

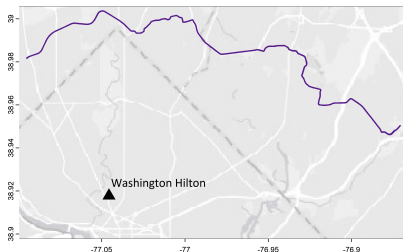
Can Light Rails Provide the Track to Cleaner Air?

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Motivation

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



Has 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

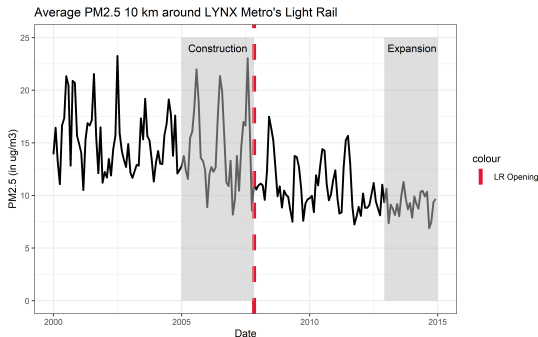
- Light rails have a lower passenger capacity.
- Light rails make more frequent stops.
- Light rails are much cheaper to build.

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 make shift people from 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 will data from light rail construction period, which can increase pollution prior light rail opening, from our analysis.

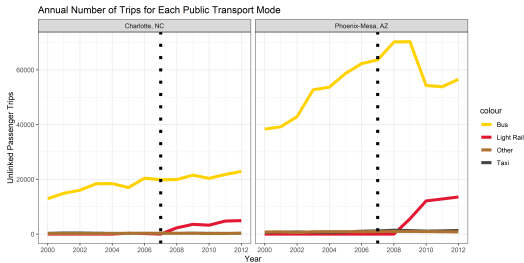
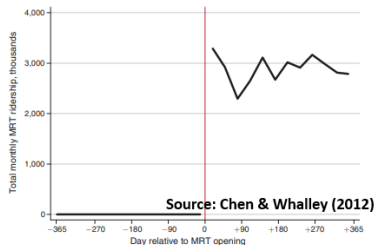


Data

- 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 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

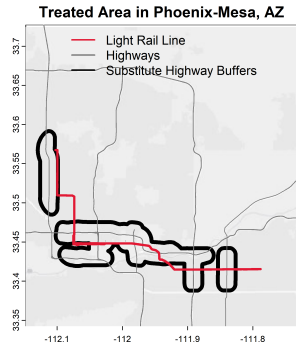
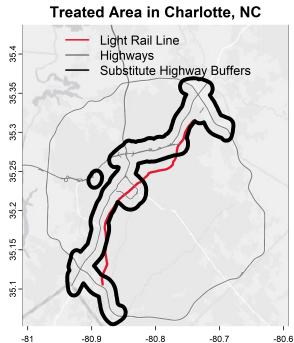
Research Design

- 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.



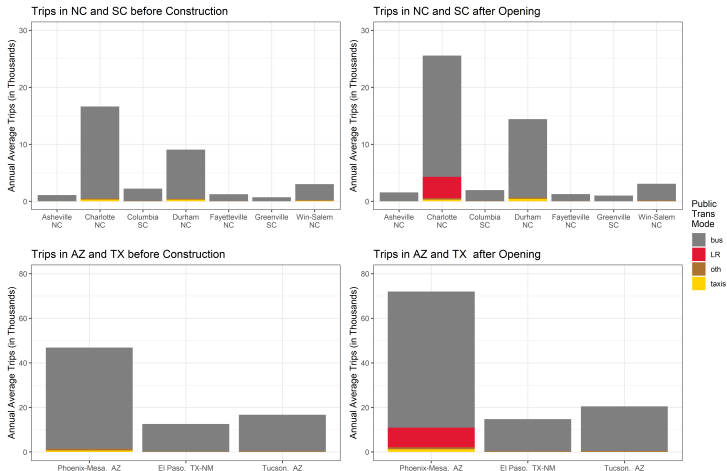
Treated Area

- We indicate potential highways that are 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.



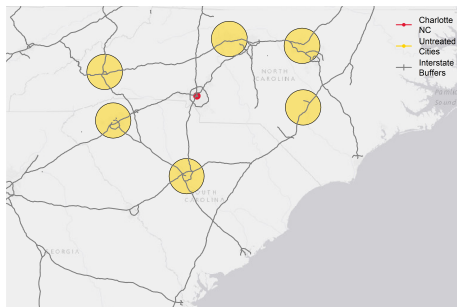
Untreated Area

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



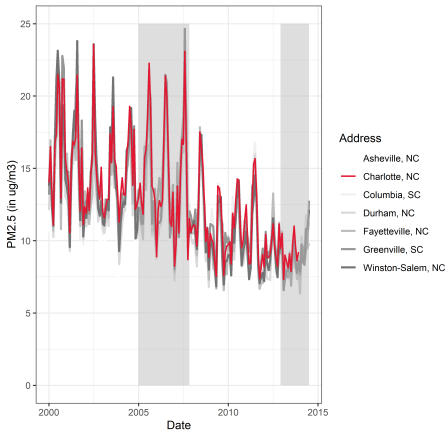
Untreated Area

- 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 PM2.5 and meteorology values within each city's interstate buffers.

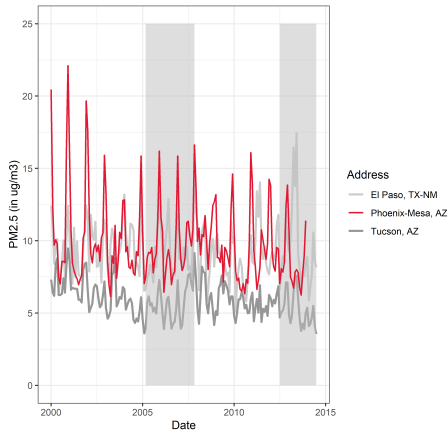


Parallel Trends

PM2.5 in Charlotte its Control Cities



PM2.5 in Phoenix-Mesa its Control Cities



DiD Specification

We first 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 Charlotte, NC

Dependent Variable:	pm25			
Model:	(1)	(2)	(3)	(4)
<i>Variables</i>				
operating × treatcity	-0.51 (0.32)	-0.54 (0.31)	-0.52 (0.28)	-0.57* (0.28)
Wind_f_tavg	-2.1*** (0.54)	-2.0*** (0.52)	-3.4*** (0.53)	-2.4*** (0.54)
Wind_f_tavg_sq			0.42*** (0.11)	0.28** (0.12)
Wind_f_tavg_cu			-0.03** (0.009)	-0.02 (0.010)
<i>Fixed-effects</i>				
dow_m	Yes		Yes	
Address	Yes	Yes	Yes	Yes
dow_my		Yes		Yes
<i>Fit statistics</i>				
Observations	29,936	29,936	29,936	29,936
Adjusted R ²	0.32	0.42	0.33	0.43

Clustered (Address) standard-errors in parentheses

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

DiD Results for Charlotte, NC in Each Day of the Week

Dependent Variable:	pm25
Model:	(1)
<i>Variables</i>	
operating × treatcity × dowFriday	-0.48 (0.27)
operating × treatcity × dowMonday	-0.57 (0.33)
operating × treatcity × dowSaturday	-0.53 (0.35)
operating × treatcity × dowSunday	-0.50 (0.31)
operating × treatcity × dowThursday	-0.78** (0.25)
operating × treatcity × dowTuesday	-0.56* (0.25)
operating × treatcity × dowWednesday	-0.61** (0.25)
<i>Fixed-effects</i>	
dow_my	Yes
Address	Yes
<i>Fit statistics</i>	
Observations	29,936
Adjusted R ²	0.43

Clustered (Address) standard-errors in parentheses

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

DiD Results for Phoenix-Mesa, AZ

Dependent Variable:	pm25			
Model:	(1)	(2)	(3)	(4)
<i>Variables</i>				
operating × treatcity	-0.39** (0.08)	-0.40* (0.12)	-0.16** (0.02)	-0.16* (0.04)
Wind_f_tavg	-1.6** (0.22)	-1.6** (0.25)	0.40 (1.8)	0.46 (2.1)
Wind_f_tavg_sq			-0.95*** (0.04)	-0.97** (0.14)
Wind_f_tavg_cu			0.12*** (0.01)	0.12*** (0.008)
<i>Fixed-effects</i>				
dow_m	Yes		Yes	
Address	Yes	Yes	Yes	Yes
dow_my		Yes		Yes
<i>Fit statistics</i>				
Observations	9,867	9,867	9,867	9,867
Adjusted R ²	0.32	0.35	0.37	0.40

Clustered (Address) standard-errors in parentheses

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

DiD Results for Phoenix-Mesa in Each Day of the Week

Dependent Variable:	pm25
Model:	(1)
<i>Variables</i>	
operating × treatcity × dowFriday	-0.07** (0.009)
operating × treatcity × dowMonday	-0.68** (0.10)
operating × treatcity × dowSaturday	0.14** (0.03)
operating × treatcity × dowSunday	0.36* (0.10)
operating × treatcity × dowThursday	-0.07 (0.09)
operating × treatcity × dowTuesday	-0.62* (0.17)
operating × treatcity × dowWednesday	-0.21 (0.12)
<i>Fixed-effects</i>	
dow_my	Yes
Address	Yes
<i>Fit statistics</i>	
Observations	9,867
Adjusted R ²	0.40

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

Possible Confounding Factors

- Maricopa County no longer had non-attainment status for 1-hour O₃ and CO in 2005.
- Mecklenberg County became non-attainment for 8-hour O₃ in 2004.
- Non-attainment status for control cities?
- Since there are only two treated cities, the standard errors might be biased.
- We are exploring using synthetic control to recalculate the impacts.

Pooled DiD

