Can Light Rails Provide the Track to Cleaner Air?

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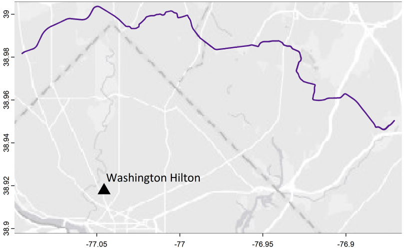
Motivation

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.

Light Rails vs. Subways

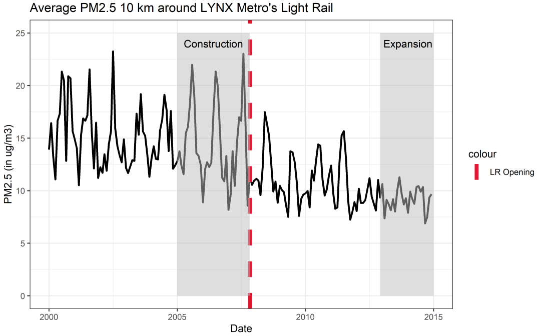
- Light rails have a lower passenger capacity.
- Light rails make more frequent stops.
- Light rails are much cheaper to build.

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 subways openings globally, only those in highly polluted cities see a 4 percent reduction.
  - Xie et al. (2024) found that 15 subways 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.

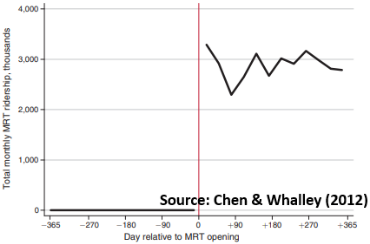


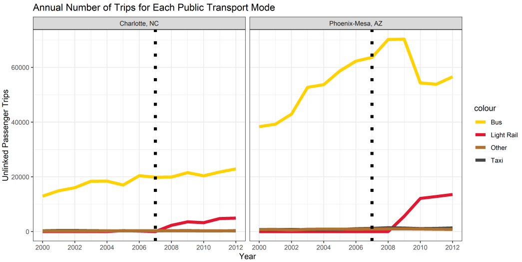
Data

- 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

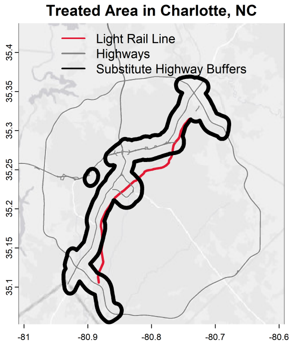
- Previous studies on subway's impact on air pollution (Chen and Whalley, 2012; Gendron-Carrier et al., 2022; Xie et al., 2024) used Discontinuity-Based OLS as there was instant uptake in ridership.
- We will use **difference-in-difference** as light rail ridership gradually increased treated cities.

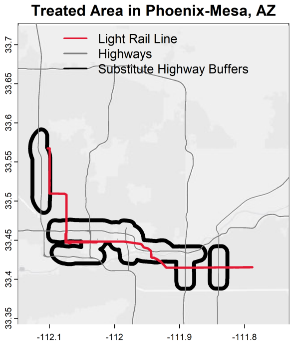




Treated Area

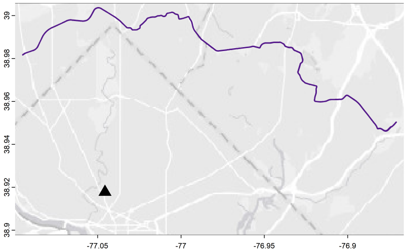
- We indicate potential highways that are the light rails serve as a substitute, and draw 1.5 km buffers around each highway.
- We then find the average daily PM2.5 and meteorological variables within those areas.

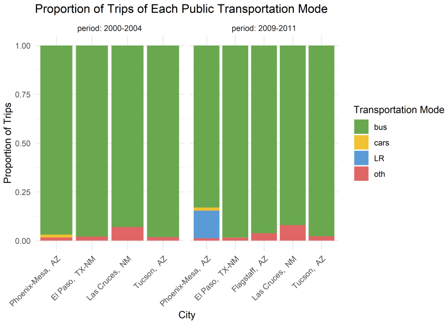




Untreated Area

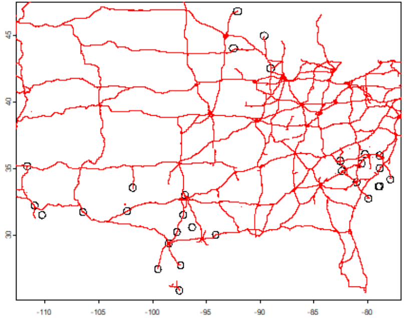
For each control city, we find cities with no light rails, no subways, and similar public transportation profiles.





Untreated Area

- For each untreated city, we draw a 30 km radius around each city's centroid, crop interstates segments that fall within that centroid, and draw 1 km radius around each cropped interstate.
- We then find the daily average PM2.5 levels within each 1 km radius around the cropped interstate area for each city.



DiD Methodology

For each treatment city, we use data from untreated city with similar public pre-light-rail transportation profiles as controls. Our main regression specification is:

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

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.

$Open_t$ is a dummy variable that is equal to one when the light rail system in the treated city is in operation.

W_{it} includes 47 meteorological control variables in its linear, square, and cubic form for each city and day.

$\mu_i t$ are city-day of week-month-year fixed effects.

DiD Results

Table 1: DiD Results for Charlotte, NC

Dependent Variable:	pm25			
Model:	(1)	(2)	(3)	(4)
Variables				
operating $\times$ treatcity	-0.51	-0.54	-0.52	-0.57*
	(0.32)	(0.31)	(0.28)	(0.28)
Wind_f_tavg	-2.1***	-2.0***	-3.4***	-2.4***
	(0.54)	(0.52)	(0.53)	(0.54)
Wind_f_tavg_sq			0.42***	0.28**
			(0.11)	(0.12)
Wind_f_tavg_cu			-0.03**	-0.02
			(0.009)	(0.010)
Fixed-effects				
dow_m	Yes		Yes	
Address	Yes	Yes	Yes	Yes
dow_my		Yes		Yes
Fit statistics				
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 Each Day of the Week

Table 2: DiD Results for Charlotte, NC

Dependent Variable:	pm25
Model:	(1)
Variables	
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)
Fixed-effects	
dow_my	Yes
Address	Yes
Fit statistics	
Observations	29,936
Adjusted R^2	0.43

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