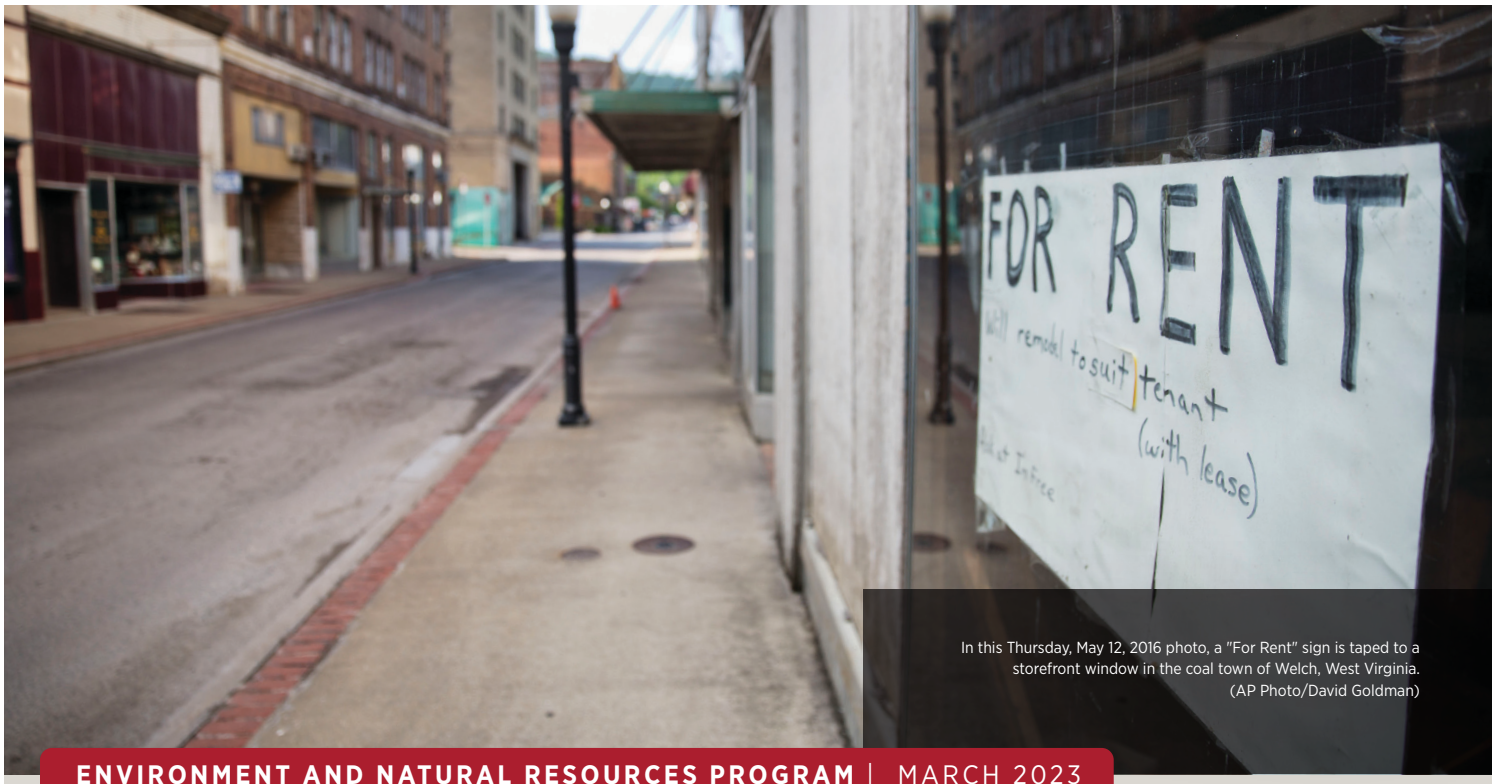

In this Thursday, May 12, 2016 photo, a "For Rent" sign is taped to a storefront window in the coal town of Welch, West Virginia. (AP Photo/David Goldman)

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The Persistent Consequences of the Energy Transition in Appalachia's Coal Country

Eleanor Krause

About This Policy Brief

Each year, the Joseph Crump Fellowship is presented to a talented Harvard Kennedy School doctoral student who is conducting research on the cutting edge of energy or environmental policy. The Fellowship, administered by the Belfer Center's Environment and Natural Resources Program and the Mossavar-Rahmani Center for Business and Government, calls for the recipient to develop a policy brief or paper summarizing the research conducted that year. The 2021-22 Crump Fellowship recipient, Eleanor Krause, authored this policy brief based on her research. Read more about the fellowship here.

Executive Summary

The persistence and intensification of earnings, employment, and opportunity gaps across place has become an increasingly salient feature of the United States economy over the past several decades.[1] This economic divergence has occurred alongside a remarkable transition away from coal-fired electricity that is expected to continue as lower-carbon energy sources become more economically viable. While essential to minimizing the damages of climate change, the shift poses significant challenges to the relatively rural and distressed communities traditionally reliant on this resource. Indeed, many historically coal-dependent communities in Central Appalachia have long been characterized by deep poverty, limited employment opportunities, and high rates of public assistance, and recurrent adverse shocks to coal employment over the past several decades have amplified many of these qualities, potentially elevating the risks associated with the energy and economic shifts ahead. How have Appalachia's coal-dependent communities adjusted to historical and contemporary declines in demand for coal, and how do these shocks – and their consequences for the educational composition of affected communities – influence the capacity for future generations to adapt to new challenges?

In this policy brief, I present estimates of how Appalachia's coal country has adjusted to recent declines in coal mining employment ("coal shocks"), and I demonstrate how this adjustment process is, in part, dictated by the persistent consequences of historical employment shocks in Appalachia.

The evidence suggests that recent coal shocks (i.e., declines in coal employment occurring between 2007 and 2017) have been relatively painful for affected communities, causing large reductions in local population sizes, declines in local employment counts, declines in earnings, and increases in the rate of government transfer receipt. All of these adjustment costs are more severe in counties with a history of "selective migration" induced by shifting employment opportunities in the 1980s. That is, the estimated effect of recent coal shocks on population sizes, employment, earnings, and transfer payments is significantly larger in counties that lost greater numbers of their college-educated adults in the 1980s thanks to historical employment shocks in proximate labor markets. The upshot is that coal-dependent communities may demonstrate little resilience to recent coal shocks in part because of the persistent consequences of historical shocks, which fundamentally altered the educational composition of affected communities. By dramatically reducing the number of college-educated individuals living in a community, adverse shocks have the capacity to put places on a pathway of decline that makes it more difficult to adapt to economic shifts in subsequent generations. These insights preview the potentially damaging implications of future contractions in the coal industry, revealing the need for greater empirical investigation of the types of policy efforts that might ameliorate the painful local adjustment costs associated with the energy transition going forward.

1 See, for example, Ganong and Shoag (2017); Chetty and Hendren (2018); Autor (2019); Moretti (2011).

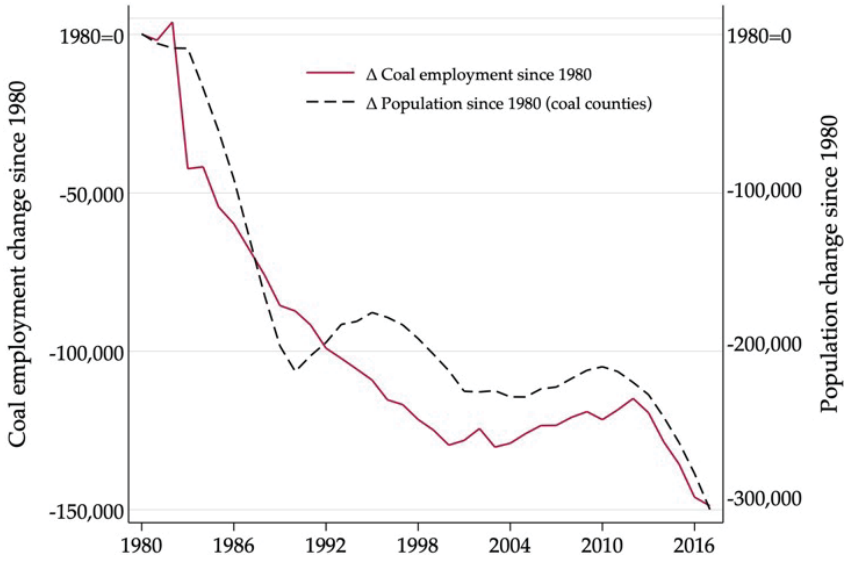
Background: Coal & Appalachia's Coal Country

While representing only a small fraction of the total United States workforce (approximately 0.003 percent of total employment), coal mining has long played an integral role in the economies of certain communities. Due to the spatial concentration of coal deposits and the inherent volatility of demand for the commodity, many coal-dependent communities have been subject to recurrent demand shocks across generations – sometimes referred to as the "boom and bust" cycle that commonly characterizes economies dependent upon resource extraction (Black et al., 2002, 2003, 2005). However, thanks to the availability cheap natural gas made accessible by hydraulic fracturing technology, environmental regulations, and increasing competition from renewable energies, the "boom" cycles appear to be over for coal (Kolstad, 2017; Linn and McCormack, 2019).

This long-term decline of the industry has put enormous pressure on the communities that have historically relied on coal as an important source of labor income and public revenue, which have long struggled with persistent poverty, low incomes, and high rates of public assistance. In 1964, Martin County, Kentucky became the face of President Lyndon B. Johnson's "unconditional war on poverty" with a highly public visit to the county seat of Inez. At the time, over 60 percent of Martin County lived in poverty and more than half of county earnings came from the coal industry. Since then, the number of mining jobs in Martin County has fallen dramatically – coal mining now represents just 5 percent of total employment – and the county's poverty rate exceeds twice the national average. By most measures, Martin County lost this war on poverty, and yet its experience is hardly unique to Appalachian coal communities. Between 1980 and 2017, Appalachia's coal mining industry shrank by 150,000 jobs, or about 85 percent. Over this same 37-year period, the total population of Appalachia's most coal-dependent counties fell by by about 300,000 persons, reflecting a 10 percent decline in head counts (Figure 1).[2]

2 For exposition purposes, I define coal-dependent counties as those with at least 0.5 percent of their working-age-adult population (ages 20-64) employed in coal mining in 2007. This cutoff reflects the median coal share in 2007 among counties with positive coal mining employment, and includes 67 Appalachian counties.

Figure 1: Population and coal mining employment, Appalachian counties



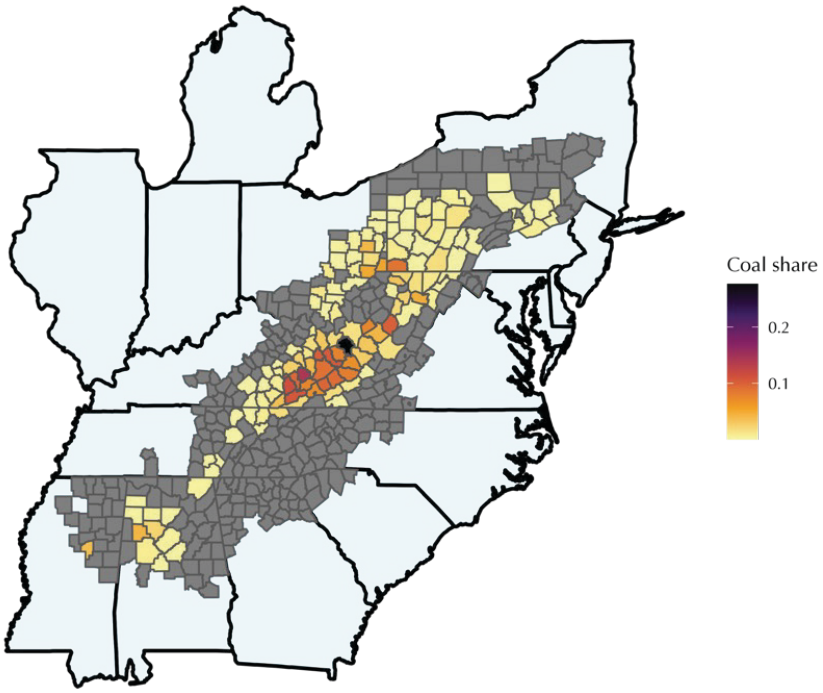
Notes: Coal mining employment is calculated based on County Business Patterns data imputed by Eckert et al. (2020). The red line captures the change in coal mining employment in all Appalachian counties between 1980 and the year indicated. The dashed black line represents the change in the annual summed population in Appalachian counties in which at least 0.5 percent of the adult population was employed in coal mining in 2007.

Importantly, the population decline reflected in Figure 1 was not evenly distributed across demographic groups. The shrinking was driven by larger relative declines in young and more-educated residents compared to other Appalachian counties. While there was a secular increase in educational attainment in the 1980s and 1990s across the United States, Appalachian counties not reflected by the black dotted line (i.e., those with no or very little coal employment in 2007) saw the college-educated share of their adult populations grow at a rate nearly 50 percent larger than those coal counties represented by the black dotted line between 1980 and 2007. Likewise, the share of the population under age 20 declined by nearly 50 percent more in these coal-dependent counties over the same period. The analysis in this policy brief zooms in on the most recent chapter of this decades-long decline, exploring how Appalachian counties have adjusted to declining demand for coal over the 2007-2017 period. However, the demographic shifts just documented indicate that, by the time we arrive at the start of this period of analysis (2007), many of Appalachia's coal communities had already been altered by historical episodes in ways that might potentially weaken their resilience to new demand shifts. Specifically, I examine the role that historical shifts in the college-educated population play in dictating the adjustments to contemporary coal shocks, demonstrating that selective migration – colloquially referred to as "brain drain" – experienced in one generation can exacerbate the consequences of shocks in the next.

Research Strategy and Key Findings

To estimate the effects of contemporary coal shocks on population change and local economic conditions, I exploit county-level variation in exposure to the national shift in coal demand between 2007 and 2017. The details of this empirical strategy are outlined in the online data appendix. I define the local "shock" as the change in the coal mining employment share of the working-age adult (ages 20-64) population over the decade, and refer to this as the change in the coal share. The essence of the empirical strategy exploits the fact that counties with a greater coal share at the beginning of the period (2007) are more exposed to macroeconomic shocks to coal demand over the subsequent decade. As seen in Figure 2, coal mining employment is concentrated in Eastern Kentucky and West Virginia, and thus these regions will drive much of the variation on which the resulting estimates are based.

Figure 2: Coal employment share of the working-age adult population

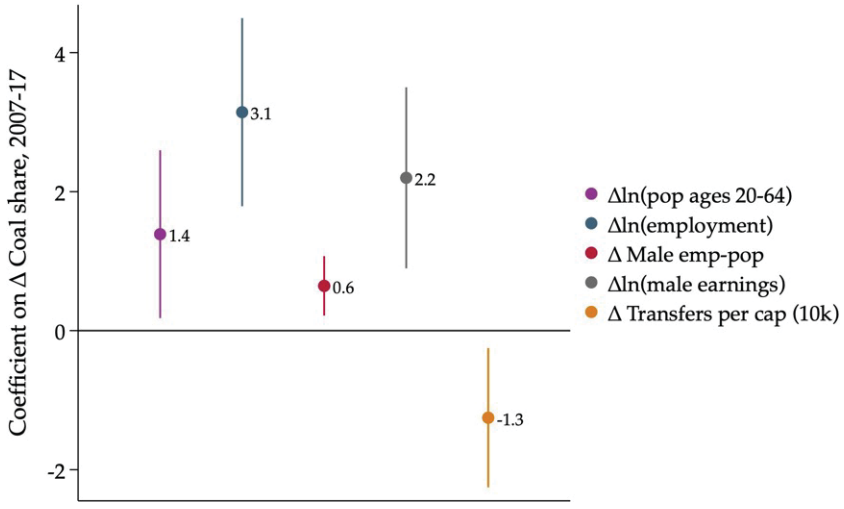


Notes: Coal mining employment is calculated based on mine-level statistics from the Mine Safety and Health Administration. Adult population is defined as the population ages 20-64.

Figure 3 shows the estimates for the effect of the contemporary coal shock on various local population and economic outcomes. A 1 percentage point (pp) decline in the coal share yields about a 1.4 percent decline in the working-age adult population, a 3.1 percent decline in county-wide

employment, a 0.6pp decline in the male employment rate, a 2.2 percent decline in male earnings, and a $130 increase in government transfers per capita. These effects appear large: the standard deviation (SD) of the change in the coal share, which measures the amount of variation in the coal shock relative to the average Appalachian coal county, was 1.6pp. This indicates that a 1-SD increase in the coal shock reduces local employment by nearly 5 percent, for example (1.6 x 3.1 ≈ 5). Some of these adjustment costs likely reflect the selectivity of population change, as population declines were driven by better-educated workers, who tend to have higher rates of employment, higher wages, and lower rates of transfer receipt. While an analysis individual-level data would be required to tease out the extent to which these estimates reflect compositional changes in the population versus newly compromised economic and employment conditions, compositional changes are unlikely the only factor driving these estimates. First, the magnitude of local economic adjustments appear larger than that of population changes – e.g., local employment contracts by double the rate of adult head counts. Second, adverse coal shocks yield negative spillovers to other local industries, evidenced via contractions in employment in service-oriented industries such as leisure and hospitality.[3] This indicates that the negative consequences of local coal shocks are farther reaching than the direct effect of reduced coal mining employment, causing declines in business activity and earnings across the economy.

Figure 3: Effect of change in coal share on select population and economic changes

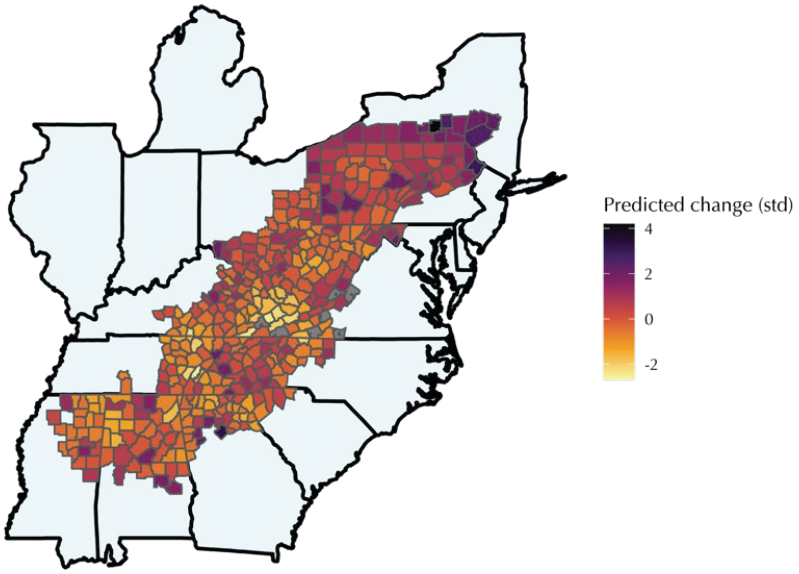


Notes: Figure reflects the coefficient estimate and 95 percent confidence interval of a regression of the outcome indicated on the change in the coal employment share of the adult population over the 2007-2017 period. Change in coal share is instrumented with the coal share at the beginning of the period. All regressions are weighted by initial county population, and control for county covariates, a dummy indicating whether the county had positive coal employment at the beginning of the period, and state fixed effects.

3 Estimates for the effect of coal shocks on other outcomes are omitted from this policy brief. Please contact eleanorkrause@fas.harvard.edu for a copy of the full research paper.

Do these documented adjustment costs vary based on the historical population trajectories of affected communities? To understand whether a history of "brain drain" exacerbates the consequences of contemporary coal shocks, I bifurcate Appalachian counties into two groups. The first experienced a larger relative loss in its college-educated population due to exogenous employment shifts in the 1980s ("drain" = 1), and the second did not ("drain" = 0). Rather than use the observed change in the college-educated population to form these groups, I use a predicted measure based on county-level exposure to the coal shock of the 1980s and a county's proximity to exogenous employment shifts in other places over the same decade. This strategy is detailed in the online data appendix. The resulting prediction for the change in the college-educated population is reflected in Figure 4. Those counties with the lightest shading are those with predicted losses in the college-educated population over this decade. I then estimate the effect of contemporary coal shocks as before, but allow for this effect to differ according to whether counties are in the bottom quartile of this predicted college-educated population change ("drain" = 1) or not ("drain" = 0).

Figure 4: Predicted change in college-educated adults, 1980-1990

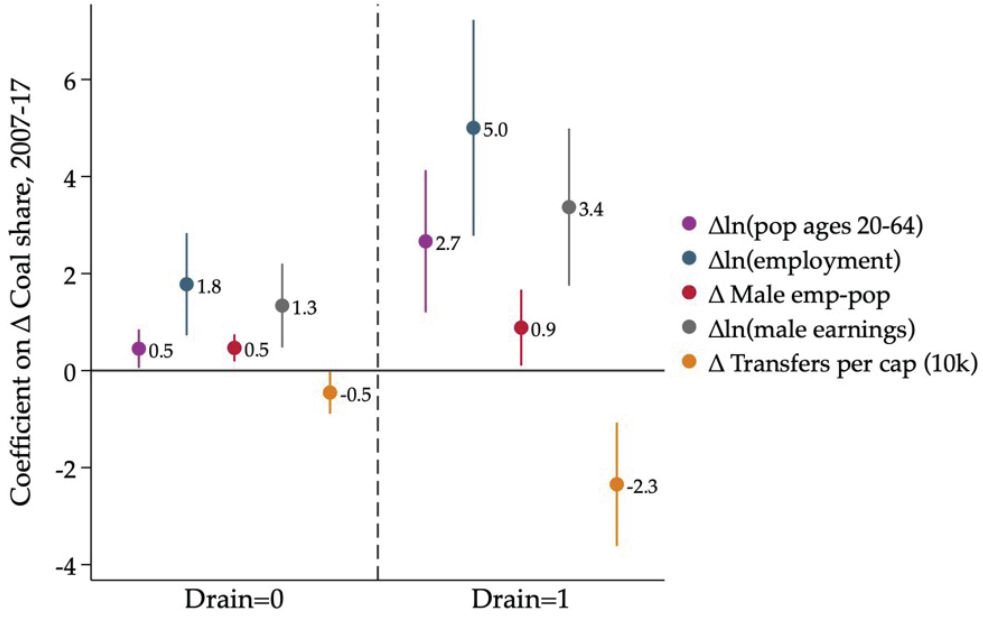


Notes: Figure reflects the (standardized) values for the predicted change in the college-educated adult population (ages 25 and older) in the 1980s. Darker shading reflects counties with larger increases in the predicted college-educated population. Lighter shading implies that counties hold low or negative values for the change in the college-educated population over this decade.

The results of this exercise are depicted in Figure 5. Across all five outcomes, the consequences of contemporary coal shocks are more severe in counties that experienced larger relative losses in their college-educated population in the 1980s due to exogenous labor demand shifts in that decade. The contemporary coal shock's impact on population change is about 5 times larger in counties in this bottom quartile of historical "brain drain" (a 2.7 percent decline versus a 0.5 percent decline).

Its effect on total employment and male median earnings are about 2.5 times as large, and its impact on government transfers per capita is nearly 5 times as large: A 1pp decline in the coal share yields a 5 percent decline in employment in counties in the bottom quartile of predicted college-educated population change in the 1980s, compared to only a 1.8 percent decline in all other counties. This same coal shock yields a $230 increase in government transfers per capita in the bottom quartile, versus a $50 increase in all other counties.

Figure 5: Selective migration and the consequences of contemporary coal shocks



Notes: Figure reflects the coefficient estimate and 95 percent confidence interval of a regression of the outcome indicated on the change in the coal employment share of the adult population over the 2007-2017 period, interacted with a dummy variable indicating whether the county experienced a greater relative loss in its college educated population in the 1980s ("drain" = 1) or not ("drain" = 0). Change in coal share is instrumented with the coal share at the beginning of the period. All regressions are weighted by initial county population, and control for county covariates, a dummy indicating whether the county had positive coal employment at the beginning of the period, and state fixed effects.

The major takeaway from the estimates presented in Figure 5 is that the consequences of contemporary coal shocks are more acute in counties that experienced larger (predicted) losses in their college-educated populations in decades prior. Notably, this phenomenon is unique to historical losses in the college-educated population within a given county, rather than broader population declines. Bifurcating counties based on total population declines does not yield the same differential impact as that shown above. This suggests that there is something unique to the loss of skilled workers that is particularly difficult to overcome. What mechanisms drive the relationship between a loss of skilled workers and the adaptation to labor demand shocks? One hypothesis is that the presence of skilled workers stimulates local economic activity through greater entrepreneurial capacity and establishment of new firms. While there are certainly many other factors likely at play, the evidence suggests that there is indeed a strong, direct relationship between the change in

the number of college-educated adults in the 1980s and number of new business establishments in subsequent periods: A 1-percent decline (increase) in the college-educated adult population in the 1980s yields a decline (increase) in the rate of new business entry of about 13 establishments in 2017 compared to the 1980 rate.[4]

The estimates presented here are robust to a wide variety of empirical specifications and sample restrictions. While the results presented in Figure 3 indicate that contemporary shocks are relatively painful for all exposed communities, those presented in Figure 5 indicate that certain places appear differentially vulnerable to their negative consequences due to the loss of human capital inspired by events of the past. Adverse labor demand shocks in one generation may thus cripple a community's capacity for adjustment in subsequent generations by fundamentally altering the educational composition of the population.

4 This estimate is based off of a regression of the change in the 5-year rolling average of new business establishments between 1980 and 2017 on the change in the (log) number of college-educated adults in 1980, where I instrument for the change in college-educated adults with a county's proximity to predicted employment growth in other counties. The construction of this proximity variable is detailed in the online data appendix. Data on business entry are retrieved from the Census Bureau's Business Dynamics Statistics program.

Conclusion & Policy Implications

The results presented in this policy brief imply that the local economic adjustment to employment shocks is deeply dependent upon the historical experiences of a given community. There is some degree of path dependence in the trajectory of an economy. Exogenously driven declines in human capital endowments have the capacity to put places on a pathway of decline, making them more vulnerable to the negative effects of shocks in subsequent generations. This insight is especially important given anticipated energy and economic shifts ahead. Future contractions in the coal industry driven by the direct effects of climate policy or the indirect effects of competition from lower-carbon energy sources will hit communities that have already been transformed by decades of waning demand for coal the hardest.

What can policymakers do to help distressed communities adjust to these changes on the horizon? Economists typically group policies that address the adjustment costs associated with shifting economic conditions into "place-based" or "person-based" policies. The former seek to improve the economic performance of a specific community or region, often via business tax credits or other spatially targeted investments intended to encourage job or wage growth in a particular local labor market. The latter intend to improve individuals' economic circumstances, regardless of their place of residence, via worker tax credits, unemployment insurance, and other forms of government transfers. Existing evaluations of things like business tax credits have raised concerns regarding the efficiency and effectiveness of these types of programs, while place-based policies that focus on workforce development and customized training typically garner more support from economists (Austin et al., 2018; Bartik, 2020a,b).

The evidence presented here indicates that both place- and people-based policies could have important roles to play in alleviating the adjustment costs of the energy transition in Appalachia's coal country. Spatially targeted investments in skill development and educational attainment can improve distressed communities' competitiveness and workers' employment opportunities. At the same time, government transfers provide critical income support in the event of job loss and – in places with few alternative employment opportunities – they may provide longer term income support and access to important services such as healthcare. While this analysis does not provide guidance on the effectiveness of any specific policy intervention to alleviate the challenges associated with the energy transition in historically coal-dependent communities, it suggests that policies that retain skilled workers while bolstering the educational and skill attainment of incumbent residents might be critical to mitigating the distributional consequences of the changes ahead.

References

Austin, Benjamin, Edward L. Glaeser, and Lawrence H. Summers (2018) "Jobs for the Heartland: Place-Based Policies in 21st-Century America," *Brookings Papers on Economic Activity*, Spring, 151–255.

Autor, David H. (2019) "Work of the Past, Work of the Future," *AEA Papers and Proceedings*, 109, 1–32, 10.1257/pandp.20191110.

Bartik, Timothy J (2020a) "Helping America's distressed communities recover from the COVID-19 recession and achieve long-term prosperity," Technical report, The Brookings Institution.

Bartik, Timothy J. (2020b) "Using Place-Based Jobs Policies to Help Distressed Communities," *Journal of Economic Perspectives*, 34 (3), 99–127, 10.1257/jep.34.3.99.

Black, Dan A., Terra G. McKinnish, and Seth G. Sanders (2003) "Does the availability of high-wage jobs for low-skilled men affect welfare expenditures? Evidence from shocks to the steel and coal industries," *Journal of Public Economics*, 87 (9-10), 1921–1942, 10.1016/S0047-2727(02)00014-2.

Black, Dan, Kermit Daniel, and Seth Sanders (2002) "The Impact of Economic Conditions on Participation in Disability Programs: Evidence from the Coal Boom and Bust," *American Economic Review*, 92 (1), 27–50, 10.1257/000282802760015595.

Black, Dan, Terra McKinnish, and Seth Sanders (2005) "The Economic Impact of the Coal Boom and Bust," *The Economic Journal*, 115 (503), 449–476, http://www.jstor.org/stable/3590402, Publisher: [Royal Economic Society, Wiley].

Chetty, Raj and Nathaniel Hendren (2018) "The Impacts of Neighborhoods on Intergenerational Mobility I: Childhood Exposure Effects," *The Quarterly Journal of Economics*, 133 (3), 1107–1162, 10.1093/qje/qjy007.

Eckert, Fabian, Teresa Fort, Peter Schott, and Natalie Yang (2020) "Imputing Missing Values in the US Census Bureau's County Business Patterns,"Technical Report w26632, National Bureau of Economic Research, Cambridge, MA, 10.3386/w26632.

Ganong, Peter and Daniel Shoag (2017) "Why has regional income convergence in the U.S. declined?" *Journal of Urban Economics,* 102, 76–90, 10.1016/j.jue.2017.07.002.

Kolstad, Charles D. (2017) "What Is Killing the US Coal Industry?"Technical report, Stanford Institute for Economic Policy Research, https://siepr.stanford.edu/publications/policy-brief/ what-killing-us-coal-industry.

Linn, Joshua and Kristen McCormack (2019) "The roles of energy markets and environmental regulation in reducing coal-fired plant profits and electricity sector emissions," *The RAND Journal of Economics*, 50 (4), 733–767, 10.1111/1756-2171.12294

Moretti, Enrico (2011) "Local Labor Markets," in *Handbook of Labor Economics*, 4, 1237–1313: Elsevier, 10.1016/S0169-7218(11)02412-9.

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Eleanor Krause is a Ph.D. candidate in Public Policy at Harvard Kennedy School and the 2021-2022 recipient of the Joseph Crump Fellowship. Krause is also a Harvard Environmental Economics Pre-Doctoral Fellow, a James M. and Cathleen D. Stone Ph.D. Scholar in Inequality and Wealth Concentration, and an affiliate with the Environmental Inequality Lab. Her research considers the intersection of place, environment, and economic inequality, seeking answers to questions such as: How are distressed communities adjusting to the energy transition? How has population mobility attenuated – or exacerbated – existing inequalities? Who benefits from local environmental and place-based policies? Drawing from labor, urban, and environmental economics, her research advances our understanding of the economics of place by examining how individuals and communities adjust to shifting economic and environmental conditions. Prior to her doctoral studies, she served as a Senior Research Assistant in the Economic Studies program at the Brookings Institution and a Research Consultant for the U.S. Climate Initiative at the World Resources Institute. She received a Master in Public Administration from the University of Washington in 2016, and a B.A. in Political Science and B.S. in Environmental Studies from the University of Vermont (summa cum laude) in 2012.

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