What Caused Racial Disparities in Particulate Exposure to Fall?

New Evidence from the Clean Air Act
and Satellite-Based Measures of Air Quality

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Abstract

- This paper examines the underlying structure that causes racial differences in exposure to ambient air pollution in the United States.
  - The difference have declined significantly over the past 20 years.
- Clean Air Act (CAA) explains the excess convergence in Black-White pollution exposure
  - Areas with larger Black populations saw greater CAA-related declines in PM2.5 exposure
  - Over 60% of the reduction in the racial convergence in PM2.5 pollution exposure since 2000

Section 1

Introduction

Motivation & Literature

- The existing evidence about racial disparities in pollution exposure is largely piecemeal and indirect.
  - Low income and/or racial minorities in the U.S. have been exposed to environmental burdens (Office, 1983; Chavis and Lee, 1987)
  - Lack of monitoring device to track small particulates (Fowlie, Rubin, and Walker, 2019)
  - Alternative measurement: distance to a polluting facility
- Moreover, we know very little about why racial gaps in pollution exposure may have changed over time.

This Paper

- Data: newly available national data on PM2.5 exposure from 2000 to 2015
  - 1km-grid measures of ambient air pollution levels for the entire United States
- Analyses
  1. Document racial gaps in ambient exposure to PM 2.5 and the time-series changes between 2000 and 2015.
  2. Explain the gaps by differences in individual and/or neighborhood characteristics.
  3. Explore the contribution of changes in **relative mobility** and **relative improvements** in neighborhood air quality.
  4. Use quantile regression to see the impact of the Clean Air Act and National Ambient Air Quality Standards (NAAQS).

Summary of Results

1. African Americans tend to live in the most polluted areas nationally, but the gap has been closing.
   - Mean gap in pollution exposure: $1.5\,\mu g/m^3 \rightarrow 0.5\,\mu g/m^3$
2. differences in individual or household-level characteristics such as income, explain only a tiny part of observed convergence in pollution levels.
   - relative mobility differences or changes in Black-White population shares are not able to explain the observed convergence in pollution exposure
3. Much of this improvement of air quality around African Americans' is driven by the introduction of the PM2.5 NAAQS.
   - Spatially targeted nature of the CAA regulations contributes to the observed convergence in mean PM2.5 differences between Blacks and Whites.

Contributions

1. The first paper to link national representative survey to nationwide grid of PM 2.5 mesurement.
    - Explored the causal determinants of narrowing pollution gaps between racial groups over time.
    - Explore how much variation in pollution exposure be explained by individual endowments (income), aggregate neighborhood-level (average years of schooling) characteristics.
    - External validity (the spatially continuous PM2.5 measurements)

2. Effects of environmental policy and the Clean Air Act more specifically
   - Previous literature estimates average effects of policies (Chay and Greenstone, 2003; Isen, Rossin-Slater, and Walker, 2017)
   - Applying unconditional quantile regression(Firpo, Fortin, and Lemieux, 2009), they can discuss the impact of the Clean Air Act on diffrent empirical moments of the nationwide pollution distribution

Section 2

Data

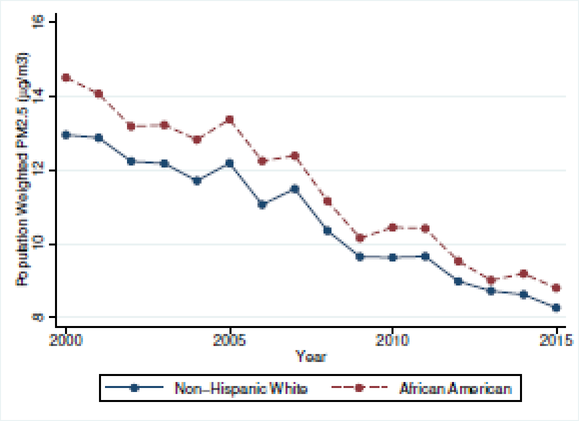
Background and Difficulties

- Spatially-continuous satellite measurements of pollution correlates
    - "out-of-sample" predictions: build a predictive model of a pollutant of interest by correlating EPA-monitor data with the observable characteristics (van Donkelaar, Martin, Brauer et al, 2016)
- This paper uses a 1km by 1km resolution daily PM2.5 concentration data of 2000-2015 (Di, Kloog, Koutrakis et al., 2016).
    - Satellite measurements are biased downward for high PM2.5 levels.

Data Construction

- Individual-level data with pollution and racial identities
  - 2000 Census long from
  - 2001-2015 American Community Surveys
- Primary comparisons focus on the non-Hispanic White and African American populations.
  - These are the largest and most-documented gaps
  - Lieber, Porter, Fernandez et al., 2017: Hispanic identity is more fluid over time than White or black racial identities.

Figure 1: Trends in Pollution Exposure by Race

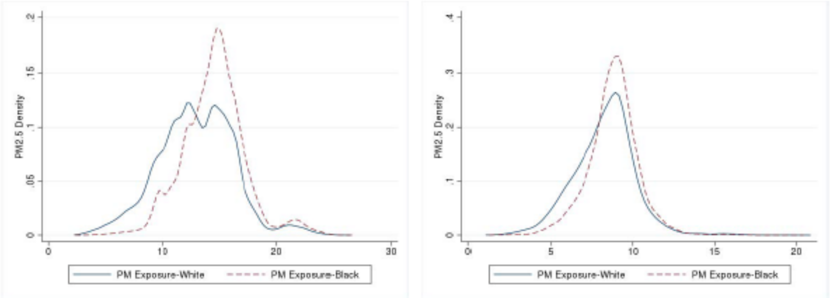


Racial Gaps in Pollution Exposure

- The observed racial gap in mean pollution exposure has declined by $1.0\,\mu g/m^3$ in 15 years.
- This improvement in the Black-White pollution gap could potentially explain 4% of the mortality gap improvement.
  - Life expectancy is reduced by .61 years for each $10\,\mu g/m^3$ (Pope III, Ezzati, and Dockery, 2015)
  - Over 2000-2015, the Black-White gap in life expectancy fell from about 5 years to 3.5 years (Arias, Xu, and Kochanek, 2019).
- The gap in exposure is explained by census-tract differences (about $5\,km^2$).

Figure 2: Distributions of Pollution Exposure, 2000 and 2015

(a) 2000 (b) 2015



NOTES: This figure plots the PM2.5 density, separately for African-Americans and the non-Hispanic White population in both 2000 and 2015. Due to Census disclosure avoidance review, we were forced to trim the upper 97th and lower 3rd percentiles of each density. Source: Decennial Census, American Community Survey, and Di et al. (2016).

Section 3

Decomposing Differences in Pollution Exposure

Table B2: Summary Statistics by Race, Overall, and Sub-Periods

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Overall		African-American		Non-Hispanic White		Mean Diff.	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	(5)-(3)	p-value
Panel A: Individual Characteristics								
Age	40.010	8.573	39.410	8.536	40.100	8.575	0.687	(0.000)
Years of School	13.650	2.650	13.130	2.405	13.720	2.674	0.587	(0.000)
Sex (1=Female)	0.514	0.500	0.549	0.498	0.509	0.500	-0.041	(0.000)
Homeowner	0.703	0.457	0.486	0.500	0.733	0.443	0.247	(0.000)
Number of Children	1.070	1.213	1.039	1.267	1.074	1.206	0.035	(0.000)
Income	48130	51590	34300	34630	50070	53250	15760	(0.000)
Bottom Income Quintile	0.200	0.400	0.264	0.441	0.191	0.393	-0.073	(0.000)
Top Income Quintile	0.200	0.400	0.106	0.307	0.213	0.410	0.108	(0.000)
PM2.5 (Satellite, Block)	10.770	2.980	11.460	2.748	10.680	2.999	-0.780	(0.000)
PM2.5 (Satellite, County)	10.770	2.812	11.390	2.608	10.680	2.829	-0.705	(0.000)
PM2.5 (EPA Monitors, County)	11.460	2.948	12.040	2.781	11.360	2.964	-0.679	(0.000)
Panel B: Census Tract Characteristics in 2000								
African American	0.123	0.131	0.262	0.175	0.103	0.110	-0.158	(0.000)
Public Assistance Income	34.04	39.98	34.35	40.89	33.99	39.85	-0.352	(0.902)
Income	48130	12920	47660	12780	48200	12930	540	(0.392)
Years of Schooling	13.640	0.708	13.680	0.683	13.640	0.712	-0.035	(0.276)
% Worked Last Year	0.834	0.047	0.828	0.046	0.835	0.047	0.007	(0.012)
Housing Value	292500	183000	292200	178900	292500	183500	299	(0.980)
Housing Rent	1096	317	1116	294	1094	320	-22.220	(0.203)
% Home Owners	0.703	0.111	0.657	0.120	0.709	0.108	0.053	(0.000)
% Single Family Residence	0.831	0.051	0.822	0.049	0.833	0.051	0.011	(0.000)
% in Urban County	0.992	0.089	0.997	0.057	0.991	0.092	-0.005	(0.000)
% Manufacturing Emp.	0.133	0.095	0.115	0.086	0.136	0.096	0.022	(0.000)
Panel C: County-Level Characteristics in 2000								
African American	0.129	0.232	0.556	0.320	0.069	0.134	-0.487	(0.000)
Welfare Income	30.50	135.80	51.71	205.90	27.53	122.60	-24.180	(0.000)
Years of School	13.590	1.409	13.150	1.305	13.650	1.412	0.496	(0.000)
Single Family Residence	0.824	0.163	0.792	0.186	0.829	0.159	0.037	(0.000)
Teen Pregnancy	-0.042	0.061	-0.063	0.074	-0.039	0.058	0.024	(0.000)
Home Ownership	0.720	0.204	0.603	0.236	0.737	0.194	0.134	(0.000)

Notes: This table presents summary statistics for individual and neighborhood characteristics for our main analysis sample. Source: 2000 Decennial Census, American Community Survey 2001-2015, and Di et al. (2016).

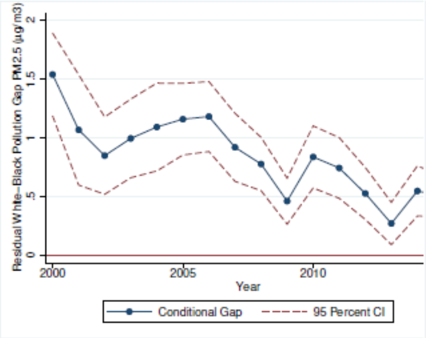
Conditional versus Unconditional Differences in Pollution Exposure

- Differences in exposure conditional on the differences in individual characteristics.
- Linear Regression: for individual i,

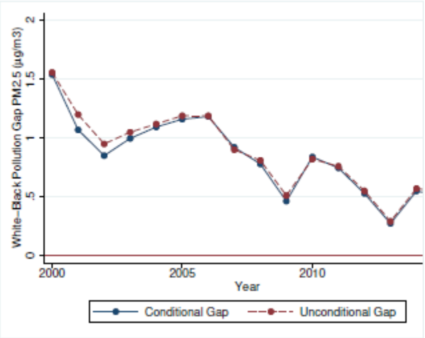
$$P_i = \gamma \mathbb{1}[\text{African American}_i] + X'\beta + \epsilon_i$$

  - X_i: individual income, age, education, number of children, gender, and an indicator for homeownership.
  - weighted by survey weights
  - SEs are clustered by commuting zone

(a) Conditional Gap with 95% Confidence Intervals



(b) Conditional vs. Unconditional Gap



- Individual characteristics seems to explain almost none of the differences.

Oaxaca-Blinder decinoisution

- Formally decomposing cross-sectional differences (Oaxaca, 1973; Blinder, 1973).

$$P_b - P_w = (X_b - X_w)\beta_b + (\beta_b - \beta_w)X_w$$

- Observable differences in individual and household characteristics are able to explain at most 8 percent of the gap in mean differences in any given year.

Table B4: Decomposition of Mean Differences in Pollution Exposure into Components Explained by Differences in Individual Characteristics and due to Differences in "Returns" to Characteristics

	(1) Year 2000	(2) Year 2015
Predicted difference	-1.616	-0.544
Panel A: Explained Gap		
Income	-0.001	0.000
Age	-0.009	-0.002
Schooling	-0.011	-0.010
Kids	0.003	0.001
Gender	0.000	0.000
Homeowner	-0.061	-0.033
Total	-0.078	-0.044
Panel B: Unexplained Gap		
Income	0.040	0.013
Age	-0.412	-0.251
Schooling	-0.419	-0.456
Kids	0.018	0.049
Gender	-0.009	-0.002
Homeowner	-0.002	0.000
Constant	-0.755	0.146
Total	-1.537	-0.500
N	10550000	1185000

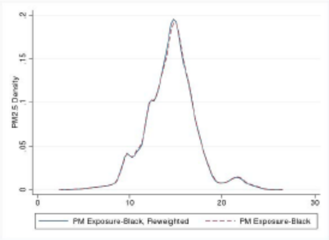
Notes: This table plots the results from an Oaxaca-Blinder decomposition of mean differences in PM2.5 exposure between African-Americans and non-Hispanic Whites. Column (1) performs this decomposition for the year 2000, whereas column (2) decomposes differences originating in 2015. Panel A displays the amount by which Black-White differences in the respective covariates explain the gap in mean PM2.5 exposure between groups. Panel B presents the amount by which Black-White differences in the respective coefficient estimates explain the gap in mean PM2.5 exposure between groups. Source: Decennial Census, American Community Survey, and Di et al. (2016).

Differences at Different Quantiles of the Pollution Distribution

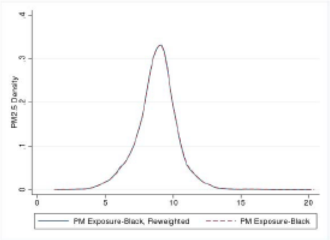
- Individual or household characteristics are able to explain differences in pollution exposure at other parts of the pollution distribution.
- DiNardo, Fortin, and Lemieux (1996): re-weighted kernel density estimate
  - estimate what the entire distribution of African American pollution exposure would look like if African Americans had the same observable characteristics
- Again, individual characteristics are able to explain little of the observed pollution gap throughout the distribution.

Figure B2: Actual versus Counterfactual African American Pollution Distribution: PM2.5

(a) Reweighted vs. Actual PM2.5 Density
African Americans, 2000



(b) Reweighted vs. Actual PM2.5 Density
African Americans, 2015



NOTES: These figures plot the actual versus counterfactual densities of pollution exposure for African Americans in 2000 and 2015. The counterfactual densities stem from an application of Dinardo, Fortin, Lemieux (1996), whereby we reweight the African American pollution distribution to reflect what the distribution would have looked like if they had the same individual characteristics as non-Hispanic Whites in our sample. See text for details. Source: Decennial Census, American Community Survey, and Di et al. (2016).

Neighborhood Characteristics

- Socioeconomic Characteristics
  - African Americans tend to be concentrated in census tracts with relatively disadvantaged neighbors.
  - mean public assistance income, the teen pregnancy rate, years of schooling, the share living in single family residences, the home ownership rate, miles of major highways, and total facility PM2.5 emissions

(c) Conditional Gap, Controlling for Tract Characteristics

- Black-White differences in neighborhood characteristics explain 0.324 of the documented 1.617 gap in PM2.5 exposure.
- tract home ownership rate explain about 20 percent of the difference in PM2.5 exposure.
- Education translates into substantially less pollution exposure for Whites than it does for Blacks.

Table B6: Oaxaca-Blinder Decomposition, Census Tract Characteristics

	(1) Year 2000	(2) Year 2015
Predicted difference	-1.617	-0.542
Panel A: Explained Gap		
Income	-0.001	0.001
Age	-0.007	-0.002
Schooling	0.001	-0.003
Kids	0.003	0.002
Gender	0.001	0.000
Homeowner	0.007	0.014
Neighborhood/Tract		
Tract Miles of Major Highway	-0.162	-0.061
Tract Total Facility PM2.5 Emissions	0.001	0.000
Tract Public Assistance Income	-0.025	-0.006
Tract Years of Schooling	-0.151	-0.042
Tract % Single Family Residence	0.336	0.014
Tract Teen Pregnancy Rate	0.002	-0.007
Tract Home Ownership Rate	-0.355	-0.111
Total	-0.351	-0.199
Panel B: Unexplained Gap		
Income	-0.045	0.014
Age	-0.267	-0.199
Schooling	-0.263	-0.324
Kids	0.025	0.055
Gender	-0.008	-0.002
Homeowner	-0.001	-0.005
Neighborhood/Tract		
Tract Miles of Major Highway	-0.144	-0.034
Tract Total Facility PM2.5 Emissions	0.001	-0.020
Tract Public Assistance Income	-0.220	0.008
Tract Years of Schooling	-4.033	-1.051
Tract % Single Family Residence	4.300	0.217
Tract Teen Pregnancy Rate	-0.030	-0.017
Tract Home Ownership Rate	-1.048	-0.290
Constant	0.732	1.289
Total	-1.252	-0.343
N	10550000	1139000

Notes: This table plots the results from two Oaxaca-Blinder decompositions of mean differences in PM2.5 exposure bet African-Americans and non-Hispanic Whites. Column (1) performs this decomposition for the year 2000, whereas colum decomposes differences originating in 2015. Panel A displays the amount by which Black-White differences in the respe covariates explain the gap in mean PM2.5 exposure between groups. Panel B presents the amount by which Black-W differences in the respective coefficient estimates explain the gap in mean PM2.5 exposure between groups. Source: Dece Census, American Community Survey, and Di et al. (2016).

The Role of Relative Mobility

- Is the improvement due to the relative movement of African Americans?
- To compare the counterfactual pollution exposure in 2015 (without mobility), the authors use Decennial Census.
  - Block-level population counts for non-Hispanic Whites and African Americans.
- If populations were fixed in their 2000 locations, the gain would have been $0.89\,\mu g/m^3$ instead of $1.02\,\mu g/m^3$ (12.7% of the total improvement.)
- The negative relationship between White population shares and pollution levels has weakened over time.

Table 2: Counterfactual Pollution Levels and Gaps Holding Location Fixed

	(1) Actual 2000 Exposure	(2) Actual 2015 Exposure	(3) Counterfactual 2015 using 2000 locations
White PM2.5 $\mu g/m^3$	12.96	8.25	8.22
Black PM2.5 $\mu g/m^3$	14.52	8.79	8.89
Black-White Difference	1.56	0.54	0.67
Change in B-W Diff		1.02	0.89

Notes: Rows (1) and (2) of columns (1) and (2) present mean pollution exposure separately for African American and non-Hispanic Whites in years 2000 and 2015. Row (3) presents the mean gap in pollution exposure in either each year. Row (4) presents the change in Black-White gap between 2000 and 2015. Column (3) presents a counterfactual exercise, whereby we ask what pollution levels would be and by how much the gap would have converged between 2000-2015 if we fixed the population in their 2000 location and assigned the 2015 pollution levels for their respective Census block. Source: Decennial Census, American Community Survey, and Di et al. (2016).

Section 4

The Clean Air Act and Relative Changes in Pollution Exposure

The Clean Air Act and Relative Changes in Pollution Exposure

- African American neighborhoods appears to have had greater improvements in air quality
- Clean Air Act (CAA)
  - regulations governing both stationary sources (factories) and mobile sources (cars).
- national ambient air quality standards (NAAQS): maximum allowable concentrations of criterion air pollutants (for stationary sources)
  - Each in year in July, the set of counties are checked (by EPA) if they violate their standard.
  - If they violate, the EPA can withhold federal funding for the state.

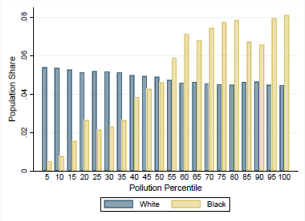
History of the CAA Policy Changes

- In 1997, the EPA tightened the NAAQS regulation about PM2.5 for the first time.
- After years of controversy in the court, the new standards were implemented in April 2005.
  - Revisions of the standard occured in 2006 and went into effect in 2009
- Because changes in 2005 was mandatory on reductions in annual PM 2.5, they focus this policy implementation.

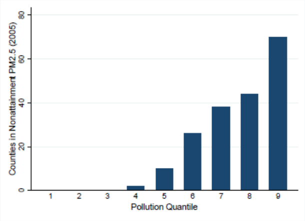
Racial Distribution and Pollution Decile

Figure 4: Racial Distribution of Population and Impact of CAA by Pollution Decile

(a) Distribution of African-American and non-Hispanic White population by decile of PM2.5 in 2000

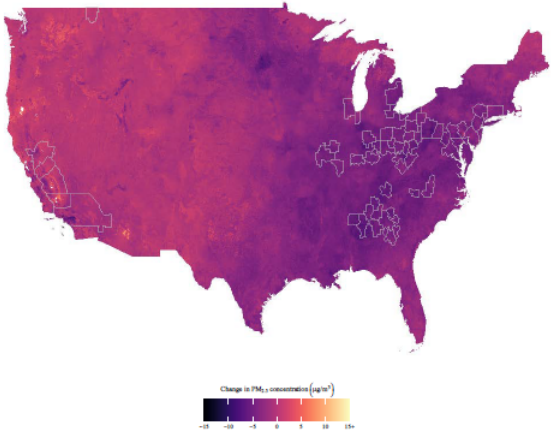


(b) Counties impacted by the CAA, by decile of PM2.5 in 2005



NOTES: Figure 4a plots population shares by pollution decile, separately for African American and non-Hispanic Whites. Figure 4b shows the total number of counties subject to the Clean Air Act's 1997 NAAQS PM2.5 standard, by pollution decile. Source: Decennial Census, American Community Survey, EPA NAAQS Greenbook, and Di et al. (2016).

Figure 5: Spatial Distribution of PM2.5 Changes from 2000-2015, Overlaid with Commuting Zones in Nonattainment of the PM2.5 National Ambient Air Quality Standards



NOTES: This figure plots the spatial distribution of 2000-2015 changes in PM2.5. We overlay this figure with the outlines of all the commuting zones containing at least one nonattainment county in 2005 for the Clean Air Act's 1997 NAAQS PM2.5 standard. While the PM2.5 NAAQS was initially proposed in 1997, the first year of regulatory enforcement began in 2005. Source: Di et al. (2016), EPA NAAQS Greenbook.

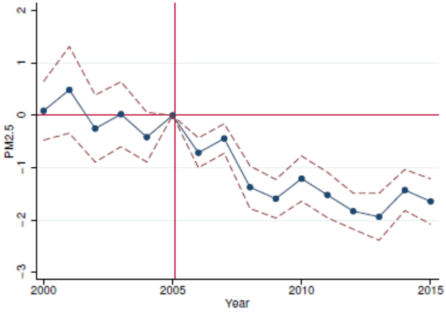
Impact of CAA: Identification Strategy

- Standard DID and event-study design
- For person i residing commuting zone c in year t,

$$P_{ict} = \sum_{t=2000}^{2015} \beta_t(\mathbb{1}[\text{Nonattain}_c] \times \mathbb{1}[\text{year}_t = t]) + \gamma_c + \rho_t + \epsilon_{ict}$$

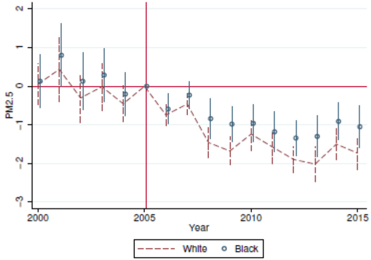
  - 62 CZs consists of 250 counties in 20 states were designated as nonattainment areas.
  - If the CZ violates the standard of pollutants, the indicator takes one.
  - weighted by survey weights
  - SEs are clustered by commuting zone

Figure 6: The Effect of the PM2.5 NAAQS on Newly Regulated Commuting Zones



NOTES: This figure plots the event-time coefficient estimates from a version of equation (2), where the dependent variable consists of PM2.5 exposure ($\mu g/m^3$) for a given individual-year. The regression model controls for county and year fixed effects. The dashed lines represent 95% confidence intervals. Regressions are weighted by Census survey weights and errors are clustered by commuting zone. Source: Decennial Census, American Community Survey, EPA NAAQS Greenbook, Di et al. (2016).

Figure B4: The Effect of the PM2.5 NAAQS on Newly Regulated Commuting Zones, By Race



NOTES: This figure plots the event-time coefficient estimates from a version of equation (2), where the dependent variable consists of PM2.5 exposure ($\mu g/m^3$) for a given individual-year. This figure estimates equation (2) separately by race. The regression model controls for county and year fixed effects. The red dashed lines correspond to estimates for non-Hispanic White individuals. The hollow circles correspond to estimates for African Americans. The vertical lines represent 95% confidence intervals for the respective point estimates. Regressions are weighted by Census survey weights and errors are clustered by commuting zone. Source: Decennial Census, American Community Survey, EPA NAAQS Greenbook, Di et al. (2016).

- Standard DID

$$P_{ict} = \beta(\mathbb{1}[\text{Nonattain}_c] \times \mathbb{1}[\text{year}_t = t]) + \gamma_c + \rho_t + \epsilon_{ict}$$

Table 3: The Impact of the 2005 Implementation of PM2.5 Standards on PM2.5 levels

	(1) PM2.5	(2) PM2.5	(3) ln(PM2.5)	(4) ln(PM2.5)	(5) PM2.5	(6) PM2.5	(7) ln(PM2.5)	(8) ln(PM2.5)
PM2.5 Nonattain×Post	-1.230	-1.237	-0.075	-0.076	-0.727	-0.726	-0.036	-0.036
	(0.335)	(0.334)	(0.020)	(0.020)	(0.080)	(0.082)	(0.006)	(0.006)
PM2.5 Non×Black×Post		0.149		0.008		0.048		0.004
		(0.088)		(0.007)		(0.091)		(0.005)
Year FE	X	X	X	X				
State-Year FE					X	X	X	X
County FE	X	X	X	X	X	X	X	X
Observations	32360000	32360000	32360000	32360000	32360000	32360000	32360000	32360000

Notes: This table presents regression coefficients from 8 separate versions of equation (3), one per column, where the dependent variable consists of PM2.5 or ln(PM2.5) for an individual in a given year. Columns (2), (4), (6), and (8) add an additional interaction for African Americans to test for heterogeneity in regulatory impacts for African Americans. Regressions are weighted by Census survey weights and errors are clustered by commuting zone. Source: Decennial Census, American Community Survey, EPA NAAQS Greenbook, Di et al. (2016).

- Within-county improvements in air quality were slightly less for African Americans than for non-Hispanic Whites (statistically insignificant).

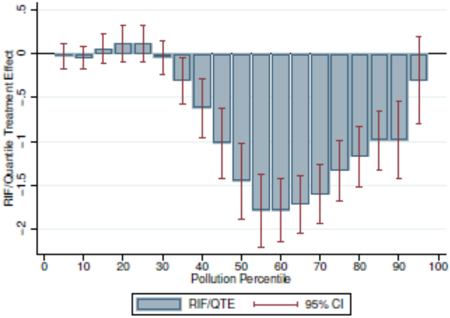
Summary of DID

- There have been large improvements over time in air quality for both African Americans and non-Hispanic Whites.
  - PM2.5 levels fell by $1.23\,\mu g/m^3$ in nonattainment counties in the years after the regulation went into place.
- Mobile-source regulations, as well as stationary sources are national in scope and have also led to signficant national improvements in air quality over this time period.

Distributional Impacts of PM2.5 NAAQS

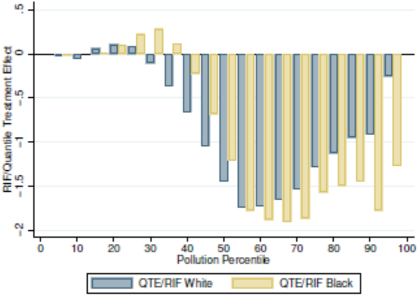
- DID tells us about the ATE.
- Quantile Regression Estimates
    -

Figure 7: RIF-Quantile Treatment Effects of the 2005 CAA PM2.5 NAAQS Implementation



NOTES: This figure plots the regression coefficient $\hat{\beta}$ from 19 separate versions of equation (3), where the dependent variable consists of the RIF-Quantile transformation of the respective PM2.5 vigintile (indicated by the x-axis). The regression model controls for county fixed effects and state-by-year fixed effects. The solid red lines represent 95% confidence intervals. Regressions are weighted by Census survey weights and errors are clustered by commuting zone. Source: Decennial Census, American Community Survey, EPA NAAQS Greenbook, Di et al. (2016).

Figure 8: Race-Specific RIF-Quantile Treatment Effects of the 2005 CAA PM2.5 NAAQS Implementation



Notes: This figure plots the regression coefficient $\hat{\beta}$ from 38 separate versions of equation (3), 19 regressions for each race, where the dependent variable consists of the RIF-Quantile transformation of the respective PM2.5 vigintile (indicated by the x-axis). The regression model controls for county fixed effects and state-by-year fixed effects. Regressions are weighted by Census survey weights and errors are clustered by commuting zone. Source: Decennial Census, American Community Survey, EPA NAAQS Greenbook, Di et al. (2016).

Table 4: Calculating the Effect of CAA Regulations on the Black-White PM2.5 Gap

(1) PM2.5 Quantile Bin	(2) Actual PM2.5 in 2005	(3) Actual PM2.5 in 2015	(4) White Counterfactual PM2.5 in 2015 Without CAA	(5) Black Counterfactual PM2.5 in 2015 Without CAA
5	5.32	4.34	4.37	4.36
10	7.87	5.63	5.69	5.63
15	8.91	6.25	6.18	6.24
20	9.65	6.72	6.62	6.62
25	10.33	7.11	7.03	6.88
30	10.90	7.45	7.56	7.17
35	11.42	7.75	8.12	7.64
40	11.90	8.01	8.67	8.23
45	12.34	8.24	9.28	8.92
50	12.73	8.44	9.89	9.65
55	13.09	8.65	10.39	10.43
60	13.44	8.84	10.57	10.73
65	13.80	9.03	10.68	10.93
70	14.15	9.22	10.75	11.09
75	14.51	9.42	10.71	11.00
80	14.91	9.67	10.80	11.17
85	15.27	9.98	10.93	11.43
90	15.72	10.49	11.41	12.27
95	17.01	12.21	12.46	13.48

Main Counterfactual: Including 2005-2015 Mobility Responses	
2005 Actual Black-White Gap:	1.20
2015 Counterfactual Black-White Gap:	0.97
Counterfactual Change in Black-White Gap:	-0.23
Actual Change in Black-White Gap:	-0.59
% of Actual Gap Attributable to CAA:	**61.2%**

Notes: This table presents calculations used to explore what fraction of the observed racial convergence in mean PM2.5 levels can be attributed to the regulatory variation embedded into the Clean Air Act's 2005 PM2.5 NAAQS. The top panel describes actual pollution levels within each quantile bin in 2000 and 2015. Columns (4) and (5) use estimates from Figure 10 to calculate what pollution would be in 2015 in the absence of the CAA PM2.5 NAAQS implementation, separately for African Americans and non-Hispanic Whites. The second panel computes the counterfactual gap in 2015 in the absence of the CAA NAAQS and the implied 2005-2015 change in the gap. Source: Decennial Census, American Community Survey, EPA NAAQS Greenbook, Di et al. (2016).

Section 5

Conclusion

Concluding Remarks

- This paper add to the small but growing literature using high-resolution, nationwide data on pollution to examine racial differences in potential pollution exposure
- Racial gaps in exposure have narrowed at each quantile of the PM2.5 distribution
- Fidings suggest that the CAA has likely played a significant role in reducing racial gaps in exposure to air pollution.