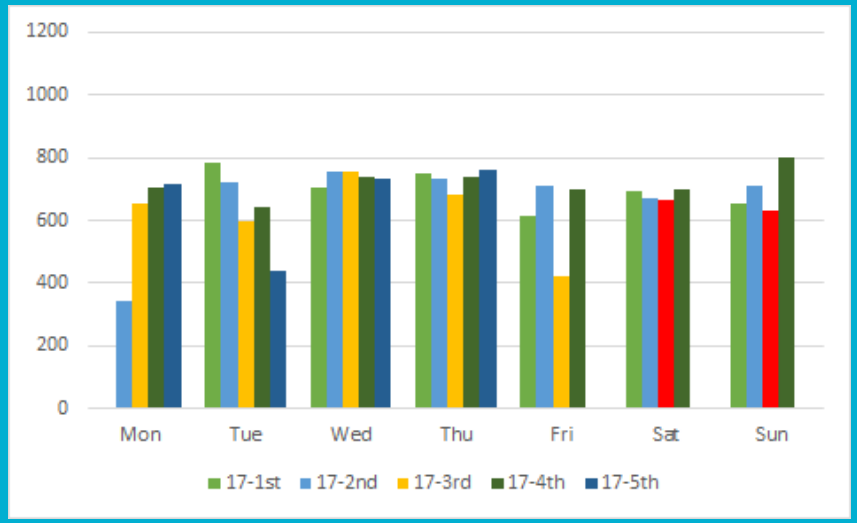

Navy Yard
Steiner Studios
Flushing Ave
Wallabout St
Williamsburg St W
Bedford Ave
Lorimer St
Flushing Avenue
Park Ave
Marcy Houses
Sumner Houses
Myrtle Avenue
Myrtle Ave
Vernon Ave
Myrtle–Willoughby Avenues
Hall St
Ryerson St
Grand Ave
Steuben St
Classon Ave
Franklin Ave
Bedford Ave
Nostrand Ave
Marcy Ave
Hart St
DeKalb Ave
Pratt Institute
Kosciuszko St
Lafayette Ave
Bedford–Nostrand Avenues
Herbert Von King Park
Van Buren St
Greene Ave
Lexington Ave
Quincy St
Clinton–Washington Avenues
Monroe St
Putnam Ave
Vanderbilt Ave
Washington Ave
Waverly Ave
Clermont Ave
Carlton Ave
Taaffe Pl
Kent Ave
Spencer St
Tompkins Ave
Gerry St
Bushwick Ave
Stanwix St
Pulaski St
Garvey Blvd
Madison St
Jefferson Ave
Marcus Garvey Blvd
© Mapbox

Comparing Aug 2018 and Aug 2017

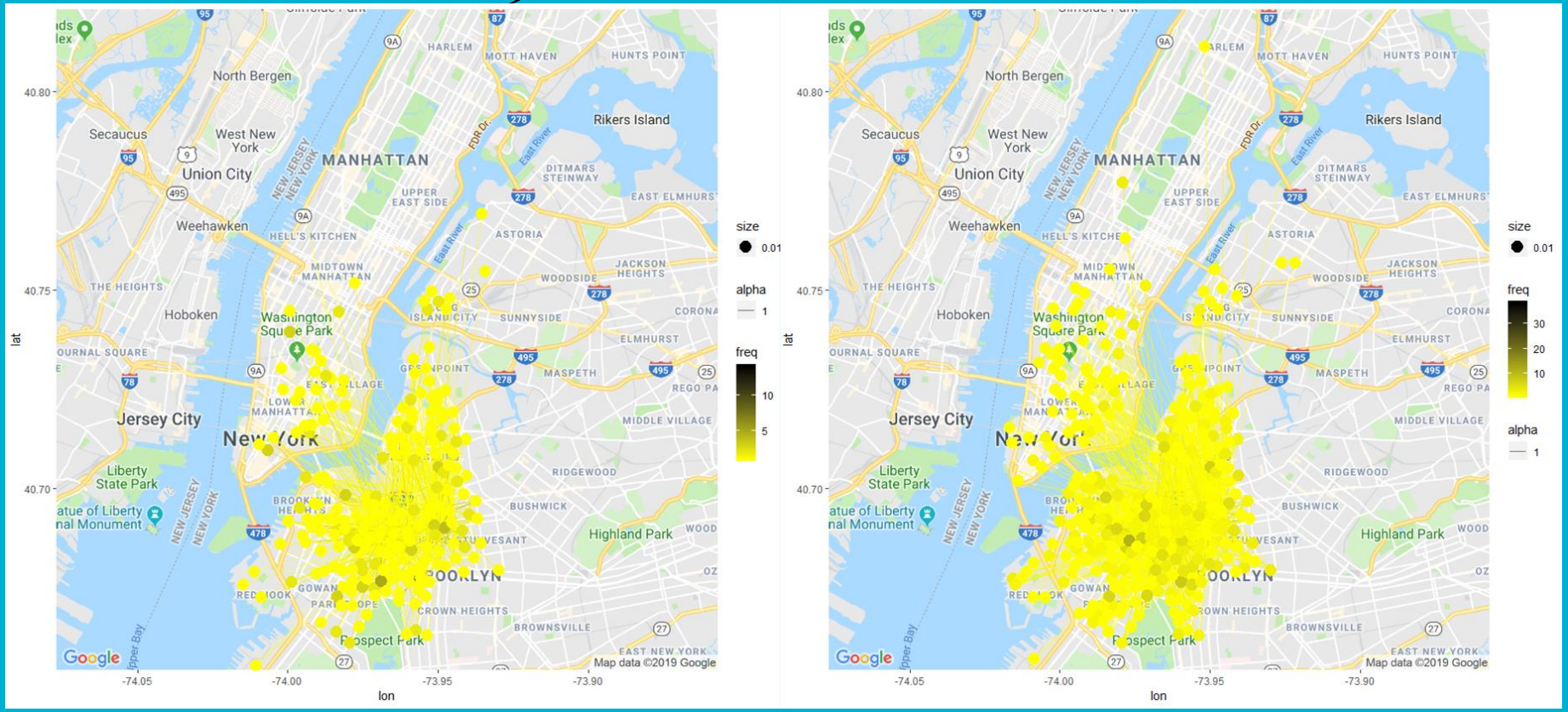
It seems did not change very much







8/18&8/19


lat
lon
40.80
40.75
40.70
-74.05
-74.00
-73.95
-73.90
North Bergen
Secaucus
West New York
Union City
Weehawken
MANHATTAN
HARLEM
MOTT HAVEN
HUNTS POINT
Rikers Island
DITMARS STEINWAY
EAST ELMHURST
UPPER EAST SIDE
ASTORIA
HELL'S KITCHEN
MIDTOWN MANHATTAN
THE HEIGHTS
Hoboken
Washington Square Park
JACKSON HEIGHTS
WOODSIDE
SUNNYSIDE
ELMHURST
MASPETH
REGO PARK
MIDDLE VILLAGE
RIDGEWOOD
BUSHWICK
Highland Park
CROWN HEIGHTS
BROWNSVILLE
EAST NEW YORK
Jersey City
Liberty State Park
Prospect Park
Google
Map data ©2019 Google
size
0.01
alpha
1
freq
10
5
30
20
10

Result

- On the weekend, CitiBike using rate is not affected by the train shut down.
- The weather does not affect the using rate significantly.
- CitiBike users will take longer travels near the 5 metro stations no matter it will be affected by Green Line’s Construction.

Incident IV : Myrtle Avenue Line Infrastructure Projects

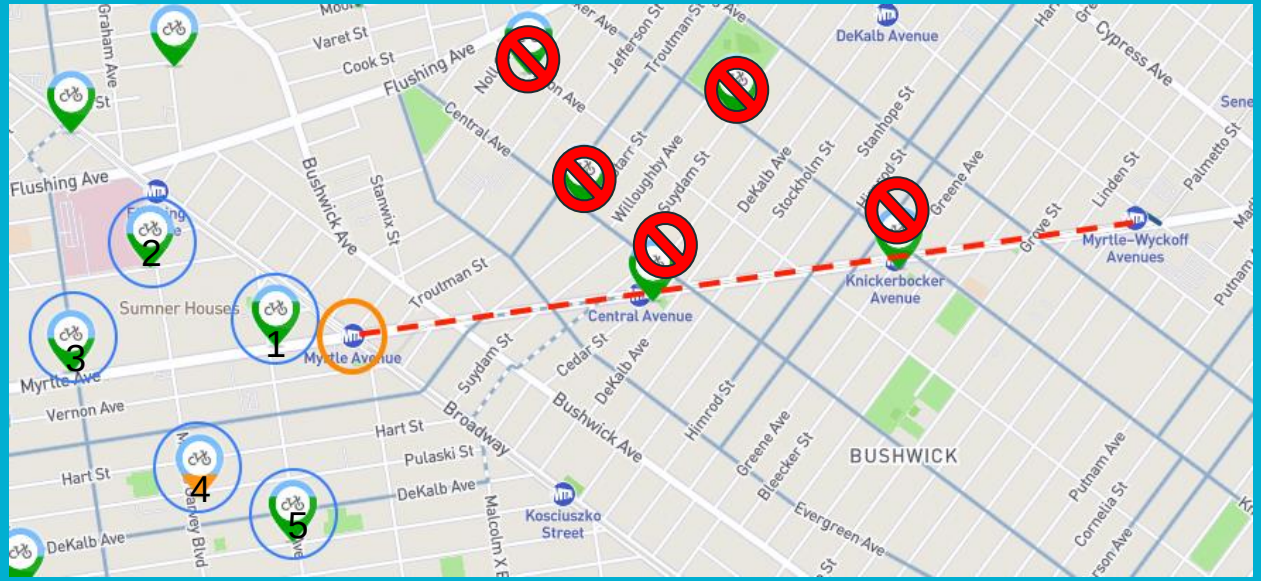
Due to the deteriorating conditions on the M line, a portion of the line were shut down for reconstruction from September 2, 2017 to April 20, 2018.

No services were provided between Myrtle Ave Station and Myrtle-Wyckoff Avs Station. 4 Stations were affected.

Affected MTA / Citi Bike Stations

1. Select bike stations for analysis

1. Compare the trips started from/ ended at the stations during different periods w/ or w/o construction going on.



Stations:
There were fewer bike stations than right now in the affected areas.
5 stations are chosen for analysis.

1. Myrtle Ave & Lewis Ave
2. Park Ave & Marcus Garvey Blvd
3. Throop Ave & Myrtle Ave
4. Pulaski St & Marcus Garvey Blvd
5. Lewis Ave & Kosciuszko St

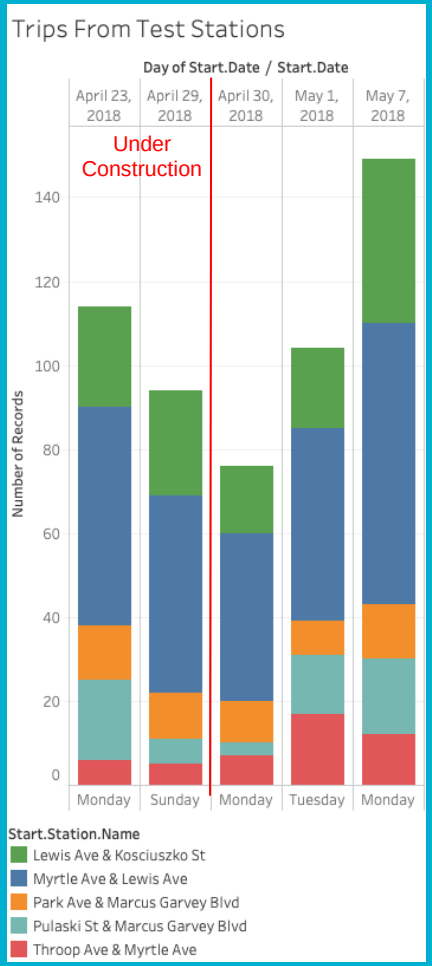
Single Day Comparison

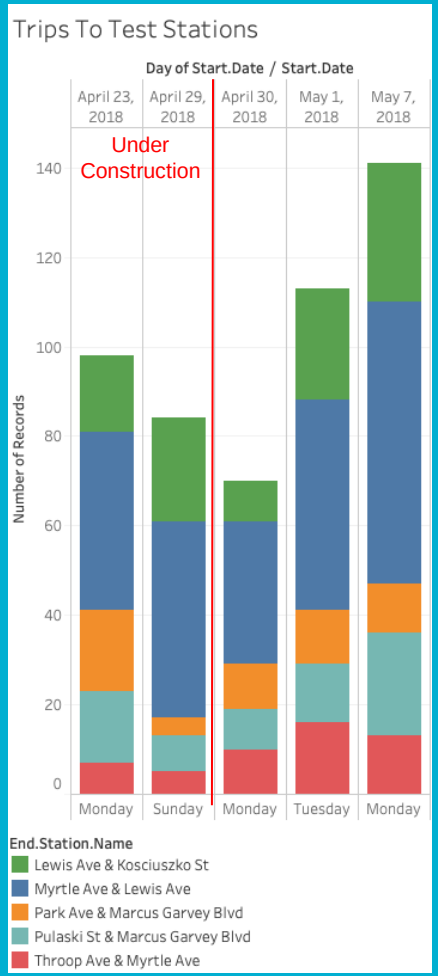
Hypothesis

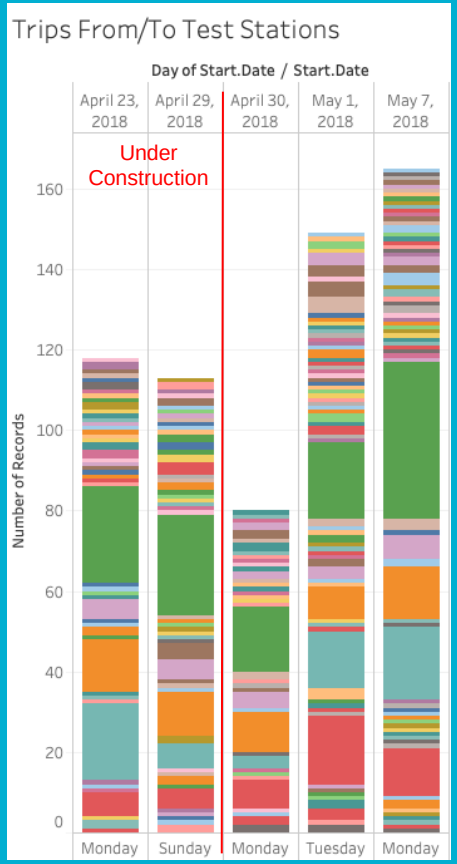
After completion of the construction on M line, the bike trips will drop, as more commuters would switch to MTA from bike.

Observation

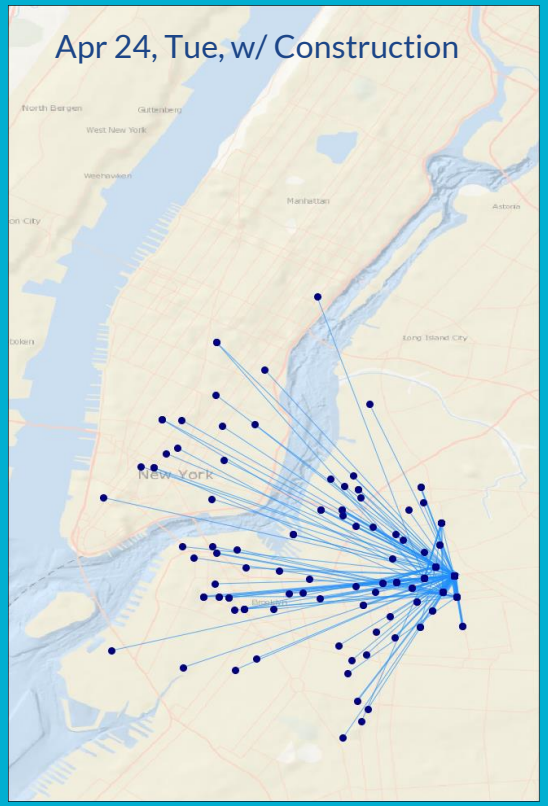
Although bike trips dropped at the re-open day (Apr 30), trips made 1-day-after / 7-day-after are more than 1-day-before / 7-day-before.



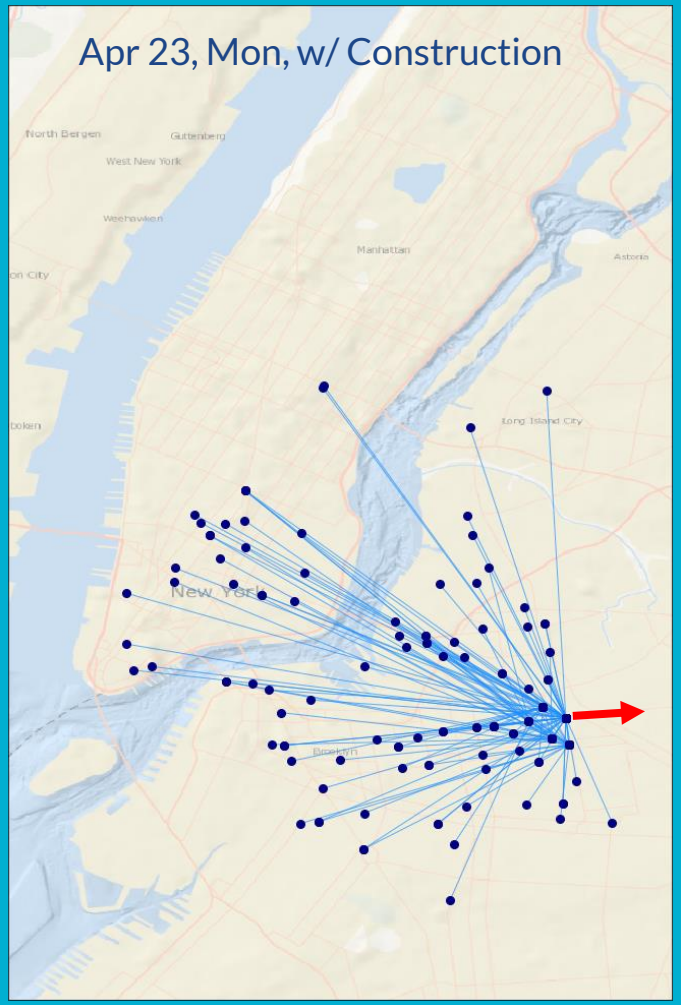




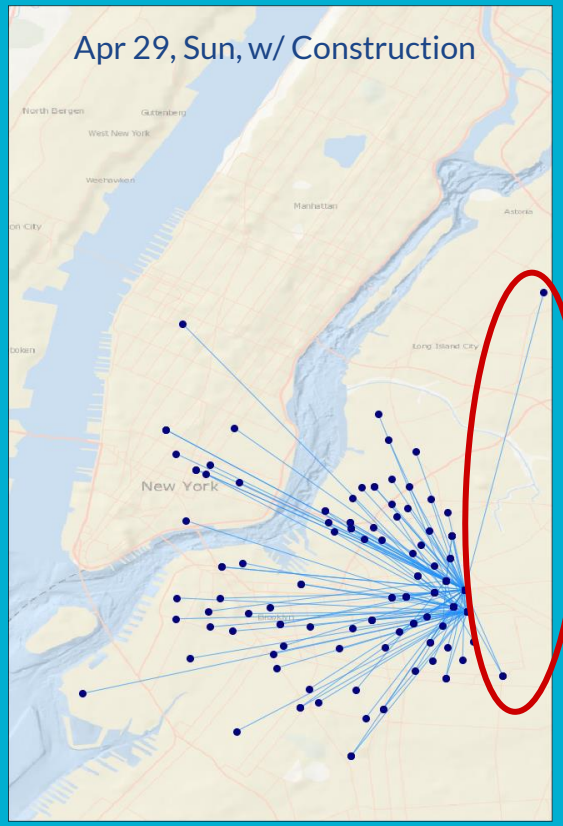
Apr 24, Tue, w/ Construction

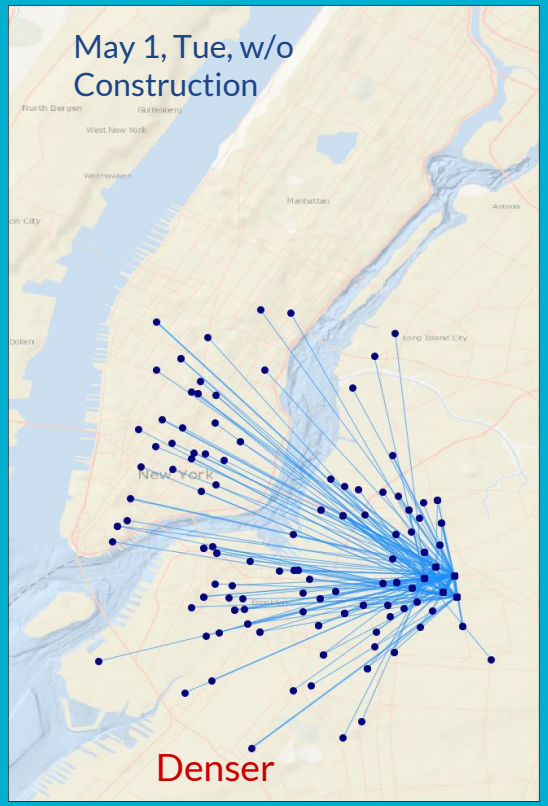


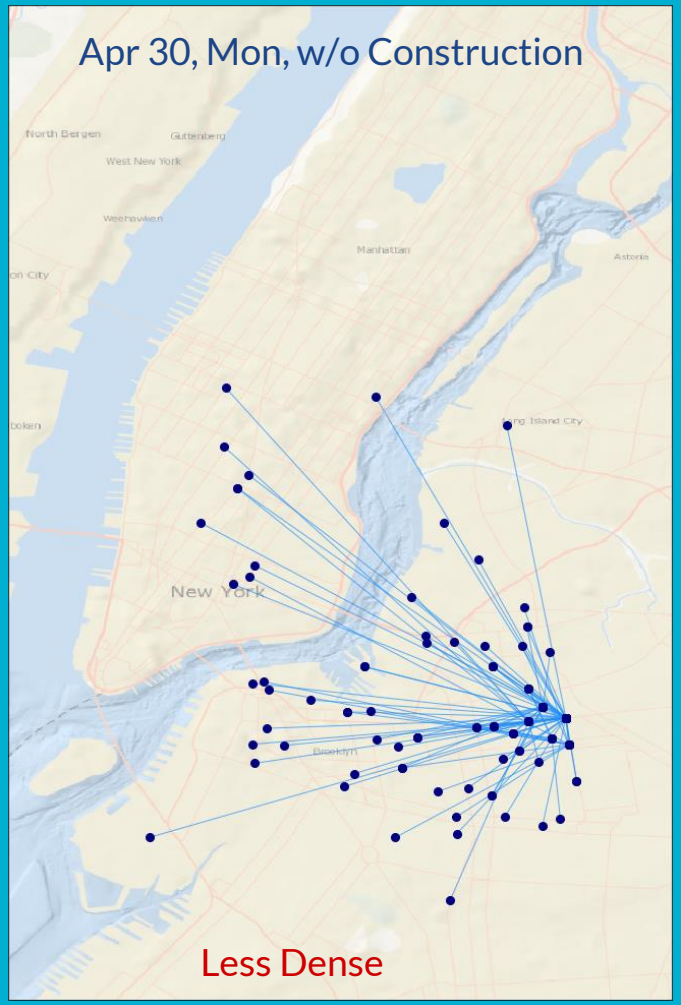
Apr 23, Mon, w/ Construction

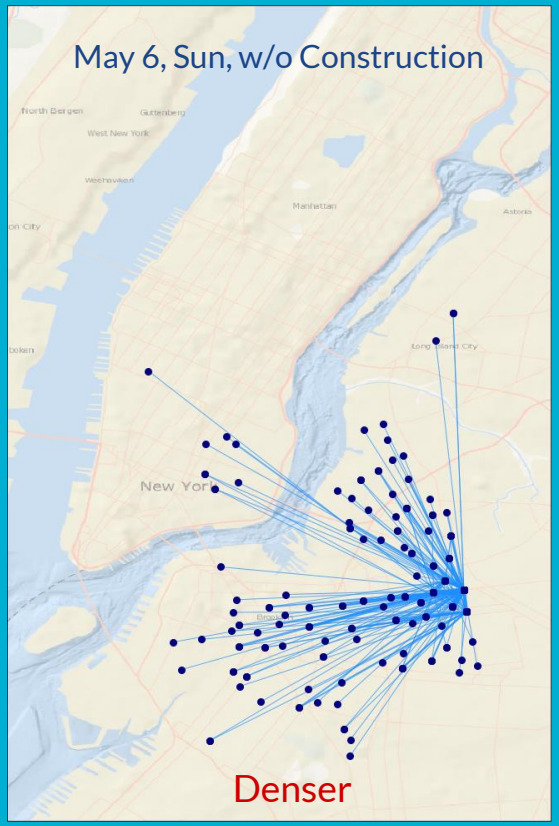


Apr 29, Sun, w/ Construction




May 1, Tue, w/o Construction
Denser


Apr 30, Mon, w/o Construction
Less Dense


May 6, Sun, w/o Construction
Denser

Result

Citi Bike may be a supplement, but could not constitute as a substitution along the M line Construction Part.

Possible Reasons:

There were no bike station along the construction line.

The interested area was not quite accessible at the moment.

Conclusion

Overall, CitiBike usage during subway service disruptions does not change much, and the small increases observed are not necessarily attributable to the shutdowns.

Possible reasons for this include:

- People prefer to take Uber/Lyft, the bus, or the free shuttle service provided by the city during a shutdown
- There is a core group of CitiBike users, and shutdown incidents are not enough to entice new people to try the service
- Some Citibike users like to take a long travel by the bike, and it will not be affected by the shutdowns.

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