Powering Down and Moving On?
Energy Transition, Gentrification, and Local Impacts

Jancy Ling Liu[†]

December 2024

Abstract

This study investigates the effects of fossil fuel power plant closures on local migration. I leverage variation in fuel prices and plant age that results in plausibly exogenous power plant retirements. The retirement results in a "stagnation effect" where both in-migration and out-migration decreases, a pattern not consistent with a typical gentrification result of increased in and out migration. My analysis shows that the stagnation effect is more pronounced in lower-income and predominantly Black communities, raising environmental justice concerns. These findings underscore the complex interplay between the environmental advantages and local economic challenges associated with phasing out fossil fuel infrastructure. (JEL Q40, Q53, Q56, R23, J61)

[†]This draft has greatly benefited from comments and suggestions from Tibor Besedes, Dylan Brewer, Casey J. Wichman, Eric Zou, Laura Taylor, John List, Lala Ma, Mathhew Kahn, Yanjun Liao, Ashley Langer, Andrew W. Stevens, Francisco Costa, and seminar participants in AEA-CSWEP online and SEA mentoring sessions, Camp Resources XXIX, 24th CU Environmental and Resource Economics Workshop, ODE@ASSA 2024, 2024 CES North America Conference, and Georgia Tech School of Economics Brownbag. All errors are mine.

[†]Department of Economics, The College of Wooster, jliu@wooster.edu.

1 Introduction

Over the past decade, fossil-fuel power plants have seen significant retirements in the United States, largely due to a shift towards renewable energy sources, rising regulatory pressure to minimize greenhouse gas emissions, and changes in electricity demand. According to the U.S. Energy Information Administration, coal accounts for 85% of U.S. electric generating capacity retirements in 2022. This trend will likely continue due to the ongoing competition from renewable resources, which has sparked interest in how these structural changes in electricity generation may affect local communities. On one hand, power plants provide jobs, tax revenues, and a stable source of electricity (Chatzimouratidis and Pilavachi, 2008; Hondo and Moriizumi, 2017; Mauritzen, 2020). On the other hand, fossil-fuel power plants are associated with disamenities like noise pollution, traffic from fuel deliveries, harmful emissions like sulfur dioxide (SO_2), nitrogen oxides (NO_x), and particulate matter (PM) that can negatively impact human health and the environment, and may have larger effects on low-income and minority communities and other environmental justice (EJ) concerned populations (Davis, 2011; Depro et al., 2015; Currie et al., 2015; EPA, 2022).

As the energy transition accelerates, understanding its ramifications becomes increasingly important for policymakers and stakeholders seeking to navigate the complex challenges it poses. I investigate how power plant retirements influence population migration patterns in the United States, particularly in relation to potential socio-economic implications and changes in local amenities. These dynamics are essential for designing policies that support sustainable energy transitions while minimizing potential adverse impacts. As power plants close, the resulting changes in air quality, public health, employment opportunities, and local economies can have far-reaching implications for communities, influencing residential sorting patterns, and potentially exacerbating social and economic inequalities (Currie et al., 2015; Burney, 2020; Komisarow and Pakhtigian, 2021). By examining the interplay between socio-economic consequences and environmental amenity changes, this study aims to provide a comprehensive understanding of the effects of power plant retirements on migration patterns, enabling policymakers to develop targeted interventions that balance competing priorities and facilitate a just transition for affected communities.

In this paper, I present the first national-scale evidence on how migration patterns respond to the retirement of fossil-fuel power generators. My analysis utilizes a novel, granular dataset based on United States Postal Service (USPS) Change of Address (COA) records from July 2018 to December 2022. Unlike previous studies that primarily rely on the Census tract or Internal Revenue Services (IRS) data, which are updated annually at the county level, the USPS COA data offers a higher frequency and more up-to-date view of migration patterns and sorting behaviors at the zip code level on a monthly basis. Specifically, it offers aggregated COA volume originating from and destined to each zip code, allowing for a separate examination of in- and out-migration flows. By matching this data to Energy Information Administration (EIA) monthly statistics on power plant retirements, I construct a dataset aggregated to the quarter-zip code level to analyze how fossil fuel phase-outs within a region affect migration over time. To capture the effects of the energy transition, I define the treated group as any zip code that experiences the complete retirement of all fossil-fuel generators within its boundaries.

My analysis reveals three main findings regarding how the full retirement of fossil-fuel generators affects local migration patterns. First, using a staggered difference-in-difference design, I find that the full retirement of fossil-fuel generators significantly impacts local migration patterns, leading to a net increase in population after retirement. This finding aligns with previous research that observed a net increase in population following environmental improvements (Banzhaf and Walsh, 2008). However, in the context of full retirement of fossil-fuel generators, my study further shows that this net increase is driven by a decrease in both inflows and a more substantial reduction in outflows following full retirement.

This pattern differs from traditional narratives of environmental gentrification, where improved amenities drive increased in-migration of wealthier residents, displacing existing disadvantaged groups through an increase in housing costs (Sieg et al., 2004; Banzhaf and McCormick, 2012). Studies find that toxic site cleanups, Superfund remediation, and air pollution reductions can precipitate gentrification pressures associated with population turnover (Gamper-Rabindran and Timmins, 2011; Depro et al., 2015; Binner and Day, 2018). However, my research finds that the retirement of fossil fuel generators causes a pronounced simultaneous reduction in both inflows and outflows, representing a “stagnation effect” that captures residents’ dormant migration responses to these major energy transitions. Despite similar net inflow outcomes, the underlying patterns differ from typical gentrification.

Specifically, I estimate that the retirement of fossil-fuel generators leads to a reduction of about 30 move-ins and 33 move-outs per zip code each quarter. This reduction represents about 7% to 16% of the average total number of people who typically move in or out of each zip code every quarter. It also translates to a slight yet significant quarterly decrease of 0.3% to 0.7% in both population inflows and outflows for each zip code. In essence, the retirement of fossil-fuel generators is associated with a modest but significant reduction in local migration activity. Long-run estimates using yearly, county-level data from the

2013-2020 IRS data also confirm the overall stagnation effects post-retirement. In order to address potential endogeneity concerns of non-random selection of zip codes with fossil-fuel generators and the decision to retire fossil-fuel generators, I conduct additional robustness checks using Coarsened Exact Matching (CEM) and instrumental variable (IV) strategies, which confirm this broader trend of diminished migration following plant closures. Multiple data sources and empirical specifications underscore how plant retirement disrupts local migration flows, leading to stagnation in both population inflows and outflows.

Second, the study delves deeper into the heterogeneity of these stagnation effects across various zip code demographics, including income, racial and ethnic composition, and age. The findings consistently reveal heightened migration stagnation in communities with a higher Black population share and lower-income groups following fossil fuel retirements. Specifically, low-income communities experience a larger stagnation impact on move-outs compared to high-income areas. This also generates a passive net inflow since the decrease in outflows exceeds the decline in inflows. Communities with higher black population shares undergo larger stagnation effects on both move-ins and move-outs versus lower share communities.

Third, I explore the potential mechanisms driving the stagnation effects. The analysis provides suggestive evidence for two key factors that may shape the migration impacts of fossil fuel power plant retirements: the decline in local economic opportunities and a seemingly counterintuitive response to environmental improvements. Utilizing county-by-quarter data from the Quarterly Census on Employment and Wages (QCEW), the results show long-run stagnation in labor outcomes such as employment, wages, and total contributions (which include both employer and employee contributions to benefit programs). This aligns with the reduced in-migration, suggesting diminishing economic prospects are a salient driver. I also find that retirement leads to an increase in air quality, indicating improved environmental quality. However, the retirement of fossil-fuel generators leads to around a 3% decrease in housing value, suggesting that economic considerations might overshadow the anticipated amenity improvements post-retirement.

This research contributes to the expanding collection of literature regarding the impacts of power plant retirements and energy transitions on local areas. While prior work on the energy transition has focused on the effects of climate change and directed innovation (Acemoglu et al., 2023), local labor markets (Hanson, 2023; Chan and Zhou, 2023; Curtis et al., 2024), household financial dynamics (Blonz et al., 2023), and effects on health and education (Komisarow and Pakhtigian, 2021, 2022), this research uniquely focuses on migration responses and the underlying mechanisms. By illuminating the intricate dynamic of amenity improvements and socio-economic shifts, it offers valuable insights to inform transition policies that support at-risk communities (Carley and Konisky, 2020).

Furthermore, this is among the first national-scale studies to examine how cumulative exposure to environmental enhancements from fossil fuel plant closure shapes residential sorting over time. Given fossil fuel plants accounted for the vast majority of retirements in the past decade, their phase-out serves as a useful proxy for enhancing local air quality. While prior studies have examined one-time amenity shocks like Toxics Release Inventory (TRI) facility emissions (Banzhaf and Walsh, 2008), hazardous waste cleanup under the Superfund program (Gamper-Rabindran and Timmins, 2011), air pollution (Close and Phaneuf, 2017; Kim, 2019; Heblich et al., 2021), and the announcement of an airport renewal program (Lindgren, 2021), they do not capture the prolonged and accumulating benefits as fossil fuel plants wind down operations and ultimately retire. Additionally, the staggered difference-in-differences design enables a dynamic assessment missing from earlier cross-sectional analyses.

This study also extends the literature on migration and community structure changes following major economic disruptions. Existing work analyzes mobility responses to various shocks and long-term economic declines in distressed regions (Molloy, Smith, and Wozniak, 2011, 2014, 2017; Ramani and Bloom, 2021; Bilal and Rossi-Hansberg, 2021). This research considers the complete retirement of fossil fuel generators as a significant economic shock given its impacts on local labor markets and tax bases. By examining the interplay between job losses and improved environmental amenities, this research offers novel insights into the conflicting factors that shape residential choices. The findings illuminate how residents navigate and balance economic and environmental shifts, providing broader implications for models of location choice and residential mobility under multidimensional changes.

More broadly, these findings highlight the multifaceted ramifications of the energy transition, which carry important policy implications. As countries continue phasing out fossil fuel plants, understanding the intricate balance between positive and negative impacts becomes crucial. While retirements can lead to improvements in air quality and public health, they may also result in job losses, economic disruptions, and shifts in the housing market that could have long-lasting effects on communities. This research underscores the need for comprehensive transition policies that balance environmental benefits with socio-economic challenges. By providing a thorough analysis of the impacts of plant retirement on migration, this study offers valuable insights into how to support affected residents and prioritize competing needs.

2 Background

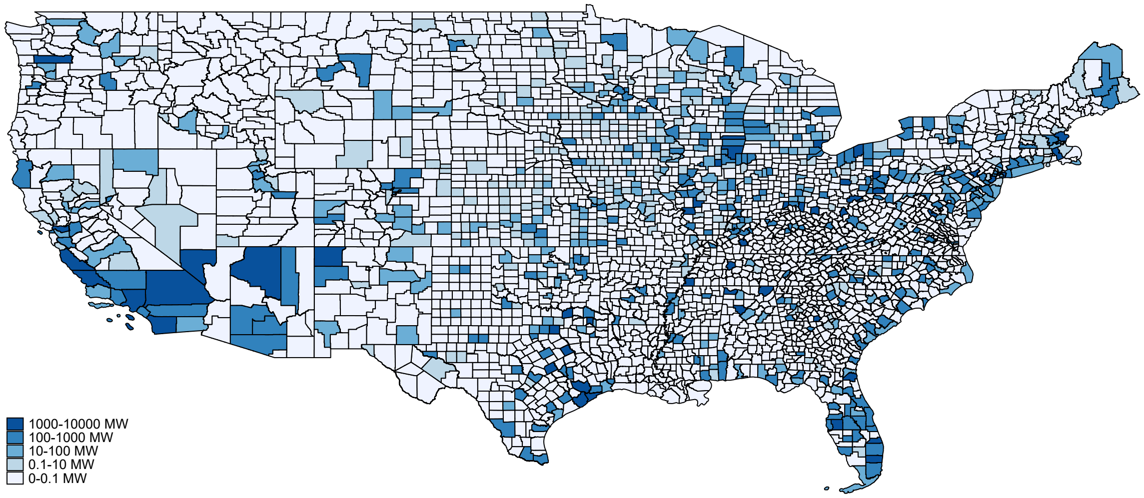
2.1 The Local Impact of Power Plants

Power plant operations can have both positive and negative impacts on local communities. Developing a new power plant can generate new jobs and businesses, spurring increased spending within the local community. Power plants can employ a substantial number of people throughout their life cycle, offering both temporary and permanent jobs that may draw new residents (Hondo and Moriizumi, 2017). According to the U.S. Energy and Employment Report, fossil fuel power generation collectively employed approximately 142,310 workers in 2018 (USEER, 2019). This accounts for about 12.73% of the total employment in the electric power generation sector. Specifically, coal-fired power plants employed 86,202 workers, natural gas power plants employed 43,526 workers,[1] and oil-fired power plants employed 12,582 workers. Power plant operations can also boost local tax revenue or state-shared revenue, supporting local public goods. Taking these factors into account, Christiadi et al. Christiadi et al. (2021) estimate that coal mining and coal-fired power generation contributed 13.9 billion dollars in output, 33,300 jobs, 2.8 billion dollars in employee compensation, and 611.3 million dollars in state and local tax revenue to West Virginia's economy in 2019.

On the other hand, fossil-fuel power plants release a variety of pollutants, including sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon dioxide (CO_2), mercury (H_g), and particulate matter (PM). These emissions can negatively affect air quality and contribute to respiratory issues (EPA, 2022; Currie et al., 2015). Power plant operations can affect water quality due to thermal pollution, chemical spills, or wastewater discharges (Eldardiry and Habib, 2018). The construction or operation of power plants can lead to land disturbances or soil erosion, potentially impacting soil productivity and raising the risk of erosion and sedimentation in nearby water bodies (Nickerson et al., 1989; Tong and Chen, 2002). Power plant operations produce solid waste, such as ash or sludge, which must be appropriately managed to avoid environmental contamination (EIA, 2022b). Finally, increased traffic related to power plant construction or operation can pose safety hazards for local communities, including heightened truck traffic on local roads or altered traffic patterns near the power plant (Davis, 2011).

[1] This does not account for advanced or low emissions natural gas generation, which employed a total of 69,159 jobs.

Figure 1: Retired Fossil Fuel Generation Capacity by County, 2001-2022



Notes: The figure shows the retired fossil fuel generation capacity by county between 2001 to 2022 for 705 counties with power plant generators. Counties in light blue are counties without power plant generators retirement in the past two decades or the retirement are less than 0.1 metewatt.

2.2 Retirement Decision of Power Plants

The global energy landscape is undergoing rapid transformation due to factors such as climate change, technological advancements, and shifting policies (Creutzig et al., 2018; Kober et al., 2020). In the United States, a substantial amount of coal-fired capacity has retired over the past decade, with a record 14.9 GW retired in 2015. Annual coal retirements averaged 11.0 GW per year from 2015 to 2020, decreased to 5.6 GW in 2021, and then increased to 11.5 GW in 2022 (EIA, 2023). 1 illustrates the retired fossil fuel generation capacity by county from 2001 to 2022. Approximately 15% of counties experienced more than 10 MW capacity retirement, while around 9% of counties saw more than 100 MW capacity retirement. Davis et al. (2022) provides a comprehensive analysis of the history of U.S. coal-fired plant retirements over the last decade and demonstrate the impact of environmental and market forces on coal-fired power plant retirements. They show that $20 per MWh electricity subsidy extends the average life of a generator by six years, while a $51 per ton carbon tax brings forward retirement dates by about two years.

In 2021, fossil fuel burning for energy accounted for 73% of total U.S. greenhouse gas emissions and 92% of total U.S. anthropogenic CO_2 emissions (EIA, 2022a). These emissions have been linked to rising global temperatures and severe environmental consequences such as more frequent and intense extreme weather events, melting ice caps, and rising sea levels (Pachauri et al., 2014; Abas, Kalair, and Khan, 2015). As a result, there has been a global push towards cleaner energy sources like wind, solar, and hydropower, which emit fewer greenhouse gases and have a smaller environmental footprint (IRENA, 2020). Technological advancements in renewable energy generation have made these sources increasingly cost-competitive (Lazard, 2021). Declining costs of solar panels, wind turbines, energy storage solutions, and improved efficiency of energy conversion, have accelerated renewable energy adoption and reduced the economic viability of older, less efficient fossil fuel-based power plants (Newell et al., 2020; BNEF, 2020; Holland et al., 2020). Consequently, many power plant operators are opting to retire these facilities and invest in cleaner, more cost-effective energy sources (EIA, 2023).

Governments worldwide are implementing policies to facilitate the transition to cleaner energy sources and reduce dependence on fossil fuels (IEA, 2020, 2022). These policies encompass carbon pricing mechanisms, renewable energy targets, and subsidies for clean energy projects (Bank, 2022; REN21, 2022). Additionally, stricter environmental regulations, such as limits on air pollutant emissions and water usage, have increased the operational costs of fossil fuel-based power plants, further contributing to their retirement (Maupin et al., 2014; EPA, 2023). Cullen and Mansur (Cullen and Mansur, 2017) demonstrate how carbon prices drive fuel switching in power plants from more carbon-intensive fuels like coal to cleaner alternatives such as natural gas.

2.3 The Local Impact of Power Plant Retirement

Power plant retirements can lead to improved environmental quality. Burney (Burney, 2020) finds that between 2005 and 2016 in the continental United States, the retirement of a coal-fired unit was associated with reduced nearby pollution concentrations and subsequent reductions in mortality and increases in crop yield. Komisarow and Pakhtigian (Komisarow and Pakhtigian, 2021) found that areas downwind of closing coal-fired power plants in Chicago experienced a reduction in PM2.5 concentrations between 0.21-0.34 $\mu g/m^3$ compared to more distant regions. Improved local air and water quality can increase the appeal of affected areas to potential residents and businesses, potentially raising property values and promoting economic development (Davis, 2011; Muehlenbachs et al., 2015).

In addition, improvements in environmental quality and amenities can make affected areas more attractive to potential residents, influencing migration patterns (Banzhaf and Walsh, 2008; Heblich et al., 2021; De Silva et al., 2022). This process can also lead to environmental gentrification, where the environmental amenity improvement drives an inflow of wealthier and white residents drawn by the enhanced amenities, often resulting in the displacement of existing disadvantaged community members due to the increasing housing costs (Sieg et al., 2004; Banzhaf and McCormick, 2012). Prior research underscores that environmental cleanups and pollution reduction efforts, akin to power plant retirements, have led to gentrification pressures (Gamper-Rabindran and Timmins, 2011; Depro et al., 2015; Binner and Day, 2018).

On the other hand, power plant retirements can result in job losses, revenue loss, and economic disruptions in local communities, particularly in regions heavily reliant on the power generation industry (Carley, Evans, and Konisky, 2018; Houser, Bordoff, and Marsters, 2017; Haggerty et al., 2018). The loss of employment opportunities and income can create a ripple effect in local economies, affecting businesses, public services, and overall community well-being. These employment disruptions may prompt affected individuals to move away in search of new job opportunities or to stay if new employment opportunities arise in other sectors, such as renewable energy projects or industries unrelated to power generation.

Power plant retirements can also have varying effects on property values, through changes in environmental quality, employment opportunities, and public perception. Property values may increase due to improved environmental conditions, or decrease due to job losses and concerns about the local economy (Kiel and Williams, 2007; Davis, 2011). Changes in property values can influence migration patterns, as individuals may be attracted to areas with rising property values or deterred by declining property values (Molloy et al., 2011). The retirement of a power plant may change public perception of the area, potentially influencing migration patterns. For instance, individuals previously deterred from living near a power plant due to pollution concerns or other negative externalities may be more inclined to move to the area once the plant is retired (Chay and Greenstone, 2005; Luechinger, 2009). Conversely, power plant retirement may create a stigma associated with job losses and economic decline, deterring potential residents (Glaeser and Gyourko, 2005).

Despite the growing body of literature on the environmental and economic consequences of power plant retirements, a gap remains in understanding how these changes affect local residents' migration patterns and sorting behaviors. This study aims to bridge this gap by examining power plant retirements' impact on migration decisions, offering insights for policymakers navigating the challenges associated with the energy transition.

3 Data and Summary Statistics

This paper leverages a diverse set of datasets encompassing migration patterns, power plant details, employment statistics, and community attributes to investigate the short-term (2018-2022, quarterly) and long-term (2013-2020, annually) effects of power plant retirements on local communities. Appendix Table A1 summarizes the data sources used in the study.

3.1 Data

The primary source for tracking migration patterns is the Change of Address (COA) dataset provided by the United States Postal Service (USPS).[2] The COA service allows individuals and businesses to inform the USPS of new mailing addresses online, by mail, or in-person. The USPS compiles these COA requests on a monthly basis at the zip code level, categorizing them by origin and destination as well as move type — family, individual, or business. The dataset provides total COA volume originating from and destined to each zip code across move types and includes both permanent and temporary address changes. I focus the analysis on permanent moves, using them as proxies for in-migration (move-in), out-migration (move-out) flows, and net inflows (move-in minus move-out). To protect customer privacy, the USPS only discloses COA volumes greater than 10.[3]

The previous literature primarily relies on Census tract or IRS data to study migration patterns. However, these data are only updated annually at the county level. Additionally, IRS data often underreports information on lower-income households. The USPS COA data is available monthly at the zip code level and thus offers the highest frequency and most up-to-date view of migration patterns and sorting behaviors. Ramani and Bloom (2021) found a strong correlation between the USPS COA and migration patterns in Census datasets, affirming the validity of COA data for capturing migration trends.

I obtain monthly power plant retirement details from the Preliminary Monthly Electric Generator Inventory based on the Energy Information Association (EIA) Form EIA-860M.[4] The data details the current status (operating, retired, and planned) of power plant generators, including retirement dates, coordinates, nameplate capacity, and energy sources.[5]

To identify the effects of power plant retirement, I construct a treatment indicator centered on the "full retirement" of all fossil fuel generators within a region. Full retirement is defined as the complete cessation of operations of all fossil-fuel generators in a given area. An illustrative example of this treatment indicator for a specific state is depicted in

[2]Data spanning from July 2018 to July 2022 was obtained via the Freedom of Information Act (FOIA), with recent data available from USPS FOIA Library. The dataset can be downloaded from the website: https://about.usps.com/who/legal/foia/library.htm. USPS only provides the total COA requests to and from a ZIP code from July 2018 to the public.

[3]Due to this reporting threshold, the business, family, and individual move counts might not always tally up to the total. In the reported data, these non-disclosed samples appear as blank rather than defined as zeroes. I filled in unreported missing values with the midpoint 5 for permanent address changes, though results remain robust without these values.

[4]See EIA-860M: https://www.eia.gov/electricity/data/eia860m/.

[5]To enable merging the EIA data with the zip code migration data, I map the latitude and longitude coordinates to Census tract geometries and their associated zip codes.

Appendix Figure A2. When all fossil fuel generators within a region are retired, that region is considered to have received the full retirement treatment.

My analysis primarily focuses on the full retirement of fossil fuel generators at the zip code level, as this granular geographic unit allows for a more precise examination of local effects. I also aggregate monthly data into a quarterly format. This aggregation reduces the noise from monthly fluctuations and smooths out seasonal effects, like summer migrations or holiday staffing patterns, which results in more precise estimates.

In addition, I incorporate data on local community characteristics sourced from the American Community Survey (ACS) 5-year samples, which offer details on median household income, median age, and racial composition.[6] Residential property value changes are gauged using Zillow's Home Value Index (ZHVI) at the zip code level.

For a longer-term perspective, I employ the annual Form EIA-860 for power plant retirements and couple it with the IRS migration flow data at the county level.[7] Employment statistics are extracted from the Quarterly Census on Employment and Wages (QCEW) at the county-quarter level, which I then aggregate annually for consistency.

3.2 Descriptive Statistics

Appendix Figure A1 shows the monthly number of generator retirements and new retirements in the U.S. Panel A indicates that from mid-2018 to late 2022, fossil fuel retirements, particularly of coal, accounted for the majority of retirements during this period. Panel B presents the monthly count of zip code areas with fully retired generators from 2002 to 2022, including all generator types, coal generators, and fossil-fuel generators. It reveals a continuous, staggered pattern of full retirement of fossil fuel generators across zip codes over time.

Appendix Table A2 provides a summary of migration patterns, generator capacity, and emissions at the zip code level from 2018Q3 through 2022Q4. Migration patterns are averaged on a quarterly basis, drawn from monthly data sets. The capacity and emissions figures represent average annual metrics from the EPA for individual generators, aggregated up to the zip code level. The sample includes over 30,000 zip code areas. Interestingly, 21% of these zip codes have a power plant. Within these, there's an average of 5 generators per zip

[6] The ACS data for 2012 and 2017 derives from the 2008-2012 and 2012-2016 ACS 5-year datasets, respectively.

[7] See EIA-860 (https://www.eia.gov/electricity/data/eia860/) for annual power plant data. For IRS data, I use total inflow and outflow between one county and the rest of the U.S. to match the format of USPS COA data.

Table 1: Pre-treatment Summary Statistics for zip code areas characteristics

	Treated ZIP code areas	Control ZIP code areas
Median Household Income	56,287.38	57,700.20
	(20,630.24)	(24,292.07)
Gini Coefficient	0.43	0.42
	(0.05)	(0.06)
Total Housing Units	7,880.21	4,780.67
	(6,710.55)	(5,946.45)
Occupied Housing Units	7,085.28	4,192.57
	(6,139.01)	(5,393.78)
Median Housing Unit Value	176,353.56	195,166.50
	(128,932.89)	(174,681.76)
Median Gross Rent	891.25	884.44
	(325.59)	(366.23)
Vacant Housing Units	794.92	588.10
	(750.42)	(910.13)
Average Household Size	2.59	2.57
	(0.45)	(0.44)
Median Age	39.95	42.01
	(6.77)	(7.93)
Total Population	19,129.34	11,316.47
	(16,889.10)	(15,026.89)
White Population Ratio	0.80	0.83
	(0.20)	(0.20)
Black	1,984.38	1,427.28
	(4,040.29)	(4,156.70)
American Indian	145.14	89.39
	(600.81)	(374.98)
Asian	901.93	600.57
	(1,977.78)	(2,197.23)
N	2271	491277

Notes: The table provides a comparison of pre-treatment characteristics of zip codes experiencing fossil fuel retirements to control zip codes, using 2018-2022 ACS 5-year estimates. Areas with full retirement of fossil-fuel generators have distinct socioeconomic features. They typically have lower income and housing value, younger residents, more housing units, larger households, and higher population. They also have higher income inequality and larger Black, American Indian, and Asian populations.

code (with a median of 3 and a maximum of 105). A subset of 129 zip codes experienced full retirement of fossil-fuel generators. In the post-retirement phase for these areas, both inflows and outflows of residents dropped, with a concurrent decrease in all emission types—even though capacity witnessed a marginal rise.

I also separate control zip codes into three groups: 1) “Not yet treated” zip areas have experienced retirements of some fossil-fuel generators, but not full retirement. 2) “Never treated” zip codes either have no retirements of fossil-fuel units or only possess non-fossil-fuel power plants. 3) "No power plants" zip codes devoid of any power plants during the observed period. The zip codes without power plants consistently demonstrate lower average move-in and move-out rates relative to other groups. However, this group also displays a more significant standard deviation for each mean, pointing to a broader variability across zip code areas. Overall, there is a trend of negative net inflow across all samples, accompanied by large, positive standard errors. The net inflow rises for zip codes in the post-treatment phase relative to those in the pre-treatment and not-yet-treated categories.

Table 1 presents summary statistics comparing pre-treatment characteristics of zip codes experiencing fossil fuel retirements to control zip codes, using 2018-2022 ACS 5-year estimates. The data reveals that zip code areas treated with full retirement of fossil-fuel generators exhibit several distinct socioeconomic features. Compared to control areas, the treated zones tend to have a lower median household income, lower median housing unit value, younger median age, and a smaller proportion of white residents. Additionally, they exhibit a higher Gini coefficient, suggesting more income inequality. These areas also house more total and occupied housing units, with a larger proportion of vacant housing units. Furthermore, they tend to have larger average household sizes and total populations. Demographically, the treated zip code areas have more substantial representations of Black, American Indian, and Asian populations. These findings suggest that areas undergoing full retirement of fossil-fuel generators tend to be younger, more densely populated, and have a higher concentration of communities of color and lower-income residents.

4 Empirical Strategy

Using the constructed treatment indicator of full retirement, I leverage the quasi-experimental variation in the timing and location of fossil-fuel generator retirements across zip codes to estimate the causal impact of these retirements on migration patterns. This is achieved using a generalized difference-in-differences approach, which compares the changes in move-in and move-out populations before and after fossil-fuel generator retirements between treated areas (those with power plant retirements) and control areas (those without retirements).

The baseline specification for this analysis is a two-way-fixed effect (TWFE) model:

$$Y_{it} = \alpha + \beta D_{it} + \lambda_i + \theta_t + \delta_{ct} + \epsilon_{it} \tag{1}$$

where Y_{it}, is a measure of internal migration for zip code i in quarter-by-year t. The key independent variable, D_{it}, is a binary treatment indicator equal to one for the full retirement of fossil-fuel generators in zip code i in quarter t. The model includes zip code fixed effects (λ_i) to control for time-invariant characteristics specific to each zip code, year-quarter fixed effects (θ_t) to account for common time shocks affecting all zip codes, and county-quarter fixed effects (δ_{ct}) to control for time-varying unobservable factors at the county level, such as changes in local policies or economic conditions.

The TWFE model helps address concerns that the COVID-19 pandemic might be a significant confounding factor in the COA migration data from 2018 to 2022. The year-quarter fixed effects capture national-level changes related to the pandemic, while the county-quarter fixed effects account for local variations in the pandemic response and other county-specific factors. By including these fixed effects, the model effectively controls for many potential confounding factors related to COVID-19 and other sources of variation in migration patterns. The identification assumption is that, conditional on these controls, the full retirement of fossil fuel generators is as good as randomly assigned (conditional strict exogeneity). Although this model may not completely eliminate all sources of bias, it provides a robust approach to estimating the impact of fossil fuel generator retirements on migration while addressing concerns related to the COVID-19 pandemic.

To further address the potential endogeneity problem arising from the non-random assignment of fossil fuel retirements, I employ two additional strategies: Coarsened Exact Matching (CEM) and Instrumental Variables (IV) estimation. These approaches, described in the following sections, help to strengthen the causal interpretation of the estimated effects by reducing bias due to differences in observed and unobserved characteristics between treated and control areas.

I also estimate a panel event study (Clarke and Tapia-Schythe, 2021) in equation 2 to capture the dynamic effects of fossil-fuel generators' retirement. This approach allows me to estimate migration patterns over time after retirement, which the previous literature using annual data has not studied. It also allows me to test for parallel trends prior to treatment.

For the panel event study, I estimate the following specification:

$$Y_{it} = \alpha + \sum_{k=-8}^{12} \beta_k D_{it}^{(k)} + \lambda_i + \theta_t + \delta_{ct} + \epsilon_{it} \qquad (2)$$

where $D_{it}^{(k)}$ represents a set of event-time dummies for each period k relative to the time of power plant retirement. The sum $\sum_{k=-8}^{12}$ indicates that I will estimate a separate coefficient

β_k for each lead and lag, ranging from 8 quarters before treatment to 12 quarters after treatment. The reference period (omitted category) is the period right before the power plant retirement.

4.1 Matching Method

One key challenge in identifying effects in Equation 1 is the non-random selection of zip codes with fossil-fuel generators, as suggested by Table 1. Specific demographic areas have disproportionately experienced fossil-fuel generator retirements. To address this concern, I employ Coarsened Exact Matching (CEM) as proposed by Iacus, King, and Porro (2012), using covariates from the 2017 ACS 5-year data and generators data.

CEM is a nonparametric method designed for data preprocessing. It works by addressing potential confounding factors through the reduction of imbalance between the treated and control groups. In this method, data points are grouped into discrete bins based on certain properties. This coarsening ensures exact matches between members within the same bins. However, the bin selection is crucial; it hinges on the covariate distribution. Due to the significant standard deviation from the mean in our dataset, overly granular binning might hinder sample adequacy.

After assessing different coarsening to optimize sample size and balance, I settled on a binning structure based on pre-treatment zip code demographic and generator characteristics, which could potentially influence the relationship between retirement and migration. Specifically, I considered median housing value, total population, generators' lifespan, and the number of generators at the zip code level. The matching coarsens these variables into bins and exactly matches treated and control units with identical bin combinations.

Appendix Table A4 presents the balance achieved for key covariates before and after matching. The post-matching results depict well-balanced groups. For assessing balance, both mean differences p-values and Standardized Mean Differences (SMD) were employed. The SMD evaluates the difference in means between the groups, normalized by the pooled standard deviation. Typically, SMD values below 0.1 or 0.2 signify minimal differences between groups (Cohen, 2013). The majority of our variables register values below or close to 0.2, indicating the matched sample sufficiently balances the treatment and control groups. Conditioning on these factors enables estimating the retirement effect by comparing observably similar treated and controlled zip code areas. CEM thus facilitates drawing more valid causal inferences on how full retirement of fossil-fuel generators impacts migration flows.

4.2 Instrumental Variables Estimation

To address potential endogeneity concerns related to the decision to retire fossil-fuel generators, I employ an instrumental variables (IV) approach. If retirement status is endogenous in Equation 1 due to selection into retirement, the estimated treatment effects will be biased. Retirement decisions for generators can be influenced by a combination of factors: the physical lifespan of the generators, shifts in the energy market, and governmental regulations, to name a few. So I use the generators' lifespan, state-quarter level natural gas prices, state-year level coal prices, and the percentage of natural gas and coal generators as instruments for the full retirement of fossil-fuel generators. The first stage is specified as:

$$\begin{aligned}\text{FullRetirement}_{ity} = {} & \alpha_0 + \alpha_1 \text{Lifespan}_i + \alpha_2 \text{CoalPriceProxy}_{s,y-1} \\ & + \alpha_3 \text{GasPriceProxy}_{s,y-1} \\ & + \alpha_4 \text{CoalPriceProxy}_{s,y-1} \times \text{Lifespan}_i \\ & + \alpha_5 \text{GasPriceProxy}_{s,y-1} \times \text{Lifespan}_i \\ & + \lambda_i + \theta_t + \delta_{ct} + \epsilon_{it} \end{aligned} \tag{3}$$

where $\text{CoalPriceProxy}_{s,y-1}$ and $\text{GasPriceProxy}_{s,y-1}$ scale the state fuel prices by the share of retired coal and gas generators to account for different generator mixes:

$$\text{CoalPriceProxy}_{s,y-1} = \frac{\text{Number of retired coal generators}_{ity}}{\text{Total fossil fuel generators}_{ity}} \times \text{CoalPrice}_{s,y-1} \tag{4}$$

$$\text{GasPriceProxy}_{it,y-1} = \frac{\text{Number of retired gas generators}_{ity}}{\text{Total fossil fuel generators}_{ity}} \times \text{GasPrice}_{it,y-1} \tag{5}$$

Subsequently, the predicted $\text{FullRetirement}_{ity}$ from this first stage is used in Equation 1 via a standard two-stage least squares (2SLS) approach. The identifying assumptions are 1) Lifespan affects retirement decisions but not directly migration. Older generators are more likely to retire, 2) Fuel prices affect the profitability of fossil generators. high prices increase retirement likelihood, 3) Fuel price impacts on retirement depend on the generator shares. Coal price matters more in coal-dominant areas, 4) Fuel prices do not directly influence migration patterns, and they only operate through retirements. Testing the strength of the first stage and over-identification restrictions helps validate these assumptions. The 2SLS method, combined with the examination of the instruments, offers a rigorous approach to estimating the causal effects of retirement.

Table 2: The Effects of Full Retirement of Fossil-fuel Generators on Migration

(a) OLS Results

	Baseline			Coarsened Exact Matching (CEM)		
	(1) Move In	(2) Move Out	(3) Net Inflow	(4) Move In	(5) Move Out	(6) Net Inflow
Fossil Fuel Full Retirement	-23.3***	-31.6***	8.3**	-17.6***	-20.4**	2.8
	(5.7)	(6.3)	(4.0)	(6.7)	(8.0)	(6.2)
Outcome mean	229.5	241.7	-12.2	229.5	241.7	-12.2
Observations	554,892	554,892	554,892	4,826	4,826	4,826
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Zip FE	✓	✓	✓	✓	✓	✓
County-quarter FE	✓	✓	✓	✓	✓	✓

(b) IV Results

	Baseline			Coarsened Exact Matching (CEM)		
	(1) Move In	(2) Move Out	(3) Net Inflow	(4) Move In	(5) Move Out	(6) Net Inflow
Fossil Fuel Full Retirement	-85.5***	-91.2***	5.7	-30.5***	-33.6***	3.0
	(21.8)	(20.3)	(8.9)	(8.9)	(11.1)	(9.0)
Weak IV F-stat	65.6	65.6	65.6	72.3	72.3	72.3
Outcome mean	229.5	241.7	-12.2	229.5	241.7	-12.2
Observations	554,892	554,892	554,892	4,826	4,826	4,826
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Zip FE	✓	✓	✓	✓	✓	✓
County-quarter FE	✓	✓	✓	✓	✓	✓

Notes: This table explores the effects of fossil fuel plant retirement on migration flows using OLS difference-in-differences (Panel (a)) and IV specifications (Panel (b)). The outcome variables are quarterly move-ins, move-outs, and net moves per zip code. Each column presents results for the full sample and matched sample. The matching procedure helps address endogenous plant closure concerns. All models include zip and quarter-year fixed effects plus time-varying controls. Across specifications, the results indicate that fossil fuel retirement reduces both move-ins and move-outs but has small, insignificant impacts on net moves. The IV estimates imply a 7-16% decrease in inflows and outflows per zip-quarter, representing a 0.3-0.7% drop in local migration churn. This provides robust evidence that plant closure stagnates local migration patterns for both existing and potential new residents. Standard errors clustered at the zip code level. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

5 Results

5.1 Baseline Results

Panel (a) in Table 2 presents the main TWFE estimates of fossil-fuel generator retirements on migration flows using the full sample and matched sample. Columns (1)-(3) present full sample results, while columns (4)-(6) offer post-matching findings. The results remain consistent between the full and matched samples, though matching yields slightly smaller effects. Both the full sample and matched sample estimates indicate that full fossil fuel retirement decreases total permanent move-ins and move-outs, while having a small positive but insignificant effect on net move-ins.

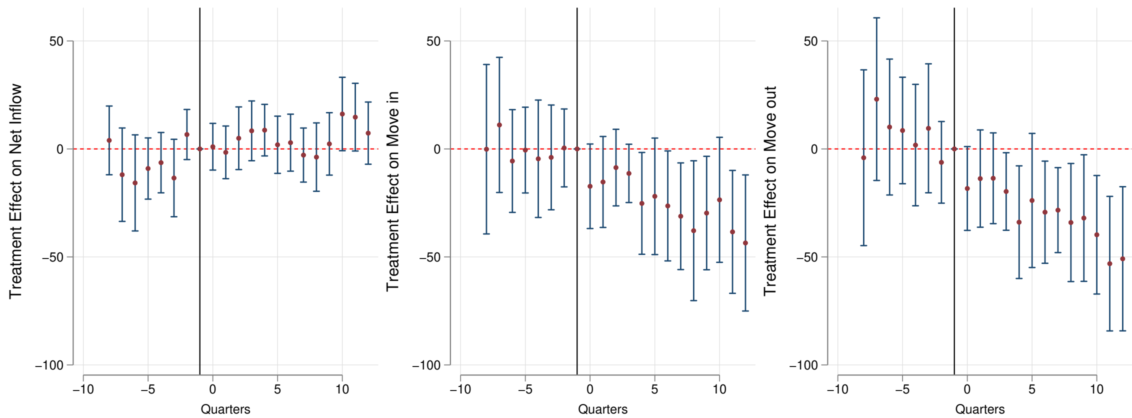
In Panel (b) of Table 2, I report IV estimates based on the full sample and matched sample. The matching results indicate that full retirement of fossil-fuel generators reduces quarterly move-ins by 30 addresses and move-outs by 33 addresses per zip code. These magnitudes are larger than those observed in the OLS estimation. While net inflows remain insignificant across both samples, the larger decline in outflows produces a small positive point estimate. To place these results in context, the average zip code experienced 243 move-ins and 258 move-outs between quarters in 2018. Drawing on the mean move-in and move-out statistics from Table A2, the observed treatment effects imply a shift of approximately 7% to 16% in both population inflows and outflows for each zip code every quarter. According to HUD-USPS Data on Address Vacancies, the average count of addresses at the zip code level was approximately 10,199. By this measure, the inferred move-in and move-out rates equate to a marginal 0.3% to 0.7% decrease in both inflows and outflows each quarter for every zip code. The estimates represent a moderate but meaningful decrease in local migration churn.

Figure 2 displays the event-study results. The coefficients for the eight quarters (two years) preceding full fossil fuel generator retirement in a zip code area are near zero, indicating no discernible pretrends and validating the research design.[8] These findings reveal the dynamics of treatment effects, exhibiting a decreasing trend over time in the post-treatment period for both move-ins and move-outs. The net inflow trend does not become evident until two years after the treatment. The heterogeneity-robust estimators for staggered treatment timing proposed by De Chaisemartin and d'Haultfoeuille (2020), Borusyak, Jaravel, and Spiess (2024), and Callaway and Sant'Anna (2021) are shown in Appendix Figure A8 and Figure A9. These results suggest a trend similar to those estimated using TWFE.

These patterns indicate that fossil fuel retirements gradually reduce local migration dynamics over time. While both flows decline, the larger drop in outflows produces a small population retention effect. This implies some increased settlement in communities experiencing fossil-fuel generator closures, likely due to fewer people moving away. However, the overall interpretation remains that retirements decrease mobility and residential churn, and lead to stagnation in local community.

[8]I use full sample to run the panel event study here given the relatively small sample size post-matching, the parallel trends shown in the figure show the basic assumption holds for the full sample to run panel event study and give a good estimate. Appendix Figure A3 presents the event study estimates using the matching sample. Although there is more variance in the treatment effects, it still shows a robust parallel trend pre-treatment, and a decreasing trend, though the post-treatment trajectories are not as sharply delineated as those observed in the full sample representation.

Figure 2: Impact of Fossil-Fuel Generator Retirement on Migration: zip-Quarter Analysis



Notes: The figure shows event study estimates from Equation 2 examining zip code level migration post full retirement of fossil fuel generators. The outcome variables are quarterly move-ins, move-outs, and net moves. Retirement year -1 is the omitted reference period. The model includes zip code, quarter, and county-year fixed effects with standard errors clustered by zip code. The sample covers 2018-2022 IRS migration data and EIA generator retirement records. The coefficients in the eight quarters prior to retirement are near zero, validating the research design by showing no discernible pre-trends. The results reveal decreasing trends in move-ins and move-outs emerging after retirement, while net inflows do not arise until two years post-closure. The bars display 95% confidence intervals.

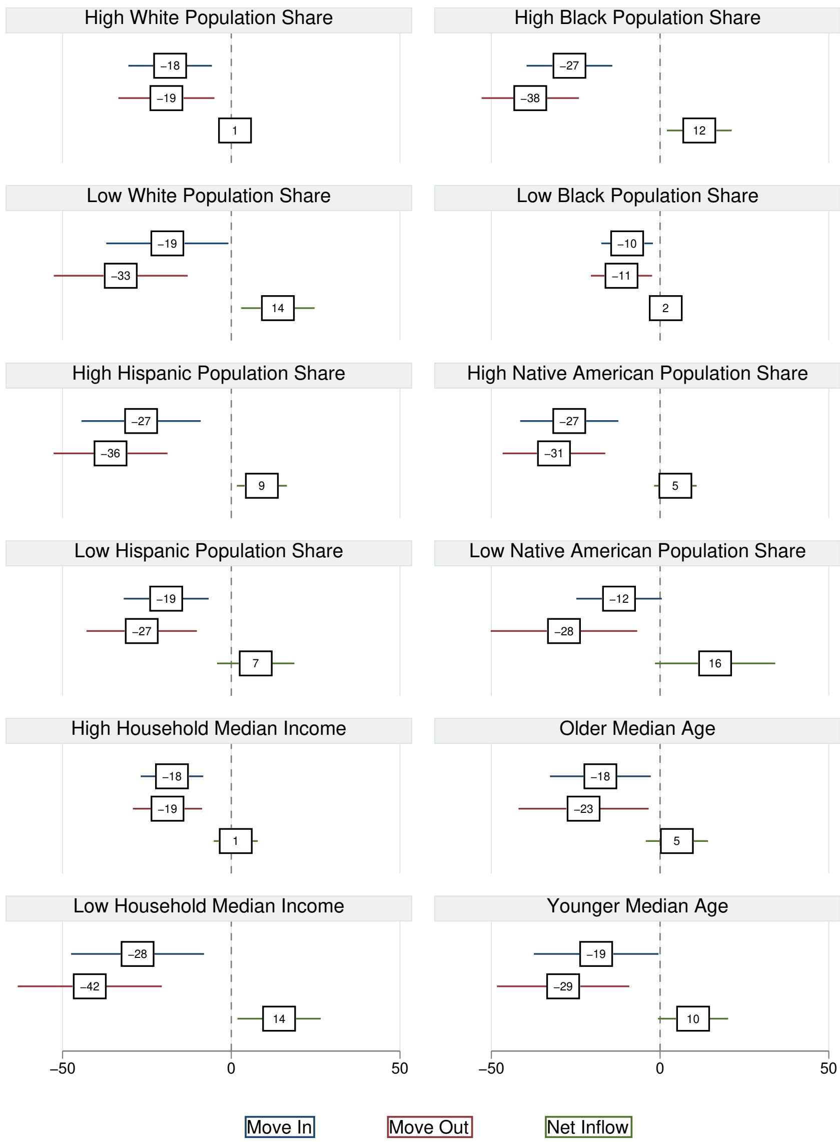
5.2 Heterogeneity

I explore heterogeneous effects of fossil fuel retirements on migration across zip code demographics including age, income, and racial/ethnic composition using the 2017 ACS 5-year estimate on the zip code level. This sheds light on which types of communities exhibit the greatest sensitivity to energy transition and identify communities that are most vulnerable to such shifts. I pursue two approaches: segmenting the sample by above/below median values for each factor estimating separate models, and interacting the factors with treatment in an augmented TWFE model.[9] Both approaches reveal similar patterns: Younger and lower-income communities experience greater stagnation, driven by move-out reductions. Higher black population share communities see larger effects on both move-ins and move-outs. Native American communities exhibit declines in move-ins but little change in move-outs. Hispanic composition shows minimal differences in effects.

For the subsampling analysis based on the median, I apply equation (1) to obtain estimates within each subsample. Figure 3 presents the results comparison between age and income groups. It shows that low-income zip communities, defined as below median household income, experience a more sizeable stagnation impact on move-outs compared to high-income areas. This also generates a passive net inflow since the decrease in outflows

[9]Given a relatively smaller sample after matching, the segmentation based on median ensures sufficient sample size within each subgroup.

Figure 3: Heterogeneity in the Migration Stagnation Effect



Notes: This figure presents event study estimates examining heterogeneous migration responses to fossil fuel retirement across demographic groups. The outcome variables are quarterly move-ins, move-outs, and net moves per zip code. The model includes location and time-fixed effects with zip code clustered standard errors. Results reveal greater out-migration stagnation in low-income versus high-income areas, increasing net inflow. Younger zip codes exhibit bigger mobility stagnation, particularly for move-outs, also raising net inflow. Zip codes with higher black shares experience amplified stagnation for both in- and out-flows compared to lower share areas. The analysis demonstrates disproportionate migration stagnation among economically disadvantaged and minority groups post-retirement. Fossil fuel closure appears to exacerbate existing inequalities along both economic and racial lines.

exceeds the decline in inflows. For younger communities, defined as the zip code median age below median age of all zip codes, exhibit greater migration stagnation following fossil fuel retirements relative to older communities. This effect is driven primarily by larger reductions in move-outs. Younger areas also display greater variance in effects. The larger decline in outflows also produces a passive net inflow.

Figure 3 also indicates that zip codes with higher black population shares, defined as above median, undergo larger stagnation effects on both move-ins and move-outs versus lower share zip codes. By contrast, lower white population share communities experience a larger move-out. In addition, low Hispanic composition zip codes do not differ substantially in effects. For Native American communities, the primary impact is a decline in move-ins.

In the second approach, I interact the treatment indicator in the TWFE model with the zip code factors to estimate their distributional effects in a joint model (Appendix Table A5). I create a dummy variable equal to one if the factor is above or equal to the median. The results show a similar trend with the sub-sampling coefficients. Higher black share zips see greater stagnation effects with declines in both move-ins and move-outs. White and Hispanic composition shows little difference in effects. Higher Native American shares experience reduced move-ins but not move-outs.

Older communities exhibit a positive interaction effect in a single column. Although this effect isn't statistically significant in the combined estimation presented in column (4), it still implies opposite effects – larger stagnation for younger areas. Likewise, for high-income communities, the treatment effect is noticeably positive in both migrations in and out patterns. This inversion suggests that economically disadvantaged communities experience more pronounced stagnation. In summary, both approaches suggest that the qualitative patterns of larger stagnation impact more black, younger, and lower-income zip code areas following fossil fuel retirements.

5.3 Long Run Effects

While prior analysis concentrated on the quarterly effects of fully retiring fossil-fuel generators at the zip code level, it is important to examine the persistence or variation of these effects over the long run, especially prior to the COVID era. As the COA data is confined to recent years, I transitioned to a dataset spanning a more extended time frame. In order to maintain consistency with the inflow and outflow setup, I use IRS migration flow data from 2013 to 2020. This dataset includes information on the inflow and outflow of residents between one county and the rest of the U.S., mirroring the definitions found in the COA dataset. Appendix Table A3 shows the demographic and generator data summary at the county level, indicating a balanced pre-treatment set between the treated and control groups. Hence, I directly proceed with the TWFE for long-term estimates.

Following equation 1, I integrate the IRS and EIA-860 annual data at the county-year level and estimate the following equation:

$$Y_{cy} = \alpha + \beta D_{cy} + \lambda_c + \theta_y + \delta_{sy} + \epsilon_{cy} \tag{6}$$

where Y_{cy} represents the migration flow metric for county c in year y. D_{cy} is a binary variable set to one when a county fully retires its fossil-fuel generators. λ_c, θ_y, and δ_{sy} are the fixed effects for county, year, and state-year, respectively. This framework isolates the dynamics of fossil fuel retirements with county and year-fixed effects plus state-by-year trends.

Figure 4 illustrates the event study results on the effects of generator retirement on migration flows, using the TWFE specification. These findings highlight the emergence of stagnation effects three years after retirement. At the county-year level, both move-ins and move-outs diminish, with a stable net inflow trend consistently observed. This suggests that the initial effects observed at the zip code level in the short term begin to manifest more broadly at the county level over the years. The full retirement of fossil-fuel generators seems to discourage migration into the treated county, and residents within these counties appear more inclined to stay put. Over time, this develops into general stagnation within the entire county.

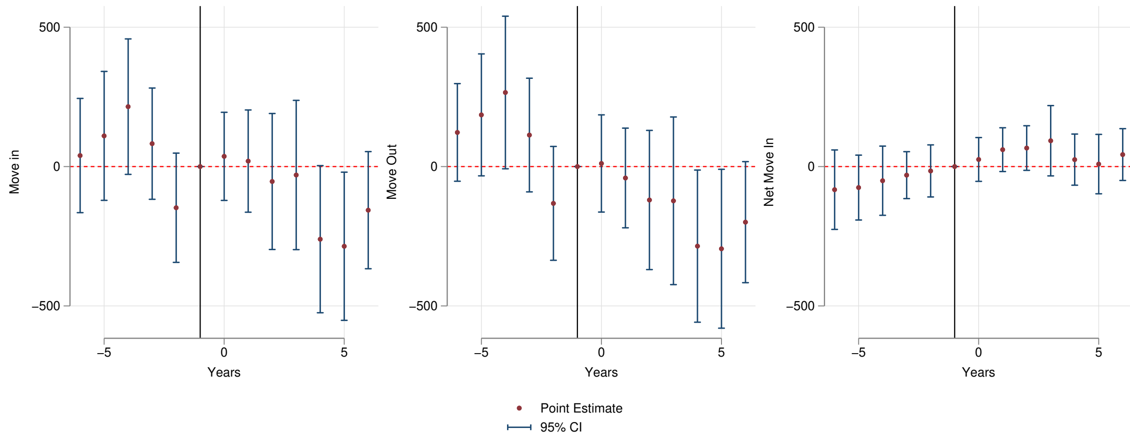
The estimates are significant without state-year fixed effects but become insignificant with them, likely due to unobserved temporal confounders at the state level (Appendix Table A6). However, Appendix Figure A4 without state-year fixed effects displays a similar stagnation pattern as Figure 4 with state-year fixed effects. While the estimates are sensitive to specifications, the general migration response of declining dynamism after retirements is robust across dynamic effect analyses. This highlights the value of exploring both short and long-run effects at multiple geographic levels and through multiple specifications to comprehensively understand the impacts on communities.

5.4 Robustness Checks and Alternative Specifications

This section presents several robustness tests and alternative model specifications to evaluate the reliability and validity of the main results under different assumptions.

Alternative Treatment Setup One concern for the current treatment indication con-

Figure 4: Impact of Fossil-Fuel Generator Retirement on Migration : County-Year Analysis



Notes: This table presents event study estimates examining county-level migration patterns surrounding fossil fuel plant retirements using IRS data from 2013-2020. The outcome variables are annual move-ins, move-outs, and net moves per county. The model includes county, year, and state-year fixed effects, clustering standard errors by county. The results show that move-in and move-out trends decrease in the years after plant closure, while net inflows remain stable over time. This demonstrates the initial zip code-level stagnation effects observed in the short-run manifest more broadly at the county level long-term. The bars display 95% confidence intervals.

struction using the full retirement of fossil-fuel generators within a geographic area like zip code or county is that it does not consider the position of power plants and its effective areas. For example, if one power plant sits on the edge of one zip code, then its retirement is supposed to affect surrounding areas including multiple zip codes. To address this concern, I follow Davis (2011) to define generators that have buffers overlapping or intersecting with population-weighted centroids will match with the zip codes as the treated group. This method ensures any generator whose buffer influences a certain zip code will be taken into account when considering the full retirement of fossil-fuel generators.

I create a 2-mile buffer around each generator as shown in Appendix Figure A5. Appendix Table A7 shows estimates using this buffer-based treatment definition in TWFE models with the full and matched samples. Results display a similar pattern of increasing stagnation after fossil fuel generators full retirements compared to the main estimates. The larger magnitude of effects is likely due to the expanded definition of treatment area under the buffer approach.

I also use additional specifications through zip code centroid-based buffer areas. The creation of the zip code buffer area was based on the smallest, median, and largest radius from centroids to the zip code boundary. Power plant generators situated within the smallest buffer will correspond to the zip code as the treated group, as shown in Appendix Figure A6. Results for the smallest zip code buffer using TWFE with full sample and matched sample are presented in Appendix Table A8. This result demonstrates a stagnant trend in local migration patterns with relatively minor treatment effects. This result can be viewed as a lower bound of the estimates since it only consider the power plants within the smallest zip code population-weighted centroid buffer.

While zip code shapes can complicate centroid-based buffers, the consistency across specifications is reassuring.[10] The stagnation effects are not sensitive to how retirements are geographically linked to zip codes. In both robustness tests, defining treatment based on overlapping geographic areas again produces declining dynamism, validating the main results. The geographic linkage does not change the qualitative stagnation effects, though it does impact magnitude.

Alternative Migration Measurement As robustness, it is also worth trying to estimate the effects on migration rates, taking into account the total number of addresses. However, a challenge arises because USPS doesn't directly give us the total address count for each zip code. To navigate this, I utilize data from the United States Department of Housing and Urban Development (HUD). Specifically, HUD receives data on address counts from USPS every quarter, which they then use to create the HUD Aggregated USPS Administrative Data on Address Vacancies. This dataset provides insights into all types of addresses at the census tract level.[11] To align this data with our zip-quarter Change of Address (COA) data, I make use of The HUD-USPS zip Code Crosswalk files. These files help map zip code data to other geographical divisions, such as census tracts.[12]

Using the quarterly total address estimates for zip code areas from the HUD data, I calculate move-in rates, move-out rates, and net inflow rates for each zip code-quarter. These rates are constructed by taking the counts of permanent move-ins, move-outs, and net moves from the USPS COA data and dividing them by the HUD total address figures. This transforms the migration flows into percentage terms, measuring moves as a percent of the total address base.

I then estimate the same TWFE models used in the main analysis, but with the move-in,

[10]It is important to note zip code geography can be irregular, unlike standardized areas like census tracts or counties. In some cases, as shown in Appendix Figure A7, population-weighted centroids fall outside the zip code itself. This might be due to measurement errors or the unique shape of that zip code, which limits the precision of centroid-based buffers.

[11]More details are available at The HUD Aggregated USPS Administrative Data on Address Vacancies in website: https://www.huduser.gov/apps/public/usps/home. It's essential to note that while HUD gets this data at a more granular zip+4 level, they aggregate it to at least the census tract level before sharing it with the public. About 1% of zip+4 records don't align with census tract-level data, likely because of differences in zip code and census tract boundaries.

[12]See https://www.huduser.gov/portal/datasets/usps_crosswalk.html

move-out, and net inflow rates as the outcome variables instead of the absolute move counts. Appendix Table A9 presents the TWFE results for both the full and matched samples using the rate-based outcomes. The estimates show a significant decrease in move-in rates following retirements. The magnitude of decrease move in is 0.7%, which falls within the range using absolute effects over the mean total address in the main specification. The magnitude of decreasing move out is between 0.9% to 3% with a larger magnitude but insignificant, which could be due to aggregation errors in constructing the total address denominators from the HUD data. Nonetheless, This result validates our main finding again: as the full retirement of fossil-fuel generators occurs, the local communities experience low mobilities and stagnation effects on migration patterns.

Robust Estimator for staggered treatments Recent work by Roth, Sant'Anna, Bilinski, and Poe (2023) summarizes potential issues with the TWFE model under heterogeneous treatment effects and staggered adoption. They explain that the OLS estimated from static TWFE is a weighted average of 2x2 difference-in-differences across all pairs of time periods and treatment groups. However, it puts negative weight on some comparisons. For example, an early treated unit in a late period can receive negative weight if used as a control for later treated units. This occurs because the TWFE predictions of the treatment indicator fall outside 0/1 bounds. When a late period has many treated units, the predicted treatment for an early adopter exceeds 1. This makes the difference between actual and predicted treatment negative and leads to negative weighting. Then the TWFE coefficient could hypothetically have the opposite sign.

To counter this potential pitfall and ensure the robustness of the results, I use a set of heterogeneity-robust estimators for staggered treatment timing proposed by De Chaisemartin and d'Haultfoeuille (2020); Borusyak et al. (2024); Callaway and Sant'Anna (2021). Appendix Figures A8 and A9 present event studies for move-ins and move-outs estimated with these robust approaches alongside the TWFE OLS specification. The results exhibit a consistent decreasing trend, a finding that is mirrored across the different robust estimators we employed. This further validates the stagnation pattern shown in the main results.

6 Potential Mechanisms

The full retirement of fossil fuel generators can influence migration through impacts on economic opportunities, amenities, and other local factors. In this section, I delve into the ways the full retirement of fossil fuel generators could shape migration patterns, leading to stagnation effects in local communities.

Economic Opportunities Power plants, particularly those that are fossil-fueled, are deeply intertwined with their local communities, providing employment, contributing to the tax base, and stimulating the local economy. The retirement of these generators can lead to job losses and reduced income, factors that can influence residents' migration decisions, as supported by numerous studies (Blanchard and Katz, 1992; Clark, 1998). To better understand this process, I analyzed annual aggregated county-quarter data from the Quarterly Census on Employment and Wages (QCEW). Applying a log transformation of labor outcomes as outcome variables in equation (6), I observed an overall stagnation in employment levels, wages, and contributions after the full retirement (See Appendix Figure A11). This trend aligns with the short and long-term decrease in migration into these areas, suggesting that diminishing economic opportunities play a significant role in local residents' sorting behaviors.

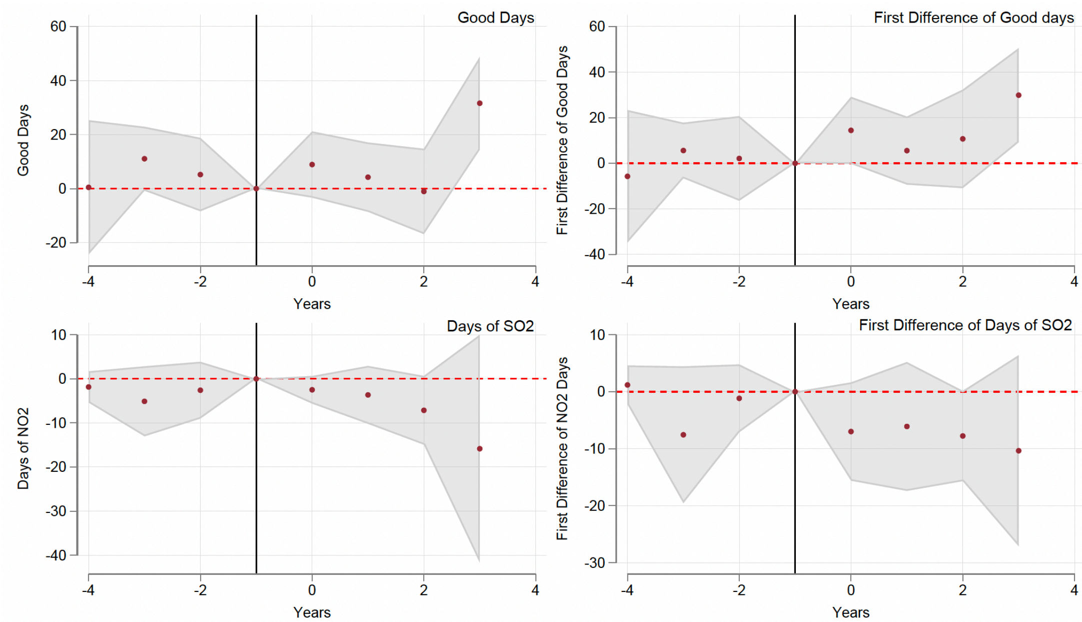
Appendix Figure A12 presents the effects on the log level of employment across different industries. When breaking down employment into different industries, the average treatment effects do not show specific effects on certain industries, except for public administration. Interestingly, this result does not show an effect on utilities and mining, which could be due to the direct employment effects being absorbed during the retirement process. However, using the log first difference of employment as the outcome variables, Appendix Figure A13 shows that the employment in wholesale trade is significantly negative. This indicates a distinct long-term decreasing trend in wholesale trade employment following the retirement of fossil fuel generators. This provides supporting evidence for the shock to the local economy caused by the full retirement of fossil fuels.

After the full retirement of fossil fuel generators, the effects on economic opportunities might be a reason for fewer people moving into these areas due to the signal of fewer job opportunities. These findings align with previous studies that have linked economic opportunities to migration decisions.

Amenity changes Environmental amenities, or the lack thereof, can have profound implications for residential choices. An extensive body of literature attests to the salience of environmental amenities in influencing migration (Chay and Greenstone, 2005; Banzhaf and Walsh, 2008; Depro et al., 2015). The opening of a power plant, with its associated environmental effects, has been found to decrease housing prices (Davis, 2011; Currie et al., 2015). Conversely, the logic would suggest that the retirement of such plants should improve environmental conditions, thereby exerting upward pressure on housing prices.

My empirical findings seem to reinforce the former but offer a nuanced view of the

Figure 5: Fossil-Fuel Generator Retirement and Air Quality: County-Year Analysis



Notes: This table presents estimates using EPA Air Quality Index annual data on good air quality days and days with SO_2 as outcome variables in a county-level difference-in-differences model. The results show that fossil fuel plant retirement leads to an increase in good days emerging two years after closure. Retirement also corresponds to a decrease in SO_2 days. These improvements appear using both absolute and first-differenced outcome measures. The findings indicate plant closure generates local air quality benefits over time, consistent with removing polluting generators.

latter. Using EPA' Air Quality Index annual data as the outcome variables in equation 6 and merging them to the year-county level data, I find that retirement leads to an increase in good days after two years for both absolute value and first difference of good days. It also shows a decrease in days of SO_2 for both absolute value and the first difference of days of SO_2 (See Figure 5). This is consistent with literature showing improved environmental quality after retirement (Burney, 2020; Komisarow and Pakhtigian, 2022; Fraenkel, Zivin, and Krumholz, 2022).

To further investigate how retirement affects amenity changes, I use housing prices as a proxy for people's preferences. I use zip-quarter average housing value estimates from Zillow in equation (1). Table 3 shows the effects of full retirement on log housing value across multiple specifications. All the results consistently show a decrease, suggesting that the retirement of fossil-fuel generators leads to around a 3% decrease in housing value. This downtrend is further supported by event-study outcomes (see Appendix Figure A14, which reveals not just post-retirement declines but also anticipatory effects).

This finding is different from the expected increase in housing values post-retirement. While Davis (2011) and Currie et al. (2015) find that the opening of fossil fuel generators and

Table 3: The Effects of Full retirement of Fossil-fuel Generators on Housing Value

	TWFE		TWFE-IV	
	(1) Baseline	(2) CEM	(3) Baseline	(4) CEM
Fossil Fuel Full Retirement	-0.024***	-0.031***	-0.062***	-0.036**
	(0.007)	(0.009)	(0.016)	(0.017)
Weak IV F-stat	-	-	72.4	52.3
Outcome mean	12.2	12.2	12.2	12.2
Observations	429,836	4,332	429,836	4,332
Year-Quarter FE	✓	✓	✓	✓
Zip FE	✓	✓	✓	✓
County-quarter FE	✓	✓	✓	✓

Notes: This table presents estimates of the effect of full fossil fuel plant retirement on zip code-level housing values using a two-way fixed effects model across various specifications. The specification includes zip code, quarter-year, and county-year fixed effects with standard errors clustered by zip code. Across specifications, the results consistently show around 3% decrease in housing values following plant closure. This suggests full retirement of fossil-fuel generators corresponds to modest adverse impacts on local housing markets

toxic plants leads to significant declines in housing prices, the latter finds negligible effects from toxic plant closures. In contrast, Fraenkel et al. (2022) discover that county-level housing values begin to increase within 6-10 months after coal plant retirement. However, these effects are confined to houses within 15 miles of the first closing unit and are only significant for complete plant retirements. In Komisarow and Pakhtigian (2021)'s zip code level analysis, they find that housing values in zip codes near the three coal-fired power plants may have slightly decreased following the closures. Given that this paper analyzes the full retirement of fossil fuel generators at the zip code level in the nation scale, my results can be interpreted as a larger scale analysis compared to Komisarow and Pakhtigian (2021) and an expansive, longer-term analysis relative to Fraenkel et al. (2022)'s results. Cumulatively, the consistent trend underscores an intriguing phenomenon: the anticipated amenity improvements post-retirement either don't instantly resonate with residents or are overshadowed by economic considerations, as indicated by the depreciation of housing values after the full retirement of fossil-fuel generators.

A closer inspection reveals an intricate heterogeneity in these effects. Table A10 shows the heterogeneity analysis of different race, age, and income groups' responses to retirement on housing value. This figure shows that housing value decreases more for households with income above the median and for Black communities. The point estimates in both column (3) and column (4) suggest that the decline in housing prices is larger in zip code areas that are above median household income relative to counties that are below the median. The joint estimation of column (6) also shows a full retirement leads to more significant declines in housing value in high Black population share communities, and increases in higher Hispanic communities, although the point estimate is only marginally significant. It also reports an increase in housing value for zip codes where the median age is above median, which shows the housing price is decreasing for areas where the median age is below median.

The housing value results show that high-income communities, which have significantly larger move-outs and slightly less significant (p-value < 0.10) and smaller move-ins as shown in Appendix Table A5, experience migration changes after the full retirement of fossil fuel generators. As Research, NASEO, and EFI (2020) shows, energy jobs pay about $25.60 an hour, 34 percent more than the median national hourly wage of $19.14 in 2020. Workers in natural gas and coal have the highest median hourly wages of the energy industries. The median wage for solar workers is $24.48 an hour compared with $30.33 for those employed by the natural gas sector, which amounts to a roughly $12,000 annual wage gap. So, the retirement of fossil-fuel generators and lead to job loss and decreasing income, which could drive high-income communities' move-out and lead to housing value declines. This heterogeneity effect also supports the idea that housing value reductions suggest complex amenity transitions where improvements are overwhelmed by other factors. Economic declines may also dominate, as higher income areas exhibit the most negative impacts, alongside the greatest out-migration.

Other Factors There exists a marked differentiation in migratory behaviors and housing value responses across communities, particularly when segregated by income and racial composition. High-income communities demonstrate a pronounced trend of increased outward migration and a decline in housing values as previous results have shown. This migration behavior suggests that residents in these affluent areas possess the resources and flexibility to relocate when faced with economic downturns. The corresponding housing value decline reflects the reduced demand in the wake of significant move-outs.

On the other hand, communities with a high proportion of Black residents tend to experience a more pronounced decrease in both inward and outward migration (Appendix Table A5). This dual movement reduction intensifies the decline in housing values for these communities (Appendix Table A10). These evidences suggest stronger stagnation effects compared to communities with a lower proportion of Black residents. Meanwhile, such effects are not observed in communities with a higher white population share.

Several other mechanisms might be at play here. Although there is not direct evidence, one possible explanation for this trend could be the hidden discrimination that Black workers face when seeking job opportunities outside their zip code, as documented in the literature. A body of studies highlights the persistent and covert racial discrimination in labor markets that can impede mobility (see, for instance, Bertrand and Mullainathan (2004)). This systemic discrimination could potentially discourage individuals from moving out of their communities, thereby contributing to the observed stagnation effects.

Moreover, the larger decrease in outward migration observed in lower-income communities could be attributed to the attraction of inexpensive housing for people with low incomes (Figure 3). This aligns with research that suggests that affordable housing can draw individuals with low incomes, thereby contributing to stagnation effects (Ganong and Shoag, 2017; Notowidigdo, 2020; Bilal and Rossi-Hansberg, 2021).

7 Conclusion

This study enriches the growing body of literature on the socioeconomic impacts of energy transitions, specifically examining the effects of fossil fuel power plant retirements (Carley et al., 2018; Houser et al., 2017; Komisarow and Pakhtigian, 2022; Blonz et al., 2023; Acemoglu et al., 2023). It builds upon prior research by systematically investigating the influence of these retirements on local migration, employment, and community dynamics, with an emphasis on environmental justice issues (Depro et al., 2015; Banzhaf et al., 2019).

My findings reveal a complex dynamic between environmental enhancements and socioeconomic challenges following plant closures. The identified 'stagnation effect', marked by decreased in-migration and out-migration, challenges the conventional narrative of environmental gentrification and underscores the nuanced impacts of such economic disruptions on local communities (Vigdor et al., 2002; Sieg et al., 2004; Banzhaf and McCormick, 2012; Gamper-Rabindran and Timmins, 2011; Binner and Day, 2018; Glaeser et al., 2018). This stagnation implies that despite environmental quality improvements, the economic void left by job losses can hinder community dynamism and lead to socioeconomic stagnation.

Significantly, the effects are disproportionately experienced in lower-income and predominantly Black communities, raising substantial environmental justice concerns during the energy transition (Carley and Konisky, 2020). These communities bear not only the initial negative externalities of power plants but also the economic fallout of their closures. Hence, our study highlights the necessity for targeted policies addressing both the environmental and economic aspects of plant retirements.

The policy implications of this research are clear-cut. Effective transition strategies must be comprehensive, incorporating job retraining programs, economic aid, and investment in renewable energy sectors to alleviate the adverse effects on impacted workers and ensure equitable outcomes (Haggerty et al., 2018; Hanson, 2023). It is crucial to engage with local communities, listen to their perceptions, and understand their specific needs to develop targeted and effective policies. This approach ensures that the transition strategies align with the unique challenges and aspirations of each affected community. Moreover, policies should also consider enhancing mobility aids for affected populations to seek employment opportunities elsewhere without encountering prohibitive costs or barriers (Notowidigdo, 2020; Bilal and Rossi-Hansberg, 2021).

This research contributes to a more comprehensive understanding of the economic and policy dimensions of energy transitions, advocating for a balanced approach that considers environmental benefits alongside the economic and social needs of vulnerable populations. Future research should persist in exploring the long-term effects of these transitions, examining regional adaptations and potential policy interventions that could further mitigate the impacts on affected communities.

References

Abas, N., A. Kalair, and N. Khan (2015). Review of fossil fuels and future energy technologies. *Futures 69*, 31–49.

Acemoglu, D., P. Aghion, L. Barrage, and D. Hémous (2023). Climate change, directed innovation, and energy transition: The long-run consequences of the shale gas revolution. Technical report, NBER Working Paper.

Bank, W. (2022). State and trends of carbon pricing 2022. *State and Trends of Carbon Pricing;. © Washington, DC: World Bank.*

Banzhaf, H. and E. McCormick (2012). Moving beyond cleanup. *The Political Economy of Environmental Justice*, 23–51.

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

Banzhaf, H. S. and R. P. Walsh (2008). Do people vote with their feet? an empirical test of tiebout. *American Economic Review 98*(3), 843–63.

Bertrand, M. and S. Mullainathan (2004). Are emily and greg more employable than lakisha and jamal? a field experiment on labor market discrimination. *American Economic Review 94*(4), 991–1013.

Bilal, A. and E. Rossi-Hansberg (2021). Location as an asset. *Econometrica 89*(5), 2459–2495.

Binner, A. and B. Day (2018). How property markets determine welfare outcomes: an equilibrium sorting model analysis of local environmental interventions. *Environmental and Resource Economics 69*(4), 733–761.

Blanchard, O. J. and L. Katz (1992). Regional evolutions. *Brookings Papers on Economic Activity, pp. I-75*.

Blonz, J., B. R. Tran, and E. E. Troland (2023). The canary in the coal decline: Appalachian household finance and the transition from fossil fuels. Technical report, NBER Working Paper.

BNEF (2020). New energy outlook 2020. *Bloomberg New Energy Finance (BNEF).*

Borusyak, K., X. Jaravel, and J. Spiess (2024). Revisiting event-study designs: robust and efficient estimation. *Review of Economic Studies*, rdae007.

Burney, J. A. (2020). The downstream air pollution impacts of the transition from coal to natural gas in the united states. *Nature Sustainability 3*(2), 152–160.

Callaway, B. and P. H. Sant'Anna (2021). Difference-in-differences with multiple time periods. *Journal of Econometrics 225*(2), 200–230.

Carley, S., T. P. Evans, and D. M. Konisky (2018). Adaptation, culture, and the energy transition in american coal country. *Energy Research & Social Science 37*, 133–139.

Carley, S. and D. M. Konisky (2020). The justice and equity implications of the clean energy transition. *Nature Energy 5*(8), 569–577.

Chan, H. R. and C. Zhou (2023). Charged up? distributional impacts of green energy on local labor markets. *Working Paper*.

Chatzimouratidis, A. I. and P. A. Pilavachi (2008). Multicriteria evaluation of power plants impact on the living standard using the analytic hierarchy process. *Energy policy 36*(3), 1074–1089.

Chay, K. Y. and M. Greenstone (2005). Does air quality matter? evidence from the housing market. *Journal of Political Economy 113*(2), 376–424.

Christiadi, Bowen, E., J. Deskins, et al. (2021). The economic impact of coal and coal-fired power generation in west virginia. *NBER Working Paper.*.

Clark, T. E. (1998). Employment fluctuations in us regions and industries: The roles of national, region-specific, and industry-specific shocks. *Journal of Labor Economics 16*(1), 202–229.

Clarke, D. and K. Tapia-Schythe (2021). Implementing the panel event study. *The Stata Journal 21*(4), 853–884.

Close, B. and D. J. Phaneuf (2017). Valuation of local public goods: migration as revealed preference for place. In *Environment Economics Seminar (Toulouse School of Economics)*, Volume 15.

Cohen, J. (2013). *Statistical Power Analysis for the Behavioral Sciences.* Routledge.

Creutzig, F., J. Roy, W. F. Lamb, I. M. Azevedo, W. Bruine de Bruin, H. Dalkmann, O. Y.

Edelenbosch, F. W. Geels, A. Grubler, C. Hepburn, et al. (2018). Towards demand-side solutions for mitigating climate change. *Nature Climate Change 8*(4), 260–263.

Cullen, J. A. and E. T. Mansur (2017). Inferring carbon abatement costs in electricity markets: A revealed preference approach using the shale revolution. *American Economic Journal: Economic Policy 9*(3), 106–133.

Currie, J., L. Davis, M. Greenstone, and R. Walker (2015). Environmental health risks and housing values: evidence from 1,600 toxic plant openings and closings. *American Economic Review 105*(2), 678–709.

Curtis, E. M., L. O'Kane, and R. J. Park (2024). Workers and the green-energy transition: Evidence from 300 million job transitions. *Environmental and Energy Policy and the Economy 5*(1), 127–161.

Davis, L. W. (2011). The effect of power plants on local housing values and rents. *Review of Economics and Statistics 93*(4), 1391–1402.

Davis, R. J., J. S. Holladay, and C. Sims (2022). Coal-fired power plant retirements in the united states. *Environmental and Energy Policy and the Economy 3*(1), 4–36.

De Chaisemartin, C. and X. d'Haultfoeuille (2020). Two-way fixed effects estimators with heterogeneous treatment effects. *American Economic Review 110*(9), 2964–2996.

De Silva, D. G., A. R. Schiller, A. Slechten, and L. Wolk (2022). Tiebout sorting and toxic releases. *Available at SSRN 3744226*.

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.

EIA (2022a). Annual energy outlook 2022 (aeo2022). *U.S. Energy Information Administration (EIA).*

EIA (2022b). Electricity explained: Electricity and the environment. *U.S. Energy Information Administration (EIA).*

EIA (2023). Coal and natural gas plants will account for 98 % of u.s. capacity retirements in 2023. *U.S. Energy Information Administration (EIA).*

Eldardiry, H. and E. Habib (2018). Carbon capture and sequestration in power generation:

review of impacts and opportunities for water sustainability. *Energy, Sustainability and Society 8*(1), 1–15.

EPA (2022). Power plants and neighboring communities. In *Washington, DC: Office of Atmospheric Programs, Clean Air Markets Division.*

EPA (2023). National ambient air quality standards. *U. S. Environmental Protection Agency (EPA).*

Fraenkel, R., J. S. G. Zivin, and S. D. Krumholz (2022). The coal transition and its implications for health and housing values. Technical report, NBER Working Paper.

Gamper-Rabindran, S. and C. Timmins (2011). Hazardous waste cleanup, neighborhood gentrification, and environmental justice: Evidence from restricted access census block data. *American Economic Review 101*(3), 620–24.

Ganong, P. and D. Shoag (2017). Why has regional income convergence in the us declined? *Journal of Urban Economics 102*, 76–90.

Glaeser, E. L. and J. Gyourko (2005). Urban decline and durable housing. *Journal of Political Economy 113*(2), 345–375.

Glaeser, E. L., H. Kim, and M. Luca (2018). Nowcasting gentrification: using yelp data to quantify neighborhood change. In *AEA Papers and Proceedings*, Volume 108, pp. 77–82.

Haggerty, J. H., M. N. Haggerty, K. Roemer, and J. Rose (2018). Planning for the local impacts of coal facility closure: Emerging strategies in the us west. *Resources Policy 57*, 69–80.

Hanson, G. H. (2023). Local labor market impacts of the energy transition: Prospects and policies. Technical report, NBER Working Paper.

Heblich, S., A. Trew, and Y. Zylberberg (2021). East-side story: Historical pollution and persistent neighborhood sorting. *Journal of Political Economy 129*(5), 1508–1552.

Holland, S. P., E. T. Mansur, N. Z. Muller, and A. J. Yates (2020). Decompositions and policy consequences of an extraordinary decline in air pollution from electricity generation. *American Economic Journal: Economic Policy 12*(4), 244–274.

Hondo, H. and Y. Moriizumi (2017). Employment creation potential of renewable power generation technologies: A life cycle approach. *Renewable and Sustainable Energy Reviews 79*, 128–136.

Houser, T., J. Bordoff, and P. Marsters (2017). Can coal make a comeback? center on global energy policy.

Iacus, S. M., G. King, and G. Porro (2012). Causal inference without balance checking: Coarsened exact matching. *Political Analysis 20*(1), 1–24.

IEA (2020). World energy outlook 2020. *International Energy Agency (IEA).*

IEA (2022). World energy outlook 2022. *International Energy Agency (IEA).*

IRENA, R. E. S. (2020). The international renewable energy agency, abu dhabi. *Renewable Power Generation Costs in 2019*.

Kiel, K. A. and M. Williams (2007). The impact of superfund sites on local property values: Are all sites the same? *Journal of Urban Economics 61*(1), 170–192.

Kim, B. (2019). Do air quality alerts affect household migration? *Southern Economic Journal 85*(3), 766–795.

Kober, T., H.-W. Schiffer, M. Densing, and E. Panos (2020). Global energy perspectives to 2060–wec's world energy scenarios 2019. *Energy Strategy Reviews 31*, 100523.

Komisarow, S. and E. L. Pakhtigian (2021). The effect of coal-fired power plant closures on emergency department visits for asthma-related conditions among 0-to 4-year-old children in chicago, 2009–2017. *American Journal of Public Health 111*(5), 881–889.

Komisarow, S. and E. L. Pakhtigian (2022). Are power plant closures a breath of fresh air? local air quality and school absences. *Journal of Environmental Economics and Management 112*, 102569.

Lazard (2021). Lazard's levelized cost of energy analysis—version 15.0. *Lazard: New York, NY, USA 20.*

Lindgren, S. (2021). Noisy neighborhood but nice house? pollution and the choice of residential location and housing quality. *Land Economics 97*(4), 781–796.

Luechinger, S. (2009). Valuing air quality using the life satisfaction approach. *The Economic Journal 119*(536), 482–515.

Maupin, M. A., J. F. Kenny, S. S. Hutson, J. K. Lovelace, N. L. Barber, and K. S. Linsey (2014). Estimated use of water in the united states in 2010.

Mauritzen, J. (2020). Will the locals benefit?: The effect of wind power investments on rural wages. *Energy policy 142*, 111489.

Molloy, R., C. L. Smith, and A. Wozniak (2011). Internal migration in the united states. *Journal of Economic Perspectives 25*(3), 173–196.

Molloy, R., C. L. Smith, and A. Wozniak (2017). Job changing and the decline in long-distance migration in the united states. *Demography 54*(2), 631–653.

Molloy, R., C. L. Smith, and A. K. Wozniak (2014). Declining migration within the us: The role of the labor market. Technical report, NBER Working Paper.

Muehlenbachs, L., E. Spiller, and C. Timmins (2015). The housing market impacts of shale gas development. *American Economic Review 105*(12), 3633–3659.

Newell, R., D. Raimi, S. Villanueva, B. Prest, et al. (2020). Global energy outlook 2020: energy transition or energy addition. *Resources for the Future*.

Nickerson, N. H., R. A. Dobberteen, and N. M. Jarman (1989). Effects of power-line construction on wetland vegetation in massachusetts, usa. *Environmental Management 13*, 477–483.

Notowidigdo, M. J. (2020). The incidence of local labor demand shocks. *Journal of Labor Economics 38*(3), 687–725.

Pachauri, R. K., M. R. Allen, V. R. Barros, J. Broome, W. Cramer, R. Christ, J. A. Church, L. Clarke, Q. Dahe, P. Dasgupta, et al. (2014). *Climate change 2014: synthesis report. Contribution of Working Groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change*. IPCC.

Ramani, A. and N. Bloom (2021). The donut effect of covid-19 on cities. Technical report, NBER Working Paper.

REN21, P. (2022). Renewables 2022 global status report. *Renewable Energy Policy Network for the 21st Century (REN21)*.

Research, B., NASEO, and EFI (2020). Wages, benefits, and change: A supplemental report to the annual u.s. energy and employment report. pp. 132.

Roth, J., P. H. Sant'Anna, A. Bilinski, and J. Poe (2023). What's trending in difference-in-differences? a synthesis of the recent econometrics literature. *Journal of Econometrics*.

Sieg, H., V. K. Smith, H. S. Banzhaf, and R. Walsh (2004). Estimating the general equilibrium benefits of large changes in spatially delineated public goods. *International Economic Review 45*(4), 1047–1077.

Tong, S. T. and W. Chen (2002). Modeling the relationship between land use and surface water quality. *Journal of Environmental Management 66*(4), 377–393.

USEER (2019). The 2019 u.s. energy and employment report.

Vigdor, J. L., D. S. Massey, and A. M. Rivlin (2002). Does gentrification harm the poor?[with comments]. *Brookings-Wharton Papers on Urban Affairs*, 133–182.

Appendix: Figures and Tables

Table A1: Data Sources Summary

	Spatial Unit	Time Range	Frequency
USPS Change-of-address(COA) Data	zip level	2018-2022	monthly
HUD-USPS Data On Address Vacancies	Census Tract	2018-2022	quarterly
Monthly Electric Generator Inventory (EIA-860M)	zip level	2018-2022	monthly
2018 TIGER/Line Shapefiles	zip level	2018	yearly
IRS Migration Data	county level	2013-2020	yearly
EIA-860/923	county level	2013-2020	yearly
ACS 5-year Data	zip/county level	2012-2021	yearly
Zillow Home Value Index (ZHVI)	zip level	2018-2022	monthly
Quarterly Census of Employment and Wages (QCEW)	county level	2013-2020	quarterly

Notes: This table summarizes the key data sources used in the analysis. There are three main categories: (1) Migration data from USPS (July 2018 - Dec 2022) and IRS (2013-2020) to track move-in and move-out, (2) Power plant data from EIA surveys (2013-2022) to identify retirements, capacity, and emissions, (3) Local community data from ACS (2012, 2017), Zillow (2018-2022), and QCEW (2013-2020) on demographics, housing, and employment to consider local impacts. These datasets are aggregated to quarterly-zip and annual-county frequencies to enable examination of both short and long-run effects of plant retirements across various outcomes.

Table A2: Summary Statistics on zip Code Level, 2018-2022

	Treated Group		Control Groups		
	Pre-treated	Post-treated	Not Yet Treated	Never Treated	No Power Plants
Move in	466	385	485	328	199
	(447)	(407)	(460)	(401)	(333)
Move out	513	414	537	343	209
	(499)	(444)	(532)	(428)	(364)
Net Inflow	-47	-29	-53	-15	-10
	(111)	(98)	(142)	(117)	(82)
Capacity (MW)	256	-	676	187	-
	(538)		(1,046)	(487)	
CO_2 Emission (Tons)	339,636	-	1,222,421	311,407	-
	(1,617,909)		(9,225,729)	(2,063,687)	
SO_2 Emission (Tons)	521	-	1,286	384	-
	(4,297)		(11,464)	(5,084)	
NO_x Emission (Tons)	536	-	1,544	461	-
	(2,249)		(7,055)	(2,152)	
Total zip codes	129	129	764	5,678	24,846
N	1,025	1,375	12,899	101,016	447,228

Notes: The table provides a summary of migration patterns, generator capacity, and emissions at the zip code level from the third quarter of 2018 through the fourth quarter of 2022. The migration patterns are averaged on a quarterly basis and are derived from monthly data sets. The capacity and emissions figures represent average annual metrics from the Environmental Protection Agency for individual generators, which are then aggregated up to the zip code level. The sample includes over 30,000 zip code areas.

Table A3: Summary Statistics for County Characteristics

	Mean Treated	Mean Control	p-value	SMD
Median Household Income	45,646.73	46,840.10	0.013	0.100
Gini Coefficient	0.43	0.43	0.004	0.117
Total Housing Units	42,557.98	35,086.72	0.135	0.060
Average Household Size	2.52	2.55	0.001	0.135
Median Age	40.39	40.15	0.246	0.046
Total Population	99,903.88	82,334.53	0.170	0.055
White Population Ratio	0.84	0.86	0.001	0.133
Capacity (MW)	472.60	655.29	0.000	0.197
Total Generators	7.40	9.11	0.012	0.101
Counties	87	1,744		
Observations	633	23,157		

Notes: This table presents county-level pre-treatment characteristics using 2012 ACS 5-year estimates. It compares means between treated counties containing fossil fuel plant retirements and control counties, with p-values testing differences in means. Standardized mean differences (SMD) are calculated as the difference in means between the two groups, normalized by the pooled standard deviation to assess balance. SMD absolute values below 0.1 or 0.2 indicate negligible differences between the treatment and control groups.

Table A4: Balance table of key covariates for Pre- and Post-Matching Sample

	Pre-Matching				Post-Matching			
	Mean Control	Mean Treated	p-value	SMD	Mean Control	Mean Treated	p-value	SMD
Median Household Income	57,700.97	55,017.14	0.000	0.121	50,674.32	54,942.73	0.000	0.233
Gini Coefficient	0.42	0.43	0.000	0.177	0.43	0.43	0.154	0.046
Total Housing Units	4,786.99	7,508.21	0.000	0.429	5,350.27	7,114.22	0.000	0.284
Occupied Housing Units	4,198.57	6,754.69	0.000	0.440	4,714.90	6,380.05	0.000	0.294
Median Housing Unit Value	195146.57	166498.68	0.000	0.195	138616.35	161999.77	0.000	0.228
Median Gross Rent	884.50	863.12	0.035	0.064	774.65	851.47	0.000	0.273
Total Population	11,331.94	18,527.82	0.000	0.443	12,504.32	17,358.28	0.000	0.313
Median Age	42.01	40.22	0.000	0.235	40.58	40.36	0.319	0.031
White Population Ratio	0.83	0.80	0.000	0.161	0.80	0.80	0.962	0.001
Capacity (MW)	49.56	275.23	0.000	0.481	381.45	282.82	0.000	0.148
Generator Lifespan	38.48	41.06	0.000	0.130	43.69	42.05	0.001	0.100
Number of Generators	1.00	4.84	0.000	0.927	5.02	4.43	0.000	0.169
Zip code areas	31295	126			284	123		
N	562027	1387			3533	1322		

Notes: The table presents the balance achieved for key covariates before and after matching. The post-matching results depict well-balanced groups. Balance assessment was conducted using both mean differences p-values and Standardized Mean Differences (SMD). SMD values below 0.1 or 0.2 typically signify minimal differences between groups. Most variables register values below or close to 0.2, indicating a sufficient balance between the treatment and control groups after matching.

Table A5: Full Retirement and Migration: Heterogeneity by zip Characteristics

(a) Full Retirement and Move In

	(1)	(2)	(3)	(4)
Fossil Fuel Full Retirement	25.1*	-32.2***	-31.4***	15.6
	(13.0)	(7.8)	(9.1)	(13.6)
Retirement × $1_{\geq \text{median}}$(White)	-0.4			-10.6
	(11.3)			(11.3)
Retirement × $1_{\geq \text{median}}$(Black)	-36.2***			-36.5***
	(9.5)			(9.7)
Retirement × $1_{\geq \text{median}}$(Hispanic)	-14.0			-16.7
	(11.2)			(11.2)
Retirement × $1_{\geq \text{median}}$(Native American)	-23.7**			-22.4**
	(10.0)			(10.2)
Retirement × $1_{\geq \text{median}}$(Age)		24.1**		15.5
		(10.5)		(10.2)
Retirement × $1_{\geq \text{median}}$(Household Income)			17.1	18.0*
			(11.0)	(10.3)
Outcome mean	229.5	229.5	229.5	229.5
Observations	554,892	554,892	554,892	554,892
Year-Quarter FE	✓	✓	✓	✓
Zip FE	✓	✓	✓	✓
County-quarter FE	✓	✓	✓	✓

(b) Full Retirement and Move Out

	(1)	(2)	(3)	(4)
Fossil Fuel Full Retirement	1.5	-42.3***	-48.1***	-14.8
	(17.9)	(8.5)	(9.8)	(18.1)
Retirement × $1_{\geq \text{median}}$(White)	13.9			2.7
	(13.8)			(13.2)
Retirement × $1_{\geq \text{median}}$(Black)	-38.4***			-38.5***
	(11.5)			(11.3)
Retirement × $1_{\geq \text{median}}$(Hispanic)	-9.6			-16.5
	(12.6)			(12.5)
Retirement × $1_{\geq \text{median}}$(Native American)	-10.5			-7.4
	(11.5)			(11.2)
Retirement × $1_{\geq \text{median}}$(Age)		28.8**		13.9
		(11.9)		(11.3)
Retirement × $1_{\geq \text{median}}$(Household Income)			34.8***	36.3***
			(11.9)	(11.0)
Outcome mean	241.7	241.7	241.7	241.7
Observations	554,892	554,892	554,892	554,892
Year-Quarter FE	✓	✓	✓	✓
Zip FE	✓	✓	✓	✓
County-quarter FE	✓	✓	✓	✓

Notes: This table presents a TWFE model interacting fossil fuel retirement and zip code demographics on migration. The model includes location and time fixed effects, clustering standard errors by zip code. Results show higher black populations share zip codes experience greater move-out stagnation. White and Hispanic shares display negligible differences. Above median income leads to increased move-outs, so lower-income areas exhibit declining out-migration. The interacted model confirms disproportionate move-out stagnation among higher black composition communities and economically disadvantaged groups following fossil fuel closure. Standard errors clustered at the zip code level. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Table A6: Fossil-Fuel Generators Retirement on Migration: County-Year Analysis

	Move In		Move Out		Net Inflow	
	(1)	(2)	(3)	(4)	(5)	(6)
Fossil Fuel Full Retirement	-63.5	-41.3	-148.5***	-87.9	84.9***	46.6
	(55.6)	(71.2)	(47.6)	(65.1)	(32.5)	(32.3)
Outcome mean	2,601	2,601	2,594	2,594	7	7
Observations	23,788	23,788	23,788	23,788	23,788	23,788
Year FE	✓	✓	✓	✓	✓	✓
County FE	✓	✓	✓	✓	✓	✓
State-Year FE		✓		✓		✓

Notes: This table presents county-level TWFE estimates of the effects of fossil fuel plant retirement on annual migration flows using IRS data from 2013-2020. The outcome variables are move-ins, move-outs, and net moves. Columns 1, 3, and 5 exclude state-year fixed effects; they show declining move-ins, significant move-out reductions, and significant net inflow increases after retirement. Columns 2, 4, and 6 include state-year fixed effects and exhibit decreasing but insignificant trends for in-, out-, and net migration. While effect sizes vary by specification, the overall pattern of reduced migration dynamism post-retirement is consistent. Analyzing both short- and long-run effects at the zip code and county levels underscores the stagnation of local mobility following plant closure, though effect sizes depend on model details. Multi-faceted analysis provides a comprehensive understanding of community impacts.

Table A7: Impact of Fossil-Fuel Generator Retirement on Migration: Power Plant Buffers

	Baseline			Coarsened Exact Matching (CEM)		
	(1) Move In	(2) Move Out	(3) Net Inflow	(4) Move In	(5) Move Out	(6) Net Inflow
Full retirement of Fossil fuel	-44.234***	-34.452***	9.782	-28.229**	-27.096***	1.133
	(8.370)	(8.355)	(6.387)	(11.036)	(10.241)	(10.152)
Constant	245.028***	232.864***	-12.164***	470.426***	418.211***	-52.215***
	(0.013)	(0.013)	(0.010)	(2.088)	(1.938)	(1.921)
Observations	556672	556672	556672	4016	4016	4016
Quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Zip fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
County-quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents estimates using a 2-mile radius buffer to define fossil fuel plant retirement treatment areas in two-way fixed effects models. The sample includes the full dataset and a matched subset. The outcome variables are quarterly move-ins, move-outs, and net moves per zip code. The results display a similar pattern of increasing migration stagnation following full generator retirement compared to the main estimates. The larger magnitude of effects likely reflects the expanded geographic treatment area under the buffer approach versus the zip code-level analysis.

Table A8: Impact of Fossil-Fuel Generator Retirement on Migration: Smallest Centroids Buffer

	Baseline			Coarsened Exact Matching (CEM)		
	(1) Move In	(2) Move Out	(3) Net Inflow	(4) Move In	(5) Move Out	(6) Net Inflow
Full retirement of Fossil fuel	-35.891***	-21.977**	13.914**	-23.625**	-16.961	6.663
	(9.741)	(8.701)	(6.904)	(11.578)	(10.739)	(8.323)
Constant	255.415***	242.225***	-13.190***	339.077***	304.892***	-34.186***
	(0.050)	(0.045)	(0.036)	(1.536)	(1.425)	(1.104)
Observations	543096	543096	543096	12834	12834	12834
Quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Zip fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
County-quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents estimates using the smallest radius fossil fuel plant buffer around zip code population-weighted centroids to define treatment. The two-way fixed effects models are run on the full and matched samples. The outcome variables are quarterly move-ins, move-outs, and net moves per zip code. The results display a similar pattern of increasing migration stagnation following full retirement of fossil-fuel generators within these localized plant buffers. The smaller magnitude of effects represents a lower bound estimate, as only the closest generators are considered treated.

Table A9: Impact of Fossil-Fuel Generator Retirement on Migration: Percentage COA

(a) Baseline Results

	Baseline			Coarsened Exact Matching (CEM)		
	(1) Move In	(2) Move Out	(3) Net Inflow	(4) Move In	(5) Move Out	(6) Net Inflow
Fossil Fuel Full Retirement	-0.007***	-0.008***	0.006	-0.007**	-0.006**	0.014
	(0.003)	(0.003)	(0.006)	(0.003)	(0.003)	(0.015)
Outcome mean	0.086	0.088	-0.003	0.086	0.088	-0.003
Observations	551,313	550,870	554,689	4,792	4,784	4,826
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Zip FE	✓	✓	✓	✓	✓	✓
County-quarter FE	✓	✓	✓	✓	✓	✓

(b) IV Results

	Baseline			Coarsened Exact Matching (CEM)		
	(1) Move In	(2) Move Out	(3) Net Inflow	(4) Move In	(5) Move Out	(6) Net Inflow
Fossil Fuel Full Retirement	-0.027**	-0.024**	-0.003	-0.012*	-0.010	-0.014
	(0.012)	(0.010)	(0.002)	(0.007)	(0.007)	(0.015)
Outcome mean	0.086	0.088	-0.003	0.086	0.088	-0.003
Observations	551,313	550,870	554,689	4,792	4,784	4,826
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Zip FE	✓	✓	✓	✓	✓	✓
County-quarter FE	✓	✓	✓	✓	✓	✓

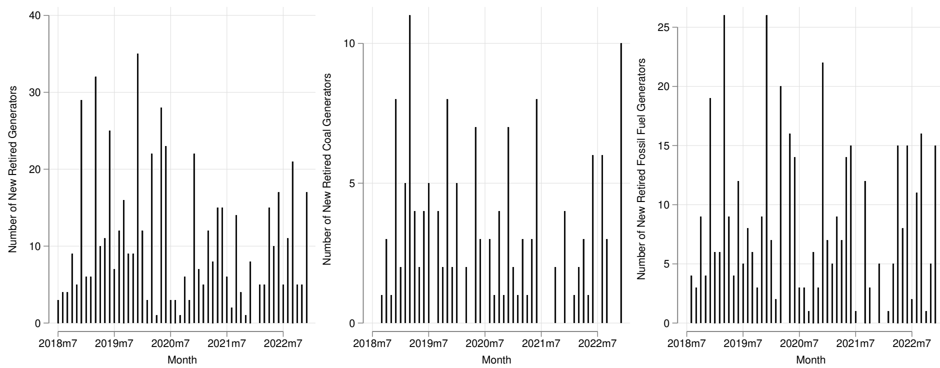
Notes: This table presents TWFE OLS (Panel A) and IV estimates (Panel B) using rate-based migration outcomes - the number of move-ins and move-outs per total addresses. The full and matched samples are analyzed. The results show significant declines in move-in rates following fossil fuel retirement, with the magnitude of 0.7% matching the range found using absolute migration flows. Move-out rates decrease 0.9-3% though insignificantly, potentially due to errors in constructing total address denominators. Nonetheless, the rate-based outcomes validate the core finding that full fossil fuel retirement stagnates local migration, reducing both inflow and outflow rates across specifications.

Table A10: The Effects of Fossil-fuel Generators on Housing Vluae

	(1)	(2)	(3)	(4)
Fossil Fuel Full Retirement	-0.011	-0.030***	-0.001	0.004
	(0.023)	(0.008)	(0.011)	(0.024)
Retirement $\times$ $1_{\geq \text{median}}$(white)	-0.007			-0.019
	(0.016)			(0.016)
Retirement $\times$ $1_{\geq \text{median}}$(black)	-0.028			-0.028*
	(0.018)			(0.017)
Retirement $\times$ $1_{\geq \text{median}}$(hispanic)	0.012			0.027*
	(0.016)			(0.015)
Retirement $\times$ $1_{\geq \text{median}}$(Native American)	0.003			-0.004
	(0.015)			(0.013)
Retirement $\times$ $1_{\geq \text{median}}$(Age)		0.018		0.031**
		(0.015)		(0.013)
Retirement $\times$ $1_{\geq \text{median}}$(Household Income)			-0.047***	-0.051***
			(0.013)	(0.012)
Outcome mean	12.2	12.2	12.2	12.2
Observations	429,836	429,836	429,836	429,836
Year-Quarter FE	✓	✓	✓	✓
Zip FE	✓	✓	✓	✓
County-quarter FE	✓	✓	✓	✓

Notes: This table presents heterogeneity analysis examining housing value changes after fossil fuel plant retirement across demographic groups. This model includes zip, year-quarter, and county-year fixed effects. Standard errors are clustered at the zip code level. The results show larger housing value declines for above median income zip codes versus below median, and for higher Black population share areas versus lower. Estimates in columns 3, 4, and 6 indicate stronger negative retirement effects on housing prices in high-income and high-Black composition zip codes. The joint model also reveals a marginally significant increase for high Hispanic share zip codes. Additionally, housing values rise in above median age zip codes, implying decreases in below median age areas.

Panel A. Generators New Retirements, 2018-2022



Panel B. Generators Full Retirements on Zip Code Level, 2002-2022

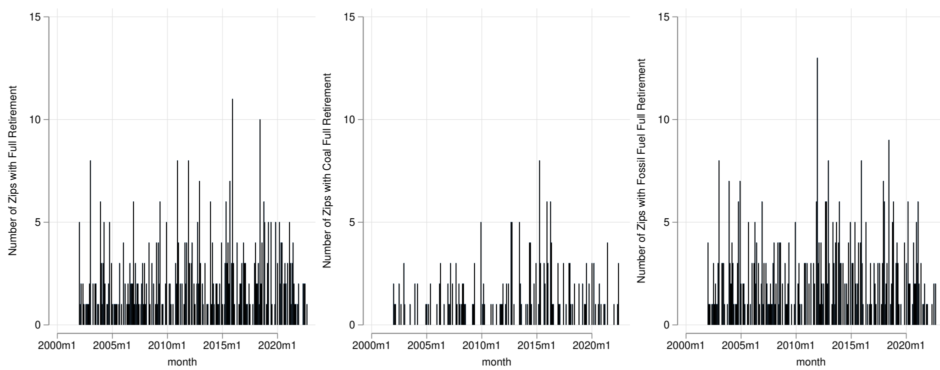
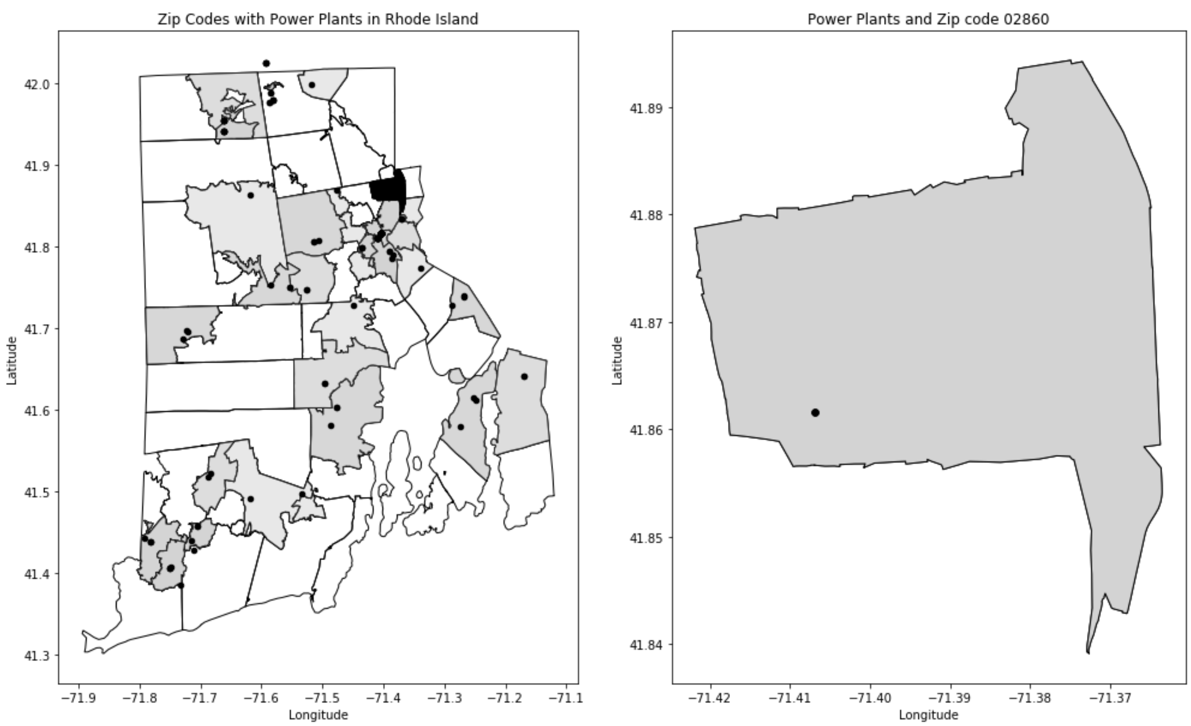


Figure A1: U.S. generators retirements

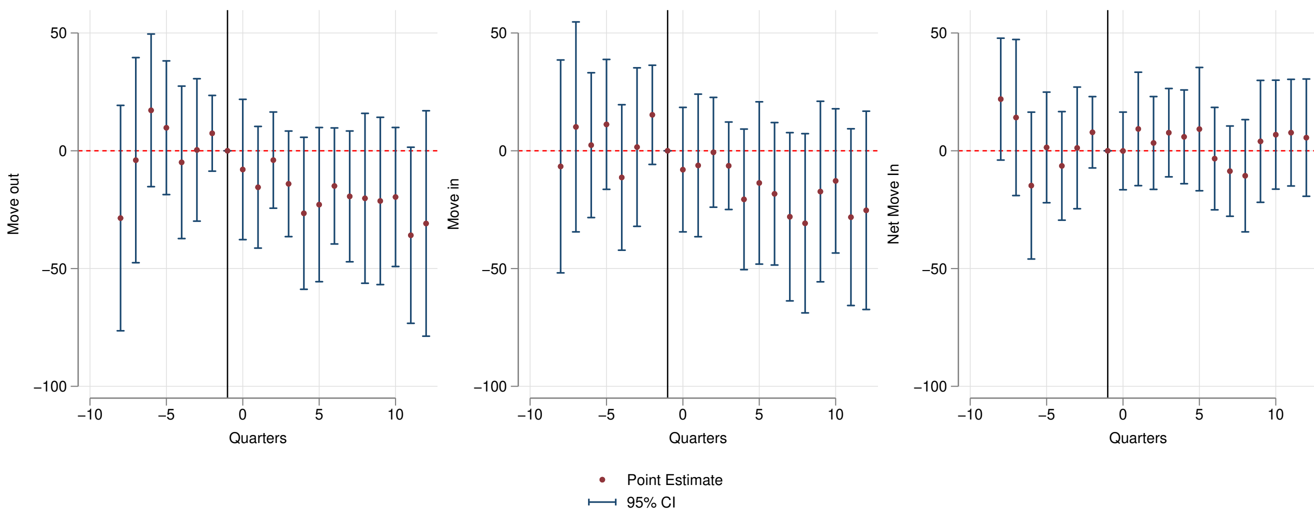
Notes: Each figure presents the scale of generator retirements across the United States, highlighting two aspects: Monthly new retirements (2018-2022), with a focus on all generators and a special emphasis on the majority of these retirements being attributed to fossil fuel sources, particularly coal; and the distribution of these retirements at the zip code level from 2002 to 2022, demonstrating a consistent, staggered pattern of complete retirement of fossil fuel generators across zip codes over time.

Figure A2: Example of Treatment Indicator for Power Plant Retirement



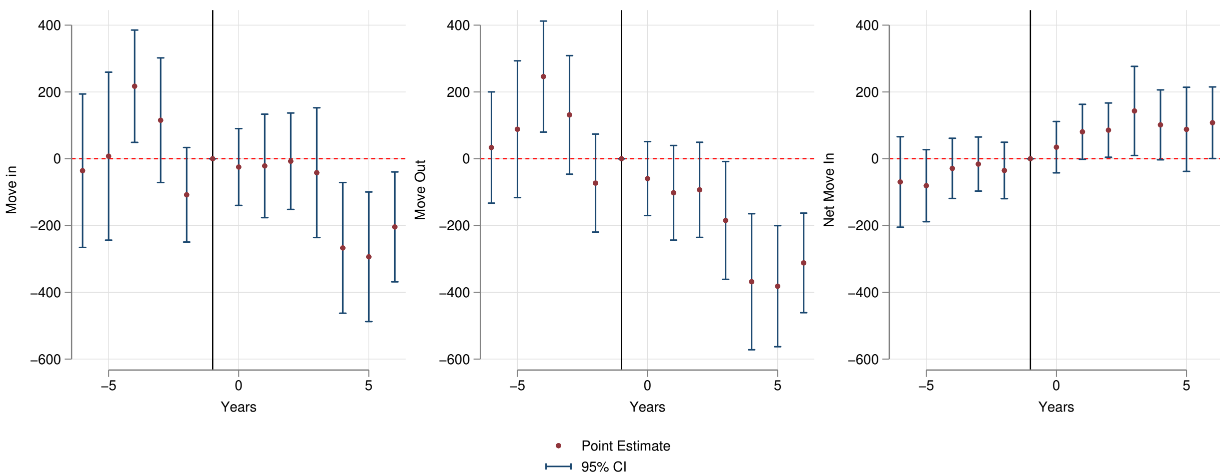
Notes: This figure provides an example of the treatment indicator used to identify zip codes experiencing full retirement of fossil-fuel generators. The left map shows Rhode Island with grey zip code areas containing power plants and the black zip code area indicating full fossil fuel retirement. The right map zooms in on the treated zip code 02860 with black dots denoting retired generators at a single power plant location. While two generators retired at this plant, their overlapping location shows as one dot. This treatment indicator is used to estimate the migration impacts of total fossil fuel retirements within a zip code.

Figure A3: Impact of Fossil-Fuel Generator Retirement on Migration: zip-Quarter Analysis with CEM



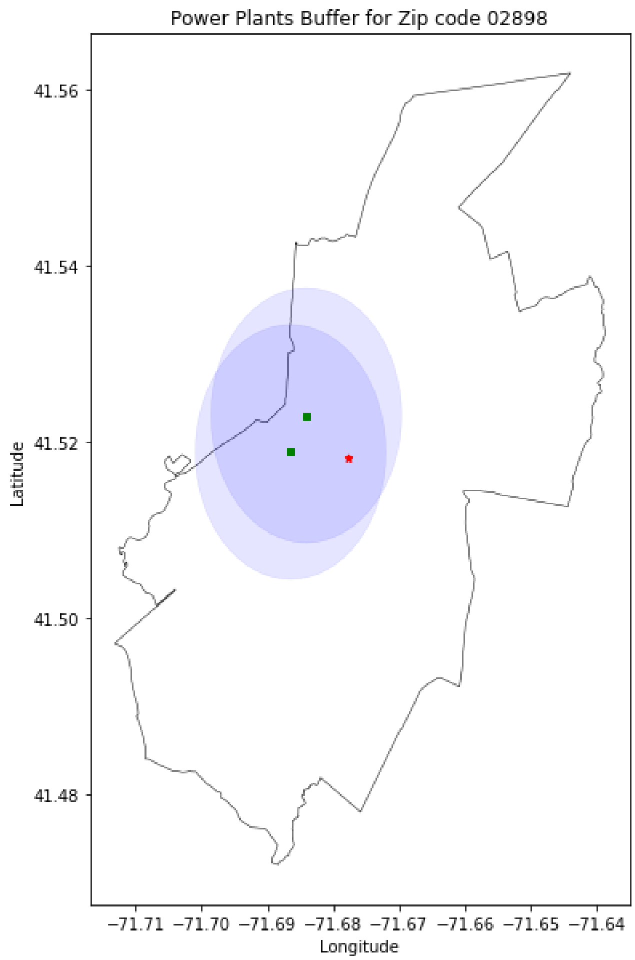
Notes: The figure shows panel event study estimates examining zip code-level migration surrounding fossil fuel retirements using post-matched data. Retirement year (0) is omitted as the reference. 95% confidence intervals are displayed. This model includes zip, year-quarter, and county-year fixed effects. Standard errors are clustered at the zip code level.

Figure A4: Impact of Fossil-Fuel Generator Retirement on Migration: County-Year Analysis



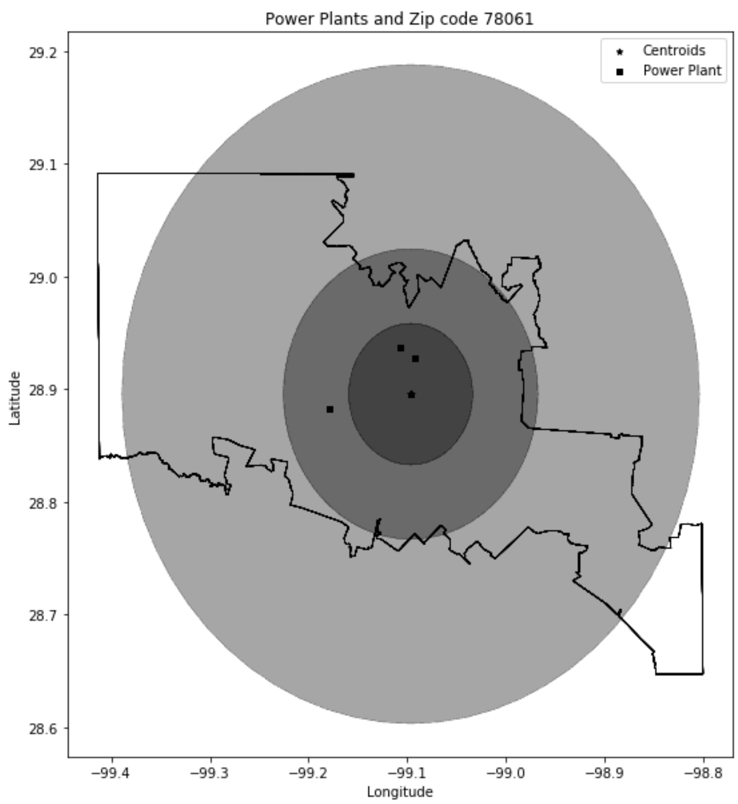
Notes: This table presents event study estimates examining county-level migration patterns surrounding fossil fuel plant retirements using IRS data from 2013-2020. The outcome variables are annual move-ins, move-outs, and net moves per county. The model includes county and year fixed effects, clustering standard errors by county. The results show that move-in and move-out trends decrease in the years after plant closure, while net inflows remain stable over time. This demonstrates the initial zip code-level stagnation effects observed in the short-run manifest more broadly at the county level long-term though different specifications on the panel event study.

Figure A5: Power Plants 2-Mile Buffer Example



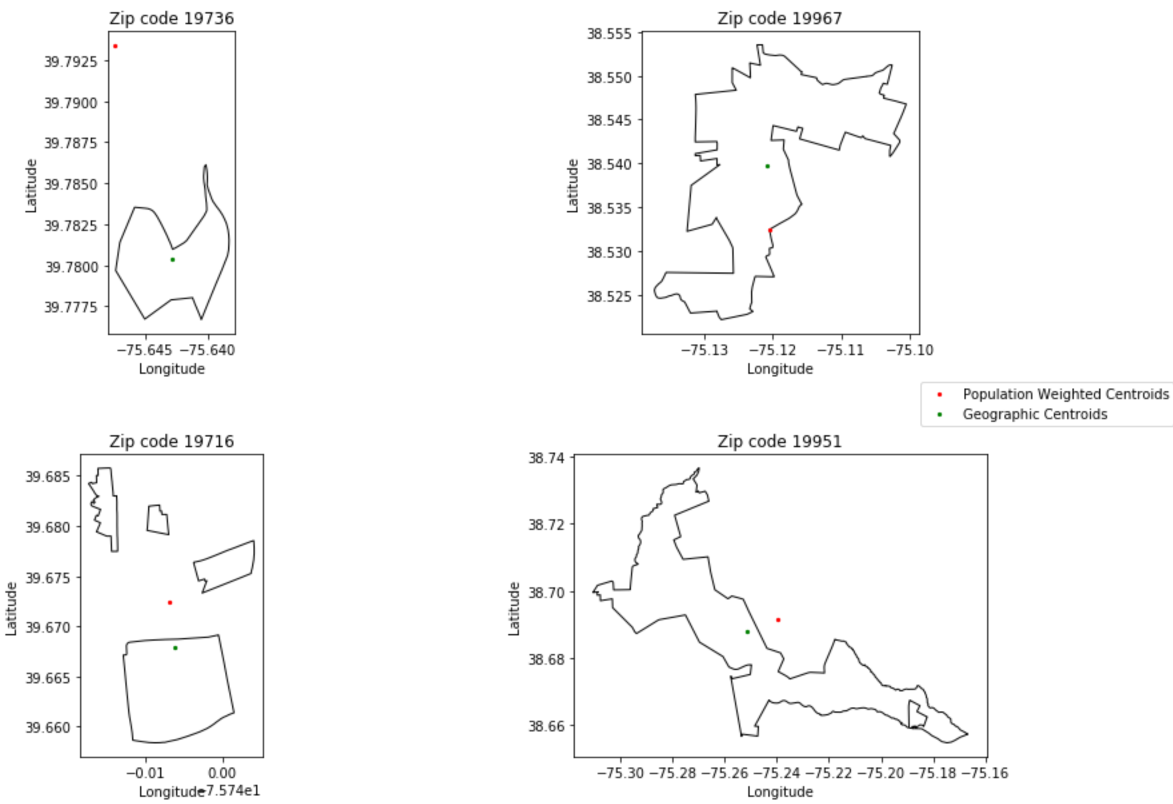
Notes: This figure displays a 2-mile radius buffer around fossil fuel power plants intersecting with zip code 02898, highlighted in red. The red dot indicates the population-weighted centroid of the zip code area. The green dots represent the locations of individual power plant generators, noting that a single power plant site may have multiple generators at the same coordinates. This visualizes the geographic distribution and proximity of fossil fuel plants near zip code 02898 used to construct the 2-mile exposure measure for the analysis. Proximity to power plants is examined as one potential mechanism influencing migration patterns following fossil fuel retirements. The population-weighted centroid ensures the buffer captures plant proximity relevant to where residents are concentrated within the zip code.

Figure A6: zip Code Centroid Buffer Example



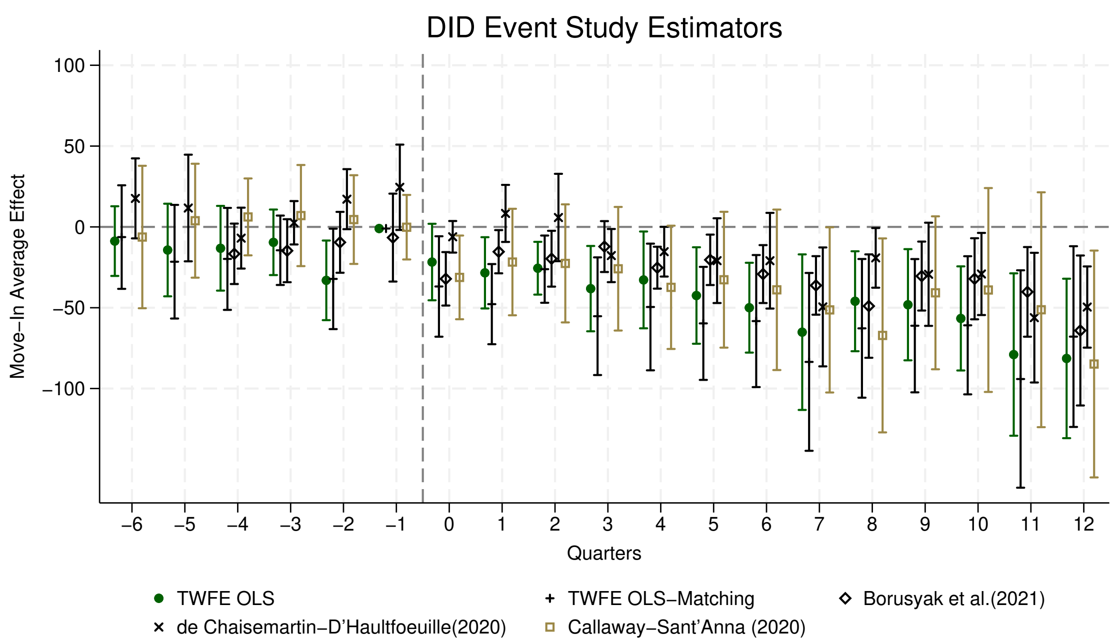
Notes: This figure displays graduated buffer zones around the population-weighted centroid (star) of zip code 78061 based on minimum, median, and maximum distance to the zip boundary. The innermost circle shows the smallest radius buffer, with fossil fuel plants (squares) inside this zone defined as treated. Multiple generators at one plant site overlap visually as one dot. The graduated buffer sizes represent lower bound (inner circle), median, and upper bound (outer circle) estimates of plant proximity effects. This demonstrates alternative geographic definitions of fossil fuel retirement exposure surrounding residential areas. The population-weighted centroid ensures the buffers reflect where residents are concentrated within the zip code.

Figure A7: zip Code Centroids Example



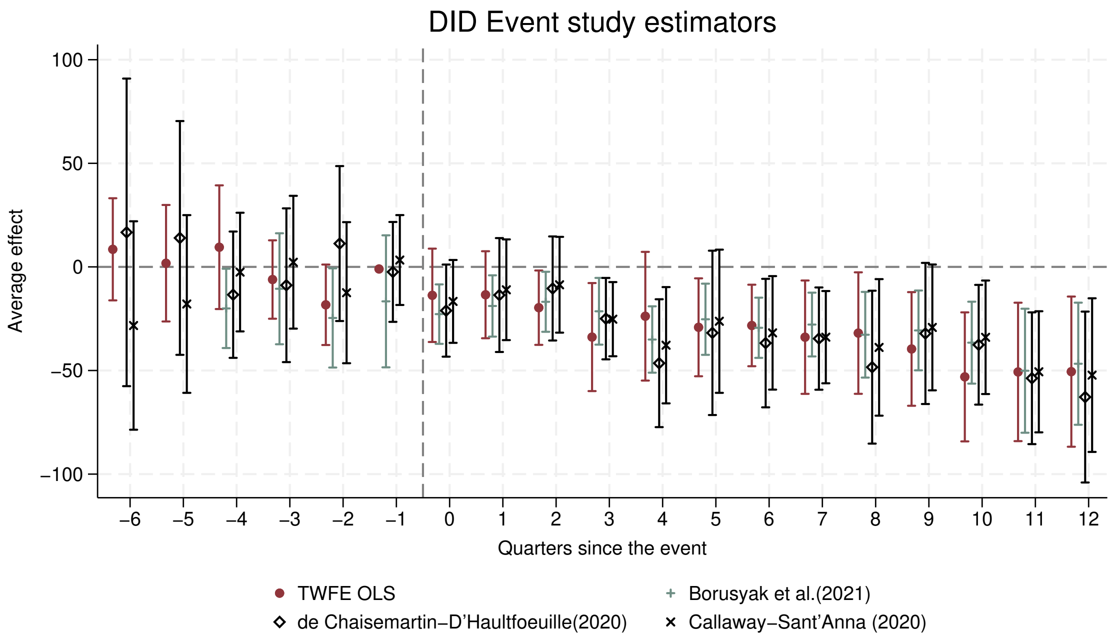
Notes: The figure shows zip code with the population-weighted centroids occasionally falling outside the zip code itself. This occurrence could be attributed to measurement errors or the unique shape of the zip code, which consequently limits the precision of centroid-based buffers.

Figure A8: Effects of Fossil-Fuel Generator Retirement on Move-In



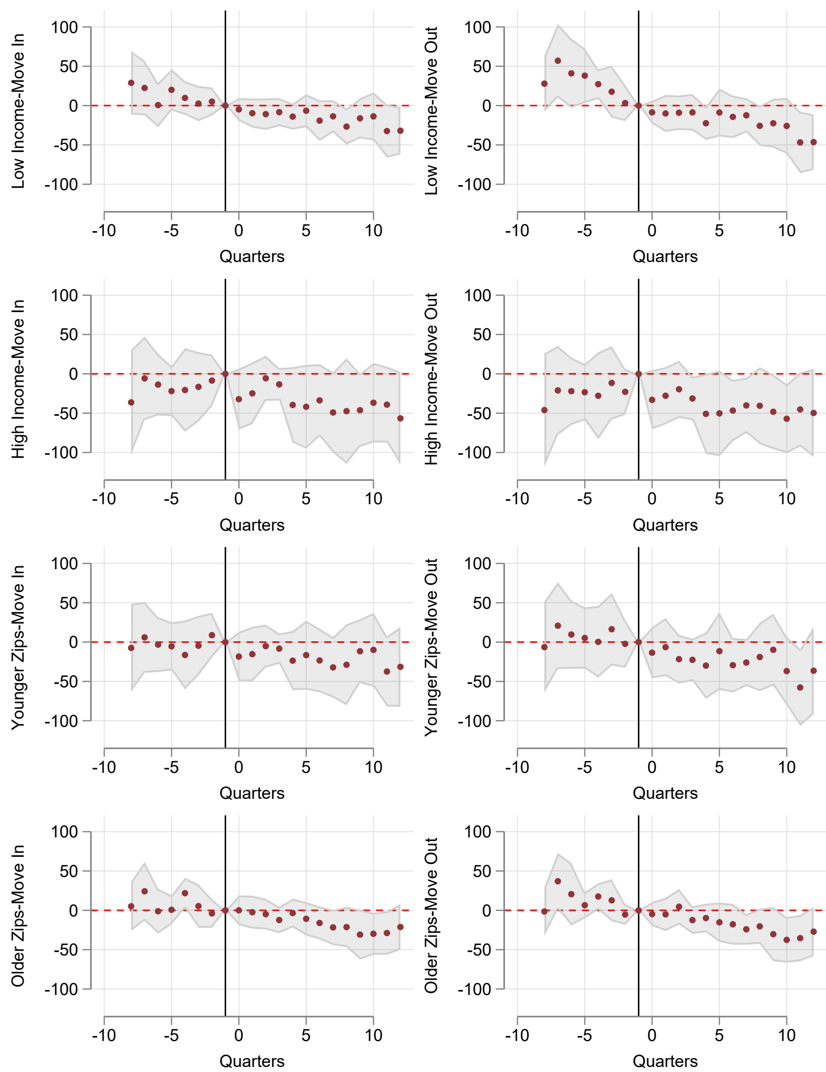
Notes: These figures present event study estimates of fossil fuel retirement effects on move-in migration using heterogeneous treatment timing robust estimators from recent literature alongside the two-way fixed effects (TWFE) OLS specification. This addresses potential issues with staggered adoption difference-in-differences designs. The robust approaches include methods proposed by De Chaisemartin and d'Haultfoeuille (2020); Borusyak et al. (2024); Callaway and Sant'Anna (2021). Across specifications, the results exhibit a consistent decreasing trend in both move-out following retirement.

Figure A9: Effects of Fossil-Fuel Generator Retirement on Move-Out



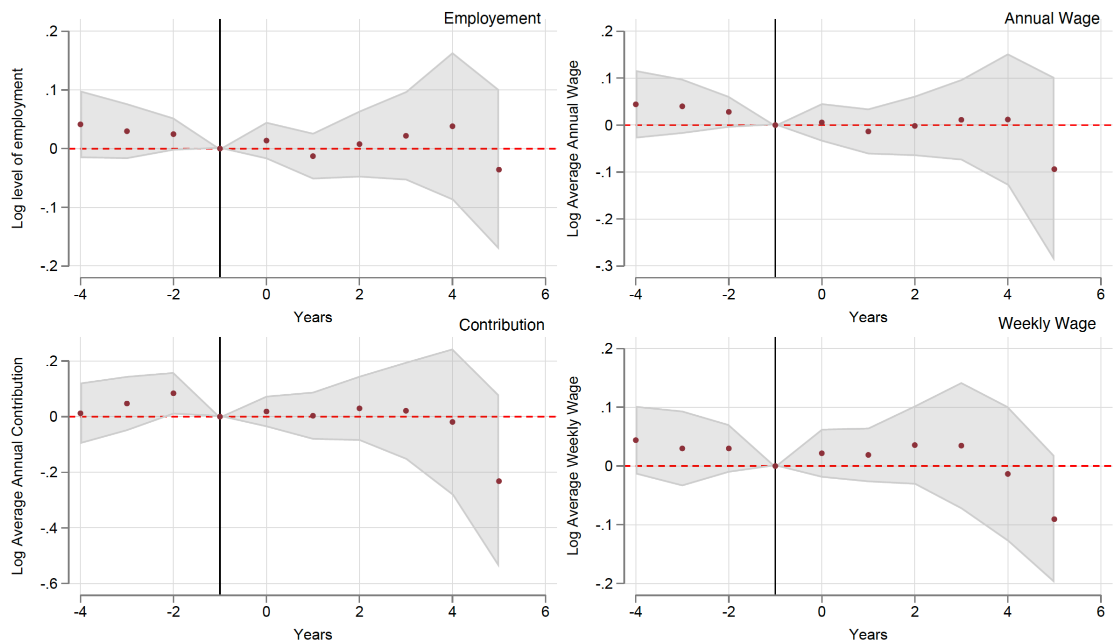
Notes: These figures present event study estimates of fossil fuel retirement effects on move-out migration using heterogeneous treatment timing robust estimators from recent literature alongside the two-way fixed effects (TWFE) OLS specification. This addresses potential issues with staggered adoption difference-in-differences designs. The robust approaches include methods proposed by De Chaisemartin and d'Haultfoeuille (2020); Borusyak et al. (2024); Callaway and Sant'Anna (2021). Across specifications, the results exhibit a consistent decreasing trend in move-out following retirement.

Figure A10: Heterogeneity Effects of Fossil-Fuel Generator Retirement on Migration



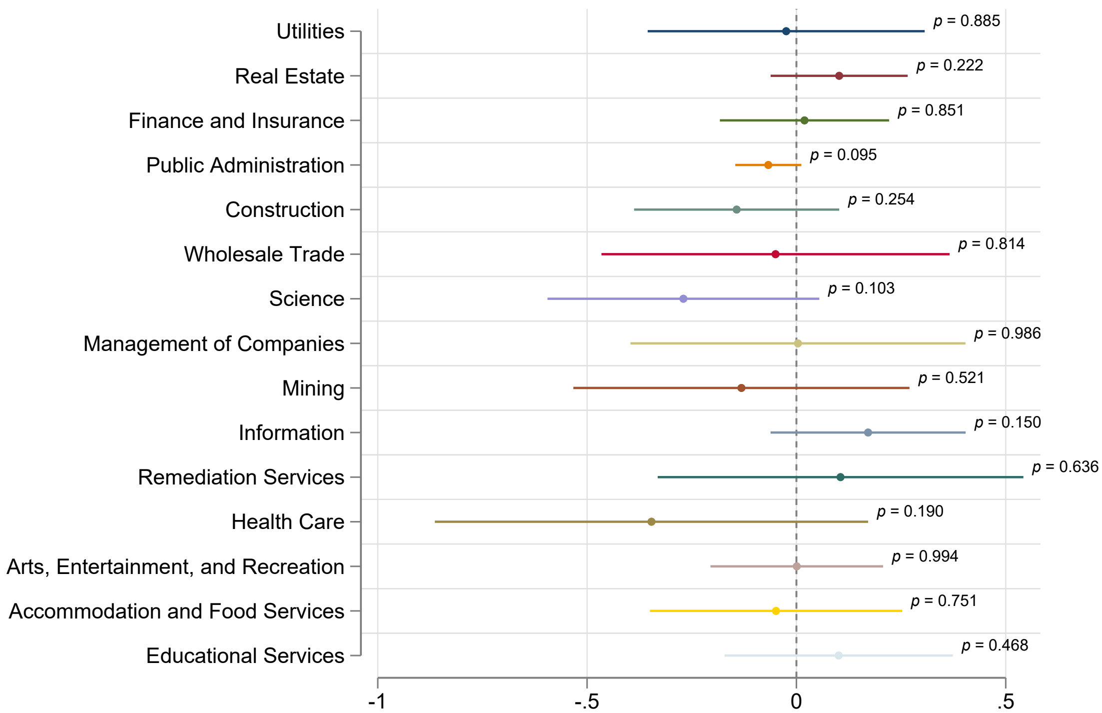
Notes: This event study examines heterogeneous migration effects of fossil fuel plant retirement across income and age groups over time. The results show more distinct stagnation patterns, with greater declines in both move-ins and move-outs, for lower-income zip codes relative to higher-income areas. Younger zip codes exhibit larger effects overall, with more pronounced migration stagnation emerging compared to older zip codes post-retirement.

Figure A11: Fossil-Fuel Generator Retirement and Employment Outcomes: County-Year Analysis



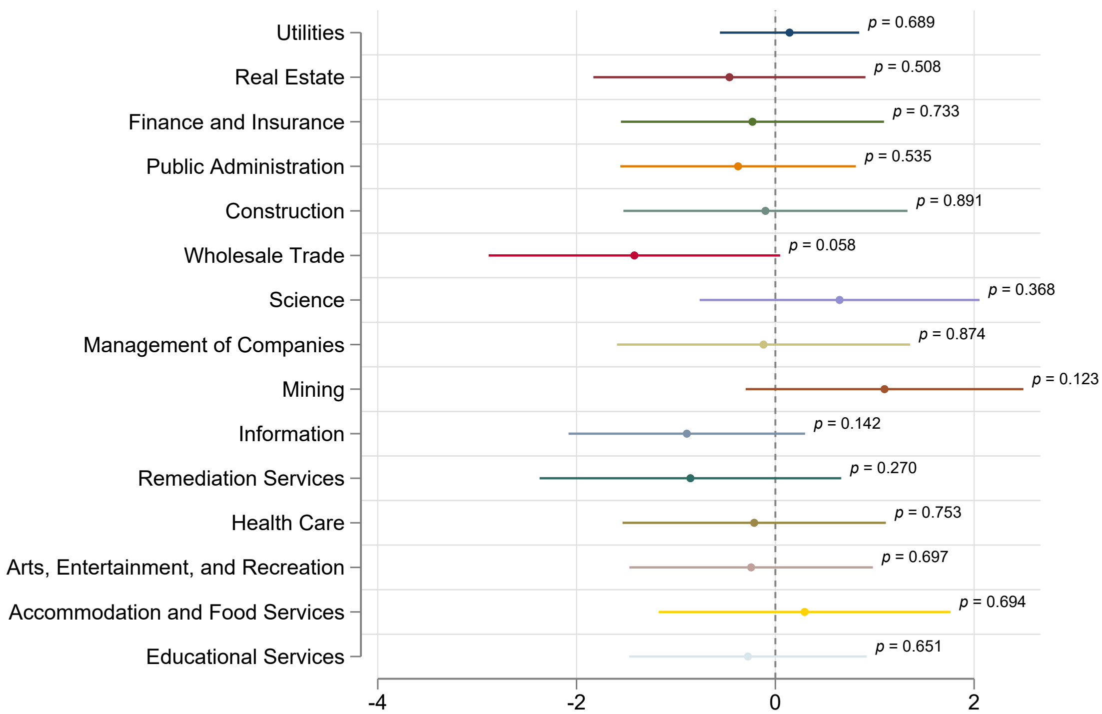
Notes: The figure shows panel event study estimates examining employment impacts surrounding fossil fuel plant retirements using QCEW data from 2013-2020. The model includes county, year, and state-year fixed effects with county-clustered standard errors. The results show an overall decline in employment levels, average wages, and total annual contributions after full retirement. This aligns with the short- and long-run decreases in migration into affected areas, suggesting diminishing economic opportunities significantly influence sorting behaviors. The grey areas display 95% confidence intervals.

Figure A12: Effects of Fossil-Fuel Generator Retirement on Log Labor



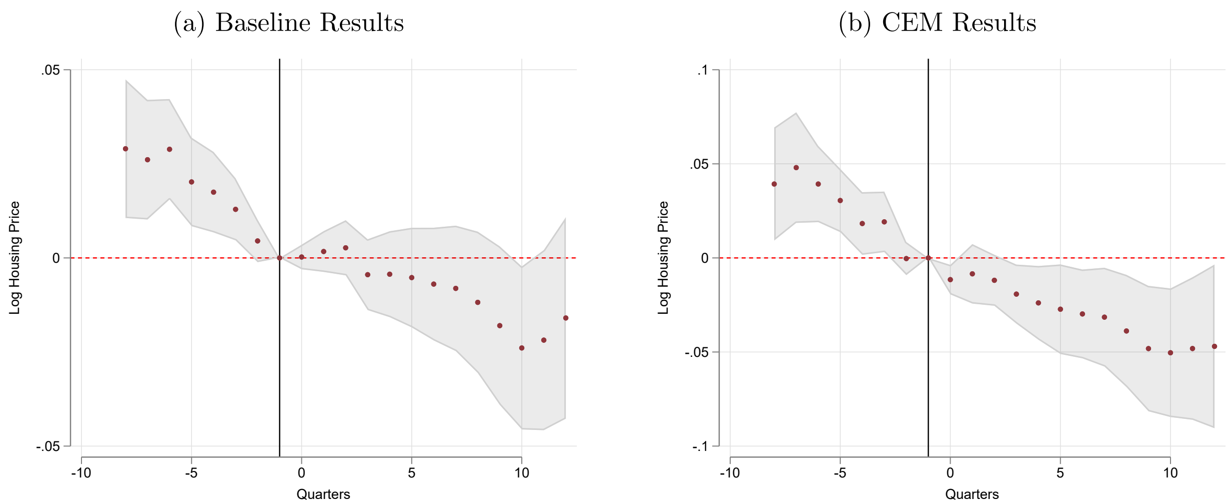
Notes: This figure presents two-way fixed effects estimates of fossil fuel plant retirement impacts on county-level employment across industries using annual aggregated QCEW dat from 2013-2020. The results show limited average treatment effects on specific industries, with the exception of public administration. No discernible effects are found on utilities and mining employment, perhaps because direct job impacts were absorbed during the retirement process.

Figure A13: Effects of Fossil-Fuel Generator Retirement on Log First Difference Labor Outcomes



Notes: This figure presents two-way fixed effects estimates using the log first difference in employment by industry as the outcome variable using annual aggregated QCEW dat from 2013-2020. The results show a significant long-term decrease in wholesale trade employment following fossil fuel plant retirement. This distinct decline for the wholesale sector provides evidence of negative shocks to the local economy arising from full generator closure.

Figure A14: Effects of Fossil-Fuel Generator Retirement on Housing Value



Notes: This figure shows the event study results examining the dynamic effects of fossil fuel plant retirement on zip code-level housing values over time. The model includes location and time fixed effects. The results reveal decreasing housing value trends emerge not only after plant closure but also in the preceding years. This provides further evidence of adverse housing market impacts, with anticipatory declines potentially as closure approaches.