# 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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December 15th, 2022
Ohtake-Sasaki Seminar

# 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

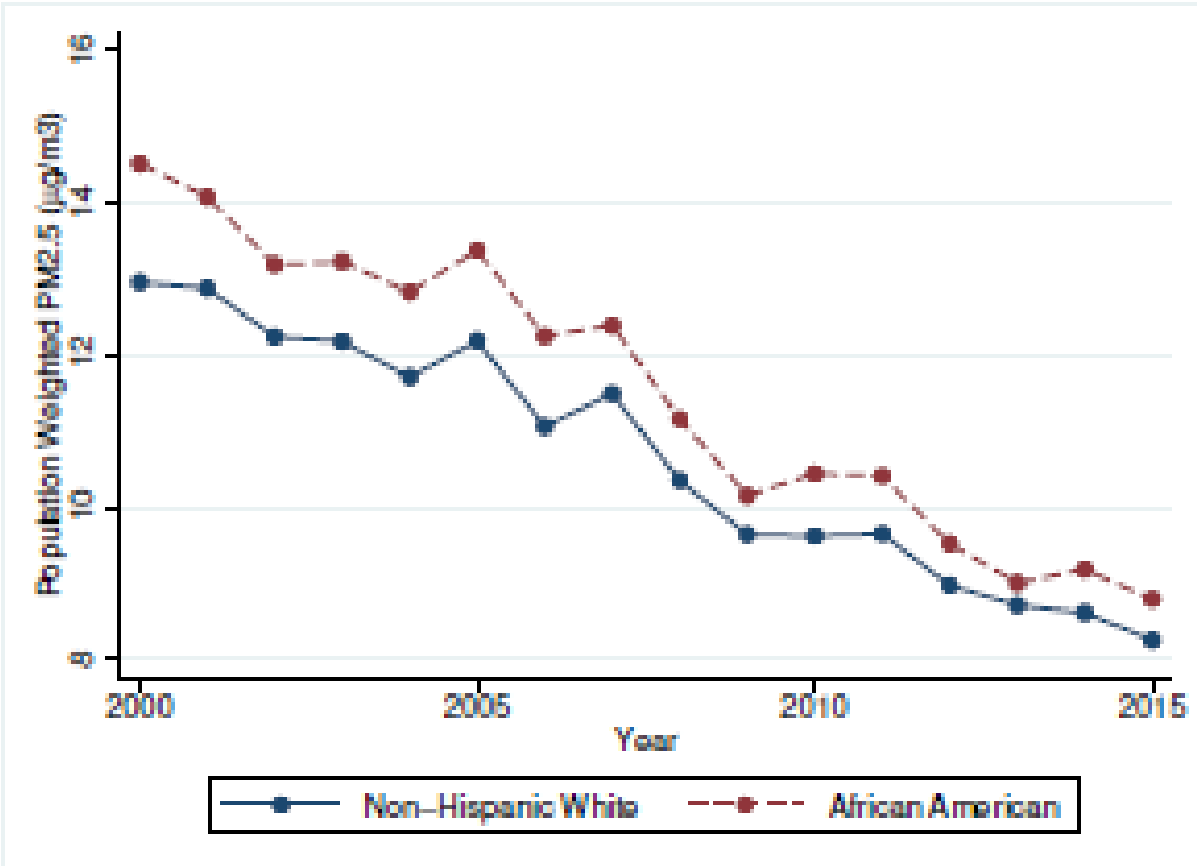
# Background and Difficulties

- 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.

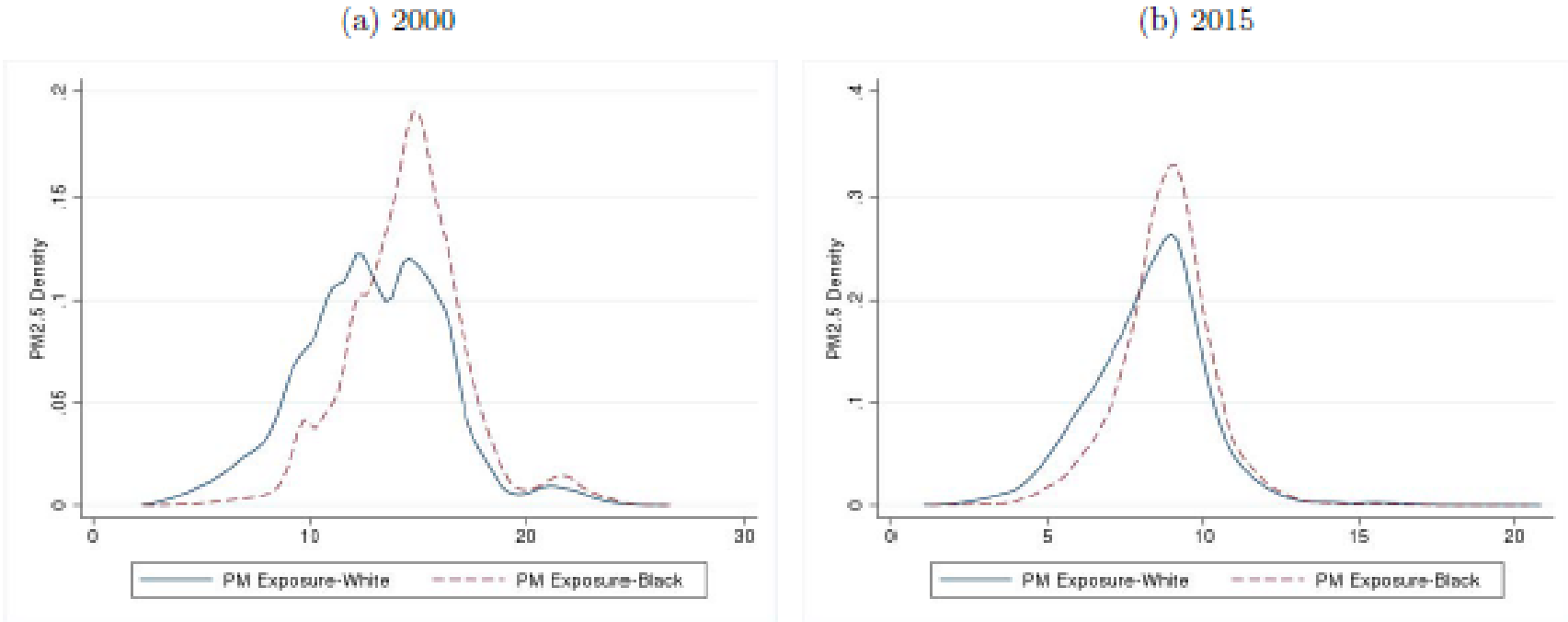
Figure 1: Trends in Pollution Exposure by Race



# 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




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

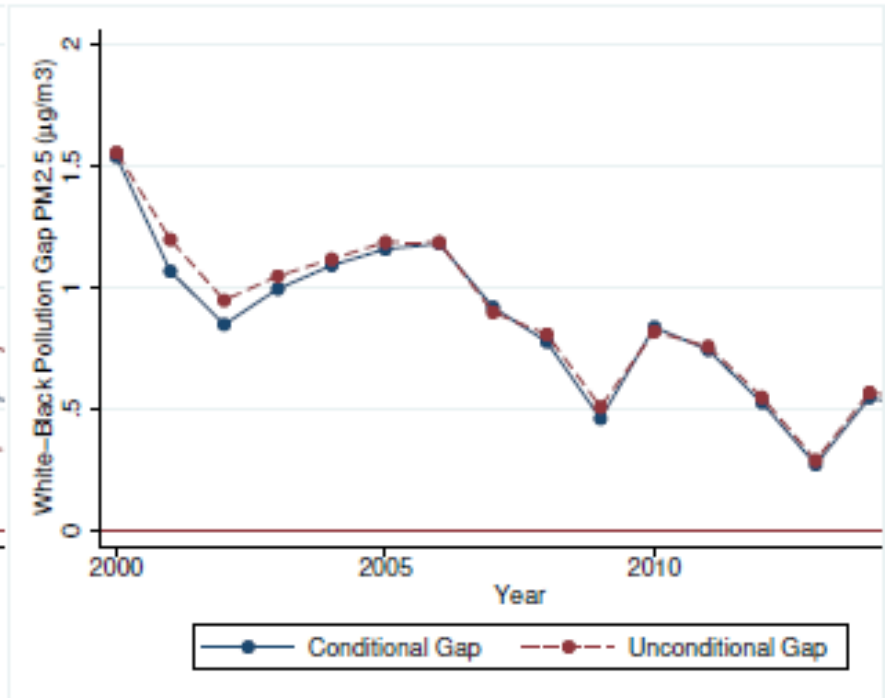
- Differences in exposure conditional on the differences in individual characteristics.
- Linear Regression: for individual $i$,

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

  - $X_i$: 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).
- 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 |

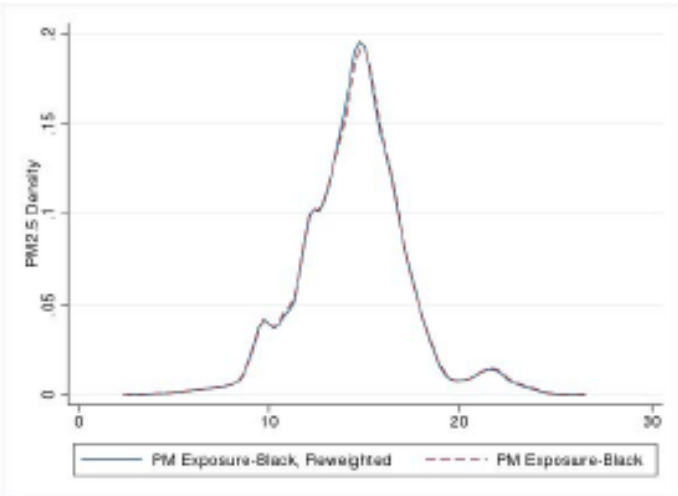
Notes: This table plots the results from an Oaxaca-Blinder decomposition of mean differences in PM2.5 exposure between African-Americans and non-Hispanic Whites. Column (1) performs this decomposition for the year 2000, whereas column (2) decomposes differences originating in 2015. Panel A displays the 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

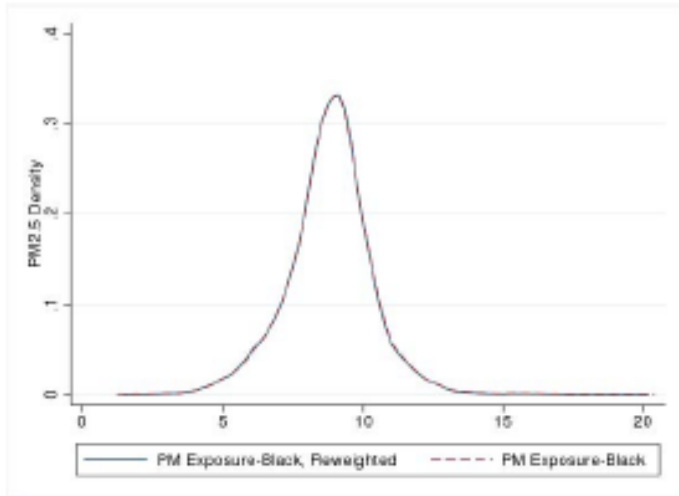
- Individual or household characteristics are able to explain differences in pollution exposure at other parts of the pollution distribution.
- DiNardo, Fortin, and Lemieux (1996): re-weighted kernel density estimate
  - estimate what the entire distribution of African American pollution exposure would 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).

# Controlling for Naeghborhood Characteristics

- Socioeconomic Characteristics
  - African Americans tend to be concentrated in census tracts with relatively disadvantaged neighbors.

(c) Conditional Gap, Controlling for Tract Characteristics

Section 4

# The Clean Air Act and Relative Changes in Pollution Exposure

Section 5

# Conclusion