The Impact of Airport Capacity Changes on the Air Quality

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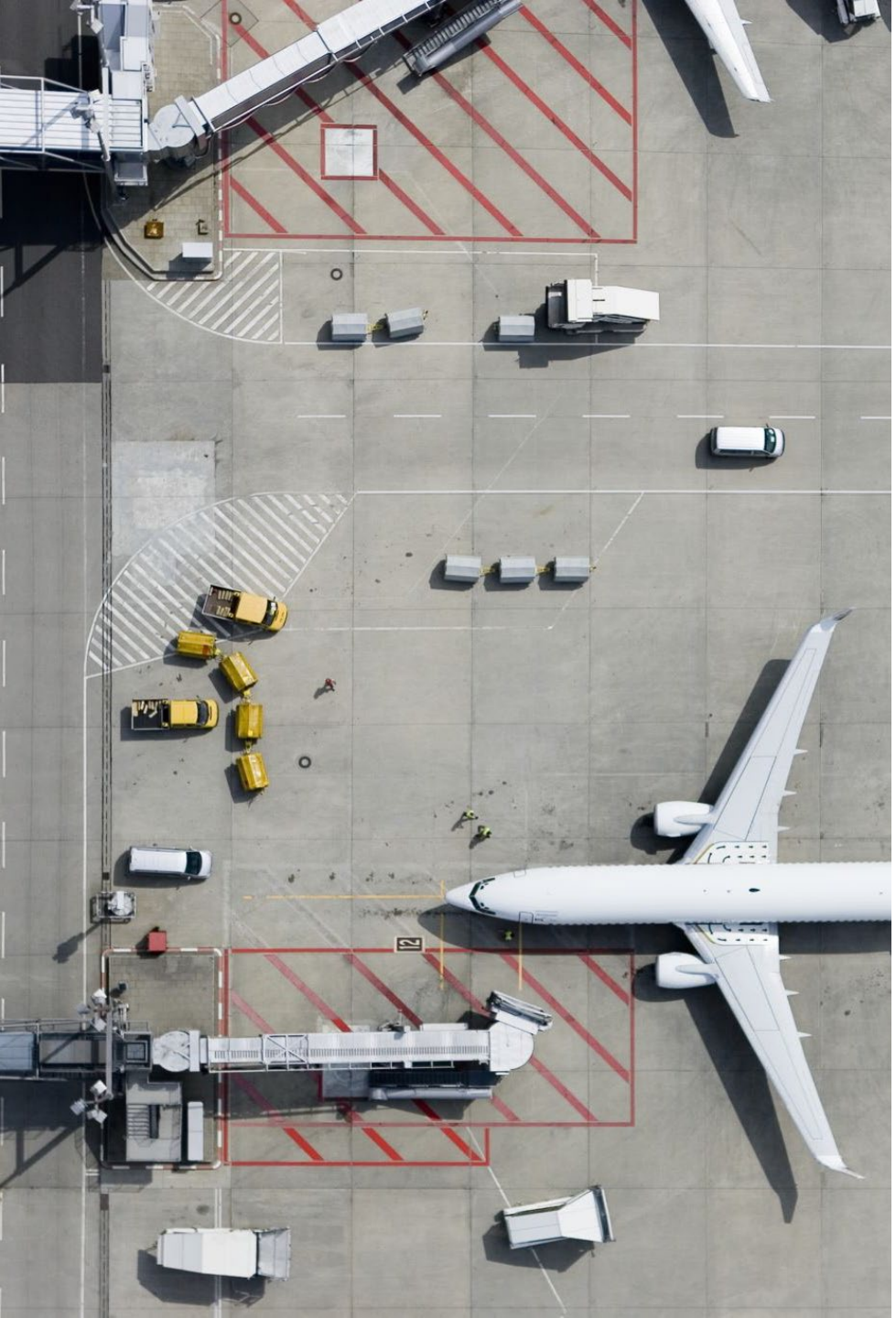


Research Question:

What is the impact of airport expansions on the air quality of respective counties?

Motivation:

Poor air quality negatively affects the health of individuals.

The transportation industries are contributing factors to the worsening of air quality.

Excessive air pollutants impact the rate of global warming.

Literature Review

- Industrial sector **factory expansion deteriorates the health** of nearby residents [Beketie et al., 2021]
- Housing prices and **residents are impacted by** the noise, air, and water **pollution** from airports [Luther, 2007; Zheng et al., 2020; Wolfe et al., 2014]
- The **highest emission** distribution from operations at airports are during **take-off and landing** [Ekici and Sevinc, 2021; Zhu et al., 2011]
- Airports can reduce emissions through **streamlining internal operations**: [Edwards et al., 2016; Ashok et al., 2017; Hudda et al., 2020]

Timely Taxiing **Thrust Levels** **Runway Choice**

- Airport expansion have a **positive economic impact** with the creation of jobs and income benefits [Nataraja and Peterson, 2019; Hewings et al., 1997]

My Research Contribution

Previous literature: Airline emissions and pollutant particles data found in the residential vicinity.

My research uses capacity changes in enplanements from the airports nationwide to find correlations with good air quality days.

Unique: uses indirect measure of flight data to compare it to the respective AQI data instead of particles.

Databases 1999-2019

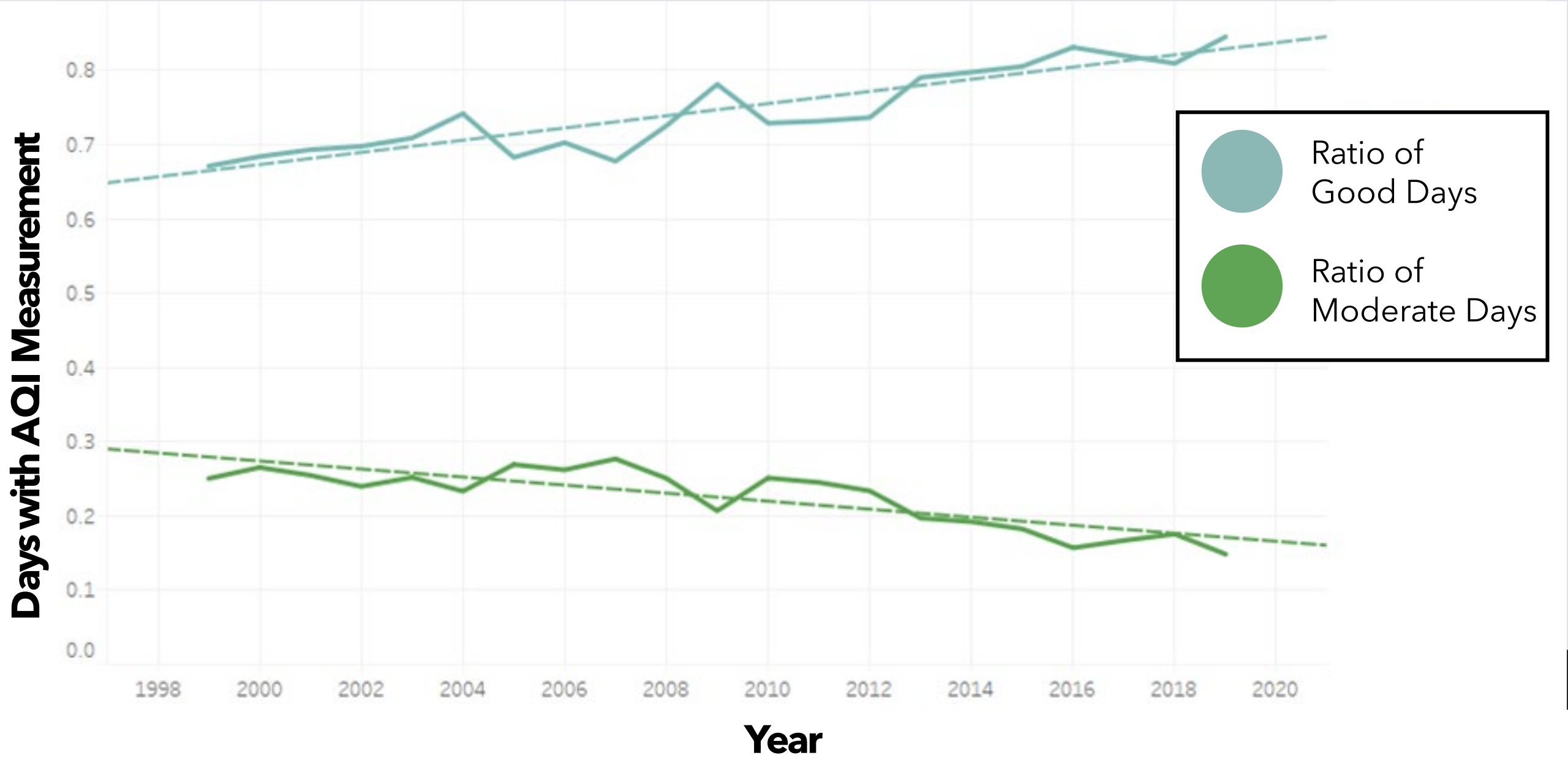
Environmental Protection Agency (EPA)	Federal Aviation Administration (FAA)	The United States Cities
• Annual Air Quality Data • County-level	• Airport Enplanement Data • City/Airport-level	• City & County Crosswalk Data

	US AQI Level	PM2.5 (μg/m³)	Health Recommendation (for 24 hour exposure)
	Good 0-50	0-12.0	Air quality is satisfactory and poses little or no risk.
	Moderate 51-100	12.1-35.4	Sensitive individuals should avoid outdoor activity as they may experience respiratory symptoms.
	Unhealthy for Sensitive Groups 101-150	35.5-55.4	General public and sensitive individuals in particular are at risk to experience irritation and respiratory problems.
	Unhealthy 151-200	55.5-150.4	Increased likelihood of adverse effects and aggravation to the heart and lungs among general public.
	Very Unhealthy 201-300	150.5-250.4	General public will be noticeably affected. Sensitive groups should restrict outdoor activities.
	Hazardous 301+	250.5+	General public at high risk of experiencing strong irritations and adverse health effects. Should avoid outdoor activities.

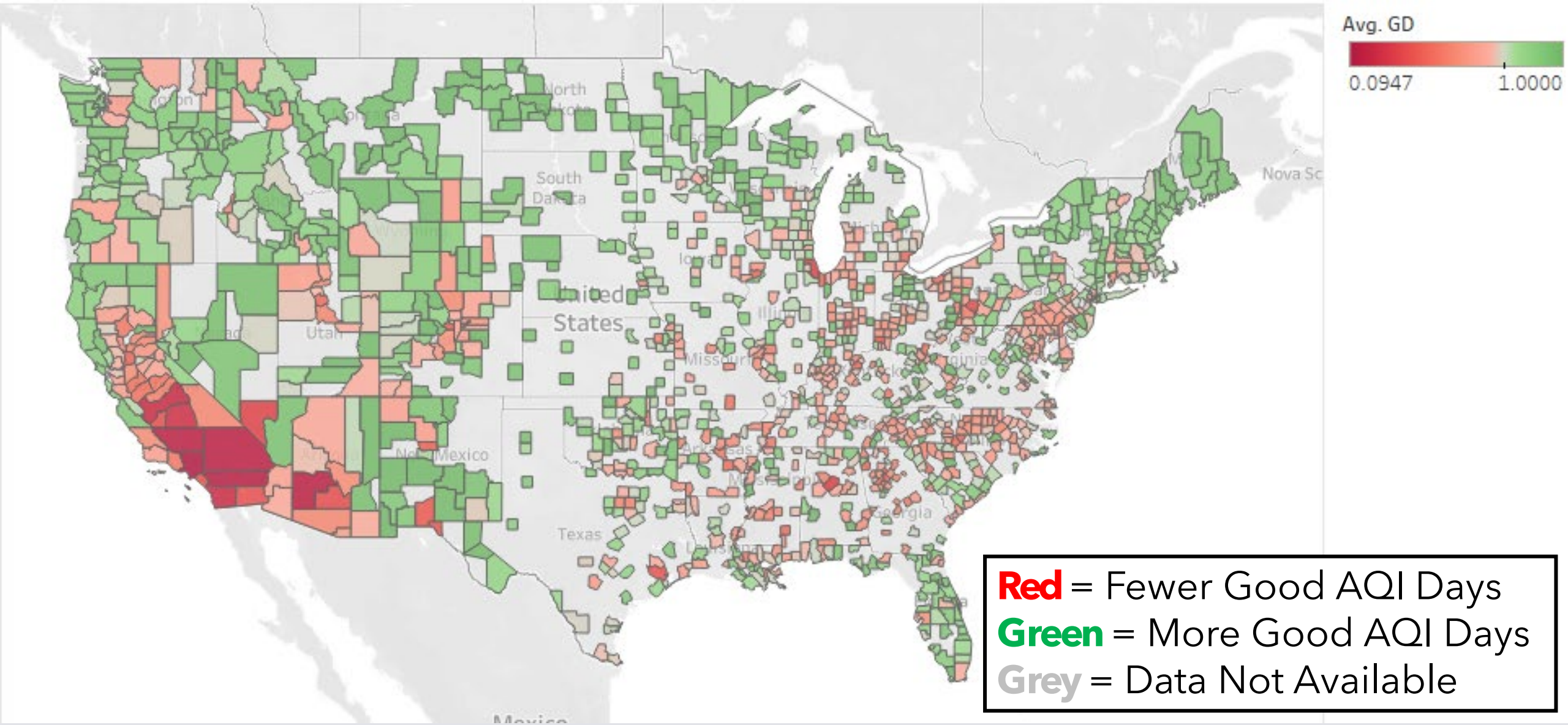
Key Takeaways from the Air Quality and Enplanement Data

- The ratio of **good air quality** days has a **positive trend,** and the other type days have negative trends (e.g. moderate days) (Appendix Graphs)
- **97%** of the days measuring AQI are **good or moderate days**
- **Enplanement capacity increases overtime**

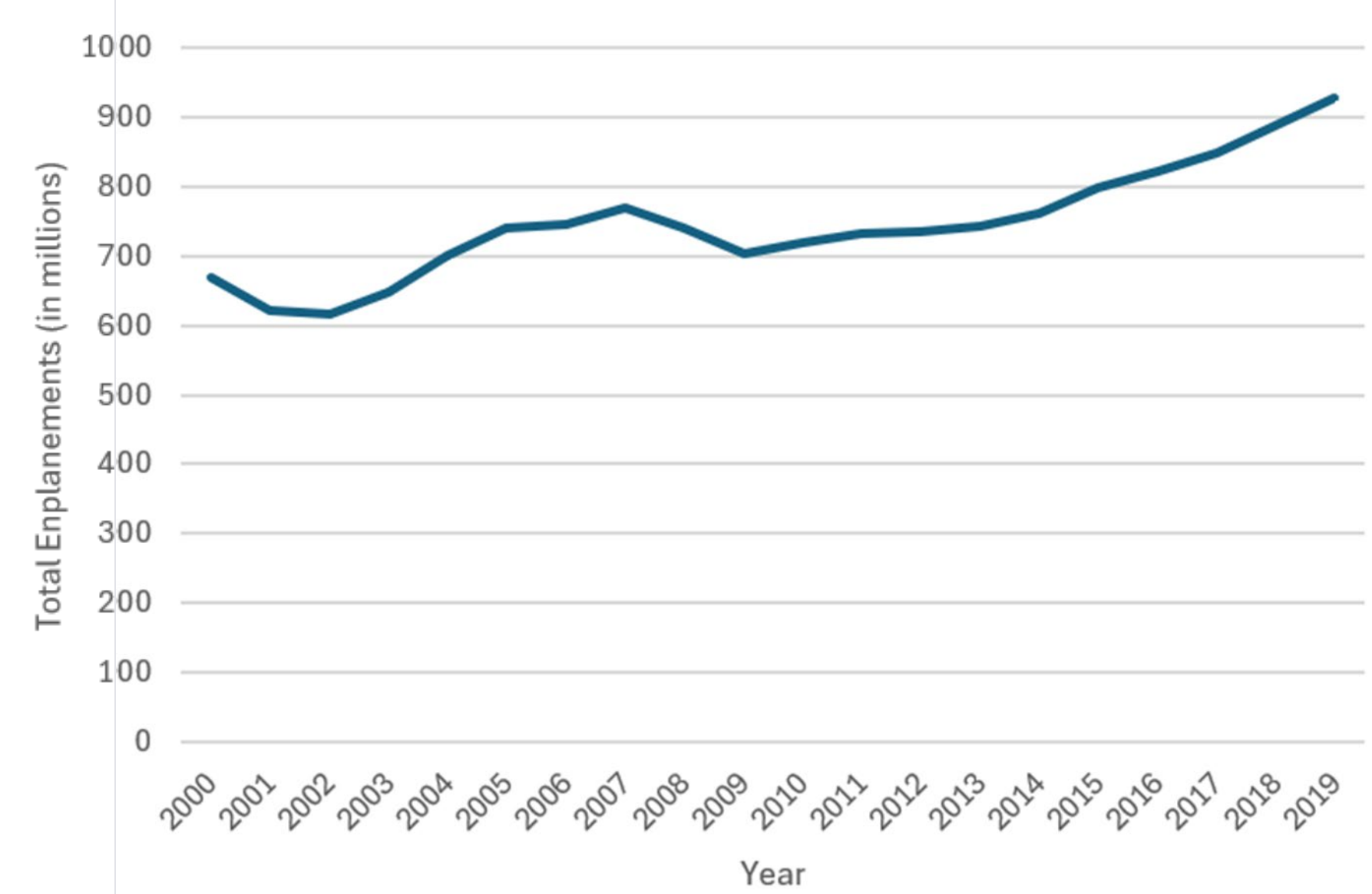
Good and Moderate Days



Average Ratio of Good AQI Days Measured by County (1999-2019)



Total Number of Enplanements in the U.S. per Year (1999-2019)



Summary Statistics for AQI Day Types, Enplanement Levels, & Controls (1999-2019)

Main Variables	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
Good Days	22,394	74.45%	18.27%	1.37%	100.00%
Moderate Days	22,394	22.55%	15.41%	0.00%	92.62%
Unhealthy for Sensitive Groups Days	22,394	2.44%	3.91%	0.00%	46.58%
Unhealthy Days	22,394	0.51%	1.62%	0.00%	31.23%
Very Unhealthy Days	22,394	0.05%	0.35%	0.00%	13.97%
Hazardous Days	22,394	0.01%	0.18%	0.00%	10.14%
Enplanement Level	13,025	3,094,306.48	7,797,286.59	10,003	53,515,982
Population	63,879	97,697.32	316,958.19	55	10,123,521
Income	63,879	33,502.46	11,328.76	8,978	260,038

Two Hypotheses

The **expected effect** of airport expansion on air quality is **negative**

- Without societal pressures or laws, airport expansion operates with no concern of its effect on air quality
- Difference in total cost determines whether the airport expansion will be environmentally friendly

The **expected effect** of airport expansion on air quality **varies based on the size of the airport**

- Outcome A: Smaller airport capacity changes are undetected at AQI levels in the county
- Outcome B: Smaller airport capacity expansions may negatively impact the air quality
- Outcome C: Larger airport expansions have a positive impact on air quality

Empirical Methodology

$$lnAQI_{it} = B_0 + B_1 lnEnplanement_{it} + X_{it} + B_2 County_i + B_3 Year_t + \varepsilon_{it}$$

Log-Log Two Way Fixed Effects Model estimated separately by air quality day type.

- lnAQI = *air quality measured in county "i" at year "t"*
- lnEnplanement = enplanement measured in county "i" at year "t"
- Control variables (X) : population, household incomes
- County and Year: Fixed Effects
- ε = White Noise

Log-Log Two-Way-Fixed-Effects Approach for Changes in Enplanement Capacity on Good Air Quality Days (without Controls)

Regressors	All Counties
Ln (Enplanement)	-0.022*** (0.008)

Overall Impact:
A 1% increase in enplanement capacity leads to a 0.02% **decrease in the ratio of good air quality days**

Enplanement Classification (Heterogeneous Treatment Effect)	
Q1	10k to 92k
Q2	92k to 430k
Q3	430k to 3.4m
Q4	3.4m to 53.5m

Log-Log Two-Way-Fixed-Effects Approach for Changes in Enplanement Capacity on Good Air Quality Days (without Controls)

Regressors	All Counties	Q1	Q2	Q3	Q4
Ln (Enplanement)	-0.022*** (0.008)	-0.015 (0.012)	-0.105*** (0.018)	0.104*** (0.034)	-0.008 (0.029)

Overall Impact:
A 1% increase in enplanement capacity leads to a 0.02% **decrease in the ratio of good air quality days**

County between 92k & 430k Enplanements:
A 1% increase in capacity leads to a 0.1% **decrease in the ratio of good air quality days**

County between 430k & 3.4m Enplanements:
A 1% increase in capacity leads to a 0.1% **increase in the ratio of good air quality days**

Log-Log Two-Way-Fixed-Effects Approach for Changes in Enplanement Capacity on Good Air Quality Days (with Controls)

Regressors	All Counties	Q1	Q2	Q3	Q4
Ln (Enplanement)	-0.008 (0.008)	0.004 (0.012)	-0.072*** (0.020)	0.189*** (0.034)	-0.018 (0.030)

Q2 with Control Variables also has a negative relationship: A 1% increase in capacity leads to a 0.072% **decrease in the ratio of good air quality days**

Q3 with Control Variables also has a positive relationship: A 1% increase in capacity leads to a 0.189% **increase in the ratio of good air quality days**

Two-Way-Fixed-Effects Approach for 10 Deciles Smallest to Largest Enplanements

Regressors	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Ln (Enplanement)	0.032	-0.031	-0.109***	-0.074*	-0.049	0.262***	-0.039	0.017	0.125**	-0.244
	(0.033)	(0.031)	(0.037)	(0.038)	(0.062)	(0.094)	(0.052)	(0.068)	(0.063)	(0.156)

Smaller Airport Counties

Smaller airport counties with increases in enplanement levels leads to a decrease in good air quality days.

- 55k to 263k (D3 & D4)

Larger airport counties with increases in enplanement levels leads to an increase in good air quality days.

- 430k to 846k (D6)
- 2.1m to 5.1m (D9)

Larger Airport Counties

Main Takeaways

- When the enplanement levels increase in a given county, the **number of good air quality days:**

  Increases for larger airports

  Decreases for smaller airports

- **Aligns with Hypotheses 2B & 2C**: Small airport capacity expansions negatively impacts the air quality and large airport capacity expansions positively impacts the air quality in the respective counties.

Implication for Policy Makers & Suggestions for Future Research

- **Better enforcement** of the **emission laws** in smaller-scale airport expansions
- **Geographical variation** in treatment effect
- Extend the analysis to **post-COVID** period

Thank You!

Questions?

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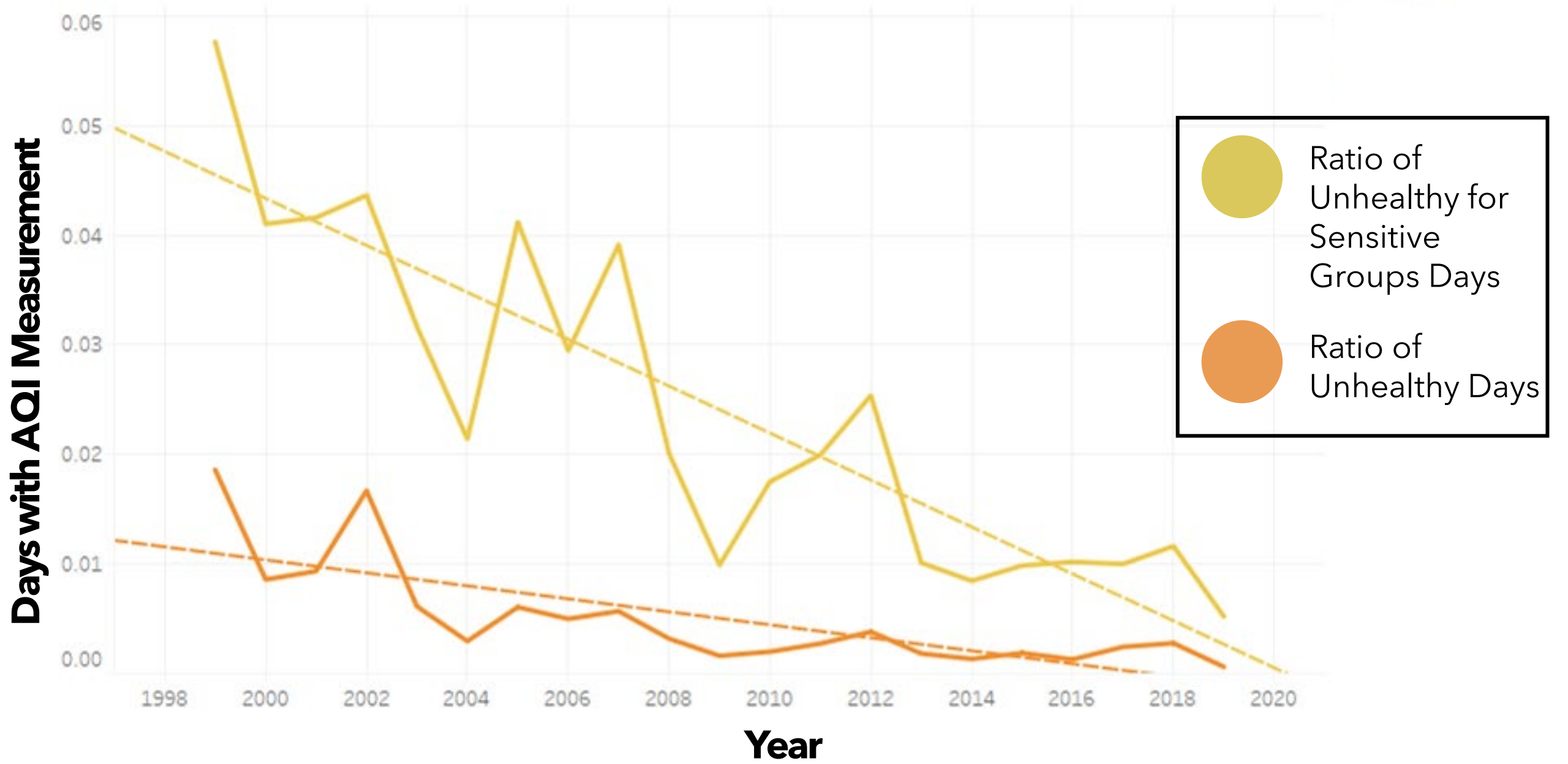
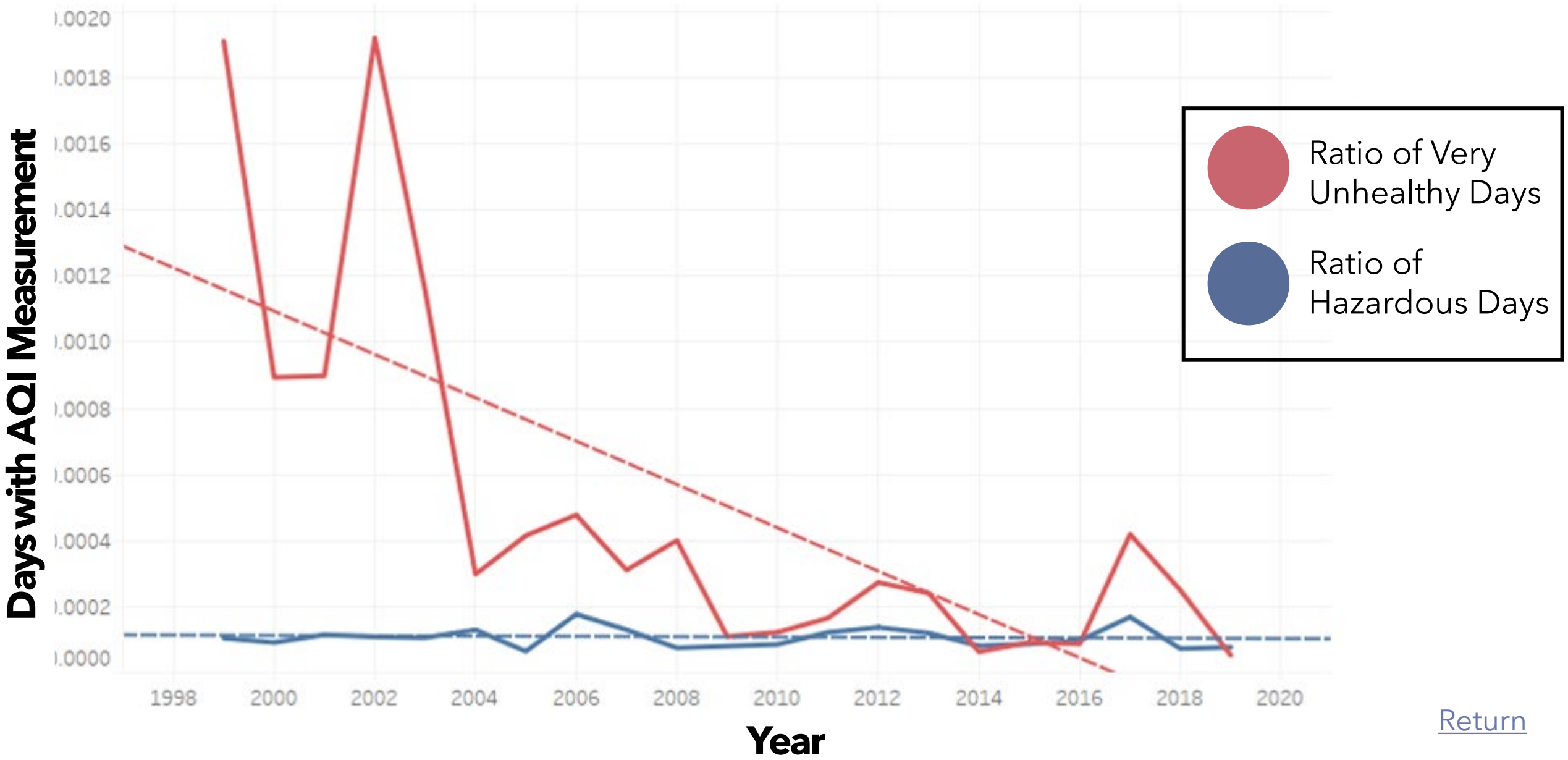
Unhealthy for Sensitive Groups and Unhealthy Days



Very Unhealthy and Hazardous Days



Return

Two-Way-Fixed-Effects Approach for Changes in Enplanement Capacity on Good Air Quality Days (Quartiles)

Regressors	Q1	Q2	Q3	Q4	All Counties
Ln (Enplanement)	-0.01493 (0.01171)	-0.10467*** (0.01829)	0.10442*** (0.03421)	-0.00760 (0.02866)	-0.02190*** (0.00754)
Intercept	-0.10987 (0.11529)	0.98069*** (0.22034)	-1.92429*** (0.48666)	-0.60417 (0.45288)	-0.16052 (0.11524)
County Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Number of Observations	2,160	2,160	2,160	2,158	8,638
Adjusted R-Square	0.7187	0.8458	0.8381	0.9111	0.8763
Overall Significance	1.22E+02***	1.13E+02***	1.30E+02***	4.72E+02***	1.85E+02***

Source: EPA (2024), FAA (2024), with own calculations.

Notes: Robust standard Errors are in Parentheses. *, **, *** indicate 10%, 5%, and 1% significance levels, respectively and are clustered at county levels. The data is unbalanced as the number of counties in each state in a given year are not constant over time, as counties are added to the data or begin measuring AQI. Quartile 1 = Model 1 tec. See the text above table for information about enplanement cut off values for different quartiles.

Two-Way-Fixed-Effects Approach for 10 Percentiles Largest to Smallest Enplanements

Regressors	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**	**Model 9**	**Model 10**
Ln(Enplanement)	-0.24446 (0.15604)	0.12463** (0.06254)	0.01719 (0.06751)	-0.03924 (0.05229)	0.26241*** (0.09406)	-0.04910 (0.06151)	-0.07416* (0.03836)	-0.10884*** (0.03740)	-0.03109 (0.03061)	0.03199 (0.03279)
Intercept	3.19453 (2.57975)	-2.56658*** (0.97930)	-0.96502 (1.02672)	0.07365 (0.75029)	-3.73440*** (1.23934)	0.19881 (0.76371)	0.69008 (0.46486)	1.02385** (0.44256)	0.24072 (0.31116)	-0.55835* (0.31877)
County Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	863	864	864	864	864	863	864	864	864	864
Adjusted R-Square	0.9082	0.9145	0.8727	0.8773	0.7717	0.6651	0.8729	0.8732	0.7217	0.8004
Overall Significance	4.74E+02***	5.94E+03***	2.57E+02***	1.17E+02***	2.43E+03***	1.54E+02***	4.21E+03***	4.17E+02***	5.00E+02***	1.37E+02***

Source: EPA (2024), FAA (2024), with own calculations.

Notes: Robust standard Errors are in Parentheses. *, **, *** indicate 10%, 5%, and 1% significance levels, respectively and are clustered at county levels. The data is unbalanced as the number of counties in each state in a given year are not constant over time, as counties are added to the data or begin measuring AQI. 90th Percentile is represented by Model 1, going down the decile ranges as the Model number increases to the 10th Percentile for Model 10.

Log-Log Two-Way-Fixed-Effects Approach for Quartiles 1 through 4 with Controls

Regressors	Quartile 1	Quartile 2	Quartile 3	Quartile 4	All Counties
Ln (Enplanement)	0.00364	-0.07221***	0.18895***	-0.01762	-0.00849
	(0.01216)	(0.01977)	(0.03414)	(0.02961)	(0.00762)
Ln (Population)	-0.50423***	-0.26762***	-0.92961***	0.29326***	-0.11175*
	(0.11171)	(0.09955)	(0.13288)	(0.10723)	(0.06006)
Ln (Income)	-0.47024***	-0.24794***	-0.08499	-0.79460***	-0.50376***
	(0.07878)	(0.08294)	(0.10021)	(0.09616)	(0.04647)
Intercept	9.19442***	6.38473***	9.59636***	3.75090**	6.24090***
	(1.17100)	(1.12837)	(1.83209)	(1.55108)	(0.72483)
County Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Number of Observations	2,114	2,127	2,041	2,037	8,319
Adjusted R-Square	0.7334	0.8480	0.8778	0.9098	0.8882
Overall Significance	1.05E+10***	1.27E+02***	2.57E+09***	4.53E+02***	7.62E+09***

Source: EPA (2024), FAA (2024), with own calculations.
Notes: Robust standard Errors are in Parentheses. *, **, *** indicate 10%, 5%, and 1% significance levels, respectively and are clustered at county levels. The data is unbalanced as the number of counties in each state in a given year are not constant over time, as counties are added to the data or begin measuring AQI. Quartile 1=Model 1, etc. Observation numbers vary across the Quartiles because the same cut-off values are used from the enplanement data without control variables so the comparison is consistent between the tables. Control variables are Population and Income

Log-Log Two-Way-Fixed-Effects Approach for 10 Deciles with Control

Regressors	Decile 1	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	Decile 10
Ln(Enplanement)	-0.04939* (0.02862)	0.03738 (0.04508)	0.00785 (0.03420)	-0.03870 (0.04414)	-0.06171 (0.04324)	-0.02365 (0.04079)	0.03296 (0.03771)	0.05019 (0.05670)	-0.00288 (0.03631)	-0.05672 (0.03812)
Ln(Population)	3.91798** (1.53290)	-1.51499* (0.79582)	0.65151 (0.79687)	-0.75262** (0.33703)	0.98322 (0.74977)	-0.18490 (0.65776)	0.67915* (0.39261)	-1.14208** (0.50558)	1.66785*** (0.49123)	3.98144** (1.74411)
Ln(Income)	-0.33400 (0.27012)	0.09541 (0.37865)	0.07872 (0.30923)	-0.47784* (0.25656)	0.55329** (0.25441)	-0.05128 (0.38115)	0.81090** (0.34933)	-0.35673** (0.17623)	-0.28601 (0.22922)	0.32378 (0.37779)
Intercept	-45.49598** (18.48321)	17.20578 (11.34580)	-9.48828 (11.48583)	14.65553*** (5.06851)	-18.19544* (10.24502)	2.90140 (9.05903)	-18.14568*** (5.15532)	17.61767*** (6.38946)	-18.88686*** (6.82082)	-54.99046** (23.27461)
County	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	864	864	864	864	863	864	864	864	864	544
Adjusted R-Square	0.9215	0.9837	0.9663	0.9314	0.9046	0.9669	0.9773	0.9788	0.9886	0.9946
Overall Significance	2.38E+07***	2.01E+07***	1.17E+05***	1.91E+08***	2.56E+05***	1.27E+08***	8.05E+05***	7.88E+05***	3.43E+07***	1.16E+08***

Source: EPA (2024), FAA (2024), with own calculations.

Notes: Robust standard Errors are in Parentheses. *, **, *** indicate 10%, 5%, and 1% significance levels, respectively and are clustered at county levels. The data is unbalanced as the number of counties in each state in a given year are not constant over time, as counties are added to the data or begin measuring AQI. Split into 10 Deciles between 10,000 to 53,515,982 enplanements; 1st Decile is Model 1, going up the decile ranges and 10th Decile is Model 10. Control Variables include Population, Income