Scooter Usage: Will it Change if Students Use their Transportation fee?
Final Report

A/B Testing, Design and Analysis - 19819

Anum Malik (anumm)

Mohammad Manzoor Mirza (mmmirza)

Elizabeth Root (eroot)

Raja Safiullah (rsafiull)

Hajra Shahab (hshahab)

Alex Talbott (atalbott)

Date: December 10th, 2021

Table of Contents

I. Abstract …………………………………………………………………………….. - 3 -

II. Introduction ………………………………………………………………….... - 3 -

III. Question and Experimental Design …………………………………………….. - 5 -

IV. Data and Analysis ..…………………………………………………………. - 6 -

V. Conclusion ..………………………………………………………………….. - 15 -

1 Abstract

Electric scooters are rapidly changing transportation in cities especially in university towns dominated by students in the United States. These devices are designed to provide a “last mile” mobility solution that’s affordable, convenient and generally better for the environment. Despite e-scooters being available in over 100 U.S cities and for approximately forty million trips in 2018[1], there is limited data to assess the shortcomings or benefits of its usage to develop data-driven policies and transportation plans. Specifically in the city of Pittsburgh, scooters were introduced on July 9th 2021 with an executive order to implement a scooter pilot program. As of September 2021, Pittsburgh had completed 131,444 zero-emission trips with subsidies for low-income individuals that lack options for reliable sources of transportation at a 50% reduced price[2].

This paper aims to understand and characterize trends related to e-scooters used among the student population in Pittsburgh. More precisely, it asks the causal question of change in scooter usage given the inclusion of unlimited rides within the flat transportation fee charged to students. The research conducted a randomized survey with a sample of university students, faculty and staff that captured current familiarity with e-scooters and weekly scooter usage, while controlling for factors such as age, income, and other perceived barriers to usage such as safety considerations and affordability.

The completed survey generated responses from 203 students, faculty and staff in Pittsburgh, 91.1% of whom were familiar with the e-scooters. 23.5% of total respondents had ridden e-scooters before, 29.4% indicated that they have been inclined to do so while 47.1% had not used them at all.

Using survey data, the paper explores the causal effect of including scooter rides as part of the university transportation fee on weekly scooter usage. The causal inference in this scenario is established due to the elimination of selection bias, which was achieved through random assignment of experimental subjects to the treatment and control group. Moreover, the analysis extends to explore heterogeneity in the average causal effect across groups within the sample using key barriers of distance, safety and income as moderators.

2 Introduction

Electric scooters have been gaining popularity in cities across the United States since 2017. According to the National Association of City Transportation Officials (NACTO), there was an increase in ridership on scooters alone from 38.5 million rides in 2018 to 88.5 million rides in 2019. [3] However, in Pittsburgh, electric scooters were not available until this past summer. In July, the City of Pittsburgh launched a mobility program with Spin, an electric scooter company owned by Ford Motors Co., to introduce electric scooters to Pittsburgh residents. They hoped that this new mode of transportation would increase mobility around the city and reduce carbon emissions. Pittsburgh residents can rent a scooter from the Spin or Transit app, available on the App Store, for

---

[1] Sandt, L., Harmon, K., 2019. “Dockless Electric Kick Scooter Systems: What we know and don’t know.” In: Presentation at the Transportation Research Board Annual Meeting. January 14, 2019.

[2] Walker, Kylie. .“Pittsburgh City Council Considering Traffic Regulations for E-Scooter Company”. September 8, 2021. https://www.wtae.com/article/pittsburgh-e-scooter-trafic-regulations/37512891

[3] National Association of City Transportation Officials. Shared Micro-mobility in the U.S.: 2019. Accessed December 9, 2021. https://nacto.org/shared-micromobility-2019/.

$1 for the first minute and $0.39 for every minute after. The scooters themselves have a maximum speed of 27 mph but riders are limited to 15 mph in Pittsburgh due to safety concerns.

By late August, Pittsburgh residents had completed 96,343 rides.[4] Over 600 complaints about the scooters across the city mainly had to do with incorrect parking of scooters after riding it. City council has also thought about addressing some complaints with traffic regulations, especially for illegal parking or scooters being in areas where they are not meant to be.[5]

There was some original pushback from Pittsburgh drivers regarding electric scooters when they were first introduced in 2017. These concerns mainly revolved around safety issues. A study from the Insurance Institute for Highway Safety found scooter riders were twice as likely to be injured by potholes, sign posts, and road cracks but bikers were three times as likely to be hit by a motor vehicle.[6] Electric scooters are more vulnerable to imperfections on streets and sidewalks than being seriously injured by other motor vehicles. However, it is still important for riders to be aware and vigilant when riding to prevent risk of injury. The Spin app and the City of Pittsburgh require riders to be at least 18 years old and be able to download the Spin or Transit app.[7] First-time riders are also informed about the safety concerns and asked to fill out a questionnaire so that they understand the risks. All riders are recommended to use helmets but it is not a requirement while riding.

Most Carnegie Mellon University (CMU) students live within a 10 or 15 minute drive to campus, which costs them $7 to $10 per ride. Students have free access to public transportation through the Pittsburgh Port Authority through the $120 transportation fee charged every semester. The University of Pittsburgh students also have a $130/semester transportation fee that allows them free usage on all buses within Pittsburgh[8]. We aim to assess the effect on students' usage of electric scooters if they could link their student account to Spin and be able to rent scooters as a part of the transportation fee they pay every semester. Our model is a regression with the hope of seeing a causal association between the transportation fee linkage to Spin and scooter usage.

Academic research on e-scooter usage in North America is limited, however, prior literature suggests adoption of new mobility services continues to accelerate with factors such as the widespread proliferation of GPS-enabled smartphones rising from 35% to 77% in the past 7 years,[9] traffic congestion, and increased financing in private mobility service companies. Reasons for usage also varied across cities and demographics. City reports from surveys conducted in Portland, Denver and Austin concluded that e-scooters are popular and seen as a valuable service, even

---

[4] Lacretia Wimbley. "Scooter Craw: Spin pilot program seeing growth in Pittsburgh and in complaints." *The Pittsburgh Post Gazette.* Published August 28, 2021. Accessed December 9, 2021. https://www.post-gazette.com/news/transportation/2021/08/27/Scooter-Craze-Spin-pilot-program-growth-Pittsburgh-complaints-tunnels-neighborhoods-rules/stories/202108270112 .

[5] Ashley Murray. "Pittsburgh City Council one step closer to traffic regulations for scooters." *The Pittsburgh Post Gazette.* Published on September 15, 2021. Accessed on December 9, 2021. https://www.post-gazette.com/local/city/2021/09/15/Pittsburgh-City-Council-one-step-closer-to-traffic-regulations-for-Spin-electric-scooters/stories/202109150125.

[6] Benjamin Preston. "New Study Shows Safety Risks of Riding e-Scooters on the Sidewalk," *Consumer Reports.* Published October 15, 2021. Accessed December 9, 2021. https://www.consumerreports.org/electric-scooters/safety-risks-of-riding-e-scooters-on-the-sidewalk-iihs-study/.

[7] Wimbley, Ibid.

[8] Natalie Frank. "Student security and transportation fee to increase for first time in 14 years." *Pitt News.* Published July 8, 2021. Accessed December 6, 2021. https://pittnews.com/article/166002/news/student-security-and-transportation-fee-to-increase-for-first-time-in-14-years/.

[9] "The Micro-mobility Revolution: the Introduction and Adoption of Electric Scooters in the United States".*Populus.* Published July, 2018. Accessed December 6, 2021.

amongst non-users; especially for shorter distances.[10] It is faster to travel shorter distances of 3 miles or less using an e-scooter than driving a car or using a ride-hailing service. City reports also examined why populations adopted e-scooters as a means of transportation, rather than for recreational purposes. Over 32% of the respondents from Denver reported using e-scooters to commute to and from work, followed by 20% using them to get to/from work.[11]

Another question of interest across demographic data is closing the gender gap in the adoption of micro-mobility technologies and exploration of the perception of e-scooters amongst men and women. According to Populus.ai, the gender gap may be smaller for newer micro-mobility services across U.S. cities: 3.2% of women have tried electric scooters versus 4.4% of men;[12] with studies showing that women have a slightly more positive view of electric scooters than men. Transportation equity was explored with other mobility modes like bike sharing systems with data establishing that some cities disproportionately set up stations in wealthier neighborhoods,[13] but with the advent of dockless e-scooters, there was an increased accessibility for lower income groups given the nature of use and the 'leave anywhere' policies. Initial findings indicate that e-scooters have garnered support, yet our study intends to specify usage amongst a subpopulation of users within a representative sample of students with varying demographics.

3 Question and Experimental Design

Our survey design aimed to collect information that could help us assess whether students/ faculty and staff members at CMU and University of Pittsburgh would increase electric scooter usage if the cost of using it is covered within the transportation fee of $120 and $130 for CMU and UPitt students and staff respectively. This survey was conducted over a span of three weeks during a regular in-person semester at both universities.

We used Qualtrics and its advanced features to customize our survey as per the needs of this experiment. Using display logic and features such as randomizer, treatment and control group assignment was done at random according to the following categories:

Control: Free scooter rides not covered on the current student transportation plan

Treatment: Unlimited rides on the student transportation coverage plan

Null Hypothesis: there is no difference in the scooter usage between the treatment and control groups.

Our intended plan was to limit our sample to CMU and University of Pittsburgh students only as both of these universities offer free access to public transportation services on individual account. However, 22 non-CMU and non-Pitt participants also ended up responding to the survey. We

[10] Rebecca L. Sanders, Michael Branion-Calles, Trisalyn A. Nelson, To scoot or not to scoot: Findings from a recent survey about the benefits and barriers of using E-scooters for riders and non-riders,Transportation Research Part A: Policy and Practice,Volume 139,2020, https://doi.org/10.1016/j.tra.2020.07.009

[11] Denver Public Works (DPW), 2018. Denver Dockless Mobility Program: Pilot Interim Report. Accessed March 3, 2019: https://www.denvergov.org/content/dam/denvergov/Portals/705/documents/permits/Denver-dockless-mobility-pilot-update-Feb2019.pdf.

[12] Populus, Ibid.

[13] Ibid.

decided to add these towards our analysis under the assumption that other universities in Pittsburgh have a similar transportation fee structure for students and staff. We aimed to gather 200-300 responses to have enough data points to draw inferences discussed later in our analysis section.

One section of the survey focused on demographic characteristics including age, gender, any mobility related disabilities, zip code, distance from the campus, annual income and current mode of transportation. These characteristics predominantly aimed to capture baseline differences between the treatment and control groups, and later used in the analysis to check for heterogeneous effects among groups with different characteristics such as income brackets and accommodation distance from campus.

Before running our control and treatment, we also collected information through multiple questions to assess user familiarity with scooters. If a user has never taken a journey on an electric scooter then any analysis thereafter would have skewed our results. By showing images of different scooters embedded within the survey, we tried to capture past user experience with scooters, frequency & reason of usage, and overall challenges faced by e-scooter users such as insufficient battery, availability, etc.

As we set control vs. treatment groups, we used Qualtrics randomizer feature to make sure that we have an equal number of subjects in the control vs. treatment group. For treatment groups, we presented the following scenario to anyone who received the treatment version of our survey, “Your university has now included electric scooters as a means of transportation covered by the transportation fee: would you increase your usage of scooters?”, followed by the question: “Given the above scenario, on average, how would you define your weekly usage?”. Among those who took the survey, roughly half of them received a version that had this scenario while the other half of the sample received two basic questions regarding scooter usage that were used to fill up space and match the number of questions with the treatment version of the survey.

4 Data and Analysis

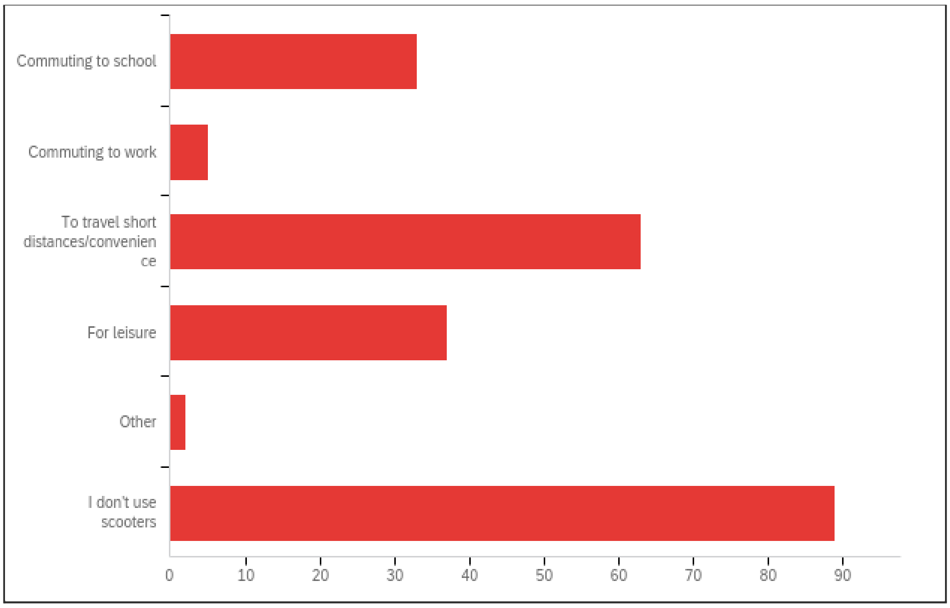
As expected, most of the survey respondents were within the age bracket of 18-25 with an approximately even split amongst gender association. Furthemore, the subjects were from varying income backgrounds. The detailed description of demographics across respondents and their respective e-scooter usage is summarized in the table below:

Age	Count (n)	Percent(%)	Riders(%)	Non-Riders(%)
<18 years	0	0.0	0.0	0.0
18-25 years	161	79.3	54.0	46.0
25-30 years	33	16.3	60.6	39.4
30-35 years	9	4.4	55.6	44.4

> 35 years	0	0.0	0.0	0.0
Gender				
Female	105	51.7	44.8	55.2
Male	89	43.9	67.4	32.6
Non-Binary	4	1.97	75.0	25.0
Other	1	0.5	0.0	100.0
Choose Not to Respond	4	1.97	50.0	50.0
Income				
$0	17	8.4	23.5	76.5
$1-9,999	33	16.3	60.6	39.4
$10,000-24,999	27	13.3	55.6	44.4
$25,000-49,999	17	8.4	47.1	52.9
$50,000-74,999	22	10.8	81.8	18.2
$75,000-99,999	15	7.4	73.3	26.7
$100,000-149,999	10	4.9	60.0	40.0
=> $150,000	22	10.8	59.1	40.9
Choose Not to Respond	40	19.7	42.5	57.5

Table 1: Demographics across Respondents and E-Scooter Usage

It was interesting to note that while the majority of participants had never used e-scooters, 27.3% used them for convenience or travelling short distances corroborating the earlier research review. 16.1% of respondents chose e-scooters for leisure while 14.9% used it to commute to school.



Status Quo: Purpose of E-Scooter Usage

I. <u>Checking Balance</u>

Next, we check for balance between the control and treatment groups with regards to age, gender, distance from respondent's university, safety rating and usage frequency. Overall, the two groups seem to share similar proportions for all three variables. We can attribute this to the random assignment of our treatment question. We plan to use these controls as part of a later regression, so making sure they are balanced between the two groups is important.

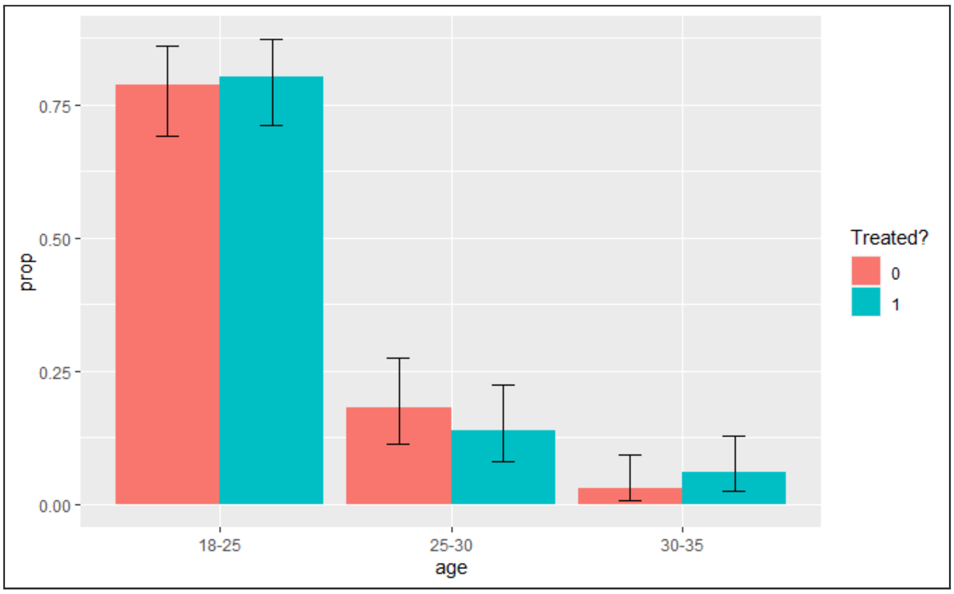


Figure 1: Age Distribution

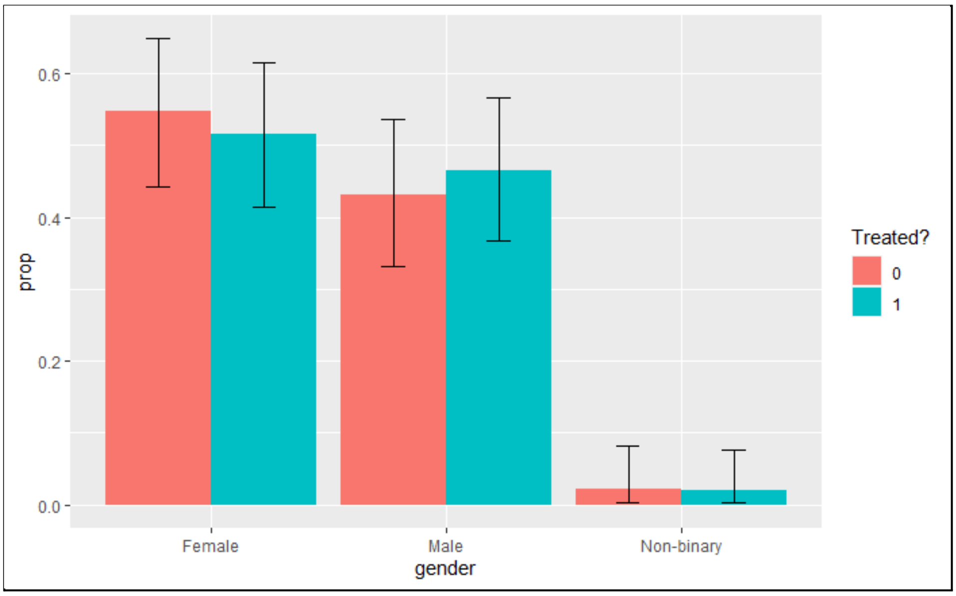


Figure 2: Gender Distribution

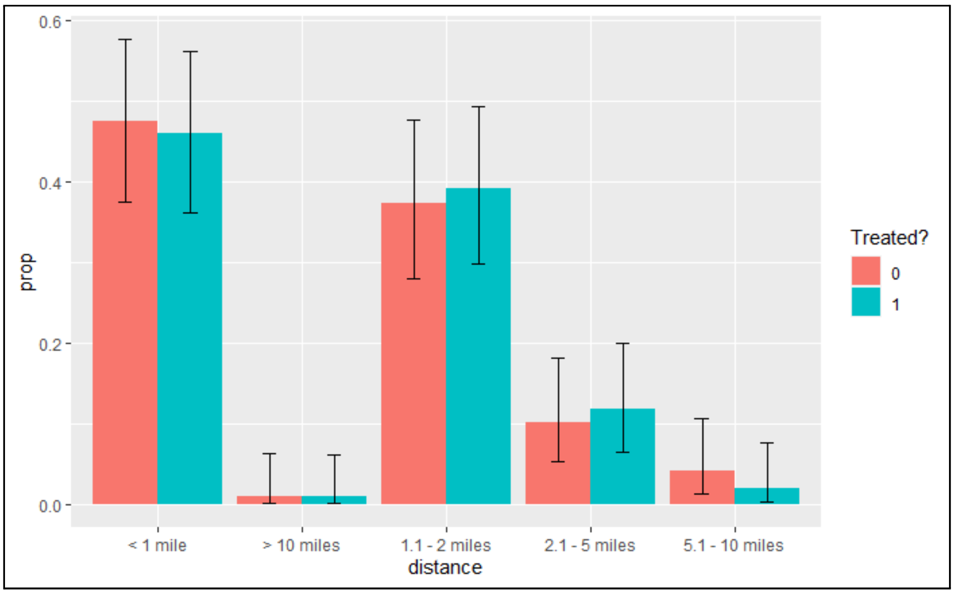


Figure 3: Distance Distribution

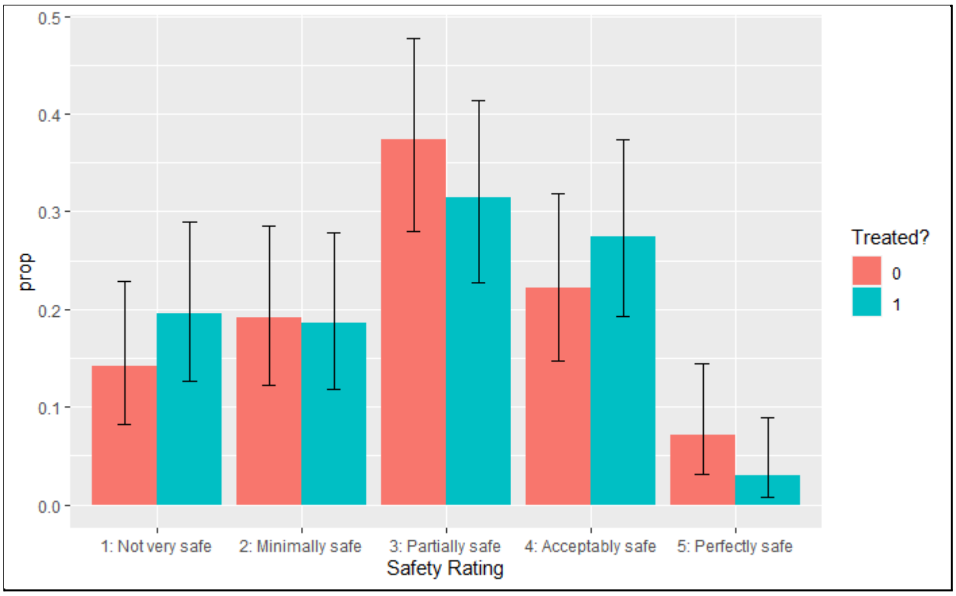


Figure 4: Safety Rating Distribution

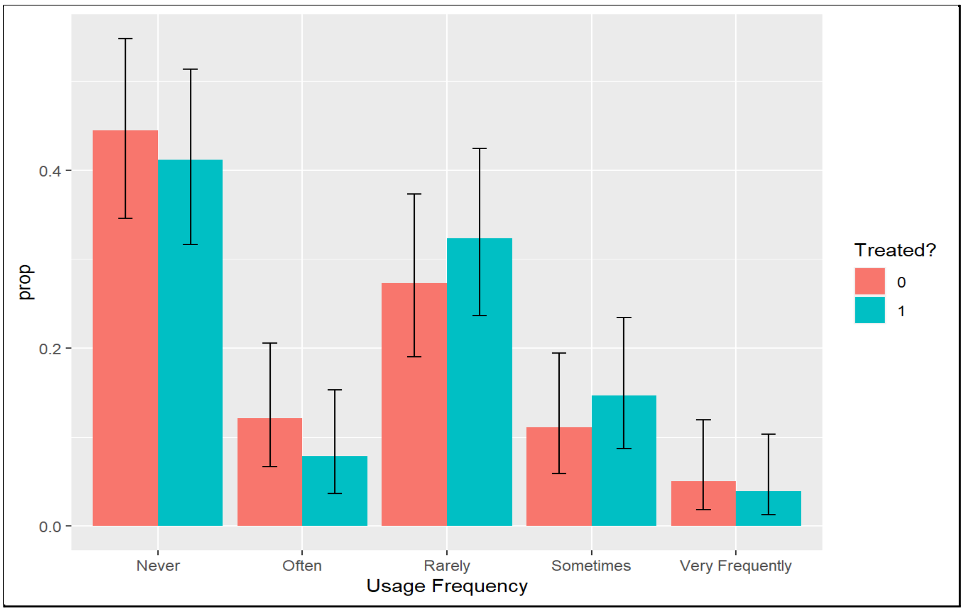


Figure 5: Usage Frequency Distribution

In Figure 1, 2, 3, 4 and 5, the distributions along with the error bars suggest that there is balance between the control and treatment Group. The balance is an indicator of how the individuals in the two groups are similar prior to the treatment, and have been randomly assigned to the two groups. Therefore, any treatment effect that is to be reported can be attributed solely to the treatment being rendered, and no other causes (biases). We checked balance across age, gender, distance, safety rating and usage frequency, and are confident that our results indicate successful randomization, and therefore balance across other observed and unobserved factors as well.

II. Regressions

For our model, we decided to use linear regression to understand how allowing students to use their transportation fee on scooter rides would change their weekly usage. We ran regressions with and without controls for gender, age, income, familiarity and experience. With minimal change observed in the coefficient for our treatment variable below, we were further able to rule out the correlation of treatment with other factors.

```
##
## Effect of including scooters in university transport fee
## ===================================================================================================
##                                                   Dependent variable:
##                     -------------------------------------------------------------------------------
##                                                  outcome_scooter_usage
##                          w/o controls       w/ demographic controls w/ scooter familiarity controls
## ---------------------------------------------------------------------------------------------------
## treated                 2.707*** (0.307)        2.703*** (0.300)            2.609*** (0.297)
## Constant                0.636*** (0.219)          1.075 (1.136)              -0.199 (0.561)
## ---------------------------------------------------------------------------------------------------
## Gender Control               No                      Yes                          No
## Age Control                  No                      Yes                          No
## Income Control               No                      Yes                          No
## Familiarity Control          No                      No                           Yes
## Experience Control           No                      No                           Yes
## Observations                 201                     201                          201
## R2                          0.281                   0.380                        0.343
## Adjusted R2                 0.277                   0.330                        0.330
## Residual Std. Error     2.178 (df = 199)        2.097 (df = 185)            2.097 (df = 196)
## F Statistic          77.602*** (df = 1; 199) 7.556*** (df = 15; 185)     25.582*** (df = 4; 196)
## ===================================================================================================
## Note:                                                                  *p<0.1; **p<0.05; ***p<0.01
```

Assessing Causal Effect

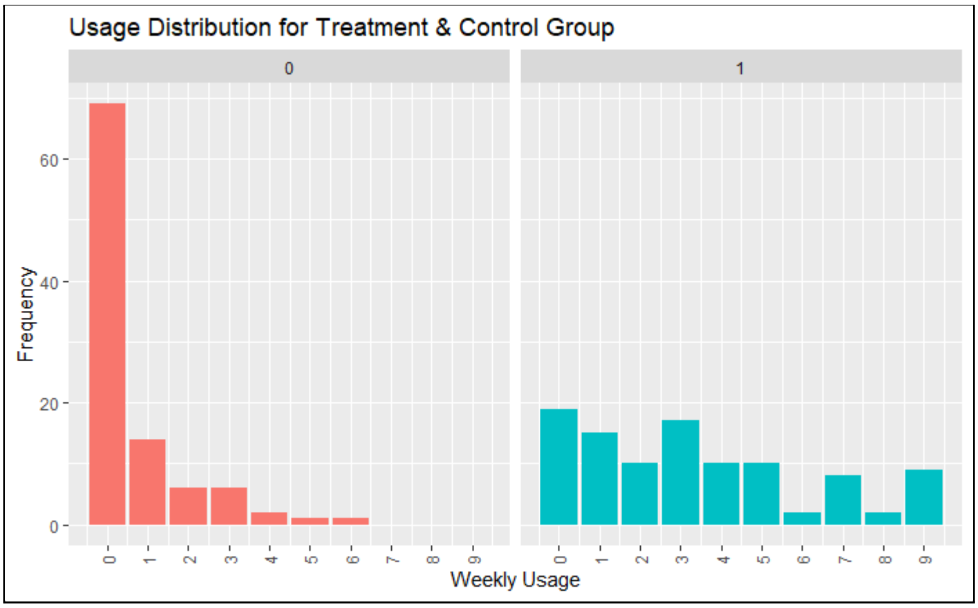


Figure 5: Weekly Usage Histogram

In figure 5, we can see that there is a right shift in weekly usage, as we apply the treatment to the treatment group. While this right shift depicts an effect of treatment in the experiment, this isn't enough evidence to suggest that the difference in average weekly usage between the control and the treatment group is statistically significant. To assess this claim we plot Figure 6.

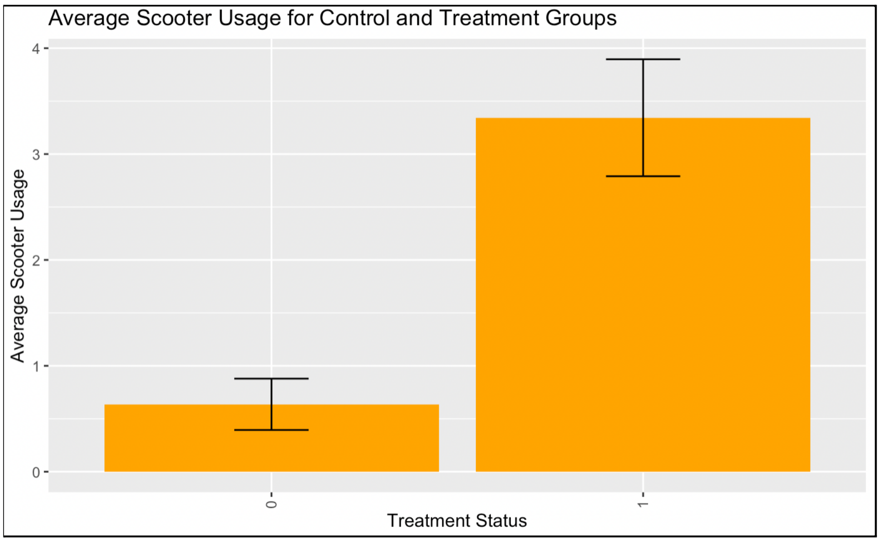


Figure 6: Average Weekly Usage - Control vs Treatment

Figure 6, shows that there is a statistically significant difference in average weekly usage of e-scooters between the control and the treatment group. It appears, on average, holding all other factors constant, offering free e-scooters rides on the current student transport plan at Carnegie Mellon University and University of Pittsburgh results in a statistically significant increase in e-scooter usage.

III. Heterogeneous Effects

We also ran a regression with heterogeneous effects to check if the causal effect of 2.707 was different across subgroups in our sample using distance from campus, safety ratings and income as moderators.

Effect of including scooters in university transport fee

	Dependent variable:			
	outcome_scooter_usage			
	no controls	heterogenous distance	heterogenous safety	heterogenous income
treated	2.707***	0.467	3.180***	2.691***
	(0.307)	(1.579)	(0.371)	(0.380)
heteroNear		0.460		
		(0.992)		
treated:heteroNear		2.298		
		(1.609)		
hetero1Unsafe			-0.455	
			(0.449)	
treated:hetero1Unsafe			-1.180*	
			(0.622)	
hetero2Low Income				0.029
				(0.470)
treated:hetero2Low Income				0.041
				(0.653)
Constant	0.636***	0.200	0.788***	0.627**
	(0.219)	(0.967)	(0.259)	(0.267)
Observations	201	201	201	201
R2	0.281	0.298	0.333	0.281
Adjusted R2	0.277	0.288	0.323	0.270
Residual Std. Error	2.178 (df = 199)	2.162 (df = 197)	2.107 (df = 197)	2.189 (df = 197)
F Statistic	77.602*** (df = 1; 199)	27.902*** (df = 3; 197)	32.798*** (df = 3; 197)	25.620*** (df = 3; 197)
Note:				*p<0.1; **p<0.05; ***p<0.01

The results for this regression are best analyzed through the following visualizations.

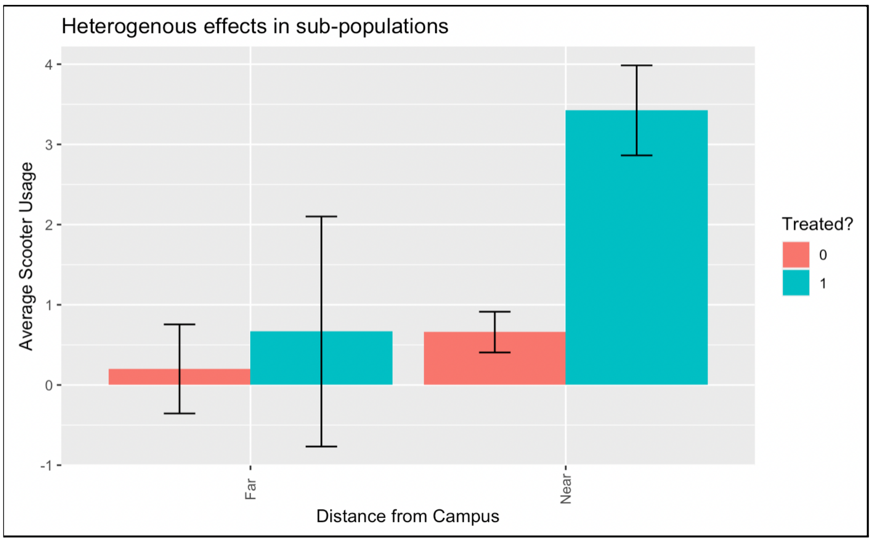


Figure 7: Heterogeneous Effect - Near vs Far

In Figure 7, we can see that there does not seem to be a statistically significant difference in average scooter usage after treatment for the subgroup ‘Far’ - subjects living more than five miles away from their relevant campus. While there does appear to be a statistically significant increase in average e-scooter usage after the treatment for subgroup ‘Near’ - subjects living less than five miles away from their relevant campus.

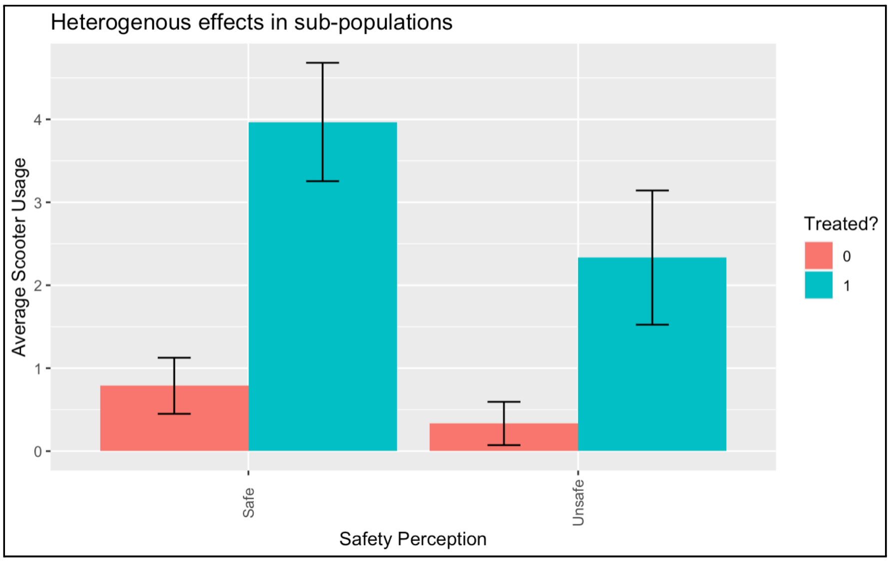


Figure 8: Heterogeneous Effect - Safe vs Unsafe

Figure 8 suggests that there is a statistically significant increase in average e-scooter usage after treatment for both subgroups: ‘Safe’ - subjects who rated scooters to be “1: Not very safe” and “2: Minimally safe” and ‘Unsafe’ - subjects who rated scooters to be “3: Partially safe” and “4: Acceptably safe” and “5: Perfectly safe”. However, the increase in average e-scooter usage is more for sub-group ‘Safe’.

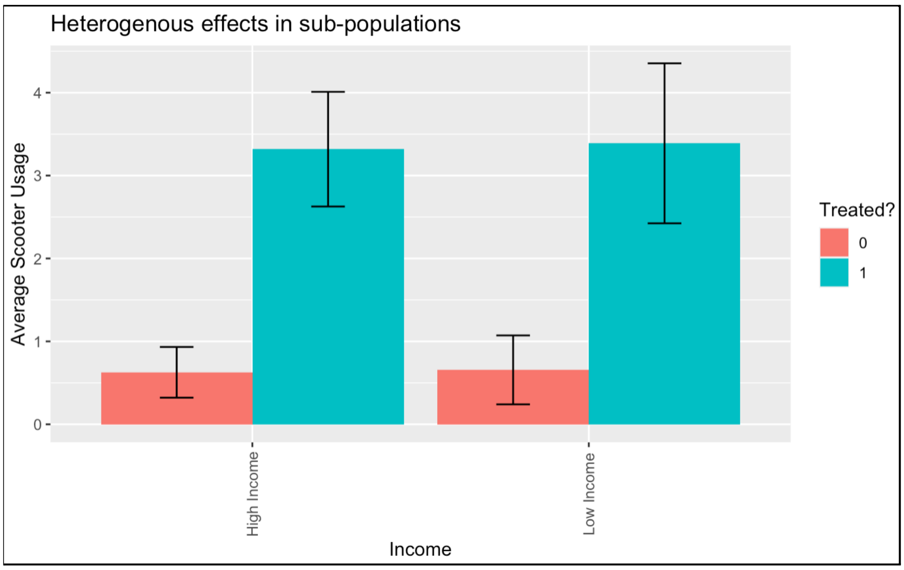


Figure 9: Heterogeneous Effect - High Income vs Low Income

Figure 9 depicts that there is no statistically significant difference in average e-scooter usage after the treatment between subgroups 'High-Income' - subjects with annual income greater than $50K and 'Low-Income' - subjects with annual income less than $50K,. This suggests that there are no heterogeneous effects to be reported between the two subgroups, as per our regression results.

Note: These analyses need to be complemented by the power analysis to assess the validity of the results, which is done in the following section.

IV. Power of the test(s)

We also conducted a power analysis of our treatment and of the heterogeneous effects. The results were as follows:

- Power of Test: 0.9414249
- Power of Heterogeneous Effects for 'far' subjects: 0.08960254
- Power of Heterogeneous Effects for 'near' subjects: 0.9324738
- Power of Heterogeneous Effects for 'safe' subjects: 0.8043321
- Power of Heterogeneous Effects for 'unsafe' subjects: 0.5497341
- Power of Heterogeneous Effects for 'high income' subjects: 0.8164451
- Power of Heterogeneous Effects for 'low income' subjects: 0.5271504

The Power Analysis suggests that we can only claim validity for the results of the overall test i.e. comparing the average e-scooter usage before and after the treatment, for the 'Near' subgroup i.e. gauging the effect of the treatment on the 'Near' subgroup, for the 'Safe' subgroup i.e. gauging the effect of the treatment on the 'Safe' subgroup, and for the 'High Income' subgroup i.e. gauging the effect of the treatment on the 'High-Income' subgroup, only. Given that we set the validity criteria to be 0.80 or above (with the power above 0.90 suggesting high validity of results).

5 Conclusion

Overall, we found that if universities allowed students to ride for free with their transportation fee, scooter usage would increase by at least two rides per week. The findings indicate that students are happy to have various means of transportation to their universities.

Our limitations include a smaller sample size since we are primarily focusing on students at University of Pittsburgh and Carnegie Mellon University, along with faculty and staff wherever possible. If we aimed to get a larger data set, we would need to change our treatment question to include all of Pittsburgh, something like "what if a daily bus pass could also be used for scooter rides?" This would provide us a larger sample size to work with and get more responses from.

If we tested the question on a larger scale or on universities in different cities with similar transportation fees, we could see how free scooter rides from universities' transportation fees would affect scooter usages. We could also try a similar program with Pittsburgh City Council to understand how scooter usage would change within Pittsburgh if residents could use pre-paid bus passes for scooter rides. Both of these options would expand our sample size and provide more insight into heterogeneous effects and the true effect of free scooter rides on scooter usage.