

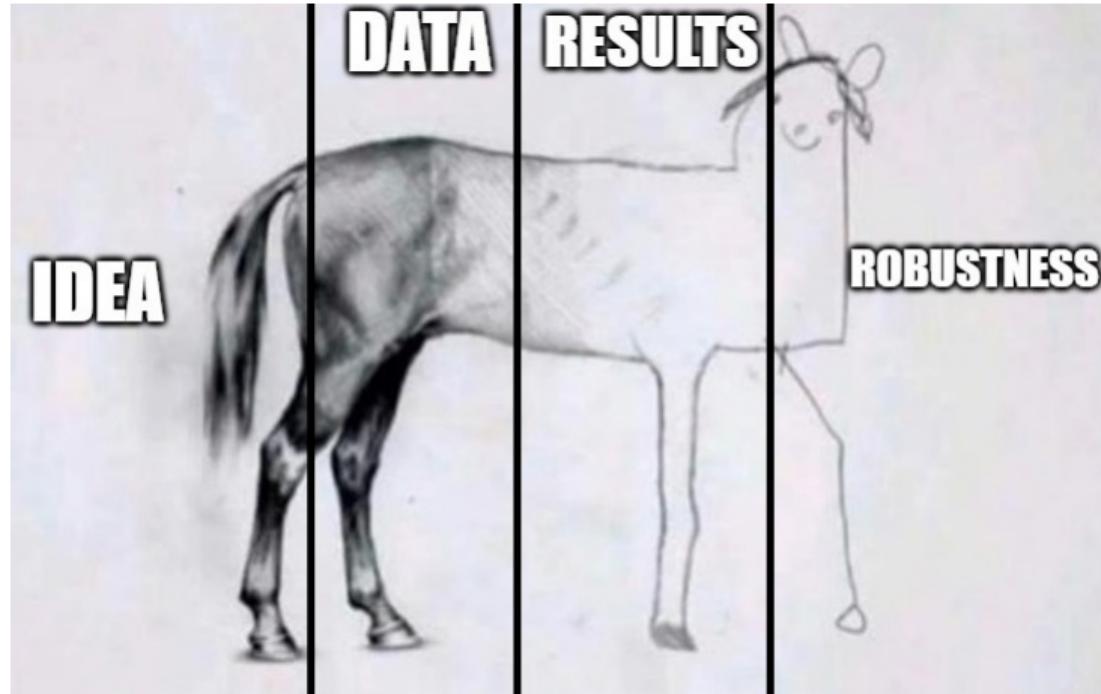
# Bad Air Day: The Influence of Air Pollution on Quarterbacks' Performance - Evidence from the NFL

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5440: Environmental Economics

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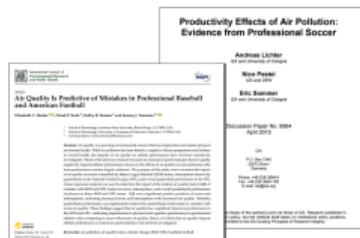
# The usual story of the insignificant term paper.



# The underlying idea: Examining the damage curve of PM10.

## Research Gap

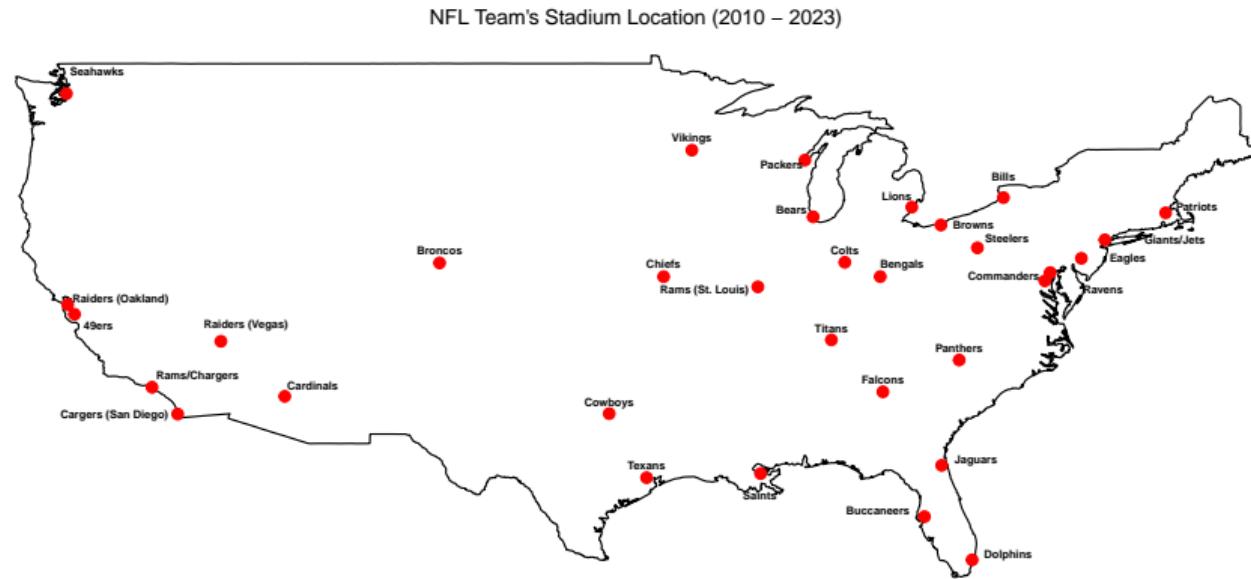
- (Short-Term) Damages affecting cognitive capabilities have not been completely identified.
- Combination of Licher et al. (2017) - rigorous econometric approach - and a first "correlation" in a similar data set (see Heintz et al., 2022).



## Approach

- Examining how Quarterbacks - as the brain of the offense - are affected by higher pollution ( $\Rightarrow$  lower bound  $\hat{\beta}$  for society).
- Strong Assumption: Physical effect is equal for all players.
- H I: Increased exposure to PM10 will lead to a reduction in quarterback performance.
- H II: The closure of the stadium will mitigate any effect of PM10.

# Exploiting regional differences to estimate short-term cognitive effects.



This is approached in a rigorous way...

$$\hat{Y}_{ijkls} = PM10 \times \beta_I + W'\zeta_I + \alpha_i + \mu_{js} + \eta_{ks} + Away \times \delta + \varepsilon_{ijkls} \quad (1)$$

### Dimensions

- $i \in Q$  (set of all quarterbacks)
- $j \in T$  (set of teams)
- $k \in O$  (set of opponents)
- $l \in \{\text{Closed, Open, Retractable}\}$
- $\{s \in \mathbb{Z} \mid 2010 \leq s \leq 2022\}$

### (Fixed-)Effects

- $\alpha_i \Rightarrow$  Quarterback Individual Effect
- $\mu_{js} \Rightarrow$  Offense  $\times$  Season Fixed Effect
- $\eta_{ks} \Rightarrow$  Defense  $\times$  Season Fixed Effect
- (+ Matrix of weather controls per stadiumtype & Away performance)

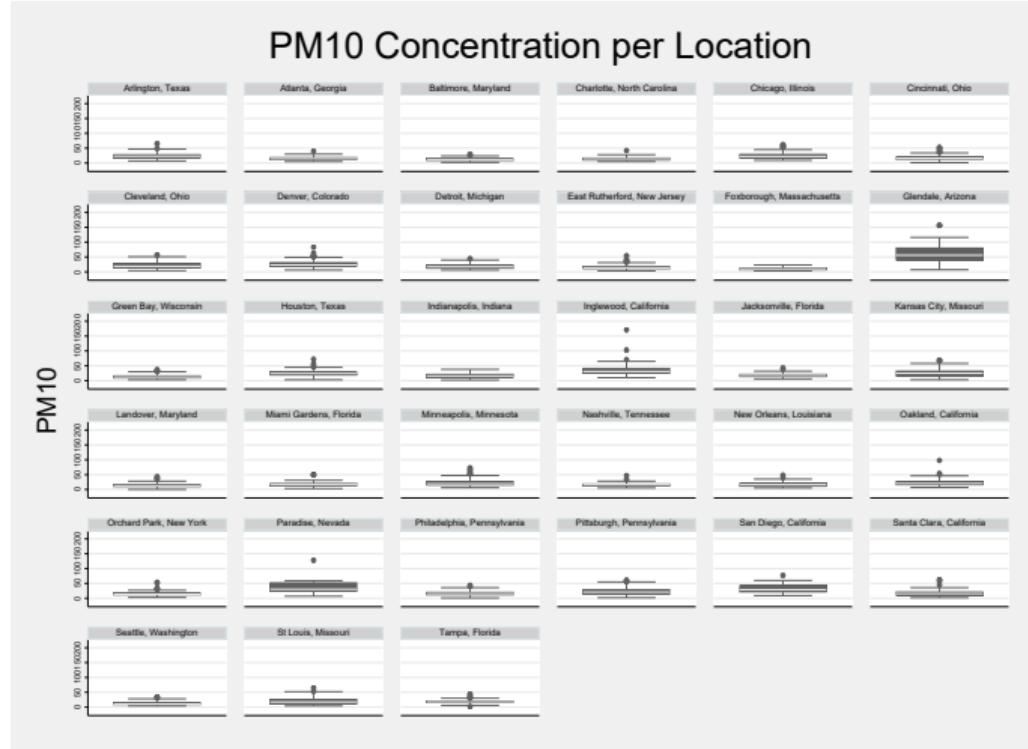
# ...with profoundly comprehensive data.

Table 1: Summary Statistics of Metric Variables

Variable	Obs	Mean	Std. dev.	Min.	Max.
<i>Quarterbacks' Performance</i>					
Rating	7,095	88.47	27.83	0.00	158.30
Attempts	7,095	32.29	10.33	5.00	68.00
Completions	7,095	20.30	7.18	0.00	45.00
Completion Rate	7,095	62.65	10.51	0.00	100.00
Yards	7,095	231.05	87.84	0.00	527.00
Yards per Attempt	7,096	7.19	1.97	0.00	17.00
Interceptions	7,095	0.80	0.93	0.00	6.00
Interception Rate	7,095	2.57	3.34	0.00	37.50
Touchdowns	7,095	1.43	1.16	0.00	7.00
Touchdown Rate	7,095	4.52	3.94	0.00	40.00
Passing Success Rate	7,095	45.16	10.96	0.00	100.00
<i>Pollution/Weather</i>					
PM10 (AQI value)	7,095	20.54	14.75	0.00	171.00
AQI (AQI value)	7,095	51.91	22.15	12.00	210.00
Precipitation (mm)	7,095	0.18	0.35	0.00	2.15
Temperature (°F)	7,095	50.13	10.53	18.50	76.00

- **NFL Data:** Every performance since 2010, scraped from NFL's Fantasy Football App and then enhanced from Stathead.com.
- **EPA Data:** Data on daily pollution since 2010. Mapping with location (closest → highest station). Three questionable cases. A few missings interpolated (second best approach; ARIMA lead to same outcome).
- **PRISM Climate Group.**

As visible, a lot a PM10 variation within and between locations exists.



# However, Results are mixed.

Table 2: Effect of PM10 on Quarterbacks' Performance (Attempts, Yards, Interceptions)

	<i>Dependent Variable:</i>		
	Attempts (1)	Yards (2)	Interceptions (3)
<i>Effect PM10</i>			
$\hat{\beta}_{closed}$	0.0023 (0.0238)	-0.0743 (0.2062)	-0.0027 (0.0025)
$\hat{\beta}_{open}$	-0.0283** (0.0140)	-0.1740 (0.1136)	-0.0025* (0.0014)
$\hat{\beta}_{retractable}$	-0.0053 (0.0124)	0.0936 (0.0996)	-0.0014 (0.0013)
<i>Controls</i>			
Offense × Season Fixed Effect	✓	✓	✓
Defense × Season Fixed Effect	✓	✓	✓
Quarterback Individual Effect	✓	✓	✓
Weather × Stadiumtype	✓	✓	✓
Away Performance	✓	✓	✓
Observations	7,095	7,095	7,095
R <sup>2</sup>	0.3661	0.3982	0.1828
RMSE	8.9059	73.816	0.9076

Note: The significance levels equal \*p<0.1; \*\*p<0.05; \*\*\*p<0.01. Furthermore, robust standard errors (HC1) are displayed. Values are rounded to four decimal places.

Table 3: Effect of PM10 on Quarterbacks' Performance (Completion Rate, Interception Rate &amp; Rating)

	<i>Dependent Variable:</i>		
	Success Rate (4)	Interception Rate (5)	Rating (6)
<i>Effect PM10</i>			
$\hat{\beta}_{closed}$	0.0112 (0.0279)	-0.0051 (0.0080)	0.0654 (0.0663)
$\hat{\beta}_{open}$	0.0167 (0.0150)	-0.0060 (0.0050)	0.0491 (0.0387)
$\hat{\beta}_{retractable}$	0.0363*** (0.0122)	-0.0039 (0.0042)	0.0787** (0.0365)
<i>Controls</i>			
Offense × Season Fixed Effect	✓	✓	✓
Defense × Season Fixed Effect	✓	✓	✓
Quarterback Individual Effect	✓	✓	✓
Weather × Stadiumtype	✓	✓	✓
Away Performance	✓	✓	✓
Observations	7,095	7,095	7,095
R <sup>2</sup>	0.3525	0.2338	0.3055
RMSE	9.5531	3.1676	25.1200

Note: The significance levels equal \*p<0.1; \*\*p<0.05; \*\*\*p<0.01. Furthermore, robust standard errors (HC1) are displayed. Values are rounded to four decimal places.

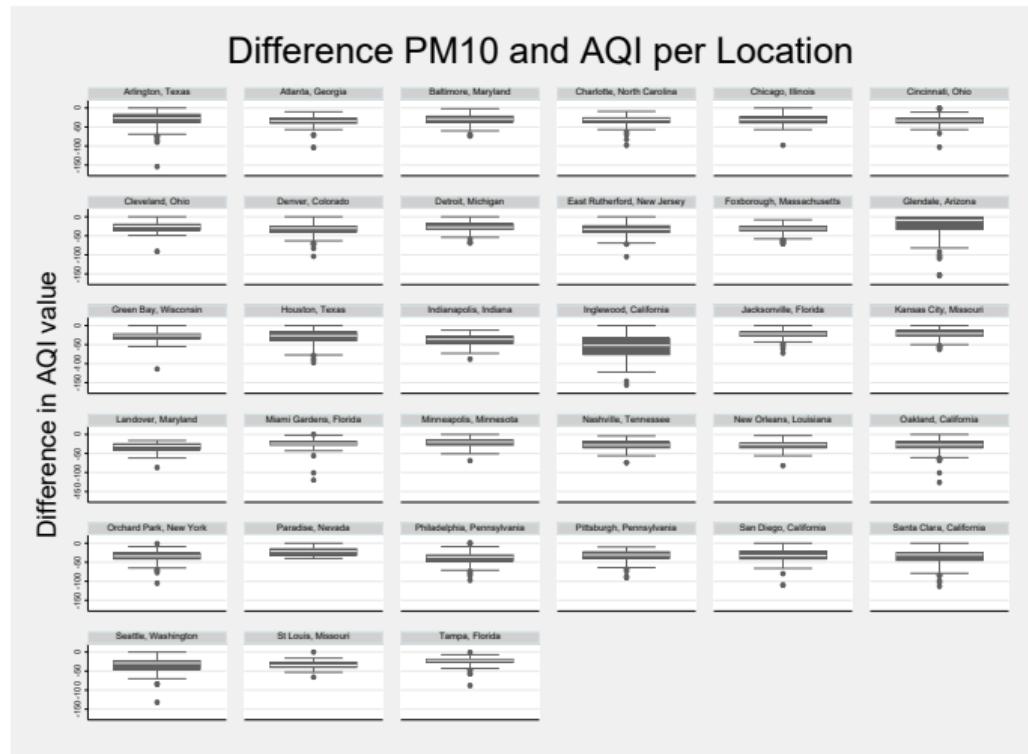
# Robustness I: Does it change when excluding the three "problematic" cases?

Table 5: Effect of PM10 on Quarterbacks' Performance (Attempts, Yards, Interceptions)  
 - without "problematic" cases

	Dependent Variable:		
	Attempts (1b)	Yards (2b)	Interceptions (3b)
<u>Effect PM10</u>			
$\hat{\beta}_{closed}$	0.0012 (0.0243)	-0.0670 (0.2124)	-0.0026 (0.0026)
$\hat{\beta}_{open}$	-0.0352** (0.0148)	-0.2059* (0.1188)	-0.0033** (0.0015)
$\hat{\beta}_{retractable}$	-0.0088 (0.0132)	0.0127 (0.1061)	-0.0011 (0.0014)
<u>Controls</u>			
Offense $\times$ Season Fixed Effect	✓	✓	✓
Defense $\times$ Season Fixed Effect	✓	✓	✓
Quarterback Individual Effect	✓	✓	✓
Weather $\times$ Stadiumtype	✓	✓	✓
Away Performance	✓	✓	✓
Observations	6,428	6,428	6,428
R <sup>2</sup>	0.3729	0.4094	0.1887
RMSE	8.9305	73.53	0.9145

Note: The significance levels equal \*p<0.1; \*\*p<0.05; \*\*\*p<0.01. Furthermore, robust standard errors (HC1) are displayed. Values are rounded to four decimal places. Excluded Stadiums: Packers, Seahawks, Patriots.

# Robustness II: Other air pollutants aka the unobserved con-founder?



# Robustness II: Other air pollutants aka the unobserved con-founder?

Table 6: Effect of AQI on Quarterbacks' Performance (Attempts, Yards, Interceptions)

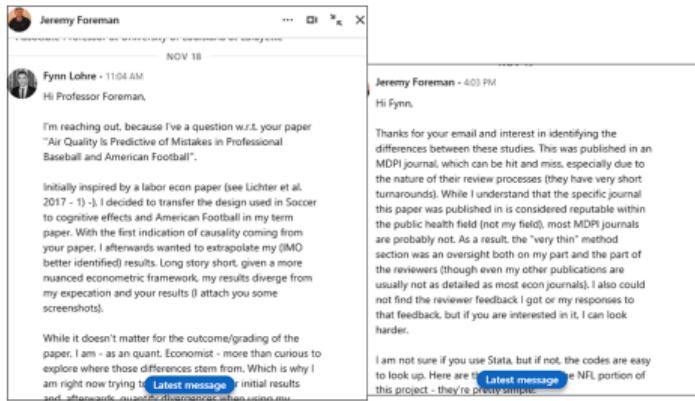
	Dependent Variable:		
	Attempts (1)	Yards (2)	Interceptions (3)
<u>Effect AQI</u>			
$\hat{\beta}_{closed}$	0.0095 (0.0124)	0.0855 (0.1051)	-0.0036** (0.0013)
$\hat{\beta}_{open}$	-0.0120 (0.0078)	0.0766 (0.0679)	-0.0008 (0.0008)
$\hat{\beta}_{retractable}$	-0.0084 (0.0080)	0.0185 (0.0623)	-0.0005 (0.0008)
<u>Controls</u>			
Offense × Season Fixed Effect	✓	✓	✓
Defense × Season Fixed Effect	✓	✓	✓
Quarterback Individual Effect	✓	✓	✓
Weather × Stadiumtype	✓	✓	✓
Away Performance	✓	✓	✓
Observations	7,095	7,095	7,095
R <sup>2</sup>	0.3661	0.3981	0.1832
RMSE	8.9061	73.825	0.9074

Note: The significance levels equal \*p<0.1; \*\*p<0.05; \*\*\*p<0.01. Furthermore, robust standard errors (HC1) are displayed. Values are rounded to four decimal places. AQI displays AQI value of the highest measured pollutant.

# Side-Arc: The (unintentionally) P-hacked MPDI paper and the red flags I ignored.

## Background

- Failure to replicate Heintz et al. (2022)  
→ LinkedIn-Conversation with one of the authors



## Problems/Red Flags of the Paper

- Thin method section: No obs, no reasoning for identification strategy.
- Self citation as argument for controls.
- Not mentioning 160 missings and their selection of certain Quarterbacks. Additionally, they run a FE-Regression without mentioning.
- By adding "Attempts" or a "Team-Fixed-Effect" effect vanishes (only one way of getting sign. results).

If you wanna read the paper or access the data:

Search for VARFynn on



or click

[https://github.com/VARFynn/University\\_Contributions/tree/main/01\\_Master/02\\_Paper/Environmental\\_Econ\\_Paper](https://github.com/VARFynn/University_Contributions/tree/main/01_Master/02_Paper/Environmental_Econ_Paper)