Tolling the Streets, Pedaling the Lanes: The Impact of NYC's Congestion Tax on Bike-Share Ridership in the City

Shahmeer Mohsin*

February 26, 2025

Abstract

Cities around the world face environmental and congestion externalities associated with motorized vehicle use (cars, motorcycles, etc). Along with generally being unsustainable and usually entailing congestion externalities, these vehicles are also inactive modes of transport (i.e. they require no physical exercise). In this paper, I empirically investigate whether New York City's recent congestion tax on motorized vehicles entering Midtown and Lower Manhattan has led to increased usage of the Citi Bike bike-sharing system using a Differences-in-Differences (DiD) approach. The results indicate that there is indeed an increase in Citi Bike ridership post-intervention, implying that such interventions can lead to increased usage of sustainable and active transport modes involving low congestion externalities. I also test the possibility of various mechanisms that could be driving the change and show that substitution from motorized vehicles is the cause of the increase, proving that the intervention led to a shift from unsustainable and inactive travel modes to an active and sustainable transport mode.

JEL classification: L91, L86

*University Paris-Dauphine-PSL: shahmeer.mohsin@dauphine.psl.eu

1 Introduction

Cities around the world face high levels of traffic congestion and motorized vehicle-induced pollution. Cities have been making use of various levers to deal with traffic congestion and local transport-induced air pollution and climate change in general. These levers include both financial and behavioral interventions to curb emissions from high-emission transport modes.

Some examples of financial incentives include investments in micro-mobility (e-scooters, bicycles, etc) and public transport infrastructure and operations, congestion pricing, tax incentives for low-emission vehicles, fuel taxes, toll discounts for high-occupancy vehicles, vehicle scrappage programs (i.e. providing financial incentives to replace older, high-emission vehicles), consumer-side subsidies for public transport and micro-mobility riders, etc. Behavioral interventions include public awareness programs (for instance, educating people about the environmental and health benefits of sustainable transport), car-free days (which entail designating specific days when cars are restricted from certain areas in cities), etc.

This paper zooms in on a recent financial measure introduced in New York City and provides empirical evidence on its congestion and environmental implications: the imposition of a congestion tax on cars, motorbikes, trucks and buses entering a certain region in Manhattan i.e. the below 60th Street, which started on the 5th of January 2025. More specifically, this paper provides empirical insights into the impact of this congestion tax on bike-share ridership, using data for the Citi Bike bike-share system (the only docked bike-share system in the city).

This paper investigates if the congestion tax has led to an increase in Citi Bike trips starting in Manhattan above 60th Street and ending below it using the Differences-in-Differences (DiD) regression technique, which involves a comparison of a treatment and control group before and after a certain intervention to understand if the intervention led to changes in the treatment group ,using the control group as a reference.

In the DiD regression analysis, I compare trips starting above 60th Street and ending below it with control routes. Since the City implemented a disparate toll rate by time of day (peak vs off-peak rate) as shown in Figure 1, I also undertake a DiD analysis comparing peak and off-peak ridership for rides starting above 60th Street and ending below it. The DiD results using both treatment-control setups (by route and by time) indicate that there is an increase in the usage of Citi Bike for trips starting above 60th Street and ending below it post-intervention.

I also test which of the following mechanisms could be causing the increase post-intervention: 1) the city increasing the supply of bikes available above 60th Street close to the intervention, 2) increased number of bikes traveling from above 60th Street to below it due to reduced congestion driven by fewer cars below 60th Street post-intervention, and/or 3) substitution from cars and motorbikes to CitiBike. The results indicate that the change is driven by the latter mechanism i.e. substitution from cars and motorbikes to CitiBike.

Cars are much more environmentally unfriendly and have much higher congestion implications than motorbikes so I also check if there is substitution specifically from cars towards Citi Bike; results suggest that indeed this is the case as will be explained further in the Methods and Results section.

The results indicate that the congestion charge has led to substitution from a mode that has higher congestion-implications (car) to a mode entailing lower congestion as well as substitution from modes involving higher pollution externalities (cars and motorbikes) towards a mode that is more environmentally friendly. The results also show that the intervention has led to people moving from inactive transport modes (motorbikes and cars), i.e. modes not involving physical exercise, towards an active mode of transport. As Cities clamp down on the externalities associated with unsustainable modes of transport by imposing financial measures like congestion taxes, these results provide important insights on the substitutionary impacts of such interventions.

As far as the literature is concerned, there are several papers that focus on the impacts of congestion taxes/Low Emission Zones (LEZs). Several papers have shown that such zones lead to improvements vis-à-vis air pollution and public health (Holman et al. (2015), Gehrsitz (2017), Gehrsitz (2017) and Malina and Scheffler (2015)).

There is limited literature investigating whether LEZs lead to people moving from inactive and environmentally unsustainable modes of transport towards environmentally sustainable and active modes of transport, something investigated in this paper. However, the limited literature that currently exists in this space focuses mostly on self-reported, survey-based studies, for instance, Tarriño-Ortiz et al. (2022) uses self-reported data to show that LEZs in Spain led to substitution from unsustainable and inactive modes of transport towards sustainable and active modes of transport (without differentiating between different active means of travel like walking, bike-sharing, personal bikes, etc). There are a handful of observational data-based papers exploring if LEZs lead to increased demand for environmentally sustainable and active modes of transport, for instance, Ding et al. (2023) uses observational data to investigate the impact of London's Ultra Low Emission Zone (ULEZ)

on bike-sharing ridership. However, this paper does not take some important confounders into account, for instance, supply changes. It also does not explain the mechanisms driving increased bike-share usage post-intervention, for instance, substitution from cars, motorbikes, etc; and/or changes in congestion post-implementation driving the change. Lastly, the paper does not distinguish between conventional and electric bikes (e-bikes). I make an attempt towards addressing all of these gaps in this paper as will be explained in the Methods and Results section.

In the next sections of this paper, I will delve into the data used for the analysis, methods utilized, results obtained and the conclusions we can draw from the results.

2 Data

The data used for the analysis are trip-level Citi Bike data. Citi Bike provides granular trip-level data on its website Citi Bike (2025).

The data provide details regarding all Citi Bike trips done since its inception in 2013. The data are anonymized and do not contain personal information of the riders (their names, for instance). The data used to contain genders and ages of riders but the latest data do not encompass this information. The data exclude trips that are taken by staff for testing and inspection, and any trips below one minute (as these could include false starts).

The data used in the analysis period of this paper contain the following information: anonymized IDs associated with each trip, type of bike (electric or conventional bike) used for each trip, trip start and end dates and times, names and IDs of the stations where each trip started and ended, geographical coordinates of the origin and destination stations of each trip, and information regarding whether a certain trip was done by a member (users with Citi Bike subscriptions) or a casual rider (riders using single trip or day passes).

3 Methods and Results

To help visualize any changes to Citi Bike rides post-intervention, I first make use of comparative pre-post weekly ridership plots for different routes.

In that regard, Figure 3 compares the total weekly Citi Bike trips that either start and end above 60th Street or start and end below 60th Street with trips that start above 60th Street and end below it. The analysis focuses only on trips with durations below the mean, which is calculated using data from approximately three months before the intervention

(September 1, 2024, to January 4, 2024). During this period, the average Citi Bike ride lasted 12.46 minutes. The vertical red indicates the week when the congestion tax was implemented. The figure encompasses both the actual counts (upper panel) and z-score normalized counts (lower panel). Z-score normalization transforms y-axis values such that they have a mean of zero and a standard deviation of one. This normalization technique allows comparing the two curves and visualizing any changes that might have occurred post-intervention. The z-score normalized panel of the figure illustrates that there was an increase in trips starting above 60th Street and Ending Below it when compared with the other route category (considering only below-mean-duration trips).

Next consider Figure 4 which depicts only the trips above the mean Citi Bike trip duration (for the same routes as in Figure 3). The z-score normalized panel of the figure illustrates virtually no divergence between the two curves post-intervention, indicating that the increase in Citi Bike trips starting above 60th Street and ending below it is driven by shorter trips only and there is no such increase for above-mean-duration trips.

Assuming substitution from cars and motorcycles (the two passenger vehicle categories impacted by the tax) to Citi Bike post-intervention, such a heterogeneity by trip duration is expected. Biking involves a different experience than driving a car or a motorbike. It is physically strenuous, so one would expect only shorter car and motorbike trips to be replaced by Citi Bike rides. Since Citi Bike also offers electric bikes which require less physical effort, one would expect above-mean trips to also see an increase post-intervention but above-mean trips do not undergo an increase possibly due to Citi Bike's pricing structure for e-bikes (Figure 2 illustrates Citi Bike's pricing structure in detail). E-bikes are charged 0.25 dollars per minute for members (people with Citi Bike subscriptions) and 0.38 dollars per minute with a day pass or single ride pass, compared to unlimited free 45-minute rides on conventional Citi Bikes for members and unlimited free 30 minute conventional bike rides with a daily pass and one single 30 minute conventional bike ride with a single ride pass. These high prices for e-bikes make e-bike pricing for longer trips expensive and competitive with the prices of taking one's car or motorcycle in the congestion zone and paying the fuel charges and congestion tax. Hence, an increase in only below-mean duration trips entering the congestion zone (as illustrated by Figures 3 and 4) seems plausible.

To establish route-based causal inference via a DiD analysis, I focus on Manhattan areas above and below 60th Street but close to it. I divide the region of Manhattan above 60th street into two halves (zone 1 and zone 2 hereafter, with zone 1 referring to the northern half and zone 2 referring to the southern half). Additionally, I divide Manhattan areas

below 60th Street into two halves (zone 3 and zone 4 hereafter, with zone 3 referring to the northern half and zone 4 referring to the southern half). I do a DiD analysis comparing trips starting in zone 2 and ending in zone 3 with trips starting in zone 4 and ending in zone 3. The regression equation is as follows:

$$ln(Count_{dt}) = \beta_1 Route + \beta_2 Route \times Post_t + \delta_d + \gamma_t + \epsilon_{dt} \quad (1)$$

The outcome variable $Count_{dt}$ of the Differences-in-Differences equation represented by equation 1 is the Citi Bike trip count on date d and at time t. *Route* is a dummy variable which is one for trips starting in zone 2 and ending in zone 3 and zero for trips starting in zone 4 and ending in zone 3. The variable *Post* is a dummy variable which is zero for pre-intervention time periods and one post-integration. δ_d represents fixed effects for the date and γ_t represents time fixed-effects. β_2 i.e. coefficient of the interaction term is the coefficient of interest and it will indicate the treatment effect.

Tables 1 and 2 show the results of equation 1 applied to below-mean-duration trips and above-mean-duration trips respectively. The results show that there is a statistically significant increase in Citi Bike ridership post-intervention for trips starting in zone 2 and ending in zone 3 for below-mean-duration trips but there is no statistically significant increase for above-mean-duration trips post-intervention. This is corroborated by visual evidence from Figures 5 and 6 which compare weekly riderships for the two routes for below-mean-duration and above-mean-duration trips respectively. While the blue curve undergoes an increase in Figure 5 w.r.t the yellow curve post-intervention, there is little post-intervention change between the blue and yellow curves in Figure 6 (also confirmed by the regression results).

Next, I check if this disparity between below- and above-mean-duration trips holds for both conventional and electric bikes. I first apply equation 1 to conventional bikes, with trips from zone 2 to zone 3 serving as the treatment route and trips from zone 4 to zone 3 serving as the control route. Tables 3 and 4 insinuate respectively that for below-mean-duration trips (i.e. mean for conventional bikes, which is 12.97 minutes), there is a statistically significant increase in ridership for the treatment route when compared to the control route while there is not a statistically significant increase for trips above-mean trip duration, focusing solely on conventional bikes. The z-score normalized plots in Figures 7 and 8 help visualize these results, illustrating respectively that the conventional bike ridership increased in the treatment route for below-mean-duration trips but not for above-mean-duration trips.

As for electric bikes, Tables 3 (regression table for below-mean-duration e-bike trips

and the same treatment and control pair as for conventional bikes) and 4 (regression table for above-mean-duration electric bike trips and the same treatment and control pair as for conventional bikes) show that the heterogeneity by trip duration exists for electric bikes just as it does for conventional bikes (considering the mean for e-bikes i.e. 12.22 minutes). This can also be visually observed in Figures 9 and 10. The figure for below-mean-duration trips illustrates the blue curve increasing relative to the yellow curve, something confirmed by the corresponding regression table, Table 3. The figure for above-mean-duration trips illustrates the blue curve slightly decreasing w.r.t. the yellow curve but the change does not appear to be too high; this is confirmed by the corresponding regression table, Table 4, which shows a statistically insignificant change in the ridership for the treatment route when compared with the control.

The tax is effective all day. Toll rates are different by time of day as depicted in Figure 1. Peak charges are applied from 5 AM to 9 PM on weekdays and 9 AM to 9 PM on weekends. All other times, off-peak charges are applied, which are 75 percent lower. Different peak and off-peak pricing provides a natural experimental setup to test if peak-hours undergo increased Citi Bike trips into the congestion zone relative to off-peak times. Consider the plots in Figures 11 and 12 where treatment refers to trips starting in zone 2 between 7 and 9 PM and ending in zone 3, while control refers to trips starting in zone 2 between 9 and 11 PM and ending in zone 3; these times were chosen since they are close to the time separating peak and off-peak times across all days of the week i.e. 9PM. The z-score normalized plot in Figure 11 illustrates an increase in Citi Bike trips during the treatment time period relative to the control time period after the intervention for below-mean-duration trips. Figure 12 shows no such decipherable changes for above-mean-duration trips.

The following DiD equation is used to test the differences by time of trip:

$$ln(Count_d) = \beta_1 Time + \beta_2 Time \times Post_t + \delta_d + \gamma_t + \epsilon_d \tag{2}$$

Time is a dummy variable which is one for trips starting in zone 2 between 7 and 9 PM and ending in zone 3, while being zero for trips starting in zone 2 between 9 and 11 PM and ending in zone 3.

Tables 7 and 8 illustrate the treatment effects when Equation 2 is applied to below-mean-duration and above-mean-duration trips respectively. The results indicate that the intervention leads to higher Citi Bike trips into the congestion tax zone during peak hours when compared with off-peak hours for below-mean-duration trips but not for above-mean-

duration trips.

The results so far indicate that there is increased volumes of Citi Bikes entering the congestion zone. There are various mechanisms that could cause this: 1) the city increasing the supply of bikes available above 60th Street close to the intervention, 2) increased number of bikes traveling from above 60th Street to below it due to reduced congestion driven by fewer cars below 60th Street post-intervention, and/or 3) substitution from cars and motorcycles (upon which the congestion tax applies in addition to trucks) to Citi Bike.

Comparing trips starting above 60th Street and ending below it with trips done the other way around should shed light on the mechanisms at play. If there is no significant increase in trips from above 60th Street to Below it when compared with trips the other way around, this provides suggestive evidence that it is the last mechanism (i.e. substitution from cars and motorbikes) driving the change (assuming that the "to and fro" nature of trips holds):

Although the charge applied to one of these routes only i.e. trips from above to below 60th Street, there is a possibility that it also caused an increase in Citi Bike trips from below 60th Street to above it as most trips are done in pairs. Imagine you live below 60th Street and work above it; on your way back from work via a car, the toll would apply to you. Or imagine you work in the congestion zone but live above 60th street; the toll would apply to you if you use a car to commute to work; assuming substitution from cars and motorbikes to Citi Bike, it is likely that people substituting to Citi Bike would use these bikes for both the journey to work and back home, since most trips are done in pairs. No significant increase in trips from above to below 60th Street relative to trips the other way around would suggest that the to-and-fro nature of trips holds and mechanisms 1 and 2 can simultaneouly be rejected (since the presence of any one of these two mechanisms or the inexistence of the two-and fro nature of trips would result in a significant increase in trips from above 60th Street to Below it relative to trips the other way around).

An insignificant change in trips between the two routes would leave substitution away from cars and motorcycles as the only mechanism that could be driving the increase in Citi Bike ridership from above to below 60th Street post-intervention. An insignificant change would hence provide suggestive evidence that the intervention led to substitution from motorcycles and cars, many of which are gasoline-powered and do not involve significant physical exercise towards an active and relatively environmentally-friendly option.

An insignificant change would also prove that at least part of the substitution is from cars to CitiBike, considering the results earlier for e-bikes: the cost of riding an electric Citi Bike is comparable to the costs incurred via a private motorcycle post-intervention, so

one would not expect any substitution from private motorbikes to electric Citi Bikes. For instance, an electric Citi Bike trip of 10 minutes costs $10 \times 0.25 \times 2 = 5$ dollars (multiplying by 2 considering the to-and-fro nature of trips), while the peak-hour congestion charge for private motorbikes is 4.5 dollars. [1]

Figure 13 compares pre-post Citi Bike ridership for trips from above to below 60th Street and trips done the other way around. There is virtually no change in the ridership post-intervention, something also confirmed by the statistically insignificant change shown in Table 9, which is the regression table for equation 1 applied to the two routes (with the variable *Route* equal to one for trips from above to below 60th Street and zero for trips done the other way around).

Figure 14 compares Citi Bike ridership for trips done from above to below 60th Street and trips done the other way around for below-mean-duration trips only. There is a very small increase in the blue curve post-intervention w.r.t. the yellow one but it does not not seem to be substantial. This is corroborated by the statistically insignificant change shown in Table 10, which is the regression table for equation 1 applied to the two routes but only for below-mean-duration trips (in the table, *Route* equals one for trips from above to below 60th Street and zero for the other route, only include below mean-duration trips).

The statistically insignificant change in ridership between these two routes, both overall and for below-mean-duration trips, confirms substitution from cars and motorcycles as being the mechanism driving the increase in Citi Bike ridership post-intervention, with there being definite substitution from cars specifically towards Citi Bike as explained earlier while comparing the pricing of electric Citi Bike rides and private motobike rides.

4 Conclusion

This paper zooms in on NYC's recent congestion tax on motorized vehicles entering Lower and Midtown Manhattan, and shows that the intervention has led to inceased demand for the Citi Bike bike-share system. I am also able to prove direct substitution from motorized transport towards Citi Bike, something previous literature has failed to address, including substitution specifically from cars.

The results of this paper have important policy implications for Cities as they implement Low Emission Zones (LEZs) to reduce motorized transport use. The findings show that LEZs

[1] These calculations do not encompass fuel costs for private motorbikes and membership costs for electric Citi Bikes; these will be considered in a future version of this paper

lead to an increase in the demand for active and sustainable modes of transport, indicating that cities must ensure they provide efficient biking infrastructure and well-operated bike-sharing systems to accommodate the increased demand resulting from LEZs.

5 Figures

Figure 1: Peak and Off-Peak Toll Rates

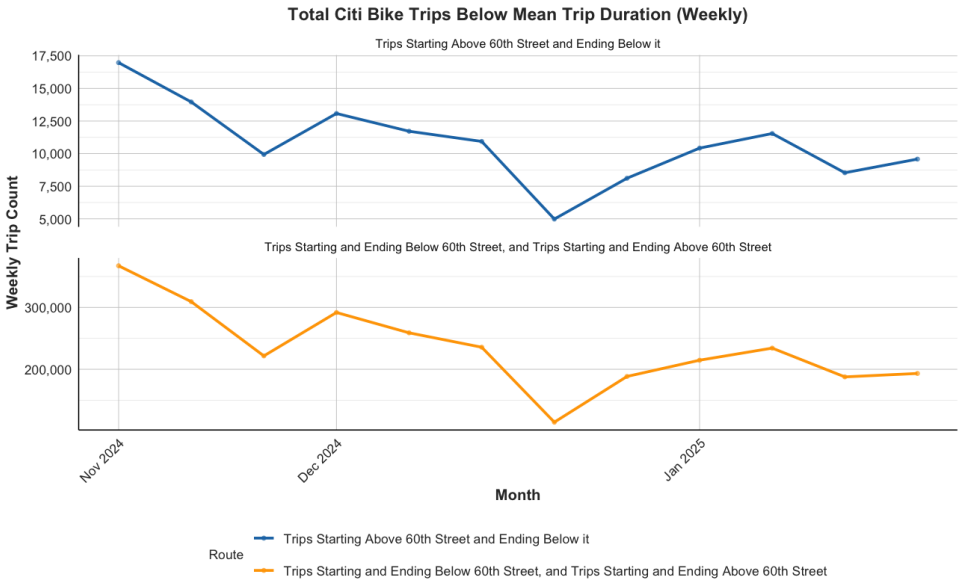
Type of Vehicle	Peak	Overnight
Passenger and small commercial vehicles (Sedans, SUVs, pick-up trucks, and small vans) *Charged once daily*	$9	$2.25
Motorcycles *Charged once daily*	$4.50	$1.05
Trucks and buses	$14.40 - $21.60	$3.60 - $5.40

Figure 2: Citi Bike Pricing Structure

	Single Ride	Day Pass	Citi Bike	Lyft Pink
	$4.99 for 30 mins	$25/day	$219.99/year	$199/year
	Get the app →	Get a day pass →	Join →	Join →
Bike unlocks	$4.99	free	free	free
Ebike prices*	$0.38/min	$0.38/min	$0.25/min	$0.25/min
Ride times	30 min	30 min	45 min	45 min
Bike Angels			●	●
Grubhub+				●
Rideshare benefits				●

*Prices subject to change. Please review this pricing page frequently to see current prices.

Figure 3: Comparison of Weekly Trip Counts by Route: Trips Starting Above 60th Street and Ending Below 60th Street vs. Trips Starting and Ending Below 60th Street and Trips Starting and Ending Above 60th Street (Including Only Below-Mean Duration Trips)



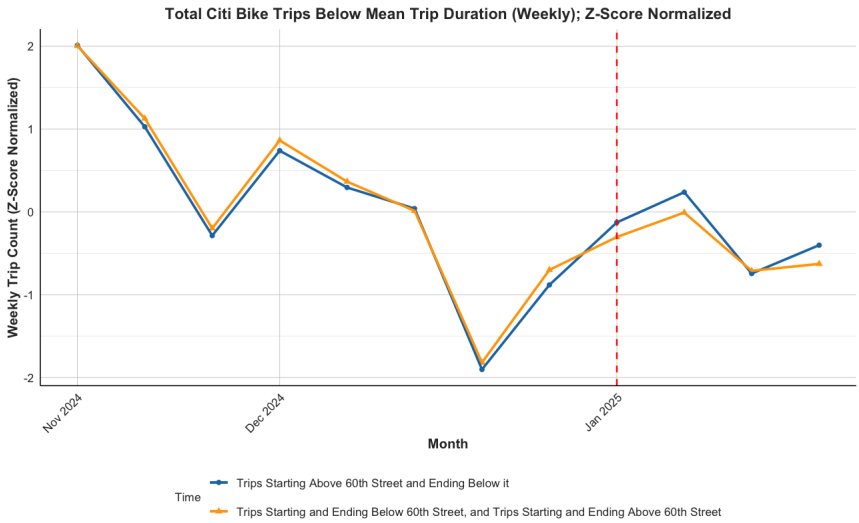
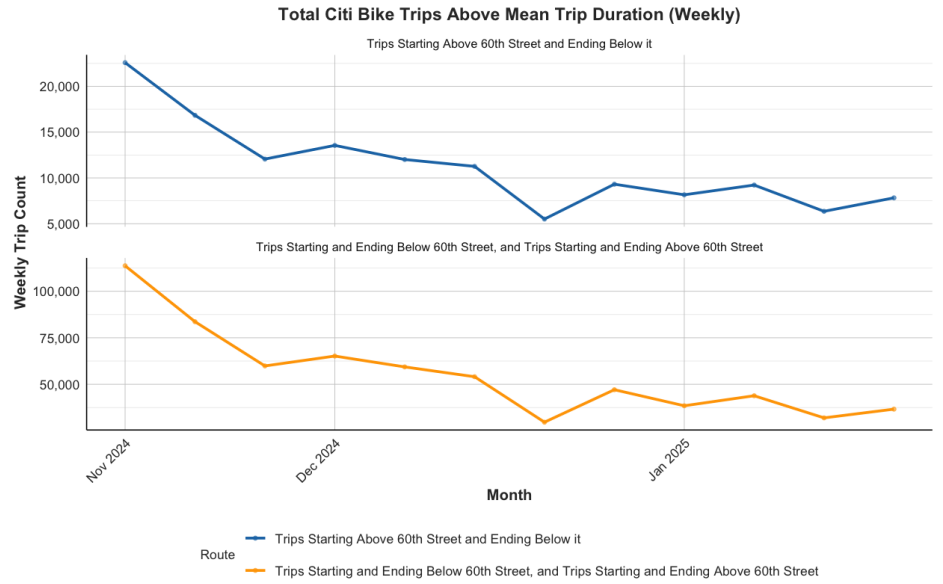


Figure 4: Comparison of Weekly Trip Counts by Route: Trips Starting Above 60th Street and Ending Below 60th Street vs. Trips Starting and Ending Below 60th Street and Trips Starting and Ending Above 60th Street (Including Only Above-Mean Duration Trips)



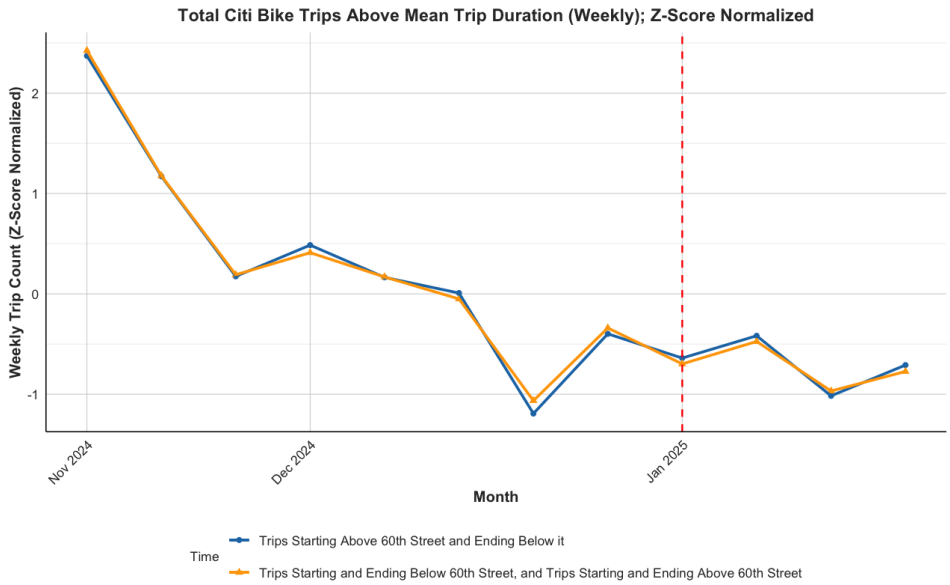


Figure 5: Comparison of Manhattan Trips Starting in Zone 2 and Ending in Zone 3 With Trips Starting in Zone 4 and Ending in Zone 3 (Only Below-Mean Duration Rides)

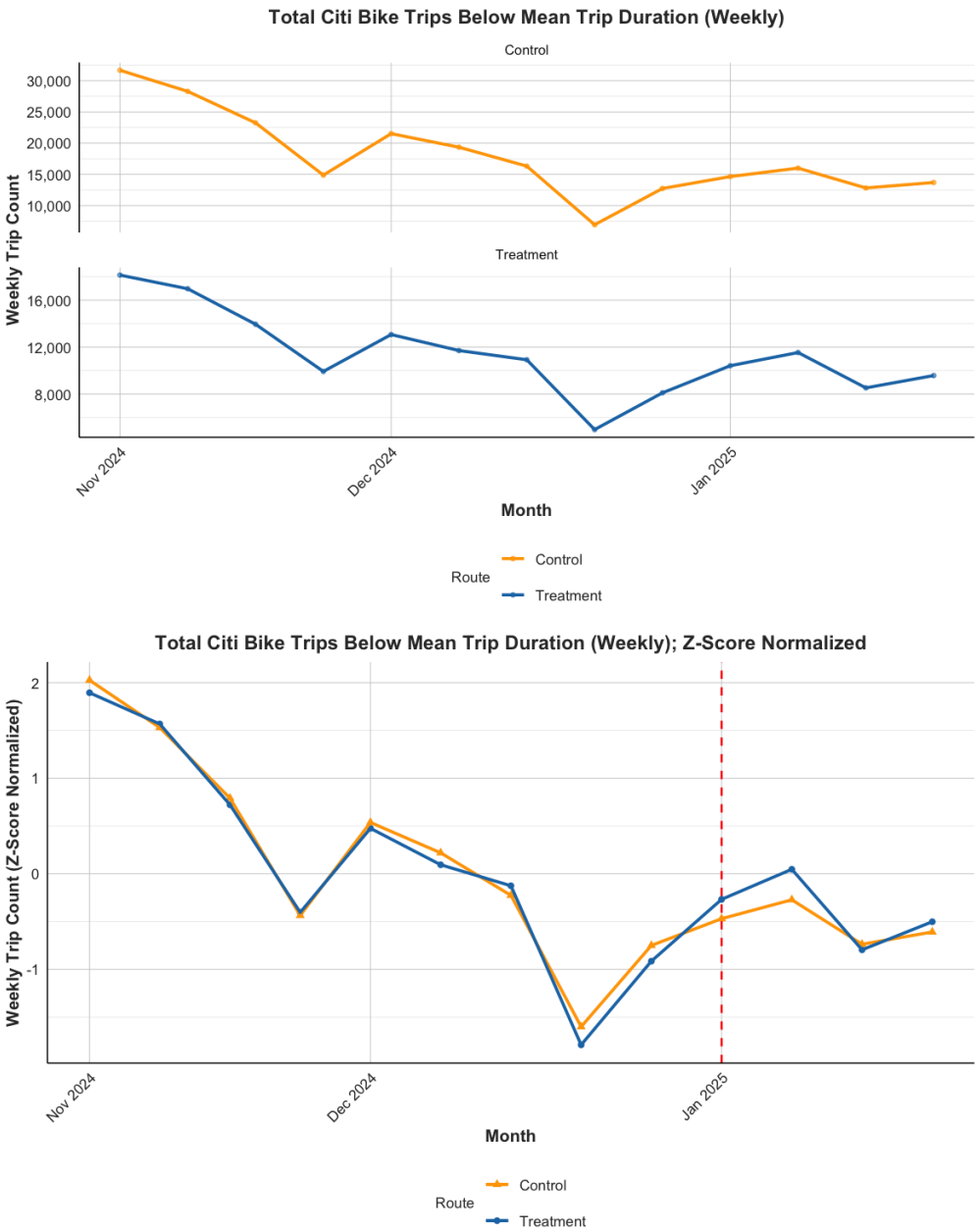


Figure 6: Comparison of Manhattan Trips Starting in Zone 2 and Ending in Zone 3 With Trips Starting in Zone 4 and Ending in Zone 3 (Only Above-Mean Duration Rides)

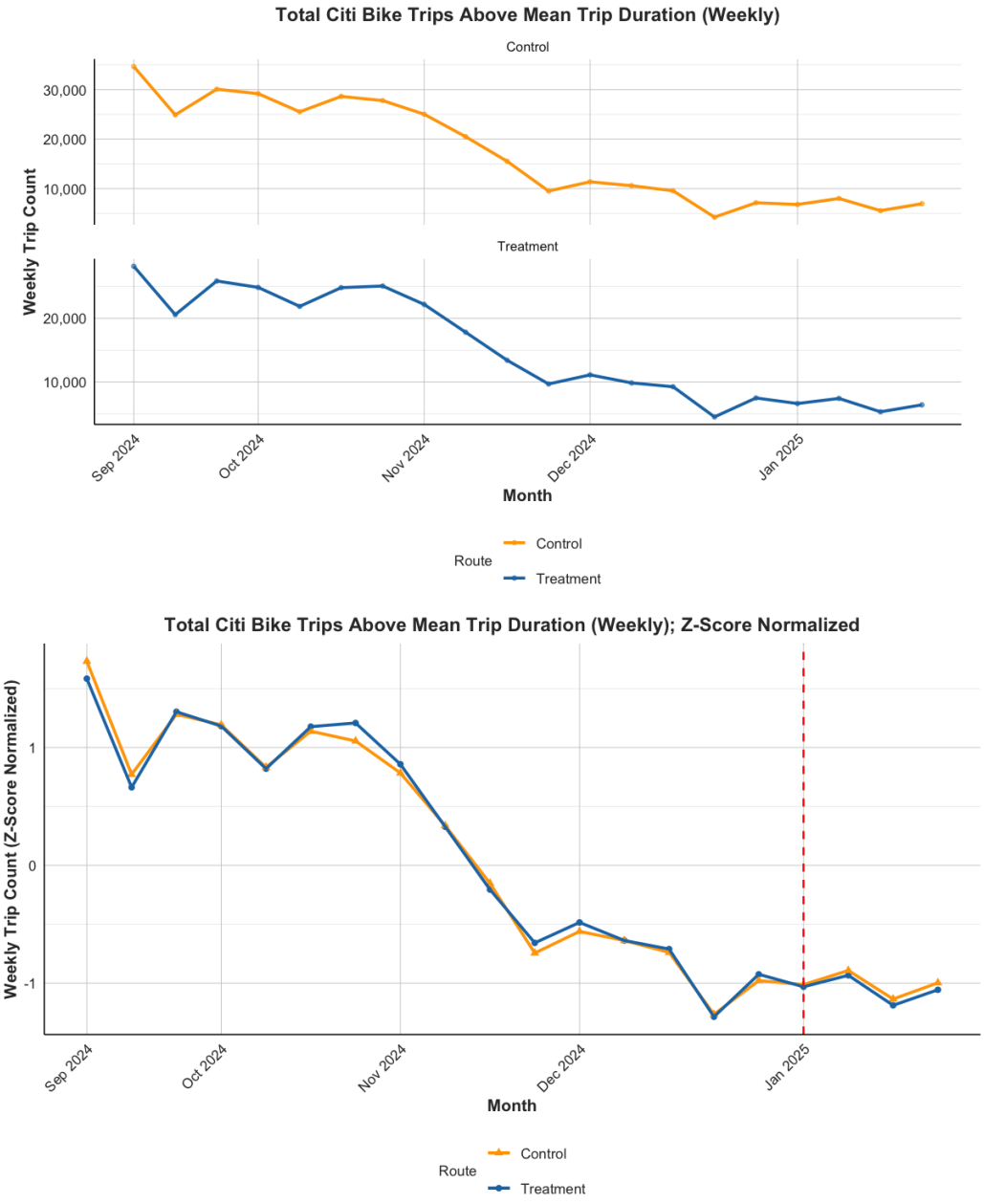


Figure 7: Comparison of Manhattan Trips Starting in Zone 2 and Ending in Zone 3 With Trips Starting in Zone 4 and Ending in Zone 3; (Only Below-Mean Duration Trips and Conventional Bike Rides Included)

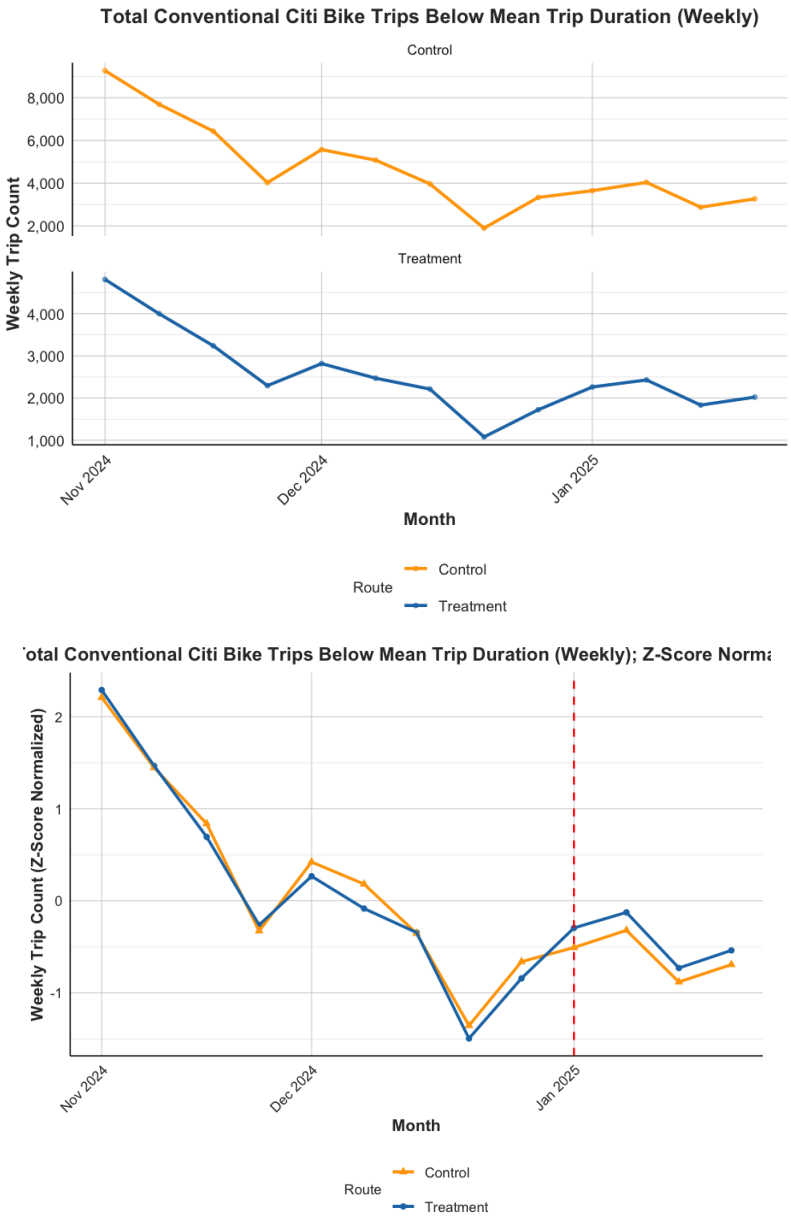
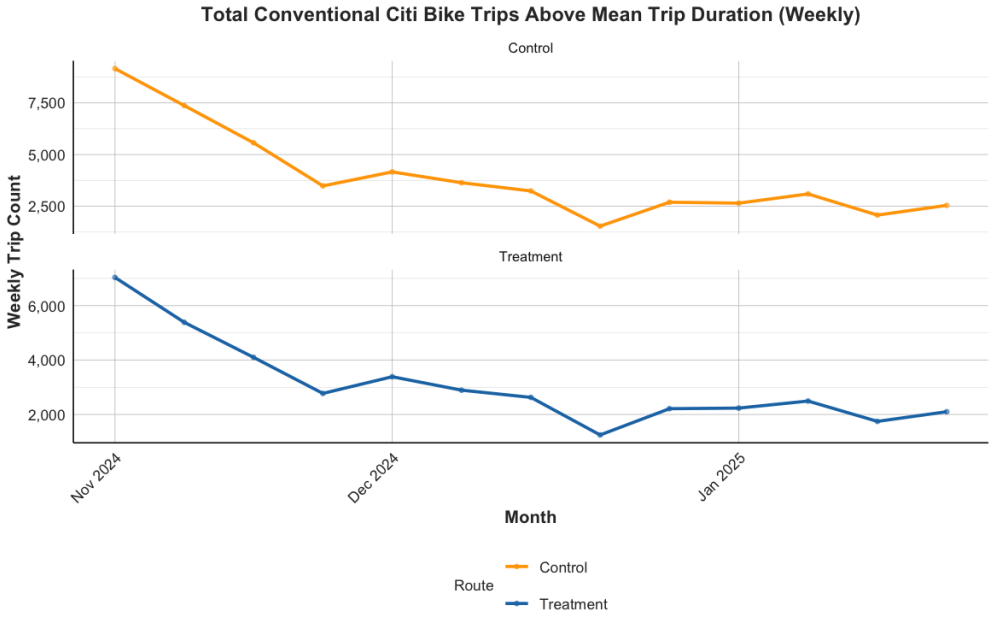


Figure 8: Comparison of Manhattan Trips Starting in Zone 2 and Ending in Zone 3 With Trips Starting in Zone 4 and Ending in Zone 3 (Only Above-Mean Duration Trips and Conventional Bike Rides Included)



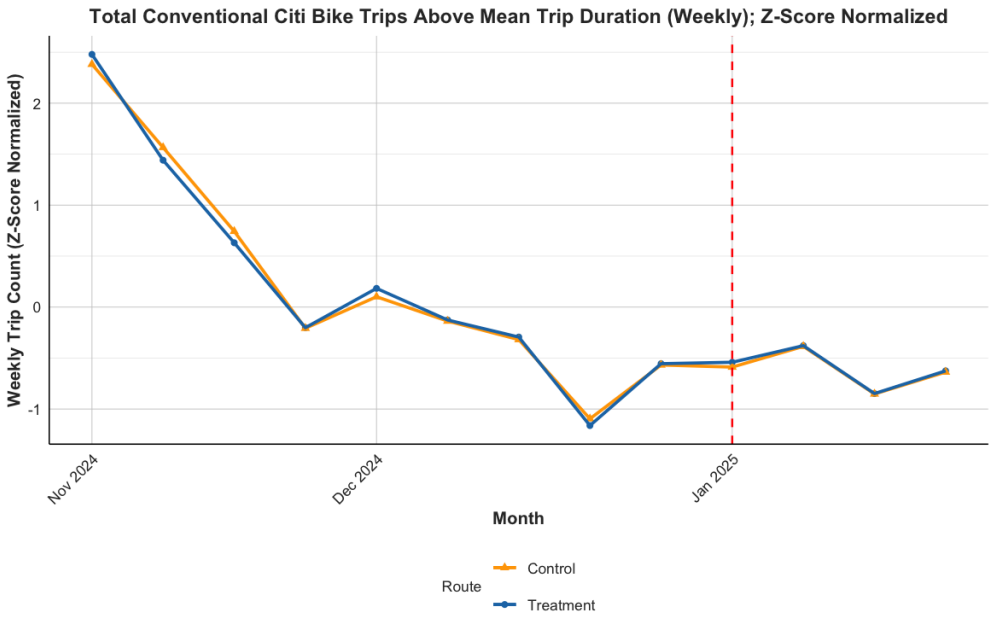
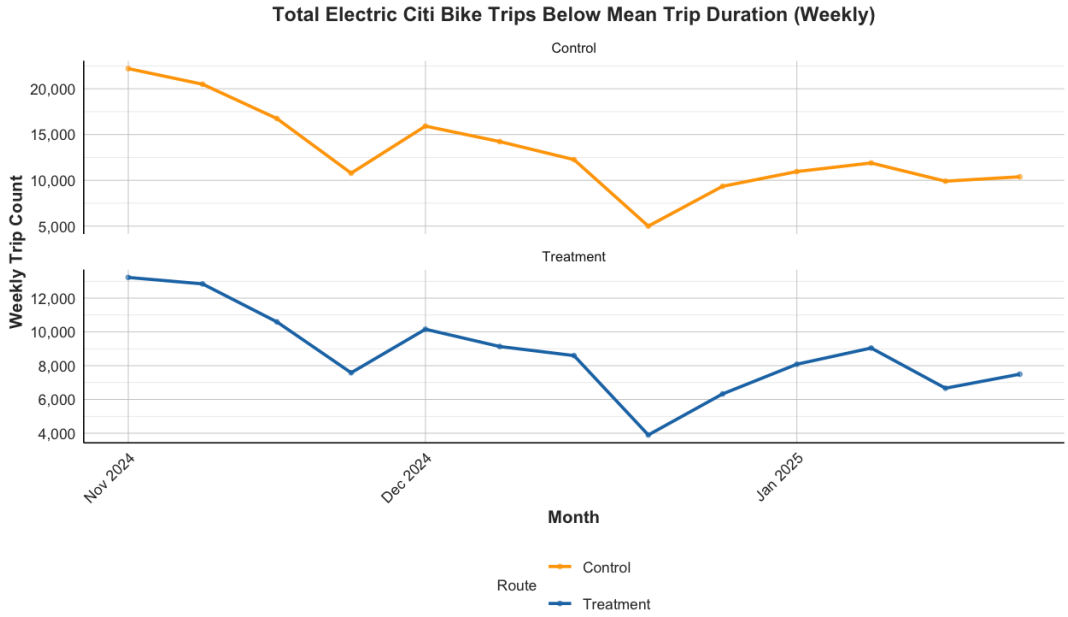


Figure 9: Comparison of Manhattan Trips Starting in Zone 2 and Ending in Zone 3 With Trips Starting in Zone 4 and Ending in Zone 3 (Only Below-Mean Duration Trips and Electric Bike Rides Included)



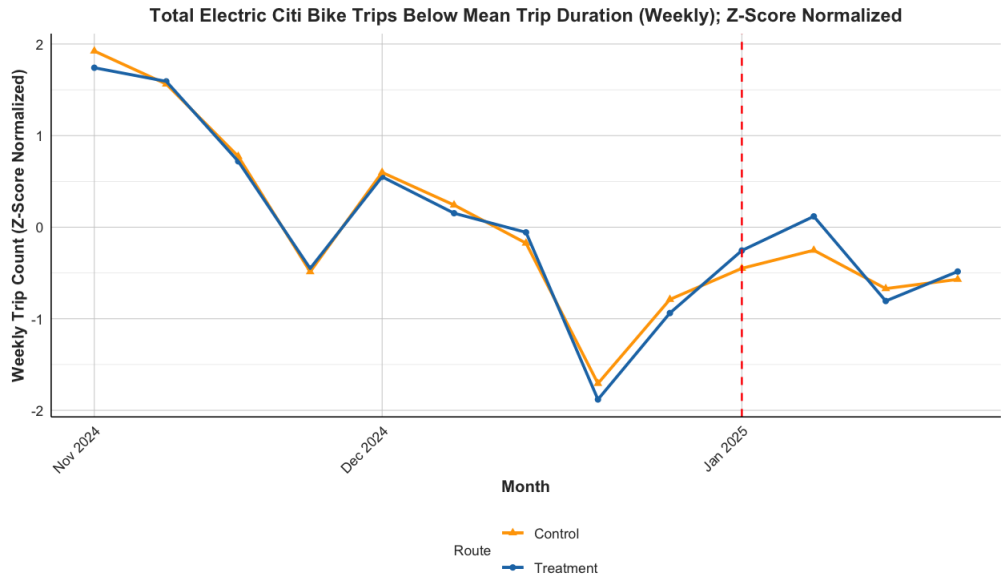


Figure 10: Comparison of Manhattan Trips Starting in Zone 2 and Ending in Zone 3 With Trips Starting in Zone 4 and Ending in Zone 3 (Only Above-Mean Duration Trips and Electric Bike Rides Included)

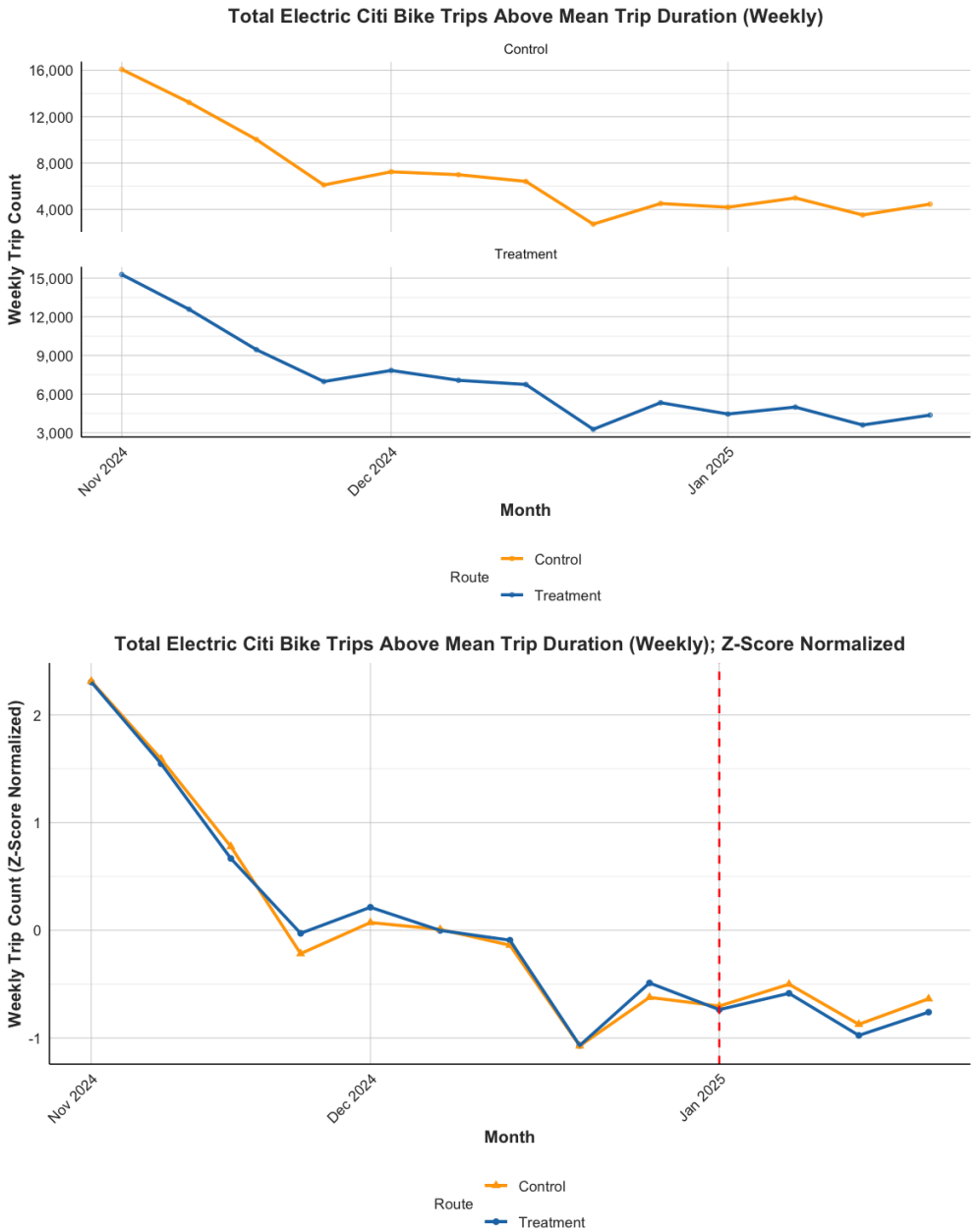


Figure 11: 7-9 PM Trips vs 9-11 PM Trips Starting in Zone 2 and Ending in Zone 3; Only Below-Mean Trip Duration Trips Included

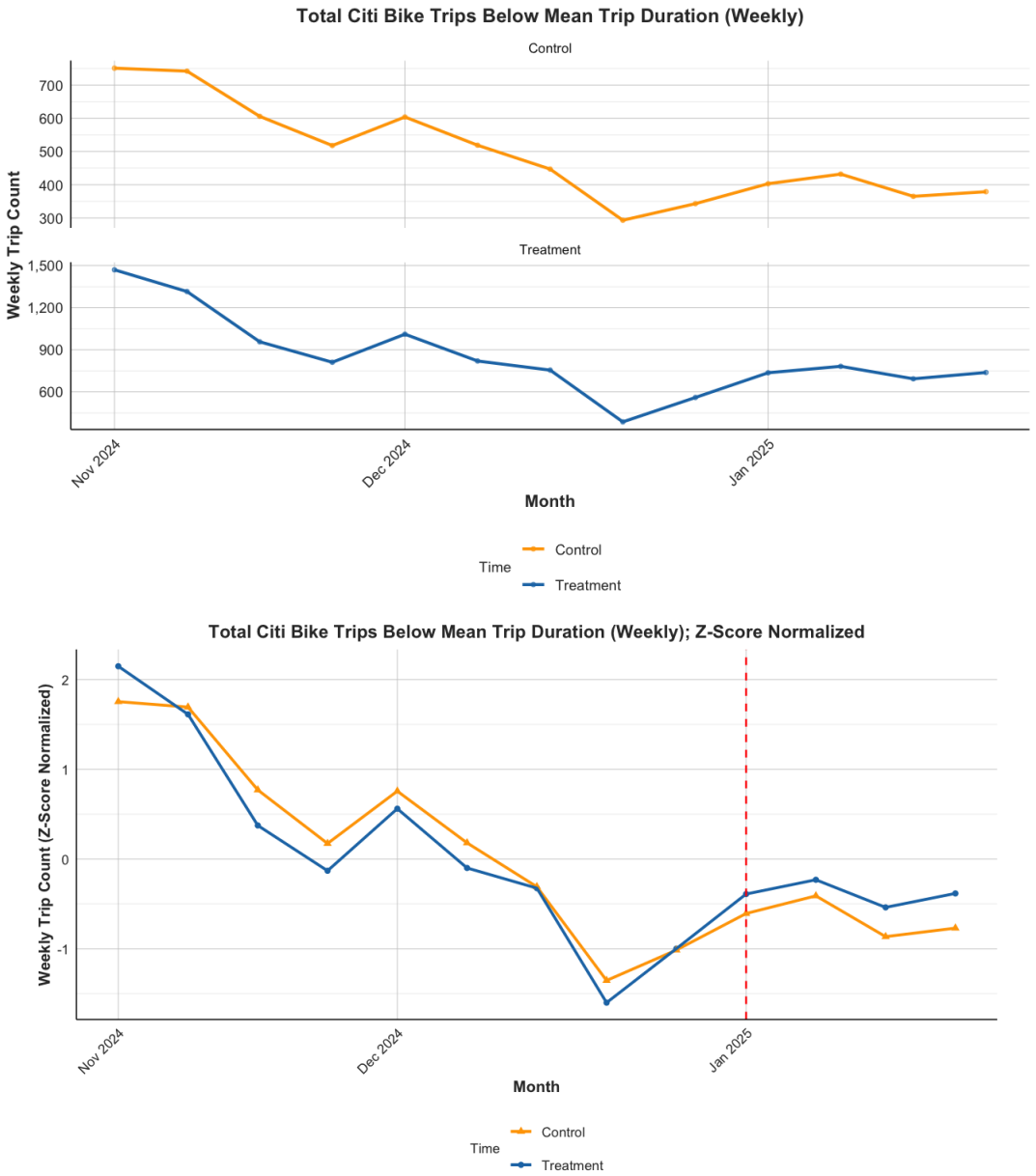


Figure 12: 7-9 PM Trips vs 9-11 PM Trips Starting in Zone 2 and Ending in Zone 3; Only Above-Mean Trip Duration Trips Included

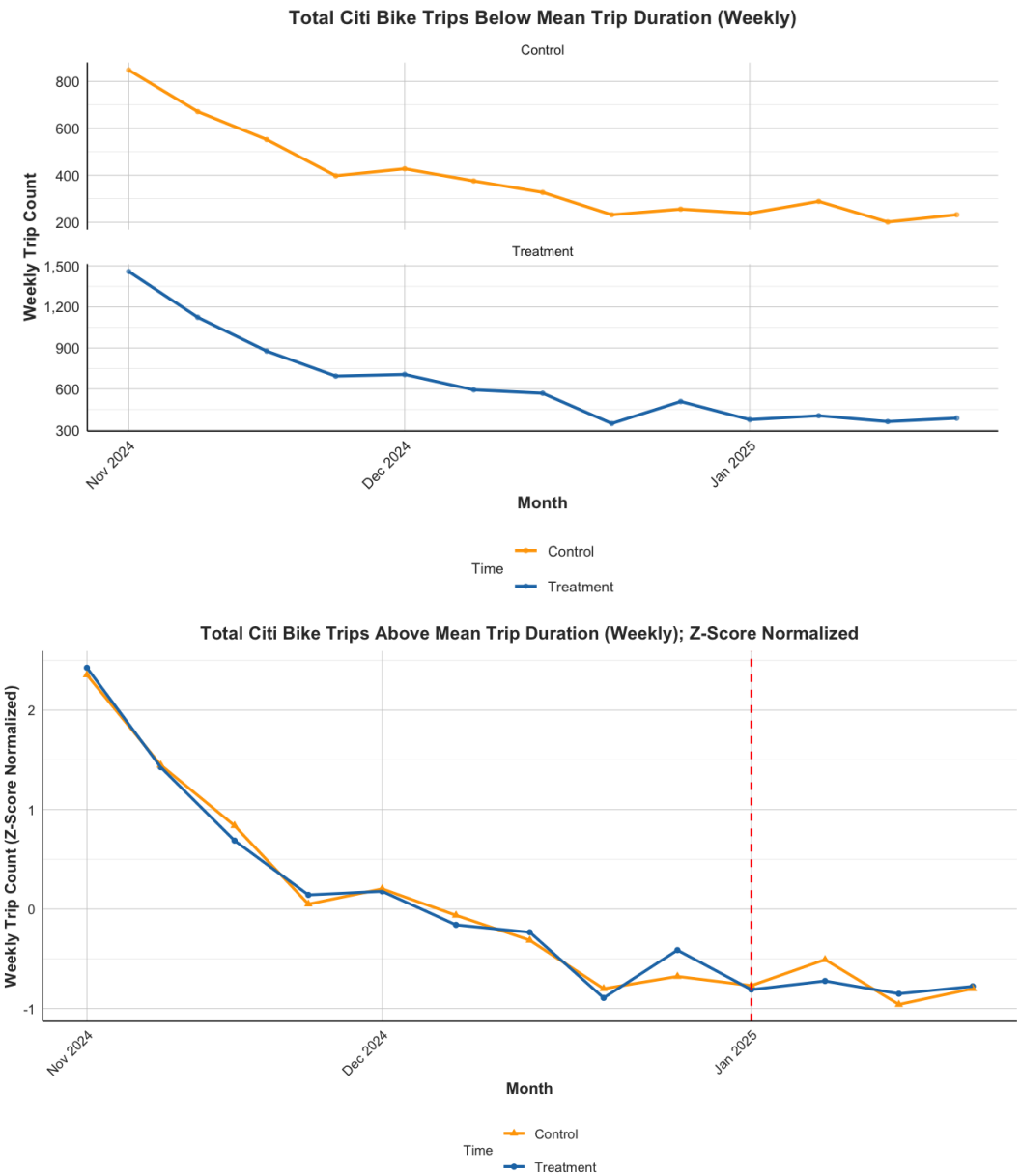


Figure 13: Comparison of Manhattan Trips Starting Above 60th Street and Ending Below it With Trips Starting Below 60th Street and Ending Above it

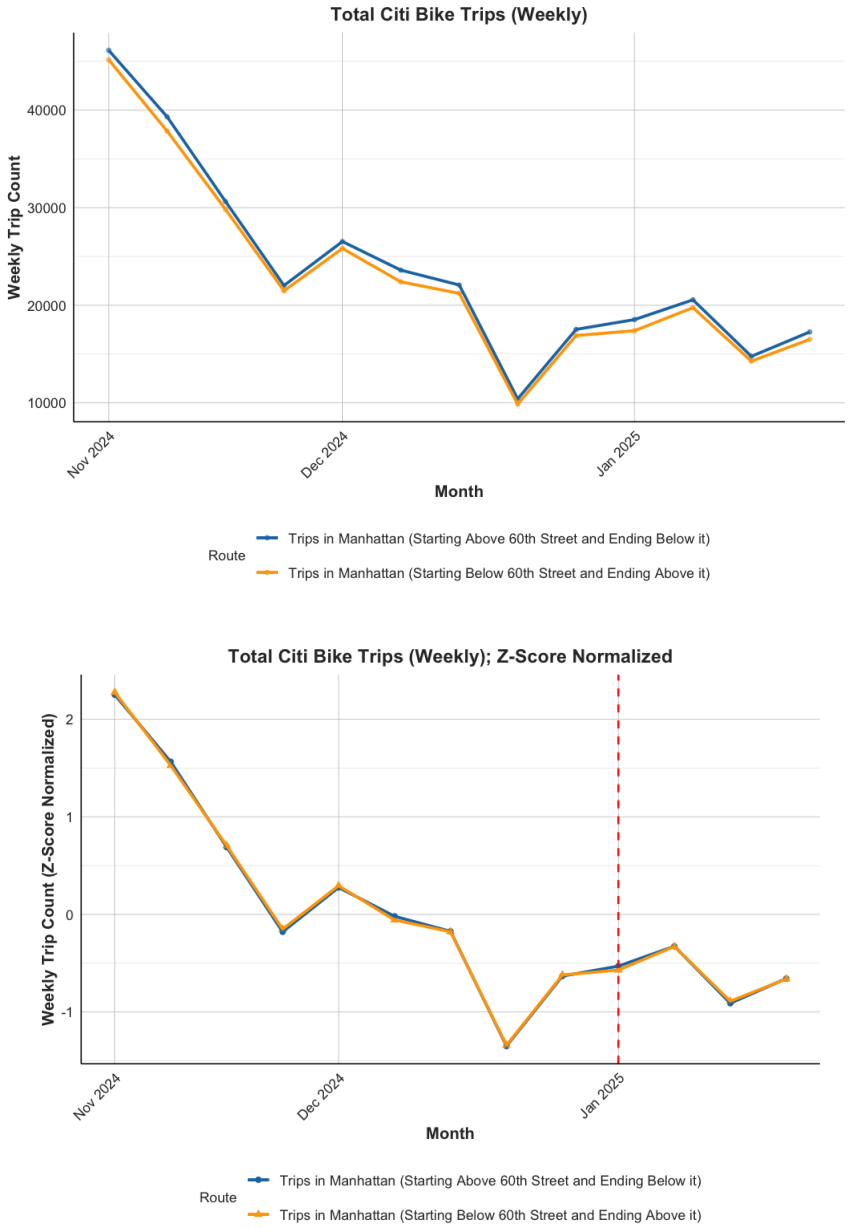
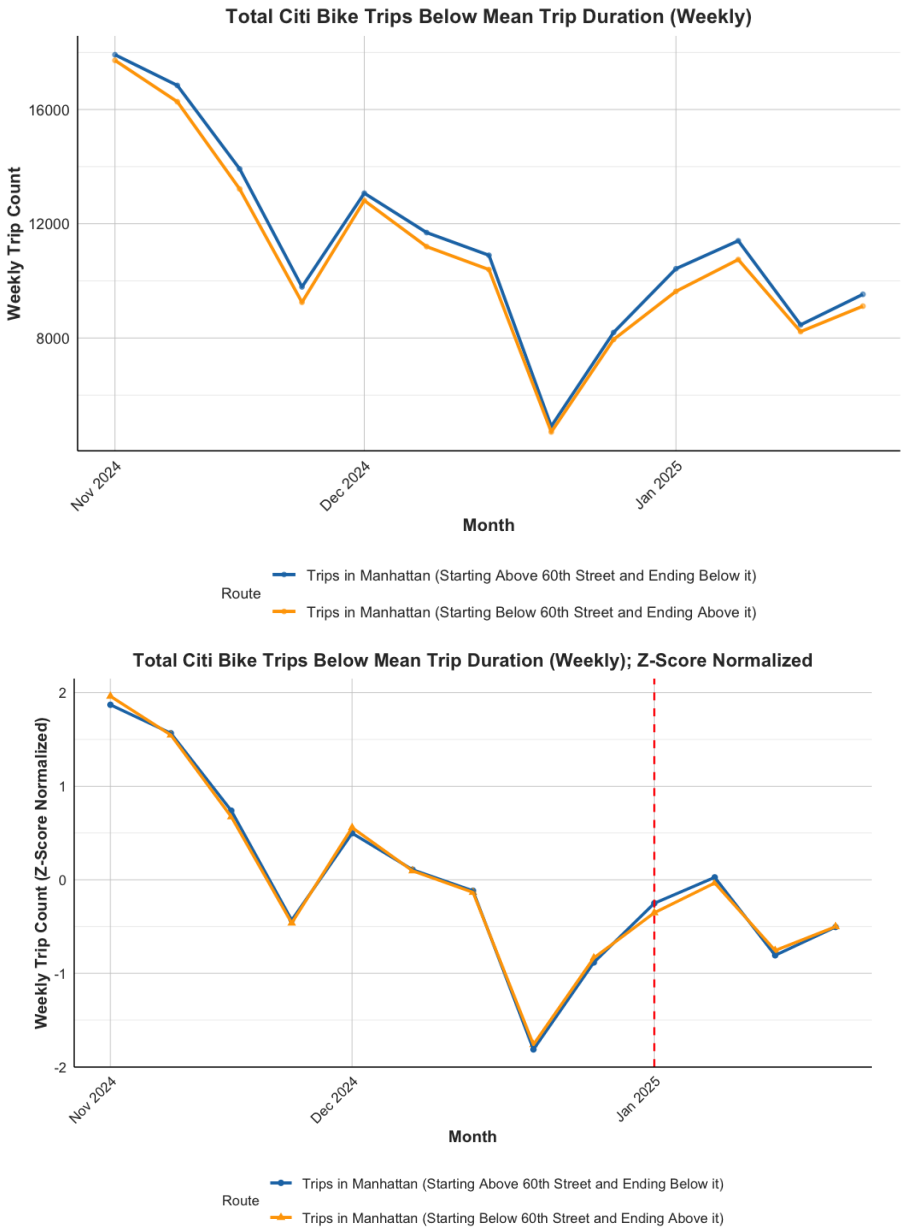


Figure 14: Comparison of Manhattan Trips Starting Above 60th Street and Ending Below it With Trips Starting Below 60th Street and Ending Above it (Only Below-Mean Duration Trips)



6 Tables

Table 1: Comparison of Manhattan Trips Starting in Zone 2 and Ending in Zone 3 With Trips Starting in Zone 4 and Ending in Zone 3 (Only Below-Mean Duration Rides)

Dependent Variable:	log(Count)		
Model:	(1)	(2)	(3)
Variables			
Constant	7.829***		
	(0.0605)		
Post	-0.1600		
	(0.1139)		
Route	-0.4899***	-0.4899***	-0.6005***
	(0.0856)	(0.0208)	(0.0630)
Post × Route	0.1148	0.1148*	0.1100***
	(0.1610)	(0.0448)	(0.0217)
Fixed-effects			
Date of Start		Yes	Yes
Time of Start			Yes
Fit statistics			
Observations	184	184	4,390
R^2	0.18896	0.97313	0.83062
Within R^2		0.87114	0.21644

Signif. Codes: ***: 0.001, **: 0.01, *: 0.05

Table 2: Comparison of Manhattan Trips Starting in Zone 2 and Ending in Zone 3 With Trips Starting in Zone 4 and Ending in Zone 3 (Only Above-Mean Duration Rides)

Dependent Variable:	log(Count)		
Model:	(1)	(2)	(3)
Variables			
Constant	7.328***		
	(0.0750)		
Post	-0.4185**		
	(0.1412)		
Route	-0.0473	-0.0473***	-0.1863*
	(0.1061)	(0.0134)	(0.0673)
Post × Route	-0.0080	-0.0080	0.0167
	(0.1996)	(0.0174)	(0.0358)
Fixed-effects			
Date of Start		Yes	Yes
Time of Start			Yes
Fit statistics			
Observations	184	184	4,306
R^2	0.09193	0.99426	0.81969
Within R^2		0.21174	0.02156

Signif. Codes: ***: 0.001, **: 0.01, *: 0.05

Table 3: Comparison of Manhattan Trips Starting in Zone 2 and Ending in Zone 3 With Trips Starting in Zone 4 and Ending in Zone 3 (Only Below-Mean Duration Conventional Bike Rides)

Dependent Variable:	log(Count)		
Model:	(1)	(2)	(3)
Variables			
Constant	6.507***		
	(0.0644)		
Post	-0.2620*		
	(0.1212)		
Route	-0.6586***	-0.6586***	-0.6887***
	(0.0911)	(0.0158)	(0.0487)
Post × Route	0.1709	0.1709***	0.2184***
	(0.1713)	(0.0396)	(0.0349)
Fixed-effects			
Date of Start		Yes	Yes
Time of Start			Yes
Fit statistics			
Observations	184	184	4,057
R^2	0.27367	0.98577	0.81547
Within R^2		0.94744	0.25738

Signif. Codes: ***: 0.001, **: 0.01, *: 0.05

Table 4: Comparison of Manhattan Trips Starting in Zone 2 and Ending in Zone 3 With Trips Starting in Zone 4 and Ending in Zone 3 (Only Above-Mean Duration Conventional Bike Rides)

Dependent Variable:	log(Count)		
Model:	(1)	(2)	(3)
Variables			
Constant	6.301***		
	(0.0777)		
Post	-0.3626*		
	(0.1462)		
Route	-0.2416*	-0.2416***	-0.3134***
	(0.1099)	(0.0127)	(0.0478)
Post × Route	0.0512	0.0512*	0.0172
	(0.2067)	(0.0233)	(0.0316)
Fixed-effects			
Date of Start		Yes	Yes
Time of Start			Yes
Fit statistics			
Observations	184	184	3,939
R^2	0.08469	0.99401	0.77639
Within R^2		0.83639	0.05987

Signif. Codes: ***: 0.001, **: 0.01, *: 0.05

Table 5: Comparison of Manhattan Trips Starting in Zone 2 and Ending in Zone 3 With Trips Starting in Zone 4 and Ending in Zone 3 (Only Below-Mean Duration Electric Bike Rides)

Dependent Variable:	log(Count)		
Model:	(1)	(2)	(3)
Variables			
Constant	7.511***		
	(0.0597)		
Post	-0.1233		
	(0.1124)		
Route	-0.4391***	-0.4391***	-0.5581***
	(0.0845)	(0.0237)	(0.0674)
Post × Route	0.0944	0.0944	0.0902**
	(0.1589)	(0.0482)	(0.0256)
Fixed-effects			
Date of Start		Yes	Yes
Time of Start			Yes
Fit statistics			
Observations	184	184	4,385
R^2	0.16081	0.96471	0.81050
Within R^2		0.81601	0.18659

Signif. Codes: ***: 0.001, **: 0.01, *: 0.05

Table 6: Comparison of Manhattan Trips Starting in Zone 2 and Ending in Zone 3 With Trips Starting in Zone 4 and Ending in Zone 3 (Only Above-Mean Duration Electric Bike Rides)

Dependent Variable:	log(Count)		
Model:	(1)	(2)	(3)
Variables			
Constant	6.894***		
	(0.0742)		
Post	-0.4493**		
	(0.1395)		
Route	0.0474	0.0474**	-0.0727
	(0.1049)	(0.0151)	(0.0621)
Post × Route	-0.0280	-0.0280	0.0138
	(0.1973)	(0.0194)	(0.0316)
Fixed-effects			
Date of Start		Yes	Yes
Time of Start			Yes
Fit statistics			
Observations	184	184	4,269
R^2	0.11017	0.99274	0.79363
Within R^2		0.12887	0.00305

Signif. Codes: ***: 0.001, **: 0.01, *: 0.05

Table 7: 7-9 PM Trips vs 9-11 PM Trips Starting in Zone 2 and Ending in Zone 3; Only Below-Mean Trip Duration Trips Included

Dependent Variable:	log(Count)		
Model:	(1)	(2)	(3)
Variables			
Constant	4.256***		
	(0.0608)		
Post	-0.1966		
	(0.1143)		
Time	0.4748***	0.4748***	
	(0.0859)	(0.0314)	
Post × Time	0.1253	0.1253*	0.1344**
	(0.1616)	(0.0556)	(0.0368)
Fixed-effects			
Date of Start		Yes	Yes
Time of Start			Yes
Fit statistics			
Observations	184	184	735
R^2	0.22580	0.95057	0.81817
Within R^2		0.81235	0.01167

Signif. Codes: ***: 0.001, **: 0.01, *: 0.05

Table 8: 7-9 PM Trips vs 9-11 PM Trips Starting in Zone 2 and Ending in Zone 3; Only Above-Mean Trip Duration Trips Included

Dependent Variable:	log(Count)		
Model:	(1)	(2)	(3)
Variables			
Constant	4.009***		
	(0.0771)		
Post	-0.4900***		
	(0.1451)		
Time	0.5314***	0.5314***	
	(0.1091)	(0.0368)	
Post × Time	-0.0655	-0.0655	-0.0561
	(0.2052)	(0.0638)	(0.0638)
Fixed-effects			
Date of Start		Yes	Yes
Time of Start			Yes
Fit statistics			
Observations	184	184	735
R^2	0.24012	0.95935	0.82534
Within R^2		0.76253	0.00134

Signif. Codes: ***: 0.001, **: 0.01, *: 0.05

Table 9: Comparison of Manhattan Trips Starting Above 60th Street and Ending Below it With Trips Starting Below 60th Street and Ending Above it

Dependent Variable:	log(Count)		
Model:	(1)	(2)	(3)
Variables			
Constant	8.087***		
	(0.0664)		
Post	-0.2579*		
	(0.1249)		
Route	0.0383	0.0383***	-0.0860
	(0.0939)	(0.0075)	(0.0767)
Post × Route	0.0127	0.0127	0.0382
	(0.1767)	(0.0105)	(0.0356)
Fixed-effects			
Date of Start		Yes	Yes
Time of Start			Yes
Fit statistics			
Observations	184	184	4,410
R^2	0.04455	0.99749	0.84669
Within R^2		0.37419	0.00511

Signif. Codes: ***: 0.001, **: 0.01, *: 0.05

Table 10: Comparison of Manhattan Trips Starting Above 60th Street and Ending Below it With Trips Starting Below 60th Street and Ending Above it (Only Below-Mean Duration Trips Considered)

Dependent Variable:	log(Count)		
Model:	(1)	(2)	(3)
Variables			
Constant	7.459***		
	(0.0746)		
Post	-0.4495**		
	(0.1404)		
Route	0.0397	0.0349***	-0.0549
	(0.1056)	(0.0077)	(0.0604)
Post × Route	0.0074	0.0168	0.0231
	(0.1986)	(0.0131)	(0.0278)
Fixed-effects			
Date of Start		Yes	Yes
Time of Start			Yes
Fit statistics			
Observations	184	184	4,376
R^2	0.10168	0.99617	0.83621
Within R^2		0.31430	0.00223

Signif. Codes: ***: 0.001, **: 0.01, *: 0.05

References

Citi Bike (2025). Citi bike trip histories. Accessed on February 08, 2025.

Ding, H., Sze, N., Guo, Y., and Lu, Y. (2023). Effect of the ultra-low emission zone on the usage of public bike sharing in london. Transportation Letters, 15(7):698–706.

Gehrsitz, M. (2017). The effect of low emission zones on air pollution and infant health. Journal of Environmental Economics and Management, 83:121–144.

Holman, C., Harrison, R., and Querol, X. (2015). Review of the efficacy of low emission zones to improve urban air quality in european cities. Atmospheric Environment, 111:161–169.

Malina, C. and Scheffler, F. (2015). The impact of low emission zones on particulate matter concentration and public health. Transportation Research Part A: Policy and Practice, 77:372–385.

Tarriño-Ortiz, J., Gómez, J., Soria-Lara, J. A., and Vassallo, J. M. (2022). Analyzing the impact of low emission zones on modal shift. Sustainable Cities and Society, 77:103562.