The Impacts of Coal-fired Power Plants' Closures on Local Employment, Gender Employment Gap, and Gender Wage Gap

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Abstract

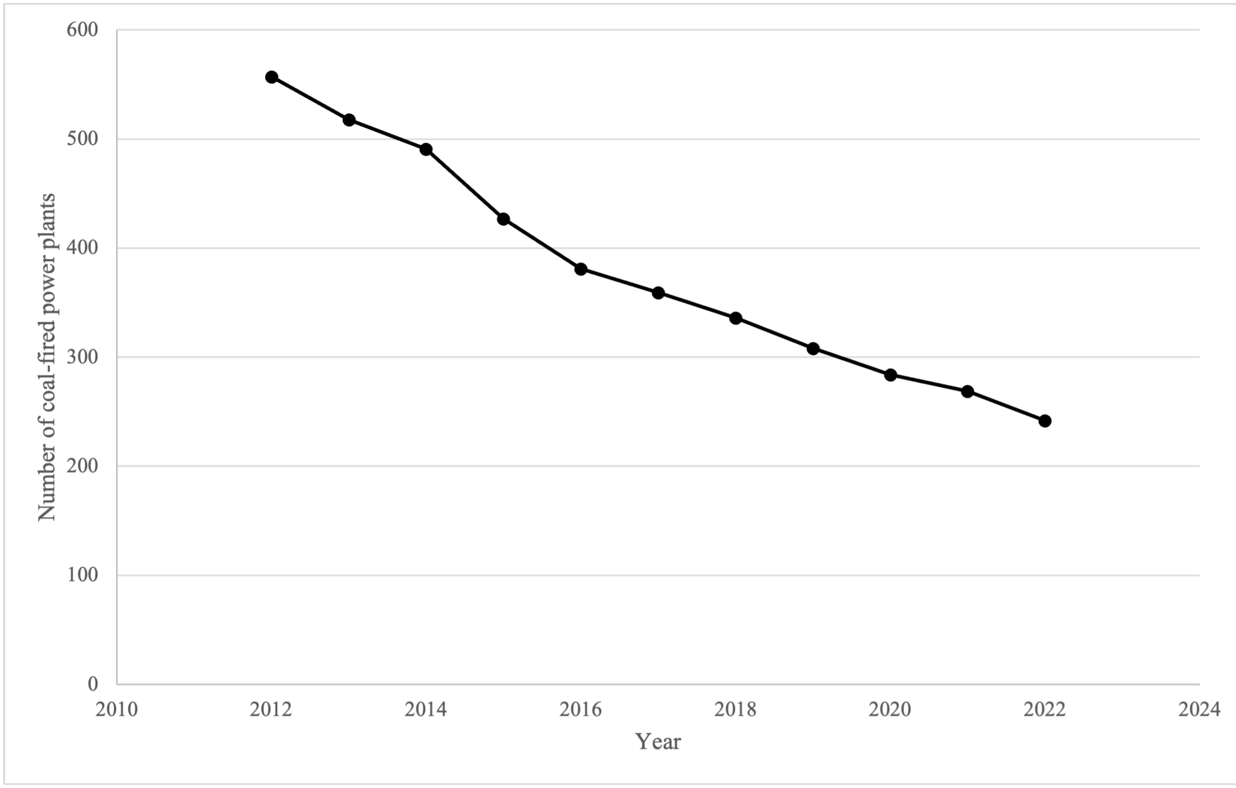
This paper examines the effects of coal-fired generator closures on regional labor market outcomes by gender and age group using coal-fired power plant closure data and U.S. microlevel census data. Our findings suggest that coal power generator closures have different impacts on the likelihood of unemployment for men and women. While younger men, who were displaced from power sector jobs, are likely to crowd out women from other industries, older men have more difficulty obtaining reemployment and end up leaving the labor force. In addition, closures negatively affect workers' annual income; however, the adverse impacts are more profound for men than for women. In affected Appalachian counties, labor force participation declines significantly following generator closures, suggesting underlying labor market withdrawal due to discouragement, early retirement, or structural barriers to reemployment. Our findings highlight the need to ensure that just transition policies are informed by and address the differential labor market outcomes identified in this research, particularly for women and older men.

1 Introduction

Coal is responsible for one-third of all global carbon dioxide emissions as it is the most carbon-intensive and abundant fossil fuel (Diluiso et al., 2021).[1] Global coal production has grown at an annual rate of 0.8% in the last decade and reached 8,803 million tonnes (Mt) in 2022 (Energy Institute, 2023). The increasing rate of global coal production is expected to continue into 2023. The growth of coal production was notably high in Asian coal-producing countries. The first six months of coal production in 2023 were from leading countries such as China, India, and Indonesia. These three Asian countries alone account for 95% of the increase in global coal production (Energy Institute, 2023). In 2022, China produced more than half of the worldwide coal supply at 4,650 Mt (Energy Institute, 2023). Throughout only the month of December 2022 alone, China's coal production surpassed 400 Mt, exceeding the annual production rate of almost any other country in the world (excluding Australia, Russia, Indonesia, India, and the United States) (International Energy Agency, 2023b).

[1] This paper is part of a symposium in honor of Dr. Richard Cebula.

Figure 1: Count of Coal-fired Power Plants in the United States, 2012 through 2022



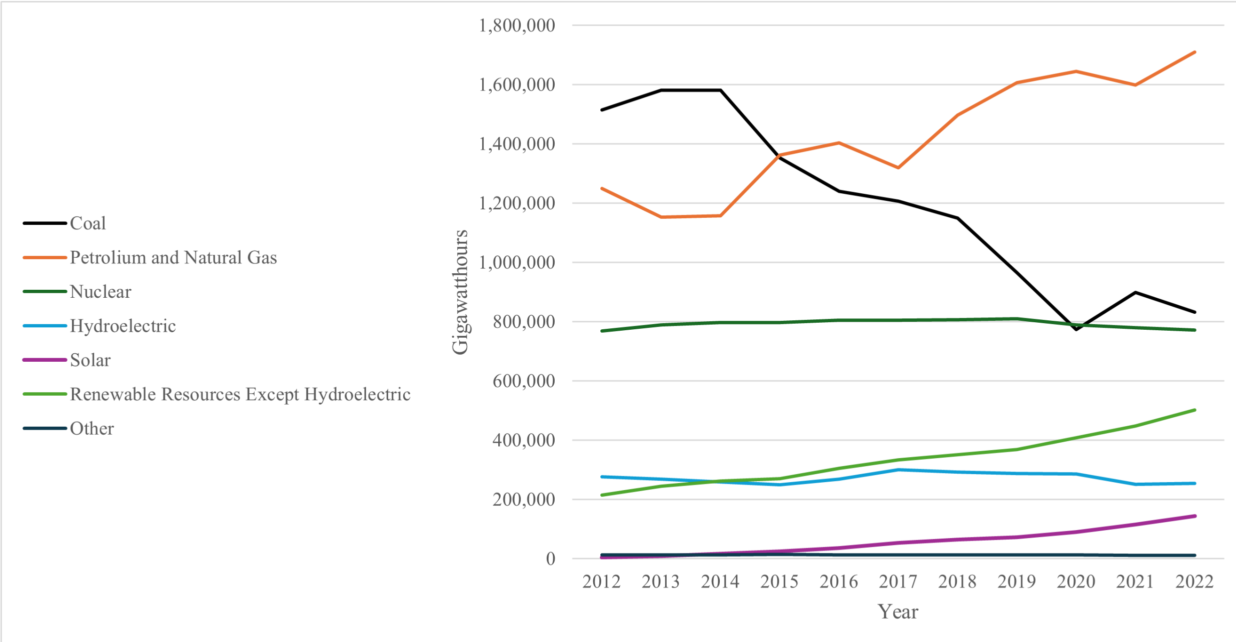
Source: Data from the U.S. Energy Information Administration (EIA). Retrieved from `https://www.eia.gov/electricity/annual/html/epa_04_01.html`

Although coal production is increasing globally, it has declined in the last decade in countries in the Organization for Economic Cooperation and Development (OECD). From 2012 to 2022, OECD's coal production fell by 30%, from 2,150 Mt to 1,507 Mt. Following the OECD trend, coal production and consumption in the US has declined over the last ten year. From 2012 to 2022, coal production in the US fell by 41.5%, from 922.1 Mt in 2012 to 539.4 Mt in 2022. (Energy Institute, 2023). U.S. coal consumption also decreased by 43.4% between 2012 and 2022 (Energy Institute, 2023).

The decline in coal consumption in the United States can be attributed to the reduction in coal-generated electricity, with 91.7% of coal consumption used in the electric power sector (Energy Information Administration, 2023). In the past decade, the U.S. utility sector has shifted from heavily relying on coal to adopting cleaner and renewable energy sources, resulting in the closure of coal-fired power plants across the country. Since reaching its peak in 2011 (Energy Information Administration, 2021; Diluiso et al., 2021), coal-generated electricity has decreased in the United States. From 2012 to 2022, a total of 315 coal-fired power plants were retired across the country (as shown in Figure 1). The capacity for coal-generated electricity has also decreased from 1,514 Terawatt Hours (TWh)[2] in 2012 to 831.5 TWh in 2022 (as illustrated in Figure 2). By 2022, coal-generated electricity accounted for only 20.54% of total net generation in the US, compared to 37% in 2012 (as illustrated in Figure 3).

[2] 1 Terawatt hour (TWh) = 1,000 Gigawatt hours (GWh)

Figure 2: US Net Electric Generation by Energy Source, 2012 – 2022



Source: Data from the Electric Power Annual Report 2022, prepared by U.S. Energy Information Administration (EIA). Retrieved on March 19, 2024 from `https://www.eia.gov/electricity/annual/pdf/epa.pdf`.

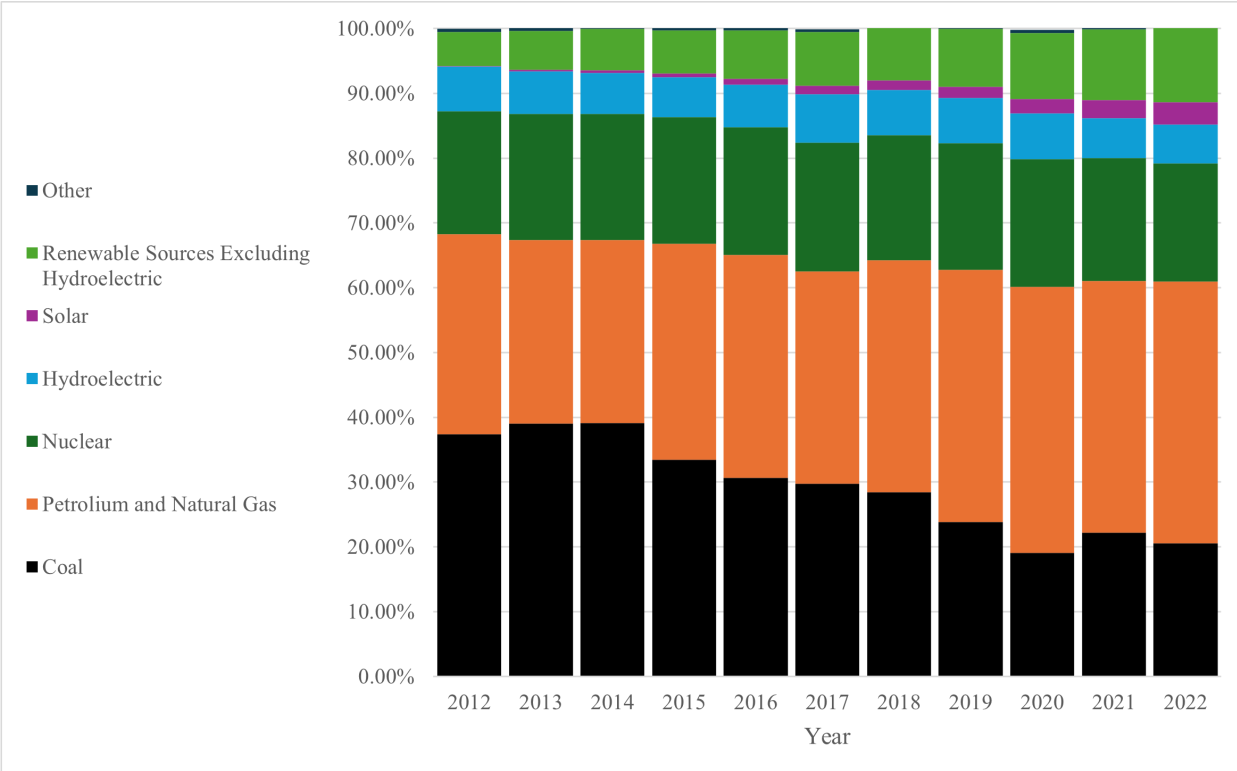
The main catalysts of the decline in US coal are increased natural gas production, lower gas prices, and the growth of renewable energy (International Energy Agency, 2023a; Gruenspecht, 2019; Diluiso et al., 2021). The lower price of natural gas production in the U.S. drove many bituminous coal-fired power plants into retirement (McGrath, 2021). For example, many coal plant closures in Ohio and Pennsylvania occurred in proximity to natural gas supplies built in the Marcellus and Utica shales located in these states. From 2012 to 2022, U.S. natural gas production increased by 50% from 649 to 978.9 billion cubic meters, and consumption grew by 28% from 688 to 881.2 billion cubic meters (Energy Institute, 2023). The electricity generated by petroleum and natural gas surpassed the electricity generated by coal in 2015, becoming the largest power source in the US (Figure 2). In 2022, petroleum and natural gas accounted for more than 40% of the total U.S. power generation (Figure 3).

As coal-fired power plants close in favor of natural gas and renewable energy sources, attention has increasingly turned to strategies for ensuring a "just transition" — minimizing the impacts on workers in fossil fuel-dependent communities. Research shows that this energy shift creates both winners and losers among communities (Carley and Konisky, 2020). In the United States, counties in regions such as Appalachia, the Texas Gulf Coast, and the Intermountain West face heightened risks from this transition, including job losses and reduced tax revenues that support public services (Raimi et al., 2022; Carley and Konisky, 2020).

Recognizing these risks, Clarke et al. (2024) called for a research agenda focused on enhancing economic resilience in fossil fuel-dependent communities. Our study contributes to that agenda and the broader just transition literature by examining the employment and wage effects — with a focus on gender — resulting from coal-fired generator closures.

The transition from coal-fired power plants to natural gas facilities, including those utilizing fracking, has significantly impacted resource-dependent communities. While natural gas production has created new economic opportunities, these are often limited in scope, particularly in rural areas formerly reliant on coal mining (Khalaf et al., 2022; Weinstein, 2014). Coal mining has long been associated with negative health outcomes, such as elevated mortality rates due to respiratory diseases (Ghosh and Cebula, 2021) Additionally, rural communities face challenges like outmigration (Jolley et al., 2012) driven by factors such as government tax and spending policies (Cebula, 1974), housing and rental prices (Cebula, 2022), and other socioeconomic factors. Recent studies also suggest that coal dust further deters in-migration to these areas (Cebula and

Figure 3: Shares of US Electric Generation by Energy Source, 2012 – 2022



Source: Data from the Electric Power Annual Report 2022, prepared by U.S. Energy Information Administration (EIA). Retrieved on March 19, 2024 from `https://www.eia.gov/electricity/annual/pdf/epa.pdf`.

Duquette, 2023). The shift away from coal-fired power generation presents both opportunities and challenges for coal-mining communities, highlighting the need for balanced strategies to address their economic and social transitions.

Another factor influencing the decline in coal-generated power is an increase in renewable energy (Energy Institute, 2023). Climate change has led to tighter air emission standards (Gorski, 2020), and coal is responsible for 40% of global emissions (Walk et al., 2021). Transitioning away from coal production and consumption is a crucial step in reducing global greenhouse gas emissions (Brown and Spiegel, 2019). In the United States, 2011 marked the peak of coal-fired power plant operation (Feaster, 2023). During this time, there were 589 coal-fired power plants throughout the country. By 2021, this figure had dropped to 269 units, representing 320 closures nationwide(Energy Information Administration, 2022). Currently, the United States is on track to lose half of its coal capacity by the end of 2026 (Feaster, 2023). As coal-fired power plants continue to be closed, jobs supported by this industry will decline. This decline could affect employment and the local economy in regions where these plants are located (Jolley et al., 2019; Burke et al., 2019; Alves Dias et al., 2018; Clark and Zhang, 2022; Aragón et al., 2018). Further, coal economy workers may face challenges finding quality reemployment, especially in occupations requiring greater digital literacy (Jolley et al., 2024).

Historically, the coal mining and power industries have been primarily dominated by men. Despite women constituting 47% of the U.S. workforce, they only represent 2% of the energy sector's overall workforce and 33% of the electric power generation industry's workforce (Cleveland and Ni, 2024). Since the majority of coal power plant workers are male, if a coal power plant shuts down in a particular region, job losses will disproportionately affect men compared to women. Former utility workers seeking new employment opportunities will cause an increase in the supply of male workers. Since male and female workers are not perfectly substitutable (Acemoglu et al., 2004; De Giorgi et al., 2015), the increase in the supply of male workers in a region can cause negative impacts on female workers. Furthermore, the impacts of coal-fired power plant closure on employment can also differ by age group since the likelihood of getting reemployed is lower for older people (Carlsson and Eriksson, 2019; Chan and Huff Stevens, 2001; Neumark et al., 2019; Lahey, 2008).

Although there is existing literature on the impacts of resource shocks on employment in general and employment by gender, there is a lack of research on how coal-fired power plants impact local labor markets, particularly in terms of gender and age. This research is important in light of the focus on creating a just transition for communities. To address the gap in the literature, our study investigates the impact of coal-fired power generator closures on regional labor market outcomes by gender and age group using coal-fired power plant closure data and micro census data at the county level.

Our findings suggest that the closure of coal-fired power plants in a given area can disproportionately impact employment opportunities for men and women. In particular, younger men who are displaced from the coal power industry will likely compete for jobs and crowd out women in other sectors. At the same time, older male workers face more difficulty obtaining reemployment, so they are likely to leave the labor market. Additionally, we found that most workers, regardless of gender, typically experience a reduction in their annual income due to these closures; however, the adverse effect is more profound for men than women.

2 Literature Review on The Effects of Coal Mine Closures on Employment by Gender

Due to the energy sector's "spillover effect", a booming extractive sector might increase local wages. Michieka et al. (2022) found that a rise in coal wages results in a rise in wages in most other economic sectors due to the increased purchasing power of residents. When higher wages circulate throughout a local economy, there is an increased demand for consumer goods. Alternatively, the economic impacts of mine closures also heavily impact the wages of jobs in other industries. The migration of workers can have long-term negative impacts on certain industries. For example, workers transferring from mining to construction can experience a decrease in wages over time.

The coal mining industry has long been steeped in masculine rhetoric, resulting in a culture of male miners. Unfortunately, this has had detrimental effects in areas where mining is the most profitable labor, as women are often forced into lower-paying and more unstable positions (Brown and Spiegel, 2019). Secondly, since around 84 to 92 percent of the global mining workforce comprises men (Ellix et al., 2021), it disproportionately affects male and female workers when a mine closes down. In a study conducted by Aragón et al. (2018) based on the closure of coal mines in the UK, they found that when a mine closes, non-primary employment increases for men but decreases for women, which implies that men transferring out of the coal mining industry crowd out women in non-mining economic sectors. There is a 0.78% decrease in female manufacturing workers within the manufacturing industry for every mine closed (Aragón et al., 2018). The average mine-closure district would displace over 209 women from manufacturing jobs while men would gain 725 jobs (Aragón et al., 2018). The crowding out effect of mine closures occurs because female and male workers are imperfect substitutes (Acemoglu et al., 2004; De Giorgi et al., 2015). Imperfect substitution causes specific industries to cultivate a primarily male workforce, primarily due to the physical attributes of men and cultural norms (Bennett et al., 2021).

The most prominent impacts of coal transitions came from out-migration, leading to the deterioration of local communities (Walk et al., 2021). Allcott and Keniston (2018) concludes that population growth and decline are pro-cyclical with natural resource boom and bust trends. During a resource bust, population decline is expected, leading to a drop in the total population of women in mining regions. Aragón et al. (2018) also indicates that mine closures lead to a decrease in population, participation rates, and the overall workforce.

Mining cycles also impact female employment, even if women are not miners themselves (Lahiri-Dutt, 2022). Bennett et al. (2021) shares a gendered perspective on the fossil fuel industry by observing how female wages are influenced by the presence of oil in a region. Although an increase in the presence of a natural resource increases overall wages earned (Allcott and Keniston, 2018), Bennett et al. (2021)'s findings suggest that in high oil markets, there is a decrease in overall female income, but an increase in male income, demonstrating that these trends do not apply to both genders evenly.

Furthermore, coal closures also had a variety of social impacts on women. Transitioning away from coal can expose the perpetuation of harmful power relations, such as gendered power asymmetries (Braunger and Walk, 2022). Patriarchal structures were very prominent in coal regions (Walk et al., 2021), which is supported by the job roles of men and women in the extractive areas. The roles assumed by male and female workers in the economy increased the prevalence of social polarization between men and women. This polarization became a primary factor in determining what opportunities are available to women and the level of difficulty it would take to reach a desired outcome (Braunger and Walk, 2022). A prominent issue women face is their role as household caretakers (Braunger and Walk, 2022). In fossil-fuel-intensive regions, women may lose personal income due to an intra-household reallocation of labor and familial responsibilities. As male incomes increase, there is less pressure for female income to support families (Bennett et al., 2021). Coal-fired power plant closures may double the burden of work on women in coal regions as there may be additional pressure to find paid work, often in the service sector, and continue to assume childcare or housekeeping functions (Walk et al., 2021). Along with cultural domestic responsibilities, other barriers to women in the labor market include lack of transportation, inadequate vocational training, and lack of work experience (Braunger and Walk, 2022).

Global energy is deeply connected to our social systems (Brown and Spiegel, 2019). A shift in the energy sector is crucial to cutting emissions and reaching our global climate goals. Women are one of the most vulnerable groups to the stresses of climate change but remain severely underrepresented in the decision-making process (Brown and Spiegel, 2019). A coal transition must be sensitive to coal employees and women in coal-dominated regions. The UN Sustainable Development Goal 5 is about gender equity and promises support and empowerment to women and girls throughout economic growth (Janikowska and Kulczycka, 2021). A "Just Transition" is recommended to ensure that current fossil fuel industry employees are not sacrificed to bear the burden of the changing energy sector (Brown and Spiegel, 2019). "Just Transitions" include equity in the forms of clear communication of expectations of future employment, financial support, and the counteraction of the historic professional exclusion of women in fossil fuel regions (Janikowska and Kulczycka, 2021).

3 Data and Empirical Approach

3.1 Data

In this study, we examine the impact of the closure of coal-fired power generators on regional labor market outcomes. We chose to focus on the effects of generator closures rather than power plant closures because most plants tend to retire some generators over time rather than shutting down the entire plant at once. We use two primary sources of data: a set of coal-fired power plant data derived from the Preliminary Monthly Electric Generator (Form EIA-860M) from the U.S Energy Information Administration (EIA) and the Inventory Integrated Public Use Microdata Series (IPUMS), which contains micro-level census data from 2010 to 2019.

Coal-fired power plant data:

We use the Preliminary Monthly Electric Generator from the EIA to construct a list of U.S. counties with coal-fired power generator closures between 2010 and 2019 and a list of nearby counties that are within 60 miles of a county with coal-fired power plant closure. According to the US Census Bureau, there are 3,144 counties in the US [3]. However, our main analysis focuses on counties within 60 miles of closures. From 2010 to 2019, closures occurred in 310 US counties. From the list of counties with closures, we identify a list of 1,546 neighboring counties (Figure 4).

Employment and demographic data:

We use micro-level census data from the Inventory Integrated Public Use Microdata Series (IPUMS) from

[3]See: `https://www.census.gov/newsroom/press-releases/2024/population-estimates-more-counties-population-gains-2023.html`

2010 to 2019. This data contains individual-level demographic and employment information such as gender, age, race, educational attainment, employment status, wage income, and the usual weekly working hours in the past year. We limit our data to working individuals aged between 16 and 67 who live in counties with closures and neighboring counties.

Data limitation:

Unfortunately, complete comprehensive micro census data at the county level is unavailable after 1950 due to the "72-year" rule [4]. Consequently, we face a limitation: many individuals in the county-level micro-census data lack county information and only have state information. For instance, if an individual has "39000" as their county FIPS code, it actually represents the state of Ohio FIPS code "39". Therefore, no county information is available for a person who resided in FIPS code "39000". In this study, we exclude all individuals lacking county information. As a result, our data contains 8,785,594 individuals who lived in 115 counties with closures and 227 neighboring counties in the 2010-2019 period (Figure 5).

Unfortunately, the American Community Survey (ACS), which forms the basis of our analysis, is collected annually. As such, we are unable to observe labor market outcomes at monthly or quarterly intervals and cannot directly test for short-term adjustments that may occur in advance of or immediately following closure announcements. The ACS's annual frequency imposes constraints on our ability to identify precise lead or lag effects.

Our identification approach relies on comparing treated counties—those experiencing generator retirements—with neighboring counties located within a 60-mile radius that did not experience such closures. The choice of a 60-mile radius to define neighboring counties is guided by both empirical considerations and data constraints. Reducing the radius would substantially limit the number of suitable comparison counties available in the ACS microdata, particularly in rural areas, thereby diminishing statistical power and variation. Conversely, increasing the radius risks includes counties that are less economically integrated with the affected area. Evidence from Aragón et al. (2018) suggests that the labor market effects of coal mine closures diminish with distance and become statistically insignificant at approximately 60 miles. This provides an empirical basis for our chosen threshold, which balances geographic relevance and sample representativeness.

Lastly, the ACS public-use microdata does not provide sufficient reliability to track detailed industry or occupational transitions at the county level. As a result, we are unable to directly observe the sectors into which displaced workers relocate or whether they remain within the same industry.

[4] See: https://blog.popdata.org/ipums-faqs-missing-u-s-counties/

Figure 4: Map of all U.S. Counties with Coal-Fired Power Plant Closures and Neighboring Counties (2010–2019)

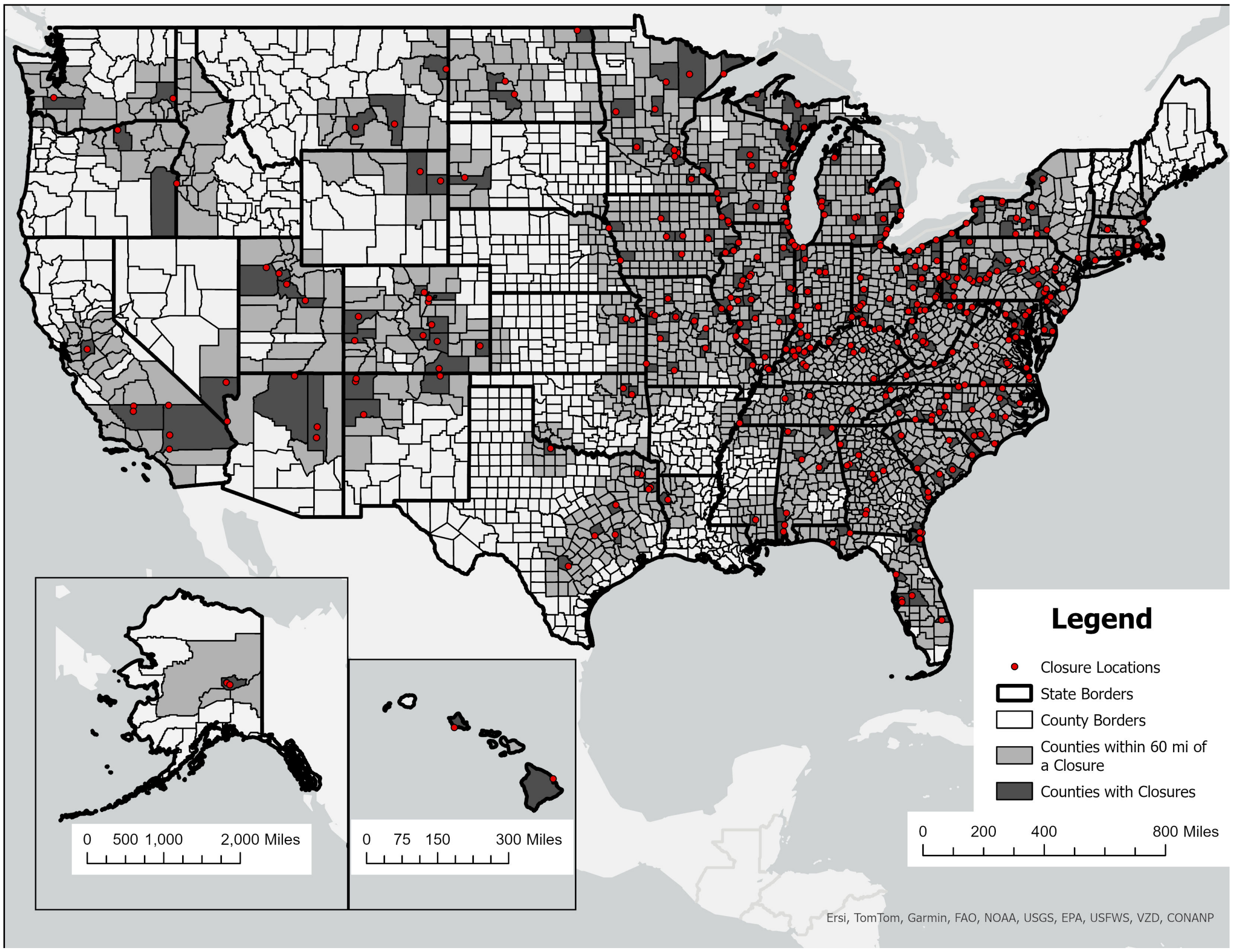
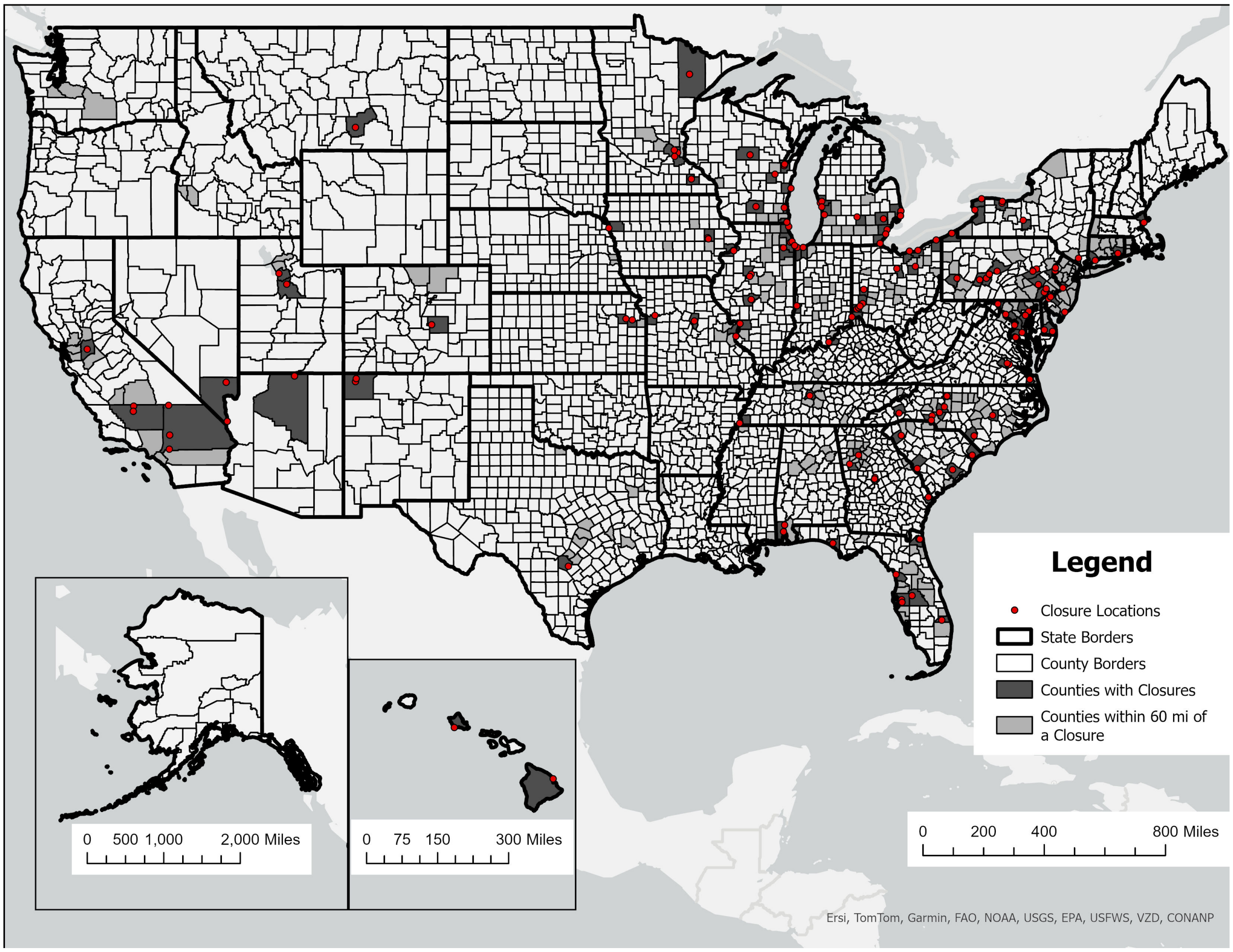


Figure 5: Map of U.S. Counties with Coal-Fired Power Plant Closures and Neighboring Counties (2010–2019) with Available Micro Census Data



3.2 Empirical Strategy

To investigate the impacts of coal-fired generator closures on labor market outcomes by gender, we employ the following regression model:

$$Y_{ict} = \alpha + \beta GeneratorClosures_{ct} + \gamma X_i + \rho T + \epsilon_i \qquad (1)$$

where Y_{ict} denotes the observable labor outcomes of individual i who live in county c in year t. The individual's labor outcomes of interest include their likelihood of being unemployed, likelihood of leaving the labor force, usual working hours, and real wage income.

$GeneratorClosures_{ct}$ denotes the number of coal-fired generators retired in county c in year t. In the context of our analysis, power plant retirements rarely occur as full-facility shutdowns. Instead, closures often unfold in stages, with individual units shutting down over time while others remain in operation. We measure exposure using the count of retired generators rather than entire plant closures to capture this incremental process. This approach allows for a more granular and continuous measure of local exposure to energy infrastructure changes.

X_i denotes the set of individual i's characteristics, such as age, race, education attainment, the number of children in their household, and whether the individual lives in the Appalachian Mountains area. T denotes a set of dummy variables for each year from 2010 to 2018. T is included in the estimation to control for unobserved variables that are constant across individuals but vary over time.

We also include cluster standard errors at the county-year level to the main model, which help further account for time-varying shocks (e.g., local economic downturns, political shifts) and local correlation (e.g., policy changes, business openings) in outcomes.

The impacts of generator closures on labor market outcomes by gender are shown in table 1. Besides gender, age is also an important factor in employment and reemployment opportunities (Carlsson and Eriksson, 2019; Chan and Huff Stevens, 2001), especially for women (Neumark et al., 2019; Lahey, 2008). To delve deeper into the impact of coal generator closures on labor outcomes, we further examine the effects of coal generator closures on labor outcomes by age group. Tables 2, 3, 4, and 5 show the effects of coal-fired generator closures on labor outcomes for men and women by age group.

4 Findings

Electric power generation, transmission, and distribution industries are high-paid industries and traditionally heavily male-dominated. According to the U.S. Bureau of Labor Statistics (2024), female workers only account for 20.7% of the industries' workforce, meaning when an electric generator or electric plant is closed in a region, men would lose more jobs than women. However, our results suggest that women face a higher risk of unemployment when a coal-fired generator is closed in their county (Table 1). Coal-fired generator closures increased the chance of unemployment for both men and women; however, the likelihood of unemployment due to a coal-fired generator shutdown was more significant for women than men (Table 1, panel A). A coal-fired generator closed in a county increased the chance of unemployment for women and men by 0.22% and 0.14%, respectively. This result supports the arguments that men and women are not perfect substitutes in the labor market (Acemoglu et al., 2004; De Giorgi et al., 2015), and men are likely to crowd out women in other sectors when there is a negative shock on employment in a male-dominated sector (Aragón et al., 2018).

While the results in Table 1 (Panel A) may initially suggest that generator closures have less adverse effects in the Appalachian region, a closer examination of both unemployment and labor force participation reveals a more nuanced picture. Specifically, although the unemployment rate appears to decline in affected Appalachian counties, we observe a substantial drop in labor force participation (Table 1, Panel B). This indicates that individuals in these areas are more likely to exit the labor market altogether rather than remain actively unemployed following a generator closure. In other words, the relatively stable unemployment rate masks underlying labor market withdrawal. This pattern may reflect discouragement effects, early retirement, or structural barriers to reemployment in economically distressed regions.

When looking at unemployment by age group, women of all ages are more likely to face unemployment than their male counterparts. The risk of unemployment is particularly high for younger women aged 16 to 40 due to the closure of coal-fired generators, while younger male workers of the same age groups are not at significant risk. (Table 2, panels A, B, and C). On the other hand, older men between the ages of 41 and 60 face higher unemployment risks compared to their younger counterparts and women in the same age groups (Table 2, panels D and E). These findings indicate that younger male workers who lost their jobs in the utility sector would likely seek reemployment in other sectors, potentially competing with and crowding out female workers. This finding is related to studies by De Giorgi et al. (2015) and Acemoglu et al. (2004) that showed men and women are imperfect substitutes. Furthermore, the results also suggest that it was more challenging for older male workers to find reemployment opportunities after losing their utility sector jobs than younger male workers.

Coal-fired generator shutdowns also affected labor force participation. Men living in a county with generator closures were 0.29% more likely to leave the labor force (Table 1, panel B). Older men who are 51 or older were most likely to leave the labor force due to coal-fired generator closures (Table 3, column 1). Men over 60 in counties with a generator closed were 1.34% more likely to leave the labor force than their male counterparts of the same age in counties without closures. In contrast, women living in a county with closures were 0.28% less likely to leave the labor force (Table 1, panel B). Only women in their 60s and near retirement age would likely leave the labor force when their county's coal plants shut down (Table 3, column

Table 1: Effect of coal-fired generator closure on unemployment, labor force participation, working hours, and real wage income.

	Total (1)	Men (2)	Women (3)
A. Unemployment			
Number of generators closed	0.0018*** (0.0006)	0.0013* (0.0007)	0.0022*** (0.0006)
Appalachian Region	-0.0040*** (0.0005)	-0.0048*** (0.0007)	-0.0032*** (0.0006)
Observations	8,785,594	4,297,404	4,488,190
R-squared	0.018	0.020	0.016
B. Leaving the labor force			
Number of generators closed	0.0004 (0.00116)	0.0032** (0.0014)	-0.0026** (0.0012)
Appalachian Region	0.0171*** (0.0009)	0.0207*** (0.0011)	0.0130*** (0.0012)
Observations	8,785,594	4,297,404	4,488,190
R-squared	0.046	0.074	0.050
C. Usual working hours (per week)			
Number of generators closed	0.028 (0.033)	0.0228 (0.0370)	0.0245 (0.0395)
Appalachian Region	0.1381*** (0.0289)	0.3436*** (0.0411)	-0.023 (0.0374)
Observations	5,875,669	3,026,397	2,849,272
R-squared	0.044	0.066	0.042
D. Real wage income			
Number of generators closed	-1,959.18*** (273.65)	-1,816.04*** (328.85)	-1,165.73*** (224.272)
Appalachian Region	-6,992.68*** (145.70)	-7,409.74*** (226.34)	-6,241.41*** (127.37)
Observations	5,875,669	3,026,397	2,849,272
R-squared	0.120	0.149	0.108

Note: *Clustered standard errors at the county level are reported in parentheses. The effect of coal-fired generator closure on the number of usual working hours and real wage income are estimated only for people who were employed.*
**** Significant at 1% level*
*** Significant at 5% level*
** Significant at 10% level*

2).

On average, coal-fired generator closures did not affect workers' average weekly working hours (Table 1, panel C). However, when looking at age groups specifically, coal-fired generator closures slightly increased weekly working hours for the youngest group of workers. Men between 16 and 20 years old in counties with a generator close experienced a slight increase of 0.4 hours per week, while women of the same age group experienced a 0.3-hour increase in their weekly working hours (Table 4, panel A). We also observed a small decrease in the number of working hours per week for women in their 60s living in counties with closures

(Table 4, panel F).

Although the closure of coal-fired generators did not have profound impacts on the average number of working hours, it resulted in lower real wage income for people living in affected counties. On average, people who lived in a county with a generator closed experienced a $1,493 reduction in their annual real wage income (Table 1, panel D, column 1). When looking at gender specifically, the adverse effects of generator closures on income were larger in men than women. While men experienced a $1,816 reduction in their real wage income due to a generator closed in their county (Table 1, panel D, column 2), women experienced a $1,043 reduction in their real wage income (Table 1, panel D, column 3).

While the youngest group of male workers, aged between 16 and 20, in the affected regions, saw some modest increase in their annual real wage income, older male workers experienced adverse impacts on their income (Table 5, column 1). In particular, men between 41 and 60 experienced the most significant adverse consequences. On average, 41 to 50-year-old and 51 to 60-year-old working men in these regions saw a $2,575 and $2,508 reduction in their real annual income, respectively (Table 5, column 1, panels D and E).

Similar to their male counterparts, most female workers in the affected regions experienced significant decreases in their annual real wage income, except for the youngest group of female workers, who saw a modest increase in their income (Table 5, column 2). Women in their 60s saw the most significant adverse impacts on their income compared to their younger female counterparts.

5 Sensitivity Analysis

The main specification of our study uses the number of retired generators in a county as the key variable of interest. However, this measure does not take into account the differences in size or capacity among generators. Some closures involve small generators, while others involve larger generators with significantly greater capacity.

To evaluate the robustness of our findings, we conduct a sensitivity analysis using total capacity loss (measured in megawatts, MW) instead of the number of generators closed while keeping all other aspects of the specification unchanged. By using total capacity loss as the variable of interest, we can better capture the intensity of the closure events, providing an alternative assessment of their impact on the labor market. The results of this sensitivity analysis are presented in Table 6.

We find that the main results remain consistent under this alternative specification. Specifically, our findings indicate that the loss of capacity due to generator closures is significantly associated with higher unemployment rates and lower real wage income for both men and women.

Capacity loss leads to a statistically significant increase in unemployment for both men and women, with the impact being slightly greater for women than for men, aligning with our main results based on generator count. Furthermore, we observe that capacity loss significantly reduces wage income for both genders, with a larger decline for men, which also aligns with our primary findings using the generator count.

The effect on usual working hours is positive but small in magnitude. In contrast, the impact of capacity loss on labor force participation is mixed. Nonetheless, it shows that women are less likely to exit the labor force compared to men, which is consistent with our main results based on the count of closed generators.

Overall, these findings indicate that our results are not sensitive to how closure exposure is measured. The count of retired generators and the associated capacity loss capture the similar effect of closures on the labor market in counties with coal-fired generator closed.

Table 2: Effect of coal-fired generator closure on unemployment by age groups.

Age group	Men (1)	Women (2)
A. 16-20 years old		
Number of generators closed	0.026	0.0050***
	(0.017)	(0.0017)
Appalachian Region	-0.0055**	-0.0024
	(0.027)	(0.0026)
Observations	368,019	352,836
R-squared	0.021	0.016
B. 21-30 years old		
Number of generators closed	0.0014	0.0023*
	(0.0015)	(0.0013)
Appalachian Region	-0.0028	0.0011
	(0.002)	(0.0017)
Observations	810,581	800,786
R-squared	0.022	0.023
C. 31-40 years old		
Number of generators closed	0.00005	0.0026**
	(0.0009)	(0.0011)
Appalachian Region	-0.0031**	-0.0022
	(0.0015)	(0.0014)
Observations	771,899	799,202
R-squared	0.018	0.015
D. 41-50 years old		
Number of generators closed	0.0025***	0.0021**
	(0.0010)	(0.0009)
Appalachian Region	-0.0052***	-0.0063***
	(0.0013)	(0.0011)
Observations	814,068	856,434
R-squared	0.018	0.010
E. 51-60 years old		
Number of generators closed	0.0021**	0.0014*
	(0.0009)	(0.0008)
Appalachian Region	-0.0069***	-0.0073***
	(0.0011)	(0.0010)
Observations	909,670	978,861
R-squared	0.010	0.006
F. Over 60 years old		
Number of generators closed	-0.0009	0.000004
	(0.0006)	(0.0006)
Appalachian Region	-0.0061***	-0.0029***
	(0.001)	(0.0008)
Observations	623,167	700,071
R-squared	0.007	0.005

Note: *Clustered standard errors at the county level are reported in parentheses.*
**** Significant at 1% level*
*** Significant at 5% level*
** Significant at 10% level*

Table 3: Effect of coal-fired generator closure on labor force participation by age groups.

Age group	Men (1)	Women (2)
A. 16-20 years old		
Number of generators closed	-0.0066*	-0.0100***
	(0.0035)	(0.003)
Appalachian Region	0.0034	0.0003
	(0.0043)	(0.0047)
Observations	368,019	352,836
R-squared	0.110	0.090
B. 21-30 years old		
Number of generators closed	-0.0004	-0.0063***
	(0.0022)	(0.002)
Appalachian Region	0.0255***	0.0100***
	(0.0027)	(0.0028)
Observations	810,581	800,786
R-squared	0.042	0.045
C. 31-40 years old		
Number of generators closed	0.0040**	-0.0061***
	(0.0017)	(0.0015)
Appalachian Region	0.0222***	0.0042
	(0.0020)	(0.0025)
Observations	771,899	799,202
R-squared	0.046	0.067
D. 41-50 years old		
Number of generators closed	0.0035**	-0.0013
	(0.0017)	(0.0016)
Appalachian Region	0.0175***	0.0115***
	(0.0019)	(0.0024)
Observations	814,068	856,434
R-squared	0.054	0.0036
E. 51-60 years old		
Number of generators closed	0.0063***	0.0026
	(0.0019)	(0.0019)
Appalachian Region	0.0135	0.0186***
	(0.0023)	(0.0024)
Observations	909,670	978,861
R-squared	0.058	0.036
F. Over 60 years old		
Number of generators closed	0.0139***	0.0056**
	(0.0024)	(0.0022)
Appalachian Region	0.0261***	0.0255***
	(0.0032)	(0.0029)
Observations	623,167	700,071
R-squared	0.088	0.069

Note: *Clustered standard errors at the county level are reported in parentheses.*
**** Significant at 1% level*
*** Significant at 5% level*
** Significant at 10% level*

Table 4: Effect of coal-fired generator closure on usual weekly working hours by age groups.

Age group	Men (1)	Women (2)
A. 16-20 years old		
Number of generators closed	0.4080***	0.2881***
	(0.1309)	(0.1115)
Appalachian Region	0.2847	-0.4146**
	(0.2019)	(0.1618)
Observations	97,325	107,582
R-squared	0.133	0.108
B. 21-30 years old		
Number of generators closed	0.0862	0.0665
	(0.0701)	(0.0675)
Appalachian Region	0.1770*	-0.0301
	(0.0933)	(0.0862)
Observations	573,104	557,956
R-squared	0.093	0.111
C. 31-40 years old		
Number of generators closed	-0.0454	-0.0361
	(0.0483)	(0.0579)
Appalachian Region	0.4841***	0.0218
	(0.0718)	(0.0728)
Observations	643,834	577,337
R-squared	0.026	0.035
D. 41-50 years old		
Number of generators closed	-0.01864	0.0284
	(0.0511)	(0.0417)
Appalachian Region	0.4133***	0.1737**
	(0.0727)	(0.0766)
Observations	680,149	625,376
R-squared	0.027	0.023
E. 51-60 years old		
Number of generators closed	-0.0126	0.0110
	(0.00482)	(0.0415)
Appalachian Region	0.5479***	0.0941
	(0.0681)	(0.0656)
Observations	702,437	674,069
R-squared	0.021	0.012
F. Over 60 years old		
Number of generators closed	0.0299	-0.1456**
	(0.0657)	(0.0707)
Appalachian Region	0.1291	-0.1818
	(0.1066)	(0.1125)
Observations	329,548	306,952
R-squared	0.027	0.023

Note: *Clustered standard errors at the county level are reported in parentheses. The effect of coal-fired generator closure on the number of usual working hours is estimated only for people who were employed*
**** Significant at 1% level*
*** Significant at 5% level*
** Significant at 10% level*

Table 5: Effect of coal-fired generator closure on real wage income by age groups.

Age group	Men (1)	Women (2)
A. 16-20 years old		
Number of generators closed	216.86**	111.07
	(106.53)	(73.03)
Appalachian Region	-525.69***	-689.12***
	(175.12)	(143.89)
Observations	97,325	107,582
R-squared	0.069	0.039
B. 21-30 years old		
Number of generators closed	-341.59*	-389.33**
	(181.16)	(155.87)
Appalachian Region	-2,809.72***	-2,708.84***
	(185.93)	(169.65)
Observations	573,104	557,956
R-squared	0.145	0.184
C. 31-40 years old		
Number of generators closed	-2,178.57***	-1,241.94***
	(359.45)	(315.08)
Appalachian Region	-8,177***	-7,035***
	(365.61)	(253.52)
Observations	643,834	577,337
R-squared	0.118	0.100
D. 41-50 years old		
Number of generators closed	-2,769.70***	-1,522.39***
	(538.28)	(295.83)
Appalachian Region	-9,926.45***	-8,170***
	(432.99)	(301.46)
Observations	680,149	625,376
R-squared	0.123	0.078
E. 51-60 years old		
Number of generators closed	-2,687.03***	-1,440.770***
	(497.88)	(262.62)
Appalachian Region	-9,318.18***	-7,740.35***
	(501.96)	(257.07)
Observations	702,437	674,069
R-squared	0.105	0.070
F. Over 60 years old		
Number of generators closed	-2,140***	1,646.61***
	(565.05)	(267.66)
Appalachian Region	-9,381.13***	-6,184.22***
	(715.24)	(415.55)
Observations	329,548	306,952
R-squared	0.068	0.059

Note: *Clustered standard errors at the county level are reported in parentheses. The effect of coal-fired generator closure on real wage income is estimated only for people who were employed*
**** Significant at 1% level*
*** Significant at 5% level*
** Significant at 10% level*

Table 6: Effect of coal-fired generator closure on unemployment, labor force participation, working hours, and real wage income. (Using capacity loss (MW) as treatment variable)

	Total (1)	Men (2)	Women (3)
A. Unemployment			
Capacity Loss (MW)	0.0000107***	0.0000098***	0.0000115***
	(0.00000247)	(0.0007)	(0.00000273)
Appalachian Region	-0.0040***	-0.0048***	-0.0032***
	(0.0005)	(0.0007)	(0.0006)
Observations	8,785,594	4,297,404	4,488,190
R-squared	0.018	0.020	0.016
B. Leaving the labor force			
Capacity Loss (MW)	-0.0002222	0.0000034	-0.0000093**
	(0.000127)	(0.00000509)	(0.00000424)
Appalachian Region	0.017***	0.0206***	0.0130***
	(0.0009)	(0.0012)	(0.0012)
Observations	8,785,594	4,297,404	4,488,190
R-squared	0.046	0.075	0.050
C. Usual working hours (per week)			
Capacity Loss (MW)	0.0002222*	0.0001011	0.0004149***
	(0.00012792)	(0.00014430)	(0.00014701)
Appalachian Region	0.14***	0.3434***	-0.019
	(0.029)	(0.0411)	(0.0374)
Observations	5,875,669	3,026,397	2,849,272
R-squared	0.044	0.066	0.042
D. Real wage income			
Capacity Loss (MW)	-3.064***	-4.190***	-1.6350**
	(1.039)	(1.289)	(0.8006)
Appalachian Region	-6943.26***	-7357.25***	-6198.53***
	(144.96)	(225.83)	(126.67)
Observations	5,875,669	3,026,397	2,849,272
R-squared	0.120	0.149	0.108

Note: *Clustered standard errors at the county level are reported in parentheses. The effect of coal-fired generator closure on the number of usual working hours and real wage income are estimated only for people who were employed.*
**** Significant at 1% level*
*** Significant at 5% level*
** Significant at 10% level*

6 Discussion, Alternative Explanations, and Implications for Future Studies

Our results suggest that in the event of a generator closure in a county, younger men who worked in the utility sector and lost their jobs will likely look for employment in other industries, which can lead to women being crowded out of those industries. Conversely, older men often struggle to find new employment opportunities (Carlsson and Eriksson, 2019; Chan and Huff Stevens, 2001) are more likely to exit the labor market altogether when a coal-fired generator closes in their county. While those who stayed employed or found employment in other industries experienced no significant changes in their weekly working hours, they experienced a substantial decline in their income. This decline is more pronounced for men than women and is more severe for older people than younger people, regardless of gender.

Our study contributes to the established literature on factors influencing female labor force participation (e.g., Cebula and Coombs (2008); Cebula and Alexander (2015); Cebula and Williams (2006); Pampel and Tanaka (1986); Blau and Kahn (2013)). Further, it establishes several lines of inquiry for further study on how energy transition impacts female labor force participation and family dynamics. First, coal-fired power plants have large employment multipliers (Jolley et al., 2019). Employment multipliers measure the additional supply chain jobs (indirect employment) and jobs supported by labor income spending (induced employment) that are directly linked to coal-fired power plant employment (Clouse et al., 2023). Our study points to the need to understand better how gender dynamics are associated with changes to indirect and induced jobs because of coal-fired power plant closures. Understanding these dynamics in greater detail assists with better design of policy interventions.

Second, a just transition should consider the impact of on family dynamics resulting from energy transition. Our findings identify several key factors that influence family dynamics as a result of coal-fired power plant closures, including younger men crowding out women in the workforce, older men leaving the workforce, and lower annual income. While some literature suggests that increased divorce rates are associated with layoffs and not plant closures (Charles, 2004; Eliason, 2012; Banzhaf, 2018), further research is needed to understand how energy transition and coal-fired power plant closures impact marriage, divorce, and decisions to have children in impacted communities. Our findings also demonstrate a modest increase in hours worked for both men and women aged 16-20 in communities impacted by a closure. While the increase is modest, it may signal that younger families members aged 16-20 bear an increased responsibility for earning family income when power plants close.

Third, emerging literature explores the transferability of skills among displaced workers to new and developing occupations (e.g., Scott and Kotlyar (2013); Jolley et al. (2024); Jolley and Khalaf (2020); Humeniuk et al. (2024); Khalaf et al. (2021)). This study highlights the importance of incorporating gender considerations and the effects of crowding out into this research to better understand the downstream impacts and the skills training needs of affected workers.

Amidst calls for a "gender-responsive" just transition approach to climate change that considers the disproportionate impact of climate change on women (Women, 2023; Blau and Kahn, 2013), our study offers cautionary considerations to the externalities associated with transition in communities reliant on coal-fired power generation.

One limitation of our analysis is the inability to account for migration across county borders in response to generator closures. Labor market shocks may prompt affected individuals or households to relocate for better employment opportunities, altering the demographic and economic composition of origin and destination counties. If migration is selective, this could bias observed labor market outcomes by underestimating the true extent of job displacement. The American Community Survey (ACS) does not track short-term or county-to-county migration at the individual level, and capturing migration flows at this micro level remains a broader challenge in empirical research. Additionally, due to data limitations, we are unable to observe whether displaced workers remain in the same industry or transition into new sectors. Understanding these transitions would provide deeper insight into mechanisms such as skill mismatch, reallocation, and labor market crowding. We view both migration patterns and industry transitions as important and interesting directions for future research, particularly with the use of administrative or longitudinal data sources that can track individual employment trajectories over time.

References

Acemoglu, D., Autor, D. H., and Lyle, D. (2004). Women, war and wages: The effect of female labor supply on the wage structure at midcentury. *Journal of Political Economy*, 112(3):497 – 551.

Allcott, H. and Keniston, D. (2018). Dutch disease or agglomeration? The local economic effects of natural resource booms in modern America. *The Review of Economic Studies*, 85(2):695–731.

Alves Dias, P., Kanellopoulos, K., Medarac, H., Kapetaki, Z., Miranda-Barbosa, E., Shortall, R., Czako, V., Telsnig, T., Vazquez-Hernandez, C., Lacal Arantegui, R., et al. (2018). EU coal regions: Opportunities and challenges ahead. *European Commission, Joint Research Centre: Petten, The Netherlands*, pages 20–32.

Aragón, F. M., Rud, J. P., and Toews, G. (2018). Resource shocks, employment, and gender: Evidence from the collapse of the UK coal industry. *Labour Economics*, 52:54–67.

Banzhaf, M. R. (2018). When it rains, it pours: Under what circumstances does job loss lead to divorce. *Southern Economic Journal*, 85(2):349–377.

Bennett, P., Ravetti, C., and Wong, P. Y. (2021). Losing in a boom: Long-term consequences of a local economic shock for female labour market outcomes. *Labour Economics*, 73:102080.

Blau, F. D. and Kahn, L. M. (2013). Female labor supply: Why is the United States falling behind? *American Economic Review*, 103(3):251–256.

Braunger, I. and Walk, P. (2022). Power in transitions: Gendered power asymmetries in the United Kingdom and the United States coal transitions. *Energy Research Social Science*, 87:102474.

Brown, B. and Spiegel, S. J. (2019). Coal, climate justice, and the cultural politics of energy transition. *Global Environmental Politics*, 19(2):149–168.

Burke, P., Best, R., and Jotzo, F. (2019). Closures of coal-fired power stations in Australia: Local unemployment effects. *Australian Journal of Agricultural and Resource Economics*, 63:142–165.

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

Carlsson, M. and Eriksson, S. (2019). Age discrimination in hiring decisions: Evidence from a field experiment in the labor market. *Labour Economics*, 59:173–183.

Cebula, R. J. (1974). Local government policies and migration: An analysis for SMSA's in the United States, 1965–1970. *Public Choice*, 19(1):85–93.

Cebula, R. J. (2022). Migration, the quality of life, and economic opportunities in the us revisited: Impacts of round-trip work commute time and rent or single-family housing prices. *American Business Review*, 25(2):9.

Cebula, R. J. and Alexander, G. (2015). An exploratory empirical note on the impact of labour market freedom on the female labour force participation rate in the US. *Applied Economics Letters*, 22(8):632–636.

Cebula, R. J. and Coombs, C. K. (2008). Recent evidence on factors influencing the female labor force participation rate. *Journal of Labor Research*, 29:272–284.

Cebula, R. J. and Duquette, C. M. (2023). An exploratory study on the migration-pattern impact of coal dust in the US. *Applied Economics*, 55(34):3996–4002.

Cebula, R. J. and Williams, A. M. (2006). Determinants of female labor force participation: Preliminary evidence. *Business Renaissance Quarterly*, 1(2):141.

Chan, S. and Huff Stevens, A. (2001). Job loss and employment patterns of older workers. *Journal of Labor Economics*, 19(2):484–521.

Charles, K. K. (2004). Job displacement, disability, and divorce. *Journal of Labor Economics*, 22(2):389–411.

Clark, A. and Zhang, W. (2022). Estimating the employment and fiscal consequences of thermal coal phase-out in China. *Energies*, 15(3):800.

Clarke, L., Curtis, M., Eisenberg, A., Grubert, E., Haggerty, J. H., James, A., Jensen, N., Kaufman, N., Krause, E., Raimi, D., et al. (2024). A research agenda for economic resilience in fossil fuel–dependent communities. *Environmental Research: Energy*, page 033004.

Cleveland, C. and Ni, A. (2024). Gender diversity in the united states energy workforce. Technical report, Institute of Global Sustainability: Visulizing Energy, Boston University.

Clouse, C., Thorvaldson, J., and Jolley, G. J. (2023). Impact factors: Methodological standards for applied input-output analysis. *Journal of Regional Analysis and Policy*, 53(2):1–14.

De Giorgi, G., Paccagnella, M., and Pellizzari, M. (2015). Gender complementarities in the labor market. *Research in Labor Economics*, 41:277 – 298.

Diluiso, F., Walk, P., Manych, N., Cerutti, N., Chipiga, V., Workman, A., Ayas, C., Cui, R. Y., Cui, D., Song, K., et al. (2021). Coal transitions—part 1: a systematic map and review of case study learnings from regional, national, and local coal phase-out experiences. *Environmental Research Letters*, 16(11):113003.

Eliason, M. (2012). Lost jobs, broken marriages. *Journal of Population Economics*, 25(4):1365–1397.

Ellix, H., Mussacaleca, M., Farmer, K., Kowalik, L., Little, R., Moonsamy, T., Ruban, P., and Zapata, G. (2021). Why women are leaving the mining industry and what mining companies can do about it. Technical report, McKinsey & Company.

Energy Information Administration (2021). 68% of U.S. coal fleet retirements since 2011 were plants fueled by bituminous coal. Technical report, Energy Information Administration.

Energy Information Administration (2022). Count of electric power industry power plants, by sector, by predominant energy sources within plant, 2012 through 2022. Technical report, Energy Information Administration.

Energy Information Administration (2023). Coal explained: Use of coal. Technical report, Energy Information Administration.

Energy Institute (2023). 72nd statistical review of world energy. Technical report, Energy Institute.

Feaster, S. (2023). U.S. on track to close half of coal capacity by 2026. *Institute for Energy Economic and Financial Analysis*.

Ghosh, S. and Cebula, R. J. (2021). Proximity to coal mines and mortality rates in the Appalachian region of the United States: A spatial econometric analysis. *Regional Studies, Regional Science*, 8(1):130–142.

Gorski, M. M. . A. (2020). As U.S. coal-fired capacity and utilization decline, operators consider seasonal operation. Technical report, Energy Information Administration.

Gruenspecht, H. (2019). The u.s. coal sector recent and continuing challenges. Technical report, Brookings.

Humeniuk, R., Erfanian, E., and Jolley, G. J. (2024). Ohio's 5G and broadband workforce: Assessing the current landscape using skillshed analysis. *Merits*, 4(1):66–78.

International Energy Agency (2023a). Coal. Technical report, International energy Agency.

International Energy Agency (2023b). Coal market update july 2023. Technical report, International Energy Agnecy.

Janikowska, O. and Kulczycka, J. (2021). Just transition as a tool for preventing energy poverty among women in mining areas—a case study of the silesia region, poland. *Energies*, 14(12):3372.

Jolley, G. J., Bone, C., Bacot, H., and Pham, T. (2024). Navigating occupational digitalization via skillshed analysis. *American Journal of Economics and Sociology*, 83:631–645.

Jolley, G. J. and Khalaf, C. (2020). Skillshed analysis as a tool to inform workforce training programs: The case of Amazon HQ2. *Economic Development in Higher Education*, 3:1–5.

Jolley, G. J., Khalaf, C., Michaud, G., and Sandler, A. M. (2019). The economic, fiscal, and workforce impacts of coal-fired power plant closures in Appalachian Ohio. *Regional Science Policy & Practice*, 11(2):403–422.

Jolley, J., Nousaine, A., and Huang, C. (2012). Effective at the margins: Outmigration and economic development in rural North Carolina. *Sustainable Agriculture Research*, 1(1).

Khalaf, C., Michaud, G., and Jolley, G. J. (2021). How to assess the transferability of worker skills: A hybrid clustering approach. *Journal of Regional Analysis and Policy*, 51(1):67–78.

Khalaf, C., Michaud, G., and Jolley, G. J. (2022). Toward a new rural typology: mapping resources, opportunities, and challenges. *Economic Development Quarterly*, 36(3):276–293.

Lahey, J. N. (2008). Age, women, and hiring: An experimental study. *Journal of Human Resources*, 43(1):30–56.

Lahiri-Dutt, K. (2022). New directions in research on women and gender in extractive industries. *The Extractive Industries and Society*, 9:101048.

McGrath, G. (2021). 68 percent of U.S. coal fleet retirements since 2011 were plants fueled by bituminous coal. Technical report, Energy Information Administration.

Michieka, N. M., Graziano, M., Musso, M., and Fouquet, R. (2022). Energy transitions and labor market patterns in the U.S. coal industry. *Structural Change and Economic Dynamics*, 63:501–514.

Neumark, D., Burn, I., and Button, P. (2019). Is it harder for older workers to find jobs? New and improved evidence from a field experiment. *Journal of Political Economy*, 127(2):922–970.

Pampel, F. C. and Tanaka, K. (1986). Economic development and female labor force participation: A reconsideration. *Social Forces*, 64(3):599–619.

Raimi, D., Carley, S., and Konisky, D. (2022). Mapping county-level vulnerability to the energy transition in US fossil fuel communities. *Scientific Reports*, 12(1):15748.

Scott, H. and Kotlyar, I. (2013). A review of skillshed analysis practices and outcomes. Technical report, Social Sciences and Humanities Research Council. A report prepared for the Knowledge Synthesis Grants: Skills Development for Future Needs of the Canadian Labour Market competition, file# 412-2013-2006.

U.S. Bureau of Labor Statistics (2024). Labor force statistics from the current population survey. Data retrieved from Table 18. Employed persons by detailed industry, sex, race, and Hispanic or Latino ethnicity, `https://www.bls.gov/cps/cpsaat18.htm`.

Walk, P., Braunger, I., Semb, J., Brodtmann, C., Oei, P.-Y., and Kemfert, C. (2021). Strengthening gender justice in a just transition: A research agenda based on a systematic map of gender in coal transitions. *Energies*, 14(18).

Weinstein, A. L. (2014). Local labor market restructuring in the shale boom. *Journal of Regional Analysis & Policy*, 44(1):71–92.

Women, U. N. (2023). A gender-responsive just transition for people and planet. Policy Brief.