

Regional Structural Policy in Pittsburgh and the Ruhr

By Lucas Kreuzer



Bernd and Hilda Becher, Oberhausen, Germany, 1967

1. Introduction

The economic and political ramifications of geographic inequality took center stage in the United States with the 2016 election of Donald Trump who came to power by, in part, connecting with voters in the “forgotten” places hollowed out by the forces of globalization, free trade, and financialization. These landscapes are overwhelmingly located in the so-called “rust-belt” which includes swing states such as Pennsylvania, Ohio, Wisconsin, Michigan that Trump won by the narrowest of margins. In his inaugural address, Trump gave voice to these places and their residents proclaiming, “Politicians prospered – but the jobs left, and the factories closed” and now “rusted out factories [are] scattered like tombstones across the landscape of our nation.”¹ Journalists, policy makers, and academics turned to these communities in an attempt to understand their inhabitants and what had caused their economic and social decline.

The United States is not alone in this regard – most Western democracies contain structurally-weak regions that have lost their core industries since the 1970s. Shifting one’s gaze from the Rust Belt to the United Kingdom’s Midlands, Germany’s Ruhr, or northeastern France reveals the extent to which global economic forces have sculpted similar post-industrial landscapes across national borders.² Three factors explain this change: first, global trade has increased foreign competition and opened low-cost sites of production, especially in Asia, to the detriment of domestic manufacturing employment.³ Second, Western economies have transitioned from manufacturing to service and knowledge-intensive industries such as finance, pharmaceuticals, technology, and robotics that employ a smaller, educated workforce and require fewer production facilities. Third, these new industries cluster in handful of metropolitan regions, also known as agglomeration economies, with specialized endowments of firms, workers, and capital enmeshed in deep social networks.⁴ Industrial regions have borne the brunt of these structural changes and the resulting social and economic pain has been acutely

¹ Donald Trump, “The Inaugural Address,” The White House, January 20, 2017, <https://www.whitehouse.gov/briefings-statements/the-inaugural-address/>.

² Simona Iammarino, Andrés Rodríguez-Pose, and Michael Storper, “Regional Inequality in Europe: Evidence, Theory and Policy Implications,” *Journal of Economic Geography* 19, no. 2 (March 1, 2019): 273–98, <https://doi.org/10.1093/jeg/lby021>.

³ David H Autor, David Dorn, and Gordon H Hanson, “The China Syndrome: Local Labor Market Effects of Import Competition in the United States,” *American Economic Review* 103, no. 6 (October 2013): 2121–68, <https://doi.org/10.1257/aer.103.6.2121>.

⁴ Enrico Moretti, *The New Geography of Jobs*, Reprint edition (Boston, Mass.: Mariner Books, 2013).

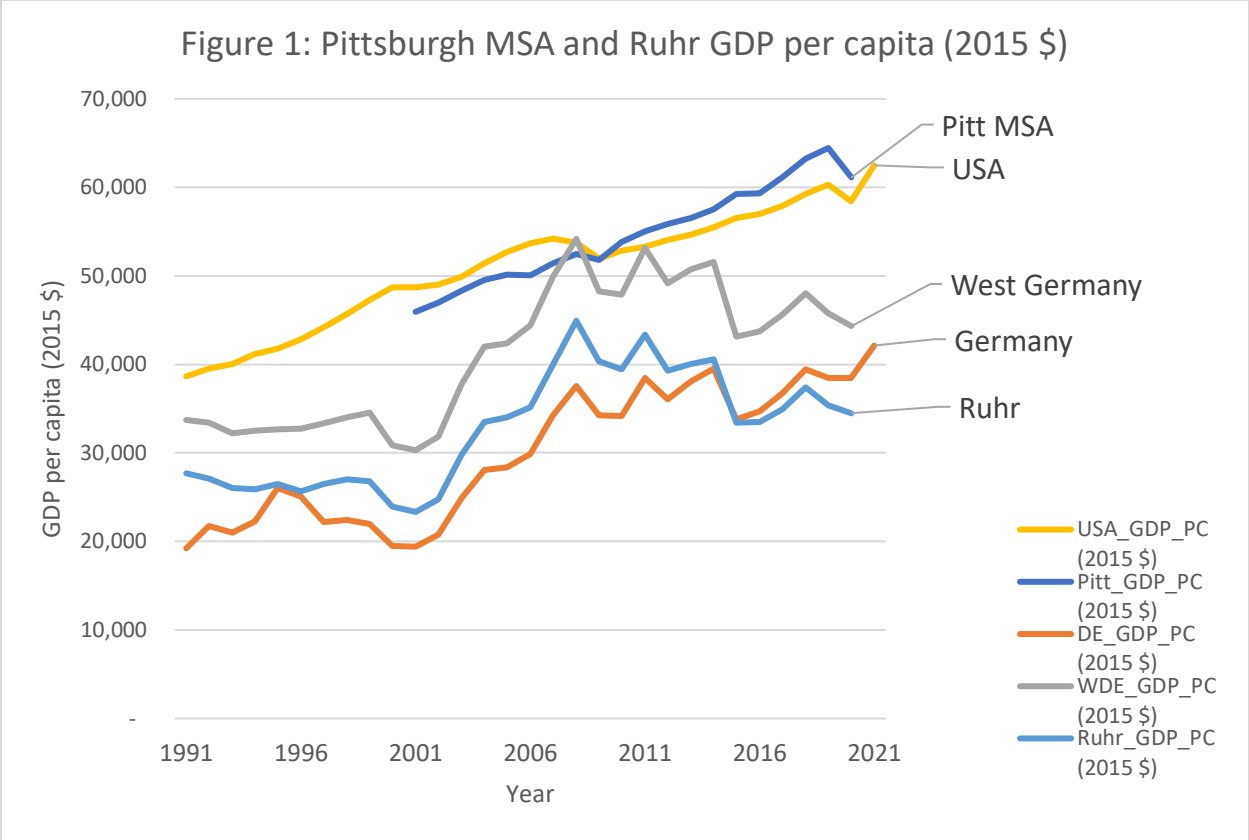
concentrated among their inhabitants and their physical landscapes leading some to turn to populist alternatives.⁵

In the context of these ostensibly overwhelmingly global forces, how have regions responded to structural change and economic dislocation? Do they have any latitude to spark knowledge economies of their own that can create prosperity for their inhabitants and temper the omnipresent populist threat? In this paper, I compare the Pittsburgh metropolitan area (henceforth “Pittsburgh”) and Germany’s Ruhr – two historical coal and steel regions that suffered deindustrialization, are hailed for their successful economic transformations, and that have utilized structural policies to guide their evolutions since the mid-twentieth century, but have employed different methods. In the absence of significant federal or state assistance, Pittsburgh has formulated a “bottom-up” and funded “lean” structural policies through public-private partnerships between local government, business, universities, and civil society that have generated economic growth and specialization. In contrast, the Ruhr had largely depended on supra-regional state actors – the European Union (EU), the German Federal Government (FRG), and the state of North Rhine-Westphalia (NRW) – to design “top-down” and finance “substantial” structural policies that have not produced comparably higher levels of growth or specialization. In short, the Ruhr received significantly more financial assistance than Pittsburgh – hundreds of billions versus several billion – but the economic outcomes are, strangely enough, stronger in the case of the latter.

⁵ Andrés Rodríguez-Pose, Javier Terrero-Dávila, and Neil Lee, “Left-behind versus Unequal Places: Interpersonal Inequality, Economic Decline and the Rise of Populism in the USA and Europe,” *Journal of Economic Geography*, April 17, 2023, lbad005, <https://doi.org/10.1093/jeg/lbad005>.

Arlie Russell Hochschild, *Strangers in Their Own Land: Anger and Mourning on the American Right* (New Press, The, 2016).

J. D. Vance, *Hillbilly Elegy: A Memoir of a Family and Culture in Crisis* (HarperCollins, 2016).



(Source: Bureau of Economic Analysis and Statistisches Bundesamt)

Figure 1 demonstrates that Pittsburgh’s economy has outperformed the Ruhr’s economy in the last decade when compared to their respective countries. It compares the real GDP per capita of each region with those of the United States, West Germany, and Germany, which serve as national benchmarks, from 1991 to 2021. West Germany was included because the Ruhr is both historically and geographically situated in its political economy which is not fully captured by the total Germany measure because the inclusion of East Germany lowers GDP per Capita significantly. Therefore, West Germany is a better benchmark to compare the Ruhr to than the total Germany measure. Pittsburgh’s GDP per capita was slightly below the national average but has grown to exceed the national average since 2010 suggesting that the economy is growing at a faster per capita rate in Pittsburgh than the United States as a whole. In contrast, the Ruhr has consistently fallen below the West German average and in 2016 it actually slipped below the total German average where it remains. All three German lines have stagnated in recent years which is likely the result of the European financial crisis. The difference between the Ruhr and West German and German averages indicates that the Ruhr’s economic fortunes have worsened

relative to Germany in recent years. It is, however, important to note that this is only a recent trend and more time must elapse to determine whether it is enduring. Nevertheless, this difference raises the question – *why has Pittsburgh outperformed the Ruhr?* Especially given that regional structural policy amounted to several billion dollars, at most, in Pittsburgh but tens of billions of marks and euros in the Ruhr.

In an attempt to answer this question, I divide this paper into four sections: First, I establish why Pittsburgh and the Ruhr are good cases for a cross-regional comparison based on their similar patterns of industrial decline and restructuring. Second, I trace the histories of Pittsburgh and the Ruhr's structural policies from the mid-twentieth century to the early 2000s to demonstrate their different approaches and suggest why they have produced different economic outcomes. Third, I contrast each region's economic outcomes in more detail by visualizing their underlying economic structures and patterns of specialization. Fourth, I consider each region's social outcomes by comparing their population declines. Finally, I offer conclusions about what lessons these regions offer for future structural policy.

2. Similar Industrial Regions in Crisis

Pittsburgh and the Ruhr shared common industrial structures, economic shocks, and macro patterns of restructuring that make them good cases to compare to glean insights about regional structural policy. The Pittsburgh metropolitan region has a population of 2.4 million residents and is located in the southwest corner of Pennsylvania and includes the city of Pittsburgh and Allegheny county at its core and the surrounding Armstrong, Beaver, Butler, and Fayette counties. Pittsburgh's downtown sits at the confluence of the Ohio, Allegheny, and Monongahela rivers which extend outwards across the region's hilly topography. Coal and steel formed the basis of the region's economy and the rivers served as its connective tissues feeding raw materials to the steel to plants nestled along their embankments that employed masses of workers and belched smoke into the air. These natural endowments gave rise to US Steel and other massive industrial and financial enterprises such as Alcoa, Westinghouse, Pittsburgh Plate Glass, Heinz, and Mellon Bank as well as a class of wealthy industrialists. The region's coal industry gradually declined over the 20th century and the steel industry experienced a wave of factory closings in the 1970s and 1980s. Today, these industrial enterprises have largely receded

and services such as healthcare, education, finance, and tourism now make up the region's economy.⁶

The Ruhr is situated in the northwest German state of North Rhine-Westphalia (NRW) and is a polycentric region containing major cities such as Dortmund, Essen, Duisburg, and Bochum. Originally a loose collection of rural towns, it grew into a heavily industrialized and urban agglomeration and one of Europe's densest areas with a population of 5.1 million following the discovery of coal in the 19th century. The economy soon specialized in coal mining, coal power generation, and steel production which gave rise to a handful of giant enterprises such as Thyssen and Krupp and a social structure of affluent industrialists and hundreds of thousands of workers. The coal and steel industries reconstituted themselves in the post-war era and fueled Germany's *Wirtschaftswunder*, but this prosperity was only temporary. The Ruhr's coal industry began to decline in the late-1950s in the face of cheap foreign imports and the steel industry entered crisis in the 1970s and 1980s like Pittsburgh. It has also made a broad transition to service sectors, especially logistics, education, and healthcare.

Pittsburgh and the Ruhr make a good comparison due to their numerous economic, social, and political similarities. "Monostructuralism" defined their economies throughout the 20th century meaning that they mainly specialized in just two industries, coal and steel, composed of several large corporations. These industries created societies divided among a small class of wealthy industrialists and masses of unionized workers who empowered the SPD (social democratic party) and the Democratic party, under the New Deal coalition, at the state and local levels.⁷ Deindustrialization hit at roughly similar times and scales and decimated Pittsburgh and the Ruhr's traditional industrial economies by the 1990s. Granted, Pittsburgh's coal industry declined gradually and well before the sudden shocks the Ruhr's coal industry underwent between the late-1950s and 1960s, but both region's steel industries faced downsizing in the 1970s and 1980s in the face of import competition from Asia.⁸ Pittsburgh and the Ruhr both

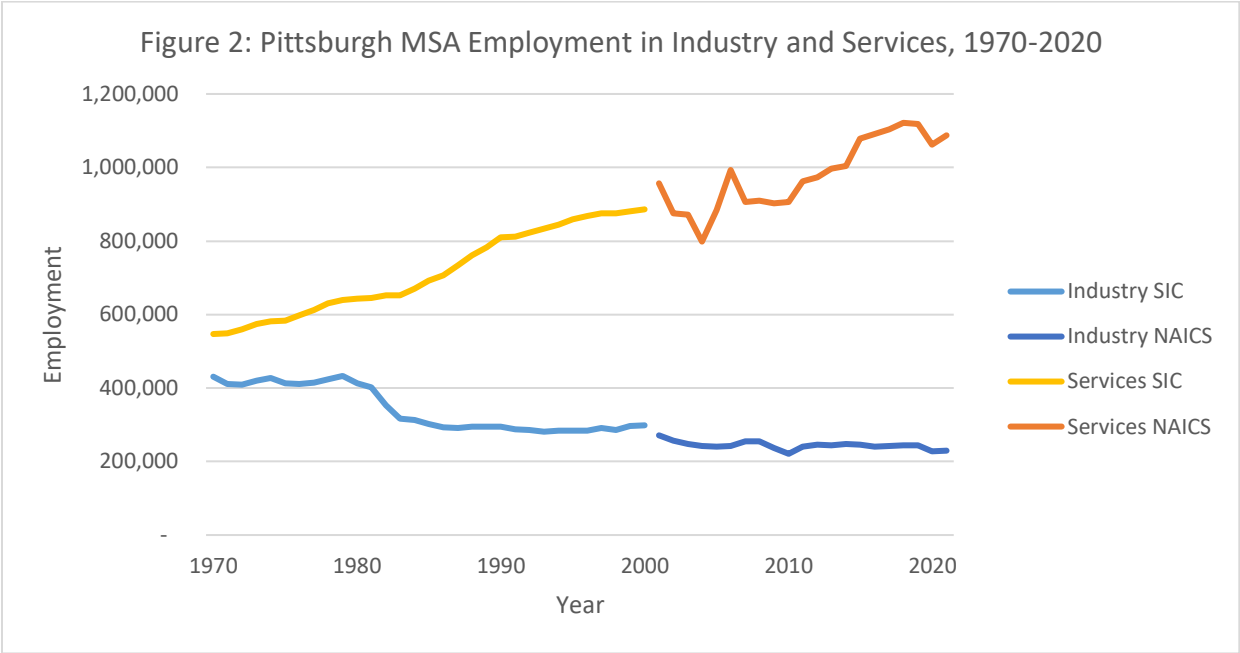
⁶ Gabriel Winant, *The Next Shift: The Fall of Industry and the Rise of Health Care in Rust Belt America* (Harvard University Press, 2021).

⁷ Jefferson Cowie, *The Great Exception: The New Deal and the Limits of American Politics* (Princeton University Press, 2017).

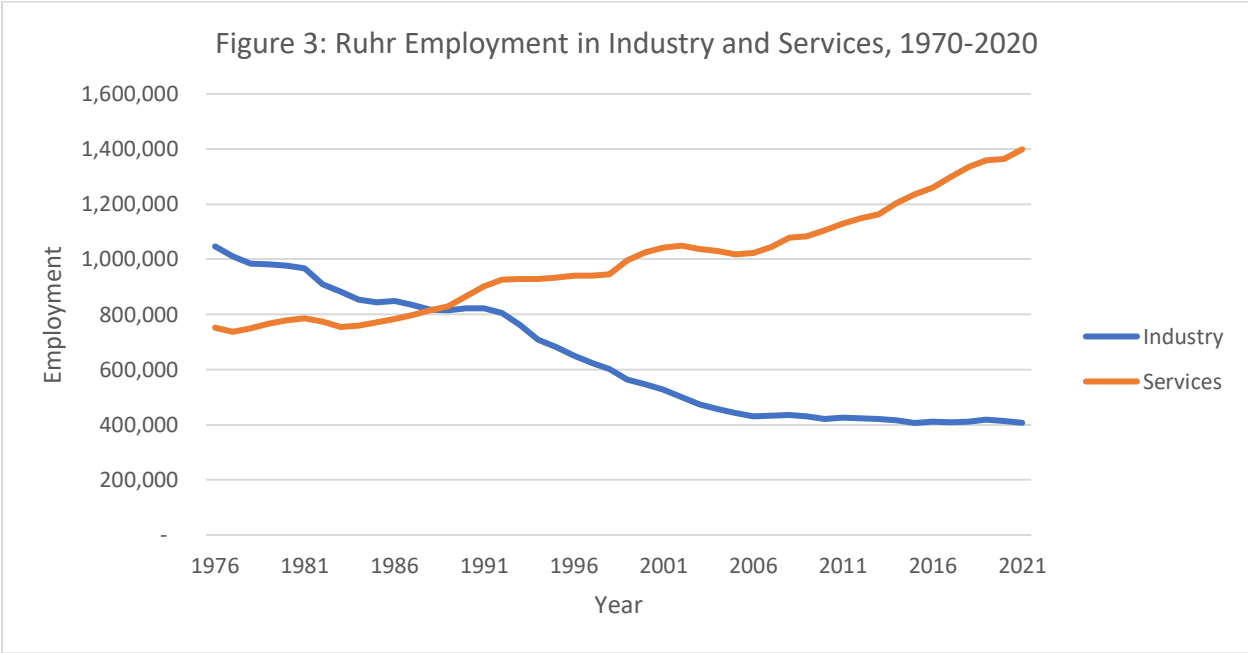
⁸ Gary Herrigel, *Manufacturing Possibilities: Creative Action and Industrial Recomposition in the United States, Germany, and Japan* (Oxford University Press, 2010).

Philipp Schepelmann, René Kemp, and Uwe Schneidewind, "The Eco-Restructuring of the Ruhr District as an Example of a Managed Transition," in *Handbook on Sustainability Transition and Sustainable Peace*, ed. Hans Günter Brauch et al., vol. 10, Hexagon Series on Human and Environmental Security and Peace (Cham: Springer International Publishing, 2016), 593–612, https://doi.org/10.1007/978-3-319-43884-9_28. Pgs. 595-597

responded by implementing structural policies around mid-century to stabilize their economies and to attract firms and build new industries for the future. Finally, both region’s economies have definitively restructured towards services in recent decades as illustrated by Figures 2 and 3.



(Source: Bureau of Economic Analysis)



(Source: Regionalverband Ruhr)⁹

⁹ Regionalverband Ruhr and Regionalstatistik Ruhr, “Statistikportal Ruhr,” Regionalverband Ruhr Statistik Portal, accessed November 25, 2022, <https://statistikportal.ruhr/#arbeitsmarkt>.

Similar governance structures empower Pittsburgh and the Ruhr at the state level yet constrain them at the regional level to address problems. The United States and Germany are both federal systems that grant considerable authority to the states and *Länder*, so Pennsylvania and NRW had political and financial latitude to respond to regional economic crisis. In contrast, fragmented regional government structures impeded collective action. Pennsylvania has one of the most complex local government structures in the United States with numerous geographic levels of political authority ranging from counties to cities to townships to boroughs with other levels of distinction in-between. This political structure divides the Pittsburgh region into numerous layers and centers of political power. Furthermore, the region's topography of hills and rivers creates natural barriers that reinforce these political divisions.¹⁰ Similarly, the Ruhr lacks a regional government and instead its polycentric constellation of cities and municipalities (*Gemeinden*) hold political authority. The one exception is the *Regionalverband Ruhr* (RVR), a regional planning and economic development organization, that the state devolved more authority to in 2004 and that even maintains its own elected body – the “Ruhr Parliament.”¹¹ Pittsburgh and the Ruhr thus had opportunities to address deindustrialization through their state governments, but faced limitations at the regional level.

These economic, social, and political similarities make Pittsburgh and the Ruhr suitable cases for a cross-national regional comparison. Of course, there are broad differences in their national political economies – the United States being a liberal market economy with a liberal welfare state and Germany being a coordinated market economy with a corporatist welfare state – and these national differences have shaped these region's different regional structural policies.¹² This paper focuses on this last difference and suggest that their different approaches to structural policy has produced different economic outcomes.¹³ In the face of common economic

¹⁰ Robert E Gleeson and Jerry Paytas, “Pittsburgh: Economic Restructuring and Regional Development Patterns, 1880–2000,” in *Sunbelt/Frostbelt: Public Policies and Market Forces in Metropolitan Development* (Brookings Institution Press, 2005).

¹¹ Dr Olaf Arndt et al., “Lehren aus dem Strukturwandel im Ruhrgebiet für die Regionalpolitik” (Bremen/Berlin/Bochum: Bundesministerium für Wirtschaft und Energie (BMWi), September 14, 2015). Ch. 2 “Bestand RVR,” Ruhr Uni Bochum, accessed May 10, 2023, https://www.isb.ruhr-uni-bochum.de/ahgr/bestand_rvr.html.de.

¹² Peter A. Hall and David W. Soskice, eds., *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage* (Oxford [England] ; New York: Oxford University Press, 2001). Gosta Esping-Andersen, *The Three Worlds of Welfare Capitalism* (Princeton, NJ: Princeton University Press, 1990).

¹³ Hall and Soskice, *Varieties of Capitalism*. Esping-Andersen, *The Three Worlds of Welfare Capitalism*.

shocks to their coal and steel industries, Pittsburgh has devised bottom-up and financed lean structural policies through partnerships between local actors that have generated economic growth and specialization while the Ruhr has mainly relied on supra-regional actors to design top-down and fund substantial structural policies that have helped but not necessarily produced superior economic outcomes given their high cost.

3. Tracing Each Region's Structural Policies

This section traces Pittsburgh and the Ruhr's structural policies from the mid-twentieth century to the early 2000s in attempt to answer how these puzzling economic outcomes came to be. Tables 1 and 2 summarize the key differences in each region's structural policy by listing the names of different plans and comparing their points of origin, main actors, objectives, and funding. These tables reflect two time periods when both regions' structural policies carried similar objectives from strengthening traditional industries between 1945 to the mid-1980s (Table 1) to growing diversified economies with knowledge-based industries from the mid-1980s to the present (Table 2). Examining these tables illustrates Pittsburgh's bottom-up and lean approach compared to the Ruhr's top-down and financially substantial approach. The remainder of this section provides a detailed account of every structural policy program in both regions with the first subsection focusing on Pittsburgh and the second subsection concentrating on the Ruhr. In investigating each region's structural policies so deeply, I attempt to demonstrate how, one on hand, Pittsburgh's approach empowered local actors and networks which has translated to greater aggregate economic growth in the present while, on the other hand, the Ruhr's approach has perhaps more fully softened deindustrialization's economic pain.

Table 1: Early Structural Policy Responses (1945 to mid-1980s)

	Pittsburgh	Ruhr
Plans	<i>Renaissance I & II</i>	<i>Entwicklungsprogramm Ruhr; NRW Programm; Technologie Programmen für Kohle, Stahl und Energie; Aktionsprogramm Ruhr</i>
Origin	Regional	Federal/State
Actors	City and Business	Federal and State Governments
Objectives	<ul style="list-style-type: none"> a. Revitalize downtown: new office buildings and parks b. Environmental clean-up c. Flood Protection 	<ul style="list-style-type: none"> a. Support and modernize existing sectors b. Subsidies for new firms c. Infrastructure – roads, trains, ports, universities d. Environmental clean-up e. Coal subsidies & support for miners
Funding	\$100s of millions to a few billion	<ul style="list-style-type: none"> a. Policy Programs: ~ DM 59 billion¹⁴ b. Coal Subsidies: ~ €72 billion¹⁵

Table 2: Later Structural Policy Responses (mid-1980s to 2000s)

	Pittsburgh	Ruhr
Plans	<i>Strategy 21 and Working Together Consortium</i>	<i>Zukunftsinitiative Montanregionen, Zukunftsinitiative für die Regionen Nordrhein-Westfalens, & EU ESDF/ERDF</i>
Origin	Regional	Planning: Regional – Funding: National/EU
Actors	City, county, business, universities, civil society	<ul style="list-style-type: none"> • Planning: RVR and industry, unions, politicians, universities, and civil society • Funding: EU (ESDF/ERDF)
Objectives	<ul style="list-style-type: none"> a. Innovation/high-tech (via universities) b. Infrastructure c. Culture/Tourism 	<ul style="list-style-type: none"> a. Innovation/high-tech (clusters) (via universities and research institutes) b. Infrastructure c. Quality of life (IBA Emscher Park) d. Culture/Tourism e. Coal subsidies & support for miners
Funding	\$100s of millions to a few billion	<ul style="list-style-type: none"> a. Policy Programs: ~ €17 billion¹⁶ b. Coal Subsidies: ~ €114 billion¹⁷

¹⁴ Pao-Yu Oei, Hanna Brauers, and Philipp Herpich, “Lessons from Germany’s Hard Coal Mining Phase-out: Policies and Transition from 1950 to 2018,” *Climate Policy* 20, no. 8 (September 13, 2020): 963–79, <https://doi.org/10.1080/14693062.2019.1688636>.

¹⁵ Karl Storchmann, “The Rise and Fall of German Hard Coal Subsidies,” *Energy Policy* 33, no. 11 (July 2005): 1469–92, <https://doi.org/10.1016/j.enpol.2004.01.006>. pg. 1491

Coal subsidies from 1958 to 1985 and converted to 2015 €

¹⁶ Oei, Brauers, and Herpich, “Lessons from Germany’s Hard Coal Mining Phase-Out.”

¹⁷ Storchmann, “The Rise and Fall of German Hard Coal Subsidies.” pg. 1491

Coal subsidies from 1958 to 1985 and converted to 2015 €

3.1 Pittsburgh's Bottom-Up and Lean Structural Policy

The Pittsburgh region implemented four structural policy programs between 1945 and the early 2000s. Their initial objective was to strengthen the city's image and location for business, but then evolved to transform the city and region's economy once the steel crisis struck in the 1970s and 1980s. In the absence of significant or sustained support from the federal or state governments, regional actors developed bottom-up coalitions to formulate structural policy programs and on public-private partnerships to fund them. These programs were "lean" given the lack of public financing and therefore leveraged the business-community and philanthropies for investment and activated their cooperation with universities to generate applied research and technology transfer. The regional coalitions grew to include a wider-array of actors with each subsequent program and extended to encompass a broader geographic scope beginning with the city center and then eventually reaching more of the region. Pittsburgh's approach to structural policy has therefore formed deep networks across sectors and actors that have sparked economic growth and innovation.

Responding to Pittsburgh's negative image, the city government and the businesses community (organized as the Allegheny Council) implemented an initial regional structural policy known as "Renaissance I" between 1945 and 1969 focusing on the city's core. The Democratic mayor formed a close working relationship with the business community that served as the foundation of this initiative.¹⁸ Renaissance I's primary objective was to revitalize Pittsburgh's downtown through real-estate development, the creation of green spaces, and the mitigation of flooding and air pollution so that it would become an attractive place for corporate headquarters that supported much of the city's tax base. The coalition successfully lobbied Pennsylvania's General Assembly to pass a slate of bills that provided funding and local political authority to expedite these projects. Major corporations such as US Steel, Mellon Bank, and Alcoa constructed modern skyscrapers and, together with the city, built major green spaces such as Point Park.¹⁹ Renaissance I was deemed a success relying heavily on the business community to develop a modern downtown and planting the seeds for future public-private collaboration.

¹⁸ Sabina Detrick, "The Post Industrial Revitalization of Pittsburgh: Myths and Evidence," *Community Development Journal* 34, no. 1 (1999): 4–12. Pg. 5

¹⁹ Renee A. Berger and R. Scott Fosler, "Four Decades of Public-Private Partnerships in Pittsburgh," in *Public-Private Partnership in American Cities: Seven Case Studies* (Lexington, Mass: Lexington Books, 1982).

The region's manufacturing industry showed its first signs of weakness in the 1960s and 1970s leading numerous layers of regional governments to prop it up with low-interest loans. The Pittsburgh region formed the Regional Industrial Development Corporation (RIDC) and loaned \$106.8 million to 96 industrial projects between 1963 and 1979. Allegheny County replicated this program creating the Allegheny County Industrial Development Authority (ACIDA) in 1970 which provided \$647 million in low-interest loans by 1980. Regional municipalities also embraced this approach creating seven more industrial development authorities. Most of this funding went to the steel industry and was essential to retain companies that used the funding to defray the costs of the EPA's air quality standards and to invest in new factories and warehouses.²⁰

Low-interest loans could not prevent the steel crisis that hit Pittsburgh beginning in the mid-1970s. A new mayor responded to the region's economic downturn by rekindling the city-business coalition to put forth a new plan, "Renaissance II," between 1979 and 1982. Renaissance II took after its precursor in name and form, more specifically, it continued the redevelopment of Pittsburgh's downtown through the construction of new office buildings and building of a light-rail line funded by a \$500 million federal grant.²¹ A major difference was that the city government had strengthened its administrative capabilities over the preceding decades and now had more power over the business community and took the initiative to design the plans. The city's leading role enabled it to draw non-profits and community groups into the planning coalition in order to more fully represent the city's diverse population. Additionally, the city's neighborhoods gained power in the 1960s as the federal government's Great Society programs permitted them to form community groups (so-called "community development corporations") and receive funding.²² These changes allowed the city and neighborhoods to address concentrated poverty in the areas around the downtown and along the rivers. Renaissance II did little to address Pittsburgh's lack of economic diversification, however, it did begin to expand the planning coalition's membership and the structural policy's geographic scope beyond the urban core.²³

²⁰ Gleeson and Paytas, "Pittsburgh: Economic Restructuring and Regional Development Patterns, 1880–2000." Pgs. 189-191

²¹ Gleeson and Paytas.

²² Roy Lubove, *Twentieth-Century Pittsburgh: The Post-Steel Era* (University of Pittsburgh Pre, 1995). Ch. 5

²³ Detrick, "The Post Industrial Revitalization of Pittsburgh." Pgs. 5-7
Berger and Fosler, "Four Decades of Public-Private Partnerships in Pittsburgh."

The most ambitious and wide-ranging period of regional structural policy came with a new plan, “Strategy 21”, in 1985 as the steel crisis cascaded and plunged the region into economic calamity. The planning coalition grew to include new members such as the major universities, Allegheny County, and the state of Pennsylvania. The plan’s aim was to diversify the region’s economy through investments in high-technology, infrastructure, and culture. Strategy 21’s inclusion of Carnegie Mellon University (CMU) and the University of Pittsburgh (Pitt) nurtured the ignition of a knowledge economy because both were major research institutions with the former specializing in engineering and computer science and the latter in life sciences and health care. The state government and non-profits played a critical role in linking the universities and industry through the creation of the Ben Franklin Partnership in 1983 which provided more than \$280 million for Strategy 21 projects by 1988, including (a) the Pittsburgh Technology Center, a 48-acre research park, that jointly holds research facilities of CMU, Pitt, and private industry; (b) a software engineering institute at CMU that the U.S. Department of Defense jointly financed; (c) a supercomputer center sponsored by CMU, Pitt, Westinghouse with funding from the National Science Foundation; and, (d) the University of Pittsburgh Applied Research Center and Technology Park.²⁴ These projects expanded the universities’ role in the region by promoting their administrators to community leaders, encouraging their cooperation with each other, and causing them to recognize economic development as an institutional priority.²⁵

Strategy 21 also upgraded the region’s infrastructure and cultural institutions. Allegheny County constructed new airport terminals and a federally-funded high from the airport to the downtown. Pittsburgh and the county provided low-interest loans to construct office parks along the highway to create a suburban airport corridor.²⁶ The plan also sought to create a tourism economy using the existing cultural institutions such as the Carnegie Museum of Art, the Carnegie Museum of Natural History, The Frick, and the Pittsburgh Symphony Orchestra as a

Margaret Cowell, “‘Bowling Out’ – Cincinnati, Pittsburgh, Indianapolis, and Columbus,” in *Dealing with Deindustrialization: Adaptive Resilience in American Midwestern Regions* (Routledge, 2014), Ch. 6.

²⁴ Lubove, *Twentieth-Century Pittsburgh*. Pg. 290

²⁵ Ben Armstrong, “Industrial Policy and Local Economic Transformation: Evidence From the U.S. Rust Belt,” *Economic Development Quarterly* 35, no. 3 (August 2021): 181–96, <https://doi.org/10.1177/08912424211022822>. Gleeson and Paytas, “Pittsburgh: Economic Restructuring and Regional Development Patterns, 1880–2000.” Pg. 195

Lubove, *Twentieth-Century Pittsburgh*. Ch. 3

²⁶ Gleeson and Paytas, “Pittsburgh: Economic Restructuring and Regional Development Patterns, 1880–2000.” Pgs. 194-196

foundation and then constructing new institutions such as the Andy Warhol Museum and the Carnegie Science Center.²⁷ Strategy 21 represented an important step forward because it brought the state and the universities into the planning coalition, adopted a regional rather than city-centered approach, and set the transformation of the region's economy into motion from heavy industry to education, science, health care, and culture.

As Strategy 21 ended, its organizers commissioned a report in 1993 that compared Pittsburgh to other industrial regions and revealed major weaknesses, namely that the manufacturing sector continued to shed jobs and that high-technology industries had not yet taken root. These sobering results prompted a similar coalition of local and county governments, the Allegheny Conference, universities, non-profits, and community organizations to form the "Working Together Consortium" (WTC) to develop the next round of regional structural policy between 1994 to the early 2000s.²⁸ Scholars have criticized WTC's plans for favoring the interests of the business community and departing from Strategy 21's socially-inclusive plans.²⁹

WTC highlighted the need to continue investing in advanced manufacturing, high-technology, entrepreneurship, education, tourism, and infrastructure but lacked a dedicated source of funding as the state of Pennsylvania was notably absent from the coalition. This challenge prompted the WTC to seek regional sources of revenue through several channels. In 1994, Allegheny County received permission from the state to implement a 1% sales tax to fund cultural and community institutions.³⁰ In 1996, the Allegheny Conference and non-profits formed the Strategic Investment Fund to provide loans for major regional investments and the reuse of industrial sites for high-technology research and enterprises.³¹ Finally, voters firmly reject the WTC coalition attempt to pass a region-wide sales tax of 0.5% across eleven counties in 1997.³² In a controversial move, Allegheny County tapped funds from the 1% sales tax to fund new stadiums for the Steelers and Pirates as well as the renovation of Pittsburgh's convention

²⁷ Lubove, *Twentieth-Century Pittsburgh*. Ch. 9

Cowell, "'Bowling Out' – Cincinnati, Pittsburgh, Indianapolis, and Columbus."

²⁸ Brian D. Jacobs, *Strategy and Partnership in Cities and Regions: Economic Development and Urban Regeneration in Pittsburgh, Birmingham, and Rotterdam* (New York, N.Y.: St. Martin's Press, 2000). Ch. 4

²⁹ Detrick, "The Post Industrial Revitalization of Pittsburgh."

³⁰ Allegheny Regional Asset District, "History | RAD Works Here," Allegheny Regional Asset District, accessed May 11, 2023, <https://www.radworkshere.org/pages/history>.

³¹ Donald K. Carter, "Pittsburgh, Pennsylvania," in *Remaking Post-Industrial Cities: Lessons from North America and Europe* (New York, NY: Routledge, Taylor & Francis Group, 2016), Ch. 6.

³² Detrick, "The Post Industrial Revitalization of Pittsburgh." Pgs. 7-10

center.³³ In short, WTC represents a continuation of Strategy 21's coalition and priorities, but perhaps most importantly it demonstrates the local governments and actors' commitment to finance the region's transformation themselves.

Renaissance I & II, Strategy 21, and WTC ran from 1945 to the early 2000s and represent a sustained attempt at structural policy to initially strengthen the city's image and downtown and subsequently reshape the region's economy in the face of deindustrialization. What are the major takeaways from over a half-century of experimentation in Pittsburgh? First, public-private partnerships stood at the core of all four plans resulting in lean and focused priorities, especially in the absence of lasting support from the state or federal governments. Pennsylvania did contribute significantly to Strategy 21, but this involvement represented an exception as the other plans only ever received occasional grants for specific projects. Second, local actors formed these partnerships through a bottom-up coalition of the Democratic city machine and the Republican business community that expanded with each plan to include participants such as Allegheny County, CMU, Pitt, non-profits, and community groups. Third, as the coalitions expanded so did the plans' geographic scope beginning with the city center and encompassing larger parts of the region later on. Nevertheless, these plans mainly benefited the city and Allegheny County due to the lack of regional governance structures to coordinate planning and the allocation of resources and therefore they have not addressed the economic dislocation and poverty in the region's outer lying areas.³⁴ Despite the problem of geographic inequality, Pittsburgh's bottom-up approach has established deep networks across sectors and actors that have sparked economic growth in the present.

3.2 The Ruhr's Top-Down and Substantial Structural Policy

The Ruhr implemented numerous rounds of structural policy beginning in 1958 and continuing to the present. As in Pittsburgh, these programs initially focused on stemming the decline of the coal and steel industries and investing in infrastructure and then shifted to promoting a knowledge economy through the region's universities. The FRG and NRW formulated the early programs top-down with substantial funding worth hundreds of billions of marks (DM) and euros. From 1958 until 2018, they provided massive subsidies to the coal

³³ "Pittsburgh Post-Gazette - Plan B," Pittsburgh Post-Gazette, accessed May 11, 2023, <https://old.post-gazette.com/planb/>.

³⁴ Lubove, *Twentieth-Century Pittsburgh*. Ch. 8
Gleeson and Paytas, "Pittsburgh: Economic Restructuring and Regional Development Patterns, 1880–2000."

industry and social support for miners. They also developed numerous structural policy programs that made targeted investments in the Ruhr. The FRG stepped back from the Ruhr with reunification to focus on East Germany, but the EU entered with its Cohesion Policy that grew in size in the 1990s. The Ruhr's structural policy has continued to draw funding top-down from the EU and NRW since the 1990s but has developed priorities bottom-up by turning to local actors and targeting local industry clusters. The Ruhr's array of programs fit into four periods that represent different economic goals and forms of top-down and bottom-up organization.

Beginning with the coal crisis in 1958, the FRG, NRW, and the Saarland, another coal producing state, propped up the domestic coal industry with supports that lasted until 2018. The root cause of this crisis was the large price gap between domestic and foreign coal and the rise of alternative energy sources. Germany responded with a wide array of measures that total over 58 separate policies, but four of these measures stand out for their scope, cost, and differing economic and social aims. One method was to ensure sufficient domestic demand: Through the *Kokskohlenbeihilfe*, running from 1967 to 1998, the FRG guaranteed the use of domestic coal in steel production by covering the price difference between it and foreign coal. The *Kohlepennig* ("coal penny") secured the use of domestic coal in power generation by placing a national tax on consumers to make up for the higher price between 1975 and 1995. The FRG also funded generous social supports for laid-off miners. The *Anpassungsbeihilfe* ("re-adaptation aid"), passed in 1960, encompassed a variety of measures ranging from compensation for earning losses to vocational training to moving assistance. The *Anpassungsgeld*, implemented in 1971, provides early retirement payments for miners until they reach retirement age and receive pensions.³⁵ Federal subsidies for the coal industry lessened in the 2000s, but still continued until 2018 when the last mine closed in the Ruhr.³⁶ These programs were incredibly expensive. One estimate finds that all the supports cost €157.7 billion between 1958 and 2002.³⁷ Another estimate cites €165 billion for the subsidies and €18 billion for the social supports between 1968 and 2018.³⁸ These

³⁵ Storchmann, "The Rise and Fall of German Hard Coal Subsidies."

³⁶ Oei, Brauers, and Herpich, "Lessons from Germany's Hard Coal Mining Phase-Out."

Philipp Herpich, Hanna Brauers, and Pao-Yu Oei, "An Historical Case Study on Previous Coal Transitions in Germany," 2018, 32.

³⁷ Storchmann, "The Rise and Fall of German Hard Coal Subsidies." Pg. 1491

Adjusted to 2015 Euros

³⁸ Oei, Brauers, and Herpich, "Lessons from Germany's Hard Coal Mining Phase-Out."Pg. 969

coal supports were beneficial in that they eased the Ruhr's economic crisis and aided struggling miners, yet they also delayed its economic transition.

With the massive coal supports in the backdrop, the FRG and NRW simultaneously crafted targeted structural policy programs to improve the Ruhr's infrastructure and diversify its economy. The first period began in 1958 with the coal crisis when the FRG and NRW implemented two well-funded structural policy programs between 1966 and 1975. The CDU-led federal and state governments did not address this crisis at its onset and only with the SPD's victory at both levels of government in the mid-1960s did regional structural policies come into being.³⁹ The SPD approved the *Entwicklungsprogramm Ruhr* (EPR) in 1966 and it came into effect in 1968 carrying 17 billion DM with three objectives. First, the EPR offered subsidies to entice large industrial firms to open factories in the Ruhr. Second, it invested heavily in the region's infrastructure resulting in new highways, rail lines, and universities. The first universities, the Ruhr-Universität Bochum and the Technology University Dortmund, had been founded in 1961 and the EPR expanded them and constructed several new *Fachhochschulen* (Universities of Applied Science). Finally, the EPR also resulted in new parks and programs to restore the Ruhr's polluted environment.⁴⁰ The FRG and NRW folded the EPR into a new plan, the *Nord-Rhein Westfalen Programm* (NRW Program), that carried similar objectives and increased funding to 31 billion DM lasting until 1975.⁴¹

The demand for coal rebounded with the oil crisis of the mid-1970s causing NRW to adopt a more sanguine outlook on the Ruhr's economy and to launch a second period of structural policies to reindustrialize the region between 1974 and 1988. The FRG stepped back from these programs and NRW took the lead in both designing and funding them. It crafted a set of four "technology programs" running from 1974 to 1978 that invested approximately 3.65 billion DM in small and medium-sized enterprises and the mining, energy, and steel industries to improve their productivity, increase knowledge-transfer with universities and research centers, and to reduce their pollution. In 1980, NRW folded these four programs into the

³⁹ Jeffrey J. Anderson, "The German Länder," in *The Territorial Imperative: Pluralism, Corporatism, and Economic Crisis* (Cambridge [England]; Cambridge University Press, 1992), 144–86.

⁴⁰ "Entwicklungsprogramm Ruhr 1968-1973" (Düsseldorf: Landesregierung Nord-Rhein Westfalen, March 5, 1968).

⁴¹ Arndt et al., "Lehren aus dem Strukturwandel im Ruhrgebiet für die Regionalpolitik." Pgs. 99-101
Elke Dahlbeck and Stefan Gärtner, "Just Transition for Regions and Generations: Experiences from Structural Change in the Ruhr Area" (Berlin: World Wildlife Fund Germany, January 2019). Pgs. 38-40

Aktionsprogramm Ruhr (APR) which cost 6.9 million DM and continued until 1984.⁴² Finally, it adopted a new version of the technology programs in 1985 with DM 400 million in funding and running until 1988 to invest in future-oriented industries such as green technology through the construction of 29 technology transfer stations.⁴³ A prominent project to emerge from this period was the Technology Park Dortmund which houses startups and was built next to University of Dortmund which had a strong computer science program and a tech incubator. Today, the Tech Park is home to many of the Ruhr's most innovative companies in biomedicine, robotics, and environmental technology.⁴⁴

A third period began in the midst of the steel crisis of the 1980s that combined top-down and bottom-up approaches. NRW introduced a new plan, the *Zukunftsinitiative Montanregionen* (ZIM), in 1987 that provided DM 2 billion from above but tasked industry, unions, politicians, educational institutions, and civil society to come together and develop plans from below. ZIM's goals nonetheless broadly emulated those of the APR such as promoting innovation and technology, developing skilled workers, investing in infrastructure, limiting pollution, and improving the local environment. NRW extended ZIM to all of NRW in 1989 under the title of *Zukunftsinitiative für die Regionen Nordrhein-Westfalens* (ZIN).⁴⁵ A region-wide exhibition, the *Internationale Bauausstellung* (IBA) Emscher Park, developed outside of ZIM, demonstrated the new approach to planning. The EU, FRG, and NRW provided DM 5 billion to reconstruct industrial lands and factories into parks, museums, and sculptures along the Emscher River, which stretches across the Ruhr, from 1989 to 1999.⁴⁶ Local inhabitants and municipalities proposed cultural projects to a regional commission that selected 120 to implement throughout

⁴² Arndt et al., "Lehren aus dem Strukturwandel im Ruhrgebiet für die Regionalpolitik." Pgs. 102-103
Dahlbeck and Gärtner, "Just Transition for Regions and Generations: Experiences from Structural Change in the Ruhr Area." Pgs. 40-41

⁴³ Béla Galgóczi, "The Long and Winding Road from Black to Green: Decades of Structural Change in the Ruhr Region," *International Journal of Labour Research* 6, no. 2 (2014): 217–40. Pg. 228

⁴⁴ Robert P Taylor, "A Review of Industrial Restructuring in the Ruhr Valley and Relevant Points for China," July 2015, 25. Pg. 10

⁴⁵ Arndt et al., "Lehren aus dem Strukturwandel im Ruhrgebiet für die Regionalpolitik." Pgs. 105-108
Dahlbeck and Gärtner, "Just Transition for Regions and Generations: Experiences from Structural Change in the Ruhr Area." Pg. 41

⁴⁶ Philip Pinch and Neil Adams, "The German Internationale Bauausstellung (IBA) and Urban Regeneration: Lessons from the IBA Emscher Park," in *The Routledge Companion to Urban Regeneration* (Routledge, 2013). Pg. 231

the park.⁴⁷ The IBA is credited with catalyzing bottom-up planning and the creation of a tourism and cultural economy.

This combination of top-down funding and bottom-up planning has continued into a fourth period of regional structural policy beginning in the early 2000s. The devolution of regional planning authority to the RVR in 2004 strengthened the Ruhr's hand.⁴⁸ The EU and NRW have provided much of the financing for these plans which often carry specific requirements. For example, the EU introduced "smart specialization" with the Lisbon Strategy in 2000 which requires regions to identify and integrate clusters into their plans in order to receive funds. Clusters are networks of interdependent firms and research centers that work in a fixed geography in specialized, knowledge-based industry such as San Francisco for technology or London for finance.⁴⁹ The Ruhr had already begun a cluster-based strategy in the late-1990s and has identified its clusters on several occasions since then. Most recently, NRW identified 16 clusters in preparation for the 2014-2020 EU budget planning process and grouped them into eight industries, namely life sciences; mechanical, plant, and process engineering; media and creative industries; mobility and logistics; and, new materials.⁵⁰ The Ruhr's universities play a central role in providing these clusters with applied research and skilled workers and, after decades of investment, the region boasts one of the densest networks in Germany containing four universities and eighteen universities of applied science that employ 31,000 professors and researchers and educate approximately 290,000 students.⁵¹ The region has continued to invest in its universities in order to grow its clusters in the future.

The Ruhr's numerous structural policy programs running from 1958 to the present exhibit a serious and sustained attempt to transform the region's economy as in Pittsburgh. Similarly, both region's early programs focused on shoring up their traditional industries and shifted to

⁴⁷ Hillary Angelo, *How Green Became Good: Urbanized Nature and the Making of Cities and Citizens* (Chicago, IL: University of Chicago Press, 2021), <https://press.uchicago.edu/ucp/books/book/chicago/H/bo61910401.html>. Ch. 5

⁴⁸ Arndt et al., "Lehren aus dem Strukturwandel im Ruhrgebiet für die Regionalpolitik." Ch. 2 "Bestand RVR."

⁴⁹ Dahlbeck and Gärtner, "Just Transition for Regions and Generations: Experiences from Structural Change in the Ruhr Area." Pg. 43

⁵⁰ Robert Hassink and Matthias Kiese, "Solving the Restructuring Problems of (Former) Old Industrial Regions with Smart Specialization? Conceptual Thoughts and Evidence from the Ruhr," *Review of Regional Research* 41, no. 2 (October 2021): 131–55, <https://doi.org/10.1007/s10037-021-00157-8>. Pg. 13

Taylor, "A Review of Industrial Restructuring in the Ruhr Valley and Relevant Points for China." Pgs. 11-13

⁵¹ Arndt et al., "Lehren aus dem Strukturwandel im Ruhrgebiet für die Regionalpolitik." Pgs. 75-82

"Wie Kooperationen das Ruhrgebiet zur Wissensregion machen," *Metropole Ruhr*, accessed June 25, 2023, <https://metropole.ruhr/artikel/bildung-und-wissen>.

kindling a knowledge economy through their universities. What are the main characteristics of the Ruhr's decades-long embrace of structural policy? First, the massive supports for the coal industry were backward looking inhibiting a more rapid economic transition but did stabilize the region's economy and provide much needed support for miners. Second, the EU, FRG, and NRW's involvement ensured that structural policy has been a fairly top-down affair as these bodies sent tens of billions of marks and euros into the region (beyond the coal supports). Second, a bottom-up approach only began in earnest in the late-1980s as the FRG stepped back and NRW tapped local actors to help formulate structural policy. The EU and NRW still provide substantial financing and attach their priorities accordingly so the current period is best described as a mix of bottom-up and top-down planning. Third, the top-down approach in conjunction with the RVR has considered the Ruhr in its entirety during the planning process rather than just the core and Allegheny county in the case of Pittsburgh. The Ruhr's state-centered, top-down approach has provided more funding to soften the economic shocks and geographic inequalities produced by deindustrialization.

4. Economic Outcomes

This sections contrasts the economic outcomes of Pittsburgh and the Ruhr's structural policies more fully. Some may argue that any regional differences observed are the results of national economic conditions, but I counter that after such sustained, intentional, and, in the case of the Ruhr, expensive regional structural programs there must have been some effects carried through time by means of historical causal processes and path dependencies. This section presents two figures that build on Figure 1 (Pittsburgh and the Ruhr's GDP per Capita compared to the USA and Germany) by visualizing their underlying economic structures and patterns of specialization and pointing to a generally healthier economy in Pittsburgh.

Figures 4 and 5 detail the structure and changes of Pittsburgh and the Ruhr's economies by representing different sectors' degree of specialization, employment size, and employment growth. Each circle represents a sector with its size corresponding to the number of employees in 2021 and its colors indicating orange for services, blue for manufacturing, green for agriculture, and yellow for public. The x-axis indicates each sector's percentage change in employment between 2008 and 2021. 2008 was chosen as the starting year because it is the first year for which Ruhr industry data is available. The y-axis uses an indicator called a location quotient

(LQ) that measures a sector's degree of specialization by dividing the percentage of employees working in a sector in a certain geography relative to the country as a whole. A LQ of 1 indicates that a sector has the same percentage of employees working in it locally as the nation as a whole and therefore serves as the center of the y-axis. A LQ of 2 signals that a sector has double the percentage of employees working in it locally as the nation as a whole. Specialization is important to capture because it is a core principle of economic growth going back David Ricardo's theory of comparative advantage. A region with a healthy, diversified economy should have several high-valued added, specialized sectors that export their products and services and serve as "clusters" that the region can nurture through targeted investments.

Comparing Figures 4 and 5 reveals several insights about the restructuring, similarities, and differences of Pittsburgh and the Ruhr's economies. The service sector has grown just as the industrial sector has declined as evidenced by the preponderance of large orange circles occupying the right side of the figures and the prevalence of medium and small blue circles situated in the middle and left sides of the figures. Both cities' economies have similar core sectors. For example, their manufacturing sectors are both large to medium-sized, have an average degree of specialization, and are declining. Their education sectors are both growing, employee a similar number of people, but Pittsburgh's education sector has a much higher degree of specialization with an LQ of 1.8 compared to 1.1 in the Ruhr. Their transportation and warehousing sectors (also known as logistics) are also rapidly growing and have an average degree of specialization.

A major difference is that Pittsburgh's economy has more growing, specialized service sectors than the Ruhr. The greater number of orange circles occupying the top right-corner in Figure 4 than Figure 5 illustrates this point. Many of these circles make sense when considering Pittsburgh's history of structural policy. The city's downtown was redeveloped numerous times, especially under Renaissance I and II, so that it would remain a hub for corporate headquarters which is indicated by the circle labeled "Management of Companies and Enterprises" which includes major corporations such as PNC Bank, Dick's Sporting Goods, PPG Industries, and Eaton today. The strength of CMU and Pitt and their applied scientific research is visible in the two neighboring circles labeled "Education" and "Professional, Scientific, and Technical Services." The legacy of world-class cultural institutions from the industrial era, the new museums built in the 1990s, and the new sports stadiums constructed in the early 2000s can be

seen in the circle labeled “Arts, Entertainment, and Recreation.” Although not very-specialized, Pitt’s large hospital system, UPMC, is visible in the large circle labeled “Healthcare and Social Assistance.” On the other hand, we do observe several growing services sectors in the Ruhr that structural policies targeted such as “Transportation and Storage”, “Education”, “Professional, Scientific, and Technical Services”, and “Arts, Entertainment, and Recreation”, but none match the levels of specialization seen in Pittsburgh. This difference indicates that while both economies have successfully grown new sectors, Pittsburgh has done better at finding niches in the national and world economies.

It is also important to notice that the Ruhr has more industries occupying the right-hand side of the graph. Pittsburgh has several industries, mainly in the service sector, with slight declines ranging from 0% to 10% while the Ruhr has very few. This difference is challenging to explain and warrants greater consideration. Perhaps it is the result of greater state support in the Ruhr that props up these industries? It does offer a silver lining for the Ruhr – despite having limited specialization, at least its economy is growing.

Figure 4

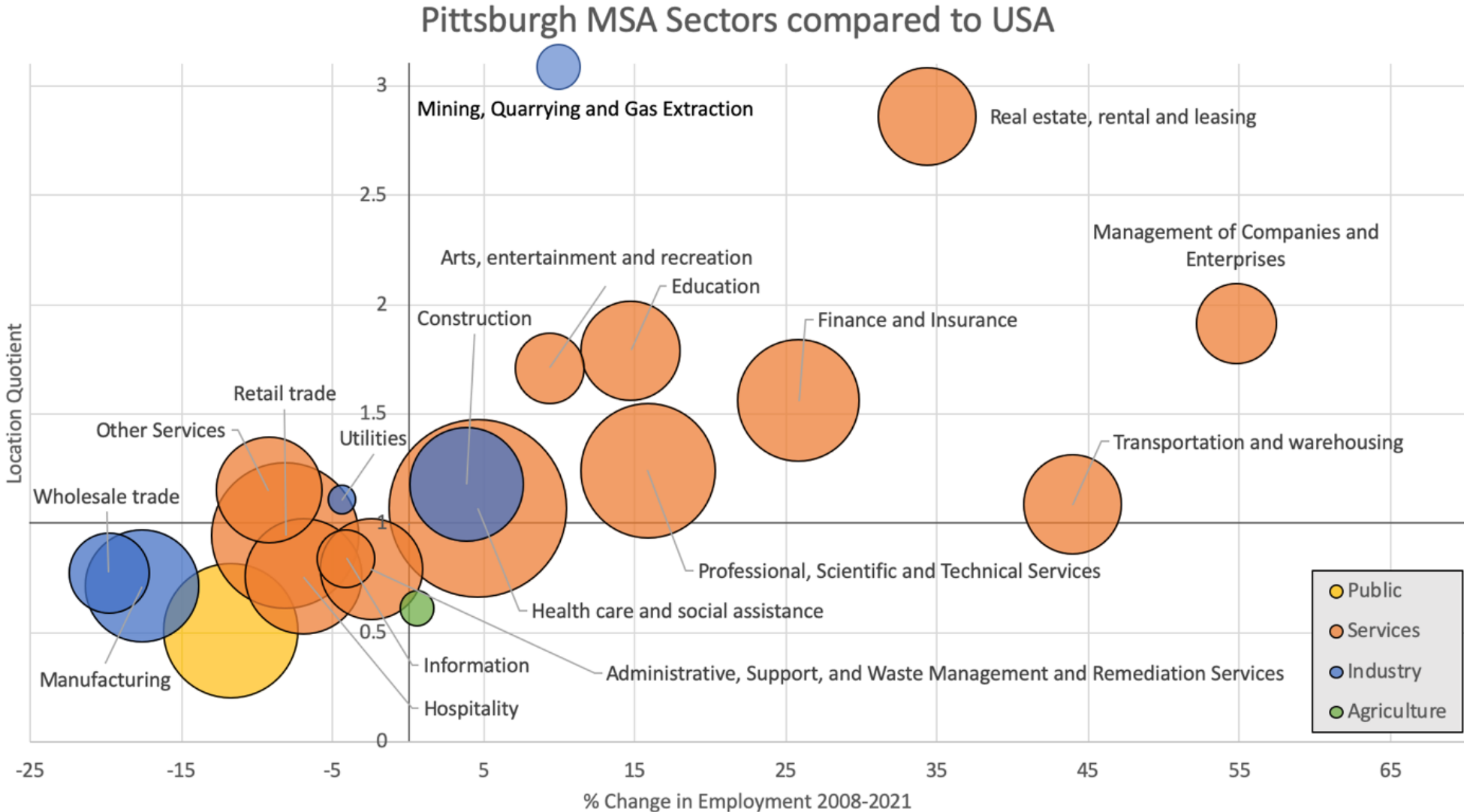
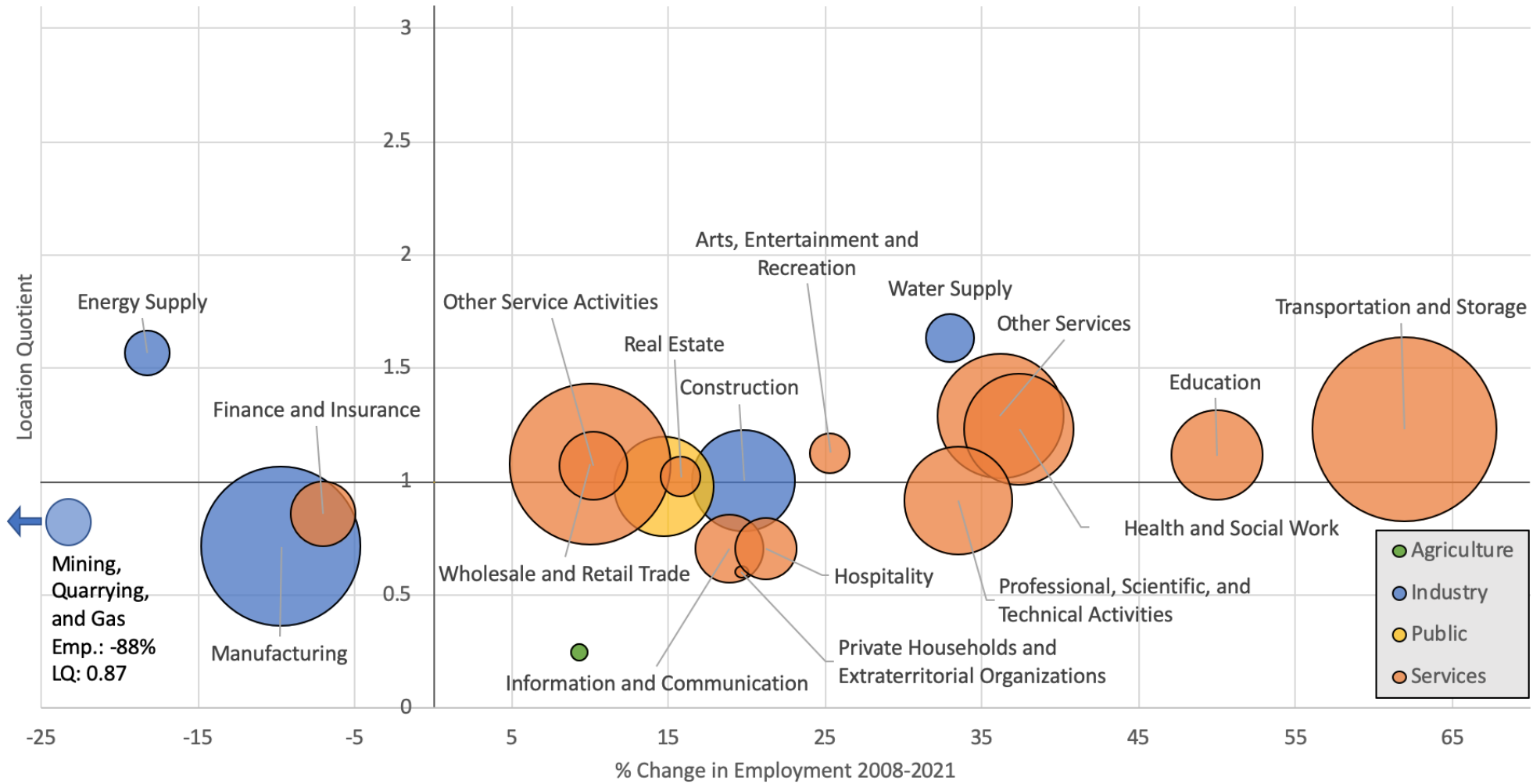


Figure 5

Ruhr Sectors compared to Germany



5. Social Outcomes

One possible explanation to account for the Ruhr's economic performance is that the hundreds of billions of euros and DM that the EU, FRG, and NRW invested in the Ruhr supported social outcomes rather than economic outcomes. In line with Germany's tradition of a "social market" economy and corporatism, perhaps much of the structural policy funding supported affected groups such as miners by ensuring their jobs and boosting their consumption, or also beautified the Ruhr's post-industrial landscape through projects such as the IBA Emscher Park.⁵² This is definitely the case with the massive coal subsidies which propped up a dying industry for decades. Expenditures on consumption likely helped raise or stabilize GDP in the short-term, but little effect in the long-term because they were not invest in new businesses or industries of the future.⁵³

One simple indicator to capture this line of reasoning is each region's population change. People vote with their feet: they stay in a region if their social and economic needs are met, and leave if not.⁵⁴ This pattern is clear in the United States and Germany – people, especially the young, have left regions such as East Germany, states such as West Virginia, and cities such as Detroit due to major social and economic challenges. If the significant spending in the Ruhr did go to supporting social outcomes, then one would expect the population change to be less in the Ruhr than in Pittsburgh.

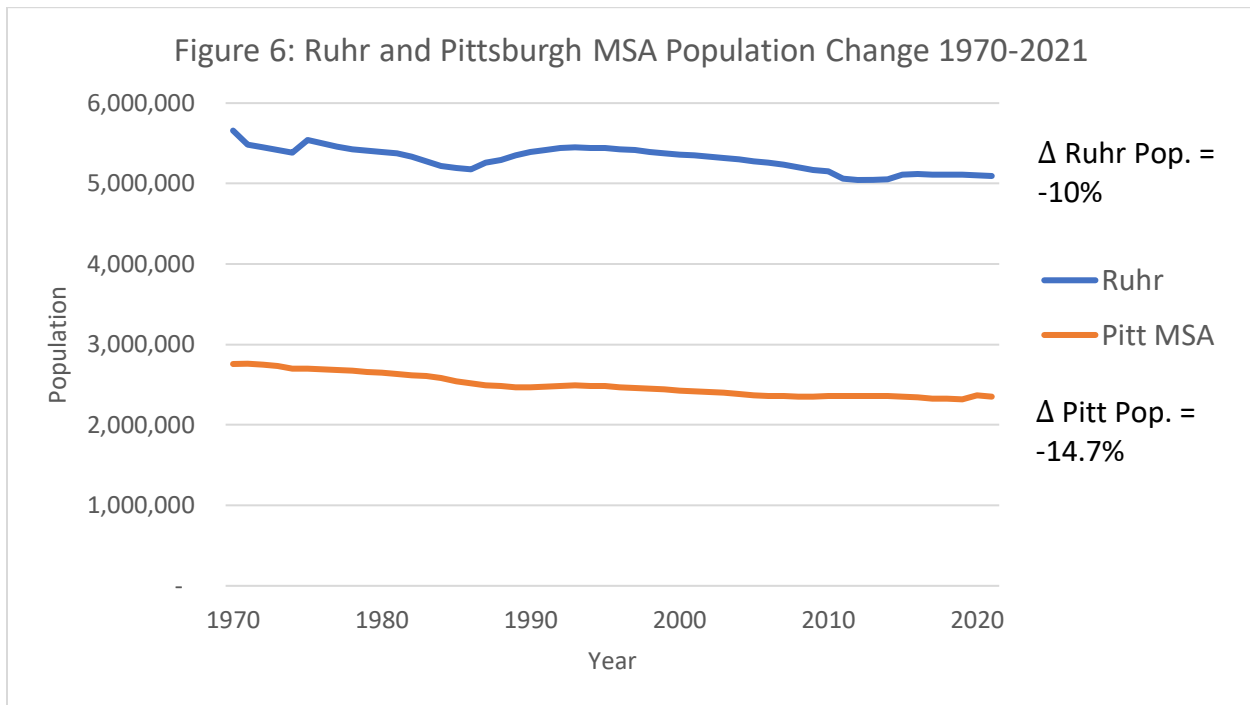
Figure 6 compares the populations of the Ruhr and Pittsburgh between 1970 and 2021. Over this period, the Ruhr's population declined from 5.7 million to 5.1 million which represents a percentage change of -10%. Similarly, the Pittsburgh MSA's population decreased from 2.8 to 2.4 million which corresponds to a percentage change of -14.7%. This difference is not particularly large – only 4.7% more population loss in Pittsburgh over 50 years. Perhaps the billions spent on structural policy and Germany's welfare state account for the 4.7% difference. Despite more spending in the Ruhr, people clearly left both regions at similar rates over the course of deindustrialization suggesting that they faced similar social and economic hardship in both places. Nonetheless, more data still needs to be collected on specific social outcomes such

⁵² Angelo, *How Green Became Good*.

⁵³ With the exception of tourism

⁵⁴ Albert O. Hirschman, *Exit, Voice, and Loyalty: Responses to Decline in Firms, Organizations, and States* (Harvard University Press, 1970).

as life expectancy, drug and substance abuse, and violence to evaluate this counter argument more fully.



(Source: Regionalverband Ruhr and FRED, US Census Bureau)⁵⁵

6. Conclusions

What might explain Pittsburgh’s stronger economic outcomes? They are likely the result of the bottom-up approach of Pittsburgh’s structural policies that formalized two practices that helped create a modern service-based, knowledge economy. First, public-private partnerships were at the core of the structural policies since Renaissance I in 1945 and encouraged the regular investment of businesses and non-profits’ capital back into the regional economy. Second, Strategy 21 activated CMU and Pitt as the drivers of the region’s economic development efforts in the 1980s. Both universities already had long traditions of applied scientific research and the delivery of services such as healthcare over the 20th century, so with some planning and capital they could create new businesses for the region. Similar practices have taken shape in the Ruhr, but the massive coal subsidies delayed the process of economic reinvention and diversification. A partial bottom-up planning approach only started in the late 1980s and it is unclear what role public-private partnerships play though it is obvious that the public sector has steered the

⁵⁵ Regionalverband Ruhr and Regionalstatistik Ruhr, “Statistikportal Ruhr.”

majority of investment in the region. The Ruhr's universities were only established in the 1960s and were teaching rather than research institutions for their first few decades, thus a tradition of applied scientific research has likely not taken root until much more recently. These historical difference in the Ruhr's structural policies suggest why the region's economy lacks specialized sectors. They also potentially point to what type of policy interventions can best spark economic growth and innovation in post-industrial regions. Furthermore, they do raise questions about what effect the hundreds of billions of marks and euros spent by the EU, FRG, and NRW had. This investigation does make one thing clear – a combination of private initiative and research universities are essential building blocks for the construction of knowledge economies.

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