

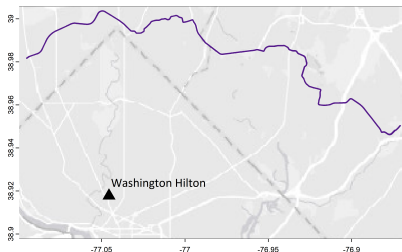
Can Light Rails Provide the Track to Cleaner Air?

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Motivation

The purple line, a new light rail system north of DC, is scheduled to open in late 2027.



Have past light rail openings lead to a decrease in air pollution?

What are Light Rails?

- Light Rails are electric-powered vehicles on dedicated tracks.
- They usually run alongside roads, with dedicated rights-of-way.



Source: charlottenc.gov

Light Rails vs. Subways

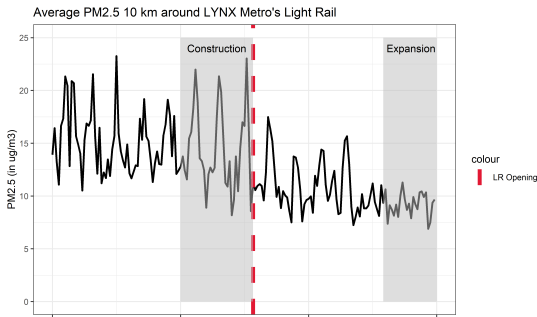
- Light rails have a lower passenger capacity.
- Light rails make more frequent stops.
- Light rails are much cheaper to build.

Literature Review

- Existing studies have found that **subways** systems are effective in reducing air pollution.
 - Chen & Whalley (2012) found that Taipei's Metro System opening reduced CO by 5 to 15 percent.
 - Gendron-Carrier et al. (2022) found that among 58 subway openings globally, only those in highly polluted cities see a 4 percent reduction.
 - Xie et al. (2024) found that 15 subway openings in China reduced PM2.5 by 19 percent.
- Fageda (2021) is the only study that used a quasi-experimental research design to estimate the impact of **light rail** openings across 98 European cities, and found a small reduction of 3 percent.

Hypothesis

- Light rail openings in the US will cause a substitution between people driving their own cars or taking buses to using the light rail, reducing air pollution.
- We expect to see smaller decrease than 3 percent as:
 - The US population drives more cars than Europe.
 - We removed data from light rail construction period, which can increase pollution prior light rail opening, from our analysis.

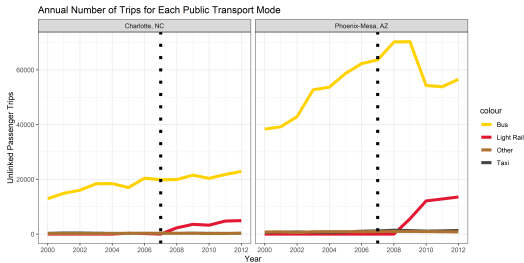
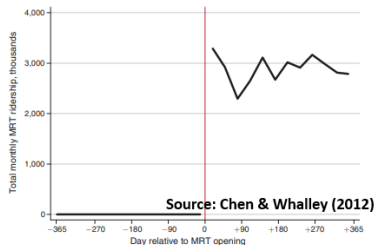


Data

- Daily PM2.5, from the years 2000 to 2016 with 1 km x 1 km grid resolution from Di et al. (2019).
- 47 land surface meteorological variables with 25 km x 25 km grid resolution from NASA GLDAS 2.
- Treated city selection criteria
 - Light rail construction period must start a few years after 2000.
 - Buses were the primary public transit mode before the light rail opened.
- These criteria narrows down to two light rail systems:
 - **Charlotte, NC's LYNX system**, which opened in 2007
 - **Phoenix, AZ's Valley Metro Rail system**, which opened in 2008

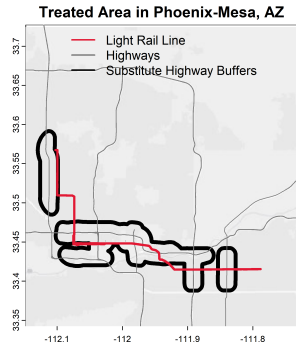
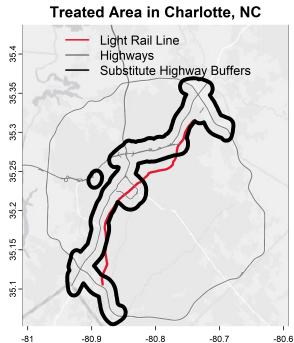
Research Design

- Previous studies on subway's impact on air pollution (Chen and Whalley, 2012; Gendron-Carrier et al., 2022; Xie et al., 2024) used Discontinuity-Based OLS as there was instant uptake in ridership.
- We will use **difference-in-difference** as light rail ridership gradually increased treated cities.



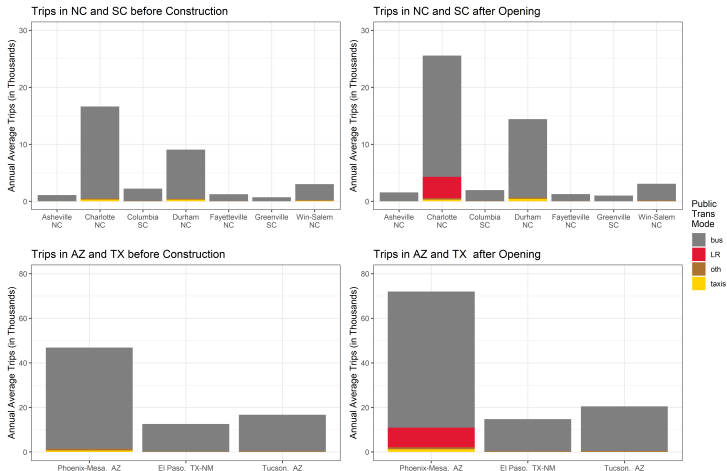
Treated Area

- We indicate potential highways that the light rails serve as a substitute, and draw 1.5 km buffers around each highway.
- We then find the average daily PM_{2.5} and meteorological variables within those areas.



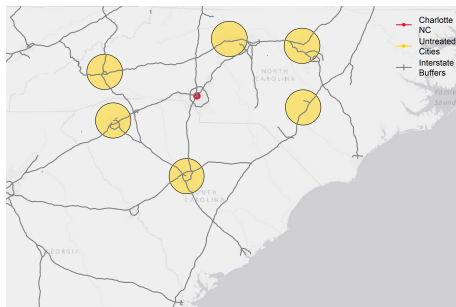
Untreated Area

For each control city, we find cities with no light rails, no subways, and similar public transportation profiles.



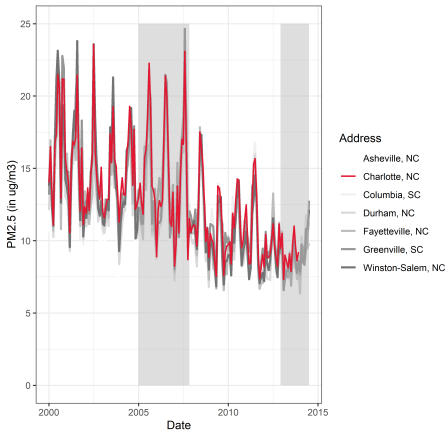
Untreated Area

- For each untreated city, we crop interstates within 30 km radius of each city, and created 1 km buffers around each cropped interstate.
- We then find the daily average PM_{2.5} and meteorology values within each city's interstate buffers.

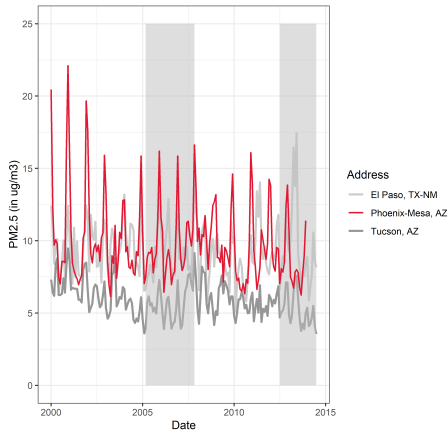


Parallel Trends

PM2.5 in Charlotte its Control Cities



PM2.5 in Phoenix-Mesa its Control Cities



DiD Specification

First, we ran regressions separately for Charlotte, NC and its control cities, and Phoenix-Mesa, AZ and its control cities. Our regression specification is:

$$P_{it} = \gamma(D_i \times Open_t) + W'_{it}\beta + \alpha_i + \mu_{it} + \kappa_t + \epsilon_{it}$$

- where P_{it} are PM2.5 levels (in ug/m3) for each city i and day t .
- D_i is a dummy variable that is equal to one when city i is the city with a light rail system.
- $Open_t = 1$ when the light rail system in the treated city has opened and $Open_t = 0$ before construction has started.
- W_{it} includes 47 meteorological control variables.
- α_i are city fixed effects.
- μ_{it} are day of week-city fixed effects.
- κ_t are month fixed effects.

DiD Results for Two Cities Separately

Treated City Dependent Variable: Model:	Charlotte, NC			Phoenix-Mesa, AZ		
	(1)	(2)	(3)	PM2.5 (4)	(5)	(6)
<i>Variables</i>						
operating	-4.1*** (0.23)	-4.2*** (0.23)	-4.1*** (0.23)	-0.42*** (0.02)	-0.48** (0.09)	-0.43*** (0.02)
operating × treatcity	-0.28 (0.24)	-0.28 (0.24)	-0.28 (0.24)	-0.39** (0.08)	-0.39** (0.07)	-0.39** (0.08)
<i>Fixed-effects</i>						
day of week-month	Yes			Yes		
city	Yes	Yes	Yes	Yes	Yes	Yes
day of week-city		Yes	Yes		Yes	Yes
month			Yes			Yes
Observations	26,194	26,194	26,194	9,867	9,867	9,867
Adjusted R ²	0.34	0.32	0.33	0.32	0.29	0.32

Clustered (Address) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

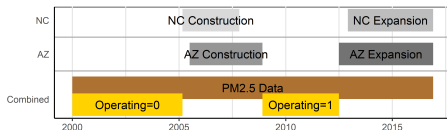
DiD Results for Two Cities Separately

Treated City Dependent Variable:	Charlotte, NC	Phoenix-Mesa, AZ PM2.5
<i>Variables</i>		
operating × dowFriday	-4.1*** (0.20)	-0.57* (0.17)
operating × dowMonday	-4.0*** (0.25)	-0.27* (0.09)
operating × dowSaturday	-4.1*** (0.31)	-0.24 (0.16)
operating × dowSunday	-3.8*** (0.25)	-0.11** (0.02)
operating × dowThursday	-4.2*** (0.21)	-0.72*** (0.02)
operating × dowTuesday	-3.8*** (0.25)	-0.45 (0.20)
operating × dowWednesday	-4.6*** (0.23)	-0.63*** (0.03)
operating × treatcity × dowFriday	-0.28 (0.21)	-0.10 (0.15)
operating × treatcity × dowMonday	0.03 (0.26)	-0.97** (0.14)
operating × treatcity × dowSaturday	-0.16 (0.32)	-0.09 (0.12)
operating × treatcity × dowSunday	-0.09 (0.28)	0.11 (0.08)
operating × treatcity × dowThursday	-0.51* (0.24)	-0.32* (0.08)
operating × treatcity × dowTuesday	-0.35 (0.25)	-0.69* (0.23)
operating × treatcity × dowWednesday	-0.62** (0.25)	-0.63** (0.08)
<i>Fixed-effects</i>		
dow_a	Yes	Yes
Address	Yes	Yes
month	Yes	Yes
Observations	26,194	9,867
Adjusted R ²	0.33	0.32

Clustered (Address) standard-errors in parentheses

Signif. Codes: ***: 0.01, **: 0.05, *: 0.1

DiD with Two Treated Cities Combined



Dependent Variable:	PM2.5		
Model:	(1)	(2)	(3)
<i>Variables</i>			
operating	-3.4*** (0.60)	-3.5*** (0.62)	-3.4*** (0.59)
operating × treatcity	0.65 (1.5)	0.67 (1.5)	0.65 (1.5)
<i>Fixed-effects</i>			
day of week-month	Yes		
day of week-city		Yes	Yes
city	Yes	Yes	Yes
month			Yes
Observations	31,670	31,670	31,670
Adjusted R ²	0.36	0.35	0.36

Clustered (Address) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

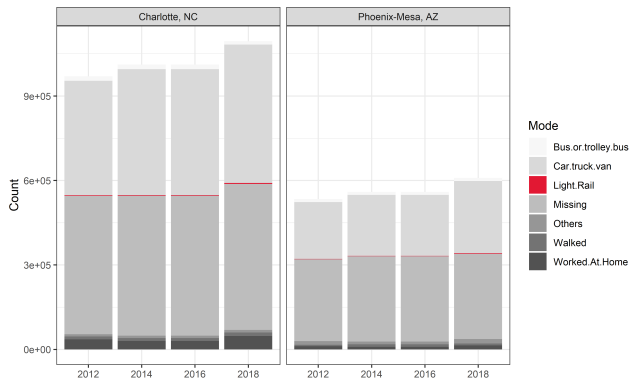
DiD with Two Treated Cities, Each Day of the Week

Dependent Variable: Model:	PM2.5 (1)
<i>Variables</i>	
operating × dowFriday	-3.5*** (0.59)
operating × dowMonday	-3.3*** (0.60)
operating × dowSaturday	-3.5*** (0.67)
operating × dowSunday	-3.2*** (0.60)
operating × dowThursday	-3.6*** (0.55)
operating × dowTuesday	-3.2*** (0.55)
operating × dowWednesday	-3.8*** (0.64)
operating × treatcity × dowFriday	0.81 (1.5)
operating × treatcity × dowMonday	0.53 (1.1)
operating × treatcity × dowSaturday	0.94 (1.6)
operating × treatcity × dowSunday	0.89 (1.6)
operating × treatcity × dowThursday	0.46 (1.5)
operating × treatcity × dowTuesday	0.41 (1.3)
operating × treatcity × dowWednesday	0.47 (1.6)
<i>Fixed-effects</i>	
day of week-city	Yes
city	Yes
month	Yes
Observations	31,670
Adjusted R ²	0.36

Clustered (Address) standard-errors in parentheses
*Signif. Codes: ***, 0.01, **, 0.05, *, 0.1*

Results Summary

- Although we found reductions on weekdays when analyzing the two cities separately, we do not see the same results when all our data are combined.
- Data from the American Community Survey showed that very few people above the age of 16 used the light rail to commute to work.



Future Work

- Since there are only two treated cities, there is low cross-sectional variation, leading to an underestimation of standard errors.
- We are exploring using synthetic control to recalculate the impacts.
- Factors that may confound with our results are changes in attainment status of the treated counties:
- Maricopa County, where Phoenix is in, no longer had non-attainment status for 1-hour O₃ and CO from 2005.
- Mecklenberg County, where Charlotte is in, had non-attainment for 8-hour O₃ starting 2004.