nyconnect

An investigation into the competitiveness of the telecommunications industry in New York City

____

Progress Report Two

____

Erik Lopez, Wesley Chioh, Yichen Liu, Ziyu Yan
CUSP mentor: Junaid Khan
External Sponsor: Zachary Gold, New York City DOITT

Abstract

The New York City Department of Information Technology and Telecommunications (DoITT) wants to understand if the current telecommunication industry regulations are effective at generating a competitive industry environment that can provide cheap and reliable internet access to all New Yorkers. For our project we are interested in discovering if there is an optimal number of Internet Service Providers (ISPs) in New York City that can improve Internet accessibility. We will analyze the current internet infrastructure coverage data and overlay it with pricing and socio-economic data to determine the relationships that can lead to the desired state. We estimate that there is an optimal number of ISPs for the NYC urban internet market but is yet to be achieved due to infrastructural and socio-economic unevenness. NYC's government may have to directly intervene in the telecommunication market to incentivize capital investments or corporate-community partnerships in less well-connected neighborhoods.

Introduction: Motivation and Literature Review

The Federal Communications Commission (FCC) defines a wired home broadband service as an "Internet access connection providing speeds of at least 25Mbps download and 3Mbps upload." (Talbot, Hessekiel, & Kehl, 2018, p.4) This usually takes the form of a cable or fiber network with the latter being capable of higher speeds and bandwidth (US Congressional Research Service, 2019) . The NYC Internet Master Plan (The New York City Mayor's Office of the Chief Technology Officer [NYC CTO], 2020) states that a reliable broadband internet connection is increasingly becoming crucial to NYC's long-term economic vitality. Universal broadband access is estimated to increase economic output in the city by 142 billion dollars, and create as many as 165,000 jobs through increased labor and capital productivity. As a result, the FCC as the national industry regulator, as well as state and municipal agencies like

DoITT, have a mandate to “foster competition and maximize consumer benefits of broadband access.” (Government Accountability Office [GAO] as cited in Palmer, 2015, p.67).

However, the unevenness in broadband affordability and availability in NYC is a microcosm of social inequality and ineffectiveness of competition and regulation of the telecommunications industry. In New York City, more than 1.5 million New Yorkers do not have any high-speed internet connection (NYC CTO, 2020). A study by the New York State Department of Public Service (DPS) Office of Telecommunications (2015) showed that “higher levels of population density and higher incomes are associated with greater broadband network availability.” (p. 95) Additionally, even among residents with wired home broadband service perceive it as extremely costly (Talbot *et al.,* 2018). The shortcomings in access and pricing can be attributed to the lack of competition between service providers because the industry is effectively a spatially segmented oligopoly (Brake and Atkinson, 2019). This represents a market failure in classic microeconomics where neither consumer welfare nor service coverage is maximized.

The belief that American consumers stand to benefit from greater competition in the telecommunication industry spans across multiple administrations starting from the Telecommunications Act of 1996, to the Federal Communications Act (DPS Office of Telecommunications, 2015). During the Obama administration, the Executive Office of the President (2015) authored a report arguing for greater competition within urban broadband markets to lower prices and improve service delivery. However, Brake and Atkinson (2019) argue that it is important to understand the underlying structure of modern urban telecommunications markets because it is not immediately apparent that greater competition necessarily results in lower prices and maximum consumer benefit. Broadband network infrastructure incurs high fixed capital costs that are subject to rapid technological change. As a result, only an oligopolistic market structure with a few big firms can achieve economies of scale and thrive. Meanwhile, smaller companies are neither able to surmount the barriers to entry nor enjoy the economies of scale, necessitating subsidies to stay afloat. In this case, increased competition as measured by the number ISPs or the Herfindahl-Hirschman Index (HHI) that measures industry concentration may not truly capture the latent efficiencies within the market that are a function of the present regulatory framework.

Presently, telecommunication companies own the internet infrastructure. Companies such as Crown Castle construct the rooftop and pole top telecommunication installations that are then leased out to ISPs. NYC's Department of Buildings (DOB), the FCC, and DoITT regulate the installation of this infrastructure, as well as internet service provision in the five boroughs through a franchise regulated by the state and the city. An alternative is for cities to construct their own fiber broadband networks, also known as municipal broadband networks or community-owned fiber networks. (Talbot *et al.*, 2018) Examples of cities that have done this successfully include Chattanooga, TN and Santa Monica, CA (Lampland and Mitchell, 2014), the latter being able to lease out unused fiber capacity to ISPs who wish to compete with Santa Monica City Net. Talbot *et al.* (2018) argue that a majority of these cities have been able to offer faster broadband connectivity at lower prices, forcing incumbents such as Spectrum to improve their services in order to effectively compete. However, the sample size of this study was small, given the limited number of community-owned fiber networks around the country. Plus, these networks serve communities with less than a million residents; it is unclear whether large metropolises such as NYC will be able to replicate and scale up effectively.

Problem Statement and Research Outcomes

We are interested in discovering if there is an optimal number of ISPs for New York City that can improve Internet accessibility in terms of coverage area, household adoption rates, and affordability. The aim is to produce a policy white paper that explains NYC's broadband market structure, the factors influencing availability of broadband internet and subscription rates, and how DoITT can improve the regulatory framework to optimize market conditions.

Data

A more detailed description of the datasets used can be found in the appendix.

Dataset	Description
Internet Master Plan: Adoption and Infrastructure Data by Neighborhood	Produced by the NYC Mayor's Office of the CTO as a checkpoint for NYC's progress in meeting its goals
Internet Master Plan: Broadband Choice and Speed by Census Block	Produced by the NYC Mayor's Office of the CTO to reflect FCC 477 Form data specific to NYC
Mobile Telecommunication Franchise Poletop Installation Locations	Locations approved by DOITT for the installation of telecommunications infrastructure
Empire City Subway (ECS) Conduit Data	Current length of underground telecommunication cables and potential for expansion
NYC Wi-Fi Hotspots Locations	Locations of NYC's Wi-Fi hotspots with provider information
LinkNYC usage statistic	Bandwidth data and subscription information for 2016-2019
NYC Free public Wi-Fi	All public Wi-Fi locations and provider information
LinkNYC Locations	Locations where a LinkNYC kiosk has been installed
TIGER Census Blocks shapefile	Produced by the United States Census Bureau based on the 2010 Decennial Census to denote population groups by area
NYC NTA shapefile	NYC Department of City Planning grouped neighborhoods
2010 Census Tract to NTA	Produced by NYC Department of City Planning to assign

Equivalency Table	tracts to neighborhoods
Broadband Provider-Compare_v.2	Provided confidentially by DoITT, listing the price and service content for main ISPs in NYC

Table 1: Data Sources

Methods

Spatial Geoprocessing	Spatial attributes of the datasets were used to match them to spatial boundaries. They were then used to create visualizations such as maps.
Spatial Autocorrelation	Given data on internet adoption and availability, Moran's I statistic can be calculated to test for the presence of spatial autocorrelation.
Clustering	Census blocks and NTAs can be clustered based to identify similar areas and their attributes analyzed. A comparison with the high-high and/or low-low areas returned by spatial autocorrelation can also be done.
Regression Analysis	We can build a regression model based on hedonic price theory. The dependent variable would be the price of mobile, cable and broadband and the independent variable(regressor) would include factors from both supply side and demand side. Factors of supply side would contain characteristic of demographics(age, sex, race, income, education)
Bayes Network	We can build a Bayes Network to identify the causal relationship between prices, and other socio-economic and infrastructural variables.
Market Analysis	We will use the Hirschman-Herfindahl Index(HHI) to identify the overall competitiveness of the industry in New York City. Based on the Bayes Network analysis, we can verify the significance of each variable.

Table 2: Methods

Initial Analysis

Our analyses fall into two distinct categories: supply-side and demand-side. The former refers to ISPs and existing infrastructure, and the latter refers to the residents and businesses of NYC.

<u>Basic Market Analysis</u>

The telecommunication industry is a capital-intensive industry since it requires an extensive network infrastructure. We used the total revenue data from a January 2020 telecommunication service report to estimate the market share of each company in New York City and calculate the HHI. HHI is the square sum of each company's market share, where S_i is the market share percentage of company i. Markets in which the HHI exceeds 2,500 points are highly concentrated. The telecommunication industry is an oligopolistic market.

$$HHI = \sum_{i=1}^{n} S_i^2 = 3096,$$

Supply-Side

All NYC Census Blocks have at least one provider of broadband-quality Internet access. Although 60% of all NTAs have some sort of access to download speeds of at least 1Gbps, access is extremely diffuse. Only a third of city Census blocks have internet connections in excess of 1Gbps, while only 3% of blocks with fiber infrastructure have more than one distinct ISP. In contrast, if cable infrastructure is included, around 80% have more than one distinct ISP.

For plans with unlimited call time, texts and 4G data , Altice USA is the cheapest at $30/month for 1 line. Verizon Wireless charges over $75 for 1 line per month, three times more. Price differences can be due to competition and other differentiated services. In the home broadband market, prices for all providers have remained unchanged except for Charter. Altice covers the Bronx and East Brooklyn, Charter serves the rest of NYC, and Verizon is available across NYC. This is evidence of a spatial segmentation of the market, resulting in oligopolistic behavior. In terms of prices, Altice's prices are the highest, followed by Verizon, and Charter. Further, their price plans also have huge differences ranging from a maximum of $120 to a low of $20.

Demand-Side

Using the Internet Master Plan Adoption dataset, on average 68.7% of households in each NTA have at least a broadband connection. However, there are a few NTAs such as Williamsburg, Borough Park, Lower East Side, and Belmont with extremely low household adoption rates.

Contrary to our expectations, mobile broadband is not a substitute for wired residential broadband. Even in residential NTAs with low rates of household wired broadband adoption, mobile broadband dependence rates are less than 10%, and not among the highest.

Most of the NTAs with the highest proportion of households with neither a wired nor a mobile broadband connection can be found in the Bronx and Brooklyn. More research has to be done to determine if a distinction can be made between those willing but unable to afford a broadband connection, and those who are unwilling to pay for such a service, and the relevant price points..

Research Plan

At this stage, our literature review along with our exploratory data analysis are complete. The team is ready to proceed with a deeper analysis of the structural issues affecting the urban broadband market. In this coming phase, because the temporal and spatial granularity of the data are limitations that cannot be resolved at all, even by the FCC and DoITT. We will have to work with error margins as we produce our models. We hope that by the end of the next phase we will have a modest website detailing our key findings, data sources, and limitations.

Team Collaboration Statement

Wesley will take the lead in geospatial visualizations and analyses using QGIS, R and Python. Erik will take charge of building and publishing the website where our final results will be published. Yichen will use machine learning to do the regression analysis. Ziyu will take charge of the economic part, including market analysis and providing potential policy suggestions.

Sources

Brake, D., & Atkinson, R. D. (2019). *A Policymaker's Guide to Broadband Competition*. Information Technology and Innovation Foundation.

Chen, Yidan, and Hafshah Ashrawi. "Equity of Access to Public Wifi in NYC." *RPubs*, 2019, rpubs.com/yidanchen95/561896.

Department of Public Service Office of Telecommunications. In the Matter of a Study on the State of Telecommunications in New York State, Staff Assessment of Telecommunications Services (2015). Retrieved from http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={1CBAE64C-C4B9-483A-8317-C76CB914344D}

Executive Office of the President. (2015). *Community-Based Broadband Solutions*.

Federal Communications Commission (2010). *Connecting America: The national broadband plan.* ERIC Clearinghouse

Guowang Miao; Jens Zander; Ki Won Sung; Ben Slimane (2016). Fundamentals of Mobile Data Networks. Cambridge University Press. ISBN 978-1107143210.

Hung-Yu Wei, Jarogniew Rykowski, Sudhir Dixit. WiFi, WiMAX and LTE Multi-Hop Mesh Networks: Basic Communication Protocols and Application Areas. Wiley, (2013).

Lampland, E., & Mitchell, C. (2014). *Santa Monica City Net: An Incremental Approach to Building a Fiber Optic Network*. Institute for Local Self-Reliance. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.673.7810&rep=rep1&type=pdf

McKetta, Isla. "LinkNYC Proves Public Wi-Fi Can Be Free, Fast and Far-Reaching." *Speedtest Stories & Analysis: Data-Driven Articles on Internet Speeds*, Speedtest Stories & Analysis: Data-Driven Articles on Internet Speeds, 31 Oct. 2017, www.speedtest.net/insights/blog/linknyc-2017/.

Palmer, K. (2015). *Broadband internet*. New York: Novinka.

Talbot, D., Hessekiel, K., & Kehl, D. (2018). Community-owned fiber networks: Value leaders in america. *Berkman Klein Center Research Publication*, (2018-1).

Telecommunications- NAICS 517, Statista Industry Report – USA, January 2020

The New York City Internet Master Plan, The New York City Mayor's Office of the Chief Technology Officer (2020). Retrieved from https://tech.cityofnewyork.us/wp-content/uploads/2020/01/NYC_IMP_1.7.20_FINAL-2.pdf

U.S. Congressional Research Service. Broadband Data and Mapping: Background and Issues for the 116th Congress. (R45962; Oct. 16, 2019), by Colby Leigh Rachfal. Text from: Congressional Research Digital Collection; Accessed: March 27, 2020

Appendix

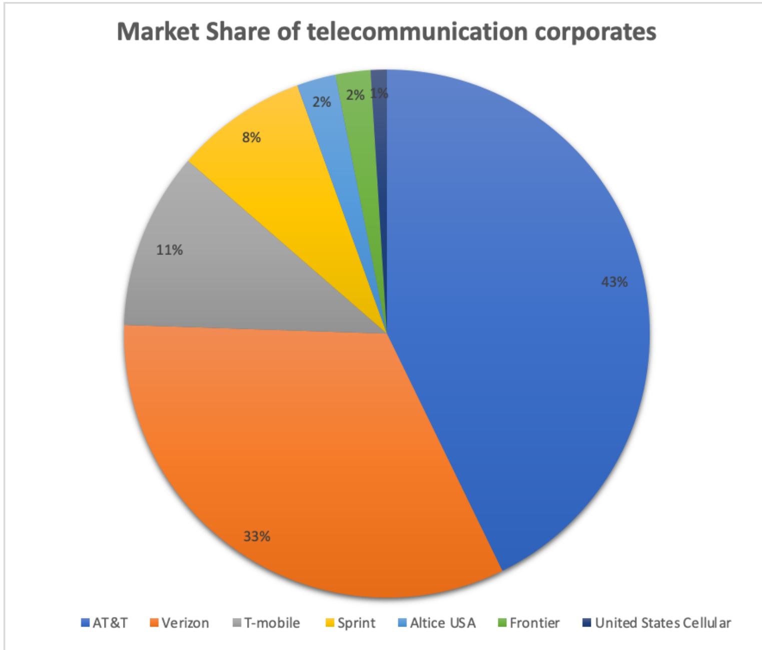

Figure 1: Telecommunication industry market share by operator

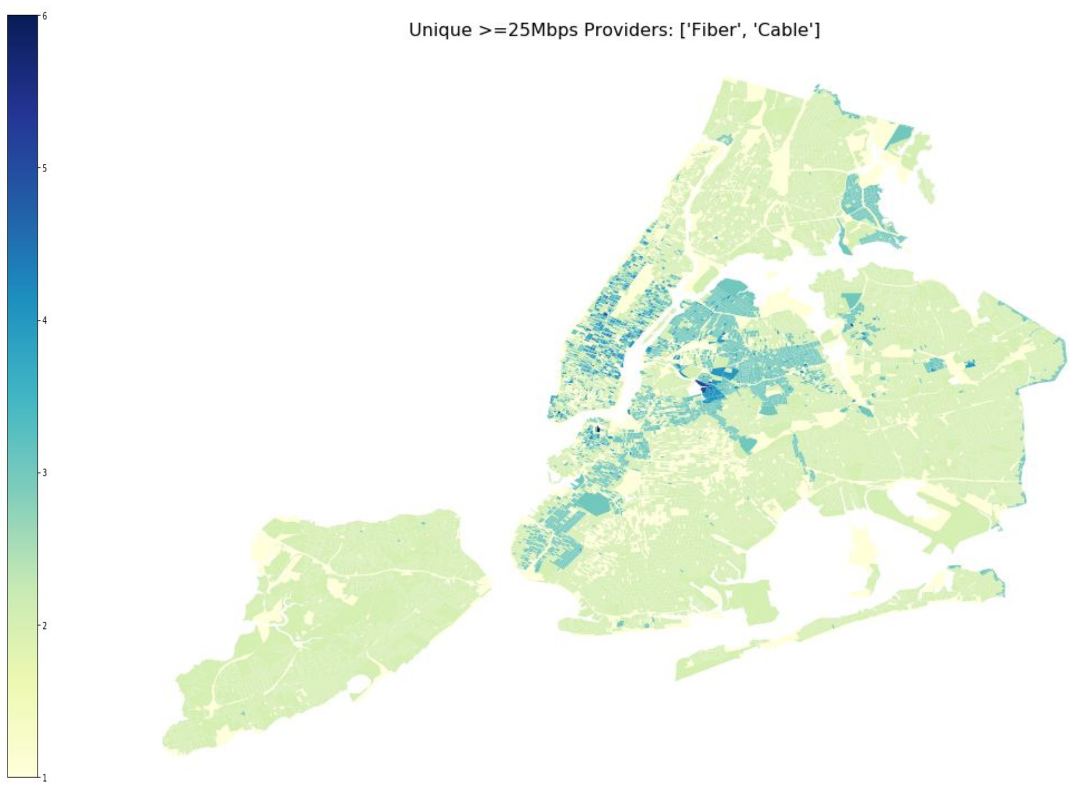

Figure 2: Number of providers per census block offering fiber/cable connections in excess of 25mbps

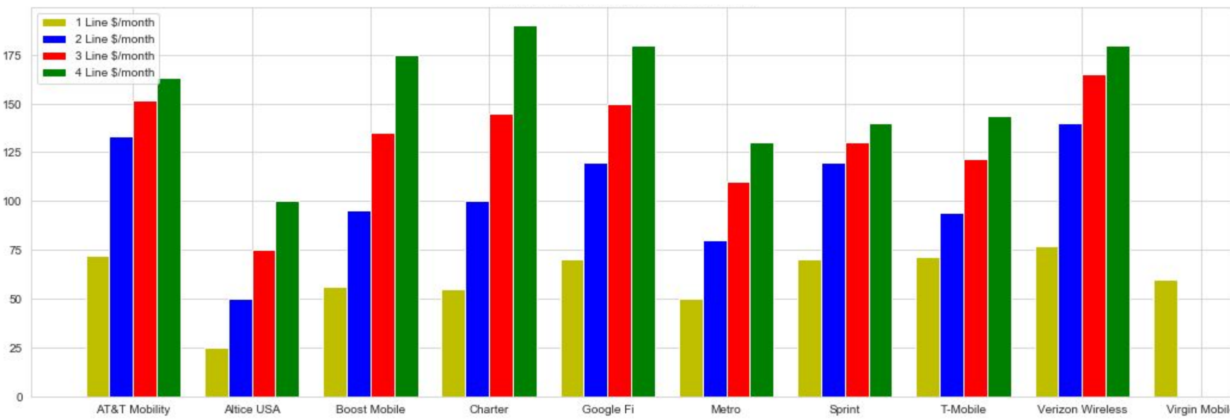

Figure 3: Mobile broadband subscriber plan cost

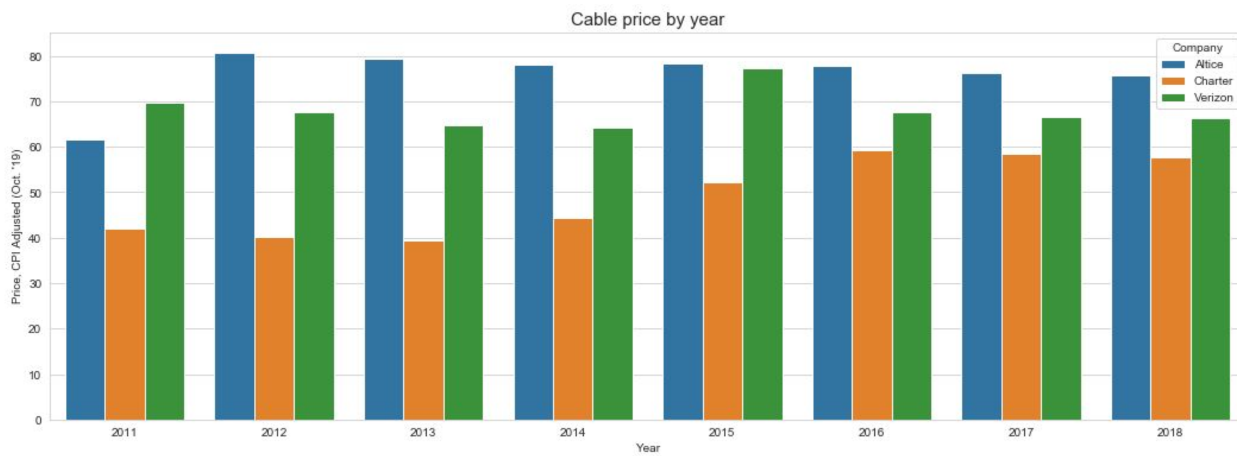

Figure 4: Cable plan pricing over the years

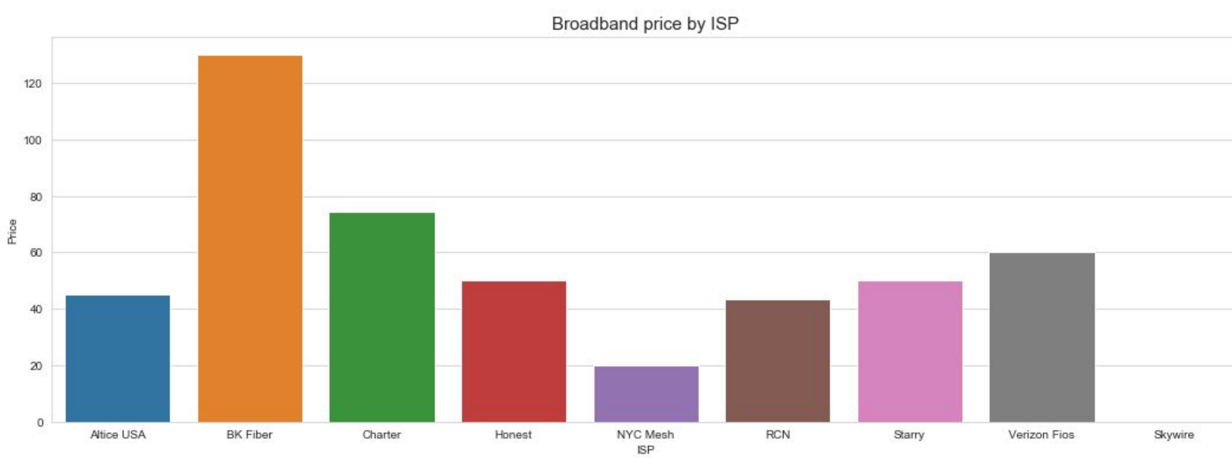

Figure 5: Residential broadband price plans by ISP

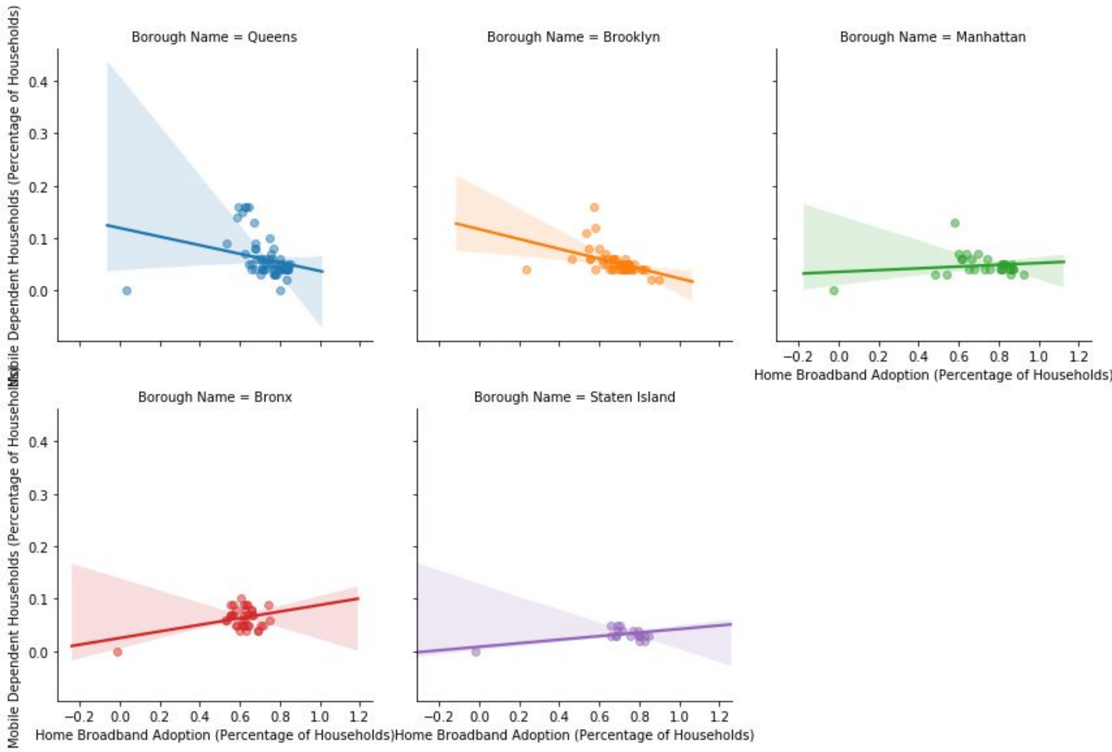

Figure 5: Poor substitute - Mobile broadband for residential wired broadband

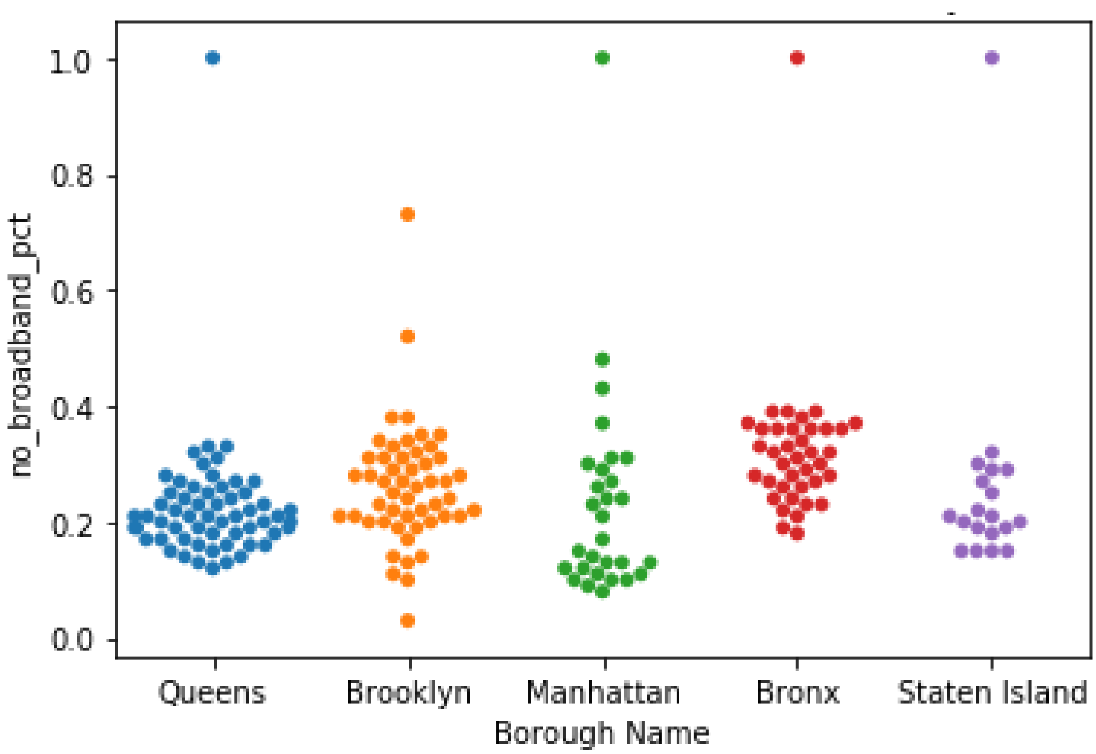

Figure 6: Households (%) with no form of broadband connection in each NTA by borough

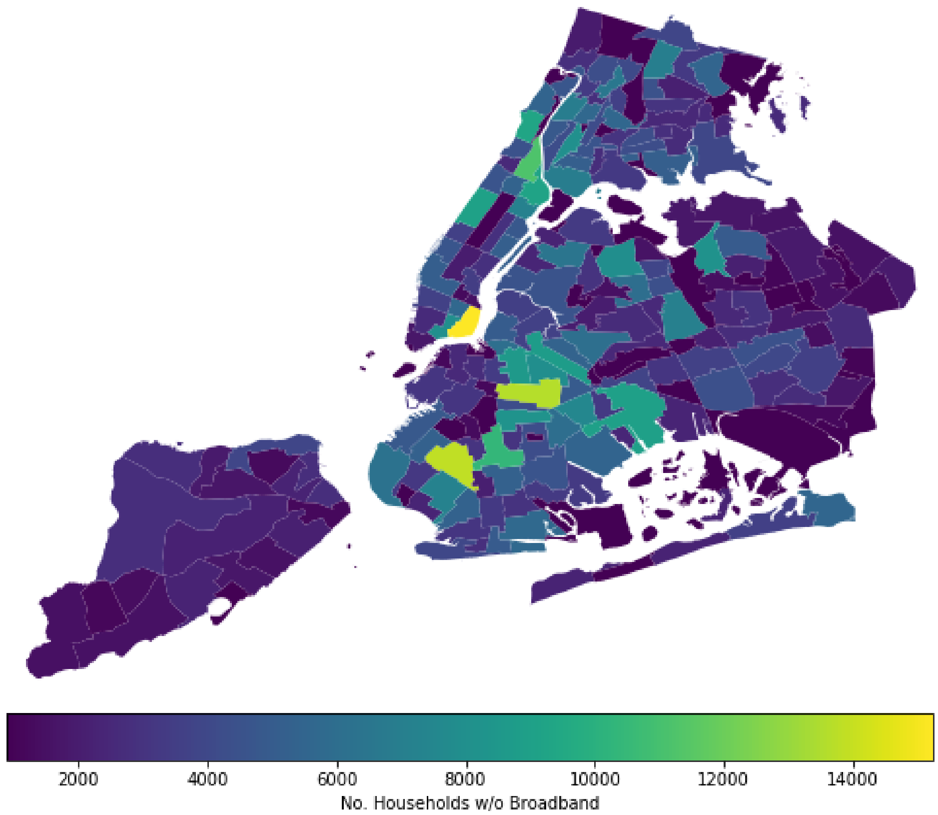

Figure 7: Geographical distribution of households in each NTA without a broadband subscription

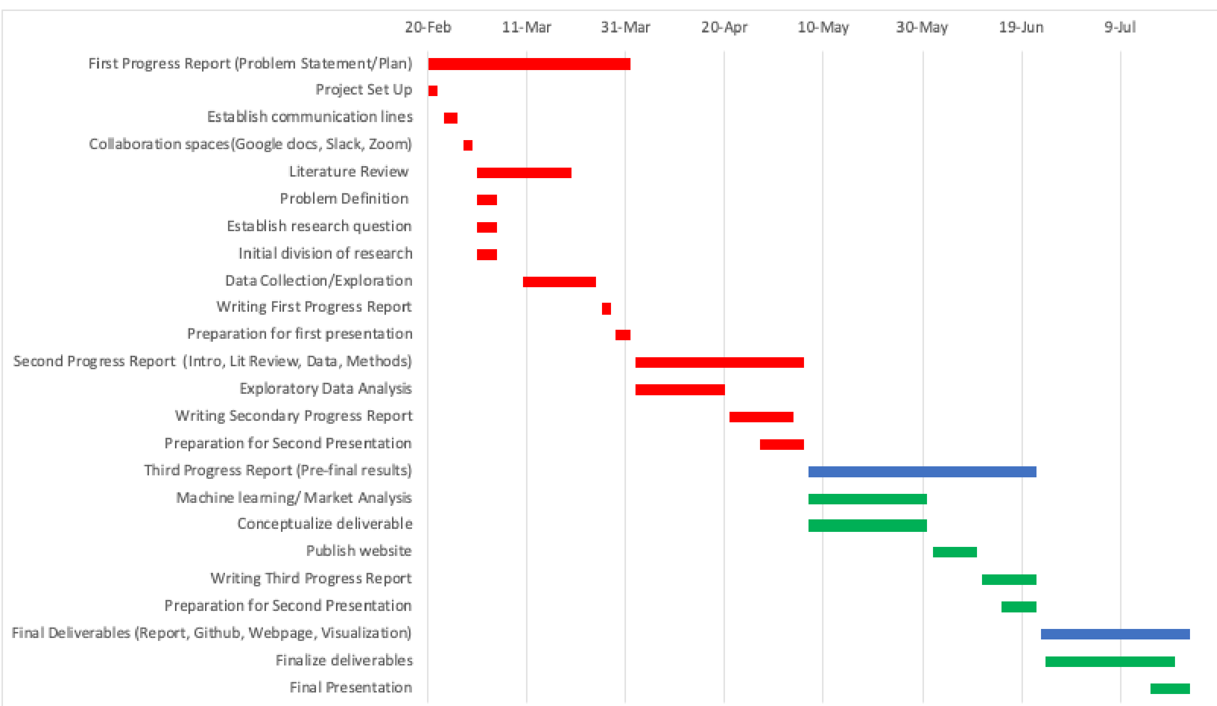

Figure 8: Research Plan

Dataset	Description	Structure	Main characteristics	Limitations
Internet Master Plan: Adoption and Infrastructure Data by Neighborhood	Produced by the NYC Mayor's Office of the CTO as a checkpoint for NYC's progress in meeting its goals	CSV file with 52 attributes at the scale of Neighborhood Tabulation Area (NTA)	Basic population count of the NTA with the availability and utilization of different means of internet access and street infrastructure survey	It is an amalgamation of potentially outdated datasets such as the 2017 American Community Survey. It is an estimation of the NTA based on samples.
Internet Master Plan: Broadband Choice and Speed by Census Block	Produced by the NYC Mayor's Office of the CTO to reflect FCC 477 Form data specific to NYC	CSV file 14 attributes at the scale of each census block	Count of the number of commercial and residential ISP providers within each census block	Limited to the December 2017 FCC 477 Form and the shortcomings of FCC's methodologies as explained below.
Mobile Telecommunication Franchise Poletop Installation Locations	Locations approved by DOITT for the installation of telecommunications infrastructure	CSV file with 20 attributes at the scale of each location	Description of installation at said location with longitude and latitude, and street address provided.	Dataset lists the firm installing the infrastructure but not the specific company leasing it
Empire City Subway (ECS) Conduit Data	Current length of underground telecommunication cables and potential for expansion	CSV file with 16 columns at the scale of NTAs	Summary of total length of current cables and NTAs with existing capacity for growth	Unclear if ECS is the only company installing the cables and whether these cables reach every building in NTA
NYC Wi-Fi Hotspots Locations	Locations of all Wi-Fi hotspots with provider information in NYC	CSV file with 29 columns at the scale of NTAs	Each record includes indicates a hotspot in NTAs, census tract and also coordinates	Unclear if it includes NYC mesh spots.

LinkNYC usage statistic	Bandwidth data and subscription information between 2016 and 2019	CSV file with 9 columns	Weekly data with increments and cumulative amount of bandwidth and subscribers	Limited to December 2019
NYC Free public Wi-Fi	All public Wi-Fi locations and provider information	CSV file with 29 columns	Contains each Wi-Fi spot’s location, type(free or limited free), provider, activated date and DOITT ID	Some records lack of BIN and BBL information
LinkNYC Locations	Locations where a LinkNYC kiosk has been installed, including sites that have replaced public pay telephones (PPT) and new sites	CSV file with 24 columns at the scale of boroughs, NTAs, census tracts and coordinate	Includes 1869 LinkNYC hotspots with specific locations and information that whether they are active or just installed	Unclear update frequency
FCC 477	Internet providers report fixed-broadband deployment data at the census block level. Form 477 data are reported using 2010 Census blocks. Providers may not offer service to every home in every block in which they report service.	CSV file with 21 columns where each row is a provider and internet service details (like speeds) reported at the Census block level.	Contains an internet provider’s offered speeds (download/upload), infrastructure used for delivery, location of service (Census block)	2018 is the latest year because NYC has been making too many requests of FCC and DOITT does not want to overwhelm FCC
Presence and Types of Internet Subscriptions in Household	As part of the ACS 5-year estimates, it shows the number of	CSV file with 7 attributes at the scale of census tracts	Estimate of number of households that subscribe to each type of	2017 and 2018 are the only years for which data at the census tract

	households in each tract that subscribe to each type of internet service.		internet access	level were available
TIGER Census Blocks shapefile	Produced by the United States Census Bureau based on the 2010 Decennial Census to denote population groups by area	ESRI shapefile with geometry and unprojected EPSG 4326 coordinate reference system.	Spatial representation of census blocks in the US	From the 2010 Decennial Census
NYC NTA shapefile	Produced by NYC Department of City Planning to group neighborhoods in NYC	ESRI shapefile with geometry	Spatial representation of NTAs in NYC, identified by NTA code	Only applicable to NYC and incompatible with datasets on the scale of census tracts and blocks
2010 Census Tract to NTA Equivalency Table	Produced by NYC Department of City Planning to assign tracts to neighborhoods	CSV file with 5 attributes at the scale of census tracts	Provides information on which NTA each tract corresponds to	Inconsistent naming of boroughs and tract ID with US Census Bureau TIGER shapefiles
Broadband Provider-Compare_v.2 dataset	Provided confidentially by DoITT, listing the price and service content for main ISPs in NYC	Excel file consisting of 6 sheets (Mobile, Cable-Historical-Protect, Cable-Historical, Fixed Broadband, CPI, Passwords)	Provides the current and historical price of mobile broadband, cable and fixed broadband for ISPs in NYC as well as according detailed service content and coverage	Historical data is available only for cable service, but not for mobile broadband and fixed broadband. Since this file was published at the end of 2019, some information might not be up-to-date.

Table 1: Detailed description of data sources