VMT Reduction from Bike Lanes

New York City Department of Transportation
February 2024

An important benefit of the expansion of New York City's bike lane network is that it supports a shift from vehicle travel to biking, with a corresponding reduction in the negative externalities of vehicular travel. This memo estimates at a citywide level the average reduction in vehicle miles traveled (VMT) associated with incremental growth in the City's protected bike lane network since 2005, which can then serve as a basis for estimating societal benefits such as reductions in greenhouse gas emissions.

Methodology

To estimate the reduction in VMT from each incremental mile of protected bike lanes in New York City, we first look at the historical relationship between the size of the network and bicycle ridership. We assume there is a causal relationship: a larger network attracts more New Yorkers to bicycling. Next, we estimate the share of new bike trips that substitute for vehicle trips, and thus result in mode shift. Finally, we estimate the average length in miles of the avoided vehicle trips. Combining these estimates, we calculate the VMT reduction associated with each incremental mile of protected bike lane.

Estimating the impact of each additional bike-lane-mile of on bicycling

The most robust estimate of bicycle ridership in New York City comes from the American Community Survey (ACS), which annually estimates the share of commute trips by bike. The ACS estimates date to 2005, with a gap in data in 2020. Other sources of bicycling, such as the Department of Health and Mental Hygiene's Community Health Survey and DOT's Citywide Mobility Survey, have a shorter history with more interruptions.

Figure 1 plots the ACS history for New York City against the size of the City's protected bike lane network. Both grow at a very steady rate during this period, except in the early 2010s when ridership grows notably faster. A likely explanation for this upshift is the introduction of Citi Bike in 2013. Citi Bike provided a new option for New Yorkers in the Citi Bike zone who were willing to bike but did not own a bike or did not have secure bike parking.

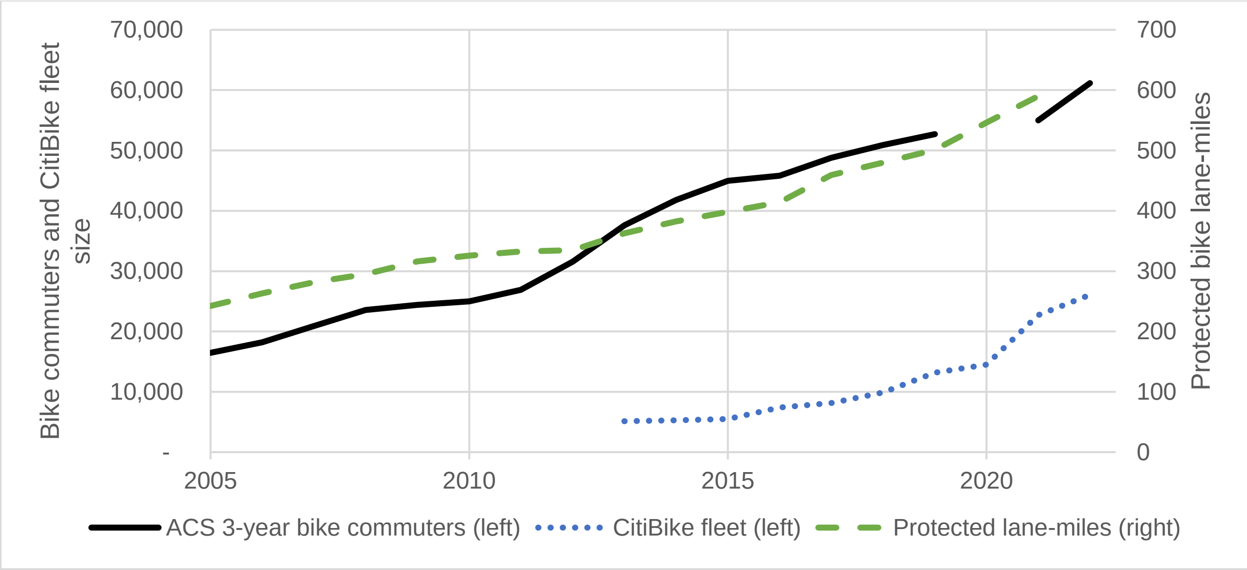

Figure 1: Bike commuters, protected lane-miles, and Citi Bike fleet data for NYC, 2005-2022

A simple regression model of ACS trips, with bike lane mileage and the existence of Citi Bike produces a very strong fit, with an R^2 of 0.98. Figure 2 compares actual and model-predicted bike commute trips. Figure 3 presents the regression diagnostics.

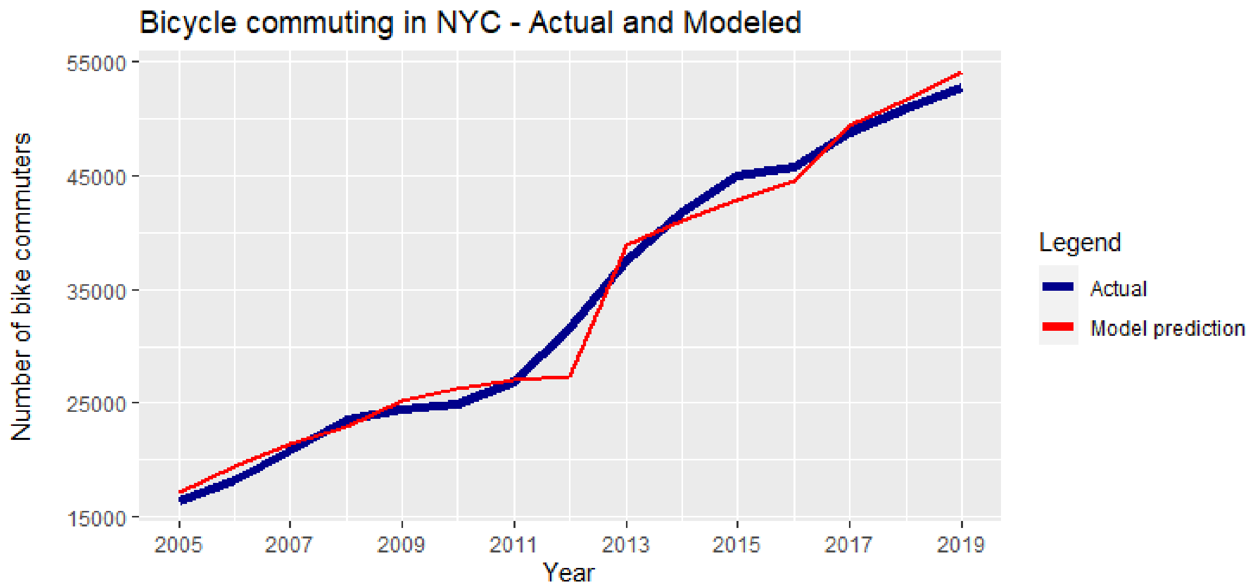

Figure 2: Bicycle commuting in NYC - Actual and Modeled

```
Coefficients:
                        Estimate    Std. Error  t value   Pr(>|t|)
(Intercept)        -9358.6322830  3321.1574871 -2.81788  0.0155208 *
LaneMiles            109.5007144    10.9247303 10.02320 3.4928e-07 ***
CitiBikeExistsTRUE  8543.8427760  1667.8981183  5.12252  0.0002522 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1711.9478 on 12 degrees of freedom
Multiple R-squared:  0.984401502,      Adjusted R-squared:  0.981801752
F-statistic: 378.652419 on 2 and 12 DF,  p-value: 1.44044505e-11
```

Figure 3: Result of the regression model

Based on the regression model, we estimate that each additional bike lane mile results in an additional 110 daily bike commutes. Since each commuter takes two trips – to and from their destination – that indicates the total would be approximately 220 more commute trips taken on bike versus other modes. This estimate is based on the change in bicycle trips to work over time, which coincides with an increase in bike lane miles.

NYC DOT generally estimates that commute trips by bike represent one fifth of all bike trips in the city (Cycling in the City, 2021). DOT's most recent Citywide Mobility Survey confirms that estimate, as 9% of bike trips in 2022 were to a workplace; doubling that gives the share of trips that are commute trips. As with Cycling in the City, we take a conservative approach and assume that commute trips actually represent 20% of all trips. Therefore, we expect the total daily additional cycling trips for each additional bike lane to be 1,100 trips. Note that this estimate ignores trips by non-residents, who would generally not be making commute trips, and thus is likely an under-estimate of total bike trips.

Mode shift

Next, we need to estimate the share of new bike trips that would have been taken by vehicles. We begin by consulting DOT's latest Citywide Mobility Survey (CMS), which recorded tens of thousands of trips by New York City residents in the fall of 2022. We develop a model of mode shift by assuming that if people had not made a bike trip, they would have used another mode in the same proportion that New Yorkers used those other modes for trips of the same distance as the new bike trip.

Approximately 75% of bike trips recorded in the 2022 CMS are less than 2 miles, with a weighted mean and median of 1.7 and 1.5 miles, respectively. Note that about 8% of all bike trips are for recreational purposes; some of these might be to recreational destinations and replace trips on other modes, but in other cases the travel on the bike might be recreational. Because we can't distinguish between these two cases, we don't make any special assumptions about recreational trips. This could result in slightly overstating diversion from other modes.

Table 1: Characteristics of bike trips in CMS 2022

Bike Trip distance	Trips counts in survey	7-day weight	Share	Bike Distance (miles)	
				Mean	Median
[0,0.5)	294	227,304	27%	0.3	0.3
[0.5,1)	296	188,749	23%	0.7	0.8
[1,2)	379	216,802	26%	1.4	1.4
[2,5)	418	144,587	17%	3.3	3.1
[5,10)	201	44,109	5%	6.6	6.3
10 or more	40	9,183	1%	12.8	11.9
Total	*1,628*	*830,734*	*100%*	*1.6*	*1.5*

Using similar distance ranges, we tabulate non-bike modes within each range. We assume that bike trips replace modes in proportion to the current modes of travel for each distance traveled. For example, if 54% of 1-2 miles non-bike trips rely on autos, then 54% of new bike trips with 1-2 miles would have been auto trips, i.e., 54% multiplied by the share of bike trips with a distance of 1-2 miles.

Table 2 presents the share of existing unlinked non-bike trips by distance. As expected, when trip length increases, the percentage of trips made by autos increases while the percentage of trips made by walking and taking the bus decreases.

Table 2: Share of non-bike trips at each trip distance

Trip distance	Walk	Bus	Rail		Vehicle			Other		
			Commuter Rail	Subway	Vehicle	FHV	FHV TNC	Micromobility	Ferry	Other
[0,0.5)	86.2%	1.1%	0.0%	1.4%	10.2%	0.0%	0.2%	0.2%	0.0%	0.5%
[0.5,1)	54.6%	6.7%	0.3%	7.6%	29.4%	0.6%	0.4%	0.1%	0.0%	0.3%
[1,2)	18.7%	8.5%	0.1%	16.3%	50.9%	1.1%	2.3%	1.5%	0.3%	0.4%
[2,5)	5.5%	10.2%	0.4%	30.8%	47.0%	1.0%	3.6%	0.4%	0.5%	0.6%
[5,10)	1.2%	4.1%	1.5%	43.4%	42.9%	0.2%	4.0%	0.0%	1.6%	1.1%
10 or more	0.2%	7.6%	3.7%	19.2%	62.6%	0.0%	3.8%	0.1%	1.5%	1.2%

Using bike trip shares at each trip distance, we can estimate the shift from non-bike modes, resulting in a 36% shift from vehicle modes. We took a further step to focus on Manhattan trips, i.e., started or ended in Manhattan (Tables 4-6) and estimated a mode shift of 15% from vehicle modes.

Table 3: Share of non-bike trips replacing bike trips

Trip distance	Walk	Bus	Rail		Vehicle			Other		
			Commuter Rail	Subway	Vehicle	FHV	FHV TNC	Micromobility	Ferry	Other
[0,0.5)	23.6%	0.3%	0.0%	0.4%	2.8%	0.0%	0.1%	0.1%	0.0%	0.1%
[0.5,1)	12.4%	1.5%	0.1%	1.7%	6.7%	0.1%	0.1%	0.0%	0.0%	0.1%
[1,2)	4.9%	2.2%	0.0%	4.2%	13.3%	0.3%	0.6%	0.4%	0.1%	0.1%
[2,5)	1.0%	1.8%	0.1%	5.4%	8.2%	0.2%	0.6%	0.1%	0.1%	0.1%
[5,10)	0.1%	0.2%	0.1%	2.3%	2.3%	0.0%	0.2%	0.0%	0.1%	0.1%
10 or more	0.0%	0.1%	0.0%	0.2%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	41.9%	6.1%	0.3%	14.3%	33.9%	0.6%	1.6%	0.5%	0.3%	0.5%
Vehicle trips					36.1%					

Manhattan trips

Table 4: Characteristics of bike trips in CMS 2022- started or ended in Manhattan

Bike Trip distance	Trips counts in survey	7-day weight	Share	Bike Distance (miles)	
				Mean	Median
[0,0.5)	86	23,746	9%	0.3	0.3
[0.5,1)	114	85,172	34%	0.7	0.7
[1,2)	157	63,829	26%	1.4	1.4
[2,5)	194	47,948	19%	3.4	3.4
[5,10)	127	24,626	10%	6.5	6.2
10 or more	22	4,765	2%	12.0	11.6
Total	*700*	*250,087*	*100%*	*2.2*	*2.0*

Table 5: Share of non-bike trips at each trip distance- started or ended in Manhattan

Trip distance	Walk	Bus	Rail		Vehicle			Other		
			Commuter Rail	Subway	Vehicle	FHV	FHV TNC	Micromobility	Ferry	Other
[0,0.5)	93.2%	1.3%	2.3%	0.0%	2.2%	0.0%	0.4%	0.4%	0.1%	0.0%
[0.5,1)	67.3%	9.1%	13.9%	0.6%	8.1%	0.3%	0.0%	0.1%	0.5%	0.0%
[1,2)	25.0%	11.3%	37.7%	0.3%	10.7%	4.2%	3.7%	5.5%	0.7%	0.8%
[2,5)	6.9%	7.7%	61.0%	0.4%	15.0%	2.8%	3.9%	0.5%	0.8%	1.0%
[5,10)	1.2%	4.3%	67.5%	1.6%	17.1%	0.2%	4.3%	0.1%	1.0%	2.8%
10 or more	0.4%	14.0%	34.0%	8.0%	34.0%	0.1%	4.4%	0.2%	1.8%	3.1%

Table 6: Share of non-bike trips replacing bike trips- Manhattan

Trip distance	Walk	Bus	Rail		Vehicle			Other		
			Commuter Rail	Subway	Vehicle	FHV	FHV TNC	Micromobility	Ferry	Other
[0,0.5)	8.9%	0.1%	0.2%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%
[0.5,1)	22.9%	3.1%	4.7%	0.2%	2.8%	0.1%	0.0%	0.0%	0.2%	0.0%
[1,2)	6.4%	2.9%	9.6%	0.1%	2.7%	1.1%	0.9%	1.4%	0.2%	0.2%
[2,5)	1.3%	1.5%	11.7%	0.1%	2.9%	0.5%	0.8%	0.1%	0.1%	0.2%
[5,10)	0.1%	0.4%	6.6%	0.2%	1.7%	0.0%	0.4%	0.0%	0.1%	0.3%
10 or more	0.0%	0.3%	0.6%	0.2%	0.6%	0.0%	0.1%	0.0%	0.0%	0.1%
Total	40%	8%	34%	1%	11%	2%	2%	2%	1%	1%
Vehicle trips					15%					

Because the bike lane network is most complete in Manhattan, and because (from ACS) we know that bike ridership is highest among Manhattan households, we believe that the Manhattan mode shift better reflects the impact of existing investments, such that historical mode shift has probably been closer to 15% than the citywide estimate of 36%. To the extent that future growth takes place in more auto-dependent parts of the City, mode shift is likely to increase over time.

Other data points

Other studies have provided alternative estimates for mode shift that could facilitate informed decision-making.

- Shared micromobility users reported replacing taxi or ride-hailing, carshare, personal car or truck, motorcycle or moped (personal or shared) for 12.2% of shared e-bike trips in Berlin and 15.6% in Paris.[1]
- A mode shift model by Sobolevsky et al projected the share of Citi Bike trips that replaced trips by private vehicle and taxi, with variations by geography, as shown below [2]:

Deployment areas/periods	Replaced by private vehicle and taxi
Manhattan (2013)	15%
Manhattan (2015)	15%
Brooklyn (2013)	21%
Brooklyn/Queens (2015)	21%

- The 2022 Citywide Mobility Survey asked Citi Bike users what mode they would have used if Citi Bike had not been available. 12.6% of respondents said they would have used a private vehicle, taxi, or for-hire vehicle.

For projections through 2030, we recommend assuming that between 15% and 20% of new bike trips replace trips by automobile.

Estimated reduction in VMT per bike-lane-mile

The next step is to estimate the reduction in VMT per reduced vehicle trip.

Our 2022 CMS found that the average length from origin to destination of bike trips is 1.7 miles. Analysis of a small sample of these trips suggested that the actual driving distance would be 40% longer, giving an avoided driving distance of 2.4 miles.

Putting it all together

Combining these assumptions, we have the following:

- Each additional mile of protected bike lanes results in 1,100 daily bike trips.
- Between 15% and 20% of these trips replace vehicle trips.
- Replaced vehicle trips have an average length of 2.4 miles.

We extrapolate these assumptions over 365 days of the year to arrive at the VMT reductions per bike-lane-mile shown below:

---

[1] Source: The Net Sustainability Impact of Shared Micromobility in Six Global Cities. Konstantin Krauss, Claus Doll, Calvin Thigpen, https://www.isi.fraunhofer.de/content/dam/isi/dokumente/ccn/2022/the_net_sustainability_impact_of_shared_micromobility_in_six_global_cities.pdf

[2] Source: Sobolevsky, S., Levitskaya, E., Chan, H., Postle, M., & Kontokosta, C. (2018). Impact of bike sharing in New York city. arXiv preprint arXiv:1808.06606.

Mode shift assumption	Shift from auto	Annual VMT reduction per bike-lane-mile
Low assumption	15%	143,336
High assumption	20%	191,114

We propose, based on the above, that new bike trips induced by additional protected bike-lane-miles are likely to result in a mode shift of between 15% and 20%, resulting in a reduction of between roughly 140,000 and 190,000 vehicle miles traveled in automobiles.