How Will the L Train Closure Impact Small Business?

Report prepared for NYU CUSP Urban Science Intensive
by Diego Garzón, Manushi Majumdar, María Ortiz and Daniel Quasney
March, 2016

1. Introduction and background information

In early January 2016, the Gothamist, a New York-based news site, published an article announcing the Metropolitan Transit Authority's (MTA) plan to repair the damage sustained by the Canarsie tunnel during Hurricane Sandy in late 2012[1]. The Canarsie tunnel connects the First Ave station in Manhattan to the Bedford Ave station in Williamsburg. After Hurricane Sandy, the MTA closed the tunnel for 11 days to repair the damage caused by 7 million gallons of saltwater flooding the tunnel.

The public reaction to this news story was one of generalized alarm. Commuters, residents and business owners took to social media to express discontent with the MTA's decision and lack of clear plans to provide alternate forms of public transportation. A "straphangers" advocacy group named "The L Train Coalition" quickly formed to organize business owners and community leaders that are seeking to have a say in the MTA's plans and inform their plan of action concerning the intermittent shutdown.

Ridership growth on the L line in Williamsburg and Bushwick has increased immensely as the neighborhoods begin to grow into their postindustrial economies (4.7% in 2014 alone and 27% since 2007[2]), and the MTA plans to increase the number of trains servicing the line between those neighborhoods and Manhattan by adding at least two more trains per hour during rush hour. The MTA cannot complete these necessary upgrades to the L train line without first repairing the damage caused by Hurricane Sandy, though it has said it can sustain current service levels without repairs[3]. The MTA had already planned upgrades to the Canarsie tunnel, and the timing for the repairs is intended to align with the predetermined upgrade schedule[4] that would minimize the duration (if not the inconvenience) of the impact on

[1] Robbins, Christopher. "L Train Service Between Brooklyn & Manhattan May Be Shut Down For Years." *Gothamist*, January 13, 2016. http://gothamist.com/2016/01/13/l_train_tunnel_closure_years.php.
[2] Bonanos, Christopher. "What Happens If There's No L Train for a Year?" *NY Mag Daily Intelligencer*, February 4, 2016. http://nymag.com/daily/intelligencer/2016/02/what-happens-if-theres-no-l-train-for-a-year.html.
[3] Dai, Serena. "MTA Seeks $300M to Increase L Train Capacity, Add Entryways at Stations." *DNAInfo*, December 12, 2014.
https://www.dnainfo.com/new-york/20141212/williamsburg/mta-seeks-300m-increase-l-train-capacity-add-entryways-at-stations .
[4] Rinn, Natalie. "Sorry, North Brooklyn: Soon, the L Train Will Probably Not Go to Manhattan for a Very Long Time—Like, Years." *Brooklyn Magazine*, January 13, 2016.
http://www.bkmag.com/2016/01/13/sorry-north-brooklyn-soon-the-l-train-will-probably-not-go-to-manhattan-for-a-very-long-time-like-years/.

commuters coming to and from Williamsburg. The latest reports state the MTA will not begin work on the tunnel until 2018 or early 2019[5]. Up to $700 million in federal funding for Sandy recovery could aid the repairs, however, these funds are not yet secure until the MTA outlines a timeline and plans for the reconstruction.

According to a 2013 DOT report, “The Economic Benefits of Sustainable Streets”, business data for retail sales are a “rigorous and compelling” way to measure local impact of changes to public transportation. Due to the fact that sales figures are immediately impacted from changes in travel patterns of shoppers, DOT states that it is “one of the most direct ways to capture economic impact...as compared to longer-term ‘ripple effects’ on property values, leasing activity, business creation or loss and employment”[6].

The first stakeholder meeting took place on January 28th, 2016 in Brooklyn Bowl in Williamsburg. More than one hundred participants attended that meeting, including business owners, residents and elected officials. The MTA representative in attendance did not articulate a concrete plan to provide alternate public transportation and was asked to leave[7]. Business owners and real estate brokers stated that “business owners are already pulling out of deals” in light of the uncertainty surrounding the MTA’s plans.The L Train Coalition held a public meeting on February 24th, where the solution put forth by the activists was to use the federal funds to build a third tunnel. The Chief of Staff for Congresswoman Carolyn Maloney mentioned this solution had been examined in a meeting between elected officials and the MTA, however was “deemed unrealistic” because it would cost around $4.5 billion dollars and have a longer timeline than that for the current repair plans[8].

Problem statement

The MTA is faced with the decision to shut down the Canarsie tunnel connecting Williamsburg and Manhattan for a currently unknown time period, affecting travelers in both directions. These changes in travel patterns will affect foot traffic and, therefore, patronage of businesses in Williamsburg and surrounding areas as well as around stations further into Williamsburg. Much of the existing literature and commentary regarding the L train shutdown has focused exclusively on the impact to the 200,000 daily commuters that traverse the Canarsie tunnel and the herculean effort required to serve that same commuter volume with alternative means of transportation[9]. While not insubstantial, the real threat to community is not the inconvenienced commuters, but rather the countless small business owners in the area who

[5] Hinds, Kate. **“**L Train Shutdown? Wait for It. Then 'Boom!'”. *WNYC,* February 25, 2016 http://www.wnyc.org/story/l-train-tunnel-wont-be-demolished-until-2018-earliest/
[6] NYC Department of Transportation, & Bennet Midland LLC. (2013). *The Economic Benefits of Sustainable Streets*. NYC Department of Transportation.
[7] “The MTA's Looming L Train Shutdown Has North Brooklyn Panicking”, Gothamist, January 28, 2016 http://gothamist.com/2016/01/28/l_train_shutdown_panic.php
[8] “L Train Advocates Demand a Third Tunnel Before MTA Shuts Down Current Ones”, Gothamist, February 25, 2016 ”http://gothamist.com/2016/02/25/new_l_train_tunnel_or_revolution.php
[9] "The L Train Closure-what Data Can Tell Us - CartoDB Blog." The L Train Closure-what Data Can Tell Us - CartoDB Blog. January 20, 2016. Accessed March 10, 2016. http://blog.cartodb.com/looking-at-the-l/.

stand to lose their business if their consumer base is no longer able to reach them conveniently. Consequently, the team revised the original intent of the project, which was developing a method to quantify changes in commuter patterns after a partial subway shutdown, and instead of developing a framework to measure the impact on the local economy in the event of a subway shutdown.

Approach

The goal of this report is to establish a methodology for calculating the economic impact on a neighborhood resulting from closing down subway stations. In this case, the analysis will focus on businesses in the Williamsburg area, conformed by zip codes 11206, 11211, and 11237; however, the framework has been designed with an emphasis on flexibility and can be applied to any region of New York City that is serviced by the MTA network. We will be looking specifically at five stations: Bedford, Lorimer, Nassau, Metropolitan and Graham. The Bedford Ave stop is central to our analysis as it is a reference point for New Yorkers and tourists wishing to explore Williamsburg and its surrounding neighborhoods and will be the cutoff point for service between Brooklyn to Manhattan.

Examining data from registered businesses within the Reference USA database for our study area, we found a predominantly small business landscape: over 40% of the 7,520 businesses have sales totaling less than $500k per year, and almost three quarters of them employ 1-4 people. The business landscape is also highly diversified.“Professional Services” is the dominant category as physicians offices comprise 6.5% of the total, followed by restaurants at 5.6% and grocery stores at 2%.

While the nature of the L train problem is complex and will impact a wide array of people, three groups of stakeholders stand to benefit the most from the methodology the team has developed; merchant associations like the Brooklyn Chamber of Commerce, city agencies including the MTA and Small Business Services (SBS), and the citizenry, particularly Community Boards 1 and 4 in Brooklyn and the Permanent Citizens Advisory Committee to the MTA.

2. Method Overview and Data

The ultimate goal of our analysis is to obtain a measurement for reduction in spending in commercial areas within a quarter mile radius of Bedford Ave station. The methodology and data used is outlined below, and we delve into further detail in the following section.

- Estimate the square footage of commercial space contained within a quarter mile radius of Bedford Avenue station using data from MapPluto.
- Estimate a percentage household expenditure on “commercial items” in the three zip codes conforming our study area using data from NYCEDC/ACS.

    - Using the two previous calculations to estimate household expenditure in commercial areas specifically in our study area.
- Estimate foot traffic in our study radius brought in by the first three stations along the L train line and two stations on the G line with MTA turnstile data
    - Estimate a reduction in foot traffic from the closure
- Estimate a relationship between foot traffic and commercial areas
- Finally, given a reduction in riders to Brooklyn, estimating the impact on the local economy in terms of expenditure in commercial areas.

Refer to Appendix for Method Overview Diagram

All of our estimates are at the zip code level for 11206, 11211, and 11237, generally adhering to the Williamsburg area. Below is a summary description of data sources used for the analysis and additional steps taken to clean and transform the data into usable formats for our purposes.

Source	Data Points
MapPluto - NYC Department of City Planning (DCP)	BBL land use within three zip codes of Williamsburg provides zoning type square footage and building area
MTA Turnstile counts[10]	Turnstile data: number of entries and exits for each turnstile from January 30th, 2016 to March 4th, 2016.
LEHD (Longitudinal Employer Household Dynamics) Origin-Destination Employment Statistics (LODES)	Number of workers whose residence and/or workplace is within a quarter mile distance of the Bedford Avenue and First Avenue Subways
American Community Survey extracted from US Census	Number of households, Household Expenditures by category.
ReferenceUSA	Business type according to NAICS classification code, business location aggregated by zip code, number employees and annual sales.

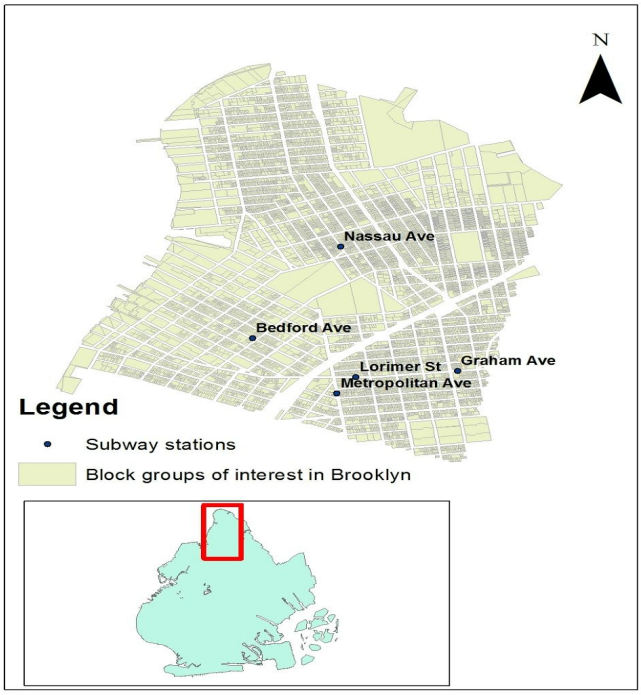
[10] MTA Turnstile data: http://web.mta.info/developers/turnstile.html

3. Analytical Methods

Estimating the square footage of commercial space contained within a quarter mile radius of Bedford Ave station.

Using ArcGIS we defined the area of interest in Brooklyn by drawing a quarter mile buffer around the Bedford Ave. station and analyzing the census blocks contained within. We then merged this defined region with the Brooklyn PLUTO data to derive BBLs (building, block, lot data) corresponding to each census block code of interest. This provided us with a table having block codes and the corresponding total area of the BBL, as well as that total area split into commercial, office, residential and retail areas. Since BBL is a smaller unit of area than a census block, we could have multiple BBLs within a census block. To obtain the total area (of each occupancy type) for each block code, the areas for each BBL within a particular census block are added together using Python scripting. This is then combined with the LEHD Journey to Work data, which provided the commuter data along with the geographical areas (total as well as subdivided) for each census block in Williamsburg. This allowed an estimation of the percentage of commercial square footage within the study area.

Focus area in Brooklyn



Results:

Total commercial square footage in three zip codes	39,715,979 sq ft
Total commercial square footage within radius	2,595,120 sq ft
Percent of square footage within radius	6.5%

Estimating a percentage of household expenditure on "commercial items" in the three zip codes conforming our study area

First, we estimated total household expenditures for our three zipcodes and then estimated percentage spent on commercial items by aggregating percentage expenditures by categories related to businesses: Healthcare, Entertainment, Apparel, Dining and Other. These categories were selected following the "Economic Snapshots" published by NYCEDC[11]. Certain categories such as Housing, Transportation, Education and Personal Insurance and Pensions were not included as they were determined to *not* contribute to the regional economy. *We are assuming the entire household expenditure in these zipcodes will be spent locally.*

- Estimate size of economy in Williamsburg. The number of households in Williamsburg and the average household total expenditure provide the total expenditures in USD for all of Williamsburg. The number of households is 68,787[12].

$$Expend_W = Households_W * \ Household\ Expenditures\ in\ USD_W$$

- Take percentage spent on categories of interest:
  - Healthcare = 5.6
  - Entertainment = 4.2%
  - Apparel = 3.9%
  - Dining = 13.2%
  - Other = 5.8%

- Multiply each percentage by total expenditure to obtain percentage of expenditure in Williamsburg that goes to commercial items: The following formula calculated the estimated economic activity in Williamsburg:

$$Relevant\ Expend = \ Expend_W \times (W_{Food} + \ W_{Apparel} + \ W_{Ent} + \ W_{Health} + \ W_{Other})$$

- Finally, calculate the size of the economy in our study area in dollars:

$$Local\ Economy\ \$ = (\%\ Economy_{radius})(Est.\ Relevant\ Expend)$$

Results:

Estimated Total Household Expenditure in Williamsburg (est. size of local economy)	$2.7 billion
Est. Commercial Expenditure in Williamsburg	$911,295,541

[11] NYCEDC, "Economic Snapshots", http://www.nycedc.com/economic-data/may-2014-economic-snapshot

[12] American Community Survey, 5-year-estimates, and http://www.point2homes.com/US/Neighborhood/NY/Brooklyn/Williamsburg-Demographics.html

Estimated Commercial Expenditure in Williamsburg a % of Total Expenditures	32.7%
Estimated Local Commercial Economy in radius around Bedford Ave	$59,545,838

Estimating foot traffic in our study radius brought in by the first three stations along the L train line and two stations on the G line with MTA turnstile data and reduction from closure.

The number of subway riders is our proxy for foot traffic coming into the Williamsburg area. For our analysis, we will not be counting foot traffic coming in via other transportation methods. As Williamsburg will be less accessible, our main concern is the riders exiting the subway, and not riders entering the subway, since we "lose" them in the system and cannot account for where they end up.

The MTA turnstile data provides entry and exit counts in four hour increments for every turnstile in every station in the NYC subway system. Data over five weeks was used to obtain the average number of exits per turnstile per day for each of the five stations.

- The script iterates through each turnstile at each station, then calculates the maximum and minimum for each to obtain the total. Additionally, it eliminates values that are deemed as outliers (more than 2.5 standard deviations from the mean)
- The next step is to calculate the percentage that each station contributes to foot traffic by dividing the total number of exits between the count for each station.
- However, a crucial step is to define a function (depending on the distance to Bedford Avenue) that models the contribution of daily riders from each station to the total foot traffic on a quarter mile buffer around Bedford Avenue station.

A function that models this behavior is defined as:

$$\varphi(x) = \frac{f(x)}{f(0)}$$

Where $\varphi(x)$ is the probability function of the Normal distribution: $N(0, \frac{1}{2}\gamma)$ where γ is the expansion coefficient that can be calibrated based on ground-truth observations. In this exercise, an expansion coefficient of $\gamma = 0.3$ represents a reasonable expansion behavior over foot traffic (see Figure 1) and because it captures the traffic coming from the stations that were initially proposed in this analysis.

Figure 2 shows the shape of the exponential function φ with different values for the expansion coefficient γ.We chose the negative exponential function to model this expansion because it reaches the value of 1 when the distance is 0 (making the weight 1.0 at Bedford Ave) and the value vanishes quickly as the distance increases as can be seen on Figure 2.

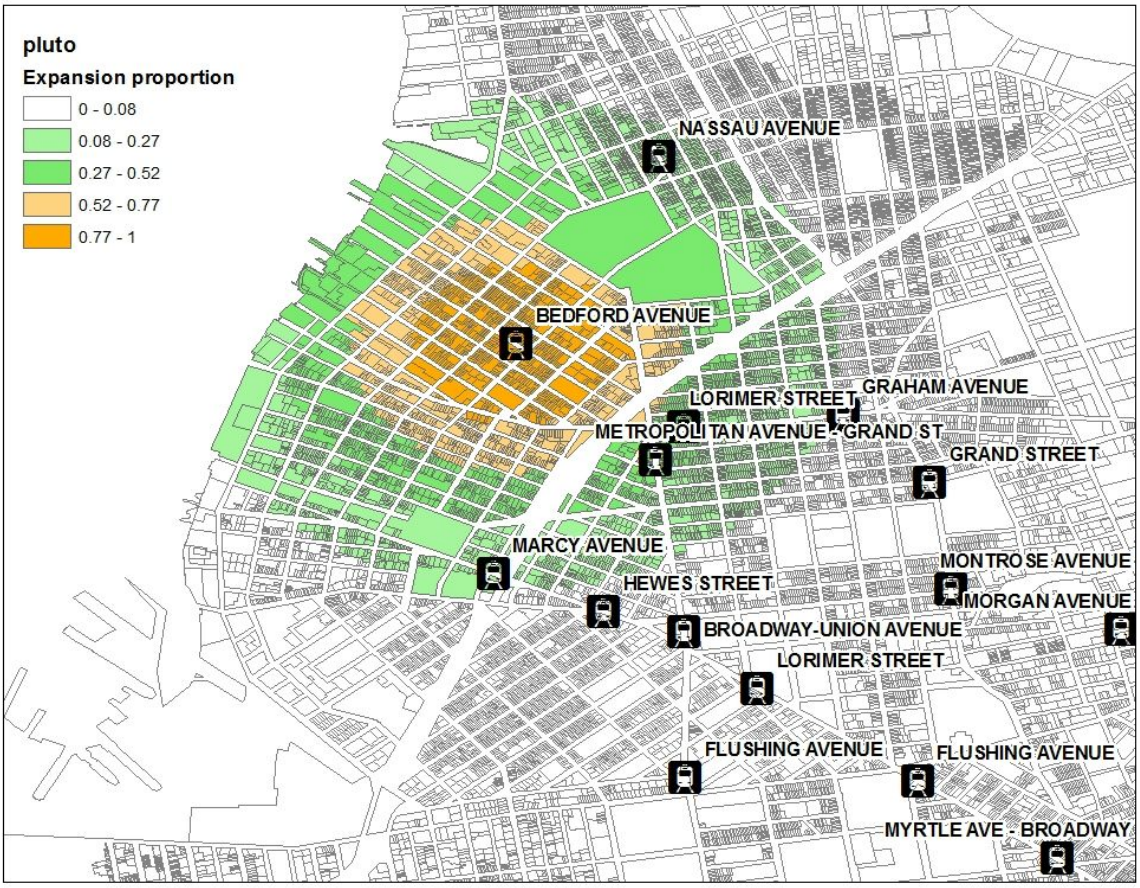


Figure 1. Calculated values of expansion proportion on foot traffic in Williamsburg

Results:

Station	Daily Exits	% of Daily Exits	Distance (miles)	Expansion Proportion
Nassau	3,807	9	0.58	0.15
Lorimer	2,553	6	0.42	0.37
Graham	5,660	13	0.70	0.06
Metropolitan	3,939	9.4	0.41	0.39
Bedford	25,944	62	0.00	1.00

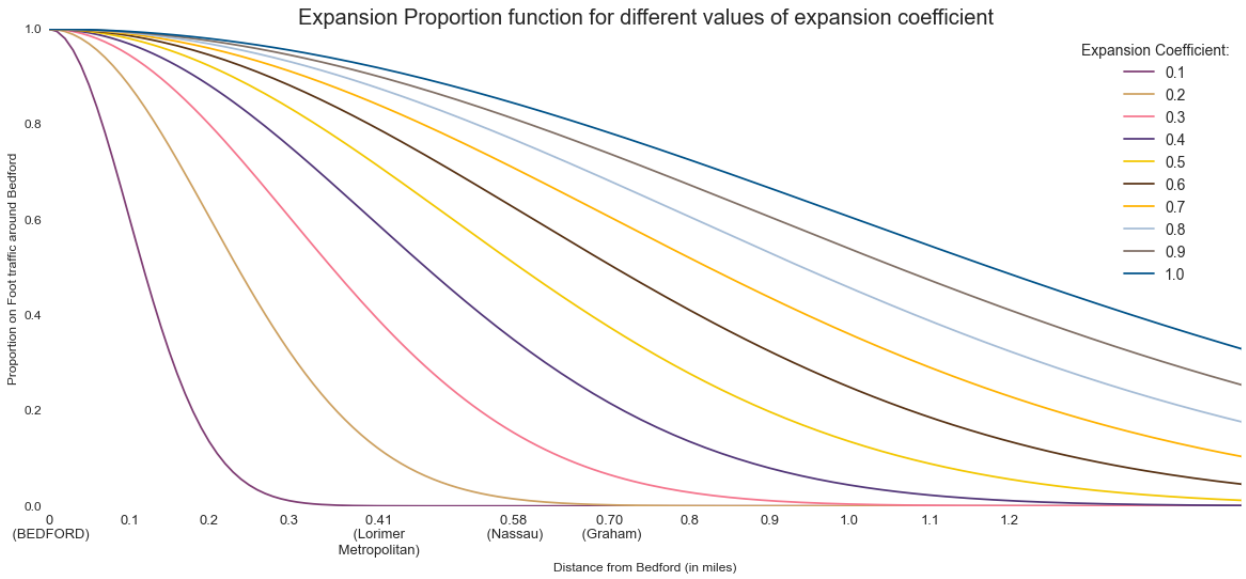


Figure 2. Expansion function $\varphi(x)$ calculated with different values of γ

- By multiplying the count of daily exits by the expansion proportion and adding them together, our estimated total **daily foot traffic in our study area coming in from the five stations is 29,409 people (R)**.
- From LEHD origin-destination data, we know that 58% of the total workers commute into Manhattan every day, that is from the Bedford Avenue station to the 1st Avenue Station (vs the 42% that commute in the other way). Taking these numbers into account, **the impact on foot traffic by the closure of the Canarsie Tunnel is estimated as a loss of 58% of turnstile exits at Bedford Avenue.**
- By applying a 58% decrease in ridership to Bedford and obtaining a **new ridership of 10,896** and then recalculating by multiplying daily counts by the expansion proportions over each station we estimate our **new foot traffic after the closure to be 14,361 (R*)**.

Estimate a relationship between foot traffic and commercial areas

- Using MapPluto data, we **estimate the commercial density** in each census block by adding the area of commercial and retail space and dividing between building area.
- Then we estimate a set of “alpha” coefficients by census block that relates the foot traffic to the commercial density on each census block. This is calculated as:

$$\alpha_i = \frac{DC_i}{(\frac{R}{1000})}$$

Where *R* is the estimated daily foot traffic in our study area as calculated in the previous step and DC_i is the commercial Density in each census block around Bedford. We divide by 1,000 to get the result per 1,000 people and to normalize figures so they can be multiplied without changing the scale.

- Using the coefficients α_i for each census block the projected commercial area after the closure in the census block *i* is calculated as:

$$DC_i^* = \alpha_i * \frac{R^*}{1000}$$

Where R^* is the estimated foot traffic in our study area after the closure.

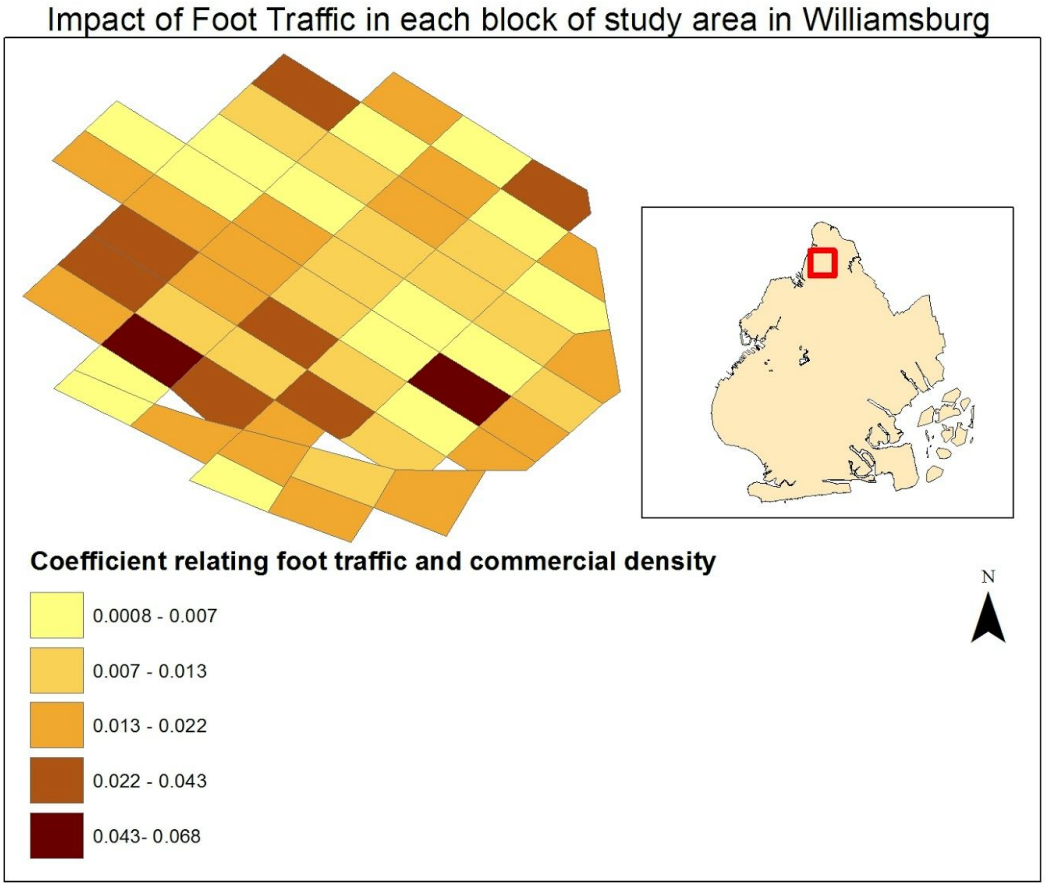


Figure 3. Coefficient relating foot traffic and commercial density by block

Estimating the impact on the local economy in terms of expenditure in commercial areas

- Using the estimated alpha coefficient, we calculate a reduction in commercial density (DC*) using the the new foot traffic (post-closure) calculation R*.

$$DC_i^* = \alpha_i * \frac{R^*}{1000}$$

- From this reduction in commercial density, we calculate a reduction in commercial area.

$$C\_area_i = DC_i^* * Building\ area_i$$

Results:

Total **commercial square footage** within radius	2,595,120 sq ft
Total **projected commercial square footage** within radius	1,303,837 sq ft
% Decrease:	49%

- Dividing the projected commercial square footage within the radius between (the previously calculated) total commercial square footage in the area we obtain a new percentage of commercial area within our radius.
- The last step is multiplying the new percentage by the previously calculated commercial expenditure to obtain the new size of the economy.

Results:

Estimated **local commercial economy** in radius	$59,545,838
Estimated **local commercial economy** in radius **after closure**	$29,916,952
% Decrease	49%

4. Results

The previous calculations were based on two majors assumptions:

1) From LEHD origin-destination data, we know that 58% of the total workers commute to Manhattan every day, that is from the Bedford Avenue station to the 1st Avenue Station (vs the 42% that commute the other way). Taking these numbers into account, the impact on foot traffic by the closure of the Canarsie Tunnel is estimated as a loss of the 58% of turnstile exits at Bedford Avenue.

2) No assumption was made on the alternative methods of public transportation that might replace service on the L train line between Brooklyn and Manhattan.

However, our model takes into account this second restriction, providing eleven different scenarios: in the first scenario, there are no alternative methods of public transportation that might replace the line, while the second scenario reproduces our calculations but in this case a 10% of the original ridership is recovered by other means of public transportation, in the third

scenario: a 20% of the original ridership is recovered by other means of public transportation and so on. The result of the different scenarios are summarized in Table 1.

Traffic Retained by Alt. Transportation (%)	**Forecasted Daily Foot Traffic Around Bedford Av.**	**Predicted Expenditure ($)**	**Est. Expenditure % Decrease**
0	14,362	29,916,952	0.49
0.1	15,867	33,052,026	0.44
0.2	17,371	36,185,016	0.39
0.3	18,876	39,320,090	0.34
0.4	20,381	42,455,164	0.29
0.5	21,886	45,590,237	0.23
0.6	23,390	48,723,228	0.18
0.7	24,895	51,858,301	0.13
0.8	26,400	54,993,375	0.08
0.9	27,905	58,128,449	0.02
1	29,410	61,263,522	0.00

Table 1. Outcomes of 11 different scenarios of foot traffic decreasing around Bedford Avenue.

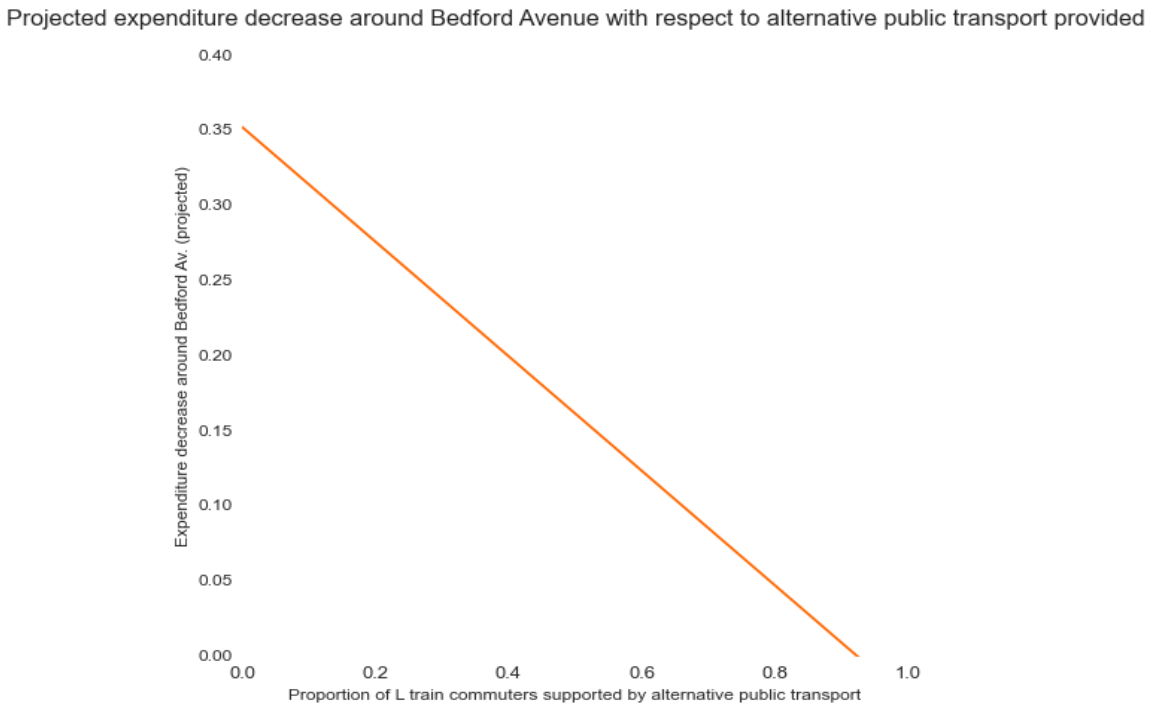


Figure 4. Linear decrease of the revenue loss around Bedford avenue depending on the proportion of commuters supported by alternative means of public transportation.

5. Discussion

The MTA finds itself in a difficult position when weighing the options for the proposed L train closure. The subway network is the arteries through which people flow throughout the city, and they must be exceptionally careful to account for the impact that their project will have on people and organizations that are not part of the actual transportation network. Though there exists a formal environmental impact analysis process, the deficiencies of the methods contained within such documents often disallow the analysis from having any meaningful impact. Given the scale of this proposed project, the unusually limited accessibility to Williamsburg via the subway, and the vehement public backlash against the proposed shutdown, the MTA needs a more thorough way of measuring the impact of its plan in order to inform its decision making. The methodology discussed here does exactly that.

The γ value of 0.3 estimates that the economy of the area around the Bedford Ave. station will retract approximately 34% as a result of the tunnel closure. This is a considerable amount, and the MTA, SBS, and other community commerce groups must be mindful of the extent of this impact to the businesses around Bedford Ave. when developing their master plan for the project. While this does seem like an extremely high percentage, it is important to remember that this model does not attempt to include variations of alternative transportation methods that the MTA has said it will provide for the duration of the shutdown.

This model also makes no attempt to explain *why* or *which* businesses might close, as the factors that contribute to the success or failure of a small business vary immensely both generally and specifically within each type of business. Since our model is an estimate based on the commercial square footage in the region, it is not possible to measure at the business level without collecting data that would be unavailable to the public and would not meet the model's goal of estimating impact based on publicly available data. Additionally, calculating the loss in expenditure to the economy is the most direct way to calculate impact, as determining loss in jobs or business closure would add complexity to the model that would make predictions considerably more inaccurate. The model also calculates a net impact and does not attempt to quantify businesses that may thrive under the new restrictions in foot traffic, such those selling services that residents would preferably purchase in Manhattan, but are now unable to as a result of the shutdown.

Reproducibility

All data used for this model is publicly available. The code for determining our variables and methodology is available on GitHub[13]. We invite others to review and provide feedback.

Ethical and Privacy Considerations

All of the data used to look at movements of subway riders through the system, census data for determining distances from subway and business footprints is publically accessible and we are not looking at any data that contains records for individual users. For the business landscape, we have NYU access to details about types of businesses through ReferenceUSA, and we used this information to understand the makeup of our study area. No identifying information for individual business such as address or sales volume is included.

6. Suggested Next Steps

Though we are confident with the results of the model, it is critical to validate the prediction by measuring the impact of the shutdown after it occurs. Additionally, better selection criteria for the expansion coefficient (γ) would provide a more robust assessment.

Also, the impact on ridership was calculated based on LEHD LODES origin-destination data. Alternative methods of estimating foot traffic, such as taking pedestrian counts from each station, could improve the accuracy of the model. By adding average number of customers, demographic variables and having a more detailed look at impact by business type, the model could further incorporate context-specific changes. Adjustments to the model that could incorporate changes over time would also be important for businesses to be able to plan ahead.

[13] Project repository: https://github.com/DQOfficial/usi_L_train

Appendix

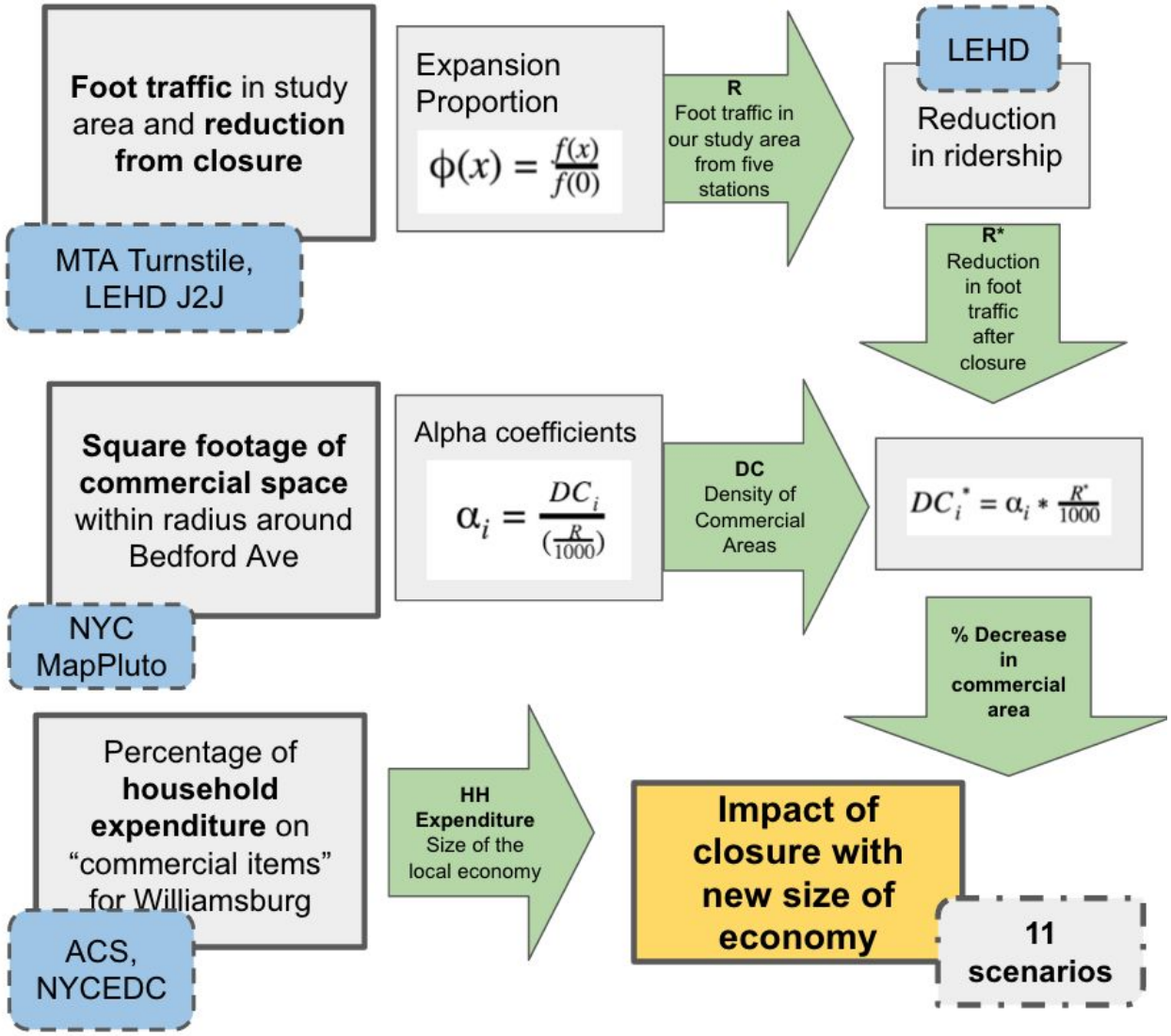


Figure 4. Diagram of methodology