The New York Subway System Public Safety and Improvement Metrics

Final Project Submission

Group Number: 3

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Executive Summary

To: **Janno Lieber**, Chair and CEO of the Metropolitan Transportation Authority (MTA)
From: Research Analysts Department, Metropolitan Transportation Authority

Restoring Rider Confidence in the New York City Subway System by Reducing Crime Rates by Studying Cameras and Warning Signs

With the recent surge in riders re-starting their use of the New York City Subway system, the transportation system is seeing rampant crime rates regardless of rider rates still being below the pre-pandemic era. We must develop a study to reduce the crime rate and test it through an experimental design as soon as possible. This effort carried out by an analytics team will benefit the Metropolitan Transportation Authority by restoring confidence in the subway system if the plan reduces crime rates.

This study aims to test the difference in mean crime rates when adding cameras across subway cars versus when adding warning signs to the cameras stating that recording is in progress.

The research design for this study will be purely experimental and will last three years, starting in 2024 and running through 2026. Following the recent MTA's decision to install cameras across all subways cars, we can test if this administrative decision will reduce crime rates by evaluating the crime rates across 300 train trips. We will then add warning signs in the subway cars and stations that visualize the presence of cameras in the area, and mention that all activity will be stored and used for persecution if any crime occurs. We will follow by evaluating the rates reported for 300 trips and compare the mean crime rates for the two groups to understand if adding cameras with warning signs is more effective in reducing crime rates than just adding cameras across subway cars.

We need to implement this study as soon as all cameras on subway cars are installed to test if they are successful and if warning signs will play a more significant role in reducing crime rates and, thus, restore rider confidence in the New York City Subway.

Statement of The Problem

The New York City Subway is a vital component of the city that keeps the city and its neighboring boroughs running 24 hours a day, 7 days a week. The subway has become home to thousands of homeless people, and this has caused much insecurity since then, especially during the night hours. Although some people in the homeless community innocently seek shelter, various groups are dedicated to robbing people in these subways. This has caused much resilience from the public to drive the homeless people out of the subway lines. According to Newman (2022), Mayor Eric Adams and Kathy Hochul, the governor, announced an aggressive plan that has been put in place to deploy law enforcement and mental-health workers in the New York Subway that is dedicated to driving away over 1,000 homeless people who shelter in the subway lines as a measure of ensuring that different vices like theft, harassment, and other forms of violence are reduced. The subway system transports an average of approximately three million people a day (MTA, 2022); its proper functioning is vital to the population of New York and to the development of the state as well. While the transport system's efficiency is of great importance to its users, another aspect has begun to deter use of the subway and makes others question their use of the subway system, no matter how efficient the system is: safety. In a recent article published by Ali Watkins in the New York Times called "Along a Subway Line's 31 Miles, Nagging Crime Fears Test Riders' Resolve," a number of New York City subway riders were asked their opinion on how safe they were as they rode on the A-line train across Manhattan. Watkins received comments such as "I don't feel safe on the trains," "There definitely is less civility," and noted that many users continued to ride the subway out of necessity (Watkins, 2022). While crime has always been a regular within the New York City subway, what makes it stand out today is "the number of crimes taking place within the transit system is roughly the same as in 2019, according to police statistics, even though the subway is seeing only around 60 percent of its 2019 ridership." (Watkins, 2022).

In the published article, author David Meyer reports that farebating rates in the subway system have surged by a two-fold since before 2020 to approximately 12% in the subway system (Meyer, 2022).

As riding the subway train is a necessity for the majority of its users, regardless of the discomfort of using the system, confidence in the system is essential for its healthy upkeep and continued success. A safe, comfortable experience onboard the New York City subway system can increase confidence in the Metropolitan Transport Authority and thus lead to an increase in the use of all its services, especially the subway system. The question is, how can crimes be prevented in the subway system?

Research Questions and Hypotheses, and Effects

The New York Subway is a significant example of proper transportation, efficient land use, and resources for future development and networking. There is an obvious truth that the decentralized population in New York City started to become uncontrollable during the urbanization of the city. Therefore, it was necessary to create different means of transportation and networking to connect different areas around the city without causing much congestion. In 2021, the MTA installed security cameras at all 472 subway stations. It did a job in reducing crime rates, but still, passengers' fears haven't gone away completely. This year, an important program, the Urban Area

Security Initiative Federal Grant Program, has become an important initiative that will fund and oversee the installation of security cameras in nearly 6400 subway cars across the entire Metro system. Because the MTA does not intend to monitor these cameras in real time, they will only serve as crime recording devices. As a result, its ability to prevent crime is limited.

Our first research question is: Will installing more cameras in the subway cars reduce crime? The MTA is betting on this strategy to aid in the highly-publicized surge of crime in their subway system. We will test if their strategy is successful or not in accomplishing the goal.

Our second research question is: will posting warning signs in stations and cars reduce crime? (such as: WARNING! ALL ACTIVITIES ARE RECORDED TO ASSIST IN THE PROSECUTION OF ANY CRIME COMMITTED AGAINST THIS FACILITY.) And camera signs have been very effective in reducing crime in other environments like private properties, restaurants, and schools. We believe that these signs can also be effective on trains.

The meaningful effect size that would result from deciding to add warning signs to all areas in the subway system that have cameras would have to be a reduction in crime rates by a mean of 0.45 for this method. Assuming the significance level of 0.05, a reduction in crime rates by 0.45 would reject the null hypothesis for this experiment, thus adding warning signs to the areas with cameras does provide a solution to reducing crime rates across the New York City Subway.

Importance of the Study and Social Impact

First of all, our hypothesis, if established, can improve the efficiency of urban traffic. Killings in the New York City subway system since 2020 have skyrocketed to the highest annual levels in 25 years, even amid plummeting ridership numbers, as the city grapples with an overall spike in random violence, NYPD data show(David, Craig, Gabrielle, 2022). Lieber acknowledged that fare evaders are the cause of unease for subway riders as "People who commit robberies and violent crimes generally don’t bother with MetroCard swipes or OMNY [contactless] taps," (Meyer, 2022). This shows that the crime rate in Metro has increased significantly. It will be followed by a large number of shocking cases, which may make more people afraid to choose Metro and choose other public transportation. This will cause a lot of pressure on other public transport, which will cause the traffic system to be paralyzed during peak hours. It would be disastrous for New York City because of its huge population. If our hypothesis holds, the number of people using Metro could increase, which would relieve traffic pressure. So that people's travel becomes more efficient.

Second, our hypothesis may also increase government revenue. In April 2022, the MTA CEO, Janno Lieber, linked the crimes that occur within the subway system to riders who evade fares at the payment stations (Meyer, 2022). The cost of fare-evaders jumping the subway system’s turnstile does not only have a social cost, but it also costs the MTA a roaring $500 million (Meyer, 2022). When we install more cameras and warning signs, this can further monitor the behavior of passengers paying when entering the subway station.

Literature Review

The subway connects millions of people who use transit to go to their jobs, homes, and other places every day. Therefore, ensuring that there is enough security in the subway is something that needs to be highly considered.

Some research by Herrmann (2021) shows that there is a need for better policing and prosecution practices that are aimed at reducing crime rates in the subway. The program will be effective since law enforcement cannot be everywhere, and it is also unpredictable to know where a crime can occur at an exact time and place. Hence, these various cameras will act as the eyes of law enforcement and will be monitored in various control rooms situated in the city. Therefore, statistics presented by Schuilenburg (2021) show that better practices can assist in preventing crime in the subway. Since March 2018, there have been 18 people murdered on the subway lines, and the post-COVID transit crime rates have been rampant.

Therefore, law enforcement is stepping up its initiatives to ensure that most crimes are avoidable and people can gain confidence and courage in using the subway lines. Other researchers like Dragan et al. (2020) have claimed that the NYPD department is stepping up, and people will continue to see the increased presence of officers in subway vehicles not only in high-priority stations but at every post that the subway lines connect. There will be different officers deployed in the transit system and specific mandates to enforce different MTA and NYCTA rules of conduct.

Some resources will be put in place to ensure the security issue is addressed in the subway. City officials have planned to deploy over thirty inter-agency collaborative security teams that bring together other organizations like the Department of Homeless Services (DHS), the Department of Health and Mental Hygiene (DOHMH), and the New York City Police Department (NYPD). These different bodies have planned to work together and focus their efforts on the subway to ensure that different issues are addressed. For example, the DHS will handle homeless groups, the DOHMH will address any health hazards in the subway, and the NYPD will ensure tightened security, like installing more cameras in different places in the subway. This vital research is crucial in establishing the treatment and control groups and creating the research plan.

Research Plan

- Population of Interest: The population of interest includes the people of New York, and with the help of various research journals, it is important to see their views on the current level of security in subway lines. Furthermore, the most affected population by the issue are the people who use the subway lines to transit from one place to another, either to their workplaces, homes, or other places across the city.
- Sample Selection: Because there are many other interfering factors, we choose the random sampling method and use the entire New York subway line as the population. In this way, the influence of other factors can be avoided as much as possible. The sample size is 900 subway different trips, randomly selected to represent the environment of the entire subway system. ***A trip is considered an operation from a beginning terminal (North) to an ending terminal (South)***, or vice-versa. 300 of them were set as the control group. There will be no cameras or signage installed in the cabin. The rest were divided into two experimental groups of 300 different trips.

One group is composed of trains installed only with cameras. Another group with the already installed cameras and warning signs inside the car.

- Operational Procedures: All subway cars and lines in the MTA system count as one. Each group was then randomly assigned 300 different trips. Control group does not change any conditions. Treatment group 1 are the trips with subway cars with the newly-installed cameras. Treatment group 2 are trips with subway cars that contain the existing cameras and newly-installed warning signs. This forms a control group and two experimental groups. Cameras will be recorded but will not be viewed in live-time, according to MTA officials (Ley, 2022). The cameras will only be used as a tool to identify a crime once it is reported to the MTA and NYPD. Ultimately, the effectiveness of our program is based on the proper reporting and filing of the NYPD for each crime that occurs.
- Brief Schedule:
  - December 31, 2024: Compile the average crime rate that occurred on the subway system for the year to use as a control group.
  - January 1, 2025: All subways across the New York City Subway system will have cameras enabled by this date according to the MTA. Research question number one study is kicked-off.
  - January 1, 2025 - December 31, 2025 at 12:00 AM: All official crimes reported to the MTA/NYPD will be recorded on our tracking system.
  - December 31, 2025: Research on question number one study is finalized.
  - January 2026: Installation of warning signs in all areas and subways where a camera is recording.
  - February 1, 2026: Research question number two study is kicked-off.
  - February 1, 2026 - January 31, 2027 at 12:00 AM: All official crimes reported to the MTA/NYPD will be recorded on our tracking system.
  - January 1, 2027: Research on question number two is finalized, which concludes the study.
- Data Collection: Data collection is also an important factor in the research since some methods like interviews and focus group observational methods will be used in the research to determine the exact metrics of crime rates in New York, specifically, the subway lines. At the same time, we will also consult with NYPD about the Metro-related alarm rate within the experimental period. A survey will also be set up to see if there has been a change in people's confidence in Metro. In addition, the collected data will aid in the identification of the best plans to be implemented in order to increase the level of security on the New York subway lines.
- Data Security: During the experiment, the obtained data needs to be digitally encrypted. And only relevant personnel have permission to unlock secondary data. And every time the relevant personnel unlock and analyze the data, there needs to be a video record to prevent the staff from conducting improper analysis. Because we need to extract the alarm information of NYPD, we also need to supervise when we extract the information of NYPD. Most of our data information is video information and identity information, so we need to delete the data (except the NYPD part) after our experiment is over.
- Variables：

1. Outcomes (Dependent Variables): The dependent variable is the crime rate data. Because we don't know who will commit the crime, we can't pinpoint every participant. Therefore, we will compare the data of the control group and the two experimental groups based on observations and NYPD alert information.
2. Treatments (Independent Variables): The independent variable is the installing of cameras and installing warning signs in the subway cars. This allows people entering the subway to see that the subway is in an area covered by cameras. Anyone who breaks the law will be held accountable. We hypothesized that doing so would reduce crime in the subway, as those potential criminals would be aware that their actions were being recorded.
3. Other Variables:Other variables may be that the government and NYPD are also implementing some measures to reduce the crime rate (such as increasing the police force). And different lines and areas may also have different crime situations.

Statistical Analysis Plan

When the experiment is over, we will conduct a 2 sample t-test on the collected data to detect its correlation. And we will analyze our final results based on the obtained t-value and p-value. A linear regression model is then built based on the data. Then an additional 300 different trips were randomly selected. And use the previously obtained model to predict the 300 different trips (installing cameras and posting warnings are 150 different trips respectively). Then cameras were installed on 150 different trips vehicles, and warning signs were posted on the other 150 different trips vehicles. Finally record real data. And use the chi-square test to test the accuracy of our model.

Sample Size and Statistical Power

The New York City Subway system has 25 different routes, each one operating from North terminal to a South terminal, and vice-versa once the trip is completed. A total of **300** different trips will be selected at random across the network's system to test for each group for every research question.

Considering a standard deviation of 2, alpha set at 0.05, and a 95th percentile of the standard Normal Distribution at 1.645 we know we can reject the null hypothesis if the mean crime rate after conducting the study is over 0.1899483. With these numbers in mind, statistical power for a sample size of 300 is at **98.78%**.

A minimum sample size of **101** different trips need to be collected for each group in each research question assuming the assumptions stated before and an effect size of 0.45.

Possible Recommendations

Here are some suggestions for our questions:

a) Null hypothesis is not rejected: We should start by reviewing our experimental design and implementation process, thus, check for experimental bias. Experimental results may vary greatly due to experimental bias. If there is no problem with the experimental design and implementation process, it proves that installing cameras and posting warning signs will not reduce the crime rate. We recommend adding more police force on stations and cars. A new gate system with stricter entrances and exits should be considered, incorporating facial technology scans when going through them These methods may reduce fare evasion behavior, thereby reducing the crime rate.

b) Null hypothesis is rejected and alternative hypothesis 1 is accepted: which shows that our hypothesis is successful. Then we need to verify the accuracy of our experiments through statistical methods. If the accuracy is not statistically high, then the experimental design and experimental procedures need to be checked. If the statistical level is high enough, the program was successful and it should be maintained throughout its lifespan emphasizing on its continued use to keep crime rates down. Comparative experiments should be carried out to test the ratio of the number of cameras installed and the reduction in crime rate in later periods.

c) Null hypothesis is rejected and alternative hypothesis 2 is accepted: It shows that our hypothesis is successful. Then we need to use statistical methods to verify the accuracy of our experiments. If the accuracy is not statistically high, the experimental design and experimental procedures need to be checked. If the statistical level is high enough, the program should be maintained and budgeting should go towards the new warning signs for their continued public display. The positions of the warning signs should be studied through an experiment later in the period to identify if and which positions reduce crime rate the most.

It may also be determined based on statistical data which is more effective to install: cameras or post warning signs. These two independent variables can be proportionally distributed in subsequent implementations.

Limitations and Uncertainties

This project does not compare how many cameras need to be installed and how many warnings are posted to achieve the maximum crime reduction threshold. There are no two identical subway lines, and crime in a subway line is related to operating area, capacity, day of the week, time of the day, season of the year, and even depends on the crime-level happening on the streets above. We are conscious about the varying factors in the study; thus, when selecting samples, we will conduct simple random sampling in an effort to produce identically distributed data. We also have to consider that the NYPD and the local government might be undertaking other initiatives to reduce the crime rate in the subway system while our study is conducted. It is imperative that we are up to date with local police and government efforts to mitigate confounding errors in our results, and that we can account for them.

SIMULATED EXPERIMENT

Introduction

In order to provide an indication of what might be obtained from the actual research conducted. We created a simulated experiment here, to generate the data set and used the techniques proposed earlier for the analysis. We considered two scenarios in the simulation for each hypothesis with or without effect. As the first hypothesis, the null hypothesis conjectures a propre regulatory policy will effectively reduce crime. To reject it, expectation for the treatment group mean crime rate will be over 0.1899483 with standard deviation of 2 and alpha is 0.05. Thus, no significant evidence supports those corresponding policies that can reduce crime in the subway system area. Hence, the government should renounce such policy to avoid wasting resources. Otherwise, if fail to reject the null hypothesis, then the crime rate will fall into the 95% of interval. Thus, strong evidence is provided, proper regulations are effectively reducing the crime. As the second hypothesis, the null conjectures labeling warning with more cameras stalling could possibly be more effective. For successfully reject the hypothesis, the warning label could be renounced, and the same efficiency is provided. Otherwise, proper warning labels would increase the efficiency of reducing crime.

In the simulation experiment, as we planned, we randomly created 900 trips to approach the effective sample size, and then split into two treatment groups and one control group. In order to predict and simulate the veritable data set that can be collected, we considered very carefully and identified the specific observations and data types. Each of all 900 trips will be identified through the entire experiment. For each trip, we will record their line service number, date of the day, whether it’s express or not, how many stops for one trip, passenger volume, and their crime report count.

At the end, we repeated 1000 simulations. Based on those 1000 simulations, estimated the results at 95% confidence interval. We also calculated the percentage of false positives in each scenario corresponding to each study question.

Description of Simulated Data

The simulated data consists of 900 observations(trips) and 7 variables. 900 observations are divided equally into 3 groups with 300 each (control, treatment1 and treatment 2). Variables consists of group label, train_id, line, month, date, day and crime_reported. (Figure 1).

Variable settings

- The group variable is used to label trains as different groups.
- The train_id variable identifies the trains so that crime reports can be matched to each train.
- The month, date variables are used to make sure our samples are equally spread among each year.
- The day variable is used to make sure our experiment samples represent the entire MTA subway system. According to the MTA website, in 2022,16.58% ridership occurred on Monday, 18.25% on Tuesday, 18.11% on Wednesday,

18.99% on Thursday, 10.45% on Friday, 10.14% on Saturday, and 7.48% on Sunday. (MTA, 2022)

- The line variable is also used to make sure our experiment samples represent the entire MTA subway system. There's currently no ridership data per line we could find and it is beyond our study to observe. To make sure the simulation represents the MTA subway system better, we used the station ridership ranking data to slightly tilt line distribution. The lines that pass the top 10 ranked stations (MTA, 2020) are slightly weighted more.
- The crime reported variable is used to record crimes reported related to each sample. In the simulation, this set of data is generated based on real cases that most riders are not committed to crimes. The normal distribution will not apply for the crime count data. Our study assumes the mean crime count for each trip in the control group to be 0.63, with the largest percentage of 0 crime reported, less percentage has 1 crime reported, and so on. Meanwhile, Treatment 1 is assumed to has mean of 0.35 (45% decrease compared to control group) and 0.32 for Treatment 2.

Group	Train_ID	Line	CrimeReported	Month	Date	Day
Treatment1	4434	1	0	2	25	Thu
Treatment1	7937	3	0	3	17	Mon
Treatment1	6702	R	1	5	16	Tue
Treatment1	18745	7	0	9	22	Thu
Treatment1	12884	W	2	2	24	Wed
Treatment1	105	N	0	8	15	Tue

(Figure 1)

Validation of the settings are done by performing t tests between each group.
T test control group vs Treatment 1 results with mean of control to be 0.623 and mean of treatment1 to be 0.390. P-value <0.05. (Figure 2)
Control group vs Treatment 1 results with mean of control to be 0.623 and mean of treatment1 to be 0.253. P-value <0.05. (Figure 3)

```
data:  mtadata[mtadata$Group == "Control", 4] and mtadata[mtadata$Group == "Treatment1", 4]
t = 3.5038, df = 589.74, p-value = 0.0002467
alternative hypothesis: true difference in means is greater than 0
95 percent confidence interval:
 0.1236224       Inf
sample estimates:
mean of x mean of y
0.6233333 0.3900000
```

(Figure 2)

```
        Welch Two Sample t-test

data:  mtadata[mtadata$Group == "Control", 4] and mtadata[mtadata$Group == "Treatment2", 4]
t = 5.9645, df = 551.96, p-value = 2.193e-09
alternative hypothesis: true difference in means is greater than 0
95 percent confidence interval:
 0.2677919       Inf
sample estimates:
mean of x mean of y
0.6233333 0.2533333
```

(Figure 3)

Repeated simulation

To further understand and verify our study, the simulation is repeated 1000 times. The effect size, upper bond (95% Confidence Interval), and p-values are recorded for each single simulation. In the end, a table is conducted as the result for further analysis. (Figure 4)

```
   Experiment     effect     upper_ci            p
1:          1 -0.3033333 -0.195017709 2.440971e-06
2:          2 -0.2666667 -0.165710015 7.993519e-06
3:          3 -0.2133333 -0.108378267 4.322720e-04
4:          4 -0.3200000 -0.208560510 1.410136e-06
5:          5 -0.2366667 -0.129294405 1.535420e-04
---
```

(Figure 4)

Simulation Results

Research Question	Scenario	Mean Effect in Simulated Data	95% Confidence Interval of Mean Effect	Percentage of False Positives	Percentage of True Negatives	Percentage of False Negatives	Percentage of True Positives
Install of cameras	No Effect	-0.003	0.113	0.322	0.036	0.618	0.024
Install of cameras	Effect: -0.284 (45% of 0.63)	-0.257	-0.151	0	0.643	0.011	0.346
Install of warning signs	No Effect	-0.002	0.114	0.332	0.035	0.619	0.014
Install of warning signs	Effect: -0.284 (45% of 0.63)	-0.275	-0.170	0	0.646	0.008	0.346

(Figure 5)

Figure 5 shows the result of 1000 simulations. Row 1 and row 3 represent the control groups with no assumption of effect, row 2 represents the treatment 1 group and row 4 represents the treatment 2 group. Both groups are expecting an effect size of 45% reduction.
Simulation of treatment 1 resulted in a mean effect of -0.257, 95% Confidence Interval of Mean Effect of -0.151, 0 Type 2 errors, 1.1% Type 1 error, and 98.9% statistical power.
Simulation of treatment 2 resulted in a mean effect of -0.275, 95% Confidence Interval of Mean Effect of -0.170, 0 Type 2 errors, 0.8% Type 1 error, and 99.2% statistical power.
The simulation suggests the experiment's power is 98.9% for treatment1 and 99.2% for treatment2. The current sample size of 900 subway trips is sufficient to support our experiment. The statistical power is strong enough to give us confidence about the experiment model.

Conclusion

To summarize the findings, our simulation experiment provides evidence for the feasibility of this study. The relevance of our hypothesis is supported. Regarding the research, the most obvious finding from this study is that installing enough cameras with warning signs would be the most effective strategy for reducing crime on New York City subway cars. The significance of the research revealed that such action as installing more cameras to improve public safety in the New York subway system is necessary. Further research in the area, such as comparing the relevance of stricter entrance and exit gate systems, is recommended.

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