Datathon Project Group 3 DS4A

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1 Introduction

This document describes the process followed to define, analyze and answer the questions of the Datathon project. The data provided correspond to datasets from 2014 and 2015 of four different transportation means: Yellow cabs, Green cabs, UBER, and MTA. Additionally, one dataset provides weather information, and another one provides demographic information of the boroughs.

1.1 Background Information

New York city is the most populous city in the United States [1] with around 8.6 million inhabitants. It is expected to reach 9 million by 2040 [2], with Bronx being the borough with the highest increase in population with 14% (between 2010 and 2040). Average Travel speeds in New York City is 10 mph, 4 mph or less in Brooklyn and Queens, and over 3 mph NYC Midtown.

In terms of transportation, according to [3], New York City is the second most congested city in the USA and number 42 in the world. It has one of the largest and oldest (1904) subway systems in the world. Due to its congestion, New York City inhabitants prefer to use public transportation (67.2% of workers commuting to work by this means in 2006 [1])

However, MTA the worst commutes in the world [4] conmute time of 35.6 minutes on average commuting has been linked to obesity, stress, anxiety, depression, higher blood pressure, higher rates of divorce, neck and back pain and shorter lifespans.

The following lists summarize key points of the different transportation means used in the Datathon.

Yellow Cabs

- Mostly located in Manhattan
- It is very difficult to get a taxi out of Manhattan, especially in rush hours.
- There are not many yellow cabs 130000, which are not enough.
- They can operate midtown and lower Manhattan and airports
- Rarely pick up outside manhattan

Green Cabs

- Where created to standardize street hails outside of NYC. They operate in Brooklyn, Queens, The Bronx, and upper Manhattan.
- Airports: they can drop-off but not pick-up unless sent by a dispatcher
- They are not allowed to stop in the South of the upper west and upper east sides.
- Rides cheaper than Yellow cab rides
- For drivers green cabs was a way to get money without the pressure that yellow drivers have.

- Green drivers **are also drivers or UBER**
- 1/3 pick ups from Brooklyn, 1/3 Northern Manhattan, 1/3 Queens, a few in Bronx and Staten Island

UBER

- Started in 2011 in Manhattan but expanded at the same time green.
- Uber has made yellow cabs steady but has impacted green that were just started
- Uber has made yellow cabs steady but has impacted green that were just started
- Connects drivers with more rides
- May 2015 busiest month on record.

According to the mobility report of 2016 [5], New York City is growing in jobs, residents and visitors. Its transportations modes have extend to mass transit, walking, and cycling. New York advances focus on applying technology to real-time traffic management, Select Bus Service routes, reducing travel times, Expanding the city's bicycle lane network, improving pedestrian access to transit. It is still required to invest in ways to keep the city moving.

Despite the incursion of new transportation means e.g. Green Cabs, UBER, among others, it is still difficult to catch a taxi from outer Boroughs to Manhattan. Lower access to legal taxi rides for people in outer Boroughs.

1.2 Topic Question

General question:

> *Is public transportation coverage in New York City*
> ***equally attending*** *all areas?*

Exploratory questions:

- What are the patterns related to unattended areas of public service?
- Is there are relationship between demographic information and peoples' choices of public transportation?

2 Data Wrangling and Data Cleaning

2.1 Data Cleaning

The data cleaning process was done in two steps:

- For yellow and green cab trips, the rows that have distances equal to 0 were deleted. This, because we are aiming to take into account only the trips that traveled some distance.
- For yellow and green cab trips, the IQR (Inter Quartile Range) methodology was used to clean the outliers from the data. A variable called "amount_per_distance" was created. It was calculated as the ratio between "total_amount" and "trip_distance". With this new variable, the values that did not show a common relationship between distance and values were deleted.
- When analyzing the data, we encountered that the columns precipitation, snowfall and snow_depth had missing values in the form of a "? ?" character. For each column, we found 237 (10.82%), 91 (4.15%), 24 (1.09%) empty values respectively. Considering that these variables are highly correlated with the average temperature, we decided to apply an iterative imputation with a decision tree regressor estimator to them.

Dataset	Initial	Deleted	Final
Uber trips	18676106	0	ss
Yellow cab trips	7926168	337998	7588770
Green cab trips	3537586	186494	3351092
MTA trips	7554197	0	ss
Weather	2190	0	2190

Table 1: Summary of the main information available to develop the project.

2.2 Feature Engineering

The following explains the different new features that were created.

- A new variable that measures the ratio between the total amount of the trip and the distance it traveled. This feature was created for Yellow trips and Green trips and was used for the outlier cleaning.
- "trips_pickup": this variable contains the total number of pick ups of all the transportation means (green cabs, yellow cabs, and UBER, NTA), for every NTA.
- "log_trips_pickup": the previous variable "trips_pickup" was transformed to log space for better visualization of the values.
- "yellow_indicator": A threshold was applied to the variable "log_trips_pickup". If the number of trips was $>$ threshold, then "yellow_indicator" is 0, otherwise 1. The threshold was defined as the 0.4 quantile of the variable "log_trips_pickup". This variable allow us to know in which NTAs, public transportation has not an adequate coverage, or in which ones public transportation is not commonly used. Both analyzed with the total number of trips per NTA.

3 Exploratory Data Analysis

What hypothesis tests and ad-hoc studies did you perform, and how did you interpret the results of these? What patterns did you notice, and how did you use these to make subsequent decisions?

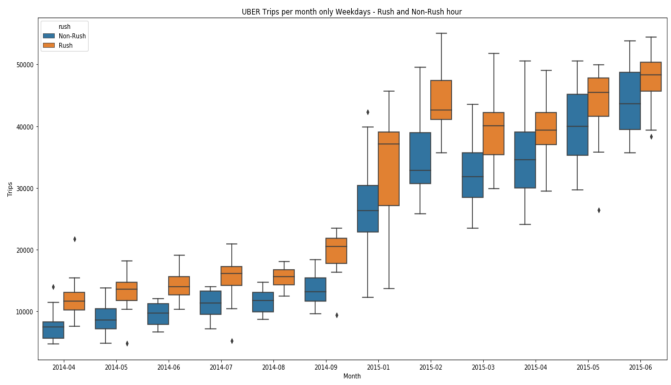
3.1 Hypothesis

During the data analysis we stated different hypothesis:

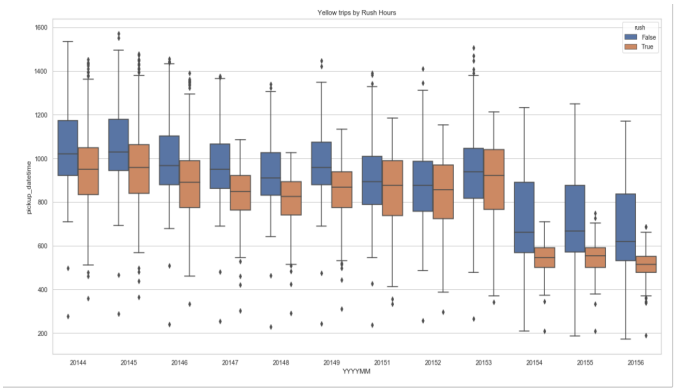
- **H1**: Due to UBER incursion in the city, the **travel distances** of yellow cabs trips increased.
- **H2**: Due to UBER incursion in the city, the **number of trips** of yellow cabs was reduced.
- **H3**: The areas of the city where there is **no public transportation** coverage, correspond to areas with **low income families**.
- **H4**: Due to UBER incursion in the city, the price of yellow cabs trips have decreased.

3.2 Data Exploration

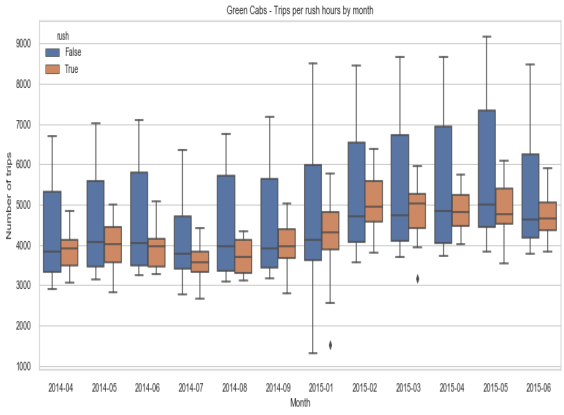
Different plots were created with the aim of understanding the behaviour of the different transportation systems. The following figures show some of the comparisons that were done, and shows the relationship of the plots with the previously mentioned hypothesis.



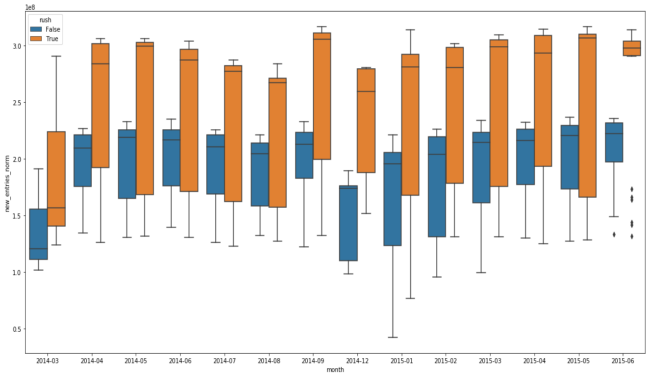
(a) Uber trips.



(b) Yellow cab trips



(c) Green cab trips



(d) MTA trips

Figure 1: Has the increase of Uber trips affected the number of trips of Yellow cab, Green cab, and MTA? Orange boxes represent the number of trips in rush hours and blue ones correspond to non-rush hours.

3.2.1 General Plots

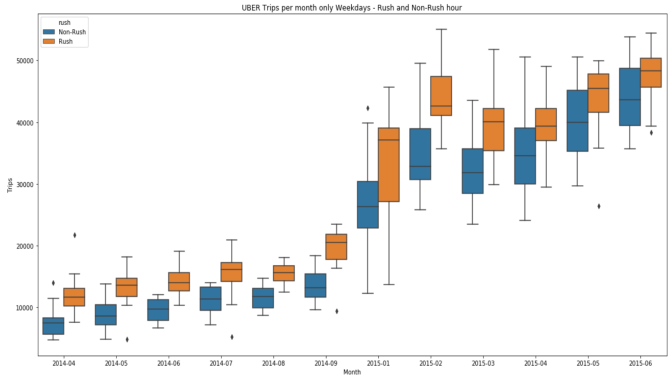
Figure 1 shows the boxplots of the monthly number of trips for the different transportation systems. Figure 5(a) for Uber's trips, Figure 6(a) for Yellow cab trips, Figure 6(b) for Green cab trips, and Figure 6(c) for MTA trips. The boxplots differentiate the trips between rush hours (orange boxes) and non-rush hours (blue boxes). From the figures, it can be seen that the MTA is busier in rush hours than in non-rush hours. Additionally, it is possible to see that there has been a significant increase of the number of trips taken by Uber from 2015 both in rush and non-rush hours; and a decrease on the number of trips taken by Yellow cabs, especially in rush hours. The latter corresponds to the ideas stated in hypothesis **H3**.

Figure 2 shows the same plot, but separating weekdays (blue boxes) from weekends. In the figure we can also see the previously mentioned behaviour: UBER trips increase and yellow trips tend to decrease.

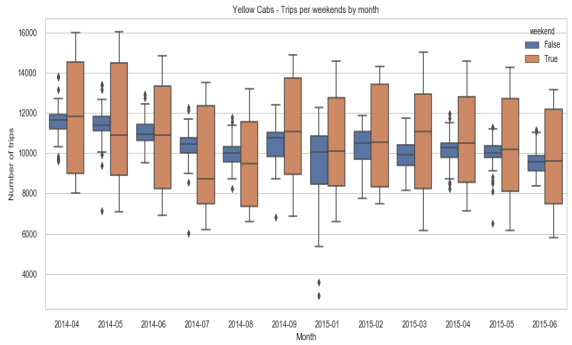
Additionally, Figure 3 was created to analyze if users prefer to use a specific service at a specific hour. We can see that pick ups are high when people are moving to work, i.e. 7 am (yellow, UBER, and green cabs have a high number of pick ups during that hour). Nevertheless, the highest number of pick ups occur between 6 and 7 pm, the time when many people go home or go out for fun. MTA, on the other hand, shows a different behaviour during the day, with different busy moments.

On the other hand to analyze Hypothesis **H4**, the plots of Figure 4 were created. Figure 4(a) and 4(c) proof what was mentioned in in Section 1.1, the price of a trip by Green cab is cheaper than by Yellow cabs. However, the plots show that the price of Green and Yellow cab trips have not reduced as we thought.

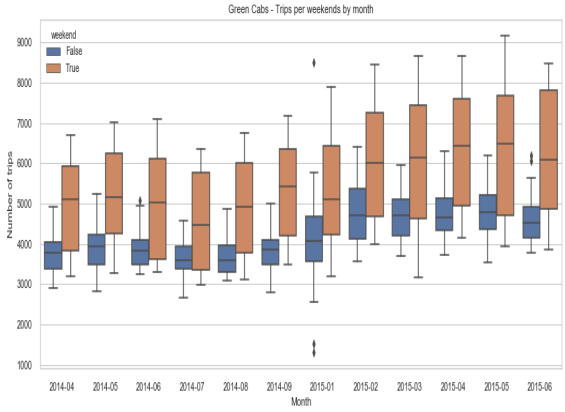
Figures 4(b) and 4(d) analyze the traveled distances of yellow and green cabs. The plots show that they have not vary significatively, as we stated in Hypothesis **H1**.



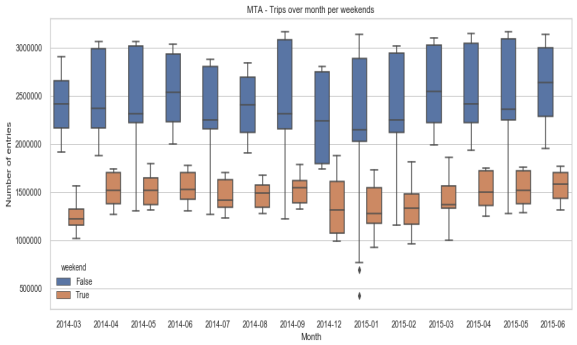
(a) Uber trips.



(b) Yellow cab trips

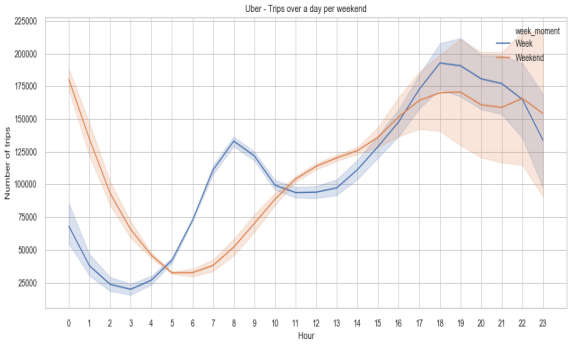


(c) Green cab trips

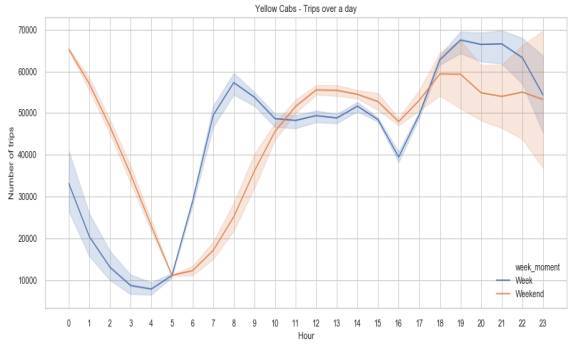


(d) MTA trips

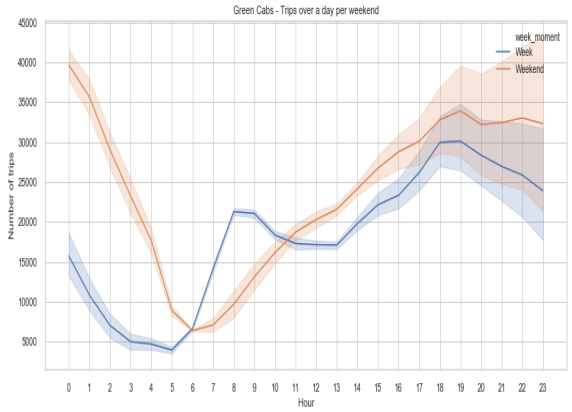
Figure 2: Has the increase of Uber trips affected the number of trips of Yellow cab, Green cab, and MTA? Orange boxes represent the number of trips in weekends and blue ones correspond to weekdays.



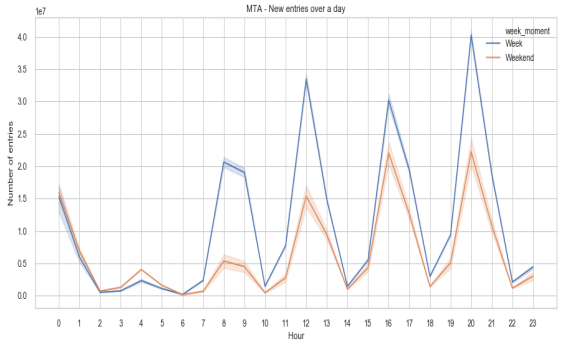
(a) Uber trips.



(b) Yellow cab trips

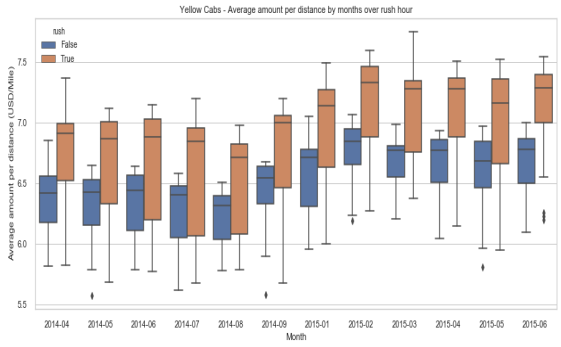


(c) Green cab trips

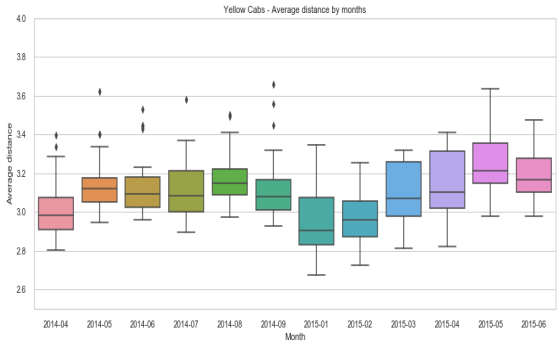


(d) MTA trips

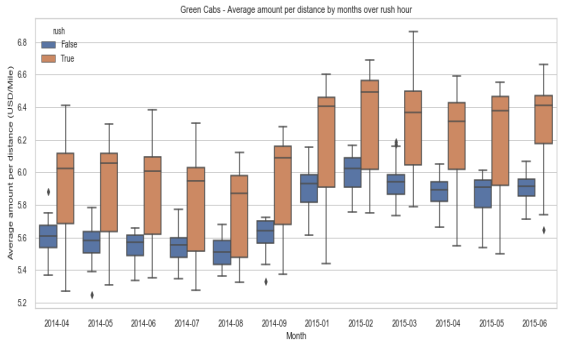
Figure 3: Behaviour of the number of trips per hour.



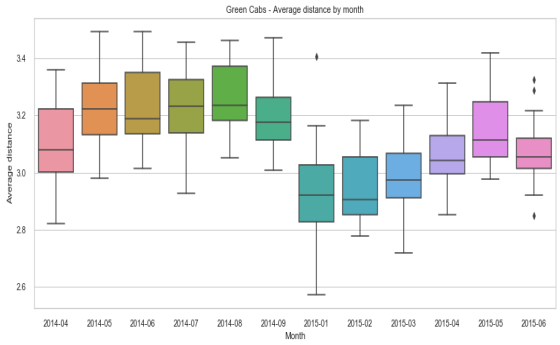
(a) Yellow cabs. Average price per distance (USD/mile)



(b) Yellow cabs. Average distance per month



(c) Green cabs. Average price per distance (USD/mile)



(d) Green cabs. Average distance per month

Figure 4: Distance analysis for Yellow and Green cabs. Images a and c shows the monthly average price per distance. Images b and d show the average distance per month.

3.2.2 Heat Maps

In this section different maps were created to analyze which areas of the city, in terms of NTAs, are the ones with less coverage; or what are the most common transportation choices of people, per NTA. Two different maps were created. The first one, Figure 5, shows the number of pick-ups and and the pickup zone, of the different transportation options. On the other hand, Figure 6, shows the number of drop-offs and the drop-off zones.

Table 2 shows the Links to access the interactive Heat Maps. The maps show the number of trips per NTA, in the different transportation options.

Figure Name	Link to Map
Trips NTA Green Dropoff Map	Link
Trips NTA MTA Dropoff Map	Link
Trips NTA Yellow Dropoff Map	Link
Trips Population NTA Green Map	Link
Trips Population NTA MTA Map	Link
Trips Population NTA Uber Map	Link
Trips Population NTA Yellow Map	Link
Total Pick Ups per NTA	Link
Total Drop Offs	Link
Pick Ups	Link
Drop Offs	Link

Table 2: Links to access interactive Heat Maps. The maps show the number of trips per NTA, in the different transportation options.

Figure 7 shows the location and the total number of pick ups and drop offs, of Green, Yellow, UBER (only pick up information was available) and MTA transportation means. The data is normalized by the population of each MTA. These maps start showing areas where public transportation is not widely used.

On the other hand, Figure 12 shows per NTA, which is the transportation option more used in the area. Analyzing the map that appears on the left (Pick ups), it can be seen that in the outer areas of the city, UBER is widely used. However, MTA is the prefer transportation option in most of the city. The latter coincides with what was found in Section 1.1: NYC is famous because people does not like to own a car, they prefer to use public transportation.

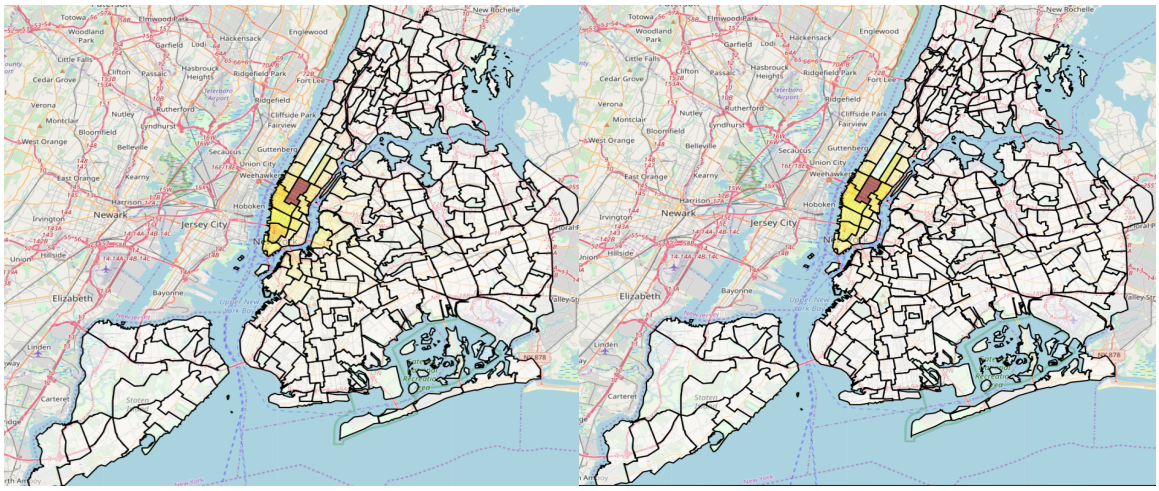
The right figure shows the drop off map. It is important to remember that there is no drop off information of UBER, and this is why in the outer areas, it is possible see that yellow and green cabs options are widely used. This map is different from what we expected. The reason is that according to the literature, Yellow cars do not like to move far from Manhattan. However, the map shows that they are moving far from it.

4 Statistical Analysis and Modeling

The Exploratory Data Analysis conducted in previous section, hypothesis **H2** was confirmed (Due to UBER incursion in the city, the **number of trips** of yellow cabs was reduced) , and hypothesis **H4** was rejected (Due to UBER incursion in the city, the price of yellow cabs trips have decreased).

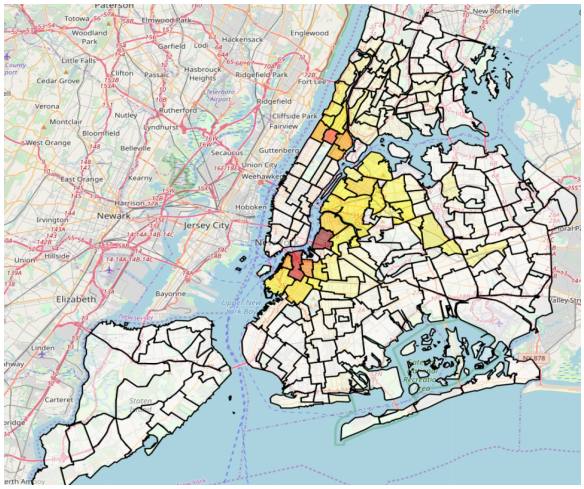
In this section we will conduct a statistical analysis to hypothesis 1 **H1** (due to UBER incursion in the city, the **travel distances** of yellow cabs trips increased), and we will provide more details to answer hypothesis 3 **H3** (The areas of the city where there is **no public transportation** coverage, correspond to areas with **low income families**).

The notebooks used to conduct the analysis can be found in the following link: Link

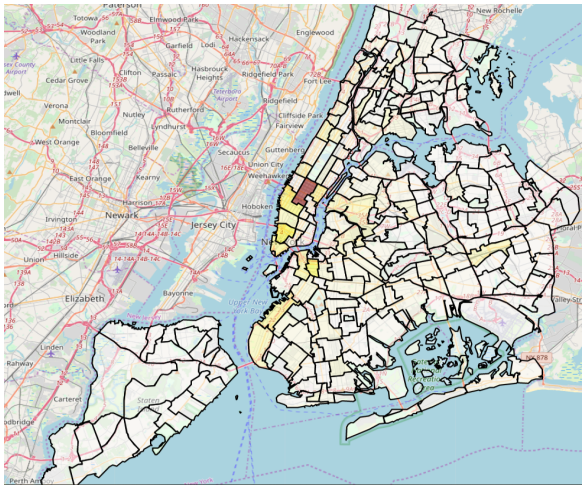


(a) Uber.

(b) Yellow cab

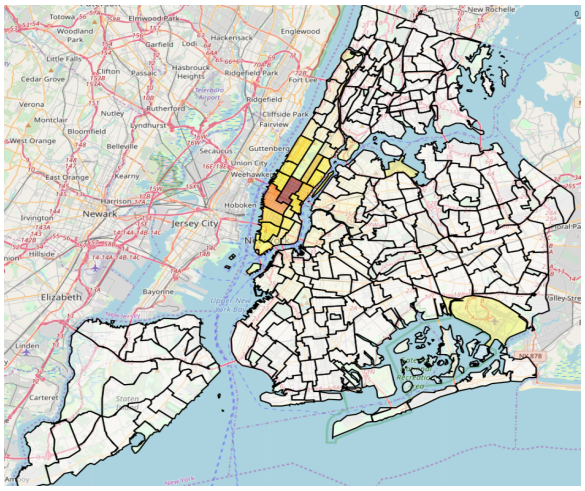


(c) Green cab

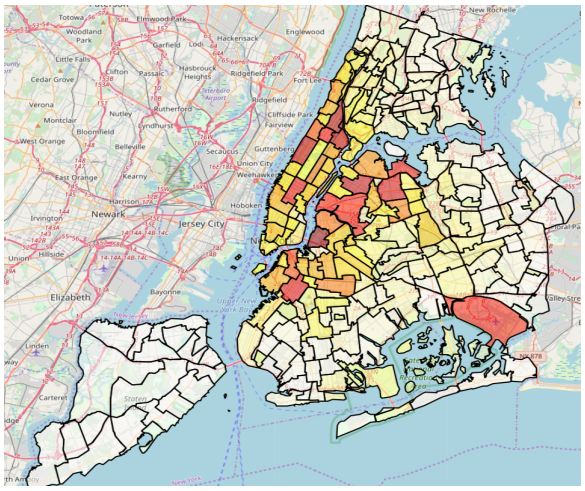


(d) MTA

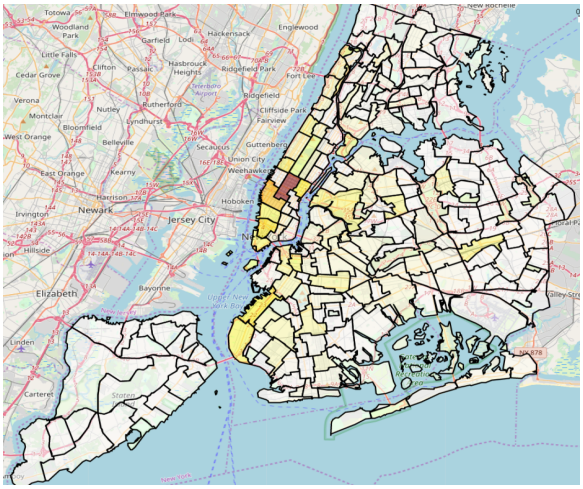
Figure 5: Heat maps of Pick Ups. The maps show the number of trips per NTA, in the different transportation options. The data has been normalized by the NTA population.



(a) Yellow cab trips

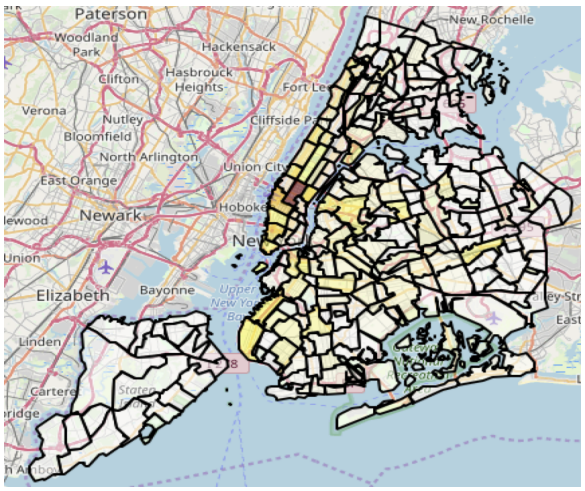


(b) Green cab trips

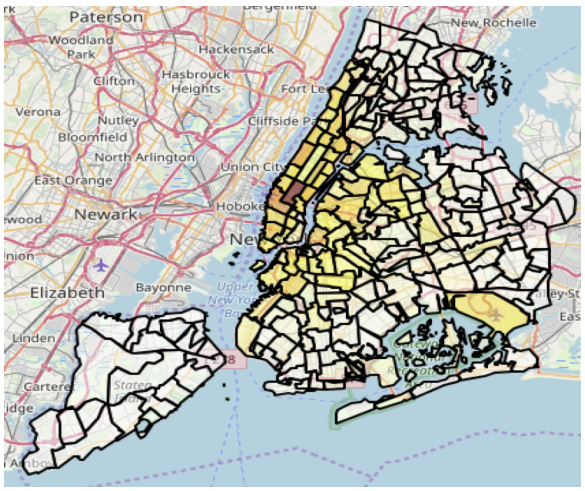


(c) MTA trips

Figure 6: Heat maps of Drop offs. The maps show the number of trips per NTA, in the different transportation options.



(a) Total Pick Ups per NTA



(b) Total Drop Offs

Figure 7: Analyzing the total number of Pick Ups and Drop Off of all the transportation options.

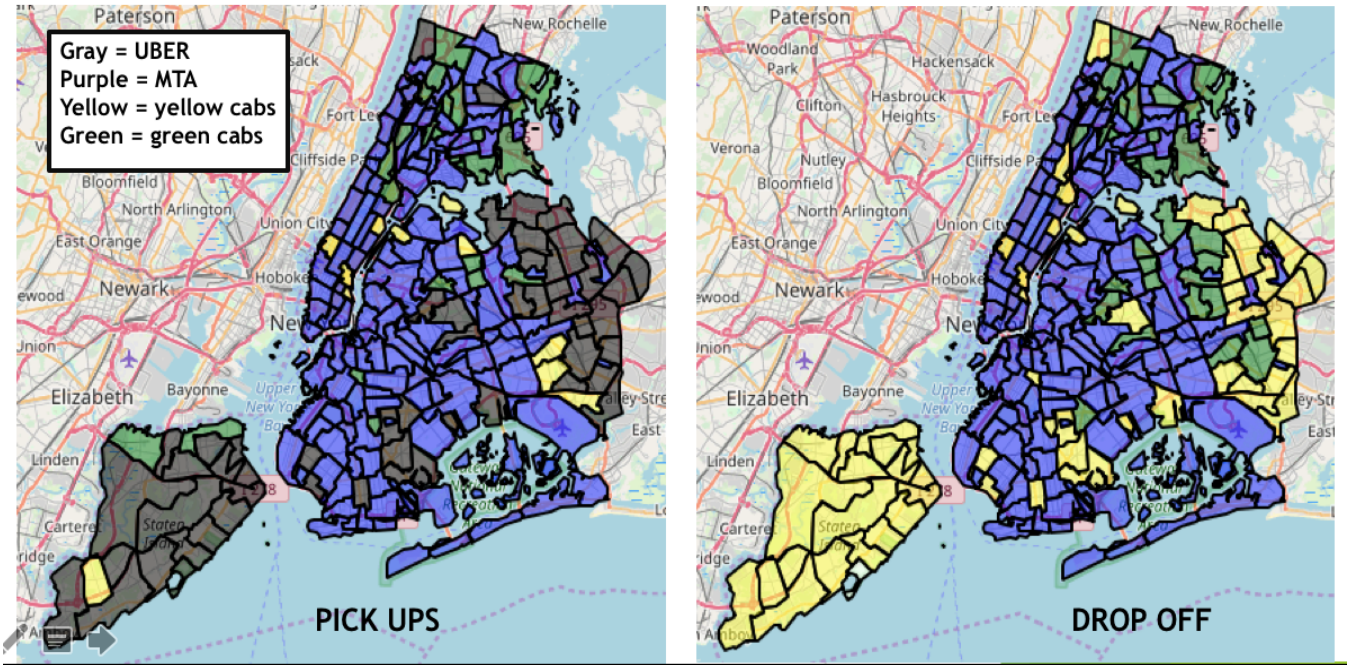


Figure 8: Most frequently transportation mean per NTA. The maps show the number of trips per NTA, in the different transportation options.

4.1 Analysis of Hypothesis 1 H1. Due to UBER incursion in the city, the travel distances of yellow cabs trips increased

We conducted a ttest between the distance of the trips that took place between 2014-04 and 2014-06. The null hypothesis that is tested is that there is no change in the mean distance in both periods.

Hypothesis Testing	P-Value
Green Cabs rush	0.0
Green Cabs weekends	0.0
Green Cabs	0.0078

Table 3: ttest Green cabs.

From Table 3, we can conclude that the null hypothesis is rejected.

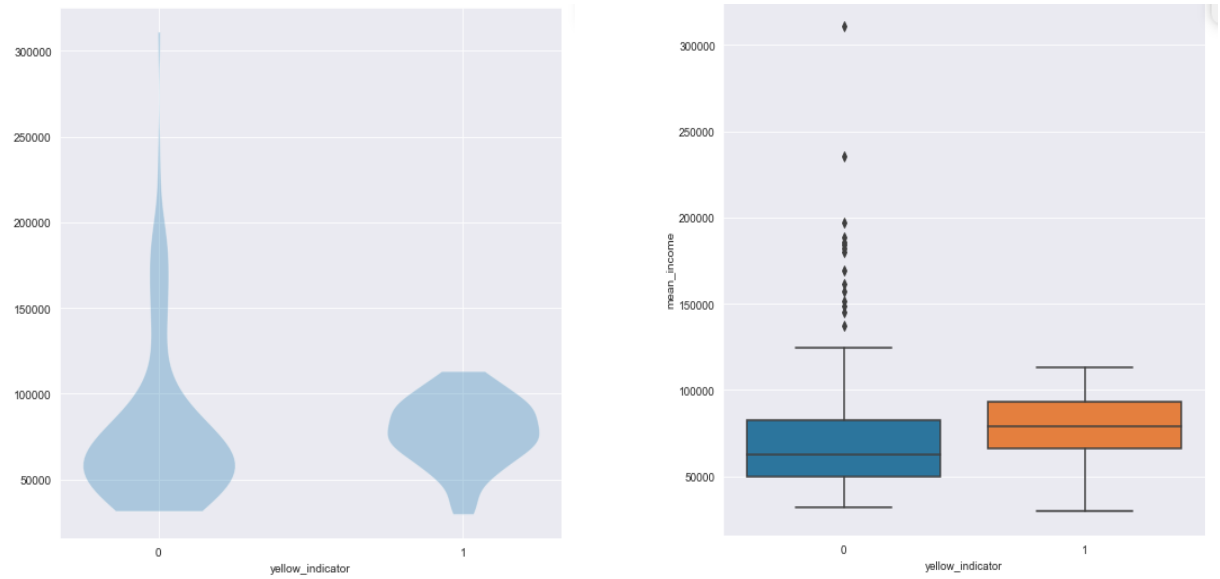
Hypothesis Testing	P-Value
Yellow Cabs weekends/weekday	0.181
Yellow Cabs rush-non rush-non	0.905

Table 4: ttest Yellow cabs.

From Table 4, we can conclude that we fail to reject the null hypothesis. There is no enough statistical evidence to assert that the distance of the trips that took place between 2014-04 and 2014-06 is DIFFERENT from the ones between 2015-04 and 2015-06.

4.2 Analysis of Hypothesis 3 H3 The areas of the city where there is no public transportation coverage, correspond to areas with low income families

The maps created in Section 3.2.2 provided a clue of the behaviour in each NTA of the different analyzed trasnportation options. The variable "yellow_indicator" was created. It allows us to know in which NTAs, public transportation has not an adequate coverage, or in which ones public transportation is not commonly used. Both



(a) Violin plot

(b) Box plot

Figure 9: Analyzing Mean income between NTAs that frequently use public transportation (yellow indicator = 0) vs. the ones that do not frequently use it (yellow indicator = 1)

analyzed with the total number of trips per NTA. Details of how this variable was created are provided in Section 2.2.

With the variable "yellow_indicator" defined per NTA (1 if not many trips started in that NTA, otherwise 0), demographic information was analyzed to know if there is a pattern in the income of the people that live in those areas.

Figure 9 shows the violin and box plots of the mean income vs the indicator of used of public transportation. From the plots we can see that most of the people that do not frequently use public transportation, do correspond to people with high incomes. Both plots show that we have some outliers in the data, that could lead to miss-interpretation of the information. In the areas where people use public transportation more frequently, live people with very high incomes.

Excluding people with very high incomes from the analysis, we can reject the stated hypothesis. Digging into more details, we found that the people with the highest rent live in Manhattan, which correspond to one of the areas where public transportation is commonly used.

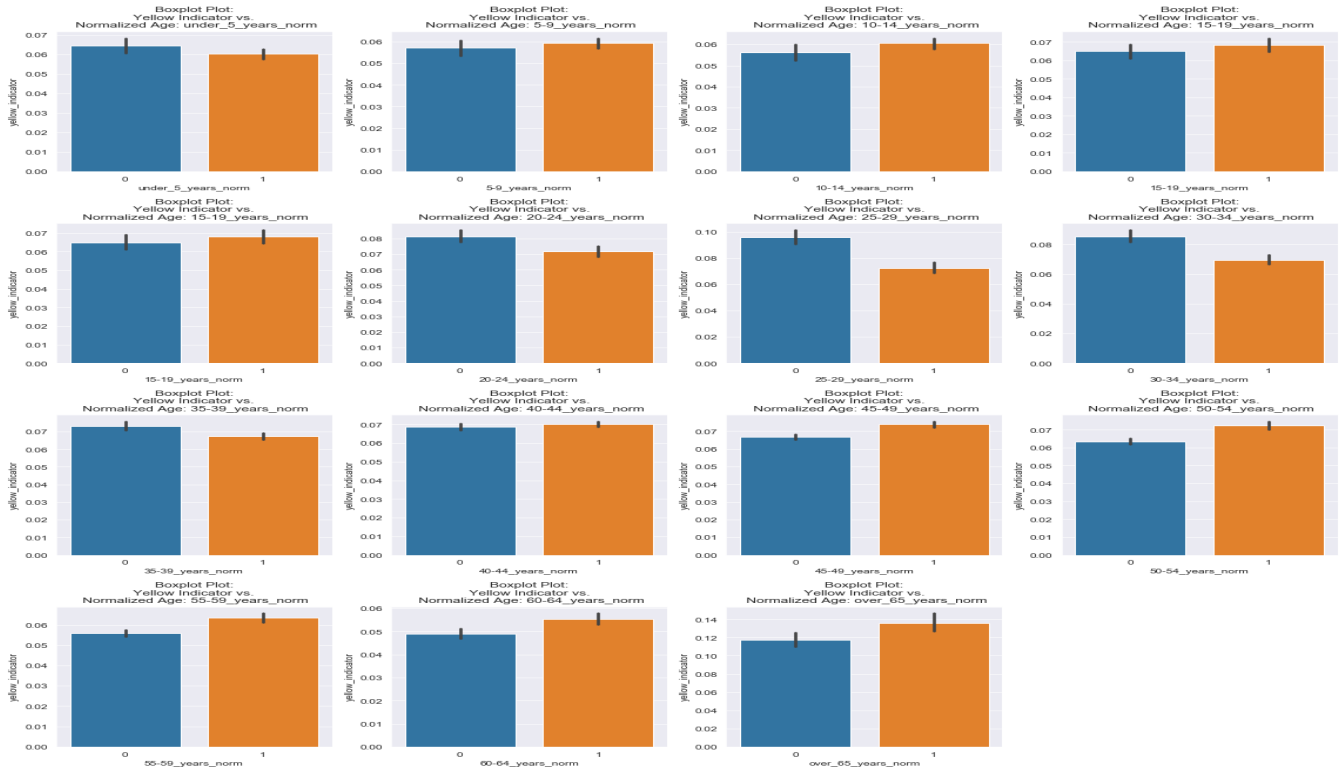
Finally, Figure 10 shows the comparison between the different age ranges and income ranges of the NTAs that have a yellow_indicator = 0 and yellow_indicator = 1. From the figure we can see the following pattern of people that live in the NTAs with yellow indicator = 1 :

- Most of the people that live in those areas are adults over 40 years old, some families with children.
- Most of them with higher incomes (50000 < incomes < 200.000 USD) than the ones that live in the zones with yellow_indicator = 0. Excluding the ones with incomes > 200.000

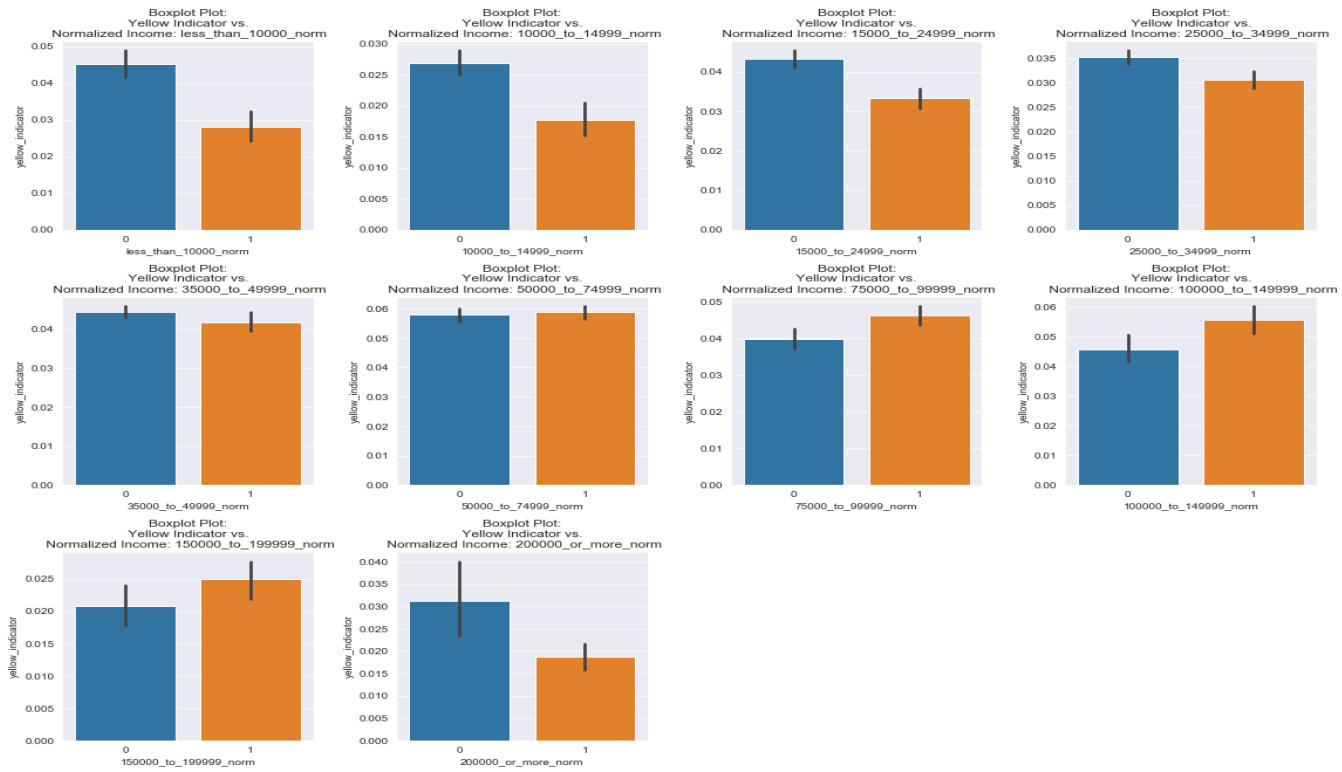
4.3 Model fitting

We fit a model a random forest to predict the Yellow Indicator, based on some demographic information. The idea was to be able to create a model trained with data from 2014 and 2015 that could be used to create a new map projected in 2019. The latter with the aim of analyzing if **no changes** are done in terms of mobility, and population grows and demographic information changes, how do those changes affect the coverage.

The model was created with the following variables. The dependent variable is the yellow_indicator. The independent variables the different age ranges (normalized by population), and the different income ranges (normalized by population). The data was split 70% for training and 30% for testing. We obtain an 87.72% of accuracy and



(a) Distribution of age between the NTAs with yellow_indicator = 0 and yellow_indicator = 1



(b) Distribution of income between the NTAs with yellow_indicator = 0 and yellow_indicator = 1

Figure 10: Analyzing the behaviour of age and income between the the NTAs with yellow_indicator = 0 and yellow_indicator = 1

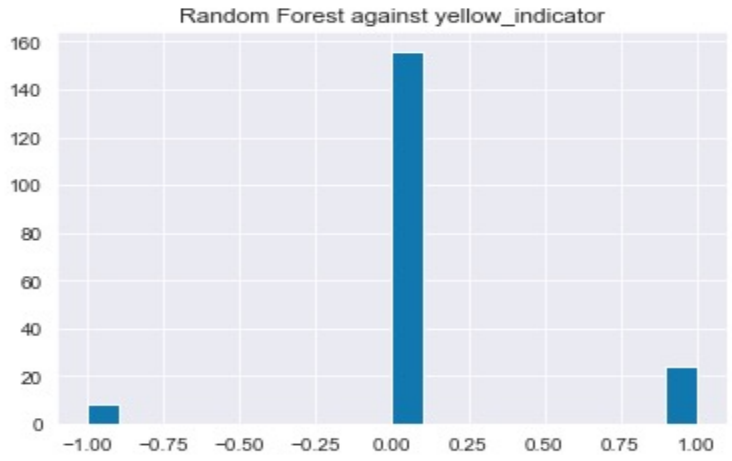


Figure 11: Random forest predictions for the yellow_indicator. The plot shows the differences between the real values and the predicted ones.

82.35% of precision. Figure 11 shows a histogram of the results with the test set. The histogram was created plotting the differences between the real values and the predicted ones.

5 Results Interpretation and Conclusions

5.1 Key Findings

One of the main findings we wanted to reveal is the UNSEEN MAP of New York. Figure 12 shows the map. The colors of the map reveal the meaning of the yellow_indicator. The NTAs in red correspond to those where the log scale of the number of pick ups was higher than a threshold (including UBER, Yellow cabs, Green cabs, and MTA entrance). The NTAs in yellow, correspond to those where the number of pick ups is zero or smaller than a threshold.

The maps reveal:

- Possible areas unattended by different transportation means (yellow areas).
- An idea of people's mobility choices, depending on where they live. Red areas correspond to the ones that frequently use public transportation. Yellow areas correspond to the ones that use other options, either because they want or because they do not have other options.

From the Exploratory Data Analysis that was conducted and some statistical analysis we can conclude that:

- New York City has a lot to do in terms of mobility, especially for people that live in the outer NTAs.
- People that live in the yellow areas have good incomes. So we could conclude that they use other transportation means such as their own car for long distance trips, or bikes, scooters, or even walk for short distances
- Uber is one of the services that is attending the outer NTAs. However, not with a very high demand yet.
- The average distance of Green cabs have reduced from 2014 to 2015.
- The number of Uber trips are increasing and It looks to affect the number o trips made by Yellow and Green cabs.

All the notebooks with the code used to generate this report can be found in the following Link

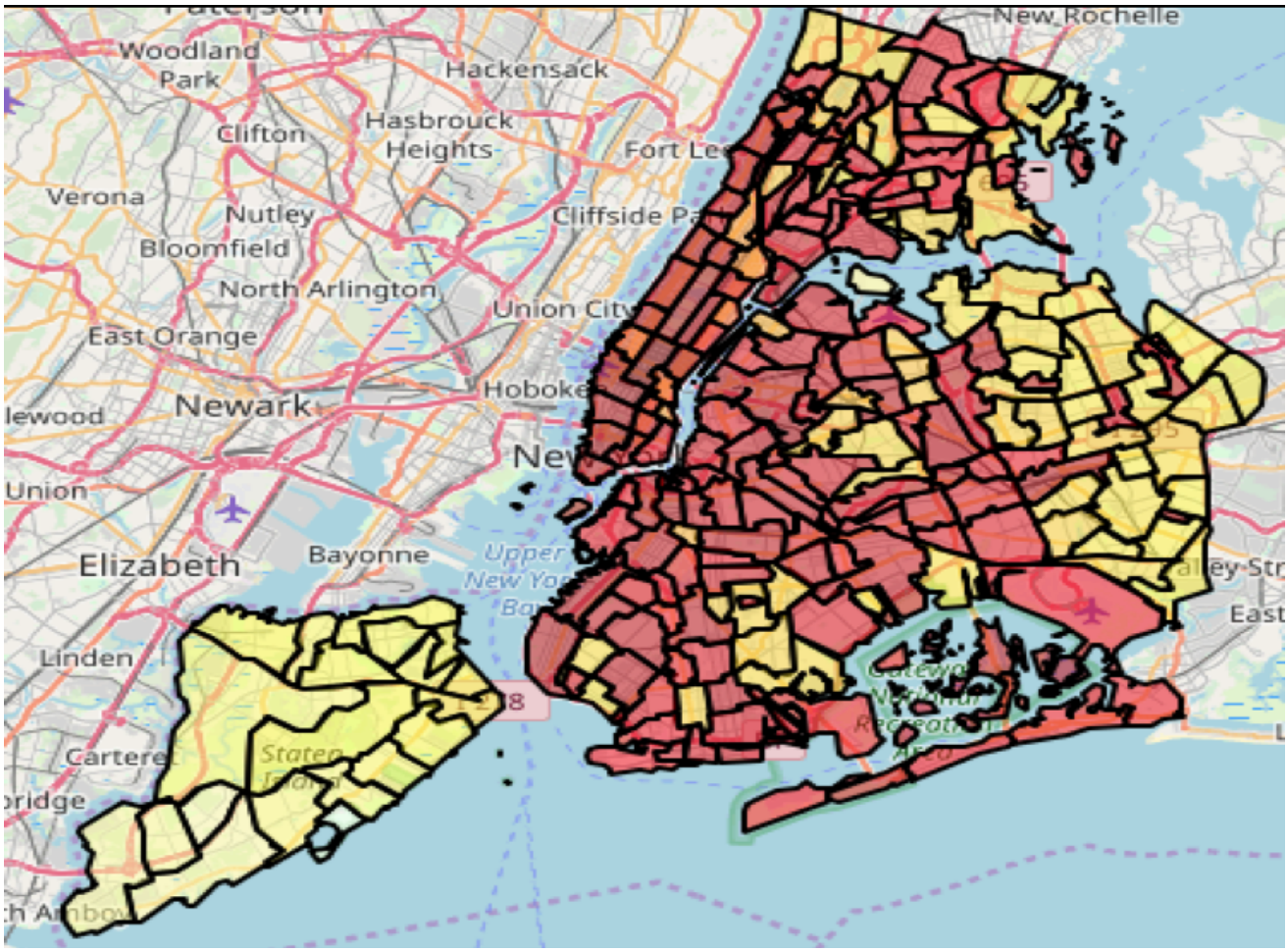


Figure 12: The UNSEEN Map of New York. The NTAs in red correspond to those where the log scale of the number of pick ups was higher than a threshold (including UBER, Yellow cabs, Green cabs, and MTA entrance)

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