Behind Environmental Injustice: Disparate Siting Industries and Post-siting Demographic Transformation

Ruohao Zhang[a,*]

[a] *Centre College, Danville, KY*

December 10, 2022

Abstract

Environmental injustice is caused by two mechanisms: disparate siting and post-siting migration. This paper shows disparate siting and post-siting transformation both significantly contribute to environmental injustice. Empirically, I analyze the relationship between the siting of fossil fuel power plants and the local racial composition at the census tract level in the U.S. between 2000 and 2019. The results suggest that fossil fuel power plants are more likely to be sited in the areas with a higher minority ratio, and on average it causes an increase in the local minority ratio by 2.7%.

Key words: Environmental Justice, Fossil Fuel Power Plant, Siting, Migration

JEL codes: H11, H51, H75, Q52, Q53, Q58

[*] Corresponding author. E-mail: ruohao.zhang@centre.edu.

1 Introduction

It has been well documented by the literature that there are long-lasting and significant socioeconomic disparities in exposure to environmental pollution sources. Studies have shown that minorities are disproportionately located in areas with more environmental pollution, and such a pattern of inequity has persisted, over almost four decades from 1980s (Colmer et al., 2020; Bullard, 1983; Banzhaf et al., 2019b) to the present, despite the huge government and public efforts in promoting environmental justice and social equity over time.

To address the racial gap in pollution exposure, it is very important to understand the mechanisms that cause such disparity and environmental injustice. According to Banzhaf et al. (2019b) and Banzhaf et al. (2019a), there exist two mechanisms: disparate siting and post-siting migration. Disparate siting means pollution industries are more likely to be sited in minority communities due to various reasons, such as lower land prices, closer distance to major highways, lower labor costs, or less local opposition by residents. Post-siting migration implies post-siting disparate migration behaviors across races due to the different socioeconomic characteristics and the change in local amenities, which eventually affect the local racial composition.

In this paper, I study the relationship between the siting of fossil fuel power plants in the U.S. and the racial composition at the census tract level during the period from 2010 to 2019. The results suggest that disparate siting and post-siting migration both significantly contribute to environmental injustice. Specifically, I found that fossil fuel power plants are more likely to be sited in the census tracts with a higher minority ratio. After the siting, on average, the local minority ratio increased by 2.7%, with a 13.7% decrease in the local white population and a 15.8% increase in the local minority population

The paper has the following structure: I discuss the conceptual perspective and summarize the previous literature in section 2, describe the data set and summary statistics in section 3, present the empirical models and analysis in section 4, and make conclusions in section 5.

2 Conceptual Prospective and Literature

2.1 Polluting Plants Siting Decisions

Plants decide their siting locations by considering operating costs, which consist of production cost, transportation cost, and pollution cost (Wolverton, 2009). Each of these costs is determined by multiple local characteristics. For example, production cost depends on local land price, labor cost, and the price of raw (or intermediate) materials; transportation cost depends on the distance of transporting products to the targeted market, and pollution cost depends on government regulation efforts and local public pressure (Lyon and Maxwell, 1999; Bi and Khanna, 2012; Zhang and Khanna, 2022). Plants choose siting locations with the lowest total operating costs.

The non-uniform geographical distribution of operating costs leads to disproportional siting probabilities of polluting plants across communities with different socioeconomic characteristics. Polluting plants are more likely to be sited near disadvantaged neighborhoods if these locations are associated with lower land and labor costs, closer distance to highways and railroad, and less regulation pressure (Banzhaf et al., 2019b). In addition, disadvantaged neighborhoods may also generate less public pressure on plants' pollution if local residents have a lower willingness to pay for a clean environment (Depro et al., 2015), inadequate information about pollution damage, and weaker collective actions and Coasian bargaining power against polluting industries (Hamilton, 1995; Shapiro, 2005; Banzhaf et al., 2019a). Therefore, disadvantaged neighborhoods are exposed to higher pollution sources.

There is a large literature studying siting disparities of polluting plants. Bullard (1983) found that solid waste sites were located in the areas with higher African American residents in Houston; Saha and Mohai (2005) found significant socioeconomic disparities in hazardous waste facilities in Michigan between 1950 and 1990; Wolverton (2009) found that income plays a significant role in polluting plant siting; McCoy (2017) found that coal-fired power plants were more likely to site in minority communities.

2.2 Post-siting Migration (Sorting)

The siting of polluting plants worsens local environmental quality, therefore in return affecting local demographic characteristics. This may be caused by disadvantaged households having difficulty "moving away from the nuisance", or even "coming to the nuisance", as pollution is usually associated with job opportunities and lower housing prices. Literature has utilized a sorting model to study such residential location choices. Bayer et al. (2009) and Klaiber and Phaneuf (2010) found that environmental quality plays important role in households' residential location choice. Depro et al. (2015) found a racial gap in willingness to pay for clean air that caused white households to move away from pollution sources. Melstrom and Mohammadi (2022) found that minorities tend to move away from the areas when there is an improvement in local environmental quality. However, as the consequence, local demographic changes are not well supported by the empirical finding in the literature. Several papers studied fail to find any significant post-siting changes in local minority share (Pastor et al., 2001; Hunter et al., 2001). Others found racial differences in migration patterns around polluting plants' locations (Stretesky and Hogan, 1998; Crowder and Downey, 2010).

2.3 Comprehensive Analysis on both Siting and Sorting

There is small literature that provides a comprehensive study on both disparate siting and post-siting migration. Mohai et al. (2009) and Banzhaf et al. (2019b) provided a detailed explanation of these mechanisms and summarized how they relate to environmental injustice. The only empirical study is Pastor et al. (2001), which investigated disparate siting and post-siting migration with respect to toxic storage and disposal facilities in Los Angeles county, CA, but failed to find any significant post-siting changes in local demographic and did not identify causality impact. To my best knowledge, this is the first paper that analyzes both siting and sorting mechanisms of the power generation industry, provides quantitative estimates of how disparate siting and post-siting migration together cause a racial gap in pollution exposure, as well as identifies causal impact on racial composition at aggregated community (census tract) level and reveals the consequence of socioeconomic segregation.

3 Data and Sample Description

I assemble a census tract-by-year data set that covers all fossil fuel power plants in the contiguous U.S. Compiled from multiple data sources, the data includes annual information on county socioeconomic characteristics, weather, and the total capacity of new, existing, and retired fossil fuel power plants in each county. The sample period is from 2010 to 2019.

The fossil fuel power plant data is provided by the Electric Generator Inventory at U.S. Energy Information Administration (EIA). The data is collected from EIA-860 form, a survey form of generator-level specific information about new, existing, and retired generators with 1 megawatt or greater of combined nameplate capacity. The data include power plants' location, energy sources, electricity generation capacity, operation starting year, and retirement year. I aggregate the generator-level data to plant-level and select a sample of fossil fuel power plants based on whether their energy sources are coal, petroleum, or natural gas. According to the data, there are in total of 3,898 fossil fuel power plants ever operated in the contiguous U.S., among which 1,479 plants are already retired by 2019, and 818 plants are newly established between 2010 and 2019. Figure 1 plots the location of these newly established fossil fuel power plants, which are mostly located around major metropolitan areas in California, Texas, and the Northeastern region.

The annual socioeconomic data is from American Community Survey at the county level, provided by the U.S. Census Bureau. The data includes income-per-capita, high school rate, population, and race composition. I also obtain county geographical data from the U.S. Census Bureau for calculating population density. The socioeconomic data covers 71,958 census tracts across 3,108 counties in the contiguous U.S. (lower 48 states and Washington D.C.).

Weather is closely related to energy consumption, thus potentially correlated with power plant siting. I collect annual temperature data from Parameter–elevation Regressions on Independent Slopes Model (PRISM), a spatial climate database (http://prism.oregonstate.edu). PRISM data are available at a spatial grid of 4 km^2, which is flexible and convenient to be aggregated to different geographical units. Following Zhang et al. (2023), I aggregate the grid temperature data to the census tract level through a weighted average method, where the weight is calculated by the overlapping areas between census tracts and grids.

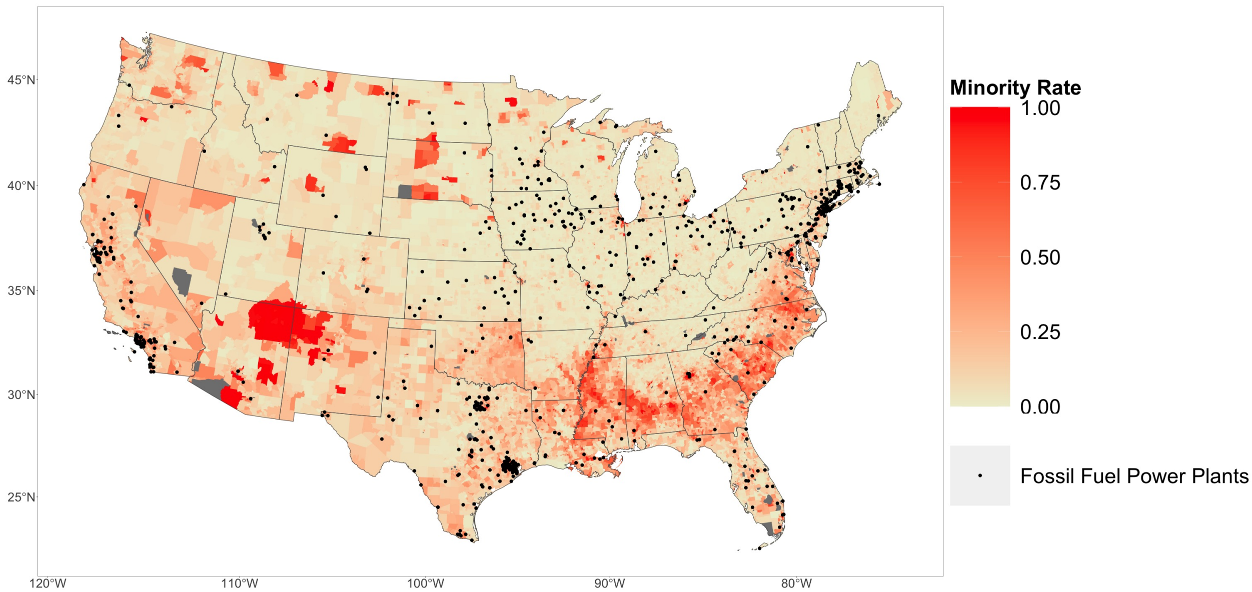


Figure 1: Fossil Fuel Power Plants Siting Location, 2010 – 2019

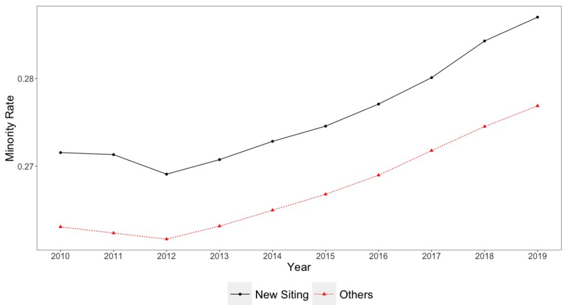
Table 1 summarizes all of the key variables for all census tracts, and for census tracts with/without new siting of fossil fuel power plants between 2010 and 2019, respectively. It shows that new fossil fuel power plants are more likely to be sited in the census tracts with relatively higher minority ratios, lower population density, lower education, lower housing value, and lower temperature. Besides, new fossil fuel power plants also tend to be sited in areas that already have large fossil fuel power plants before. However, new fossil fuel power plants are more likely to be sited in the census tracts with relatively higher income per capita, which is probably because of the positive association between local energy consumption (that is related to new plant siting probability) and economic development (that related to income). Figure 2a plots the annual trend of racial composition. In general, there is an increase in the minority ratio across all census tracts. However, as shown in Figure 2b, the minority ratio is relatively higher in census tracts with new siting of fossil fuel power plants, and their increase in minority ratio is also relatively faster.

Table 1: Summary Statistics

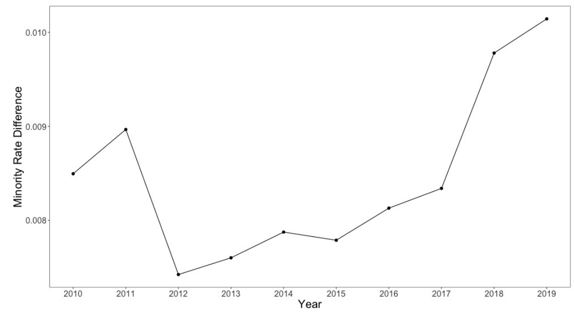
Variable	Full Sample	New Siting Census Tracts	Other Census Tracts
Minority Rate	0.2675	0.2759	0.2674
	(0.2525)	(0.2305)	(0.2526)
Current Elec. Cap. (MW)	12.3333	224.1702	11.2470
	(134.4152)	(535.6579)	(128.2881)
Newly Retired Elec. Cap. (MW)	0.1367	2.5661	0.1243
	(11.4675)	(51.8936)	(10.8785)
Population Density (1,000 per KM^2)	2.0416	1.2635	2.0456
	(4.5591)	(3.1010)	(4.5650)
Income per Capita ($1,000)	29.4086	30.4661	29.4032
	(0.1132)	(0.1104)	(0.1132)
High School Grad. Rate	0.8579	0.8557	0.8579
	(0.1132)	(0.1104)	(0.1132)
Median Housing Value ($10,000)	23.6149	23.5990	26.7850
	(20.0420)	(20.0300)	(22.0774)
Min. Temperature (°C)	8.7882	8.3762	8.7903
	(4.6670)	(4.6681)	(4.4194)
Max. Temperature (°C)	19.9026	19.4814	19.9048
	(4.8878)	(4.5309)	(4.8895)
Number of Census Tracts	72,040	367	71,673
Number of Observations	719,349	3,670	715,679

Note: Column "New Siting Census Tracts" reports the statistics of all census tracts with newly established fossil fuel power plants between 2010 and 2019, regardless of participating year. Column "Other Census Tracts" reports the statistics of all census tracts that do not have newly established fossil fuel power plants between 2010 and 2019. Current and newly Retired Capacities are only fossil fuel power plants. *p<0.1; **p<0.05; ***p<0.01.

Figure 2: Minority Rate Trend in Census Tracts with/without New Fossil Fuel Power Plants, 2010 – 2019



(a) Separate Trends of Census Tract Minority Ratios with/without New Siting, Respectively



(b) Difference between Census Tracts with/without New Siting

4 Empirical Analysis

Empirically, I analyze the impacts of disparate siting and post-siting migration on racial gaps in pollution source exposure, respectively. I use the fossil fuel power plant data to test the following two hypotheses: 1. the fossil fuel power plants are more likely to be sited around minority communities; 2. there is a demographic change after the siting of fossil fuel power plants.

4.1 Siting Decision

I use a logistic model to test whether fossil fuel power plants are more likely to be sited in communities with a higher minority ratio. Consider the following model:

$$Logit(y_{it}) = \alpha + \beta M_{it} + \gamma X_{it} + \varepsilon_{it}, \tag{1}$$

where y_{it} is a binary siting outcome with $y_{it} = 1$ if a new fossil fuel power plant is sited in census tract i in year t. M_{it} is minority rate, X_{it} is a vector of control variables, and ε_{it} is residual. In practice, I run multiple models with a different set of control variables and report the results in Table 2.

In columns (1) to (3), I control for the characteristics of existing fossil fuel power-generating industries, population density, and local socioeconomic characteristics. In columns (4) and (5), I in addition add state and year fixed effects to capture unobserved local and time factors. The coefficient of interest, minority ratio, is always positive and significant across all model specifications, which suggests that census tracts with a relatively greater ratio of minority residents are more likely to be chosen for siting a new fossil fuel power plant, which implies that minority population is disproportionately exposed to the pollution source such as fossil fuel power plants.

In addition, these regression results suggest that new fossil fuel power plants are more likely to be sited in the areas with clusters of power generating industry since current and newly retired electricity capacity are both significantly and positively related to the siting probability. New fossil fuel power plants are also more likely to be sited in areas with lower population density and lower temperatures. Although the relationship between siting probability and other socioeconomic characteristics is less significant, they are in general consistent with our expectation that new plants are more likely to be sited in areas with lower income and education levels. It is a little bit surprising that median housing value is positively related to siting probability, which may because of the strong correlation between housing value and other factors such as income per capita.

4.2 Post-siting Migration

I use the difference-in-differences method to study the causal impact of the siting of a new fossil fuel power plant on migration and local demographics. In this analysis, all census tracts are separated into a treated group and a control group. The treated group includes all census tracts that site at least one new fossil fuel power plant during the sample period (2010-2019). In order to eliminate unobserved characteristics that relate to siting, I use the previous siting logistic regression described by equation 1 to estimate the propensity score of siting a new fossil fuel power plant in every census tract. The control group is selected as follows: for every treated census tract, I compare its propensity score with all control census tracts in the year of siting and select ten control census tracts with propensity scores most similar to the treated one. The propensity score matched sample is shown in Appendix Figure A2.

Consider the following event study analysis:

$$q_{it} = \sum_{\tau=-9}^{-2} \eta_t \mathbf{I}[t - t_i^s = \tau] + \sum_{\tau=0}^{9} \eta_t \mathbf{I}[t - t_i^s = \tau] + \gamma X_{it} + Group_i + Year_t + \varepsilon_{it} \tag{2}$$

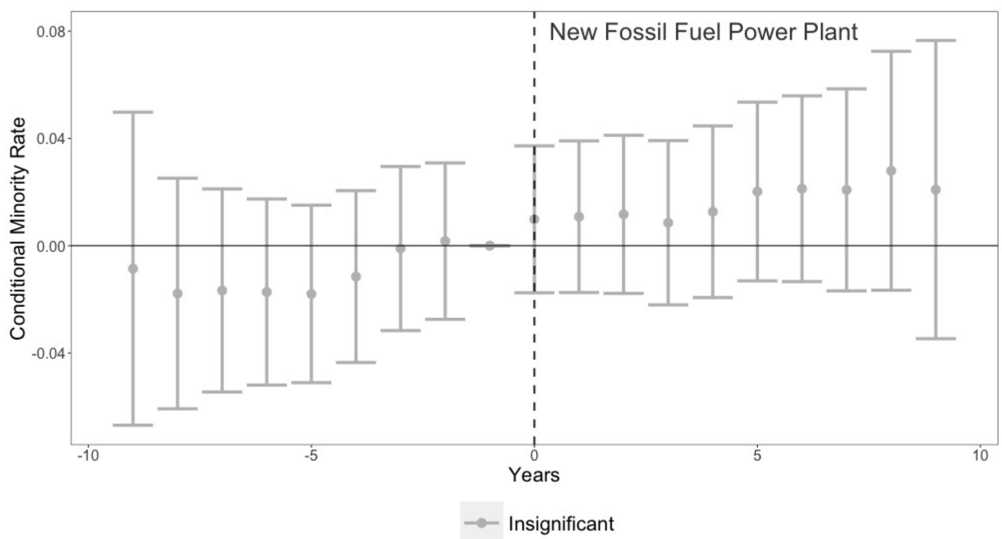
Table 2: New Fossil Fuel Power Plant Siting

	Dependent variable:				
	New Fossil Fuel Power Plant Siting Dummy				
	(1)	(2)	(3)	(4)	(5)
Minority Ratio	0.3507*	0.6968***	0.8463***	0.8961***	0.8864***
	(0.1946)	(0.2049)	(0.2364)	(0.2679)	(0.2691)
Current Elec. Cap. (MW)	0.0014***	0.0014***	0.0015***	0.0016***	0.0016***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Newly Retired Elec. Cap. (MW)	0.0021***	0.0021***	0.0021***	0.0021***	0.0020***
	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)
Population Density (per KM^2)		−0.0001***	−0.0002***	−0.0003***	−0.0002***
		(0.00003)	(0.00003)	(0.00004)	(0.00004)
Income per Capita ($1,000)			−0.0117**	−0.0079	−0.0082
			(0.0059)	(0.0069)	(0.0070)
High School Grad. Rate			−0.6724	0.1933	0.2331
			(0.6453)	(0.6522)	(0.6559)
Median Housing Value ($10,000)			0.0219***	0.0052	0.0046
			(0.0031)	(0.0045)	(0.0045)
Max. Temperature (°C)			−0.0386	−0.1336***	−0.1359***
			(0.0279)	(0.0367)	(0.0372)
Min. Temperature (°C)			−0.0091	0.0932**	0.0813**
			(0.0295)	(0.0382)	(0.0385)
Constant	−7.7259***	−7.6668***	−6.4299***		
	(0.0774)	(0.0786)	(0.6751)		
State FE	N	N	N	Y	Y
Year FE	N	N	N	N	Y
Observations	719,349	719,297	708,082	708,082	708,082
Log Likelihood	−3,198.8008	−3,188.2782	−3,020.9643	−2,873.7231	−2,862.3509
Akaike Inf. Crit.	6,405.6016	6,386.5563	6,061.9287	5,863.4462	5,858.7017

Note: Current electricity capacity and newly retired electricity capacity are only for fossil fuel power plants. Newly retired electricity capacity are for all fossil fuel power plants that retired within the year. *p<0.1; **p<0.05; ***p<0.01

where i and t are census tract and year indexes. q_{it} is the demographic of census tract i in year t, where I use three different measurements: white population, minority population, and minority ratio. t_i^s is the year that the new plant is sited in census tract i. For census tracts that never site a plant during the sample period, I set $t_i^s = \infty$. τ is the difference in years between year t and the siting year t_i^s. $\mathbf{I}[t - t_i^s = \tau]$ is the indicator function, which equals 1 if the condition in the bracket is satisfied and 0 otherwise. η_τ captures the annual gap between the siting census tracts and the others, conditional on the set of covariates X_{it}. $Group_i$ and $Year_t$ are the group and time fixed effects.[1]

Figure 3: Post-Siting Changes in Minority Rate

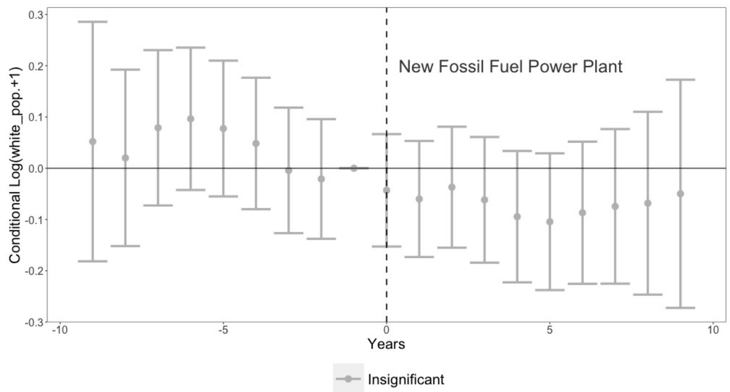


Note: The event studies use the propensity score matched sample. Control variables are current electricity capacity, newly retired electricity capacity, population density, income per capita, high school graduation rate, maximum and minimum temperature, new siting (treated) group dummy, and year fixed effect.

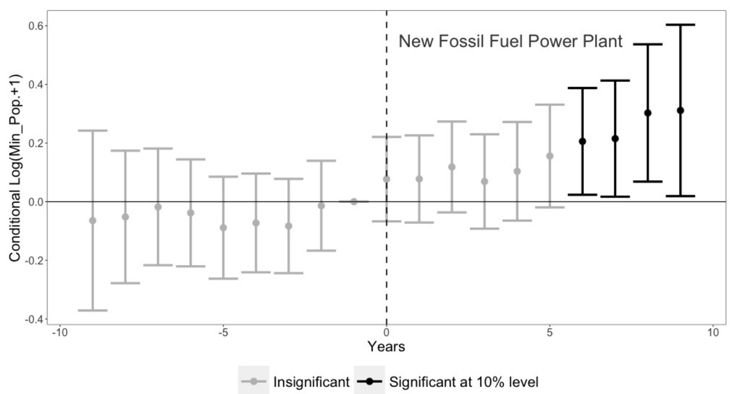
Figure 3 and 4 report the event study results, controlling for current and newly retired fossil fuel electricity capacity, population density, income, education, housing values, and temperature. The results show that after the new fossil fuel power plants are sited, there is an increasing trend in local minority ratio and minority population, and a decreasing trend in white population. Although most of the coefficients in Figure 3 and 4a are mostly insignificant, but the figures still show clear

[1] I have also tried to use the census tract fixed effect instead of the group fixed effect. However, the model with census tract fixed effect seriously overfits the data: the census tract fixed effect captures most of the variation in the data, with the overall R-square of 0.969 and the within R-square of only 0.013.

Figure 4: Post-Siting Demographic Changes, Population by Races



(a) Siting Impact on White Population



(b) Siting Impact on Minority Population

Note: The event studies use the propensity score matched sample. Control variables are current electricity capacity, newly retired electricity capacity, population density, income per capita, high school graduation rate, maximum and minimum temperature, new siting (treated) group dummy, and year fixed effect.

patterns that local racial composition has immediate changes after new plants are sited. All three event study results are consistent with each other, providing clear evidence of white households moving away from the siting areas while minorities moving toward the "nuisance".

I use the following difference-in-differences regression to estimate the average treatment effect:

$$q_{it} = \delta D_{it} + \gamma X_{it} + Group_i + Year_t + \varepsilon_{it} \tag{3}$$

where D_{it} is the treatment dummy that captures whether a new plant has been sited in census tract i. Table 3 reports the results. On average, the siting of a new fossil fuel power plant significantly

Table 3: The Impact of New Fossil Fuel Power Plant Siting on Local Racial Composition, a Difference-in-differences Analysis

	Dependent variable:		
	minority rate (%)	log(white_pop.+1)	log(min_pop.+1)
	(1)	(2)	(3)
New Siting (Treatment) Dummy	0.0211***	−0.0919***	0.1663***
	(0.0073)	(0.0294)	(0.0386)
Income per Capita ($1,000)	−0.0059***	0.0111***	−0.0244***
	(0.0001)	(0.0005)	(0.0007)
High School Grad. Rate	−0.4217***	1.4406***	−0.9326***
	(0.0141)	(0.0564)	(0.0740)
Median Housing Value ($10,000)	0.0030***	−0.0036***	0.0156***
	(0.0001)	(0.0003)	(0.0004)
Current Elec. Cap. (MW)	−0.0000***	0.0001***	−0.0002***
	(0.0000)	(0.0000)	(0.0000)
Newly Retired Elec. Cap. (MW)	−0.0000	−0.0002*	−0.0002
	(0.0000)	(0.0001)	(0.0001)
Population Density (1,000 per KM^2)	0.0149***	−0.0236***	0.0788***
	(0.0005)	(0.0018)	(0.0024)
Max. Temperature (°C)	−0.0087***	0.0748***	0.0498***
	(0.0006)	(0.0024)	(0.0031)
Min. Temperature (°C)	0.0189***	−0.0679***	0.0496***
	(0.0006)	(0.0025)	(0.0033)
Group FE	Y	Y	Y
Year FE	Y	Y	Y
Observations	33,266	33,266	33,266
R^2	0.2967	0.1215	0.2871
Adjusted R^2	0.2963	0.1210	0.2867
Residual Std. Error (df = 33246)	0.2121	0.8488	1.1148

Note: The regressions use the propensity score matched sample. Current electricity capacity and newly retired electricity capacity are only for fossil fuel power plants. Newly retired electricity capacity is for all fossil fuel power plants that retired within the year. *p<0.1; **p<0.05; ***p<0.01.

increases the local minority ratio by 2.7%, decreases the local white population by 13.7%, and increases the local minority population by 15.8%.

4.3 Robustness Checks

Alternative Matching Strategy: Geographic Matching

An alternative strategy to make treated and control groups more comparable is to compare the census tracts located in the same areas. In specific, I repeat the event study and difference-in-differences analysis with an alternative matched sample with the same treated group as before, but with a different control group, which includes control census tracts that are located in the same counties as of treated group census tracts. The geographically (county) matched sample is shown in Appendix Figure A3. The results are reported in Appendix Figure A4 and Table A1, which are very similar to the baseline analysis with propensity score matched sample.

Cluster Standard Errors

I also test whether the findings are sensitive to robust standard errors. Appendix Figures A5 and A6 report the event study analysis of propensity and geographically matched samples respectively, both with standard errors clustered at the county level; and Appendix Tables A2 and A3 report the corresponding difference-in-differences results. There are some changes in the significance of coefficients: the difference-in-differences results are less significant, but most coefficients are at least still significant at 10% level. However, the coefficients in event studies become relatively more significant. I notice that there are several significant pre-trend gaps for white population results in Figures A5b and A6b that weaken the parallel trend assumption in the event study. However, given that the figure shows a clear pattern that the white population immediately and significantly declines after new plants are sited, I believe that it still provides strong evidence that siting has a causal impact on the white population moving away from the "nuisance".

Staggered Treatment

The event studies and difference-in-differences analysis described above provide evidence that the siting of new fossil fuel power plants causes a discrepancy in migration behaviors across races, and increases the local minority ratio. However, the different siting years yield staggered treatment settings, which remains to be a concern of our causality identification (Sun and Abraham, 2021; Goodman-Bacon, 2021). To investigate the potential bias of treatment timing variation, I use Sun and Abraham (2021)'s method to re-estimate the event study and difference-in-differences models. The results are reported in Online Appendix Figure A8 and Table A5. These results are consistent with the baseline analysis.

5 Conclusion and Discussion

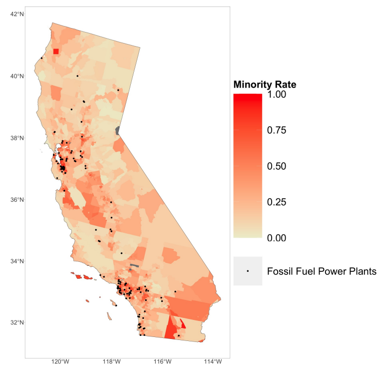
To address the environmental injustice problem, it is important to understand the mechanism of disproportional exposure to pollution sources across different demographics. In this paper, I disentangle the overall racial disparities in exposure to fossil fuel power plants into two channels: disparate siting of fossil fuel power plants, and post-siting migration pattern. I assembled a data set by combining fossil fuel power plant data from EIA, socioeconomic data from Census, and weather data from PRISM. I used logistic regression to analyze the relationship between siting of fossil fuel power plants and local demographics and found that fossil fuel power plants are more likely to be sited in the census tracts with higher minority ratios. I used the event study and difference-in-differences method to analyze the impact of plant siting on local racial composition and found that, on average, the local minority ratio increased by 2.7%. More specifically, I found out-migration decreased the local white population by 13.7%, whereas minorities moved toward the "nuisance" and increased the local minority population by 15.8%.

In conclusion, environmental injustice across races is the consequence of both disparate siting and post-siting migration. This paper highlights the post-siting migration mechanism that changes local racial composition after the siting of polluting plants, which may be due to racial differences in income, willingness to pay for environmental amenities, and occupational skills. In order to mitigate the racial inequity in exposure to pollution sources, disparate siting, as the firms' strategy, can be addressed by government regulation. However, post-siting migration, as the individuals' behavior, are much harder to be adjusted. This paper motivates future studies to investigate the mechanisms of post-siting demographic migration.

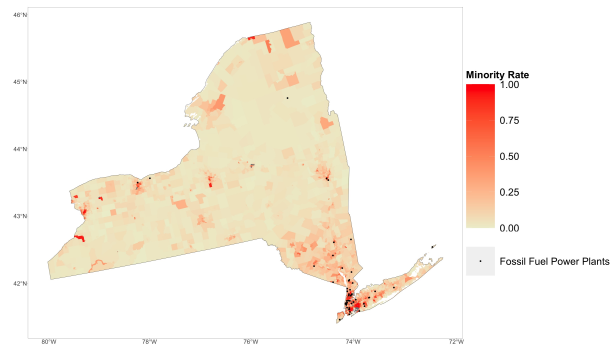
A Online Appendix

A.1 Additional Maps

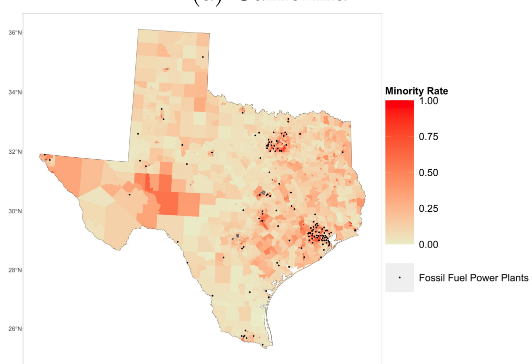
Figure A1: Fossil Fuel Power Plants Siting Location by Major States, 2010 – 2019



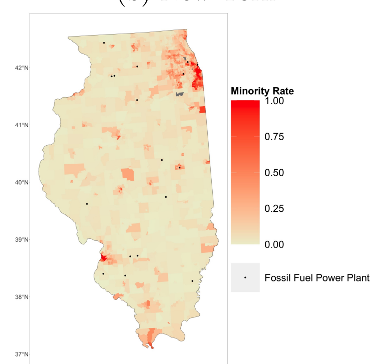
(a) California



(b) New York



(c) Texas



(d) Illinois

A.2 Two Matched Samples

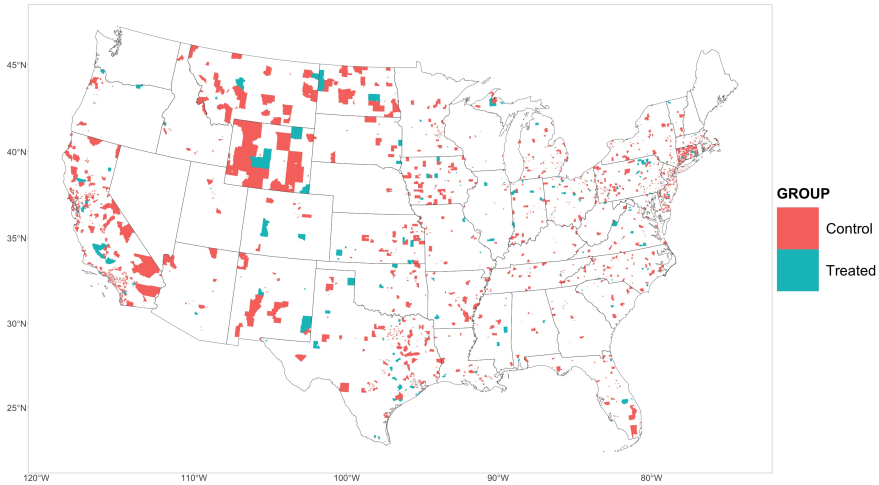


Figure A2: The Treated and Control Census Tracts in the Propensity Score Matched Sample

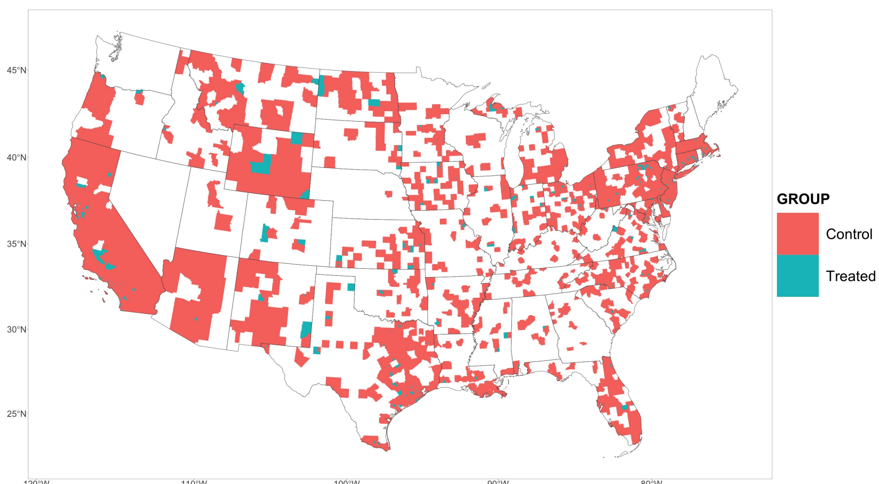


Figure A3: The Treated and Control Census Tracts in the County Matched Sample

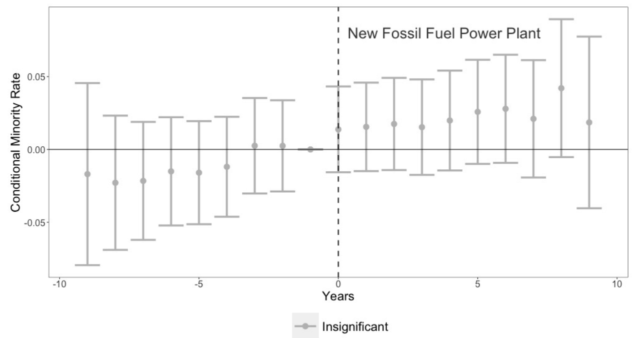
A.3 Geographic Matching: Match by County

Table A1: The Impact of New Fossil Fuel Power Plant Siting on Local Racial Composition, County Matched Sample, A Difference-in-differences Analysis

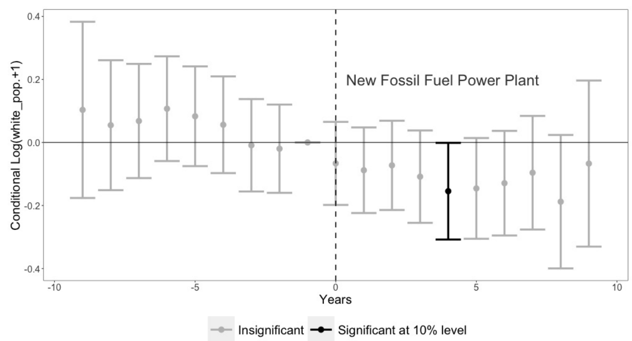
	Dependent variable:		
	minority rate (%)	log(white_pop.+1)	log(min_pop.+1)
	(1)	(2)	(3)
New Siting (Treatment) Dummy	0.0265***	−0.1366***	0.1580***
	(0.0078)	(0.0349)	(0.0336)
Income per Capita ($1,000)	−0.0061***	0.0163***	−0.0189***
	(0.00005)	(0.0002)	(0.0002)
High School Grad. Rate	−0.2486***	0.5303***	−0.7726***
	(0.0052)	(0.0232)	(0.0224)
Median Housing Value ($10,000)	0.0020***	−0.0024***	0.0084***
	(0.00003)	(0.0001)	(0.0001)
Current Elec. Cap. (MW)	−0.0001***	0.0002***	−0.0002***
	(0.0000)	(0.0000)	(0.0000)
Newly Retired Elec. Cap. (MW)	−0.0000	0.0000	−0.0001
	(0.0001)	(0.0002)	(0.0002)
Population Density (1,000 per KM^2)	0.0066***	−0.0061***	0.0348***
	(0.0001)	(0.0004)	(0.0004)
Max. Temperature (°C)	−0.0163***	0.1258***	0.0392***
	(0.0002)	(0.0011)	(0.0011)
Min. Temperature (°C)	0.0246***	−0.1185***	0.0344***
	(0.0003)	(0.0013)	(0.0013)
Group FE	Y	Y	Y
Year FE	Y	Y	Y
Observations	216,069	216,069	216,069
R^2	0.2901	0.1436	0.2578
Adjusted R^2	0.2901	0.1436	0.2577
Residual Std. Error (df = 216049)	0.2283	1.0208	0.9822

Note: The regression uses the geographically (county) matched sample. Current electricity capacity and newly retired electricity capacity are only for fossil fuel power plants. Newly retired electricity capacity is for all fossil fuel power plants that retired within the year. *p<0.1; **p<0.05; ***p<0.01.

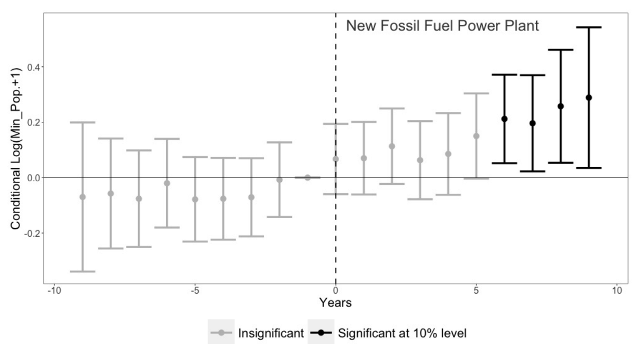
Figure A4: Post-Siting Demographic Changes, County Matched Sample, An Event Study Analysis



(a) Siting Impact on Minority Ratio



(b) Siting Impact on White Population

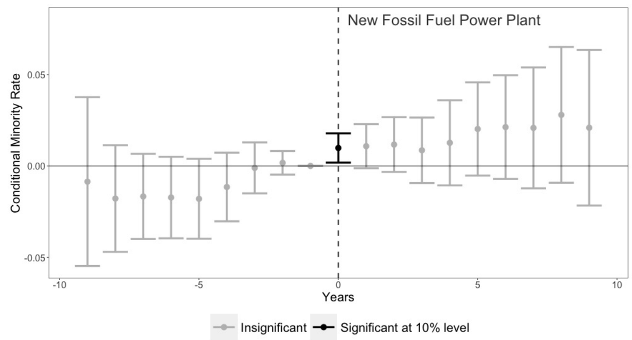


(c) Siting Impact on Minority Population

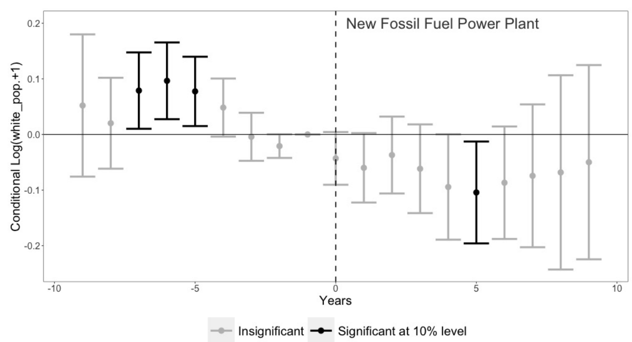
Note: The event studies use the geographically (county) matched sample. Control variables are current electricity capacity, newly retired electricity capacity, population density, income per capita, high school graduation rate, maximum and minimum temperature, new siting (treated) group dummy, and year fixed effect.

A.4 Cluster Standard Errors

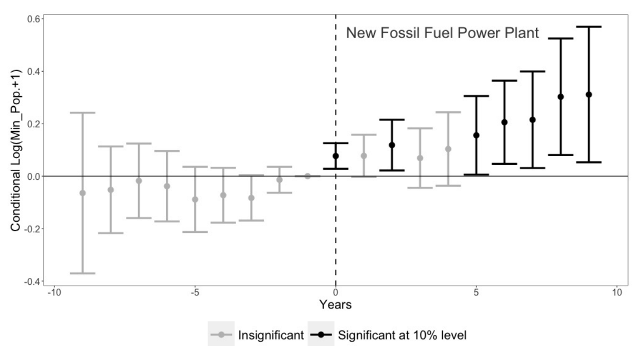
Figure A5: An Event Study Analysis of Post-Siting Demographic Changes, Propensity Matched Sample, Standard Errors are Clustered at County Level



(a) Siting Impact on Minority Ratio



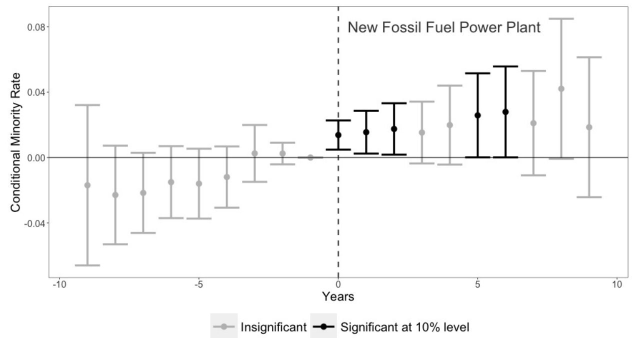
(b) Siting Impact on White Ratio



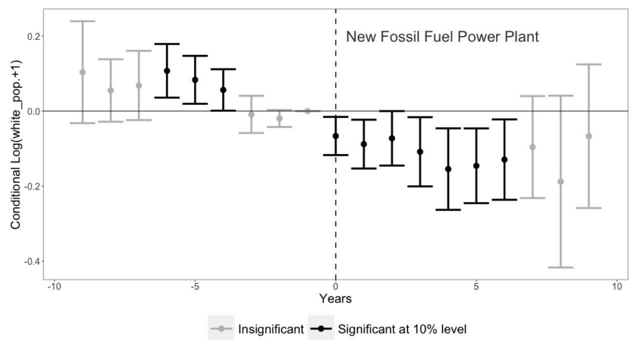
(c) Siting Impact on Minority Population

Note: The event studies use the propensity score matched sample. Control variables are current electricity capacity, newly retired electricity capacity, population density, income per capita, high school graduation rate, maximum and minimum temperature, new siting (treated) group dummy, and year fixed effect. Standard errors are clustered at the county level.

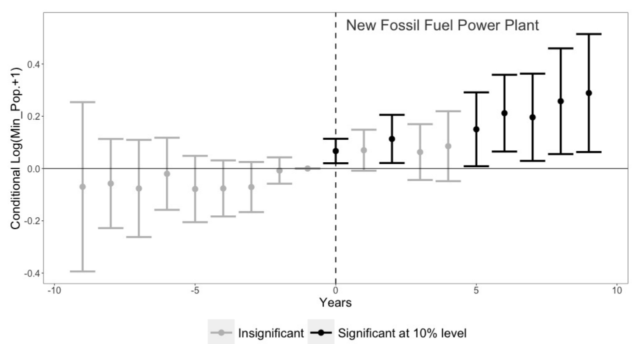
Figure A6: An Event Study Analysis of Post-Siting Demographic Changes, County Matched Sample, Standard Errors are Clustered at County Level



(a) Siting Impact on Minority Ratio



(b) Siting Impact on White Ratio



(c) Siting Impact on Minority Population

Note: The event studies use the geographically (county) matched sample. Control variables are current electricity capacity, newly retired electricity capacity, population density, income per capita, high school graduation rate, maximum and minimum temperature, new siting (treated) group dummy, and year fixed effect. Standard errors are clustered at the county level.

Table A2: A Difference-in-differences Analysis of the Impact of New Fossil Fuel Power Plant Siting on Local Racial Composition, Propensity Score Matched Sample, Standard Errors are Clustered at the County Level

	Dependent variable:		
	minority rate (%)	log(white_pop.+1)	log(min_pop.+1)
	(1)	(2)	(3)
New Siting (Treatment) Dummy	0.0211	−0.0919*	0.1663*
	(0.0155)	(0.0547)	(0.0883)
Income per Capita ($1,000)	−0.0059***	0.0111***	−0.0244***
	(0.0007)	(0.0022)	(0.0030)
High School Grad. Rate	−0.4217***	1.4406***	−0.9326***
	(0.0942)	(0.3264)	(0.3459)
Median Housing Value ($10,000)	0.0030***	−0.0036**	0.0156***
	(0.0006)	(0.0016)	(0.0026)
Current Elec. Cap. (MW)	−0.0000***	0.0001***	−0.0002***
	(0.0000)	(0.0000)	(0.0000)
Newly Retired Elec. Cap. (MW)	−0.0000	−0.0002	−0.0002
	(0.0000)	(0.0002)	(0.0002)
Population Density (1,000 per KM^2)	0.0149***	−0.0236**	0.0788***
	(0.0047)	(0.0115)	(0.0215)
Max. Temperature (°C)	−0.0087**	0.0748***	0.0498***
	(0.0038)	(0.0161)	(0.0154)
Min. Temperature (°C)	0.0189***	−0.0679***	0.0496***
	(0.0041)	(0.0162)	(0.0154)
Group FE	Y	Y	Y
Year FE	Y	Y	Y
Observations	33,266	33,266	33,266
R^2	0.2967	0.1215	0.2871
Adjusted R^2	0.2963	0.1210	0.2867
Residual Std. Error (df = 33246)	0.2121	0.8488	1.1148

Note: Current electricity capacity and newly retired electricity capacity are only for fossil fuel power plants. Newly retired electricity capacity is for all fossil fuel power plants that retired within the year. Standard errors are clustered at the county level. *p<0.1; **p<0.05; ***p<0.01.

Table A3: A Difference-in-differences Analysis of the Impact of New Fossil Fuel Power Plant Siting on Local Racial Composition, County Matched Sample, Standard Errors are Clustered at the County Level

	Dependent variable:		
	minority rate (%)	log(white_pop.+1)	log(min_pop.+1)
	(1)	(2)	(3)
New Siting (Treatment) Dummy	0.0265*	−0.1366**	0.1580*
	(0.0158)	(0.0603)	(0.0853)
Income per Capita ($1,000)	−0.0061***	0.0163***	−0.0189***
	(0.0006)	(0.0023)	(0.0028)
High School Grad. Rate	−0.2486**	0.5303	−0.7726**
	(0.0980)	(0.3291)	(0.3654)
Median Housing Value ($10,000)	0.0020***	−0.0024	0.0084***
	(0.0006)	(0.0019)	(0.0024)
Current Elec. Cap. (MW)	−0.0001***	0.0002***	−0.0002**
	(0.00001)	(0.0001)	(0.0001)
Newly Retired Elec. Cap. (MW)	−0.0000	0.0000	−0.0001
	(0.0001)	(0.0003)	(0.0002)
Population Density (1,000 per KM^2)	0.0066***	−0.0061	0.0348***
	(0.0017)	(0.0071)	(0.0046)
Max. Temperature (°C)	−0.0163***	0.1258***	0.0392***
	(0.0051)	(0.0271)	(0.0143)
Min. Temperature (°C)	0.0246***	−0.1185***	0.0344**
	(0.0051)	(0.0261)	(0.0156)
Group FE	Y	Y	Y
Year FE	Y	Y	Y
Observations	216,069	216,069	216,069
R^2	0.2901	0.1436	0.2578
Adjusted R^2	0.2901	0.1436	0.2577
Residual Std. Error (df = 216049)	0.2283	1.0208	0.9822

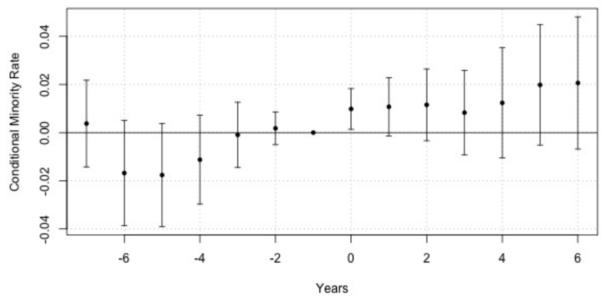
Note: The regression uses the geographically (county) matched sample. Current electricity capacity and newly retired electricity capacity are only for fossil fuel power plants. Newly retired electricity capacity is for all fossil fuel power plants that retired within the year. Standard errors are clustered at the county level. *p<0.1; **p<0.05; ***p<0.01.

A.5 Staggered Treatment Setting

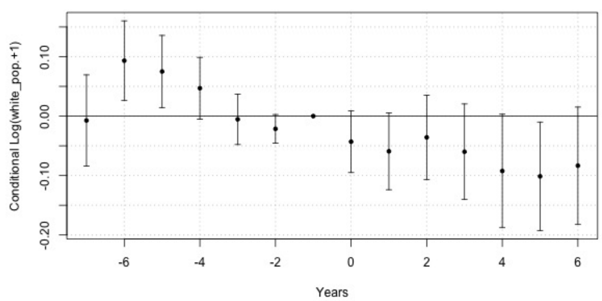
Sun and Abraham (2021)'s method separates treated groups into subgroups by treatment years and constructs a large number of dummy variables (in our scenario, there will be 100 dummy variables constructed to capture the different annual trends for 10 subgroups). This, together with the limited number of observations for large lag and lead periods (with respect to treatment year), will cause huge standard errors or even multi-collinearity problems.[2] To overcome such difficulty, I combine far lags and leads in the regression, so that lag -9 to -7 share a unique dummy variable, and leads 6 to 9 also share a unique dummy variable. I conduct the analyses using both the propensity score matched sample (Appendix Figure A7 and Appendix Table A4) and the geographically (county) matched sample (Appendix Figure A8 and Appendix Table A5), respectively.

[2]For example, lag period "-9" only includes one year (2010) observations for the subgroup with treatment time in 2019.

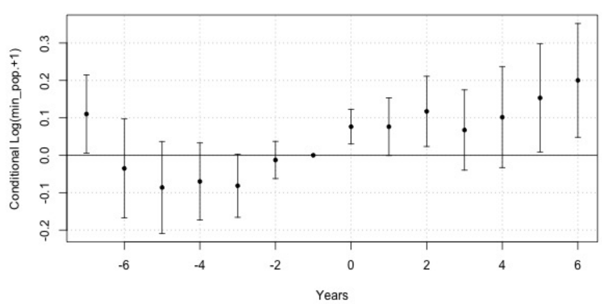
Figure A7: Post-Siting Demographic Changes with Staggered Treatment Adjustment, Propensity Score Matched Sample



(a) Siting Impact on Minority Ratio



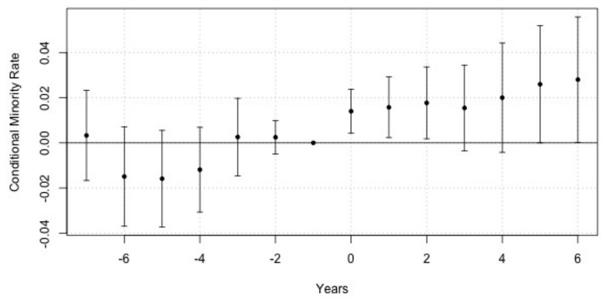
(b) Siting Impact on White Population



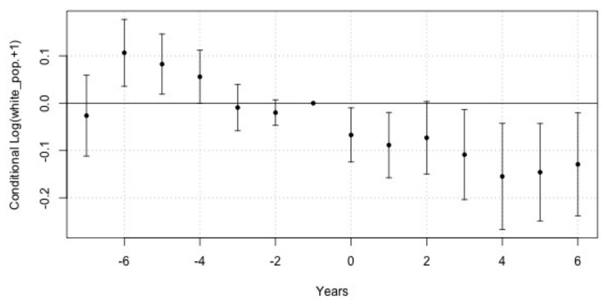
(c) Siting Impact on Minority Population

Note: These analyses use Sun and Abraham (2021)'s method to adjust the potential bias from the staggered treatment setting. The propensity score matched sample is used. Lag periods -9 to -7 and lead periods 6 to 9 are grouped together, respectively, as the limited numbers of observations in these treatment groups cause huge/NA standard errors. Control variables are current electricity capacity, newly retired electricity capacity, population density, income per capita, high school graduation rate, maximum and minimum temperature, new siting (treated) group dummy, and year fixed effect. Standard errors are clustered at the county level.

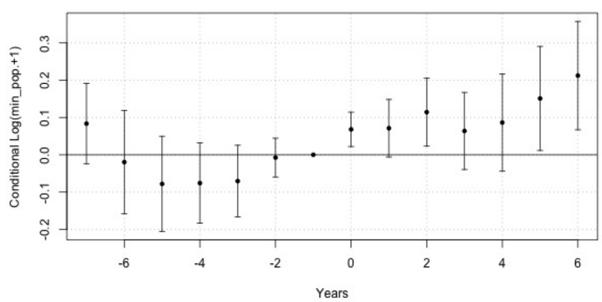
Figure A8: Post-Siting Demographic Changes with Staggered Treatment Adjustment, County Matched Sample



(a) Siting Impact on Minority Ratio



(b) Siting Impact on White Population



(c) Siting Impact on Minority Population

Note: These analyses use Sun and Abraham (2021)'s method to adjust the potential bias from the staggered treatment setting. The geographically (count) matched sample is used. Lag periods -9 to -7 and lead periods 6 to 9 are grouped together, respectively, as the limited numbers of observations in these treatment groups cause huge/NA standard errors. Control variables are current electricity capacity, newly retired electricity capacity, population density, income per capita, high school graduation rate, maximum and minimum temperature, new siting (treated) group dummy, and year fixed effect. Standard errors are clustered at the county level.

Table A4: The Impact of New Fossil Fuel Power Plant Siting on Local Racial Composition, A Difference-in-differences Analysis with Staggered Treatment, Propensity Score Matched Sample

	Dependent variable:		
	minority rate (%)	log(white_pop.+1)	log(min_pop.+1)
	(1)	(2)	(3)
New Siting (Treatment) Dummy	0.0124	−0.0627	0.1039*
	(0.0090)	(0.0427)	(0.0534)
Income per Capita ($1,000)	−0.0059***	0.0112***	−0.0244***
	(0.0007)	(0.0022)	(0.0031)
High School Grad. Rate	−0.4210***	1.4320	−0.9313**
	(0.0949)	(0.3263)	(0.3507)
Median Housing Value ($10,000)	0.0030***	−0.0036*	0.0156***
	(0.0006)	(0.0016)	(0.0026)
Current Elec. Cap. (MW)	−0.0000***	0.0001**	−0.0002**
	(0.0000)	(0.0000)	(0.0000)
Newly Retired Elec. Cap. (MW)	−0.0000	-0.0002	−0.0002
	(0.0000)	(0.0002)	(0.0002)
Population Density (1,000 per KM^2)	0.0148***	−0.0235*	0.0783***
	(0.0047)	(0.0116)	(0.0216)
Max. Temperature (°C)	−0.0088***	0.0754***	0.0499***
	(0.0038)	(0.0161)	(0.0154)
Min. Temperature (°C)	0.0190***	−0.0685***	0.0496**
	(0.0041)	(0.0162)	(0.0154)
Group FE	Y	Y	Y
Year FE	Y	Y	Y
Observations	33,266	216,069	216,069
R^2	0.2973	0.1230	0.2886
Adjusted R^2	0.2951	0.1203	0.2864
Residual Std. Error (df = 33162)	0.2119	0.8478	0.8478

Note: These analysis use Sun and Abraham (2021)'s method to adjust the potential bias from the staggered treatment setting. The regression uses the propensity score matched sample. Current electricity capacity and newly retired electricity capacity are only for fossil fuel power plants. Newly retired electricity capacity is for all fossil fuel power plants that retired within the year. Standard errors are clustered at the county level. *p<0.1; **p<0.05; ***p<0.01.

Table A5: The Impact of New Fossil Fuel Power Plant Siting on Local Racial Composition, A Difference-in-differences Analysis with Staggered Treatment, County Matched Sample

	Dependent variable:		
	minority rate (%)	log(white_pop.+1)	log(min_pop.+1)
	(1)	(2)	(3)
New Siting (Treatment) Dummy	0.0183*	−0.1019**	0.0994*
	(0.0096)	(0.0476)	(0.0509)
Income per Capita ($1,000)	−0.0061***	0.0163***	−0.0189***
	(0.0006)	(0.0023)	(0.0028)
High School Grad. Rate	−0.2484**	0.5285	−0.7720**
	(0.0981)	(0.3290)	(0.3656)
Median Housing Value ($10,000)	0.0020***	−0.0024	0.0084***
	(0.0006)	(0.0019)	(0.0024)
Current Elec. Cap. (MW)	−0.0001***	0.0002***	−0.0002**
	(0.0000)	(0.0001)	(0.0001)
Newly Retired Elec. Cap. (MW)	−0.0000	0.0000	−0.0002
	(0.0001)	(0.0003)	(0.0002)
Population Density (1,000 per KM^2)	0.0066***	−0.0061	0.0348***
	(0.0017)	(0.0071)	(0.0046)
Max. Temperature (°C)	−0.0163***	0.1259***	0.0393***
	(0.0051)	(0.0272)	(0.0143)
Min. Temperature (°C)	0.0246***	−0.1186***	0.0343**
	(0.0051)	(0.0261)	(0.0156)
Group FE	Y	Y	Y
Year FE	Y	Y	Y
Observations	216,069	216,069	216,069
R^2	0.2903	0.1439	0.2582
Adjusted R^2	0.2899	0.1434	0.2578
Residual Std. Error (df = 216049)	0.2283	1.0206	0.9819

Note: These analysis use Sun and Abraham (2021)'s method to adjust the potential bias from the staggered treatment setting. The regression uses the geographically (county) matched sample. Current electricity capacity and newly retired electricity capacity are only for fossil fuel power plants. Newly retired electricity capacity is for all fossil fuel power plants that retired within the year. Standard errors are clustered at the county level. *p<0.1; **p<0.05; ***p<0.01.

References

Banzhaf, S., L. Ma, and C. Timmins (2019a). Environmental justice: Establishing causal relationships. *Annual Review of Resource Economics 11*, 377–398.

Banzhaf, S., L. Ma, and C. Timmins (2019b). Environmental justice: The economics of race, place, and pollution. *Journal of Economic Perspectives 33*(1), 185–208.

Bayer, P., N. Keohane, and C. Timmins (2009). Migration and hedonic valuation: The case of air quality. *Journal of Environmental Economics and Management 58*(1), 1–14.

Bi, X. and M. Khanna (2012). Re-assessment of the impact of EPA's voluntary 33/50 program on toxic releases. *Land Economics 88*, 341–361.

Bullard, R. D. (1983). Solid waste sites and the black houston community. *Sociological inquiry 53*(2-3), 273–288.

Colmer, J., I. Hardman, J. Shimshack, and J. Voorheis (2020). Disparities in pm2. 5 air pollution in the united states. *Science 369*(6503), 575–578.

Crowder, K. and L. Downey (2010). Interneighborhood migration, race, and environmental hazards: Modeling microlevel processes of environmental inequality. *American Journal of Sociology 115*(4), 1110–1149.

Depro, B., C. Timmins, and M. O'Neil (2015). White flight and coming to the nuisance: can residential mobility explain environmental injustice? *Journal of the Association of Environmental and resource Economists 2*(3), 439–468.

Goodman-Bacon, A. (2021). Difference-in-differences with variation in treatment timing. *Journal of Econometrics 225*(2), 254–277.

Hamilton, J. T. (1995). Testing for environmental racism: Prejudice, profits, political power? *Journal of Policy Analysis and Management 14*(1), 107–132.

Hunter, L. M., M. J. White, J. S. Little, and J. Sutton (2001). Environmental hazards, migration, and race. *Population and Environment 23*(1), 1–21.

Klaiber, H. A. and D. J. Phaneuf (2010). Valuing open space in a residential sorting model of the Twin Cities. *Journal of Environmental Economics and Management 60*, 57–77.

Lyon, T. P. and J. W. Maxwell (1999). Corporate environmental strategies as tools to influence regulation. *Business Strategy and the Environment 8*(3), 189–196.

McCoy, E. D. (2017). Which came first, coal-fired power plants or communities of color? assessing the disparate siting hypothesis of environmental injustice. *The University of Michigan Master of Science Thesis*.

Melstrom, R. T. and R. Mohammadi (2022). Residential mobility, brownfield remediation, and environmental gentrification in Chicago. *Land Economics 98*(1), 62–77.

Mohai, P., D. Pellow, and J. T. Roberts (2009). Environmental justice. *Annual review of environment and resources 34*, 405–430.

Pastor, M., J. Sadd, and J. Hipp (2001). Which came first? toxic facilities, minority move-in, and environmental justice. *Journal of Urban Affairs 23*(1), 1–21.

Saha, R. and P. Mohai (2005). Historical context and hazardous waste facility siting: Understanding temporal patterns in Michigan. *Social Problems 52*(4), 618–648.

Shapiro, M. D. (2005). Equity and information: Information regulation, environmental justice, and risks from toxic chemicals. *Journal of Policy Analysis and Management 24*(2), 373–398.

Stretesky, P. and M. J. Hogan (1998). Environmental justice: An analysis of superfund sites in Florida. *Social Problems 45*(2), 268–287.

Sun, L. and S. Abraham (2021). Estimating dynamic treatment effects in event studies with heterogeneous treatment effects. *Journal of Econometrics 225*(2), 175–199.

Wolverton, A. (2009). Effects of socio-economic and input-related factors on polluting plants' location decisions. *The B.E. Journal of Economic Analysis & Policy 9*(1), 14.

Zhang, R. and N. Khanna (2022). Public pressure and heterogeneous effects of voluntary pollution abatement. *Working Paper*.

Zhang, R., H. Li, N. Khanna, E. L. Hill, A. J. Krupnick, and D. J. Sullivan (2023). Air quality impacts of shale gas development in Pennsylvania. *Journal of the Association of Environmental and Resource Economists, forthcoming*.