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ABSTRACT

Society's transition toward more sustainable energy sources is well underway. But substantially reducing the use of fossil fuels to generate electricity, to power vehicles, and to manufacture the stuff of everyday life will profoundly disrupt the communities that currently dedicate themselves to carbon-intensive industries. In this paper, I consider the potential for adverse labor market consequences from the energy transition and the suitability of existing policies to counteract them. Top of mind in this discussion is to avoid repeating the painful adjustment to globalization and automation, which in recent decades brought concentrated job loss and long-lasting economic distress to local labor markets that had been specialized in manufacturing. I begin by mapping the spatial distribution of employment in fossil-fuel-intensive activities across US commuting zones from 2000 forward. Then, using the labor market consequences of the post-1980 decline of coal as a backdrop, I discuss policy options for easing adjustment to the energy transition, including letting market forces work, reinforcing the social safety net, and expanding place-based policies.

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1. Introduction

Curtailing greenhouse gas emissions is likely to require far-reaching changes in countries' production and consumption patterns. Efforts are well underway to reduce reliance on fossil fuels in generating electricity, heating buildings, powering vehicles, and manufacturing the stuff of everyday life. Alongside the long-run costs and benefits of these adjustments are the immediate impacts of decarbonization on communities that continue to depend on fossil fuels for their livelihoods.[1] For these places, a rapid societal reduction in carbon intensity could prove profoundly disruptive.

In this paper, I consider how the energy transition will affect regions that are specialized in fossil-fuel-intensive industries and explore options to mitigate its negative labor market consequences. Top of mind in this discussion is how the recent decline of manufacturing employment has affected labor markets in the United States and other high-income economies. Manufacturing—like the oil, gas, and coal industries—pays relatively high wages to workers without college degrees. Job loss in manufacturing over the last several decades has consequently hit traditional industrial regions especially hard (Charles et al., 2019). After import competition from China caused extensive closures of US factories, for instance, many displaced workers neither found new jobs in other sectors nor migrated elsewhere (Autor et al., 2013, 2014; Acemoglu et al., 2016). Local employment rates, earnings for less-educated workers, and average incomes all declined upon shock impact and stayed depressed for decades after (Autor et al., 2022). Affected communities saw fewer families form, more children raised in poverty, and higher mortality from drug and alcohol abuse (Autor et al., 2019; Pierce and Schott, 2020). Because the energy transition is still in its early stages, many options remain available to help exposed regions to avoid the hardship that has accompanied local labor market adjustment to automation and globalization (Autor et al., 2016; Acemoglu and Restrepo, 2020; Dorn and Levell, 2021). Without improving how local economies respond to job loss, we risk miring more communities in distress.

I begin by mapping the spatial distribution of employment in fossil-fuel-intensive activities across US regions from 2000 forward. Perhaps the most immediate impacts of the energy transition will be to displace workers who currently extract and refine coal, natural gas, and petroleum. Employment in these activities is concentrated regionally and among non-college-educated workers (Black et al., 2005; Jacobsen and Parker, 2016; Raimi, 2021). Many workers at legacy suppliers of electricity, such as the coal-fired power plants that are now being retired (Davis et al., 2021), are also likely to be affected. Also at risk are those employed in energy-intensive manufacturing industries—such as basic chemicals, nonmetallic minerals, paper, and primary metals—which are often located where access to electricity was cheapest at the historical moment when those industries developed (Kahn and Mansur, 2013; Glaeser et al.,

[1] For prior research on regional exposure to the energy transition in the United States, see Beckfield et al. (2020), Gallagher and Glasmeier (2020), Raimi (2021), Greenspon (2022), and Krause (2022).

2015). In response, energy-intensive industries may relocate to where green energy sources are available, which could displace workers in current manufacturing centers. Whatever the cause of job loss, successful adjustment to the energy transition requires that displaced workers find new positions. Candidate sectors include those tied to wind, solar, hydro, and other renewable energy sources (Curtis and Marinescu, 2022; Popp et al., 2022). But because much of the job growth in these sectors is likely to occur far from where today's fossil fuel industries are located, the shift to green technology may not absorb many workers displaced by the energy transition.

In the second part of the analysis, I turn to policy options for addressing the energy transition's adverse labor market consequences. One is simply to let market forces work. Basic economic logic suggests that if decarbonization causes unemployment to spike in some regions, local wages would fall, new or existing firms would expand their operations, and these new investments would help to absorb displaced workers. In practice, however, we rarely see regional unemployment gaps close via capital chasing labor (Blanchard and Katz, 1992). As an alternative, geographically mobile workers could equilibrate labor markets across space, but recent evidence has overturned confidence that distressed regional labor markets are able to recover quickly via labor chasing capital. We now appreciate that the local net supply of non-college-educated workers responds only modestly to negative labor demand shocks (Bound and Holzer, 2000; Autor et al., 2013; Diamond, 2016; Notowidigdo, 2020). In labor markets beset by large downturns, joblessness can therefore become entrenched (Austin et al., 2016). Without outside action of some kind, the energy transition could depress employment rates and living standards in exposed communities for an extended period of time (Bartik, 2020).[2]

A second approach to labor market adjustment to the energy transition is to *target exposed individuals*, such as those who have lost their jobs, low-wage workers whose earnings have dropped, and households that have fallen into poverty. The existing US social safety net is built around such assistance. In theory, the safety net should help low-income households to smooth consumption over time and to make productive investments in job search and training, while also redistributing resources to those for whom extra income would bring a relatively large improvement in well-being. Unemployment insurance (UI) provides benefits to laid-off workers for up to six months after the loss of their jobs. Payments are calculated as a percentage of the recipient's most recent wage, up to a cap. Following spikes in unemployment, such as during the

[2] Declines in nominal earnings do not necessarily imply a decline in real earnings. Glaeser and Gyourko (2005) and Notowidigdo (2020) suggest that the durability of housing causes housing prices to adjust asymmetrically, falling more sharply in response to a negative shock than they rise in response to a positive shock. Housing price adjustments can thus help incomes equilibrate across locations, even with limited labor mobility. Moretti (2013) and Diamond and Moretti (2021) find that real wage differences across US metropolitan areas are smaller than nominal wage differences. An alternative (and readily available) indicator of real labor earnings is the employment rate. As the return to working declines, so too does the willingness to work. Abraham and Kearney (2020) suggest that falling wage rates for less-educated US men was a major force behind the decline in their employment rates in recent decades. Because differences in employment rates across US regions are large and growing (Austin et al., 2016; Charles et al., 2019), it stands to reason that differences in the return to working are widening across regions, too.

Great Recession and the COVID-19 pandemic, Congress often temporarily expands the duration and generosity of UI benefits.[3]

Among the employed, low-wage workers are eligible for the Earned Income Tax Credit, which supplements earnings by a percentage that declines to zero as wages rise; these percentages are set much higher for workers who have dependent children at home (Hoynes, 2019). And low-income households may be eligible for benefits from means-tested entitlement programs, including Medicaid, the Supplemental Nutrition Assistance Program (food stamps), Temporary Assistance to Needy Families, and energy or housing assistance, regardless the employment status of those in the household. Because the generosity of these programs varies widely across US states, as well as among families and over the national business cycle, job or earnings losses caused by the energy transition may trigger transfer payments that end up being highly conditional on location, time, and household structure.

To see how the safety net might address job loss from the energy transition, consider the consequences of the post-1980 decline of coal. During the past 40 years, coal mining has had two major contractions. The first occurred in the 1980s, when oil prices fell from their 1970s highs and caused a major reduction in coal demand (Black et al., 2005); the second came in the 2010s, as natural gas and renewable energy increasingly supplanted coal in generating electricity (Fell and Kaffine, 2018). Following the first shock, employment and earnings fell precipitously in coal counties, which then saw sharp increases in uptake of government transfers across a wide set of programs (Jacobsen and Parker, 2016; Black et al., 2002; Black et al., 2003). At the time, some analysts worried that monetary support for coal communities was insufficient, while others raised concerns that government assistance would create a culture of welfare dependence. To evaluate these possibilities, I examine the regional impacts of the decline of coal over the period spanning 1980 to 2019. Regions exposed to the four-decade coal bust have seen long-run reductions in earnings and employment rates, temporary increases in government income assistance, ballooning Medicare and Medicaid usage, and delayed but substantial net decreases in population, especially among younger workers. The picture that emerges is one of collapsing local labor markets in which gradual net outmigration ultimately leaves behind a population that is disproportionately old, sick, and poor. I discuss options for modifying the social safety net to help communities affected by the coming energy transition avoid the hardship that has afflicted coal country.

An alternative to addressing job loss by targeting individuals is to *target exposed regions* through placed-based policies, which condition assistance on the state of the local economy.[4] These

[3] Although in theory unemployment insurance may cause unemployment rates to rise artificially, evidence suggests that in practice such impacts are small (Chodorow-Reich et al., 2019; Boone et al., 2021).

[4] These policies include broader efforts to help entire distressed towns and cities and narrower efforts to help distressed neighborhoods within larger metropolitan areas. Because the energy transition represents a shock to the comparative advantage of regions as a whole, I focus on the former over the latter set of initiatives. See Neumark and Simpson (2015) for a complete discussion of place-based policies.

policies include tax incentives to recruit or to retain companies, subsidies for worker training, subsidized lending for real estate development, and technical assistance to local business (Bartik, 2020). Because the energy transition is likely to reduce the export capabilities of regions currently specialized in fossil fuels, the role of place-based policies would be to help communities to develop a new export base and to replace the well-paying jobs that have been lost.[5] Such efforts, though clearly ambitious, are justified if they reduce distortions caused by localized spillovers, which if left unaddressed may cause the most skilled workers and innovative firms to further concentrate in superstar cities (Kline and Moretti, 2014b; Fajgelbaum and Gaubert, 2020; Bilal, 2021) and contribute to destructive cycles of industry deagglomeration in distressed regions (Dix-Carneiro and Kovak, 2017). Place-based policies may also be justified if they achieve large gains in equity at small costs to efficiency, such as by transferring resources to communities in which needy households are clustered (Gaubert et al., 2021).

Economists tend to be skeptical of place-based policies (e.g., Glaeser and Gottlieb, 2008; Duranton and Venables, 2018), in part because of their many drawbacks. They may intensify zero-sum tax competition among regions to attract firms (Kim, 2021), be manipulated by elected officials for political gain (Jensen et al., 2015; Slattery, 2020; Slattery and Zidar, 2020), or have their benefits captured by landowners (Ehrlich and Seidel, 2018). These concerns notwithstanding, place-based policies often have long-lived effects on regional specialization (Kline and Moretti, 2014a; Freedman, 2017; Garin and Rothbaum, 2020; Bianchi and Giorcelli, 2022), which suggests that they have the potential to catalyze local investments in human and physical capital.

I discuss options for tailoring place-based policies to address the energy transition. Examples from past policy successes and failures reveal several challenges to applying them successfully. First, most resources are absorbed by tax incentives offered to recruit large companies from outside the targeted region (Bartik, 2020). These incentives appear to have small effects on overall regional economic activity and may divert resources from more effective policy alternatives (Slattery and Zidar, 2020; Bartik, 2022). Second, policy implementation tends to be badly fragmented across state and federal government agencies, which often fail to coordinate their efforts and instead frequently design incentive structures that cause them to work at cross purposes. Third, although worker training is intended to supply workers with skills that potential employers would find attractive, employers are often only weakly involved in these training programs. I close by considering strategies to address these challenges.

2. Regional Employment in Fossil-Fuel-Intensive Industries

The energy transition's potential to disrupt local labor markets draws from the spatial agglomeration of fossil-fuel-intensive industries. Agglomeration arises in part from the

[5] In this context, exporting means selling goods and services to buyers outside of a local labor market, be they elsewhere in the same state, elsewhere in the same country, or in foreign countries.

concentration of energy reserves in relatively few places, and their absence in most others (Moreno-Cruz and Taylor, 2017). These places often specialize in a narrow set of activities and are thus highly exposed to industry-specific shocks. Upstream energy supplies also attract downstream industries that refine and distribute fossil fuels, build equipment for extraction and refining, generate electricity from fossil fuels, or make intensive use of this electricity. By changing how society generates electricity, the energy transition may dent the export capabilities of the regions that specialize in the upstream extraction and refining of fossil fuels, while also dampening downstream consumption.

Forecasters do not know how many fossil fuel jobs will be lost or over what time horizon. But to avoid major contractions, places specialized in extraction and refining may have to find a new export base; places specialized in using fossil fuels in production, either directly as inputs or indirectly via electricity, may have to find new energy sources and methods of production. These challenges are likely to be most acute in the smaller regional labor markets in which industry specialization is greatest. In this section, I review where in the United States employment in fossil-fuel-intensive industries is located and which regions may therefore be most exposed to the adverse effects of the energy transition.

2.a. Fossil-Fuel-Intensive Industries

To characterize regional exposure to decarbonization, I trace the spatial distribution of employment along the energy supply chain. For ease of exposition, I focus on the narrower set of industries that make direct and substantial use of fossil fuels, and not the larger set of industries that use fossil fuels in modest quantities or that indirectly consume inputs that are intensive in fossil fuels. Although this approach may paint an incomplete picture of regional dependence on fossil-fuel-related activities, it is likely to identify the places that would be subject to the first-order impacts of reducing carbon intensity. For national employment totals in energy-related jobs, I use data from the U.S. Energy Employment Jobs Report for 2022.[6] For employment by region, I aggregate local employment by major energy sector up to US commuting zones using data from Ipums.org based on the 2000 US Decennial Census and the 2019 American Communities Survey.[7]

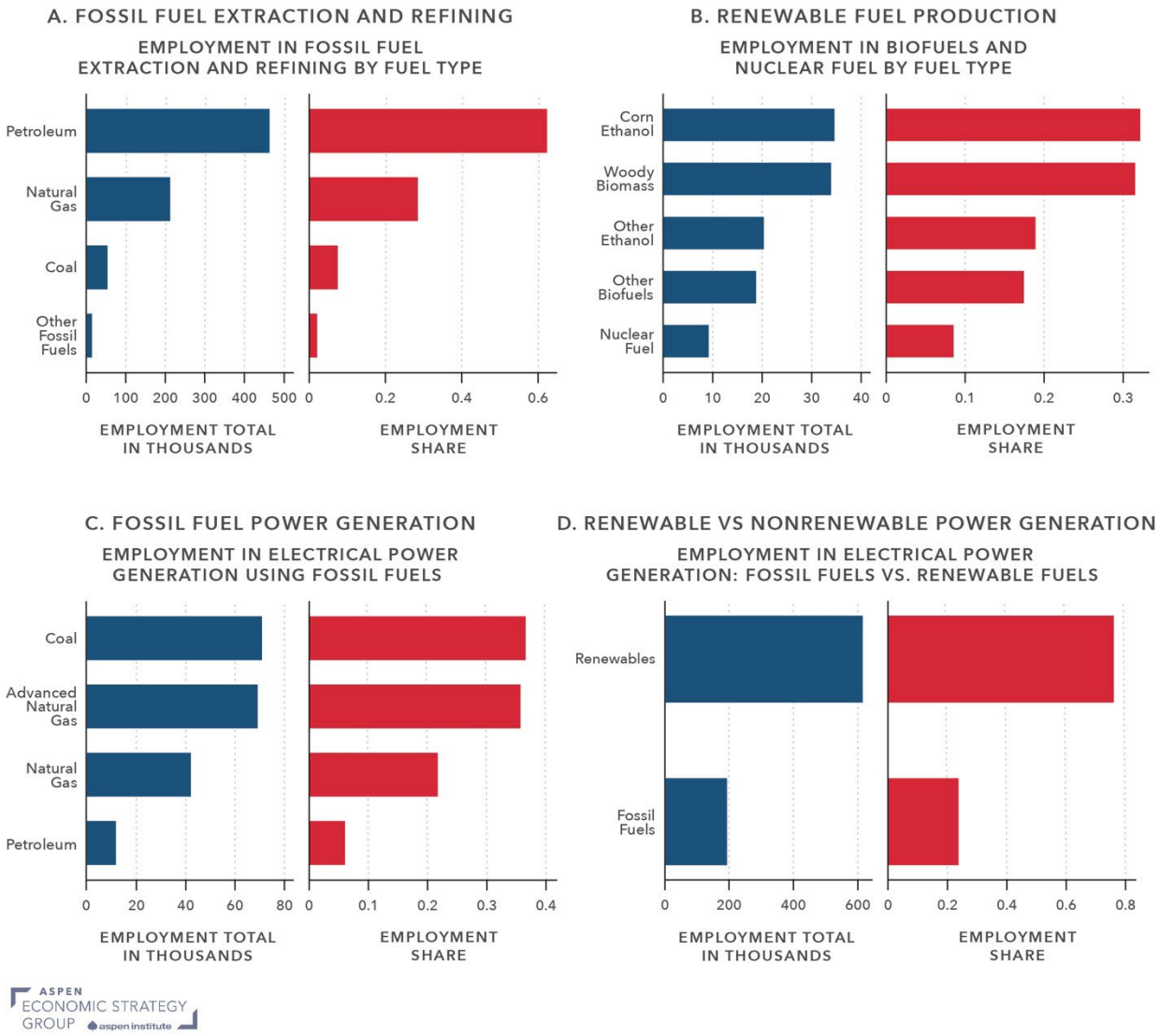
2.a.1. Fossil Fuel Extraction and Refining

At the beginning of the energy supply chain is fossil fuel extraction and refining, which in 2021 employed 729,000 workers (Figure 1A). Extraction is the largest source of jobs in the sector, accounting for 45 percent of the 2021 total. Most extraction jobs (89 percent) are in gas and oil, as opposed to mining coal, which in previous decades was subject to widespread job loss.

[6] See Keyser et al. (2022).
[7] For 2019, I combine ACS annual surveys from 2017, 2018, and 2019, which expands sample sizes in small localities. County-level employment is available for more recent years from the Quarterly Census on Employment and Wages. However, the suppression of data for small cells in this source leaves many counties with missing data in key industries.

Relative to other jobs tied to fossil fuels, employment in extraction is volatile, fluctuating elastically in response to energy prices. The refining of renewable fuels (corn ethanol, woody biomass, and other biofuels) is a small industry by comparison to that for nonrenewables (Figure 1B). In 2021, renewable fuels employed 108,000 workers. Most jobs in the sector are primarily agricultural (for instance, growing corn or tending other biomass). Among prime-age workers (ages 25 to 54) employed in fossil fuel extraction and refining, 69 percent did not have a bachelor's degree in 2019, as compared to 60 percent of all prime-age workers.

Figure 1. Employment in Energy Extraction, Refining, and Electricity Generation, 2021



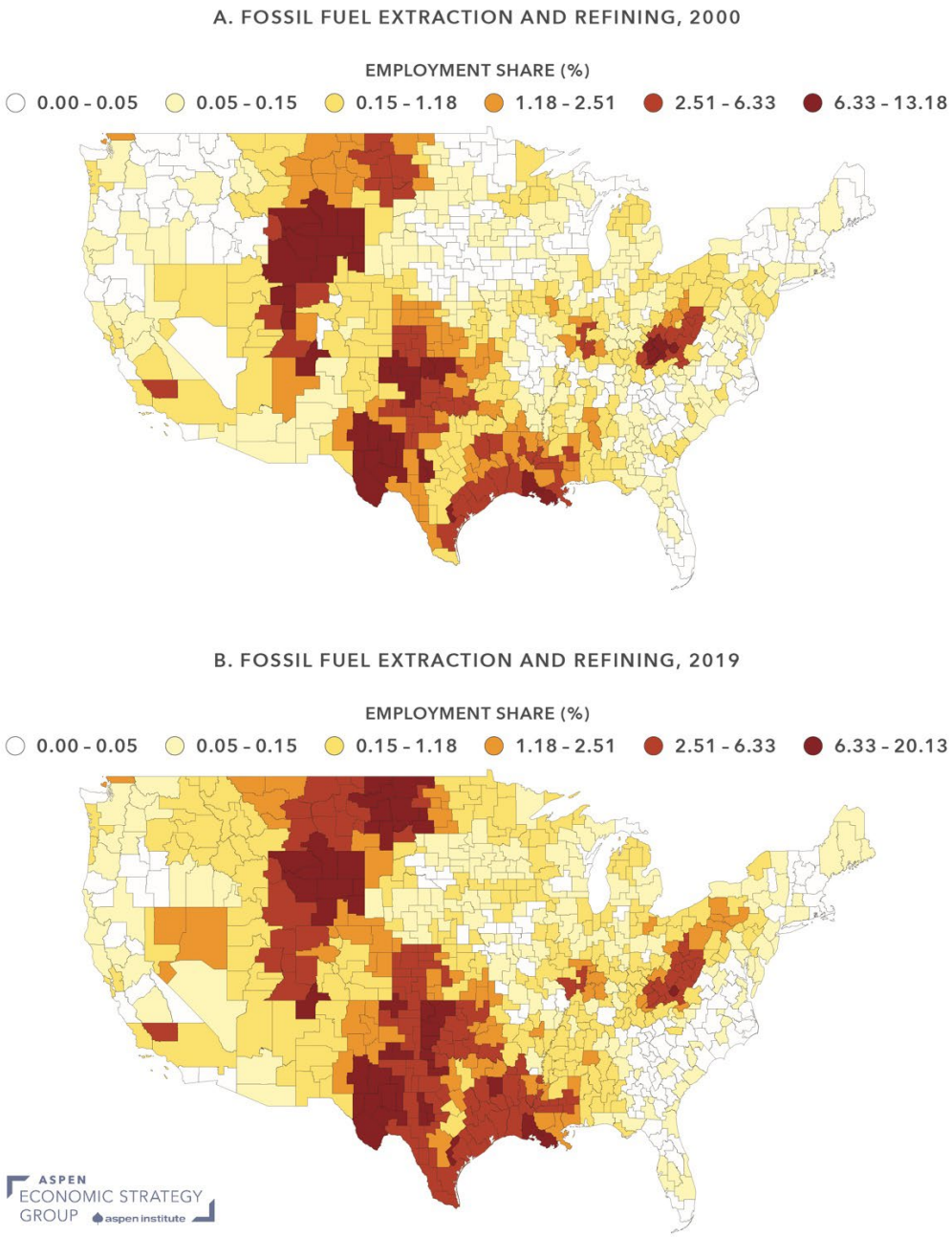
Note: Calculations are based on data from the U.S. Energy Employment Jobs Report for 2022.

Figure 2 shows the share of employment of prime-age workers in fossil fuel extraction and

refining across commuting zones in the continental United States for 2000 and 2019.[8] Specialization in extraction and refining is concentrated in four regions: Appalachia, East Texas-Louisiana, West Texas-Eastern New Mexico-Oklahoma Panhandle, and the Mountain West-northwestern Plains.[9] Excepting Houston and Salt Lake City, few extraction and refining commuting zones overlap with major metropolitan areas. Many are remote from major population centers. Although some production centers, such as the Permian Basin in Texas and the North Dakota oil fields, developed only recently during the fracking boom of the 2000s and 2010s (Bartik et al., 2019), others including Appalachia, East Texas-Louisiana, and western Kentucky have long specialized in fossil fuels. Because of this history, adjusting to worker displacement in these locations may be painful. In 2019, Perkins County, North Dakota, with 7.3 percent of its prime-age employment devoted to extraction and refining, was the commuting zone at the 95th percentile of specialization in the sector. The commuting zones with the highest shares of employment in fossil fuel extraction and refining in that year were Odessa, Texas (20.1 percent); Hobbs, New Mexico (17.4 percent); and Brewster County, Texas (16.5 percent).

[8] In Figure 2, which is based on Census/ACS data, extraction and refining includes oil and gas extraction (NAICS 211), coal mining (NAICS 2121), and petroleum and coal products (NAICS 3241). This definition of extraction and refining is somewhat narrower than in Figure 1, which is based on data from the US Department of Energy.
[9] Smaller clusters include the inland empire of Los Angeles, southern Illinois-western Kentucky, and (sparsely populated) northern Nevada.

Figure 2. Employment in Fossil Fuel Extraction and Refining, 2000 and 2019



Note: The figures show share of employment of prime-age workers (ages 25-54) by commuting zone in fossil fuel extraction and refining using the 2000 Census (5 percent sample) and 2017-2019 ACS (combined 1 percent samples) from Ipums.org. The INDNAICS industries are: oil and gas extraction (211), coal mining (2121), support industries for mining (213), petroleum refining (32411), and petroleum and coal products (3241M). Support services for mining include a small amount of employment in activities unrelated to fossil fuels. The six categories in the legend are for shares in the bottom three quartiles, the 75th–84th percentiles, the 85th–94th percentiles, and the 95th–99th percentiles. See Figure A2A for the change in employment shares over 2000 to 2019.

2.a.2. Electric Power Generation

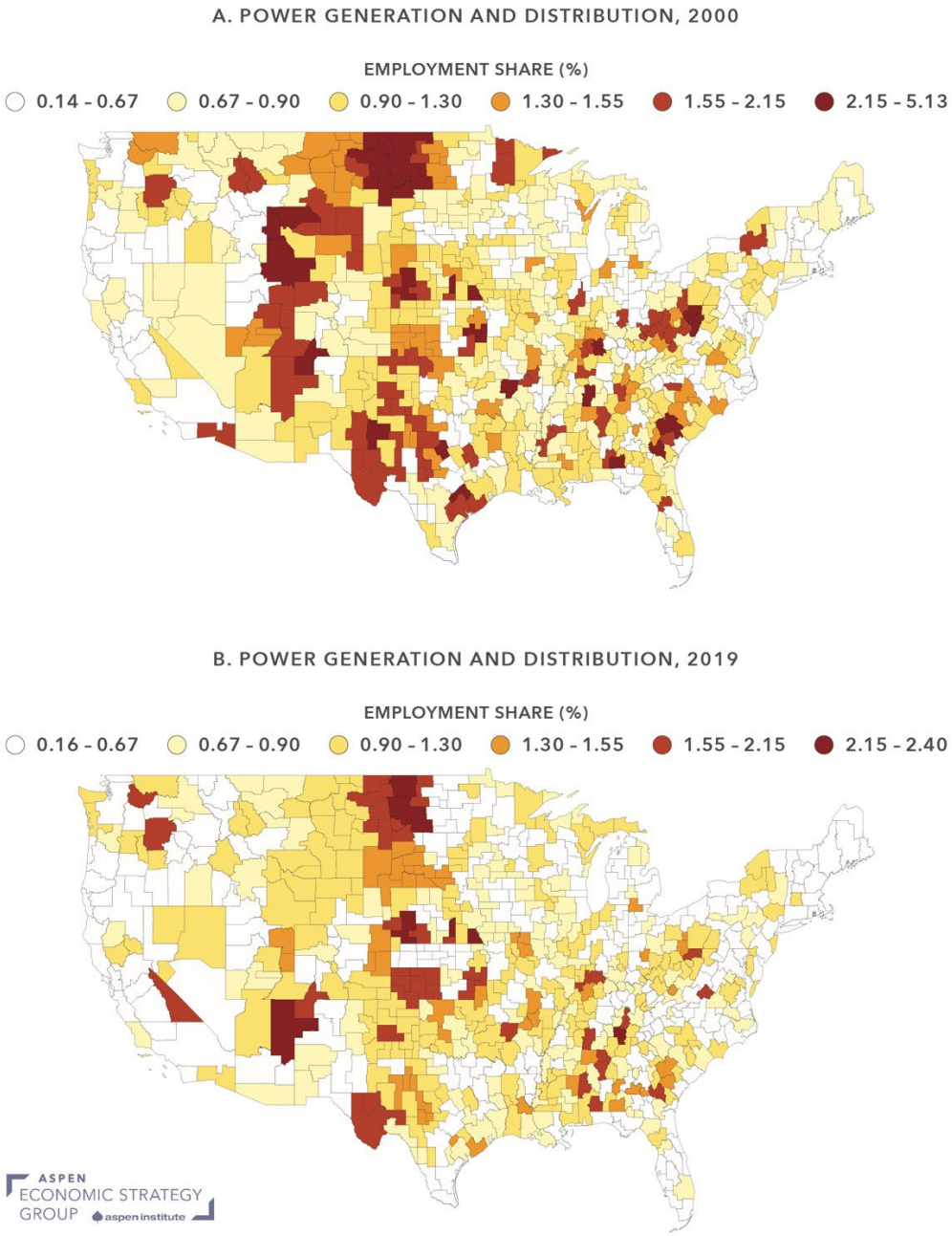
In 2021, electric power generation using fossil fuels employed 194,000 workers (Figure 1C). Newer power plants, which use advanced technologies to burn natural gas cleanly, comprised 36 percent of industry employment, while older power plants, which use legacy technologies to burn coal, gas, and oil, accounted for the remaining 64 percent. This latter group of 125,000 workers are those who are most likely to be exposed to job loss during the energy transition. In 2019, 61 percent of prime-age workers in electric power generation and distribution had a bachelor's degree.

Figure 3 shows regional shares of prime-age employment in power generation and distribution for all energy sources, including renewables.[10] In the large majority of commuting zones, employment shares in power generation and distribution are small. In 2019, less than 5 percent of commuting zones had employment shares in the sector of greater than 2.5 percent. Notable in the figure is the decline in employment shares over time—most commuting zones are seeing a net shift in jobs away from power generation and distribution. This shift appears clearly in Appendix Figure A2B, which shows the change in the share of prime-age employment in power generation and distribution between 2000 and 2019. The retirement of coal-fired power plants may be contributing to these losses (Davis et al., 2021). Meanwhile, the comparatively few commuting zones with employment gains appear to be in areas in which power generation using renewable energy is most prevalent (Raimi, 2021).

Employment in power generation using renewable energy was a sizable 595,000 workers in 2021, as shown in Figure 1. But the sector may have limited potential to absorb workers released from fossil-fuel-intensive industries, for two reasons. First, construction jobs account for 43 percent of this employment figure (and may not be included in the totals shown in Figure 3, which do not count employment that is indirectly linked to power generation). These jobs are likely to remain abundant while renewable power generating capacity is rapidly expanding, but may later decline as the sector matures. Second, power generation in solar, wind, and hydro—the three main sources of renewable energy—is primarily located in places that are sunny, have consistently high winds, or have hydrodynamic potential, many of which are far from where fossil-fuel-based power generation occurs today.

[10] Because Census/ACS data on employment in power generation combine renewable and nonrenewable energy, they differ from the USEER data reported in Figure 1, which exclude power distribution, separate employment according to the energy source used, and add in estimates of construction-related employment that supports the sector.

Figure 3. Employment in Electric Power Generation and Natural Gas Distribution, 2000 and 2019



Note: The figures show share of employment of prime-age workers (ages 25-54) by commuting zone in electric power generation and natural gas distribution using the 2000 Census (5 percent sample) and 2017-2019 ACS (combined 1 percent samples) from Ipums.org. The INDNAICS industries are: electric power generation, transmission, and distribution (211P), natural gas distribution (2212P), and electric and gas and other combinations (221MP). The six categories in the legend are for shares in the bottom three quartiles, the 75th–84thpercentiles, the 85th–94thpercentiles, and the 95th–99thpercentiles. See Figure A2B for the change in employment shares over 2000 to 2019.

2.a.3. Energy-Intensive Manufacturing

Manufacturing industries vary widely in their consumption of electricity and fuels. In 2018, energy costs per dollar of shipments in the most energy-intensive sectors—basic chemicals, iron and steel, nonmetallic minerals, and paper—were seven to 28 times higher than those in the least energy-intensive sectors, including beverages, computers and electronics, furniture, and motor vehicle parts.[11] Historically, manufacturing plants in highly energy-intensive industries saved on energy expenses by locating near power-generating facilities, many of which in turn were proximate to coal or other fossil fuel reserves (Kahn and Mansur, 2013; Glaeser et al., 2015). If power generation continues to shift from fossil fuels to renewables, energy-intensive industries may face cost pressures to relocate closer to these new fuel sources. Such pressures are likely to be felt more strongly by firms that produce tradable goods such as manufactures, which can be produced in many locations, than by firms in nontradable services, whose location is limited by where their customers live.

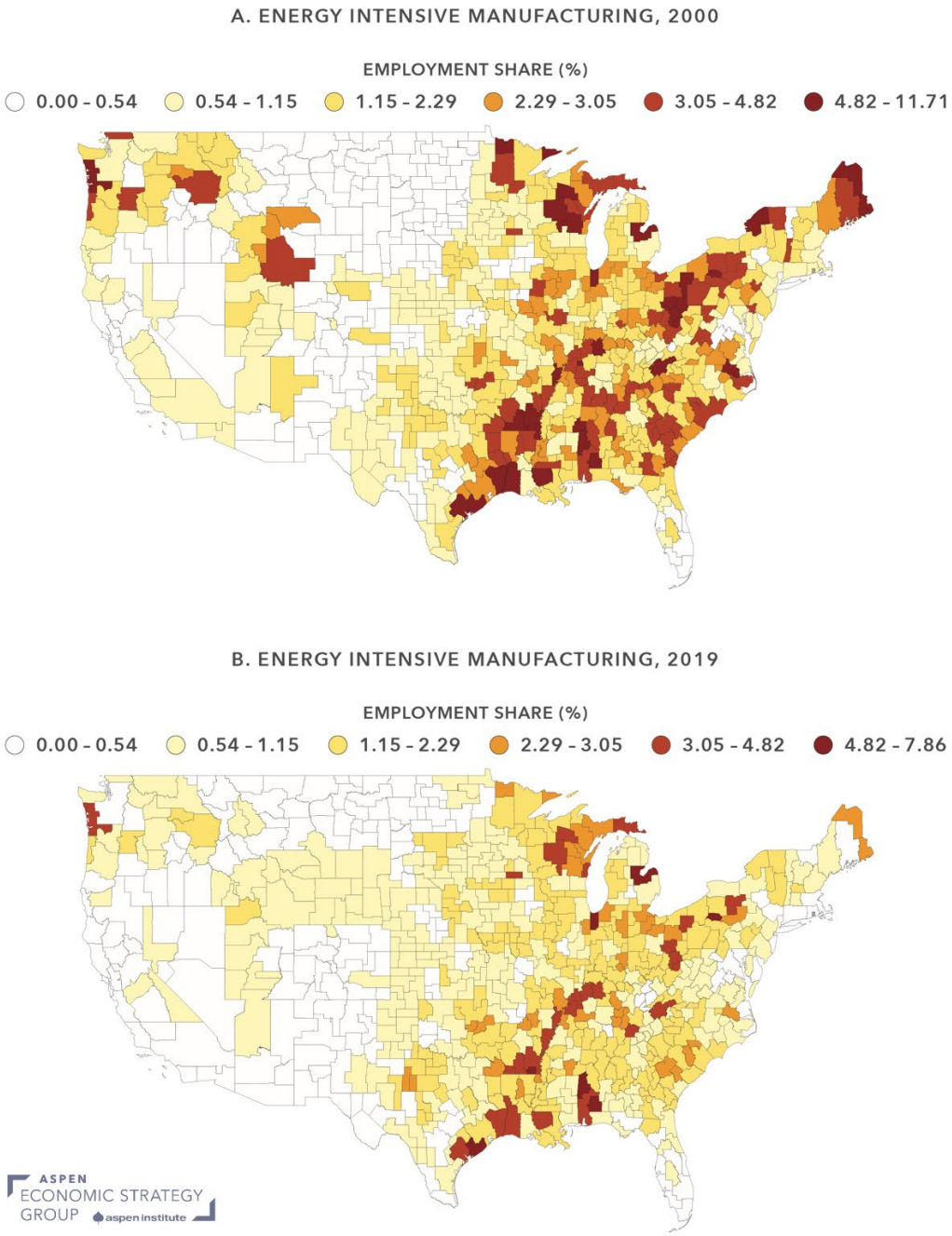
To gauge the potential for such disruption, I examine where employment in highly energy-intensive industries is located. For three-digit NAICS industries within manufacturing, I define as energy-intensive those above the 90th percentile based on average energy used per dollar of shipments for the 2014-2018 period using the NBER-CES Manufacturing Industry Database, which is motivated by the approach in Kahn and Mansur (2013).[12] The electricity and fuel use of these industries were 3.5 to 10.2 times that of the (shipments-weighted) median manufacturing industry over the time period. In decreasing order, the most energy-intensive industries are lime and gypsum, pulp and paper, glass products, industrial chemicals, iron and steel mills, aluminum, clay products, fiber and thread mills, and cement and concrete. In 2018, these nine industries employed a total 731,000 workers, of which 74 percent did not have a bachelor's degree.

Figure 4 shows regional shares of prime-age employment in energy-intensive manufacturing. As of 2019, Mobile, Alabama was the commuting zone at the 95th percentile of specialization in the sector, with 3.1 percent of its prime-age workers employed in energy-intensive production. The commuting zones with the highest employment shares in the sector were Escambia County, Alabama (7.9 percent); Sugar Land, Texas (6.1 percent); and Ashley County, Arkansas (6.1 percent). Declines in employment shares across many commuting zones are readily apparent in the Figure, and are further highlighted in Appendix Figure A2C. The commuting zones where energy-intensive manufacturing employment declined to the greatest extent from 2000 to 2019 were Steubenville, Ohio (-10.1 percentage points); Wheeling, West Virginia (-9.7 percentage points); and Gary, Indiana (-4.8 percentage points). But the data alone leaves unclear whether these employment losses were due to local changes in energy infrastructure or other industry shocks.

[11] These figures are based on averages for the 2014-2018 period using data on three-digit NAICS industries from the NBER-CES Manufacturing Industry Database.

[12] This definition of energy intensity is based on the direct consumption of energy and not the indirect consumption via the purchase of inputs that are themselves energy-intensive.

Figure 4. Employment in Energy Intensive Manufacturing, 2000 and 2019



Note: The figures show share of employment of prime-age workers (ages 25-54) by commuting zone in energy intensive manufacturing using the 2000 Census (5 percent sample) and 2017-2019 ACS (combined 1 percent samples) from Ipums.org. The INDNAICS industries are: fiber, yard, and thread mills (3131); pulp, paper, and paperboard (3221); industrial chemicals (325M); clay products (3271); glass products (3272); cement and concrete (3273); lime and gypsum (3274); iron and steel mills (3311); and aluminum (3313). The six categories in the legend are for shares in the bottom three quartiles, the 75th–84th percentiles, the 85th–94th percentiles, and the 95th–99th percentiles.

2.a.4. Other Sectors

Other significant sectors related to the fossil fuel industry include retail gas and motor vehicle manufacturing. Retail gas stations employed 938,000 workers in 2021. Because they provide a nontradable service, gas stations tend to be distributed across the country in proportion to the size of local populations. Replacing traditional cars and trucks powered by internal combustion engines with electric vehicles would reallocate employment from gas stations to vehicle charging stations. Although this shift may require a nationwide response from a large population of workers, it is unlikely to be much more disruptive in some regions than in others. As manufacturers expand production of electric vehicles, they will reduce the demand for labor producing traditional power trains and increase the demand for labor producing batteries and related parts. In 2021, 54,000 workers produced motor vehicle gasoline engine and parts (NAICS 33631), out of total employment in motor vehicle parts of 539,000 (NAICS 3363); an additional 73,000 workers produced motor vehicle power train components (NAICS 33635). Over three-quarters of employees in these jobs are production workers, and there is little way to predict how the move to electric vehicles will affect where these jobs are located or how many employees will remain necessary.

2.b. Prospects for the Energy Transition

Reducing the carbon intensity of US power generation and manufacturing output would have sweeping effects on the jobs that workers perform and where they perform them. Dealing with job loss is a familiar challenge for regions engaged with fossil fuels. The volatility of energy prices has subjected these regions to repeated cycles of boom and bust.[13] In the past, local economies have expanded when energy prices have risen and stayed high, with employment and wage rates rising in concert; to the contrary, local economies have contracted when energy prices have fallen and stayed depressed, with many workers losing their jobs. But the energy transition is not likely to subject these economies to short-lived fluctuations; rather, it will herald a permanent reduction in the demand for fossil fuels. Regions that have weathered past booms and busts would now face the stiffer challenge of helping many local residents to find entirely new careers and perhaps to move elsewhere.

A substantial body of research demonstrates that job loss is scarring (Topel, 1990; Ruhm, 1991). Six years after their displacement, workers who were laid off because their employer either shut down or dramatically downsized earn 13 to 25 percent below their pre-displacement salaries, relative to otherwise similar workers who were not let go (Jacobson et al., 1993; Couch and Placzek, 2010). These losses are more severe when they recur during a recession (Davis and von Wachter, 2011; Huckfeldt, 2022).

[13] On regional booms and busts in energy production, see Michaels (2011), Jacobsen and Parker (2016), Allcott and Keniston (2017), Feyrer et al. (2017), Bartik et al. (2019), Clay and Portnykh (2018) and Kearney and Wilson (2018).

But worker displacement that is more concentrated in place and time entails even greater repercussions. Import competition from China, for instance, produced greater job losses in commuting zones that were initially more specialized in their core manufacturing industries (Autor et al., 2022). And regions that undergo more severe recessions see larger drops in employment rates not just initially but in the medium and longer run (Yagan, 2019).

Appendix Figure A3 shows regional employment shares of prime-age workers in fossil-fuel-intensive industries when combining fossil fuel extraction and refining, natural gas distribution, and energy-intensive manufacturing. In 2019, the top 5 percent most specialized commuting zones in these sectors had between 8.9 percent (Bismark, South Dakota) and 21.1 percent (Odessa, Texas) of their prime-age workers employed in industries closely tied to fossil fuels. None of these exposed communities is a major metropolitan area. The largest commuting zone in this group—Lafayette, Louisiana—had a 2019 population of 409,000 inhabitants. Others are smaller towns spread across eastern New Mexico, North Dakota, eastern Oklahoma, East and West Texas, West Virginia, and Wyoming. If the energy transition were to cause a rapid decline in these communities' core export industries, the local consequences could be devastating.

3. Dealing with Job Loss

In this section, I discuss policy options for addressing the consequences of job loss. The familiar approach in federal US policy is to provide targeted income assistance and training to individuals that depends on their employment and disability status, income, and family structure. Social assistance programs (partially) insure individuals against the consequences of being laid off or suffering a large drop in earnings while remaining employed. Such programs may help people to manage the immediate consequences of displacement and provide the financial cushion they need to search for a new position or to retrain for a new line of work. A perhaps less familiar approach targets places by tuning assistance to local economic conditions. These "place-based" policies are enacted through overlapping efforts by federal, state, and local governments; they are meant to encourage firms to invest in promising ventures and workers to invest in skills that employers find desirable—which local economic conditions may otherwise prevent them from doing—thereby helping a region out of depressed earnings and employment rates. I discuss policy frameworks for achieving these objectives and the drawbacks that may limit their effectiveness. To connect the policy discussion directly to the energy transition, I consider how local labor markets have adjusted to employment declines in coal mining since 1980.

3.a. Targeting Individuals: The Social Safety Net

The social safety net exists to help people adjust to negative shocks to their employment status, income, and health. Because adverse selection and moral hazard impede private markets from supplying adequate wage insurance, such insurance tends to be provided by the government. The demand on social insurance most likely to be occasioned by the transition to renewable energy is

helping individuals to manage the consequences of permanent job loss. In the shorter run, the jobless need to replace lost income; in the longer run, they need to find a new line of work at a desirable wage. I discuss the adequacy of the US social safety net to meet these challenges in the context of the energy transition.

3.a.1. Programs

The programs that comprise the safety net include social insurance programs, which people pay into, partially covering the programs' costs, and transfer programs, which are financed out of general tax revenues.

Unemployment Insurance. The front-line policy to address job loss is unemployment insurance. Those who lose their jobs through no fault of their own and who meet work history and minimum earnings requirements are eligible to receive 26 weeks of UI benefits. Benefits are typically set at somewhere below half of the recipient's pre-displacement wage, up to a cap, but vary substantially by state. In January 2020, just prior to the COVID-19 pandemic, maximum weekly benefits ranged from a low of $235 in Mississippi to a high of $823 in Massachusetts. Receipt of UI benefits can affect eligibility for other social assistance programs.

Public Assistance Programs. These programs tend to be oriented more toward alleviating poverty than toward returning previously gainfully employed people to work. Medicaid provides access to subsidized healthcare for those with low incomes. The Supplemental Nutrition Action Program (SNAP) provides a debit card for food purchases to households that have incomes less than 130 percent of the federal poverty line and that meet other eligibility requirements.[14] For those who qualify, there is no time limit for benefit receipt. Temporary Assistance for Needy Families (TANF) provides direct cash assistance to low-income families with children. Benefits are calculated as a decreasing function of income and are modest, maxing out at 27 percent of the federal poverty line; most states impose a five-year limit on benefit receipt over a recipient's lifetime. Supplemental Security Income (SSI) is available to adults who are over age 65, blind, or disabled, and are in lower income brackets. In 2021, monthly benefits were limited to $841 for a qualifying adult and $1,261 for a qualifying couple. Other income assistance programs, which are small in the aggregate, include the Free and Reduced Price Lunch program, the Special Supplemental Nutrition Program for Women, Infants, and Children, energy assistance, and housing assistance (East and Simon, 2020).

Social Security Programs. The Social Security Administration provides retirement benefits to qualifying people of retirement age (age 62 or older), disability insurance benefits to those who are deemed to be permanently disabled, and payments to the surviving spouses and children of previously qualifying recipients. Prior research finds that uptake of Social Security Disability Insurance (SSDI) increases during economic downturns, and that those who take up SSDI during

[14] In 2021, the federal poverty line was $12,880 for a one-person household and $26,500 for a four-person household.

downturns tend to exit the labor force permanently and to remain benefit recipients until retirement or death (Autor and Duggan, 2003; Maestas et al., 2018; Kearney et al., 2021). Although not the program's original intent, SSDI appears to be used predominantly by people whose labor market prospects have deteriorated.

Earned Income Tax Credit. The Earned Income Tax Credit (EITC) transfers money to low-income households with positive earned income (Hoynes, 2019). The subsidy depends heavily on having dependent children in the household. In 2019, for a single head of household with no children, the income limit for benefit eligibility was $15,570 and the maximum benefit was $529; for a single head of household with two children, these values rose to $46,703 and $5,828. Most benefits are received by poor single mothers who work. Research indicates that the EITC reduces poverty and improves long-run outcomes for children in poor households, but given that it is conditioned on positive earnings, it is by design not a reliable source of income assistance for people who are out of work for a year or longer.

3.b. The Safety Net and Job Loss

How well do safety net programs perform in helping workers to deal with the consequences of job loss? East and Simon (2020) use longitudinal data from the Survey of Income and Program Participation over 1996 to 2018 to evaluate how social assistance helps workers who have been displaced.[15] Unemployment insurance is by far the most important program in helping the jobless to replace lost income, at least in the months immediately following displacement. UI payments are mildly regressive by design. In the months following displacement, workers with household incomes below the poverty line had 21 percent of their lost earnings replaced, while workers in households whose income was one to five times the poverty line saw 26 to 28 percent of their income replaced. And although participation in means-tested entitlement programs increases substantially in the aftermath of job loss—at least for workers in households with incomes less than 200 percent of the federal poverty line—these programs replace small amounts of income relative to UI payments. Whereas UI benefits provided an average of $560 in extra monthly income just after job loss, SNAP—the entitlement program most responsive to displacement—provided just an extra $10 in monthly income.

Despite its promise, unemployment insurance also features potential drawbacks in dealing with job loss. One is that its benefits may be too generous, encouraging workers to stay out of work for longer and potentially reducing economic efficiency and aggregate income (see, e.g., Barnichon and Zylberberg, 2021). But in practice, extra UI benefits do not appear to reduce aggregate employment. During the Great Recession, Congress increased the potential duration of UI receipt from 26 to as many as 99 weeks. States with higher unemployment rates were allowed to provide benefits for longer, and because many local labor markets straddle state boundaries, UI benefits often differed substantially between adjoining counties that shared a local labor

[15] Their analysis does not include the contribution of the EITC to income replacement for displaced workers.

market. Between 2009 and 2013, differences in UI benefit duration between these adjoining counties were commonly greater than five weeks and occasionally greater than 10 weeks. Comparing adjoining counties located in different states, Boone et al. (2021) find no evidence that counties offering more substantial UI benefits witnessed lower employment as a result. Other approaches find similar evidence of the limited macroeconomic consequences of increased UI benefits during the Great Recession (Chodorow-Reich et al., 2019). Governments that expand UI benefits during periods when local labor markets are in severe recession appear not to significantly risk adverse consequences.

A second potential pitfall of unemployment insurance as a response to job loss is that benefits may not be generous enough. At the exhaustion of UI benefits, individual spending drops sharply (Ganong and Noel, 2019), which is consistent with binding liquidity constraints. Such constraints may impede recipients from investing in training, job search, or moving to a new location, and these constraints may be more binding in local labor markets that are more depressed. There may therefore be cause to tune benefits to local economic conditions. The federal program implicitly recognizes the need for increased benefits in times of distress: since 1970, states have been allowed to provide 13 to 20 weeks of additional UI benefits if their unemployment rate exceeds a trigger. Yet these triggers are so stringent that they are rarely enacted, and even when they are enacted the extra benefits may be too small to improve long-run worker outcomes (Chodorow-Reich et al., 2022). A further problem is that when dealing with highly localized shocks, tuning benefits to state-level economic conditions may be too coarse to be effective. Figure A3 speaks to variation in economic conditions within states. Both employment shares in fossil-fuel-intensive industries (panel B) and changes in these shares between 2000 and 2019 (panel C) vary widely within states, suggesting that using state-level unemployment triggers to tune UI benefits to local economic conditions may be insufficient for addressing job loss from the energy transition. A better trigger may be the unemployment rate in the local labor market.

In a 2021 paper written for the AESG, VonWachter (2021) argues that income support and workforce programs run through the UI program are underutilized by the most vulnerable workers who are most likely to benefit from them. He makes specific suggestions for improving the delivery of assistance through UI, including the use of targeting income support and workforce services to workers at risk of poverty or of adverse consequences from job loss and long-term unemployment, expanding Short-Time Compensation programs, instituting automatic triggers to benefit and eligibility expansions, and reforming the UI data infrastructure systems to improve real-time decision-making.

3.c. Local Labor Market Adjustment to the Decline of Coal

The repercussions of the coal industry's decline since 1980 may presage the coming energy transition's consequences on the labor market. Because coal production is so spatially agglomerated, the shock that resulted from its decline was highly localized. How measures

including earnings, employment, and the uptake of government transfers responded to the coal bust provides a glimpse of how well past policies performed in addressing concentrated job losses. In this section, I extend the analysis on labor market adjustment to the 1980s coal bust in Autor et al. (2022) to cover the decline of coal over the entire time period between 1980 and 2019. Both analyses build on Black et al. (2005), who find that during the 1983-1993 coal bust, counties more specialized in coal in Kentucky, Ohio, Pennsylvania, and West Virginia incurred larger decreases in employment rates, total earnings, and earnings per worker, and larger increases in the uptake of government transfers.

Figure 5 plots US employment in coal mining from 1969 to 2021. It demonstrates a boom in coal production during the 1970s—employment in coal rose from 140,000 workers in 1969 to 234,000 workers in 1979—caused by surging energy prices during the decade's two major oil price shocks. After 1980, coal prices and then jobs began an extended decline. Employment fell to 136,000 workers in 1990 and to 72,000 workers in 2000. After a brief rebound in the 2000s, coal employment plummeted again in the ensuing decade, dropping to 51,000 workers in 2019, just before the COVID-19 pandemic. The industry then shed another 13,000 jobs during the first two years of the pandemic.

Figure 5. The Decline of Employment in Coal Mining

Note: Data are from the BEA National Industry Product Accounts.

To consider how the loss of coal jobs affected local labor markets specialized in coal, I rank commuting zones based on their exposure to the national decline in coal mining that took place between 1980 and 2019 and then compare the outcomes of zones at the median with those at the 95th percentile of exposure.[16] Because zones near the median had virtually no employment in coal to begin with, the comparison describes how the most highly exposed regions fared relative to regions that were not directly affected by coal's decline. Figure 6 shows the average differential changes (i.e., for commuting zones at the 95th versus 50th percentiles of exposure) in employment among working-age (18-64) adults (panel A), compensation per worker (panel B), and the size of the working-age population (panel C) over various time horizons (x-axis).

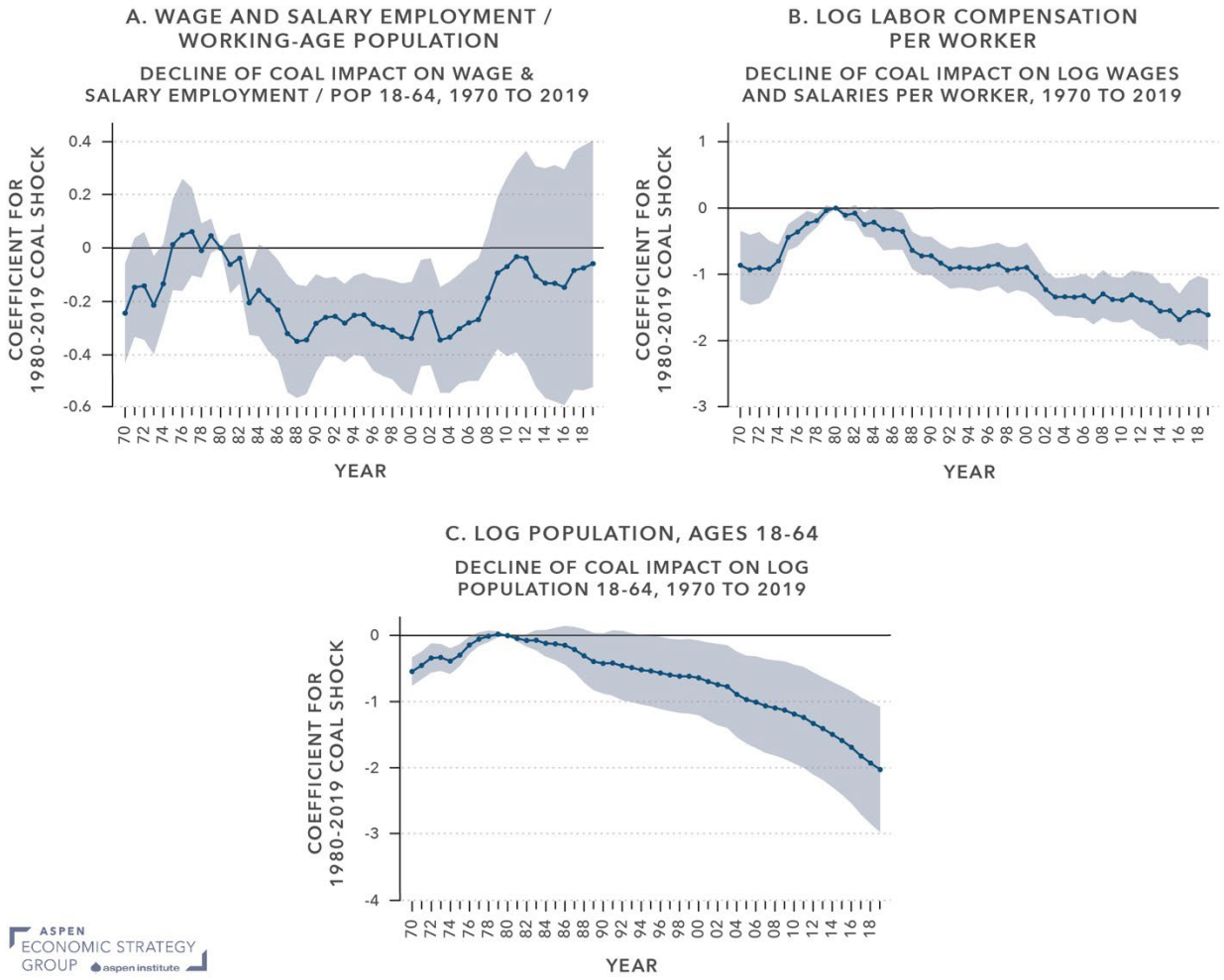
Employment, Earnings, and Net Migration. Relative to the median commuting zone, local labor markets that were most exposed to the coal shock had larger declines in employment rates, average compensation per worker, and the size of the working-age population. These results are highly statistically significant over most time horizons. The negative impact of the coal shock on employment rates persisted from the 1980s through the 2000s, and then attenuated in the 2010s, despite the intensification of the coal shock in that decade. Population declines (panel C) might possibly indicate why employment rates recovered. Commuting zones more exposed to the coal shock ultimately saw larger declines in head counts of the working-age population, which is consistent with positive net outmigration. Krause (2022) finds that younger and more-educated workers were those most likely to leave exposed Appalachian counties, and the results of this analysis support these conclusions.[17] Negative population impacts were much stronger for the cohort from age 18 to 39 than for the cohort from age 40 to 64 (see Figure A1). Even though the coal decline began in the 1980s, substantial relative population declines do not begin to register until the 2000s and especially the 2010s. Although net outmigration ultimately may have helped to reduce gaps in employment rates between coal country and other regions, the process took decades to initiate and to play out. A push factor for departures was the decline in average labor compensation in coal-impacted regions, which is evident in Figure 6B.[18]

[16] I undertake regression analysis in which I project changes in commuting zone outcomes over varying time horizons on a commuting zone's exposure to the national decline in coal mining that occurred from 1980 to 2019. The Appendix gives complete details. The graphs below show, for a given labor market outcome, regression-based estimates of how the nationwide decline in coal affected a commuting zone at the 95th percentile of exposure to the coal shock relative to a commuting zone at the median of exposure to the coal shock, for time horizons that extend from 1980, when the coal bust began, to one year later (i.e., 1981) out to 39 years later (i.e., 2019). In the analysis, I control for many other factors that could have affected local labor market outcomes over the time period, including access to college-educated workers, exposure to immigration, exposure to the decline of manufacturing (including the China trade shock), and other potential confounds. Because of the distorting effects of the COVID-19 pandemic, I conclude the analysis in 2019.

[17] See Appendix.

[18] Because these are average wages, they are subject to composition bias. Average wages likely fell in part because those who left in larger numbers were more-educated workers (Krause, 2022). Declines in the local cost of housing caused by the coal shock may have softened the impact of falling nominal earnings on real incomes.

Figure 6. Impact of the Decline of Coal on Employment, Earnings, and Population

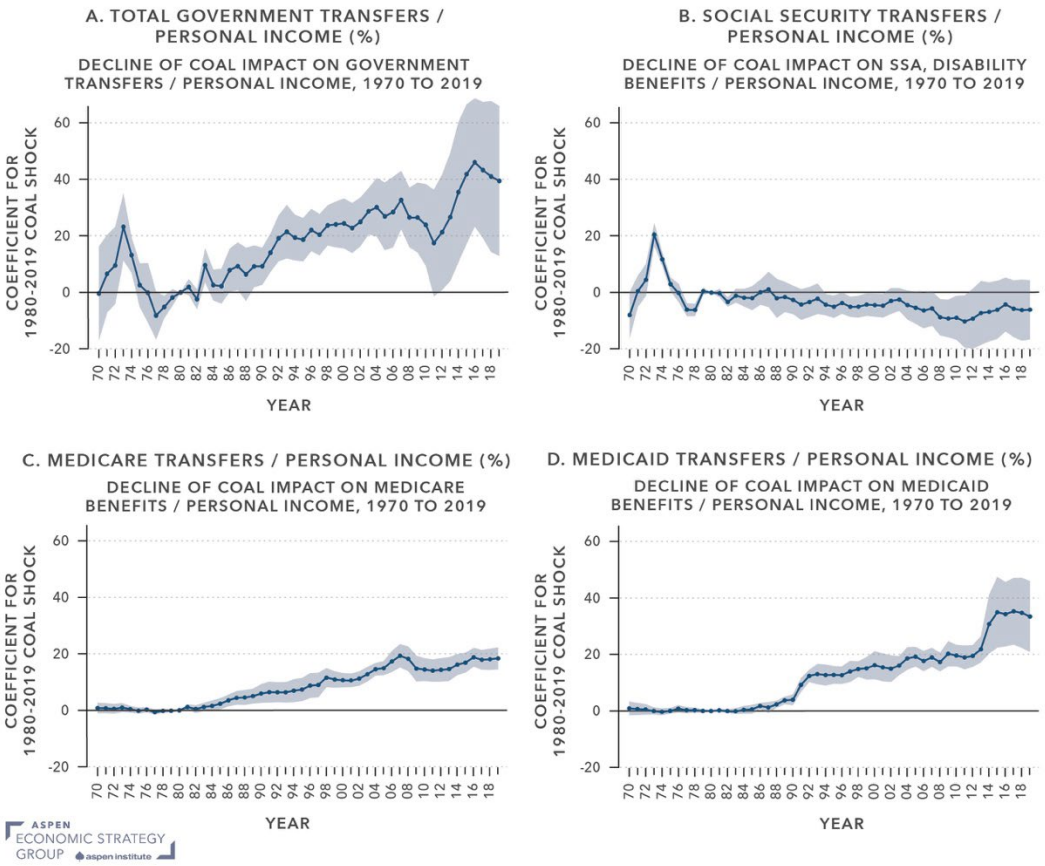


Note: The panels report OLS coefficient estimates for the coefficient β_{1h} in equation (1) (see Appendix) and 95 percent confidence intervals for these estimates. The dependent variable is the change in the indicated measure between 1980 and the year on the horizontal axis; the coal shock is defined in equation (2); and the control variables are described in the Appendix. Regressions are weighted by the commuting zone working-age population in 1980; standard errors are clustered by state.

Government Transfers. How did government transfers respond to falling wage and employment rates in coal country? Prior research shows that during the 1990s counties with larger declines in coal employment registered sharp increases in UI payments (Jacobsen and Parker, 2016), uptake of transfers from Aid to Families with Dependent Children (the precursor to TANF) (Black et al., 2003), and participation in disability programs (Black et al., 2002). Using data from the BEA Regional Economic Information System (REIS), I consider the full range of government transfers to which locals would have had access and the long-run impact of coal's decline on benefit uptake. Figure 7 shows the impact of the decline of coal on the change

in total government transfers (panel A), Social Security retirement and disability benefits (panel B), transfers associated with Medicare (panel C), and transfers associated with Medicaid (panel D), each expressed as a percentage of total personal income.[19] For total government transfers, Figure 7A demonstrates that relative to the commuting zone at the median of shock exposure, a commuting zone at the 95th percentile of shock intensity experienced a stunning 40 percentage-point larger increase in government transfers as a share of personal income. Figures 7C and 7D reveal that nearly all of this increase was due to differentially greater uptake of Medicare and Medicaid benefits in local labor markets that were more exposed to the coal bust. By contrast, the long-run impact of the coal shock on increased uptake of Social Security benefits, which includes retirement and disability payments, was essentially null.

Figure 7. Impact of the Decline of Coal on Government Transfers



Note: The panels report OLS coefficient estimates for β_{1h} in (1) and 95 percent confidence intervals for these estimates (see Appendix). The dependent variable is the change in the indicated measure

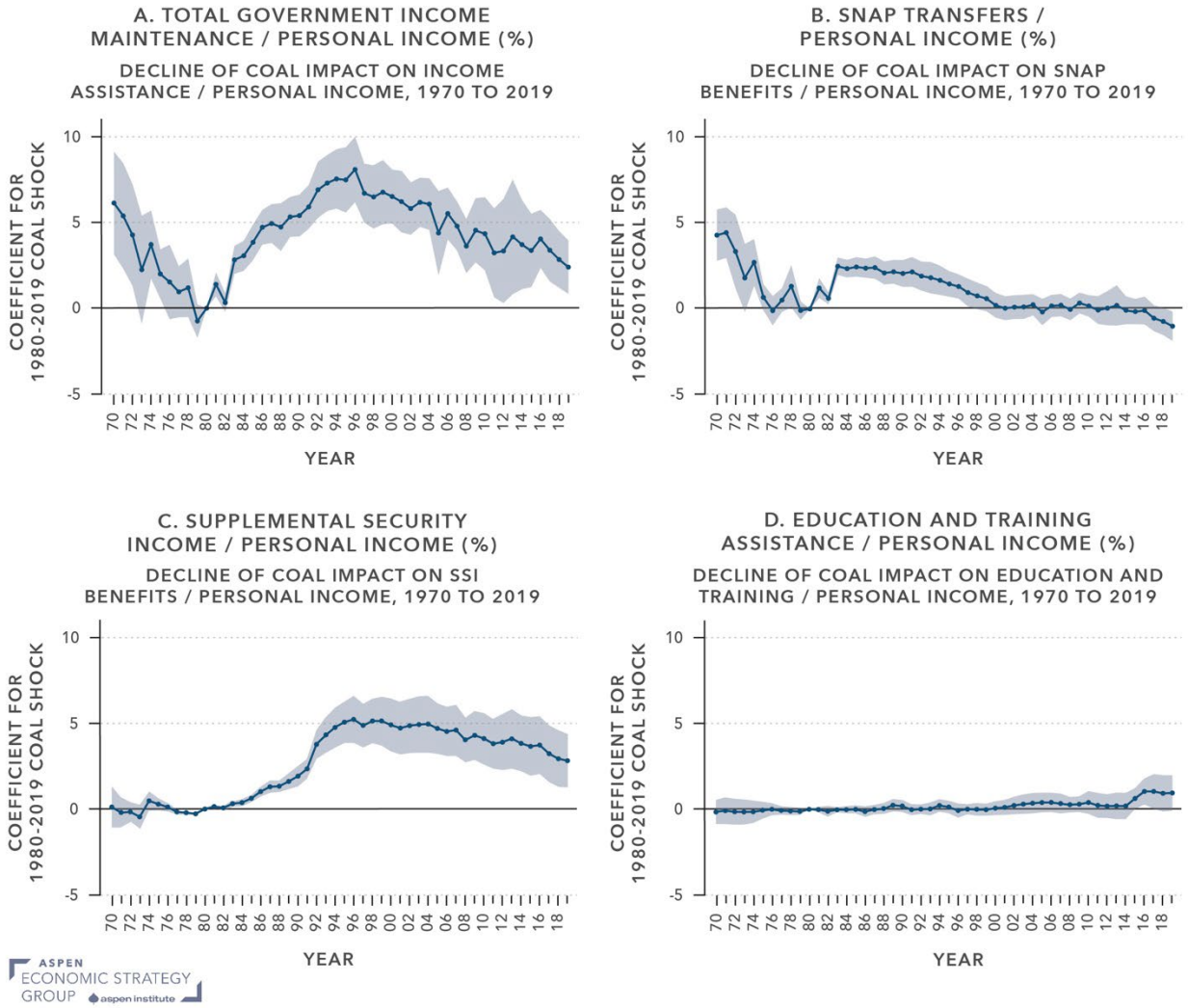
[19] BEA estimates of county personal income include labor compensation (wages, salaries, bonuses, employer contributions to health and pension plans), proprietor income (income of sole proprietorships, partnerships, tax-exempt cooperatives), financial returns (rent, interest, dividends, realized capital gains), government transfers (both cash and in-kind), and adjustments to capture income by place of residence. BEA personal income thus approximates aggregate local income. I aggregate county personal income up to the level of the commuting zone.

between 1980 and the year on the horizontal axis; the coal shock is defined in (2); and the control variables are described in the Appendix. Regressions are weighted by the commuting zone working-age population in 1980; standard errors are clustered by state.

Finally, I consider the impact of the decline of coal on uptake of government income assistance programs, which is shown in Figure 8. Commuting zones more exposed to the decline of coal saw larger long-run increases in total government income maintenance as a share of personal income (panel A).[20] However, the impacts were modest relative to those for Medicaid and Medicare. Highly exposed commuting zones saw increases in income assistance as a share of total personal income only five percentage points higher than the median commuting zone, a minor difference in comparison to the near 40 percentage-point differential for Medicaid and Medicare combined. Likewise, in the short- to medium-run, commuting zones more exposed to the coal shock had greater uptake of food stamps (panel B), but these impacts shrank to zero by later in the shock period. Panel C indicates that nearly all of the long-run increase in uptake of government income maintenance in commuting zones more exposed to the coal shock was in the form of Supplemental Security Income, which is primarily distributed to the elderly poor and the disabled poor. Important for the discussion of placed-based policies, the coal shock had close to zero impact on the uptake of education and training assistance (panel D), including programs intended to help displaced workers retrain for new careers. Although individuals in communities exposed to the decline of coal may have received more income maintenance benefits in the short run, in the longer run such differences were small.

[20] Income maintenance includes Supplemental Security Income, the Earned Income Tax Credit, Supplemental Nutrition Assistance, and other benefits including foster care and adoption assistance, child tax credits, energy assistance, and vouchers under the Special Supplemental Nutrition for Women, Infants and Children (WIC) program.

Figure 8. Impact of the Decline of Coal on Government Transfers



Note: The panels report OLS coefficient estimates for β_{1h} in (1) and 95 percent confidence intervals for these estimates (see Appendix). The dependent variable is the change in the indicated measure between 1980 and the year on the horizontal axis; the coal shock is defined in (2); and the control variables are described in the Appendix. Regressions are weighted by the commuting zone working-age population in 1980; standard errors are clustered by state.

Summary. The picture that emerges of regional adjustment to the decline of coal is bleak. Places highly specialized in coal saw declines in employment and wage rates that persisted for 20 years or longer. On net, younger job-seekers ultimately left the areas in large numbers to pursue opportunities elsewhere, but their outflows took decades to fully materialize. The population that remained, which tended to have considerably less education than the groups that left, became substantially more dependent on government transfers, primarily in the form of subsidized healthcare. The decline of coal appears to have left behind communities that are smaller, older, sicker, and with sharply lower average earnings power.

3.d. Targeting Regions: Place-Based Policies

Even the best-designed social safety net may be only partially effective in a local labor market that is severely depressed. More substantial and longer-lasting UI benefits may not help laid-off employees to avoid the scarring effects of joblessness in a market in which few return to work. The consequences of the decline of coal and the China trade shock are sobering reminders that regional economies that fall into distress can remain distressed for decades. Because the mobility choices of less-educated workers tend to be unresponsive to negative local labor demand shocks in the medium and even long run, policies that target individuals may only go so far in helping regional economies to escape the hardship that has accompanied recent episodes of widespread worker displacement. Region-level challenges call to mind region-level solutions, such as place-based policies.

3.d.1. Promises and Drawbacks of Place-Based Policies

Designing effective place-based policies requires understanding the imperfections that complicate how markets work. One is the combination of immobile labor (e.g., less-educated workers not leaving when the local economy hits hard times), mobile capital (e.g., firms responding to downturns by shutting down their operations to relocate elsewhere in the United States or abroad), and the myriad economic benefits that come from clustering firms and workers together in larger cities (see, e.g., Fajgelbaum and Gaubert, 2020; Bilal, 2021). In such a context, industry disruptions—be they from globalization, technological change, or new environmental regulations—can trigger localized processes of industry growth or decline that are self-reinforcing (Diamond, 2016; Dix-Carneiro and Kovak, 2017). In places beset by negative shocks, firms exit, wages decline, and workers who are tied to the region suffer losses in real income, though falling housing prices can offset some of these impacts.[21] More-educated workers become less likely to stay in the region, and their absence further hinders the attractiveness of a location to firms looking for a place to invest. Interventions that induce either more productive workers or firms to relocate to distressed regions can raise well-being nationally. In practice, these outcomes may also be achieved by helping high-potential firms and workers located in distressed regions to improve their capabilities (for instance if lower-income workers and newer, smaller firms face disadvantages in obtaining loans). More generally, localized employment creation can improve well-being if it targets places in which joblessness is relatively damaging (Wilson, 2011), and in which the non-employed eagerly take up jobs when offered the opportunity to work (Austin et al., 2016; Bartik, 2022).

Perhaps the most notable application of place-based policies in the United States was the Tennessee Valley Authority (TVA), which began in 1933 and used federal money to build bridges, canals, highways, power plants, and schools throughout the impoverished Appalachian

[21] Falling housing prices can have negative consequences, too. A decline in home equity reduces the collateral that potential entrepreneurs can put forward to obtain loans to start new businesses. Housing-market declines are commonly followed by reduced job creation in new enterprises (Davis and Haltiwanger, 2019).

region over several decades.[22] Kline and Moretti (2014a) find that in treated counties the TVA temporarily expanded employment in agriculture and permanently expanded employment in manufacturing. But their results highlight a central weakness of placed-based policies: they may reallocate activity across space without raising national income; in the case of the TVA, the region's manufacturing gains were offset by manufacturing losses elsewhere in the United States.[23] As discussed in the 2020 AESG paper by Timothy Bartik, recent evidence suggests that place-based policies may be zero-sum even within regions, expanding employment in targeted sectors but leaving aggregate employment unchanged (Ehrlich and Seidel, 2018; Slattery and Zidar, 2020). Zero-sum competition seemed egregiously evident in the Kansas City border war, for instance, in which over the 2011 to 2019 period municipal authorities in Kansas and Missouri spent large sums of money to induce companies to relocate across state lines within the same metropolitan area.[24] Such behavior is suggestive of elected officials using placed-based policies purely for political gain (Kim, 2021; Slattery, 2020). In analyzing place-based policies, economists have devoted most of their attention to whether tax incentives are successful in attracting investment to a region. This focus is understandable. These subsidies appear to account for the majority of spending on place-based initiatives (Bartik, 2020). Yet, place-based policies consist of much more than business tax incentives. Local economic development has evolved into a sophisticated if underappreciated area of practice, in which policymakers deploy a wide range of tools. However the energy transition plays out, it will be these tools that policymakers will likely apply first, especially at the state and local levels.

3.d.2. Place-Based Policies in Practice

A reasonable goal of place-based policy is to increase employment and earnings in distressed regions, especially among low-wage workers, and to improve both regional and national well-being in a manner that would not happen in the absence of the intervention (see, e.g., Bartik, 2022; Austin et al., 2016). The elected officials, policy professionals, and non-government actors who are responsible for local economic development typically handle the policies' design and implementation. In the United States, the practice of local economic development—not to be confused with the scholarly economics subfield of development economics—tends to be organized around five major areas: business retention and recruitment, workforce development, financial and technical assistance to small business, infrastructure development, and financial incentives to invest in low-income areas (Bartik, 2020). I will discuss the first three areas of practice.[25] These areas tend to be managed by different bureaucracies, funded from different

[22] The Appalachian Regional Commission later continued this work on a smaller scale.
[23] Even in the absence of positive impacts on aggregate output, the TVA may have been justified on welfare grounds: it improved very low-income communities' well-being (Gaubert et al., 2021).
[24] See Shayndi Raice, "Tired of Fighting for Business, Missouri and Kansas Near Cease-Fire Over Incentives," *The Wall Street Journal*, June 25, 2019.
[25] Scope for action on the fourth area, new infrastructure, may be limited by the federal government's authorization of a major infrastructure spending bill in 2022. The fifth area includes government support for investments in federally recognized Empowerment Zones and Opportunity Zones and state-designated Enterprise Zones. Because these programs appear to allocate most of their resources to real estate projects in low-income neighborhoods within

sources, and guided by different and often conflicting incentives. The result is a decentralized process in which decision-making is divided across a complex set of jurisdictional boundaries. I discuss how these areas of practice might be deployed to address job loss from the energy transition.

Business Recruitment (building capital). The goal of business recruitment is to catalyze investments in physical capital in a geographic region. A common approach is to provide tax incentives to a large company in return for promised investments in new productive capacity, the expansion of existing operations, or the creation of R&D facilities (Slattery, 2020). If the company breaks ground, the logic goes, it will attract upstream industry suppliers and downstream industry buyers, thereby realizing external economies of scale and raising regional productivity and wages. For regions hurt by the energy transition, the idea would be to use tax incentives to develop new export industries unrelated to fossil fuels. There is considerable evidence that policies that target specific industries in specific regions succeed in expanding regional capacity in the target area well beyond the duration of the policies, in a manner consistent with agglomeration economies (Greenstone et al., 2010; Freedman, 2017; Garin and Rothbaum, 2020; Bianchi and Giorcelli, 2022). Whether these policies do more than reallocate employment within or across regions is less clear, but the rough consensus of the literature seems to be that they do not. That is, business tax incentives likely move targets but not aggregates.

Business tax incentives may yield disappointing aggregate results because they are inherently flawed. Alternatively, the flaw may not be in their design but in their implementation. Business recruitment is typically the purview of a local or state entity, staffed by professionals (as opposed to elected officials) and funded from a combination of public and private sources. These quasi-government entities are often (confusingly) called “economic development agencies,” even though they are not responsible for all aspects of development practice. Economic development agencies help states and localities find companies to recruit, and then assist these companies in locating a production site, obtaining the statutory tax incentives for which they are eligible, managing the permitting and regulatory process, and expanding into new markets. The agencies’ performance is typically measured in terms of the *gross* number of companies that they recruit or retain and the associated *gross* number of jobs that are created or saved (Bartik, 2022). The emphasis on gross versus net job creation may contribute to why business tax incentives frequently disappoint.

The two possible conclusions that bear policy lessons for the energy transition are difficult to separate. One is that business tax incentives are a valuable tool for helping distressed regions, but that the incentives governing their implementation need to be realigned to match social objectives. A second is that tax incentives represent a large pool of poorly used resources that

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larger metropolitan areas (see, e.g., Lambie-Hanson, 2008), they may be unlikely sources of major support for the smaller towns and cities on the front lines of disruption by the energy transition. For recent work on such initiatives, see Neumark and Simpson (2015), Chen et al. (2019), and Neumark and Young (2020).

could be redeployed for more productive ends through alternative place-based policies. Either way, the resources that states and localities devote to business tax incentives may feature prominently in responses to worker displacement induced by the energy transition.

Workforce Development (improving labor). Many workers displaced by the energy transition will need to retool their skills for new occupations. In the presence of localized human capital externalities, public investments in retraining may bring gains to society at large. A better equipped local workforce may help a region to rebound more quickly from the loss of key export industries. In most regions, workforce development agencies oversee the provision of vocational and technical training to local workers.[26] Their role includes helping displaced workers acquire new skills—in part by relaxing constraints on obtaining funding for education and training that may impede those workers from making worthwhile investments—and assisting low-income youth in successfully entering into the labor force, possibly by compensating for disadvantages they have accumulated in the past (Holzer, 2008).

Research shows that specific types of training known as "active labor market programs" yield high returns: raising wages for low-wage workers and sometimes paying for themselves within five years (Katz et al., 2022). These programs, after screening candidates for their suitability for employment, provide training in sector-specific skills demanded by local employers—who themselves often help to define the training—and offer wrap-around services regarding career readiness, career counseling, job placement, and post-placement job advancement. International evidence supports the effectiveness of well-designed sectoral training programs in improving individual employment outcomes (Card et al., 2018). Although successful training models have been identified, there appear to be challenges in replicating and scaling them. While the effectiveness of certain approaches developed by specific nonprofit organizations has been established in randomized controlled trials, the success of these approaches does not always replicate when applied by other organizations and in other contexts (Kanengiser and Schaberg, 2022). Employers' wariness to participate in these programs—for instance by guaranteeing to hire certain numbers of qualified graduates—is a common problem.

Part of the challenge in scaling successful training programs may be the bureaucracy that governs them. Central to this bureaucracy are Workforce Development Boards, which are the product of federal legislation on worker training in recent decades (Holzer, 2008). These Boards oversee the provision of employment services to displaced workers, disadvantaged youth, and other constituents. Their services include help in obtaining UI benefits, vouchers for worker training, career counseling, and other employment related assistance, which are often provided at job centers located in community colleges. The Boards are typically run by local leaders selected by the mayor or governor. Whereas some states have a single Board, others have 20 or more. In total, the United States has over 600 such boards, which appear to vary enormously in their

[26] Here, I ignore the (plausibly modest) role of K-12 education and public universities in regional labor market adjustment to the energy transition.

administrative capacity. Their jurisdictional boundaries bear little relation to the geographic structure of local labor markets, and often do not align with the regional structure of local economic development agencies.

Workforce Development Boards help workers to obtain training but do not conduct that training themselves. This responsibility usually falls on community colleges and private or nonprofit technical institutes. In community colleges, job-specific training typically takes the form of certificate programs. These are practical courses of study of less than two years in length, which target specific occupations such as construction, manufacturing, repair, transportation, and other vocational trades. In panel data, certificates yield significantly improved earnings and employment outcomes for attendees (Jepsen et al., 2014). Prior research finds that when local economic conditions deteriorate, enrollment in certificate programs tends to rise—in particular for programs that provide certification in industries where employment is expanding—which suggests that workers are using the programs to move between occupations in response to changing economic conditions (Foote and Grosz, 2020; Acton, 2021). Yet most community colleges allocate substantially fewer resources to certificate programs than to two-year associate degree programs, many of which are geared to prepare students for entry into four-year colleges and universities (Schanzenbach and Turner, 2022). Goolsbee et al. (2019) develop a detailed proposal for expanding the training capacity of community colleges, as part of a broader agenda to fortify the accumulation of human capital in the United States.

Despite several decades of job loss among non-college-educated workers in manufacturing, energy extraction, and other well-paying industries, workers continue to have difficulty in retraining for new lines of work. Although research and practice have identified training approaches that work in some settings, and although the ubiquity of community colleges provides ready infrastructure for such training, these programs have yet to be scaled regionally or nationally. There would appear to be substantial scope for improving workforce development in advance of the energy transition.

Business Technical Assistance (raising productivity). In economically distressed regions, local entrepreneurs may have difficulty in securing loans to launch a new business while owners of existing firms may face challenges in financing business improvements or expansions. By reducing housing values and potential collateral, the decline of a region's existing export industries may initiate a financial accelerator mechanism that stifles business formation (Davis and Haltiwanger, 2019), possibly impeding economic recovery. In the aftermath of localized economic downturns, there may be cause to subsidize services to businesses that have a demonstrated interest in expanding local employment. Intriguingly, several public sector programs, which are neither well known nor well studied, are doing just that.

The US government provides a wide range of support to small- and medium-sized businesses. The Small Business Administration, in addition to guaranteeing loans to qualifying small businesses, runs over 900 Small Business Development Centers, which are often housed in

community colleges or universities and which provide technical assistance and consulting services to local firms. The Economic Development Administration, through its grants to colleges and universities, funds similar business services. Specific to industrial production, the Manufacturing Extension Program run by the National Institute of Standards and Technology helps companies to upgrade their technology through a national network of centers. Could these programs help regions that will be adversely affected by the energy transition? In truth, we do not know. Rigorous evaluation of such programs in the United States is limited. We know a great deal, however, about the efficacy of related types of interventions in developing countries. In randomized controlled trials, supplying consulting services to medium-sized businesses in developing countries leads to long-lasting improvements in economic performance (Bloom et al., 2013, 2020; Iacovone et al., 2022). The absence of evidence in the US context is particularly concerning considering that many such programs received enormous funding increases —often many times their annual budgets—as part of COVID-19 relief packages. Opportunities to evaluate their effectiveness would seem to abound.

Looking ahead to the energy transition, economists anticipate that local economic downturns may complicate business formation. Given that new, small firms are the primary source of net, new job growth, forces that block business growth may dim prospects for successful adjustment to job loss in fossil-fuel-related industries. Although the US government funds a wide range of services to promote business expansion, researchers and policy makers have a poor sense of which would be best-suited for the coming challenge of mitigating worker displacement in fossil-fuel-intensive industries.

Summary. The practice of place-based policy in the United States is highly decentralized, confusingly fragmented, and poorly understood outside of the regions in which it occurs. State and local governments are likely to play a large role in helping local economies hurt by the energy transition to chart a path toward economic recovery. In advance of this adjustment process, it behooves us to understand place-based policies more soundly.

4. Final Discussion

Economists have long known that people are scarred by job loss. Displaced workers earn significantly less than otherwise similar workers who have not been displaced, even years after the separation occurred. Over the last several decades, import competition from China, the automation of manufacturing production, and the shift in electricity generation away from coal have caused locally concentrated job loss in the United States, which has led to lasting declines in employment rates, earnings, and social conditions in the local labor markets that were exposed to these shocks. Because less-educated workers were slow to migrate away from these regions, localized distress has persisted for decades beyond the actual displacement events. Despite now well-documented instances of painful adjustment to large contractions in labor demand, there is no consensus about how to remediate such injuries. If we continue with business as usual, the

energy transition seems likely to add new chapters to the already unfortunate story of industry decline and regional hardship. Adjustment experiences to date suggest three areas in which revising existing approaches may produce gains.

Tuning unemployment insurance to local economic conditions. During the Great Recession, the government sharply increased the generosity and duration of unemployment insurance benefits. The long-standing concern about such interventions is that they induce workers to delay seeking new jobs and thereby elevate unemployment rates and prolong economic recovery. Yet, the literature provides compelling evidence that greater UI benefits in response to the Great Recession had little impact on aggregate employment, while helping recipients replace lost income and smooth their spending over time. There appears to be scope to further tune UI benefits to local economic conditions, beyond the existing and infrequently used state-level trigger mechanisms. Because job loss caused by the energy transition is likely to be highly concentrated in specific local labor markets, state-level triggers may be too crude to help the regions that will suffer high levels of worker displacement. Labor market adjustments during the Great Recession and the COVID-19 pandemic may be instructive for how to tune UI benefits with greater precision.

Expanding technical and vocational training. Because the energy transition may require affected regions to develop new export bases, local workers may need to acquire skills suitable for new and unfamiliar industries. There is now abundant evidence that active labor market programs can be successful in helping displaced and disadvantaged workers to find employment in new occupations and at wage rates that are higher than they otherwise would have commanded. Community colleges, through the certificate programs that they already offer, represent a training infrastructure that is seemingly ready to be deployed (Goolsbee et al., 2019). Existing approaches to workforce development, however, appear to be deficient in many respects. Challenges include how to scale up active labor market programs and to expand them into new regions, and how to fortify and to expand the technical and vocational training missions of community colleges that vary widely in their capacities and that tend to favor preparing students for entry into four-year universities. Possibly working against experimentation and expansion is an existing system in which Workforce Development Boards' jurisdictions, mandates, and administrative structures may be poorly aligned with other actors and thereby impeding innovation. The task at hand thus seems less a matter of identifying viable training programs or building training infrastructure than of harnessing a decentralized and fragmented system to accomplish new and more ambitious objectives.

Coordinating place-based policies. If a development economist were to tour towns and cities in the United States, she would find the local interventions in lending to small businesses and expanding their managerial capacities entirely familiar. Although mainstream economics has become comfortable with such policies when implemented in Colombia or India, skepticism over place-based policies in high-income countries, which involve many of the same features, remains strong. Yet, local-level industrial policies favored by the World Bank and by states including

Michigan, Minnesota, and Virginia have a lot in common. The challenge is not to convince states and localities to undertake place-based policies—they are already doing so and have been for close to a century (Cobb, 1993). Rather, the challenge is that we know relatively little about which place-based policies are effective and in which contexts. Although there seems to be a building consensus that offering generous tax breaks to recruit large companies yields low social returns, there is less consensus about how these funds could be better deployed. There is no accepted formula for how to combine business recruitment, worker training, technical assistance to business, and infrastructure development in a manner that would raise employment rates and wage levels in a distressed local labor market. Spending by the federal government in response to the COVID-19 pandemic, which has temporarily and dramatically expanded the budgets of the federal agencies that support place-based policies, including the Economic Development Administration, the Employment and Training Administration, and the Small Business Administration, presents an immediate opportunity to experiment with alternative policy formulas. We have an opportunity to evaluate which place-based policies work, just at the moment when the demands of preparing for the energy transition are becoming pressing.

Just as in 1980, when economists did not see the decline of coal coming, in 1990 economists did not see the China trade shock on the horizon. Although in retrospect it seems obvious that these events would have large, concentrated, and negative impacts on exposed local labor markets, few economists foresaw them (an exception is Wood, 1995). The energy transition, however, is a shock foretold. We have a keen sense of which industries will see reduced employment, which local labor markets will be most exposed to the resulting job loss, and which existing policies have worked poorly in addressing past disruptions. This time, we have the opportunity to get things right.

5. References

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Appendix

A1. Econometric Framework

In this section, I describe the econometric framework I apply to produce the estimation results shown in Section 3.3. To evaluate adjustment to the decline of coal across US commuting zones, I use the following specification, which adapts that in Autor et al. (2022) and which is inspired by the local projections approach in Jordà (2005):

$$\Delta Y_{it+h} = \alpha_t + \beta_{1h}\Delta SS_i^{coal} + \mathbf{X}'_{it}\beta_2 + \varepsilon_{it+h}. \quad (1)$$

The variable ΔY_{it+h} is the change in an outcome for commuting zone (CZ) i between the base year t = 1980, when the coal decline began in earnest, and year $t + h$ for $h = -5, \ldots, 39$; ΔSS_i^{coal} is a shift-share variable that projects the US national shock to coal employment onto CZ i; and $\mathbf{X}_{it}$ is a vector of controls. I include time changes before 1980 to evaluate the presence of pretrends in the data.

I specify the decadalized shift-share coal shock as,

$$\Delta SS_i^{coal} = -\left(\frac{100}{39}\right) \times \frac{L_{ic1980}}{L_{i1980}} \left[\ln L^{-i}_{coal,2019} - \ln L^{-i}_{coal,1980}\right], \quad (2)$$

where L_{ic1980}/L_{i1980} is the share of coal production in the employment of CZ i in the initial year of 1980, and the term in brackets is the log change in national employment in coal production over 1980 to 2019, outside of the state in which CZ i is located. The shock period spans both the 1980s and 2010s coal busts. To ease interpretation of the regression analysis, I multiply the shock in (2) by −1, such that a higher value of the shift-share variable indicates a larger negative change. The population-weighted mean of this projected employment change is 0.121 (σ = 0.670) percentage points, where the shock at the 95th percentile of exposure is 0.453 percentage points and at the 50th percentile of exposure is 0.002 percentage points. Thus, while commuting zones at the median of shock intensity and below feel effectively zero impact of the decline of coal, CZs near the peak of shock intensity are highly exposed. I divide the value in (2) by the quantity (0.453 − 0.002), such that the coefficient β_{1h} is the differential impact of the shock between a commuting zone at the 95th of shock exposure and a commuting zone at the 50th percentile of shock exposure.

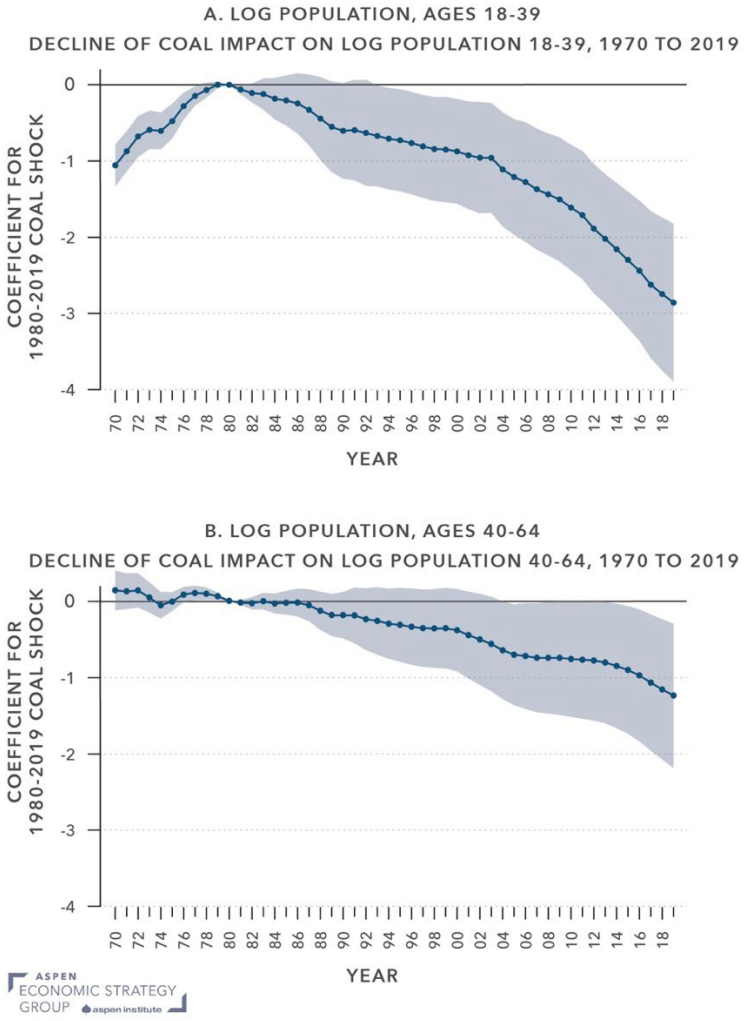
Control variables in the regression include a dummy for the CZ having positive coal employment in 1980, the corresponding shift-share variable to that in (2) defined for manufacturing,[27] time

[27] The coal shift-share variable in (2) is very weakly correlated either with the corresponding shift-share variable for the change CZ manufacturing employment (ρ = 0.02) or the China shock shift-share variable studied in Autor et al.

trends for Census region divisions, and values in 1980 for the share of CZ employment in manufacturing, the share of women in CZ employment, the share of the college-educated in the CZ adult population, and the share of the foreign-born in the CZ population.

A.2. Figures

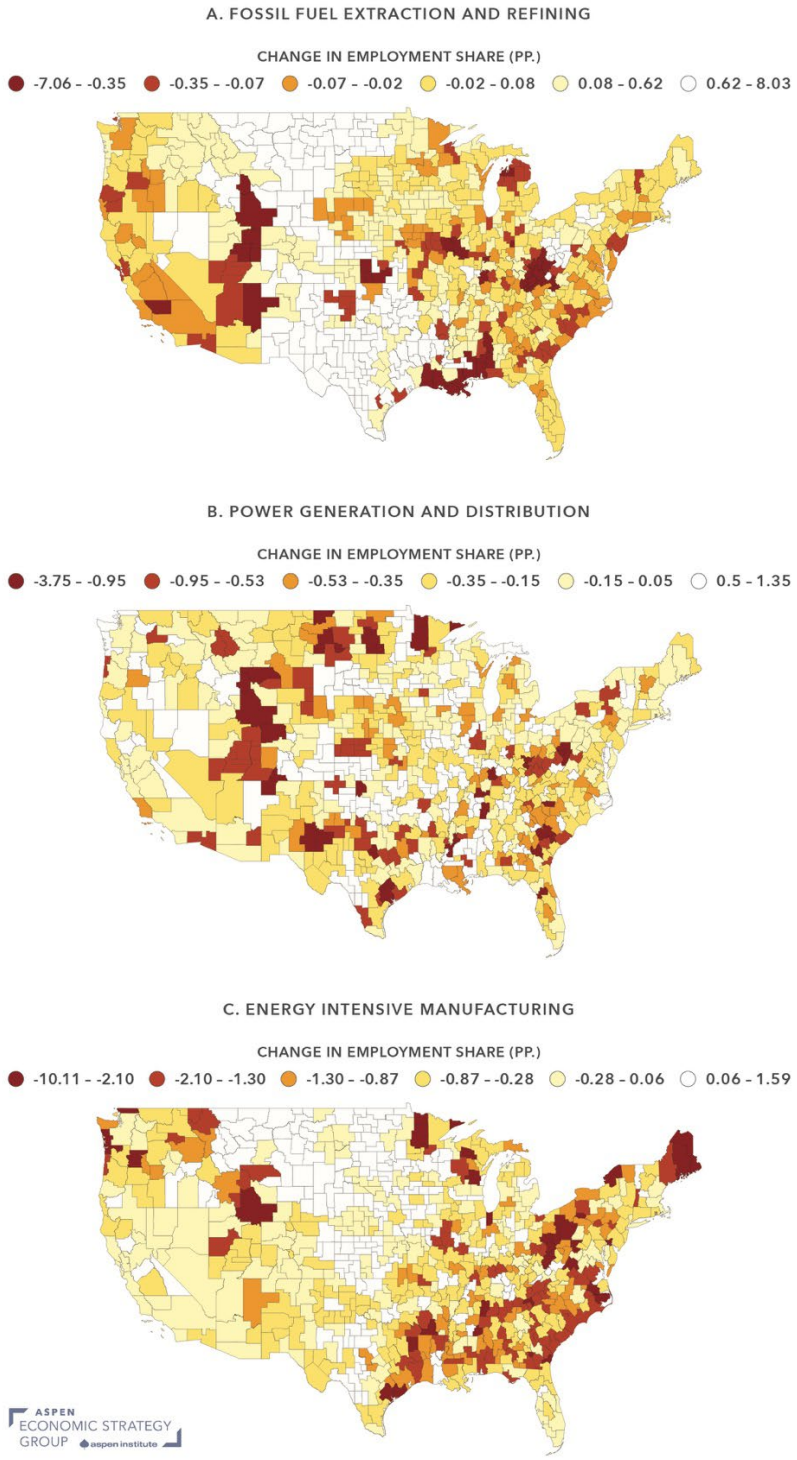
Figure A1. Impact of the Decline of Coal on Population Headcounts by Age Cohort



Note: The panels report OLS coefficient estimates for β_{1h} in (1) and 95 percent confidence intervals for these estimates. The dependent variable is the change in the indicated measure between 1980 and the year on the horizontal axis; the coal shock is defined in (2); and the control variables are described in the Appendix. Regressions are weighted by the commuting zone working-age population in 1980; standard errors are clustered by state.

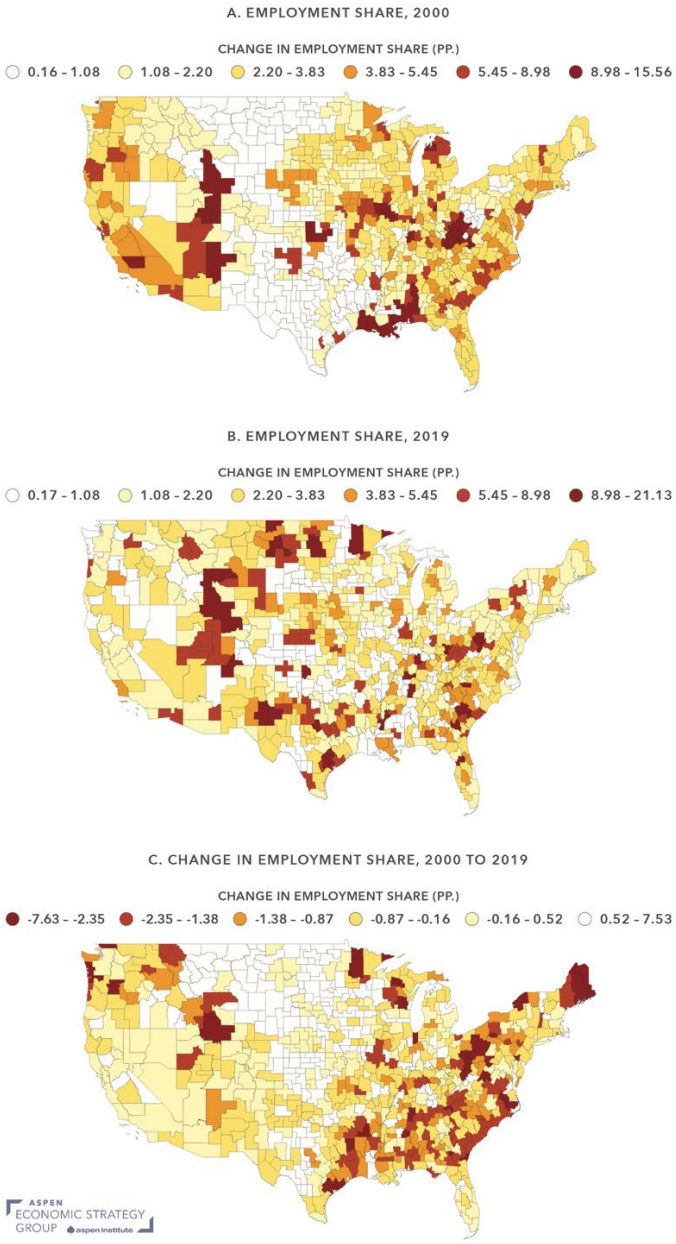
(2022) ($\rho = -0.08$).

Figure A2. Change in Employment in Energy Industries, 2000 to 2019



Note: The figures show changes in the share of employment of prime-age workers (ages 25-54) by commuting zone in energy related industries. The six categories in the legend are for shares in the bottom three quartiles, the 75th–84th percentiles, the 85th–94th percentiles, and the 95th–99th percentiles.

Figure A3. Fossil Fuel Extraction, Refining, and Distribution plus Energy Intensive Manufacturing



Note: The figures show the combined share of employment of prime-age workers (ages 25-54) by commuting zone in the INDNAICS industries oil and gas extraction (211), coal mining (2121), support industries for mining (213); natural gas distribution (2212P); petroleum refining (32411), petroleum and coal products (3241M); and fiber, yard, and thread mills (3131); pulp, paper, and paperboard (3221); basic chemicals (325M); clay products (3271); glass products (3272); cement and concrete (3273); lime and gypsum (3274); iron and steel mills (3311); and aluminum (3313). The six categories in the legend are for shares in the bottom three quartiles, the 75^{th}–84^{th} percentiles, the 85^{th}–94^{th} percentiles, and the 95^{th}–99^{th} percentiles.