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LOCAL ENERGY ACCESS AND INDUSTRY SPECIALIZATION: EVIDENCE FROM WORLD WAR II EMERGENCY PIPELINES

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ABSTRACT

How does improving access to the supply of energy affect regional specialization in manufacturing?We evaluate the long-run employment impacts of pipelines constructed by the U.S. government during World War II to transport oil and gas from the oil fields of the Southwest to wartime industrial producers in the Northeast. The pipelines were built rapidly to connect end points along a direct path that minimized use of scarce construction materials. Postwar they were converted to supply en route customers, giving counties close to the pipelines access to a cheap and plentiful source of energy. Between 1940 and 1950, counties with better access to pipeline gas had larger increases in their share of employment in energy-intensive industries. These impacts persisted to the mid-1980s for all energy-intensive industries and to the late 1990s for the subset of industries intensive in the direct use of electricity, despite the disruptive effects of the 1970s energy crisis. Our findings are relevant for understanding energy-related path dependence in local economic development patterns and how government intervention in energy markets affects industry location in the short and long run.

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1 Introduction

Across distinct waves of industrialization and transitions from one major energy source to another, direct access to energy reserves has been materially important for local economic development.[1] A two-century expansion of transportation infrastructure has made energy available over ever greater distances (Gaggl et al., 2021; Blanchard, 2021), which should have integrated energy markets and expanded where manufacturing is viable. Yet, we know little about how such infrastructure affects the spatial organization of production. Understanding that connection is pertinent today, as the world reconstitutes where and how energy is produced. Historical evidence provides insight into how the changing transportation of energy may affect regional economic activity.[2]

In this paper, we study whether the construction of oil and gas pipelines by the U.S. government during World War II affected regional specialization in manufacturing over the ensuing five decades. After the outbreak of the war, the United States rapidly built two emergency pipelines (hereafter, the WW2 pipelines), designed for the sole purpose of transporting energy supplies from large oil and gas fields in Louisiana, Oklahoma, and Texas to wartime refineries and manufacturers clustered near Northeastern terminus locations. These efforts, which created the longest and highest-capacity oil and gas pipelines in the world at the time, curtailed the need to transport oil by sea, which had left U.S. supplies exposed to attacks by German U-boats, and provided Appalachian wartime manufacturers with a substitute for depleted local gas supplies.[3] The WW2 pipelines were part of a dramatic expansion of U.S. infrastructure to meet wartime needs (Rockoff, 2016). Although new pipelines from the Southwest to the Northeast had been discussed before the war, construction was beset by economic, legal, and technological challenges. Wartime realities both relaxed regulatory constraints, such as eminent domain laws, and made large-scale public financing available. After the war, the pipelines were expanded and quickly converted to supply en-route customers.

The WW2 pipelines affected post-war regional energy supplies through two channels. First, the pipelines made natural gas directly available to industrial users near pipeline routes. Some

[1] Fernihough and Hjortshøj O'Rourke (2021), for instance, find that for two centuries after 1750, European cities closer to coalfields grew substantially faster than those further away.

[2] See, e.g., Arkolakis and Walsh (2023) for quantitative analysis of how projected changes in electricity generation and transmission would affect the global distribution of economic activity.

[3] Throughout, we use 'gas' to refer to natural gas, and refer to manufactured coal gas as such.

industries—primary metals, industrial chemicals, cement, glass, paper—need much higher levels of heat in production than purchased electricity can typically provide, which requires them to burn fossil fuels within their facilities as part of the manufacturing process. Second, gas-fired power plants near pipelines could use new supplies of natural gas to expand local electricity generation. Prior to the WW2 pipelines, power plants in the region had primarily relied on more expensive coal. The ability to purchase electricity in larger supplies and at lower prices would have been especially helpful to industries intensive in the direct use of electricity in production, including textile and grain mills and manufacturers of dairy, rubber, mineral and stone products. Whereas expanded natural gas supplies would have benefited many types of consumers, more energy intensive manufacturing industries potentially stood to gain the most.

Using data on employment in U.S. counties from 1940 to 1997, we examine whether after the war locations closer to WW2 pipeline routes, and thus more able to access its gas supplies, became more specialized in energy intensive manufacturing industries, relative to more distant locations.[4] Our county-level treatment is based on the joint event of being closer to a WW2 pipeline route and already having a gas utility as of 1941. Communities that had a gas utility before the pipelines were constructed were more likely to see improvements in local gas access because last-mile distribution infrastructure was already in place. To address the potential endogeneity of pipeline routes, we instrument for a county's proximity to the pipelines using hypothetical least cost path/minimum spanning tree pipeline routes, which closely overlap actual pipeline routes.[5]

Our analysis begins with the immediate impacts of access to the WW2 pipelines on regional industry specialization and then examines changes over the longer run. On the one hand, ongoing industrial innovation—such as the conversion of steel production from energy-hungry blast furnaces to energy-efficient mini mills—may have caused the impacts of regional energy supply shocks to attenuate over time. Indeed, other analyses have found little or even negative impacts of resource supplies on long-run local economic growth, akin to a resource curse (Clay and Portnykh, 2018; Matheis, 2016; Papyrakis and Gerlagh, 2007; Klein and Crafts, 2012). On the other hand,

[4] We analyze impacts of WW2 pipelines outside of the main mid-century gas-producing states of Texas, Louisiana, and Oklahoma. Although West Virginia, Ohio, and Pennsylvania also supplied natural gas in the 1960s and 1970s, their production was less than 10% of that in the three southern states (EIA, 2024); see Figure 3a. We end the analysis before 2000, when the transition to renewable energy began to precipitate the decommissioning of power plants burning fossil fuels, with potentially far-reaching effects on local economies.

[5] Historical evidence indicates that pipeline routes were chosen via a technocratic process that sought to create the fastest possible means of transporting oil and gas from the Southwest to Northeast, while minimizing the use of construction inputs made scarce by the war (see Section 2.2). See Scott (2023) for analysis that uses electrical generating plants' proximity to natural gas pipelines to explain plant-level conversion from coal to gas.

non-convexities in industrial production may have made impacts long-lived. Historical literature has found evidence of path dependence in industrial activity related to regional oil reserves (Michaels, 2011), coal reserves (Glaeser et al., 2015; Fernihough and Hjortshøj O'Rourke, 2021), and hydroelectric power potential (Severnini, 2023; Fiszbein et al., 2024).[6]

To preview our findings, we detect near-term increases in energy-intensive employment in counties with greater gas access, which persisted until the mid-1980s for gas-intensive industries and until at least the late 1990s for electricity-intensive industries. Over 1940 to 1950 for counties that had a gas utility prewar, being one standard deviation closer to the pipelines (71.2 miles) led to gains in county industry employment shares of 0.5 percentage points for gas-intensive manufacturing and 0.9 percentage points for electricity-intensive manufacturing. By the late 1960s, these impact effects reached 2.6 and 4.0 percentage points, respectively. Rising county employment shares in energy-intensive manufacturing came along with declining employment shares in agriculture, suggesting that pipeline construction altered regional comparative advantage.

We further explore why the impact of gas access attenuated more quickly for gas-intensive than for electricity-intensive industries. During the energy crisis of the 1970s, regulations meant that profit opportunities for natural gas producers were greater in the unregulated intrastate markets (within Louisiana, Oklahoma and Texas, for example) than in regulated interstate transmission markets, in which gas prices were set by the federal government (Blanchard, 2021). Gas producers thus diverted supplies from out-of-state to in-state users, which disrupted gas-intensive industries in gas-importing states (FEA, 1975). Electrical utilities, by contrast, were better able to substitute coal for natural gas, which left electricity-intensive industries relatively insulated from the new regulations. In line with this logic, the effect of pipeline access on gas-intensive employment fell substantially during the 1970s and disappeared by 1985, while elevated electricity-intensive employment in pipeline-treated counties persisted to the end of our study period.

Our work contributes to two bodies of literature. The first addresses how the New Deal of the 1930s and the mobilization for World War II affected regional economies.[7] Among the many New Deal programs discussed in Fishback (2017), Kline and Moretti (2014) find that the Tennessee Valley Authority led to gains in manufacturing employment that persisted well after

[6]Other related literature studies path dependence related to river transport (Bleakley and Lin, 2012), place-based policy (Kline and Moretti, 2014), and World War II public investments in manufacturing (Bianchi and Giorcelli, 2023; Garin and Rothbaum, 2022; Jaworski, 2017).

[7]World War II had many other economically-relevant impacts: see Lleras-Muney et al. (2025); Goldin et al. (2025); Brunet et al. (2025); Collins and Zimran (2025); Vickers and Ziebarth (2025) and Barrera et al. (2025).

federal transfers had lapsed, as consistent with agglomeration economies. Evidence on the long run regional impacts of war-related investments is mixed. While Jaworski (2017) detects little evidence that county-level wartime investments elevated postwar economic growth, Garin and Rothbaum (2022) estimate enduring impacts of World War II emergency production on industry location.[8] Our contribution to this work is to assess the regional economic impacts of wartime energy transportation infrastructure investments. To date, analysis of the wartime energy transition has been limited to its macroeconomic effects (Johnstone and McLeish, 2020; ?).[9]

A second body of related literature studies the regional economic consequences of energy supply. Here again, evidence is mixed. Results of positive long-run impacts from access to local energy supplies include Michaels (2011) on how oil abundance at the U.S. county-level increased manufacturing employment, population growth, and per capita incomes; Severnini (2023) on how U.S. dams constructed before 1950 spurred persistent increases in local population via cheap local electrical power; and Fiszbein et al. (2024) on how proximity to early hydroelectric power plants led to long-run productivity gains for local manufacturers.[10] In data for more recent time periods, Kahn and Mansur (2013) find that between 1998 and 2009 U.S. counties with lower electricity prices had higher employment in energy-intensive industries.[11]

Other studies find the economic impact of energy access to be small or even negative. This work includes Klein and Crafts (2012) who find that coal prices did not affect the location of fuel-intensive U.S. industries over 1880 to 1920;[12] Clay and Portnykh (2018) who find that after 1936 U.S. states with larger coal reserves had slower growth in population (but not in income);[13] Matheis (2016) who finds that increased coal production in U.S. counties from 1870 to 1970 affected population and manufacturing positively in the short run but negatively in the long run; and Glaeser et al.

[8] Jaworski and Yang (2025) find modest welfare impacts of WWII mobilization, with estimates varying by region and across types of mobilization. In data for Italy, Bianchi and Giorcelli (2023) find that provinces that received more reconstruction grants under the Marshall Plan became more industrialized.

[9] Much existing research on wartime pipeline projects focuses on their connection to advances in engineering (Casella and Wuebber, 1999; Jensen and Ellis, 1967) and regulatory innovations and public-private cooperation (Castaneda, 1990; Johnson, 1967), rather than on their economic impacts. Barreca et al. (2014) mention the pipelines as a reason why natural gas displaced coal in Northeastern urban households after the war.

[10] In data for Switzerland, Brey (2021) uses spatial variation in hydroelectic power potential to show how adoption of electricity was conducive to local economic development in the short and long-run.

[11] Our findings are also relevant for modern place-based and industrial policies intended to smooth the economic transition away from fossil fuels (Hanson, 2023).

[12] Similarly, Crafts and Wolf (2014) find that coal prices did not affect the location of U.K. cotton mills in the 1830s (but did affect the size of those mills), and Wolf (2007) finds that mineral endowments did not explain the location of fuel-intensive Polish industries in the 1920s and 1930s. Berbée et al. (2022) find that German regions that industrialized early because of coal reserves were more likely to deindustrialize after 1926.

[13] For the more recent period of 1986 to 2001, Papyrakis and Gerlagh (2007) find that natural resource abundance is associated with lower investment, schooling, openness, and R&D expenditure.

(2015) who find that cities closer to coal deposits in 1900 had less entrepreneurship after 1970. Relative to this work, we examine how access to energy via transportation networks, rather than via direct proximity to reserves, affects regional industrial specialization.

In Section 2, we discuss the history of natural and manufactured gas, the WW2 pipelines, and the 1970s energy crisis. In Section 3, we describe our data, including newly digitized data on gas access and industry energy intensity. In Section 4, we detail our identification strategy, and in Section 5 we present our empirical results. Finally, in Section 6 we offer a concluding discussion.

2 Historical background: Natural gas, the WW2 emergency pipelines, and the 1970s energy crisis

2.1 Uneven early adoption of natural gas

Natural gas did not became a primary source of energy for U.S. manufacturing until well into the 20th century. Manufactured coal gas had been used in the United States for decades prior to the 1859 discovery of large quantities of natural gas, primarily for lighting and later for heating and cooking (Castaneda, 2001). Manufactured gas was produced by heating coal in the absence of oxygen and adding oil, an inefficient and polluting process that created a product inferior to natural gas in terms of thermal efficiency, safety and cost (Tarr, 1999). However, for most of the late 19th and early 20th centuries natural gas was considered a nuisance to be vented or flared from oil wells, in the absence of viable means of transporting it to customers.[14]

The first natural gas pipelines appeared in the 1880s and 1890s, connecting gas deposits outside Pittsburgh to users within the city and gas fields in central Indiana to Chicago (Hopkins, 2007; Blanchard, 2021). Natural gas had clear benefits—having, e.g., twice the heating content of manufactured gas—but was subject to supply limitations (Castaneda and Pratt, 1989). For residential use, natural gas heating meant utilities did not need to build polluting gasification plants within cities nor use expensive coal inputs (Castaneda and Pratt, 1989). For a time in Pittsburgh, iron and steel works took advantage of natural gas and local residents and commercial establishments used natural gas for heating purposes, temporarily improving air quality

[14] Natural gas also made oil exploration more dangerous given the possibility of unstable and flammable pockets of gas within oil deposits. Blanchard (2021) reports that in the early days of petroleum drilling "the first prayer of the roughneck was to find oil. His second prayer was not to find natural gas."

(Castaneda, 2001). In Indiana, local governments offered free natural gas to manufacturers relocating to the state, enabling it to become the second-largest U.S. producer of glass, an industry also reliant on heat-intensive production (Blanchard, 2021). The high heat natural gas provided was also valuable for producing rubber, chemical, carbon-black, and bricks (Tussing and Tippee, 1995; Castaneda, 1990). However, because diminishing local gas supplies could not meet growing demand, these early natural gas industries collapsed within two decades. Both Pittsburgh and Indiana returned to burning coal (Blanchard, 2021).

New gas fields in the South and West began production in the early 1900s. Nearby cities took advantage of their proximity to move into manufacturing (Tussing and Tippee, 1995). Kansas, for instance, leveraged this new gas supply to become the largest U.S. producer of zinc (Blanchard, 2021). Although local supplies in the Southwest initially started to run out, as they had in Appalachia, vast new deposits such as the combined Panhandle/Hugoton Field were discovered, which guaranteed plentiful gas supplies well into the future (Castaneda, 2001).

In the 1920s, innovations in pipeline construction, such as stronger steel pipes and new welding methods using acetylene and the electric arc (Jensen and Ellis, 1967), enabled Southwestern natural gas to be shipped northward and eastward. This led to the first wave of long-distance pipeline construction (over 1928 to 1931) connecting the Southwest to the Midwest and Southeast (Castaneda, 2001). These new lines, however, did not extend northeast further than Michigan. The Appalachian industrial heartland remained unconnected to natural gas supplies (Blanchard, 2021). This first wave of pipeline construction ended with the onset of the Great Depression. Gas demand fell, leading to excess capacity in existing pipelines and dwindling pipeline investment (Blanchard, 2021). Manufactured gas and other coal-based fuels remained the primary source of heat and non-hydropower electricity in Appalachia and the Northeast.

2.2 WW2 emergency pipelines

The two major WW2 pipelines were the longest, most technically-advanced and highest capacity that had ever been constructed.[15] Both pipelines were built during the war as straw lines, with the singular aim of rapid end-to-end transmission. And both were used after the war for natural gas. Yet, the rationales for their construction differed (Jensen and Ellis, 1967).

The largest and most publicized pipeline was in fact two 'Inch lines': the 24-inch diameter and

[15] Two shorter and lower capacity pipelines, the Plantation and Southeastern lines, were also built during World War II, but are excluded from our analysis since they were only used for refined products (Johnson, 1967).

1,341 mile-long 'Big Inch' line and the 20-inch diameter and 1,475 mile 'Little Inch' line, which were twinned along most of their route (Jensen and Ellis, 1967). These pipelines were built to carry oil and refined products, respectively, to the Northeast for consumption and onward shipping to Europe during the war, and converted postwar to transport natural gas. At the onset of the war, 95% of oil delivered to the U.S. eastern seaboard was shipped by sea, with only 50,000 out of a total 1.4 million barrels per day shipped via pipeline and 5,000 shipped by rail (Jensen and Ellis, 1967; Blanchard, 2021). By 1941, oil was in shortly supply in the Northeast; first because the United States loaned oil tankers to Great Britain and then because after the United States entered the war German U-boats began to sink large numbers of oil tankers along the eastern seaboard, both of which reduced gas transport capacity (Blanchard, 2021).

In late 1941, presidential advisors began advocating for the construction of a cross-country oil pipeline to address supply shortages due to reduce tanker traffic (Casella and Wuebber, 1999). In March 1942, pipeline industry executives and engineers devised a plan for reorganizing and expanding the U.S. pipeline network to move oil from the Southwest to the Northeast (Johnson, 1967). The pipeline was quickly approved; by June 1942 construction supplies, now under severe wartime limits, were allocated to the project (Blanchard, 2021).

Planning of pipeline routes was based largely on design feasibility (Johnson, 1967). Wartime shortages of construction equipment, skilled labor and materials—especially steel—meant the pipelines had to follow the most direct route possible (Blanchard, 2021). The final routes had the Big Inch pipeline start in Longview, Texas and run northeast through Arkansas and Missouri to a rail depot in Norris City, Illinois, where oil was temporarily loaded onto rail tankers to enable delivery to the East Coast during construction of the second leg of the pipeline eastward through Indiana, Ohio, Pennsylvania, and New Jersey (Casella and Wuebber, 1999; Blanchard, 2021) (see Figure 1). The Little Inch line started further south in Baytown, Texas and crossed northern Louisiana before joining with the Big Inch near Little Rock, Arkansas. Construction began in the summer of 1942 and finished on the Big Inch the following July, with the Little Inch being completed in December 1943 (Casella and Wuebber, 1999).

The second WW2 pipeline was the Tennessee Gas Line, named for its owner-operator the Tennessee Gas and Transmission Company. This was a 24-inch diameter and 1,265 miles long (Raley, 2008). Unlike the Inch Lines, this pipeline transported natural gas from its inception. It was constructed in 1943 and 1944 with the goal of supplying northern Appalachian war industry manufacturers with an alternative source of gas given declining local supplies.[16] By August 1943, a year after the Inch Lines were approved, the Tennessee Gas pipeline was given permission to procure construction materials. Aerial surveys of possible pipeline routes and preliminary engineering designs had begun prewar in 1941 (Castaneda, 1993). The final route was based on a right of way purchased for another line, which was caught in legal entanglements (Raley, 2008), and then amended in 1942 to serve wartime industries (Blanchard, 2021). Upon opening in 1944, the pipeline ran from gas fields in Texas northeast through Louisiana, Mississippi, Tennessee, and Kentucky until its terminus in Cornwall, West Virginia.

Despite the wartime prerogative, the pipelines faced opposition from landowners along the routes, including coal interests, for whom expanded gas supplies may have seemed like an existential threat, and railroads, for whom coal and oil transport was a lucrative business and who could leverage their large property holdings to block construction (Blanchard, 2021).[17] Government backing and the use of eminent domain was therefore essential for the construction of the pipelines (Raley, 2008; Castaneda, 1990). Government financing also played a key role, both for the directly government owned and operated Inch Lines as well as the privately-owned Tennessee Gas line, which relied on Reconstruction Finance Corporation loans (Blanchard, 2021).

Following the war, there was vast potential demand for natural gas in the Northeast. Parsons (1950) reports that 80 gas utilities then distributing manufactured gas in the Mid-Atlantic and New England were willing to buy as much natural gas as was available and as soon as possible. The WW2 pipelines enabled the Southwest's vast natural gas supplies to flow to large Northeastern markets previously reliant on manufactured gas.[18] The Inch Lines were auctioned to a private owner, the Texas Eastern Corporation (TETCO) and eventually converted to natural gas (Castaneda and Pratt, 1989).[19] Both pipelines were 'looped' with additional pipes and run at higher pressures to increase their carrying capacity (Casella and Wuebber, 1999; Parsons, 1950). In 1949, the Tennesee

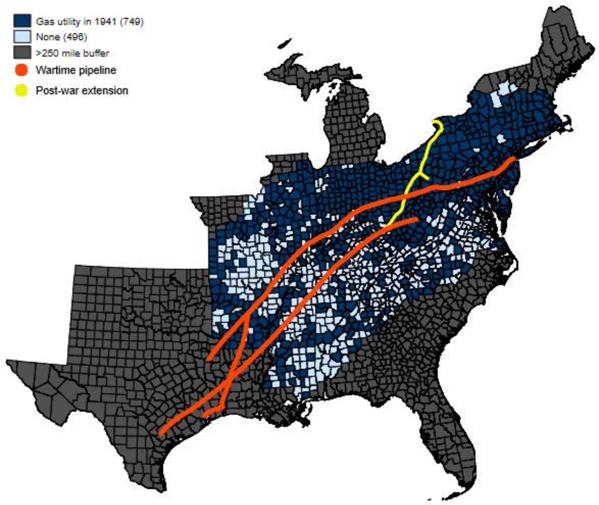
[16] Appalachian gas production had peaked in 1917, despite rising local demand and prices doubling over the following five years (Tussing and Tippee, 1995). Appalachia had remained a "gas island, unconnected to the great fields in Texas, Oklahoma, and Louisiana" after the 1920s pipeline boom (Blanchard, 2021). Appalachian gas supplies continued to decline through the early 1940s, just as factories critical to the war effort (for example producers of steel, aluminum, and chemicals) needed to expand production (Blanchard, 2021).

[17] For example, another wartime pipeline for refined products, the Plantation Pipeline from Louisiana to North Carolina, had been planned before World War II but could not be completed due to railroads refusing to grant right of ways, fearing competition for their petroleum shipping business (Johnson, 1967).

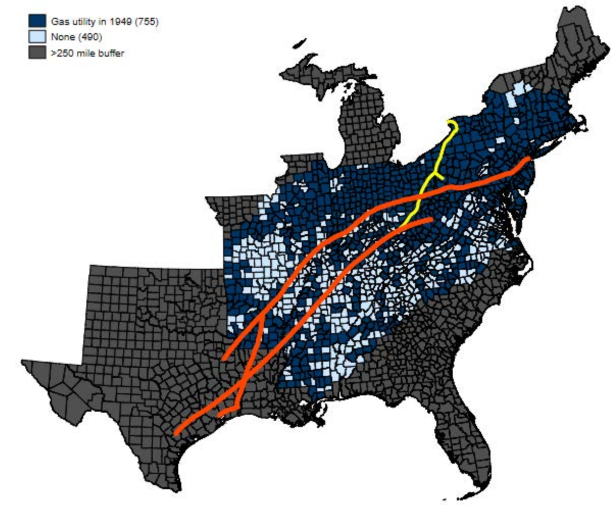
[18] Liquefied natural gas technology developed much later and its consumption did not become common until the 1970s (Barreca et al., 2014; Blanchard, 2021).

[19] In 1957, the Little Inch was converted back to petroleum over part of its route (Jensen and Ellis, 1967). See Johnson (1967) for an account of this privatization.

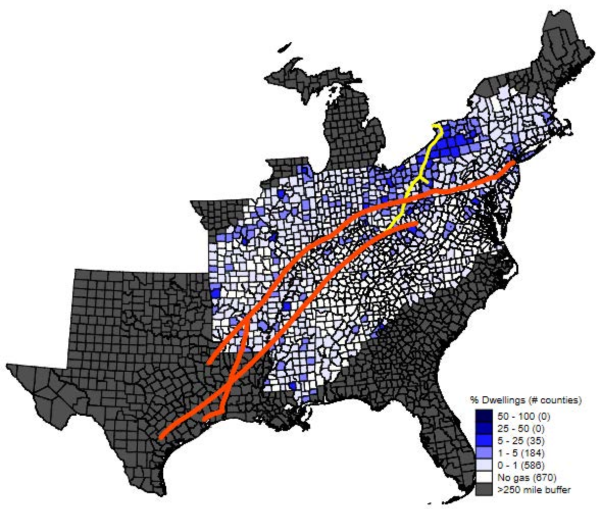
Figure 1: WWII pipeline routes and growth of utility gas, 1940-1950



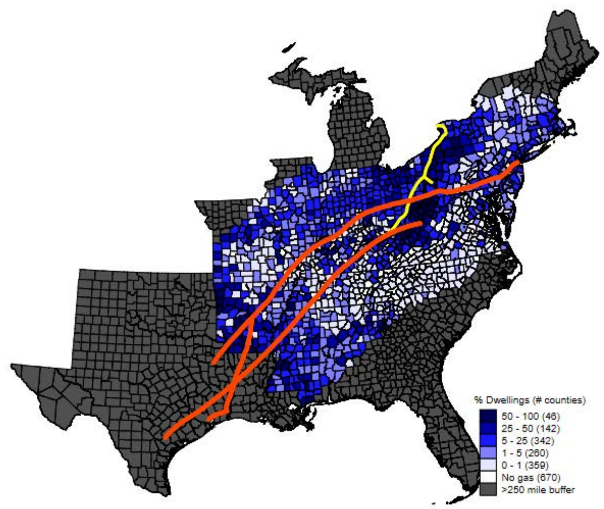
(a) 1941 counties with ≥ 1 gas utility



(b) 1949 counties with ≥ 1 residential gas utility



(c) 1940 % homes use gas for central heating



(d) 1950 % homes use utility gas for heating

Notes: These maps show the wartime pipeline routes in red and county-level changes in utility gas availability on two extensive-margin measures. Panels (a) and (b) are shaded for a county-level indicator of the presence of a local gas utility (for 1941 as indicated by whether any community in a county was served by a gas utility in FPC (1942), and for 1949 as indicated by whether a county had any residential gas utility customers in AGA (1950)). Panels (c) and (d) are shaded by the share of occupied dwellings in each county that reported primarily using utility gas for heating in the Census (in 1940 as proxied by use of gas for central heating; in 1950 based on directly reported use of utility gas for heating). The thin yellow line is the 1949 Tennessee Gas pipeline extension.

Gas line was extended from West Bend, Kentucky to Buffalo, New York (Parsons, 1950).

Conversion from manufactured coal gas to natural gas was not only profitable for pipeline companies but also popular in the Northeast as natural gas offered a safer, cheaper means of heating homes and supplying energy to industry. In 1947, natural gas from Texas cost less than a third as much in New York City as the alternative gas manufactured from coal, and was much more efficient (Constant, 1989). Similar price dynamics drove the postwar replacement of manufactured coal gas elsewhere in the Northeast and convinced state officials in Pennsylvania that manufacturers would desire locating in areas with natural gas access (Castaneda, 1990).

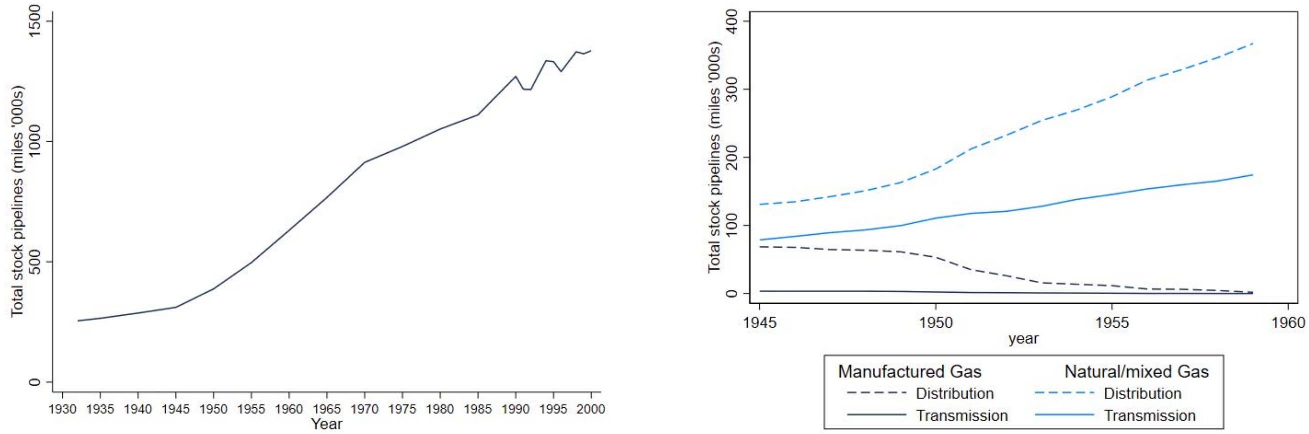
By 1950, the two pipelines combined to provide over 10 percent of total U.S. gas demand (Blanchard, 2021). Some gas-producing regions were less enthusiastic about these flows, with one official predicting that the "syphoning" of natural gas from the Southwest to Northeast would "remove the main basis for the hopes for industrial decentralization" (Parsons, 1950) given their use of low-priced natural gas to incentivize industry location (FPC, 1948).

Nonetheless, profit opportunities from the WW2 pipelines made natural gas difficult to combat, enabling it to become the fastest growing domestic energy source from the late 1940s through the 1960s (Castaneda, 1993). By 1949, even after field prices had quadrupled over the preceding 8 years, burning natural gas produced heat at 1/6th the cost of oil and 1/25th the cost of coal (Parsons, 1950). The main cost associated with consuming natural gas was from its transportation, though even after taking transport costs into account, natural gas was still 1/4th the price of manufactured gas per unit of heat provided (Parsons, 1950). Utilities could easily transition from supplying local distribution systems with natural gas rather than coal gas, and in some cases as an enriched 'mixed gas', though some end-user appliance conversions were required (Tarr, 1999; Castaneda and Pratt, 1989). This led to widespread growth across all uses, where increases in industrial use of gas slightly outpaced residential use from 1939 to 1970. After World War II, new technological possibilities also enabled an increase in natural gas-fired electrical generation (Miser, 2015). From 1949 to 1955, 17% of electricity generated in the United States was from natural gas.[20]

By 1957, natural gas provided 23% of the nation's energy, versus 13% in 1945, and over 1 million miles of natural gas distribution pipelines had been installed, compared to 25,000 miles the previous decade (Carpenter, 2021). Figure 2 shows the increase in total pipeline mileage installed, driven by the increase in pipeline mileage dedicated to transporting natural gas. Meanwhile the mileage of manufactured gas pipelines fell. However, constraints on steel production, exacerbated by the Korean War, continued to limit construction of some larger transmission lines and resulted in oil pipeline construction receiving priority over gas pipelines (Carpenter, 2021; Parsons, 1950).

[20] This is in terms of kilowatt hours; author calculations using data from the U.S. Energy Information Administration Annual Energy Review, 2012, https://www.eia.gov/totalenergy/data/annual/showtext.php?t=ptb0802a.

Figure 2: Growth in U.S. pipelines due to natural gas



(a) Total installed pipeline mileage

(b) Total mileage by gas and pipe type

Notes: Panel (a) displays the total mileage (in thousands) of all pipelines installed in the U.S. Panel (b) compares the total mileage (in thousands) of pipelines by the type of gas (excluding liquid petroleum gas) and the type of pipeline (excluding field/gathering pipelines). Data are from AGA (1961) and BTS (2021).

2.3 Interstate gas shortages during the 1970s energy crisis

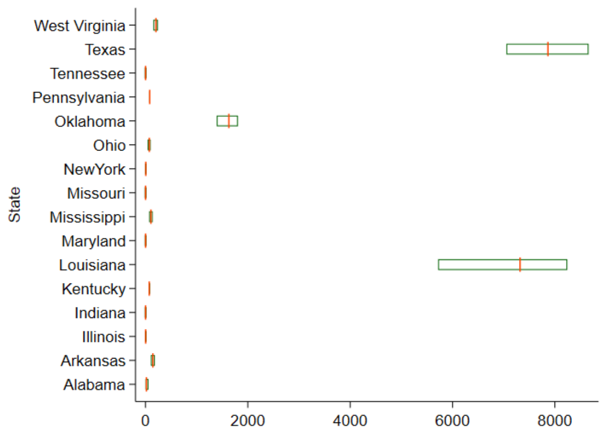
By the late-1960s, federal regulations began to constrain the supply of gas supplied from the South and West to the Northeast (Blanchard, 2021). Figure 3a shows the size advantage of Southwestern gas production over the minimal levels elsewhere in the eastern half of the United States, and the decreasing availability of Southwestern natural gas on interstate markets in the late 1960s and 1970s. The decline was due mainly to regulation of interstate, but not intrastate, gas prices by the Federal Power Commission (FPC), which made intrastate gas sales relatively profitable and eliminated price signals that could have incentivized greater gas production for the interstate market or reduced consumption (Blanchard, 2021).[21]

In 1971, the resultant decrease in gas supplied to interstate markets forced the FPC to develop criteria for rationing natural gas (Lifset, 2014); in 1972, interstate pipelines began to curtail gas supplies to customers; and in 1973, the FPC began rationing gas by priority-of-service category, with industrial customers having lowest priority after residences and businesses (Blanchard, 2021). Supply problems in the U.S. natural gas market were thus well established before the Organization of the Petroleum Exporting Countries banned oil exports to the United States and drastically

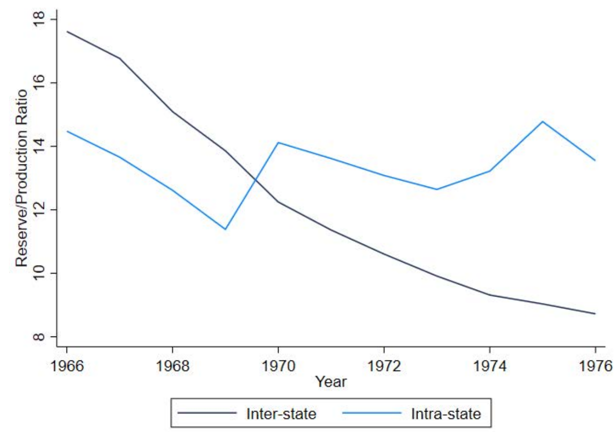
[21] This pricing system reflected the belief of federal regulators that interstate supply relationships were relatively uncompetitive because long-distance transmission pipelines were tied to specific interstate firms and because natural gas was discovered only as an "adjunct" to oil exploration, such that price changes would not induce changes in gas supplies or gas exploration (Lifset, 2014).

reduced global oil supplies in late 1973 (Lifset, 2014). During the embargo, factories switched boiler fuels from petroleum to natural gas, exacerbating gas shortages (Castaneda, 2001).

Figure 3: Relative decline of interstate gas supply during 1970s



(a) State annual gas production levels, 1967-77 (minimum, mean, and maximum billion feet^3)



(b) Intrastate vs. interstate gas availability

Notes: Panel (a) displays the mean (orange line) and minimum and maximum (green boxes) annual level of marketable gas production in each state between 1967 and 1977 in billions of cubic feet. Panel (b) compares the reserves-to-production ratios (estimates of remaining years of consumption available) for gas dedicated to intrastate vs. interstate pipelines. A declining ratio means that natural gas was being extracted faster than new gas was being discovered. Figures are reproduced from Blanchard (2021).

The energy crisis continued throughout the 1970s, worsening during the winter months. In the winter of 1976-1977, gas shortages resulted in 1.2 million workers becoming unemployed due to gas curtailments; factories, schools and hospitals were forced to shut down for extended periods; and industries such as metals, glass, textiles, chemicals and food processing were routinely denied gas deliveries (Cramer, 1983). Because most counties were served by a single pipeline, these adverse impacts tended to be localized. For example, a 1975 report from the Federal Energy Administration foresaw factory contractions and shutdowns in Northeastern and Midwestern states based on their pipeline-specific gas supplies and industrial composition (FEA, 1975).[22] By contrast, areas of the United States with access to natural gas experienced economic growth. The Gulf Coast, which had begun developing energy-intensive petrochemical industries in the late 1940s thanks to low-cost

[22] This was in part because in the 1970s, although there were ‘emergency interconnections’ between gas pipelines, the U.S. pipeline system was not an interconnected grid between transmission pipelines (Cramer, 1983). New Deal-era federal natural gas regulation had not deemed gas transmission companies as common carriers (Blanchard, 2021). Only in the mid-1980s did the FERC transform interstate pipelines into "virtual common carriers" allowing utilities and end-users to purchase gas directly from producers (Castaneda, 2001).

natural gas (Parsons, 1950), became a "manufacturing powerhouse" in petrochemicals and other energy-intense industries during the 1970s (Blanchard, 2021).

3 Data and measurement

3.1 Employment by county and industry

Our main outcome of interest is regional industrial specialization, which we measure using the share of county employment in industrial sectors defined according to their energy intensity in 1947.[23] For 1940 and 1950, we tabulate population and employment of individuals ages 16 and above by county and industry using the full-count Census from Ipums.org (Ruggles et al., 2022). For employment covering 1964 to 1997, we use data from the County Business Patterns (CBP) constructed by Eckert et al. (2020, 2022).[24] Because the CBP excludes employment on farms and in the public sector, its total employment counts are less than those in the Census. We focus the analysis on the 1,245 counties in the eastern half of the United States whose county centroids were within 250 miles of any point on the pipeline routes, as defined by their 1940 boundaries.[25]

3.2 Energy-intensive industries

To detect changes in energy-intensive employment, we group manufacturing industries into the top decile, top quartile or bottom three quartiles of energy intensity, using two alternative measures of energy use. We calculate energy intensity using newly digitized data on national-level industry energy consumption and value-added from historical tables of fuel consumption and general industry statistics in the 1947 Census of Manufactures (Census Bureau, 1950). For all years

[23] Industries are based on the IND1950 variable from Ipums.org (Ruggles et al., 2022).

[24] Prior to 1964, the CBP often reported data for larger county groups rather than individual counties. We crosswalk SIC industry codes in the CBP to IND1950 using concordances from Eckert et al. (2020), Eckert et al. (2022), and Autor et al. (2019). Some county-level employment in the historical CBP is available only at a two-digit SIC sector level. We remove these 'residual' employment counts from the denominator when calculating the share of county manufacturing employment in energy-intensive manufacturing industries. We retain them in the denominator when calculating the share of county employment in non-manufacturing sectors, all other manufacturing industries than those in the top quartile or top decile according to each energy-intensity measure, agriculture, and services and all other sectors. This allows us to explore the impact across all groups of employment in a county.

[25] We crosswalk county data from other years to 1940 boundaries using weights in Ferrara et al. (2022), which divide counties into urban and rural areas using historical population estimates from Fang and Jawitz (2018). We further combine independent cities in Virginia into neighbouring counties as defined in AGA (1950, 1953).

employment by sector is based on industry energy intensity in 1947. We study 51 manufacturing industries defined in the Ruggles et al. (2022) IND1950 classification from the 1950 Census.[26]

We define industry energy intensity based on consumption of two types of fuel:[27]

- all gas consumed (in million cubic feet) per million dollars of value-added, including coal, natural and 'mixed' gas,[28]
- spending on purchased electricity as a share of value-added.

Table 1 lists the industry composition of each energy-intensity sector of the economy (listed in order of all gas-intensity) and the values of energy intensity in 1947. It also lists the share of industry gas consumption that is natural or mixed gas (rather than solely manufactured gas) and industry total spending on fuels and electricity. Only two industries are in the top decile of both measures of energy intensity (all gas and electricity costs): blast furnaces, steel works, and rolling mills (336) and cement, concrete, gypsum and plaster products (317). Another five industries are in the top quartile of both measures: primary nonferrous industries (338); chemicals and allied products (469); pulp, paper, and paperboard mills (456); and other metal industries (348).

We can track industry trends in energy usage by comparing the 1947 values in Table 1 with the energy-intensity statistics for these industries as of 1939 in Appendix Table A1. We see a surge in natural gas usage from 1939 to 1947 in energy-intensive industries. The most gas-intensive industry in 1947—blast furnaces, steel works, and rolling mills—doubled the volume of all gas used per dollar of output and increased the share of gas that was natural or mixed by nearly six-fold. Petroleum refining showed little change in overall gas intensity, but shifted to using natural or mixed gases almost exclusively. Structural clay, pottery, and related products had a stable share of natural or mixed gases in total gas consumed, while more than doubling the gas-intensity of production. Some of the most electricity-intensive industries in 1947, including primary nonferrous

[26] We crosswalk industry energy intensity from SIC to IND1950 industries using concordances from Eckert et al. (2020), Autor et al. (2019), and Fiszbein et al. (2024) as well as a hand-coded crosswalk from SIC1945 codes to IND1950 (available upon request.) Following Fiszbein et al. (2024), we combine industries to reach 51 in total. Since the crosswalk from the 1940 Census of Manufactures to IND1950 used in Fiszbein et al. (2024) combines these industries, we repeat this step for all years in order to have a consistent number of industries (specifically, we combine 408, 416, 417, 419, 426 into an 'other foods' category; 466 and 467 into 'synthetic fibers, drugs, and medicines'; and 318 and 319 into 'structural clay, pottery, and related products'). We exclude logging from manufacturing since it does not have energy consumption in early years of the Census of Manufacturing.

[27] Note that we focus solely on consumption of gases for fuel rather than as raw material inputs.

[28] 'Mixed gas' consumption includes manufactured coal gas enriched with natural gas by utilities or end-users as well as some gas for which the type was not reported by end-user establishments (Census Bureau, 1942).

industries (338) and not specified metal industries (348), increased their electricity spending as a share of value-added, though not as dramatically.

3.3 Local access to natural gas

Our analysis posits that counties that were more proximate to the WW2 pipeline routes experienced larger increases in local access to natural gas. We digitized pipeline routes using historical maps in Johnson (1967); Casella and Wuebber (1999); Raley (2008) and Blanchard (2021).[29] We use additional data related to geographic features for our least cost/minimum spanning tree optimal pipeline route analysis, as described in Section 4.2.

We also posit that communities that had a gas utility before the war, prior to the pipeline construction, were more likely to subsequently experience an increase in local gas access because the last mile distribution infrastructure for gas was already in place. We digitized lists of all communities of at least 250 residents that were served by a gas utility in 1941, as documented by the Works Progress Administration and published in a 1942 report of the Federal Power Commission (FPC).[30] We also digitized tables from reports of the American Gas Association (AGA, 1950, 1953), which detail the number of residential gas customers of each local utility company in each county. This source provides an indicator of which counties had a gas utility post-war, in 1949. By identifying which local utilities were active in each county after the war, we are able to detect which counties were supplied with gas from one of the transmission companies that assumed post-war ownership of a WW2 pipeline. To do so, we used newly digitized information on the utilities served by each transmission company in 1948 as reported by the FPC (FPC, 1949), supplemented with information for later years digitized from the Tennessee Gas and Transmission Company and Texas Eastern Corporation corporate annual reports.

[29] We traced routes while cross-checking maps in each version and validated traced routes with the mid-route compressor station locations that were listed in Casella and Wuebber (1999) and Love (1944).

[30] These communities were geolocated in 1940 county boundaries using an online forward-geocoding service and matching by name to lists of places in each county from Manson et al. (2022).

Table 1. Energy-intensive industries in 1947

	Gas intensity	All gas ($\text{Mf}^3/VA\$M$)	% Natural/mixed gas	Electricity intensity	Electric costs % VA	Fuel + Electric costs ($M)	Emp. ('000s)
Blast furnaces, steel works, and rolling mills (336)	Top decile	1726.0	58.1	Top decile	4.6	731.3	547.4
Miscellaneous petroleum and coal products (477)	Top decile	1066.5	11.7	Other	1.9	20.0	66.2
Petroleum refining (476)	Top decile	524.6	100.0	Other	1.8	45.7	145.8
Cement, concrete, gypsum and plaster products (317)	Top decile	279.2	88.4	Top decile	5.5	80.0	105.8
Glass and glass products (316)	Top decile	272.2	96.0	Other	2.2	39.1	138.9
Structural clay, pottery, and related products (318; 319)	Top decile	206.6	97.0	Other	2.3	39.1	127.3
Primary nonferrous industries (338)	Top quartile	118.6	91.7	Top decile	6.2	71.8	186.7
Miscellaneous chemicals and allied products (469)	Top quartile	89.9	92.7	Top quartile	2.7	167.4	410.8
Pulp, paper, and paperboard mills (456)	Top quartile	88.5	99.9	Top decile	3.5	119.5	198.4
Not specified metal industries (348)	Top quartile	70.2	73.2	Top decile	3.7	6.0	22.1
Fabricated steel products (346)	Top quartile	57.0	91.9	Other	2.3	15.6	49.9
Meat products (406)	Top quartile	38.1	96.6	Other	1.5	25.5	274.4
Other primary iron and steel industries (337)	Top quartile	37.7	70.6	Top decile	3.0	56.8	267.3
Miscellaneous nonmetallic mineral and stone products (326)	Other	31.4	94.7	Top quartile	2.3	17.1	90.1
Dairy products (407)	Other	22.5	97.6	Top quartile	2.5	21.9	92.7
Grain-mill products (409)	Other	17.3	96.9	Top quartile	2.3	18.4	113.2
Rubber products (478)	Other	11.7	97.4	Top quartile	2.5	62.4	518.2
Yarn, thread, and fabric mills (439)	Other	2.0	96.1	Top quartile	2.8	53.1	606.3

Notes: This table shows IND1950 industries that rank in the top quartile of either energy-intensity measures (all types of gas consumed (in Mf^3) per $M of value-added and electricity costs as share of value-added) in 1947 based on data from the Census of Manufactures. Industries are listed in order of all gas-intensity. 'Natural/mixed gas' consumption includes pure natural gas as well as coal gas enriched with natural gas by utilities or end-users as well as some gas for which the type was not reported by end-user establishments (Census Bureau, 1942) (the remaining gas consumed is manufactured coal gas). All dollar values are deflated to 1939 levels based on price indices for Industrial Commodities and Fuels and Related Products and Power from Series E 23-39 of Bureau (1975).

A final source of newly digitized data is county-level tabulations of the number of occupied dwellings that primarily used utility gas (either natural, manufactured, or mixed) for heating from the 1940 and 1950 Census. Since a direct measure of whether dwellings used utility gas for heating is only available in the 1950 Census (reported in AGA (1953)), for 1940 we use as a proxy counts of dwellings with central heating primarily fueled by gas.[31] Of the 806 counties in our sample with at least one dwelling that primarily used gas central heating, 84% had a gas utility in 1941. Correspondingly, only 16% of the counties that reported zero dwellings with gas central heating in 1940 had a gas utility in 1941.

3.4 Sample and variable description

The final data for the analysis is a cross-section of 1,245 counties that are within 250 miles of the wartime routes of the TETCO Big and Little Inch Lines or the Tennessee Gas pipeline.[32] This area can be seen as the non-gray shaded counties in Figure 1 (which shows whether counties had a gas utility in 1941 or in 1949). We include data on employment by industry sector of energy intensity in each county from 1940 to 1997 as well as covariates by county. Table 2 provides summary statistics on the variables used in the regressions.[33]

The construction of key variables is as follows:

- **Gas utility, 1941** - an indicator for whether any of the communities with population above 250 residents in a county were served by a gas utility in 1941 (FPC, 1942).
- **% of households with gas central heating, 1940** - share of dwellings in a county that reported being primarily heated by central heating using any type of gas in the 1940 Census.
- **Gas utility, 1949** - an indicator for whether a county had any residential customers of a gas utility in 1949 (AGA, 1950).
- **% of households with utility gas heating, 1950** - share of dwellings in a county that reported being primarily heated by any type of gas delivered by a utility in the 1950 Census.
- **Est. % of households with natural gas from WW2 pipelines, 1949-50** - estimated as (% of dwellings using natural gas for heating in 1949-50) × (% of natural gas customers

[31]It is possible that this measure includes homes with central heating fueled by bottled gas since this fuel source is not separately reported in the 1940 Census of Housing. However, restricting the counts to dwellings with gas central heating reduces this likelihood given that gas central heating is very fuel intensive, meaning that a utility would be required to deliver such a large amount of gas.

[32]The full dataset is available on the openICPSR repository: Greenspon and Hanson (2025)

[33]Appendix Section A.2 gives summary statistics on other variables used in analyses in the appendix.

Table 2. Summary statistics

	Pre-war gas utility		No pre-war utility	
	Mean	Std.Dev.	Mean	Std.Dev.
% HHs with gas central heating, 1940	1.04	1.82	0.04	0.25
Gas utility in 1949	0.99	0.12	0.83	0.38
% of HHs with utility gas heating, 1950	16.45	18.19	2.00	4.53
% HHs with WW2 pipeline gas, 1949/50	7.91	15.85	0.07	0.88
ln(Distance to 50K+ pop. county)	3.31	0.49	3.64	0.46
ln(pop.) 1940	10.65	1.01	9.65	0.58
ln(pop.) 1950	10.72	1.07	9.62	0.63
Distance to pipeline	92.45	70.78	105.72	71.11
Distance to MST pipeline	92.61	70.65	106.35	71.76
% emp. agriculture, 1940	27.98	18.81	51.82	15.49
% emp. manufacturing, 1940	20.12	12.05	11.23	7.59
Observations	749		496	

in a county that were customers of a local utility supplied by a WW2 transmission pipeline), based on data from AGA (1950) and FPC (1949).

- **ln(Distance to 50K + population center)** - calculated as log of straight-line distance (in miles) from county centroid to the nearest county with a population of at least 50,000.
- **ln(pop.)** - calculated as log of county population (in thousands), from the decennial Census in 1940 or 1950.
- **Distance to pipeline** - the straight line distance (in miles) from a county centroid to the nearest point on any WW2 pipeline route or alternatively the least cost/minimum spanning tree optimal WW2 pipeline route.
- **% employed in agriculture or manufacturing, 1940** - calculated as the share of individuals ages 16 and above in a county employed in agriculture or manufacturing, from the 1940 Census.

4 Identification strategy

We analyze changes in the industrial structure of employment among counties within a 250 mile band of WW2 pipeline routes. Treatment is defined as a continuous measure based on a county's proximity to a WW2 pipeline, under the rationale that counties closer to the pipelines were more likely to have access to and to utilize natural gas. We also account for the last-mile infrastructure needed in a county in order for local users to consume gas supplied by a nearby transmission pipeline. We argue that communities that had a gas utility before the war (whether supplied with coal or natural gas) and prior to the pipeline construction, were more likely to have improved access to natural gas after the war because the last-mile distribution infrastructure was already in place. Our county-level treatment is therefore based on counties being both closer to a wartime pipeline route and having a gas utility in 1941. This identifying variation is largest in southern states in our sample, where only 45% of counties had a gas utility pre-war, and is narrower in areas with less variation: in the Midwest (72% of counties) and Northeast (96%).

4.1 Exogenous variation in pipeline placement

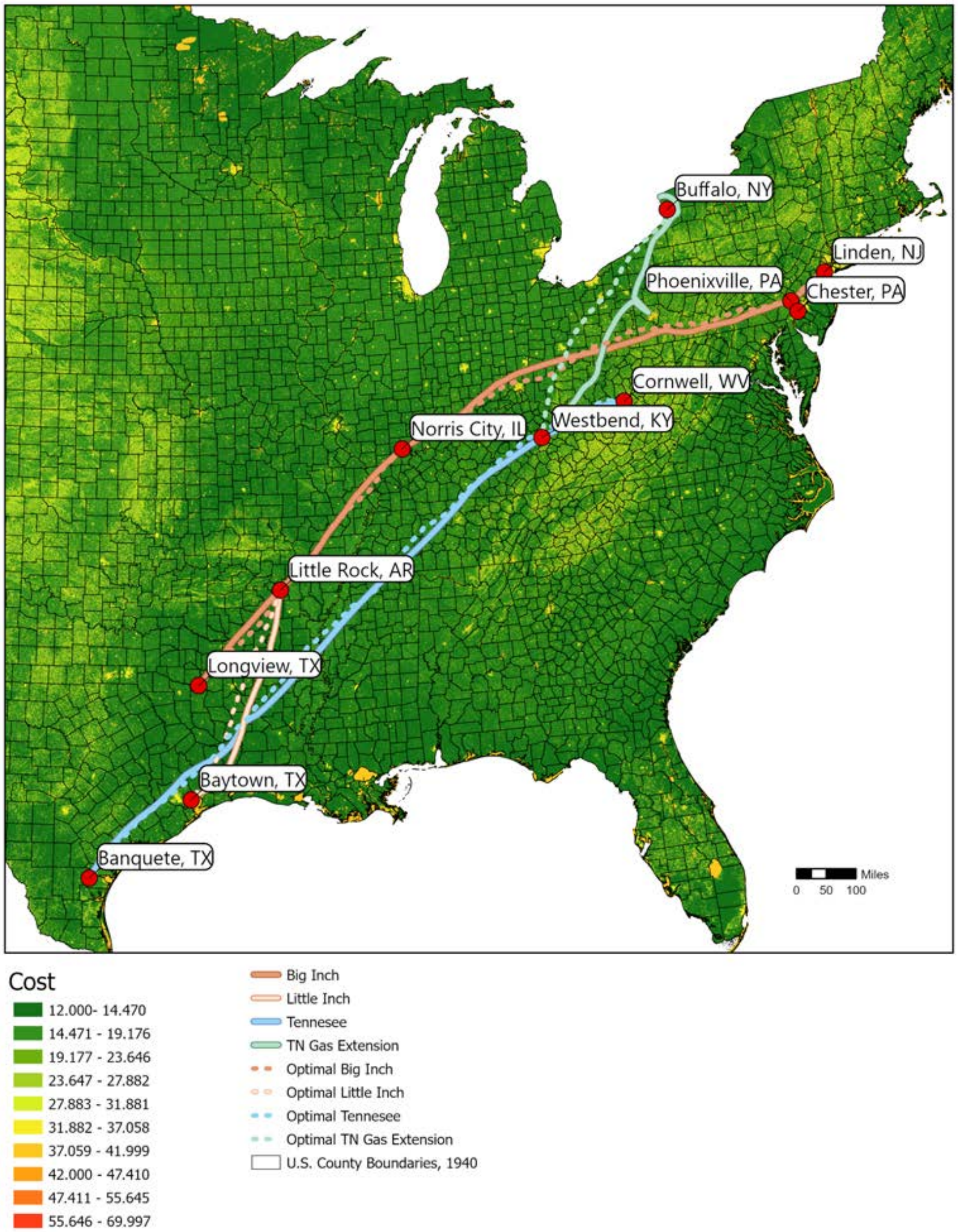
To evaluate how energy infrastructure affected post-war industrial specialization, we need to isolate exogenous variation in where the pipelines were placed. Historical evidence in Section 2 suggests pipeline routes were planned technocratically so as to connect endpoints while minimizing use of construction inputs,[34] such that planners would have elevated expediency over parochial concerns regarding which counties pipelines passed through. It is of course possible that planners still weighed political considerations or potential postwar business opportunities when routing the pipelines. To address this concern, we propose an instrumental variable (IV) strategy based on a hypothetical least cost path/minimum spanning tree pipeline route.

Following the spatial research design of Faber (2014) for transportation infrastructure, we construct notional pipeline routes under the assumption that planners' sole objective was to connect endpoint (and any required midpoint) nodes in a single path for each pipeline subject to minimizing construction costs. We use elevation data and backcasted remote-sensing data on land cover at the time of the pipeline construction to compute the least cost paths between the pipeline endpoint and midpoint target nodes. Least-cost pipeline routes appear in Figure 4. We then calculate the minimum distance from each county centroid to these routes and use these values as an instrument

[34] We therefore exclude from our baseline analysis the Tennessee Gas pipeline extension opened in 1949 from Kentucky to Buffalo, NY. By focusing exclusively on pipelines constructed during wartime, we take a conservative approach to defining treatment. However, the immediate extension of the Tennessee pipeline in 1949 may have in effect have been caused by the wartime pipeline construction, since the WW2 pipelines dramatically reduced the cost of such an extension. Under the logic that the Kentucky-New York extension would not have been constructed but for construction of wartime pipelines, in Appendix Section A.6.1 we re-run our baseline analysis including this additional pipeline segment; results are unchanged.

for the distance of the county centroid to the actual pipeline route.

Figure 4: Map of least-cost and actual pipeline routes

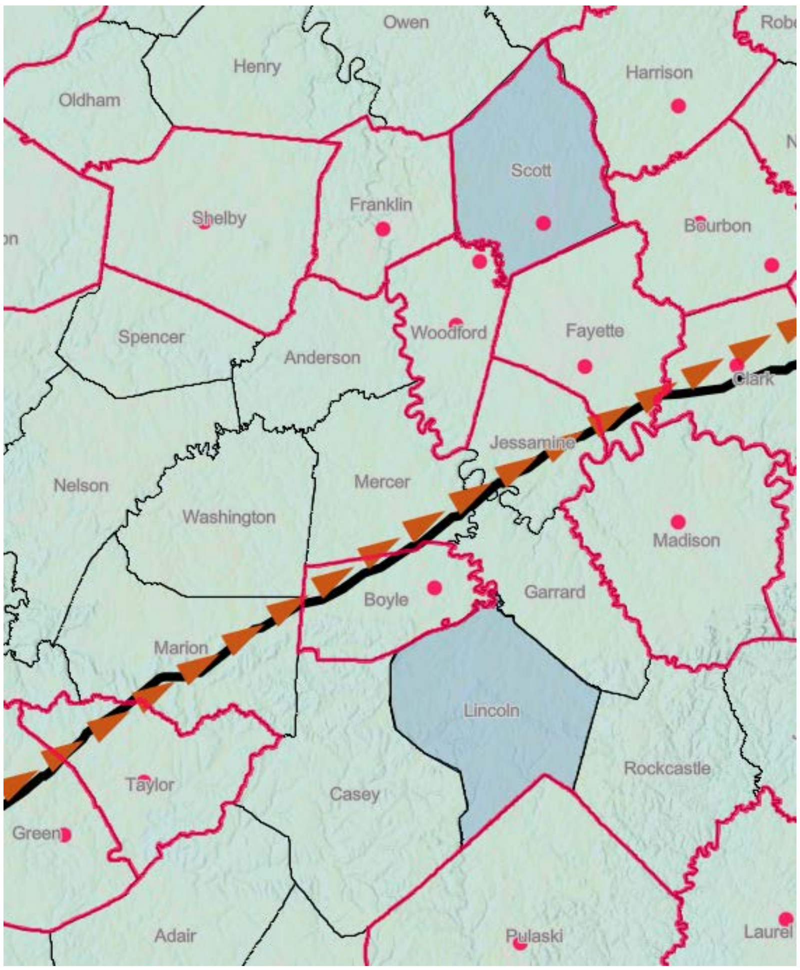


Note: Cost value of crossing a 250m x 250m pixel, $Cost_i = slope_i + lc_i$, is based on sum of the average slope gradient and a land cover-specific cost: Wetlands (25), Developed/urban (33), Agricultural (17), Forest (25), Open water (40), Rocky land (22), Grassland/brush/pasture (12). Pixels with average slope gradient $\geq 30\%$ were assumed to be impassable. See Appendix Section A.3 for further details.

Before describing construction of the instrument in more detail, consider the example in Figure 5 taken from central Kentucky. Lincoln County and Scott County are similarly distant from the

Tennessee Gas pipeline (21 miles and 27 miles from their respective centroids), with close overlap between the actual and optimal pipeline routes (their respective distances to the optimal pipeline route are 19 and 28 miles). In 1940, both counties had similar levels of total employment (5,473 and 4,989 workers, respectively) and employment in top-quartile gas-intensive industries (33 and 16 workers, respectively). However, of the two only Scott County had a gas utility pre-war in 1941, in Georgetown (shown as the red dot in Scott County in Figure 5).

Figure 5: Example of identification strategy: Scott County vs. Lincoln County, KY



Note: We illustrate our identification strategy using two counties in central Kentucky, Scott and Lincoln (shaded blue, near top and bottom of map). They are similarly distant from the actual pipeline route (orange arrows) and the least cost/minimum spanning tree optimal route (in black); only Scott County had a gas utility in 1941 (red dot, in Georgetown). Other red-outlined counties also had a local gas utility in 1941 (represented by red dots).

After construction of the Tennessee Gas Pipeline in 1944, the *potential* local supply of natural gas in Lincoln and Scott Counties would have expanded. However, access to this supply would have depended on having a distribution facility in place, such as a local gas utility. Although we do not observe consumption of gas by industry at the county level (only at the national level), the Census does record whether households used gas supplied by a utility to heat their homes. The usage of utility gas is therefore an indicator of the level of local access to gas. By 1950, 23.6% of dwellings in Scott County were primarily heated by utility gas, up from 1.0% in 1940, whereas in Lincoln County only 1.7% of dwellings were using utility gas for heating.[35] Over 1940 to 1950, the share of employment in top-quartile gas-intensive industries increased in Scott County by 0.28 percentage points but fell in Lincoln County by -0.13 percentage points. By 1964, Scott County had registered a 17.9 percentage-point increase in the share of county employment in top-quartile gas-intensive industries, while Lincoln County had no jobs in these industries. By 1997, top-quartile gas-intensive jobs accounted for 7.2% of employment in Scott County (mostly in fabricated steel products, cement and chemicals), compared to just 3.8% in Lincoln County. This example suggests that among counties similarly proximate to a WW2 pipeline, last-mile connections mattered both for postwar adoption of gas and longer run specialization in gas-intensive industries. In Section 4.3, we examine evidence of such relationships across all counties in our sample.

4.2 Optimal pipeline route instrument

Using GIS tools, we calculate the least-cost/minimum spanning tree optimal pipeline routes for a raster of costs for a pipeline to cross each 250m x 250m pixel in our sample of counties.[36] The starting point is backcasted 1942 land use data from the U.S. Geological Survey at 250m resolution across 14 different land use/land cover categories from Sohl et al. (2016). Based on Jensen and Ellis (1967) and TETCO (2000), we assume the pipeline right of way was 50-100 feet wide, which rationalizes our choice of a 250m pixel size (thereby allowing construction over a wider work site than the physical pipeline itself). We then calculate the average slope gradient of each pixel. Following the pipeline engineering literature, we assume that pixels with slopes greater than 30% were impassible (Durmaz et al., 2019). Appendix Section A.3 provides further details.

[35] Further, the 23.6% of dwellings in Scott County with natural gas were ultimately supplied by the WW2 pipelines, based on AGA (1950) reporting that all gas customers in the county were served by a local utility (the Central Kentucky Natural Gas Company) which is a second degree customer of the Tennessee Gas Transmission Company supplied via the Equitable Gas Company in FPC (1949).

[36] Specifically, we use the Distance Accumulation and Optimal Path as Line tool in ArcGIS Pro.

The construction cost of a wartime pipeline crossing each 250m x 250m pixel i is structured similar to the highway construction cost function in Faber (2014) as:

$$Cost_i = slope_i + lc_i$$

where $slope_i$ is the average slope gradient in percent and lc_i is a fixed cost for construction that depends on the type of land cover. This fixed cost includes the cost of crossing a pixel that is common to all land types (e.g., for steel, other materials, equipment and skilled workers) and a cost that is specific to the type of land cover (e.g., crossing grassland is less costly than crossing open water or traversing urban areas),[37] where we set relative values by land cover type based on historical and contemporary documentation of wartime pipeline construction (Love, 1944; Casella and Wuebber, 1999) and modern studies of least-cost pipeline routes (Abudu and Williams, 2015; Durmaz et al., 2019). Appendix Table A3 lists land cover types and their cost weights.

Figure 4 presents the results of this analysis and the cost raster. Nodes for officially designated pipeline endpoints and midpoints are labeled by name. This map shows substantial overlap between the minimum spanning tree pipeline route and the routes of the constructed pipelines. Notably, the main area of divergence is the 1949 extension of the Tennessee Gas pipeline from West Bend, Kentucky to Buffalo, New York, which was built after WW2 when the constraints on construction costs were less strict and business considerations may have played a larger role.

4.3 Preliminary analysis

Before turning to our main empirical results, we evaluate the relevance of our instrument for the postwar increase in the use of natural gas. Because we do not observe the use of gas by industrial establishments at the county level, we instead examine its use by households. We check first that our minimum spanning tree instrument predicts proximity to WW2 pipelines, akin to a first-stage regression, and then whether such proximity predicts the prewar to postwar change in the share of households using gas (i.e., whether proximity to WW2 pipelines affected household adoption of

[37] The value of the fixed cost is implicitly denominated in units of slope gradient (i.e., the cost of building on a pixel with a 1% grade). To initialize the value for the lowest-cost landcover type (grassland/brush/pasture) in slope-gradient-equivalent units, we performed a grid search.

gas for heating) and the share having access to gas from WW2 pipelines (as described below).

The empirical specification is as follows:

$$DV_c = \beta_0 + \beta_1 Utility_{1941,c} + \beta_2 PipelineDistance_c + \beta_3 (Utility_{1941,c} \text{ x } PipelineDistance_c) + \beta_x X_c + \beta_r FE_r + \epsilon_c \quad (1)$$

where the dependent variable DV_c is distance from county c to a WW2 pipeline or the change in household usage of or access to gas in county c, $Utility_{1941,c}$ is an indicator for whether county c had a gas utility in 1941, $PipelineDistance_c$ is the distance in miles from the country c centroid to the nearest point along a WW2 pipeline route, as predicted by our minimum spanning tree algorithm;[38] X_c is a vector of control variables for county c including log population in 1940, log distance to the nearest population center in 1940 (defined as a county with population of $\geq$ 50,000), and shares of employment in manufacturing and agriculture in 1940; and FE_r are Census region fixed effects. When the dependent variable is minimum distance to a WW2 pipeline, the specification resembles the first-stage regression in our main empirical analysis. When the dependent variable is the change in household usage of or access to gas, the coefficient of interest is β_3 which captures the impact of pipeline access—via the interaction of predicted pipeline proximity and having an existing gas utility—while controlling for the main effects of these two terms.

Estimation results for equation (1) appear in Table 3. In the first two columns, the dependent variable is distance from a county centroid to actual pipeline routes, where column (1) includes the gas utility indicator, minimum spanning tree pipeline distance and their interaction alone and column (2) adds control variables. Minimum spanning tree distance to a WW2 pipeline is strongly predictive of actual distance (with F statistics above 3000).[39] This is consistent with technocratic considerations being the dominant factor in where pipelines were placed, in line with the historical account provided in Section 2.2 where the pipelines were constructed during wartime to transport oil and gas as quickly as possible from endpoint-to-endpoint. In the first row, we see that controlling for predicted distance, counties with a gas utility in 1941 were weakly more distant from a WW2

[38] By constraining counties to be within 250 miles of a pipeline, our results are unlikely to be affected by any nonlinearities in the impact of pipeline distance, which we verified in extended analysis.

[39] As a consequence of the strong predictive power of our instrument, OLS and 2SLS results for our main empirical specification turn out to be very similar. We report 2SLS results to be consistent with empirical literature on evaluating the regional economic consequences of transportation infrastructure.

pipeline. This negative relationship suggests that those planning WW2 pipelines did not favor counties with a gas utility already in place (as one may have expected if the objective of the pipelines was their postwar civilian use and not just their wartime utility).

In columns (3) and (4), the dependent variable is the county level change over 1940 to 1950 in the fraction of households using utility gas. In the first row we see, not surprisingly, that household usage of utility gas for heating increased by much more in counties that already had a gas utility in 1940. Comparing counties with and without a gas utility that were zero miles from the pipeline, households in the former group saw a 18.7 percentage point (t-statistic = 4.7) to 21.0 percentage point (t-statistic = 4.8) larger increase in the use of utility gas. To understand this result, consider that after the war household incomes rose and wartime restrictions were lifted, such that more households may have been able to purchase gas-based appliances for heating and cooking, which were marketed by local utilities, thereby increasing household adoption of utility gas (Tarr, 1999). Central to our analysis, we see in the third row that among counties with a gas utility, those that were further from WW2 pipelines had smaller increases in the adoption of utility gas by 1950. The column (4) coefficient estimate indicates that a county that was one standard deviation further from a WW2 pipeline (71.2 miles) would have had a 3.6 ($= 71.2 \times 0.05$) percentage point (t-statistic = 2.5) smaller increase in the fraction of households using utility gas than a county that was right on the pipeline. In the second row we see that the coefficient on direct proximity to a WW2 pipeline is near zero. Holding constant whether a county had a gas utility, household adoption of utility gas was unrelated to pipeline proximity. Using gas thus depended both on proximity *and* having a gas utility to provide local distribution.

In columns (5) and (6), the dependent variable is the fraction of households in a county that had access to gas from WW2 pipelines in 1950. We do not observe this quantity directly and so estimate it as the product of the share of dwellings with utility gas for heating in 1950 (which includes gas of all types and not just natural gas) and the share of utility gas customers using natural gas in 1949 supplied by the WW2 pipelines (using records in FPC (1949) that describe local utility-transmission company supply relationships). Consistent with the results in columns (3) and (4), we see in the third row among counties with a gas utility in 1940 those that were further from a WW2 pipeline were less likely to be using natural gas, indicating that pipeline construction made natural gas more available to nearby users.

Table 3. Preliminary regression results

	DV = Distance to pipeline		DV = p.p. Δ % HHs with utility gas		DV = % HHs with WW2 pipeline gas, 1950	
	(1)	(2)	(3)	(4)	(5)	(6)
Gas utility in 1941=1	-1.187	-1.805*	20.991***	18.712***	13.430**	10.011**
	(1.073)	(1.048)	(4.376)	(3.961)	(5.133)	(4.122)
Distance from MST route	0.987***	0.984***	0.001	0.005	-0.001	-0.006
	(0.011)	(0.010)	(0.006)	(0.007)	(0.001)	(0.005)
Gas utility in 1941=1 × Distance from MST route	0.006	0.007	-0.052**	-0.053**	-0.054**	-0.047**
	(0.009)	(0.008)	(0.022)	(0.021)	(0.022)	(0.021)
ln(pop.) 1940		-0.015		1.647		-0.117
		(0.612)		(1.155)		(1.182)
ln(Distance to 50K+ pop. county)		-0.281		2.185		-1.836
		(0.524)		(1.777)		(1.117)
% emp. manufacturing, 1940		0.075		-0.207**		-0.096
		(0.053)		(0.086)		(0.087)
% emp. agriculture, 1940		0.003		-0.169**		-0.163**
		(0.035)		(0.071)		(0.078)
Constant	-0.146	0.347	-2.593	-16.559	0.077	17.225
	(1.313)	(8.376)	(2.623)	(14.393)	(3.068)	(14.199)
Census Region FE	Y	Y	Y	Y	Y	Y
Obs.	1245	1245	1245	1245	1245	1245
DV Mean	97.74	97.74	10.05	10.05	4.79	4.79
R-Squared	0.99	0.99	0.27	0.31	0.15	0.19
F-statistic	3997.5	3143.6	13.3	12.6	4.2	2.7

Standard errors clustered by state in parentheses.
* p < 0.10, ** p < 0.05, *** p < 0.01

Notes: Sample is 1,245 counties within 250 miles of any wartime pipeline route, excluding those in the three major gas-producing states (LA, OK, and TX). The dependent variable in columns (1) and (2) is minimum distance from a county centroid to the actual WW2 pipeline route, in columns (3) and (4) is the percentage point change over 1940 to 1950 in the share of dwellings in a county that primarily used utility gas for heating, and in columns (5) and (6) is the estimated share of dwellings in a county in 1950 that were supplied with natural gas from a WW2 pipeline. Odd-numbered columns exclude control variables (1940 values of log population, distance to a population center, agriculture and manufacturing employment shares); even-numbered columns include them. All regressions include Census region fixed effects.

5 Regression results

We estimate the impact of access to natural gas via WW2 pipelines on county employment in energy-intensive industries over shorter (1940 to 1950) and longer (1940 to 1964/1997) time horizons. Our baseline specification for county c, end year t and sector s is,

$$\Delta Y_{c,1940-t,s} = \beta_0 + \beta_1 Utility_{1941,c} + \beta_2 PipelineDistance_c + \beta_3 (Utility_{1941,c} \text{ x } PipelineDistance_c) + \beta_x X_c + \beta_r FE_r + \epsilon_c \quad (2)$$

where $\Delta Y_{c,1940-t,s}$ is the change in the share of county employment in sector s from 1940 to year t, $Utility_{1941,c}$ is an indicator for whether county c had a gas utility in 1941, $PipelineDistance_c$ is the actual distance from county c to the nearest point along any WW2 pipeline route, X_c is a vector of control variables identical to that used in equation (1) (to account for how initial county size, market access and industry structure affect changes in industry specialization) and FE_r are

Census region fixed effects (to absorb region level trends in industry specialization).

Sector s refers to a subset of industries defined according to energy intensity. We focus on industries in the top decile or top quartile of gas-intensity and/or electricity-intensity as of 1947.[40] Energy intensity is defined based on consumption of all types of gas (in million cubic feet per million dollars of value-added) or spending on purchased electricity (as a share of value-added). By defining gas intensity based on consumption of all gas and not just natural gas, we capture industries that consumed large amounts of manufactured coal gas prewar, when natural gas was harder to come by, and then switched to natural gas postwar, when availability improved. We also examine changes in employment shares for other manufacturing industries (i.e., outside of the top quartile of energy intensity), agriculture and services and other sectors. This allows us to explore how access to gas affected overall regional industrial specialization and whether any of these non-energy-intensive sectors were specifically helped or hurt by growth in energy-intensive industries. We also examine impacts of access to natural gas on county population growth.[41]

5.1 Estimation results for 1940 to 1950

We first examine how access to natural gas pipelines affected regional industrial specialization over 1940 to 1950, which spans the immediate postwar period. OLS estimation results appear in Table 4 and two-stage least squares (2SLS) estimation results, in which we use an instrument based on a least cost/minimum spanning tree algorithm to predict distance to a WW2 pipeline, appear in Table 5. Because results with additional control variables included (even columns) are very similar to those without controls (odd columns), we focus on the former set. Given the very strong predictive power of minimum spanning tree distance for actual pipeline distance seen in Table 3, OLS and 2SLS results are very similar. Complete results for all covariates are in Appendix Tables A5 (OLS regressions), A6 (reduced-form regressions) and A7 (2SLS regressions).

[40] We focus on the postwar energy intensity of industries in order to capture location decisions of the firms that would benefit most from gas access at the time when local supplies increased in a county due to the WW2 pipelines. Regression results are similar when we instead use 1971 to define industry energy intensity.

[41] In unreported results we also find that counties with above-median WW2 government contract spending had slightly larger energy-intensive employment growth in the short-term (to 1950) but smaller growth in the longer-term (between 1964 and 1997) while counties with below-median WW2 contracting had smaller short-term employment changes but in some cases larger longer-term changes. However, there are identification challenges related to the location of WW2 contract spending that are beyond the scope of this paper.

Consider the 2SLS results in Table 5a for industries in the top decile of energy intensity. The interaction of having a gas utility and distance to a pipeline (in the third row) is negative and precisely estimated for each definition of industry energy intensity (intensive in gas, intensive in electricity, and intensive in either). For top decile electricity-intensive industries, a coefficient of -0.004 (t-statistic = 2.8) implies that when comparing counties with a gas utility in 1941, a county that is one standard deviation further from a WW2 pipeline (71.2 miles) would have had a 0.3% percentage point smaller increase in employment over 1940 to 1950, relative to a mean 1940 electricity-intensive employment share of 2.5% and a mean 1940-1950 change in the electricity-intensive employment share of -0.6 percentage points.[42] Turning to industries in the top quartile of energy intensity in Table 5b, the utility-distance interaction term is negative, larger in magnitude than for all top decile sectors, and precisely estimated for all three definitions of energy intensity. Comparing columns (2) and (4), impact effects are 1.9 (0.013/0.007) times larger for top-quartile electricity intensive industries than for top-quartile gas-intensive industries.

Results for non-energy intensive industries appear in Table 5c. Notable here is the positive impact of the gas utility-pipeline distance interaction for agriculture and its null impact for services. There were thus smaller reductions in agriculture employment in counties further from the pipelines (among counties with a gas utility). Comparing counties with a gas utility in 1941, a county that was one standard deviation further from a WW2 pipeline would have had a 1.6% ($= 71.2 \times 0.023$) percentage point smaller decrease in its share of employment in agriculture. Adverse impacts of access to natural gas on farm employment are intuitive: for a region to specialize more in one tradable activity (energy-intensive manufacturing) it would likely need to specialize less in some other tradable activity (farming). It is further sensible that the employment losing sector (in relative terms) is agriculture and not services, given the preponderance of nontraded activities within the service sector (especially in earlier periods such as the mid-20th century). Access to natural gas thus appears to have altered regional comparative advantage.

One might be tempted to see a negative impact of energy transportation infrastructure on

[42]Coefficients on the indicator for 'Gas utility in 1941' (in the second row) are typically larger when the dependent variable is gas-intensive industries share of county employment rather than electricity-intensive industries, suggesting that the presence of a pre-existing gas utility is more important for growth of gas-intensive industries (which are likely to be more reliant on local gas distribution networks) than for electricity intensive industries (which are likely to be more reliant on local electricity distribution networks).

agriculture as indicative of a structural transformation out of farming. Yet, other results cast doubt on this interpretation. In Appendix A.5.1, we examine the impact of access to natural gas on county level population growth in 1950 and find null effects. If the construction of gas pipelines were contributing to a structural transformation, one might expect industry to have agglomerated in places with newfound gas access, yielding a greater overall concentration of economic activity in those locations. The absence of impacts of gas access on population growth suggests that such a broader process of agglomeration was not at work.

5.2 Long-term impacts

We next examine whether the initial positive impacts of access to natural gas on regional specialization in energy-intensive industries extended beyond the immediate post-war period and into later decades. On the one hand, the literature has found evidence consistent with path dependence in regional specialization in energy related activities (e.g., Severnini, 2023), which would suggest that the impacts of the WW2 pipelines may have been long lived. On the other hand, there were other powerful economic forces at work in the postwar era—including technological change in manufacturing, the construction of interstate highways and expansions of gas pipelines and high-voltage electricity lines—which could have blunted the impacts of the WW2 pipelines on industry location. Also affecting industry access to energy during this time period were disruptions arising from the energy crisis of the 1970s, including federal price regulations which reduced the attractiveness of supplying gas on the interstate market and which contributed to gas shortages in manufacturing regions of the Midwest and Northeast (see Section 2.3).

We modify equation (3) by redefining $\Delta Y_{c,1940-t,s}$ to be the change in county-sector employment shares from 1940 to each year $t \in [1964, 1997]$. The first end year is 1964, when annual CBP data became available consistently for all individual counties; the last end year is 1997, when CBP data were subject to changes in industry definitions (from SIC to NAICS) that affected comparability with earlier years. All variables on the right-hand side of the regression remain the same. Figure 6 plots the estimated coefficients on the interaction between the distance from a county to a WW2 pipeline and whether it had a gas utility in 1941 (and standard error bounds). Each coefficient

Table 4. OLS regression of 1940-50 emp. change on $\mathbf{I}(UtilityGas_{1941,c})$ x $PipelineDistance_c$

(a) Top decile energy-intensive manufacturing industries

	Gas		Electricity		Gas or Electricity	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to pipeline	0.001	0.000	0.003***	0.004***	0.003**	0.004**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Gas utility in 1941=1	0.536**	0.336*	-0.157	0.147	0.375*	0.593***
	(0.234)	(0.180)	(0.175)	(0.172)	(0.213)	(0.204)
Gas utility in 1941=1 × Dist to pipeline	-0.004**	-0.003**	-0.003**	-0.004**	-0.006***	-0.006***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Census Region FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	0.09	0.09	-0.64	-0.64	-0.43	-0.43
1940 Mean Emp %	1.73	1.73	2.51	2.51	3.23	3.23
R-Squared	0.04	0.05	0.07	0.10	0.04	0.06

(b) Top quartile energy-intensive manufacturing industries

	Gas		Electricity		Gas or Electricity	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to pipeline	0.004**	0.003*	0.011***	0.012***	0.012***	0.012***
	(0.001)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
Gas utility in 1941=1	0.935***	0.767**	0.539**	0.816***	1.438***	1.323***
	(0.331)	(0.289)	(0.259)	(0.225)	(0.425)	(0.395)
Gas utility in 1941=1 × Dist to pipeline	-0.008***	-0.007***	-0.013***	-0.013***	-0.016***	-0.015***
	(0.002)	(0.002)	(0.004)	(0.004)	(0.004)	(0.004)
Census Region FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	0.34	0.34	-0.20	-0.20	0.72	0.72
1940 Mean Emp %	3.98	3.98	5.30	5.30	6.26	6.26
R-Squared	0.03	0.04	0.09	0.10	0.04	0.05

(c) Other sectors

	Other Manufacturing		Agriculture		Services/Other	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to pipeline	0.007	0.007	-0.025**	-0.025**	0.006	0.006
	(0.005)	(0.006)	(0.009)	(0.009)	(0.005)	(0.005)
Gas utility in 1941=1	-1.271*	0.137	-1.655	-3.844***	1.488**	2.384***
	(0.637)	(0.518)	(1.110)	(0.940)	(0.580)	(0.486)
Gas utility in 1941=1 × Dist to pipeline	-0.008*	-0.010*	0.022***	0.023***	0.002	0.002
	(0.005)	(0.005)	(0.008)	(0.007)	(0.006)	(0.005)
Census Region FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	2.75	2.75	-7.88	-7.88	4.42	4.42
1940 Mean Emp %	10.32	10.32	37.48	37.48	45.94	45.94
R-Squared	0.06	0.12	0.15	0.26	0.17	0.20

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered by state in parentheses. Sample is 1,245 counties within 250 miles of any wartime pipeline route, excluding those in the three major gas-producing states (LA, OK, and TX). Independent variables are full interaction of indicator that county c had gas utility in 1941 and its distance to nearest point on any pipeline route (in miles). Controls include 1940 log population, log distance to closest county of population $\geq$ 50K, share of total employment in manufacturing or in agriculture, and census region fixed effects. Dependent variables in Panels (a) and (b) are 100 x percentage point change from 1940 to 1950 in employment in top-quantile energy-intensive industries, defined as all types of gas consumed (in million feet^3) per million dollars of value-added and/or cost of purchased electricity as share of value-added. In Panel (c) dependent variables are change from 1940 to 1950 in sector share of county employment

Table 5. 2SLS regression of 1940-50 emp. change on $\mathbf{I}(UtilityGas_{1941,c})$ x $PipelineDistance_c$

(a) Top decile energy-intensive manufacturing industries

	Gas		Electricity		Gas or Electricity	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to pipeline	0.001	0.000	0.003***	0.004***	0.003**	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Gas utility in 1941	0.564**	0.365*	-0.124	0.180	0.411*	0.631***
	(0.242)	(0.193)	(0.164)	(0.162)	(0.215)	(0.215)
Gas utility in 1941 x dist to pipeline	-0.004**	-0.003**	-0.004***	-0.004***	-0.006***	-0.006***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
Census Region FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	0.09	0.09	-0.64	-0.64	-0.43	-0.43
1940 Mean Emp %	1.73	1.73	2.51	2.51	3.23	3.23
R-Squared	0.04	0.05	0.07	0.10	0.04	0.06
F-stat	7110.8	7090.2	7110.8	7090.2	7110.8	7090.2

(b) Top quartile energy-intensive manufacturing industries

	Gas		Electricity		Gas or Electricity	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to pipeline	0.004***	0.003*	0.011***	0.012***	0.012***	0.011***
	(0.001)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
Gas utility in 1941	0.973***	0.807***	0.527**	0.803***	1.437***	1.321***
	(0.330)	(0.297)	(0.241)	(0.206)	(0.413)	(0.383)
Gas utility in 1941 x dist to pipeline	-0.008***	-0.007***	-0.013***	-0.013***	-0.016***	-0.015***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.004)	(0.004)
Census Region FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	0.34	0.34	-0.20	-0.20	0.72	0.72
1940 Mean Emp %	3.98	3.98	5.30	5.30	6.26	6.26
R-Squared	0.03	0.04	0.09	0.10	0.04	0.05
F-stat	7110.8	7090.2	7110.8	7090.2	7110.8	7090.2

(c) Other sectors

	Other Manufacturing		Agriculture		Services/Other	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to pipeline	0.007	0.008	-0.025***	-0.026***	0.006	0.007
	(0.005)	(0.005)	(0.009)	(0.009)	(0.005)	(0.005)
Gas utility in 1941	-1.206*	0.197	-1.698	-3.875***	1.467***	2.357***
	(0.635)	(0.519)	(1.091)	(0.920)	(0.550)	(0.448)
Gas utility in 1941 x dist to pipeline	-0.009*	-0.011**	0.023***	0.023***	0.002	0.002
	(0.005)	(0.005)	(0.008)	(0.007)	(0.005)	(0.005)
Census Region FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	2.75	2.75	-7.88	-7.88	4.42	4.42
1940 Mean Emp %	10.32	10.32	37.48	37.48	45.94	45.94
R-Squared	0.06	0.12	0.15	0.26	0.17	0.20
F-stat	7110.8	7090.2	7110.8	7090.2	7110.8	7090.2

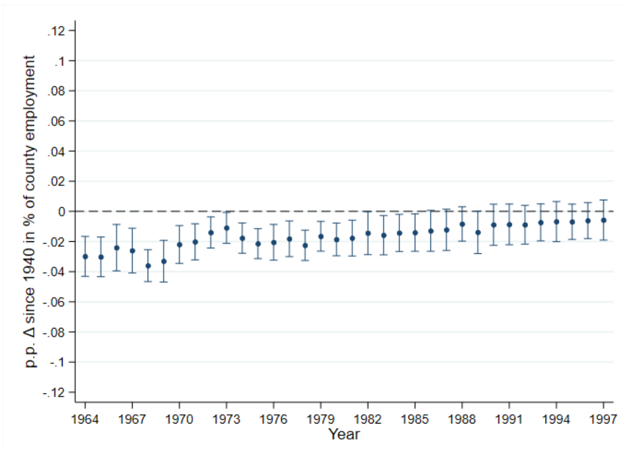
Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered by state in parentheses. Sample is 1,245 counties within 250 miles of any wartime pipeline route, excluding those in the three major gas-producing states (LA, OK, and TX). Two stage least squares regression, with second stage results and cluster-robust Kleibergen-Paap Wald rk F statistic from 1st stage reported. Independent variables are full interaction of indicator that county c had gas utility in 1941 and its distance to nearest point on any pipeline route, where latter is instrumented with least-cost/minimum spanning tree optimal pipeline route (in miles). Controls include 1940 log population, log distance to closest county of population $\geq$ 50K, share of total employment in manufacturing or in agriculture, and census region fixed effects. Dependent variables in Panels (a) and (b) are 100 x percentage point change from 1940 to 1950 in employment in top-quantile energy-intensive industries, defined as all types of gas consumed (in million feet^3) per million dollars of value-added and/or cost of purchased electricity as share of value-added. In Panel (c) dependent variables are change from 1940 to 1950 in sector share of county employment estimate is from a separate regression for the period 1940 to the end year indicated on the horizontal axis. Full regression results for select years are in Appendix Table A.4.2.

Overall, we find strong evidence of persistence in impacts of WW2 pipelines into the 1970s and mixed evidence of persistence into later decades. Figure 6a plots coefficient estimates for industries in the top quartile of gas intensity. Impact effects for 1940-1964 (-0.030, t-statistic = 4.4) and 1940-1968 (-0.036, t-statistic = 6.7) are more than four times as large as those for 1940-1950 in column (2) of Table 5b (0.007). The impact of proximity to the WW2 pipelines thus grew after 1950. Yet, starting in 1970 the impacts of pipeline access diminish, which aligns with when federal price regulations on interstate shipments of natural gas began to bite (see Section 2.3). The impacts on gas-intensive employment become imprecisely estimated after 1985.

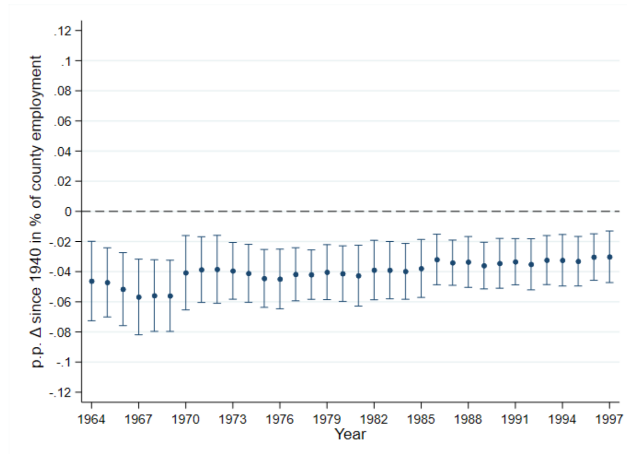
These results contrast somewhat with those for electricity-intensive industries. Impact effects for industries in the top-quartile of electricity intensity in Figure 6b cluster around 0.05 in the 1960s and around 0.04 throughout the 1970s—which is still over three times larger than the corresponding estimate for the 1940-1950 change in column (4) of Table 5b (0.013)— and are precisely estimated in all years.[43] Impact effects for electricity-intensive sectors diminish far less during the early 1970s than those for gas-intensive employment. This is consistent with electricity-intensive industries being better able to access energy during the energy crisis due to electrical generators being able to substitute to alternative fuels, such as coal. Finally, in Figure 6c and 6d we see positive coefficient estimates for non-energy-intensive manufacturing and services and other industries, which are estimated with considerable noise. Positive impact effects indicate that on average these industries had larger decreases in county employment shares in counties that had better access to pipeline gas. The noisiness of the estimates may indicate that there was heterogeneity across counties in whether it was other manufacturing or services industries that were the effective source of residual labor supply to energy-intensive manufacturing.

[43]For top-decile electricity-intensive industries (shown in Figure A1) we see similarly large, positive and precisely estimated impacts, though only until the early 1980s.

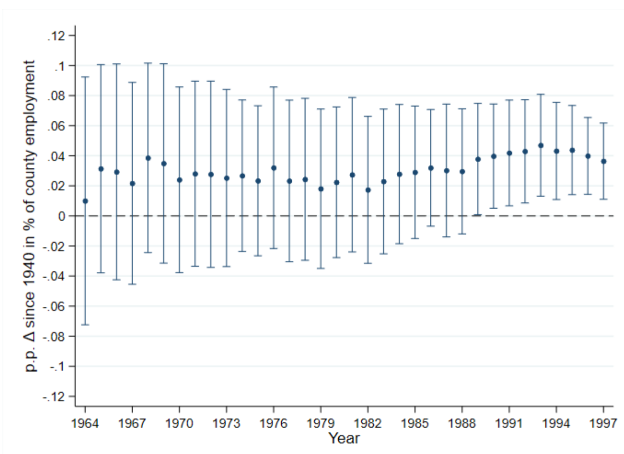
Figure 6: Coefficients from 2SLS regression of p.p. change in sector share of total county employment on $\mathbf{I}(UtilityGas_{1941,c})$ x $PipelineDistance_c$ from 1940 to each end-year



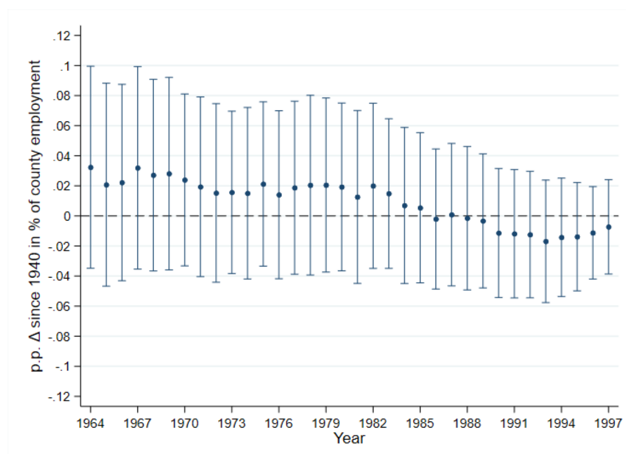
(a) Gas-intensive industries (top quartile)



(b) Electricity-intensive industries (top quartile)



(c) Other manufacturing



(d) Services and other industries

Notes: Sample is 1,245 counties within 250 miles of any wartime pipeline route, excluding those in the three major gas-producing states (LA, OK, and TX). Plot shows the estimated coefficient on the interaction between distance from county c centroid to nearest point on actually-constructed pipeline route and an indicator that county c had a gas utility in 1941, from two stage-least squares regression, with 95% confidence interval. Negative coefficients show increase in employment with decreased distance to pipeline (i.e. increased proximity). Distance to actual pipeline route is instrumented with least-cost/minimum spanning tree optimal pipeline route (in miles). Includes census region fixed effects and controls for 1940 log population, log distance to closest county with population $\geq$ 50K, and share of county employment in manufacturing and in agriculture. Standard errors clustered by state. Dependent variable on Y-axis is change from 1940 to each year in share of total county employment in sector, defined based on industry energy consumption and value-added in 1947 (see text for details). See Appendix Section A.4.2 for tables of results.

5.3 Robustness checks

Next, we explore the robustness of these empirical results in three dimensions. First, we include an additional pipeline segment: a branch of the Tennessee Gas line from West Bend, KY to Buffalo, NY constructed post-war and opened in 1949. Its construction was therefore not likely to have been subject to the same wartime constraints as the WW2 pipeline routes in our baseline analysis. Indeed, its route diverges significantly from the least cost/minimum spanning tree optimal route, as shown in Figure 4. However, the opening of this branch line pre-dates our first observation of post-war employment outcomes in 1950. It seems plausible that it would not have been constructed as a branch line had the wartime Tennessee Gas line not been built first. Including this additional pipeline segment in our analyses translates to modifying our data sample to include one additional county that is only within 250 miles of this branch line (not any other WWII pipeline route) as well as modifying the proximity of 169 counties to the nearest actual and/or optimal pipeline route (since they are closer to this additional branch than the wartime pipelines). Appendix Section A.6.1 includes results from re-estimating our baseline analyses with this modified data sample. We find no substantial differences with our baseline results.

Second, we explore an alternative specification with an additional control for the initial share of county employment in a sector in 1940 (see Appendix Section A.6.2), which allows for mean reversion in county-sector employment growth. We again find similar impacts as in our baseline regressions, with weaker initial impacts for top decile gas-intensive employment but slightly greater persistence in impacts on top quartile gas-intensive employment.

Third, we use state fixed effects rather than census region fixed effects in our regressions (see Appendix Section A.6.3), which controls for possible state-specific changes in policies that may have affected manufacturing. The initial impacts we estimate are similar to our baseline results, although some estimates become less precise. In particular, there is no longer a statistically significant impact of the pipeline distance-gas utility interaction on the 1940-1950 change in employment in top-decile gas-intensive industries. However, impacts on all other energy-intensive sectors remain precisely estimated. For all industries, long-run impacts for end years 1964 to 1997 when estimated with state fixed effects are very similar to our baseline results.

6 Conclusion

In this paper we study the employment impacts of a plausibly exogenous increase in local energy access arising from counties being more or less proximate to natural gas pipelines that were constructed to meet U.S. military needs during World War II. We find that an increase in local energy access at a time when that energy source (i.e., interstate natural gas in the Northeast) was newly available led to persistently high employment in energy-intensive industries. These impacts moderated for some sectors in later decades, possibly due to regulatory shocks that partially undid the energy market integration that pipeline construction had brought about.

Our results relate to current discussions about the local employment impacts of access to energy (Hanson, 2023), which are arising from the increased use of clean energy sources (Arkolakis and Walsh, 2023). One can imagine alternative paths that the U.S. economy might take in managing its energy transition. Along one path, investments in energy transportation infrastructure may end up being localized, either because U.S. states vary in the priority each places on switching to renewable energy sources or because regional system operators, transmission organizations and other regulatory entities vary in their capacity to integrate electricity grids. In this scenario, locations with plentiful and inexpensive energy may specialize in energy-intensive manufacturing, similar to what happened in the aftermath of the WW2 pipelines. Such a localization of energy access would restore what Severnini (2023) calls a "cheap local power advantage" for some regional economies. Along another path, the energy transition may motivate a more expansive redesign of U.S. energy transportation infrastructure, such as by expanding high-voltage power lines that would transmit electricity from regions with abundant solar, wind or hydro power to other parts of the country. Local variation in power access would be compressed, leaving other forces to determine regional comparative advantage. As during World War II, current energy policy choices may have long-lived effects on which industries locate where.

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A Appendix

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A.1 1939 energy and general statistics of post-war energy-intense industries

Table A1. 1939 statistics of post-war energy-intensive industries

	Gas intensity	All gas (Mf^3/$VA\$M$)	% Natural/mixed gas	Electricity intensity	Electric costs % VA	Fuel + Electric costs ($M)	Emp. ('000s)
Blast furnaces, steel works, and rolling mills (336)	Top decile	858.9	9.9	Top decile	3.2	317.4	470.9
Miscellaneous petroleum and coal products (477)	Top decile	387.0	14.3	Other	2.9	14.1	36.7
Petroleum refining (476)	Top decile	512.1	43.6	Other	2.0	70.0	105.2
Cement, concrete, gypsum and plaster products (317)	Top decile	244.0	98.5	Top decile	6.9	46.6	56.2
Glass and glass products (316)	Top decile	254.6	96.7	Other	2.3	26.3	91.5
Structural clay, pottery, and related products (318; 319)	Top decile	86.2	96.3	Other	2.1	41.0	175.3
Primary nonferrous industries (338)	Top quartile	115.7	77.9	Top decile	4.1	31.8	102.2
Miscellaneous chemicals and allied products (469)	Top quartile	526.3	99.9	Top quartile	1.8	22.9	125.4
Pulp, paper, and paperboard mills (456)	Top quartile	55.4	99.9	Top decile	4.2	77.7	178.6
Not specified metal industries (348)	Top quartile	18.2	45.8	Top decile	2.9	3.8	20.2
Fabricated steel products (346)	Top quartile	12.5	76.0	Other	1.7	84.9	890.6
Meat products (406)	Top quartile	41.6	96.2	Other	1.8	20.9	203.8
Other primary iron and steel industries (337)	Top quartile	7.7	61.8	Top decile	1.7	16.8	202.6
Miscellaneous nonmetallic mineral and stone products (326)	Other	10.4	92.1	Top quartile	2.9	9.1	61.0
Dairy products (407)	Other	46.4	90.1	Top quartile	4.0	16.1	50.4
Grain-mill products (409)	Other	11.3	96.8	Top quartile	4.0	9.5	41.1
Rubber products (478)	Other	11.7	78.5	Top quartile	2.5	17.9	152.9
Yarn, thread, and fabric mills (439)	Other	2.8	96.6	Top quartile	5.0	51.1	564.1

Notes: This table shows the energy consumption and other statistics as of 1939 for IND1950 industries that rank in the top quartile in 1947 of either energy-intensity measures (all types of gas consumed (in Mf^3) per $M of value-added and electricity costs as share of value-added) based on data from the Census of Manufactures. Industries are listed in order of all gas-intensity. 'Natural/mixed gas' consumption includes pure natural gas as well as coal gas enriched with natural gas by utilities or end-users as well as some gas for which the type was not reported by end-user establishments (Census Bureau, 1942). All dollar values are deflated to 1939 levels based on price indices for Industrial Commodities and Fuels and Related Products and Power from Series E 23-39 of Bureau (1975).

A.2 Description of additional variables used in appendix analyses

Table A2. Summary statistics

	Mean	Std.Dev.
Est. % of dwellings using natural gas for heating, 1949/50	9.53	16.41
ln(Distance to 100K+ pop. county)	3.82	0.59
ln(Distance to 250K+ pop. county)	4.29	0.71
Mean temp. Jan.	3.99	2.21
Observations	1245	

The construction of additional variables used in analyses in this appendix is as follows:

- **Est. % of dwellings using natural gas for heating, 1949-50** - estimated as (% of county dwellings with utility gas heating in 1950) × (% of county utility gas customers served by utilities that supplied natural or mixed gas in 1949), based on data from AGA (1950).
- **ln(Distance to 50K + population center)** - calculated as log of straight-line distance (in miles) from county centroid to nearest county with a population of at least 100,000 or alternatively of at least 250,000.
- **Mean Jan. temperature, 1939** - mean of daily high temperatures in county during January 1939, based on data from NOAA National Centers for Environmental Information.[44]

[44]See https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/county/mapping.

A.3 Optimal pipeline routes calculation

Figure 4 shows the least-cost/minimum spanning tree optimal pipeline route and the routes of the actual pipeline constructed, mapped on the cost raster.

The optimal route for each pipeline segment was calculated between start and end points as well as key mid points (e.g. interconnections) geocoded to centers of cities listed in Love (1944) and Casella and Wuebber (1999). These points were:

- Big Inch Pipeline (TETCO)
  1. Start: Longview, TX
  2. Midpoint 1: Little Rock, AR - point of convergence with Little Inch pipeline
  3. Midpoint 2: Norris City, IL - rail junction where pipeline(s) were constructed to in first stage of building, to initially transport oil to northeast via rail while construction on second stage eastward was still ongoing
  4. Midpoint 3 (split in two afterwards): Phoenixville, PA
  5. Endpoints (Chester Junction, PA and Linden, NJ)
- Little Inch Pipeline (TETCO)
  1. Start: Baytown, TX
  2. Midpoint: Little Rock, AR - point of convergence with Big Inch pipeline
  3. Same route as Big Inch Pipeline afterward
- Tennessee Gas Pipeline
  1. Start: Banquette, TX
  2. Endpoint (initially): Cornwell Station, WV
- TN Gas Pipeline Extension (built in 1949)
  1. Start: West Bend, KY
  2. Endpoint: Buffalo, NY

Table A3 provides the costs associated with crossing each 250m x 250m pixel for the calculation of the least cost path/minimum spanning tree optimal pipeline routes, as described in Section 4.2.

Table A3. Pixel cost weights for pipeline construction

Pixel characteristic group	**Land cover classifications (1942)**	**Weight (lc_i value)**	**Source and notes**
Extreme slope (>30%)	N/A	Impassible	Durmaz et al. (2019) states that pipelines cannot be built on slope gradient greater than 30%
Average slope gradient	N/A	1	Weight is linear with average slope gradient, as used in Faber (2014). Jensen and Ellis (1967) document extra construction cost for machinery needed to bend pipe in difficult terrain, and Raley (2008) notes shortage of these machines during WW2 pipeline construction
Wetlands	Herbaceous Wetland; Wetland	25	Abudu and Williams (2015) use a weight half as large as for water
Developed	Urban/Developed	33	Average of 'urban centre' weights in different categories in Abudu and Williams (2015).
Agricultural	Cultivated Cropland	17	Terrain is not difficult, but opposition to Tennessee Gas Pipeline from farm owners en-route well-documented, e.g. in Raley (2008)
Forest	Deciduous Forest; Evergreen Forest; Mixed Forest	25	Love (1944) and Casella and Wuebber (1999) qualitatively describe construction in forests as having a cost somewhat greater than agriculture and far less than water.
Water (major rivers/lakes)	Open Water	40	Highest cost given time and specialized labor, materials, and equipment required for river crossings (TETCO, 2000; Love, 1944).
Rocky land	Mining; Barren	22	Weight assumed - Harder to dig ditches in rocky areas for Big Inch pipeline (Casella and Wuebber, 1999)
Grassland, brush and pasture	Grassland; Shrubland; Hay/Pasture	12	Lowest-cost land to build on

In order to show the predictive power of the least-cost/minimum spanning tree optimal pipeline route for the actual pipeline route, we estimate the equation:

$$DistActualRoute_c = \beta_0 + \beta_1 DistMSTRoute_c + \zeta_i$$

Where $DistActualRoute_c$ and $DistMSTRoute_c$ represent the distance (in miles) from county c centroid to the nearest point on the actual pipeline routes and least-cost/minimum spanning tree pipeline routes, respectively. The results are provided in Table A4, with measures used in each column numbered as in the list above. The least-cost route strongly predicts the actual pipeline route, with slightly weaker results when our sample is modified to include the 1949 branch extension of the Tennessee Gas pipeline.

Table A4. Regressing actual pipeline route on least-cost optimal route

	Dep Var: Distance to actual pipeline route	
	(1)	(2)
	Baseline sample	+ TN Gas Line extension
Distance to MST route	0.992***	0.986***
	(0.008)	(0.012)
Constant	0.444	0.908
	(0.910)	(1.507)
Obs.	1245	1246
DV mean	97.735	93.712
DV Std Dev	71.179	71.082
R-Squared	0.990	0.982
F-statistic	13977.038	7264.038

Standard errors clustered by state in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Sample is counties within 250 miles of any pipeline route, excluding those in the three major gas-producing states (LA, OK, and TX). Column 1 is baseline sample excluding 1949 extension of Tennessee Gas pipeline from analysis while Column 2 sample includes extension, resulting in an additional county within 250 miles of any pipeline and changes in value of distance to nearest actual and/or MST pipeline route for 169 counties. Dependent variable is distance from county centroid to nearest point on actual pipeline route (in miles) and independent variable is defined analogously for optimal pipeline route calculated through least-cost/minimum spanning tree analysis based on geographic features.

A.4 Full regression results

A.4.1 Full initial impacts regressions results

Table A5. OLS regression of 1940-50 emp. change on $\mathbf{I}(UtilityGas_{1941,c})$ x $PipelineDistance_c$

(a) Top decile energy-intensive manufacturing industries

	Gas		Electricity		Gas or Electricity	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to pipeline	0.001	0.000	0.003***	0.004***	0.003**	0.004**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Gas utility in 1941=1	0.536**	0.336*	-0.157	0.147	0.375*	0.593***
	(0.234)	(0.180)	(0.175)	(0.172)	(0.213)	(0.204)
Gas utility in 1941=1 × Distance to pipeline	-0.004**	-0.003**	-0.003**	-0.004**	-0.006***	-0.006***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
ln(pop.) 1940		0.054		-0.101		-0.196*
		(0.088)		(0.100)		(0.098)
ln(Distance to 50K+ pop. county)		-0.235**		0.089		-0.009
		(0.105)		(0.105)		(0.129)
% emp. manufacturing, 1940		-0.002		-0.029***		-0.033**
		(0.009)		(0.010)		(0.014)
% emp. agriculture, 1940		-0.003		-0.002		-0.009
		(0.005)		(0.004)		(0.006)
Constant	0.302	0.840	-0.592***	0.341	-0.394**	2.209
	(0.205)	(1.163)	(0.159)	(1.219)	(0.183)	(1.314)
Census Region FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	0.09	0.09	-0.64	-0.64	-0.43	-0.43
1940 Mean Emp %	1.73	1.73	2.51	2.51	3.23	3.23
R-Squared	0.04	0.05	0.07	0.10	0.04	0.06

Standard errors clustered by state in parentheses.
* p < 0.10, ** p < 0.05, *** p < 0.01

(b) Top quartile energy-intensive manufacturing industries

	Gas		Electricity		Gas or Electricity	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to pipeline	0.004**	0.003*	0.011***	0.012***	0.012***	0.012***
	(0.001)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
Gas utility in 1941=1	0.935***	0.767**	0.539**	0.816***	1.438***	1.323***
	(0.331)	(0.289)	(0.259)	(0.225)	(0.425)	(0.395)
Gas utility in 1941=1 × Distance to pipeline	-0.008***	-0.007***	-0.013***	-0.013***	-0.016***	-0.015***
	(0.002)	(0.002)	(0.004)	(0.004)	(0.004)	(0.004)
ln(pop.) 1940		-0.192		-0.212*		-0.178
		(0.126)		(0.122)		(0.130)
ln(Distance to 50K+ pop. county)		-0.170		-0.229		-0.429
		(0.235)		(0.186)		(0.262)
% emp. manufacturing, 1940		-0.002		-0.029		-0.001
		(0.015)		(0.018)		(0.025)
% emp. agriculture, 1940		-0.012**		-0.000		-0.003
		(0.006)		(0.007)		(0.008)
Constant	0.238	3.373*	-1.056***	2.093	-0.166	3.346*
	(0.285)	(1.663)	(0.280)	(1.303)	(0.429)	(1.665)
Census Region FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	0.34	0.34	-0.20	-0.20	0.72	0.72
1940 Mean Emp %	3.98	3.98	5.30	5.30	6.26	6.26
R-Squared	0.03	0.04	0.09	0.10	0.04	0.05

Standard errors clustered by state in parentheses.
* p < 0.10, ** p < 0.05, *** p < 0.01

Notes: See next page

OLS regression of 1940-50 emp. change on $\mathbf{I}(UtilityGas_{1941,c})$ x $PipelineDistance_c$(continued)

(c) Other sectors

	Other Manufacturing		Agriculture		Services/Other	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to pipeline	0.007	0.007	-0.025**	-0.025**	0.006	0.006
	(0.005)	(0.006)	(0.009)	(0.009)	(0.005)	(0.005)
Gas utility in 1941=1	-1.271*	0.137	-1.655	-3.844***	1.488**	2.384***
	(0.637)	(0.518)	(1.110)	(0.940)	(0.580)	(0.486)
Gas utility in 1941=1 × Distance to pipeline	-0.008*	-0.010*	0.022***	0.023***	0.002	0.002
	(0.005)	(0.005)	(0.008)	(0.007)	(0.006)	(0.005)
ln(pop.) 1940		-0.668*		0.730**		0.116
		(0.340)		(0.346)		(0.333)
ln(Distance to 50K+ pop. county)		0.257		1.233***		-1.062**
		(0.323)		(0.375)		(0.388)
% emp. manufacturing, 1940		0.059**		-0.082***		0.023
		(0.023)		(0.025)		(0.032)
% emp. agriculture, 1940		0.058***		-0.133***		0.079***
		(0.019)		(0.024)		(0.024)
Constant	3.792***	5.850	-4.292**	-8.595*	0.666	-0.602
	(1.135)	(4.420)	(1.601)	(4.520)	(0.595)	(4.173)
Census Region FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	2.75	2.75	-7.88	-7.88	4.42	4.42
1940 Mean Emp %	10.32	10.32	37.48	37.48	45.94	45.94
R-Squared	0.06	0.12	0.15	0.26	0.17	0.20

Standard errors clustered by state in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Sample is 1,245 counties within 250 miles of any wartime pipeline route, excluding those in the three major gas-producing states (LA, OK, and TX). Independent variables are full interaction of indicator that county c had gas utility in 1941 and its distance to nearest point on any pipeline route (in miles). Controls include 1940 log population, log distance to closest county of population $\geq$ 50K, share of total employment in manufacturing or in agriculture, and census region fixed effects. Dependent variables in Panels (a) and (b) are 100 x percentage point change from 1940 to 1950 in employment in top-quantile energy-intensive industries, defined as all types of gas consumed (in million feet^3) per million dollars of value-added and/or cost of purchased electricity as share of value-added. In Panel (c) dependent variables are change from 1940 to 1950 in sector share of county employment

Table A6. Reduced form regression of 1940-50 emp. change on $\mathbf{I}(UtilityGas_{1941,c})$ x $PipelineDistance_c$

(a) Top decile energy-intensive manufacturing industries

	Gas		Electricity		Gas or Electricity	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to MST pipeline	0.001	0.000	0.003***	0.004***	0.003**	0.004**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Gas utility in 1941=1	0.565**	0.367*	-0.126	0.176	0.410*	0.628***
	(0.248)	(0.199)	(0.168)	(0.166)	(0.221)	(0.221)
Gas utility in 1941=1 × Distance to MST pipeline	-0.004**	-0.003**	-0.004**	-0.004**	-0.006***	-0.006***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
ln(pop.) 1940		0.052		-0.102		-0.197*
		(0.088)		(0.099)		(0.098)
ln(Distance to 50K+ pop. county)		-0.231**		0.092		-0.006
		(0.104)		(0.104)		(0.129)
% emp. manufacturing, 1940		-0.001		-0.028**		-0.032**
		(0.009)		(0.010)		(0.014)
% emp. agriculture, 1940		-0.003		-0.002		-0.008
		(0.005)		(0.004)		(0.006)
Constant	0.317	0.850	-0.596***	0.332	-0.389**	2.211
	(0.208)	(1.152)	(0.159)	(1.212)	(0.186)	(1.311)
Census Region FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	0.09	0.09	-0.64	-0.64	-0.43	-0.43
1940 Mean Emp %	1.73	1.73	2.51	2.51	3.23	3.23
R-Squared	0.05	0.05	0.07	0.10	0.04	0.06

Standard errors clustered by state in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(b) Top quartile energy-intensive manufacturing industries

	Gas		Electricity		Gas or Electricity	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to MST pipeline	0.004**	0.003*	0.011***	0.012***	0.012***	0.011***
	(0.001)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
Gas utility in 1941=1	0.972***	0.807**	0.520*	0.790***	1.430***	1.310***
	(0.341)	(0.308)	(0.253)	(0.217)	(0.432)	(0.401)
Gas utility in 1941=1 × Distance to MST pipeline	-0.008***	-0.007***	-0.013***	-0.013***	-0.016***	-0.015***
	(0.002)	(0.002)	(0.004)	(0.003)	(0.004)	(0.004)
ln(pop.) 1940		-0.194		-0.215*		-0.183
		(0.126)		(0.121)		(0.131)
ln(Distance to 50K+ pop. county)		-0.166		-0.234		-0.431
		(0.234)		(0.186)		(0.262)
% emp. manufacturing, 1940		-0.001		-0.029		0.000
		(0.015)		(0.018)		(0.025)
% emp. agriculture, 1940		-0.012**		-0.000		-0.003
		(0.006)		(0.007)		(0.009)
Constant	0.249	3.378*	-1.011***	2.191	-0.102	3.463**
	(0.285)	(1.663)	(0.281)	(1.291)	(0.432)	(1.676)
Census Region FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	0.34	0.34	-0.20	-0.20	0.72	0.72
1940 Mean Emp %	3.98	3.98	5.30	5.30	6.26	6.26
R-Squared	0.03	0.04	0.09	0.10	0.04	0.05

Standard errors clustered by state in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: See next page

Reduced form regression of 1940-50 emp. change on $\mathbf{I}(UtilityGas_{1941,c})$ x $PipelineDistance_c$(continued)

(c) Other sectors

	Other Manufacturing		Agriculture		Services/Other	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to MST pipeline	0.007	0.008	-0.025***	-0.025**	0.006	0.007
	(0.005)	(0.006)	(0.009)	(0.009)	(0.005)	(0.005)
Gas utility in 1941=1	-1.211*	0.190	-1.678	-3.844***	1.459**	2.344***
	(0.648)	(0.529)	(1.124)	(0.950)	(0.565)	(0.462)
Gas utility in 1941=1 × Distance to MST pipeline	-0.009*	-0.010**	0.022***	0.023***	0.002	0.002
	(0.005)	(0.005)	(0.008)	(0.007)	(0.005)	(0.005)
ln(pop.) 1940		-0.664*		0.727**		0.120
		(0.340)		(0.344)		(0.331)
ln(Distance to 50K+ pop. county)		0.259		1.240***		-1.068**
		(0.326)		(0.380)		(0.389)
% emp. manufacturing, 1940		0.058**		-0.081***		0.023
		(0.022)		(0.025)		(0.032)
% emp. agriculture, 1940		0.057***		-0.133***		0.079***
		(0.019)		(0.024)		(0.024)
Constant	3.715***	5.750	-4.233**	-8.572*	0.620	-0.641
	(1.140)	(4.401)	(1.605)	(4.493)	(0.593)	(4.143)
Census Region FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	2.75	2.75	-7.88	-7.88	4.42	4.42
1940 Mean Emp %	10.32	10.32	37.48	37.48	45.94	45.94
R-Squared	0.06	0.12	0.15	0.26	0.17	0.20

Standard errors clustered by state in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Sample is 1,245 counties within 250 miles of any wartime pipeline route, excluding those in the three major gas-producing states (LA, OK, and TX). Independent variables are full interaction of indicator that county c had gas utility in 1941 and its distance to nearest point on least-cost/minimum spanning tree optimal pipeline route (in miles). Controls include 1940 log population, log distance to closest county of population $\geq$ 50K, share of total employment in manufacturing or in agriculture, and census region fixed effects. Dependent variables in Panels (a) and (b) are 100 x percentage point change from 1940 to 1950 in employment in top-quantile energy-intensive industries, defined as all types of gas consumed (in million feet^3) per million dollars of value-added and/or cost of purchased electricity as share of value-added. In Panel (c) dependent variables are change from 1940 to 1950 in sector share of county employment

Table A7. 2SLS regression of 1940-50 emp. change on $\mathbf{I}(UtilityGas_{1941,c})$ x $PipelineDistance_c$

(a) Top decile energy-intensive manufacturing industries

	Gas		Electricity		Gas or Electricity	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to pipeline	0.001	0.000	0.003***	0.004***	0.003**	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Gas utility in 1941	0.564**	0.365*	-0.124	0.180	0.411*	0.631***
	(0.242)	(0.193)	(0.164)	(0.162)	(0.215)	(0.215)
Gas utility in 1941 x distance to pipeline	-0.004**	-0.003**	-0.004***	-0.004***	-0.006***	-0.006***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
ln(pop.) 1940		0.053		-0.101		-0.197**
		(0.086)		(0.097)		(0.096)
ln(Distance to 50K+ pop. county)		-0.231**		0.093		-0.004
		(0.102)		(0.102)		(0.126)
% emp. manufacturing, 1940		-0.001		-0.028***		-0.032**
		(0.009)		(0.010)		(0.014)
% emp. agriculture, 1940		-0.003		-0.002		-0.008
		(0.005)		(0.004)		(0.006)
Constant	0.314	0.841	-0.599***	0.319	-0.395**	2.193*
	(0.204)	(1.120)	(0.155)	(1.189)	(0.181)	(1.274)
Census Region FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	0.09	0.09	-0.64	-0.64	-0.43	-0.43
1940 Mean Emp %	1.73	1.73	2.51	2.51	3.23	3.23
R-Squared	0.04	0.05	0.07	0.10	0.04	0.06
F-stat	7110.8	7090.2	7110.8	7090.2	7110.8	7090.2

Standard errors clustered by state in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(b) Top quartile energy-intensive manufacturing industries

	Gas		Electricity		Gas or Electricity	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to pipeline	0.004***	0.003*	0.011***	0.012***	0.012***	0.011***
	(0.001)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
Gas utility in 1941	0.973***	0.807***	0.527**	0.803***	1.437***	1.321***
	(0.330)	(0.297)	(0.241)	(0.206)	(0.413)	(0.383)
Gas utility in 1941 x distance to pipeline	-0.008***	-0.007***	-0.013***	-0.013***	-0.016***	-0.015***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.004)	(0.004)
ln(pop.) 1940		-0.193		-0.215*		-0.182
		(0.123)		(0.119)		(0.128)
ln(Distance to 50K+ pop. county)		-0.165		-0.230		-0.427*
		(0.229)		(0.180)		(0.254)
% emp. manufacturing, 1940		-0.001		-0.029*		0.000
		(0.015)		(0.017)		(0.024)
% emp. agriculture, 1940		-0.012**		-0.000		-0.003
		(0.006)		(0.007)		(0.008)
Constant	0.242	3.357**	-1.021***	2.152*	-0.114	3.418**
	(0.277)	(1.615)	(0.269)	(1.281)	(0.415)	(1.626)
Census Region FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	0.34	0.34	-0.20	-0.20	0.72	0.72
1940 Mean Emp %	3.98	3.98	5.30	5.30	6.26	6.26
R-Squared	0.03	0.04	0.09	0.10	0.04	0.05
F-stat	7110.8	7090.2	7110.8	7090.2	7110.8	7090.2

Standard errors clustered by state in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: See next page

2SLS regression of 1940-50 emp. change on $\mathbf{I}(UtilityGas_{1941,c})$ x $PipelineDistance_c$(continued)

(c) Other sectors

	Other Manufacturing		Agriculture		Services/Other	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to pipeline	0.007	0.008	-0.025***	-0.026***	0.006	0.007
	(0.005)	(0.005)	(0.009)	(0.009)	(0.005)	(0.005)
Gas utility in 1941	-1.206*	0.197	-1.698	-3.875***	1.467***	2.357***
	(0.635)	(0.519)	(1.091)	(0.920)	(0.550)	(0.448)
Gas utility in 1941 x distance to pipeline	-0.009*	-0.011**	0.023***	0.023***	0.002	0.002
	(0.005)	(0.005)	(0.008)	(0.007)	(0.005)	(0.005)
ln(pop.) 1940		-0.663**		0.726**		0.120
		(0.331)		(0.336)		(0.323)
ln(Distance to 50K+ pop. county)		0.262		1.231***		-1.066***
		(0.319)		(0.370)		(0.380)
% emp. manufacturing, 1940		0.058***		-0.081***		0.022
		(0.022)		(0.025)		(0.031)
% emp. agriculture, 1940		0.058***		-0.133***		0.079***
		(0.018)		(0.023)		(0.023)
Constant	3.708***	5.719	-4.217***	-8.499*	0.623	-0.637
	(1.115)	(4.292)	(1.570)	(4.386)	(0.586)	(4.030)
Census Region FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	2.75	2.75	-7.88	-7.88	4.42	4.42
1940 Mean Emp %	10.32	10.32	37.48	37.48	45.94	45.94
R-Squared	0.06	0.12	0.15	0.26	0.17	0.20
F-stat	7110.8	7090.2	7110.8	7090.2	7110.8	7090.2

Standard errors clustered by state in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Sample is 1,245 counties within 250 miles of any wartime pipeline route, excluding those in the three major gas-producing states (LA, OK, and TX). Independent variables are full interaction of indicator that county c had gas utility in 1941 and its distance to nearest point on least-cost/minimum spanning tree optimal pipeline route (in miles). Controls include 1940 log population, log distance to closest county of population $\geq$ 50K, share of total employment in manufacturing or in agriculture, and census region fixed effects. Dependent variables in Panels (a) and (b) are 100 x percentage point change from 1940 to 1950 in employment in top-quantile energy-intensive industries, defined as all types of gas consumed (in million feet^3) per million dollars of value-added and/or cost of purchased electricity as share of value-added. In Panel (c) dependent variables are change from 1940 to 1950 in sector share of county employment

A.4.2 Full long-term employment regression results

Table A8. 2SLS regression of emp. change since 1940 on $\mathbf{I}(UtilityGas_{1941,c})$ x $PipelineDistance_c$

(a) Gas-intensive manufacturing industries

	Top decile				Top quartile			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	1964	1974	1984	1994	1964	1974	1984	1994
Distance to pipeline	-0.004	0.002	0.004	0.005*	0.013**	0.008	0.016***	0.015**
	(0.003)	(0.003)	(0.002)	(0.003)	(0.006)	(0.006)	(0.006)	(0.006)
Gas utility in 1941	0.940**	0.604**	0.381	-0.270	7.174***	5.058***	3.897***	2.741**
	(0.401)	(0.301)	(0.302)	(0.377)	(1.372)	(0.915)	(1.100)	(1.304)
Gas utility in 1941 x distance to pipeline	-0.003	-0.001	0.001	0.004	-0.030***	-0.018***	-0.014**	-0.007
	(0.003)	(0.003)	(0.003)	(0.004)	(0.007)	(0.005)	(0.006)	(0.007)
Census Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y	Y
DV Mean	0.87	0.40	-0.07	-0.41	4.48	4.45	3.46	2.80
DV Std Dev	5.32	3.55	3.38	3.43	11.32	9.28	8.94	9.20
R-Squared	0.02	0.02	0.08	0.14	0.04	0.06	0.12	0.18
F-stat	7089.5	7089.5	7118.9	7118.9	7089.5	7089.5	7118.9	7118.9

(b) Electricity-intensive manufacturing industries

	Top decile				Top quartile			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	1964	1974	1984	1994	1964	1974	1984	1994
Distance to pipeline	0.013***	0.012***	0.013***	0.013***	0.041***	0.025***	0.028***	0.020***
	(0.003)	(0.003)	(0.005)	(0.004)	(0.011)	(0.009)	(0.008)	(0.007)
Gas utility in 1941	2.497***	2.111***	1.598***	1.189**	6.210***	4.624***	4.092***	3.180***
	(0.655)	(0.425)	(0.577)	(0.571)	(1.497)	(1.078)	(1.182)	(1.048)
Gas utility in 1941 x distance to pipeline	-0.016***	-0.013***	-0.011*	-0.009	-0.046***	-0.041***	-0.040***	-0.032***
	(0.003)	(0.004)	(0.006)	(0.006)	(0.013)	(0.010)	(0.009)	(0.009)
Census Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y	Y
DV Mean	0.54	0.71	0.24	-0.28	3.01	2.36	0.70	-0.54
DV Std Dev	6.49	6.01	6.06	5.81	11.24	9.22	8.70	8.27
R-Squared	0.02	0.05	0.12	0.17	0.05	0.11	0.20	0.31
F-stat	7089.5	7089.5	7118.9	7118.9	7089.5	7089.5	7118.9	7118.9

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered by state in parentheses. Sample is 1,245 counties within 250 miles of any wartime pipeline route, excluding those in the three major gas-producing states (LA, OK, and TX). Two stage-least squares regression, with second stage results in table. Independent variables are full interaction of indicator that county c had a gas utility in 1941 and distance from county c centroid to actually-constructed pipeline route, with latter instrumented with least-cost/minimum spanning tree optimal pipeline route (in miles). Includes census region fixed effects and controls for 1940 log population, log distance to closest county with population $\geq$ 50K, and share of county employment in manufacturing and in agriculture. Standard errors clustered by state in parentheses. Cluster-robust Kleibergen-Paap Wald rk F statistic from 1st stage reported. Dependent variables in Panels (a), (b), and (c) are 100 x percentage point change from 1940 to 1950 in employment in top-quantile energy-intensive industries, defined as all types of gas consumed (in million feet^3) per million dollars of value-added and/or cost of purchased electricity as share of value-added. In Panel (d) dependent variables are change from 1940 to 1950 in sector share of county employment.

2SLS regression of emp. change since 1940 on $\mathbf{I}(UtilityGas_{1941,c})$ x $PipelineDistance_c$(continued).

(c) Gas- or Electricity-intensive manufacturing industries

	Top decile				Top quartile			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	1964	1974	1984	1994	1964	1974	1984	1994
Distance to pipeline	0.008**	0.010***	0.014***	0.013***	0.040***	0.022**	0.027***	0.021**
	(0.004)	(0.004)	(0.005)	(0.004)	(0.012)	(0.009)	(0.007)	(0.008)
Gas utility in 1941	3.197***	2.647***	1.995***	1.027*	9.492***	6.690***	5.793***	4.268***
	(0.855)	(0.458)	(0.565)	(0.617)	(1.684)	(1.237)	(1.349)	(1.529)
Gas utility in 1941 x distance to pipeline	-0.017***	-0.014***	-0.010*	-0.007	-0.052***	-0.041***	-0.037***	-0.028***
	(0.004)	(0.004)	(0.006)	(0.006)	(0.014)	(0.011)	(0.009)	(0.009)
Census Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y	Y
DV Mean	1.25	0.98	0.31	-0.39	6.08	5.48	3.53	2.39
DV Std Dev	7.77	6.47	6.50	6.28	13.12	10.59	10.19	10.60
R-Squared	0.02	0.06	0.13	0.20	0.05	0.09	0.20	0.27
F-stat	7089.5	7089.5	7118.9	7118.9	7089.5	7089.5	7118.9	7118.9

(d) Other sectors

	Other Manufacturing				Services/Other			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	1964	1974	1984	1994	1964	1974	1984	1994
Distance to pipeline	0.001	-0.027	-0.024	-0.043**	-0.033	0.004	-0.001	0.021
	(0.045)	(0.025)	(0.023)	(0.017)	(0.043)	(0.029)	(0.026)	(0.020)
Gas utility in 1941	-5.119	-4.930	-4.804	-5.568**	-2.624	-1.920	-0.724	1.173
	(4.938)	(3.512)	(3.519)	(2.268)	(4.436)	(4.092)	(4.016)	(2.872)
Gas utility in 1941 x distance to pipeline	0.010	0.027	0.028	0.043***	0.032	0.015	0.007	-0.014
	(0.042)	(0.026)	(0.024)	(0.016)	(0.034)	(0.029)	(0.026)	(0.020)
Census Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y	Y
DV Mean	20.02	20.07	15.49	11.28	9.55	11.57	17.90	23.22
DV Std Dev	19.93	16.73	15.81	15.15	20.48	17.23	15.79	14.83
R-Squared	0.22	0.34	0.35	0.40	0.36	0.34	0.27	0.25
F-stat	7089.5	7089.5	7118.9	7118.9	7089.5	7089.5	7118.9	7118.9

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered by state in parentheses. Sample is 1,245 counties within 250 miles of any wartime pipeline route, excluding those in the three major gas-producing states (LA, OK, and TX). Two stage-least squares regression, with second stage results in table. Independent variables are full interaction of indicator that county c had a gas utility in 1941 and distance from county c centroid to actually-constructed pipeline route, with latter instrumented with least-cost/minimum spanning tree optimal pipeline route (in miles). Includes census region fixed effects and controls for 1940 log population, log distance to closest county with population $\geq$ 50K, and share of county employment in manufacturing and in agriculture. Standard errors clustered by state in parentheses. Cluster-robust Kleibergen-Paap Wald rk F statistic from 1st stage reported. Dependent variables in Panels (a), (b), and (c) are 100 x percentage point change from 1940 to 1950 in employment in top-quantile energy-intensive industries, defined as all types of gas consumed (in million feet^3) per million dollars of value-added and/or cost of purchased electricity as share of value-added. In Panel (d) dependent variables are change from 1940 to 1950 in sector share of county employment.

A.5 Additional regression results

A.5.1 Testing for initial impact on population

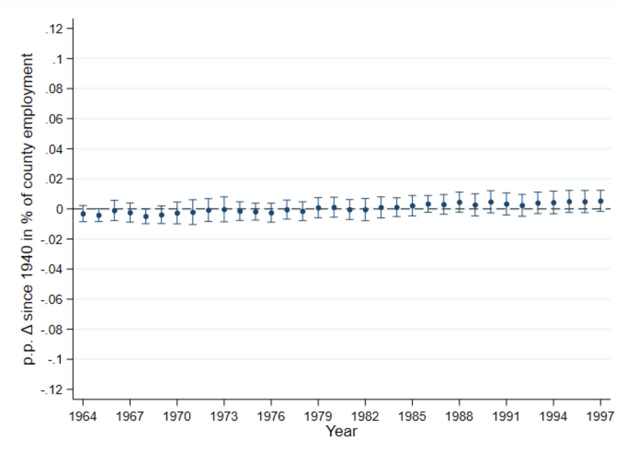
Table A9. 2SLS regression of 1940-50 population change on $\mathbf{I}(UtilityGas_{1941,c})$ x $PipelineDistance_c$

	(1)	(2)
Distance to pipeline	0.043***	0.017*
	(0.017)	(0.010)
Gas utility in 1941	7.222***	-0.270
	(1.837)	(1.937)
Gas utility in 1941 x distance to pipeline	-0.011	0.012
	(0.012)	(0.010)
ln(pop.) 1940	5.205***	0.532
	(0.894)	(1.015)
ln(Distance to 50K+ pop. county)		-7.325***
		(2.079)
% emp. manufacturing, 1940		0.065
		(0.108)
% emp. agriculture, 1940		-0.354***
		(0.079)
Constant	-58.598***	31.758*
	(9.883)	(18.677)
Census Region FE	Y	Y
Controls	N	Y
Mean p.p. Change in Emp %	3.16	3.16
1940 Mean Emp %	10.28	10.28
R-Squared	0.21	0.40
F-stat	7109.8	7090.2

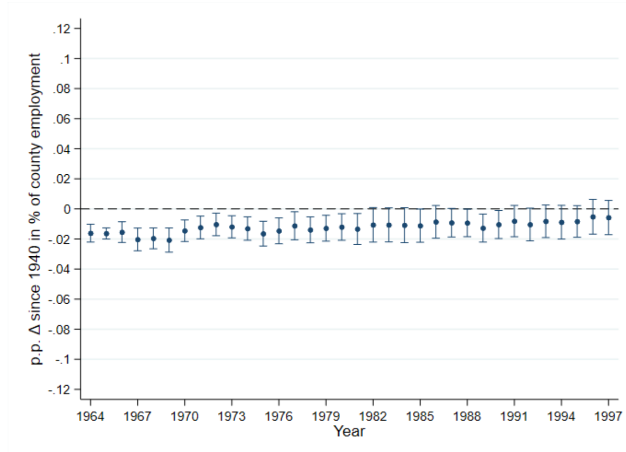
Notes: * p < 0.10, ** p < 0.05, *** p < 0.01. Standard errors clustered by state in parentheses. Sample is 1,245 counties within 250 miles of any wartime pipeline route, excluding those in the three major gas-producing states (LA, OK, and TX). Two stage least squares regression, with second stage results and cluster-robust Kleibergen-Paap Wald rk F statistic from 1st stage reported. Independent variables are full interaction of indicator that county c had gas utility in 1941 and its distance to nearest point on any pipeline route, where latter is instrumented with least-cost/minimum spanning tree optimal pipeline route (in miles). Controls include 1940 log population, log distance to closest county of population $\geq$ 50K, share of total employment in manufacturing or in agriculture, and census region fixed effects. Dependent variable is log change in county population from 1940 to 1950.

A.5.2 Long-term results for other sectors

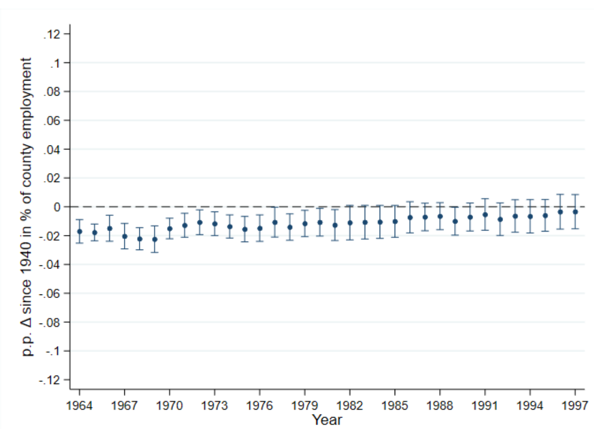
Figure A1: Coefficients from 2SLS regression of p.p. change in sector share of total county employment on $\mathbf{I}(UtilityGas_{1941,c})$ x $PipelineDistance_c$ from 1940 to each end-year



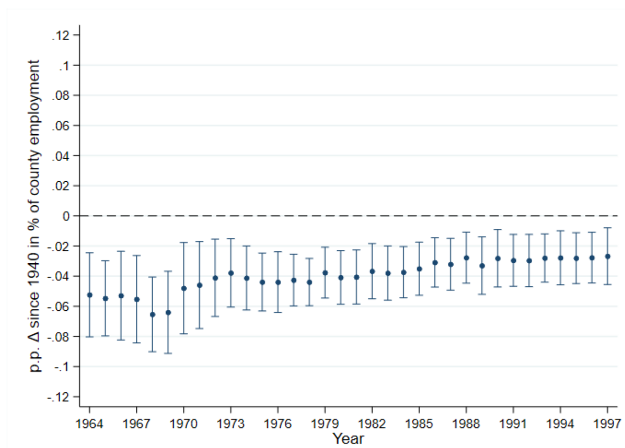
(a) Gas-intensive industries (top decile)



(b) Electricity-intensive industries (top decile)



(c) Gas or electricity-intensive industries (top decile)



(d) Gas or electricity-intensive industries (top quartile)

Notes: Sample is 1,245 counties within 250 miles of any wartime pipeline route, excluding those in the three major gas-producing states (LA, OK, and TX). Plot shows the estimated coefficient on the interaction between distance from county c centroid to nearest point on actually-constructed pipeline route and an indicator that county c had a gas utility in 1941, from two stage-least squares regression, with 95% confidence interval. Negative coefficients show increase in employment with decreased distance to pipeline (i.e. increased proximity). Distance to actual pipeline route is instrumented with least-cost/minimum spanning tree optimal pipeline route (in miles). Includes census region fixed effects and controls for 1940 log population, log distance to closest county with population $\geq$ 50K, and share of county employment in manufacturing and in agriculture. Standard errors clustered by state. Dependent variable on Y-axis is change from 1940 to each year in share of total county employment in sector, defined based on industry energy consumption and value-added in 1947 (see text for details). See Appendix Section A.4.2 for tables of results.

A.5.3 Long-term OLS regression results

Table A10. OLS regression of emp. change since 1940 on $\mathbf{I}(UtilityGas_{1941,c})$ x $PipelineDistance_c$

(a) Gas-intensive manufacturing industries

	Top decile				Top quartile			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	1964	1974	1984	1994	1964	1974	1984	1994
Distance to pipeline	-0.003	0.002	0.004	0.005*	0.013**	0.008	0.015**	0.014**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.006)	(0.006)	(0.005)	(0.006)
Gas utility in 1941=1	0.933**	0.648**	0.433	-0.175	7.213***	5.052***	3.892***	2.737*
	(0.420)	(0.303)	(0.322)	(0.392)	(1.365)	(0.924)	(1.135)	(1.334)
Gas utility in 1941=1 × Distance to pipeline	-0.003	-0.002	0.001	0.003	-0.030***	-0.018***	-0.014**	-0.007
	(0.003)	(0.003)	(0.003)	(0.004)	(0.007)	(0.005)	(0.006)	(0.007)
Census Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y	Y
DV Mean	0.87	0.40	-0.07	-0.41	4.48	4.45	3.46	2.80
DV Std Dev	5.32	3.55	3.38	3.43	11.32	9.28	8.94	9.20
R-Squared	0.02	0.02	0.08	0.14	0.04	0.06	0.12	0.18
Obs	1244	1244	1244	1244	1244	1244	1244	1244

(b) Electricity-intensive manufacturing industries

	Top decile				Top quartile			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	1964	1974	1984	1994	1964	1974	1984	1994
Distance to pipeline	0.013***	0.012***	0.013**	0.012***	0.043***	0.026***	0.028***	0.020**
	(0.003)	(0.003)	(0.005)	(0.004)	(0.011)	(0.008)	(0.008)	(0.007)
Gas utility in 1941=1	2.522***	2.108***	1.577**	1.200*	6.452***	4.756***	4.138***	3.220***
	(0.673)	(0.450)	(0.611)	(0.593)	(1.574)	(1.102)	(1.187)	(1.047)
Gas utility in 1941=1 × Distance to pipeline	-0.016***	-0.013***	-0.011*	-0.009	-0.049***	-0.042***	-0.040***	-0.033***
	(0.003)	(0.004)	(0.006)	(0.006)	(0.014)	(0.010)	(0.009)	(0.009)
Census Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y	Y
DV Mean	0.54	0.71	0.24	-0.28	3.01	2.36	0.70	-0.54
DV Std Dev	6.49	6.01	6.06	5.81	11.24	9.22	8.70	8.27
R-Squared	0.02	0.05	0.12	0.17	0.05	0.11	0.20	0.31
Obs	1244	1244	1244	1244	1244	1244	1244	1244

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered by state in parentheses. Sample is 1,245 counties within 250 miles of any wartime pipeline route, excluding those in the three major gas-producing states (LA, OK, and TX). OLS regression. Independent variables are full interaction of indicator that county c had a gas utility in 1941 and distance from county c centroid to actually-constructed pipeline route, with latter instrumented with least-cost/minimum spanning tree optimal pipeline route (in miles). Includes census region fixed effects and controls for 1940 log population, log distance to closest county with population $\geq$ 50K, and share of county employment in manufacturing and in agriculture. Standard errors clustered by state in parentheses. Dependent variables in Panels (a), (b), and (c) are 100 x percentage point change from 1940 to 1950 in employment in top-quantile energy-intensive industries, defined as all types of gas consumed (in million feet^3) per million dollars of value-added and/or cost of purchased electricity as share of value-added. In Panel (d) dependent variables are change from 1940 to 1950 in sector share of county employment.

OLS regression of emp. change since 1940 on $\mathbf{I}(UtilityGas_{1941,c})$ x $PipelineDistance_c$(continued).

(c) Gas- or Electricity-intensive manufacturing industries

	Top decile				Top quartile			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	1964	1974	1984	1994	1964	1974	1984	1994
Distance to pipeline	0.008**	0.010**	0.013***	0.013***	0.042***	0.022**	0.027***	0.020**
	(0.004)	(0.004)	(0.005)	(0.004)	(0.012)	(0.009)	(0.007)	(0.008)
Gas utility in 1941=1	3.201***	2.653***	2.000***	1.074	9.731***	6.785***	5.825***	4.278**
	(0.881)	(0.473)	(0.599)	(0.647)	(1.763)	(1.266)	(1.377)	(1.546)
Gas utility in 1941=1 × Distance to pipeline	-0.017***	-0.014***	-0.011*	-0.007	-0.055***	-0.042***	-0.038***	-0.028***
	(0.004)	(0.004)	(0.006)	(0.006)	(0.015)	(0.011)	(0.009)	(0.009)
Census Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y	Y
DV Mean	1.25	0.98	0.31	-0.39	6.08	5.48	3.53	2.39
DV Std Dev	7.77	6.47	6.50	6.28	13.12	10.59	10.19	10.60
R-Squared	0.02	0.06	0.13	0.20	0.05	0.09	0.20	0.27
Obs	1244	1244	1244	1244	1244	1244	1244	1244

(d) Other sectors

	Other Manufacturing				Services/Other			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	1964	1974	1984	1994	1964	1974	1984	1994
Distance to pipeline	-0.001	-0.027	-0.022	-0.042**	-0.033	0.004	-0.002	0.020
	(0.045)	(0.024)	(0.023)	(0.017)	(0.043)	(0.028)	(0.026)	(0.020)
Gas utility in 1941=1	-5.302	-4.910	-4.604	-5.456**	-2.694	-2.012	-0.898	1.066
	(4.919)	(3.481)	(3.519)	(2.241)	(4.432)	(4.094)	(4.092)	(2.915)
Gas utility in 1941=1 × Distance to pipeline	0.012	0.027	0.026	0.042**	0.033	0.016	0.009	-0.013
	(0.042)	(0.025)	(0.023)	(0.016)	(0.034)	(0.029)	(0.027)	(0.020)
Census Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y	Y
DV Mean	20.02	20.07	15.49	11.28	9.55	11.57	17.90	23.22
DV Std Dev	19.93	16.73	15.81	15.15	20.48	17.23	15.79	14.83
R-Squared	0.22	0.34	0.35	0.40	0.36	0.34	0.27	0.25
Obs	1244	1244	1244	1244	1244	1244	1244	1244

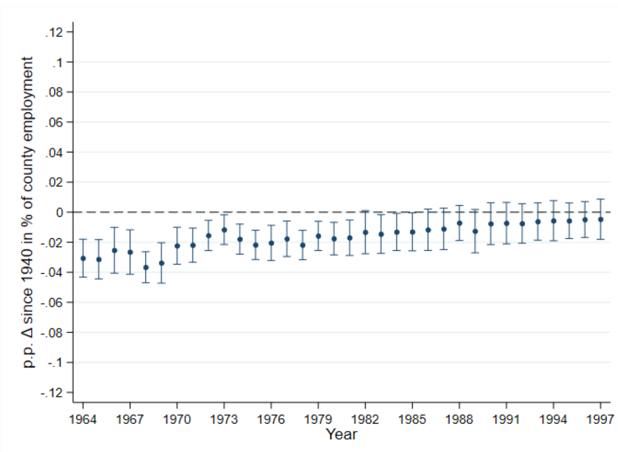
Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered by state in parentheses. Sample is 1,245 counties within 250 miles of any wartime pipeline route, excluding those in the three major gas-producing states (LA, OK, and TX). OLS regression. Independent variables are full interaction of indicator that county c had a gas utility in 1941 and distance from county c centroid to actually-constructed pipeline route, with latter instrumented with least-cost/minimum spanning tree optimal pipeline route (in miles). Includes census region fixed effects and controls for 1940 log population, log distance to closest county with population $\geq$ 50K, and share of county employment in manufacturing and in agriculture. Standard errors clustered by state in parentheses. Dependent variables in Panels (a), (b), and (c) are 100 x percentage point change from 1940 to 1950 in employment in top-quantile energy-intensive industries, defined as all types of gas consumed (in million feet^3) per million dollars of value-added and/or cost of purchased electricity as share of value-added. In Panel (d) dependent variables are change from 1940 to 1950 in sector share of county employment.

A.6 Robustness checks regression results

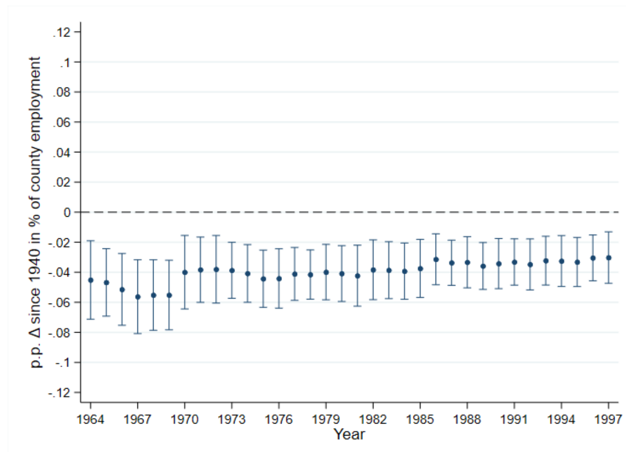
A.6.1 Including 1949 Tennessee Gas pipeline branch extension

This section contains results from re-estimating our baseline 2SLS regression analyses on a data sample that includes the 1949 extension of the Tennessee Gas pipeline. This sample differs due to inclusion of one additional county that is only within 250 miles of this extension (not any other WWII pipeline route) as well as changes for 169 counties in their distance to the nearest actual and/or optimal pipeline route as calculated through least-cost/minimum spanning tree analysis based on geographic features.

Figure A2: Adding 1949 pipeline robustness check - Coefficients from 2SLS regression of p.p. change in sector share of total county employment on $\mathbf{I}(UtilityGas_{1941,c})$ x $PipelineDistance_c$ from 1940 to each end-year



(a) Gas-intensive industries (top quartile)



(b) Electricity-intensive industries (top quartile)

(c) Other manufacturing

(d) Services and other industries

Notes: Sample is 1,246 counties within 250 miles of any wartime pipeline route, including 1949 Tennessee Gas extension line, excluding counties in the three major gas-producing states (LA, OK, and TX).Plot shows the estimated coefficient on the interaction between distance from county c centroid to nearest point on actually-constructed pipeline route and an indicator that county c had a gas utility in 1941, from two stage-least squares regression, with 95% confidence interval. Negative coefficients show increase in employment with decreased distance to pipeline (i.e. increased proximity). Distance to actual pipeline route is instrumented with least-cost/minimum spanning tree optimal pipeline route (in miles). Includes census region fixed effects and controls for 1940 log population, log distance to closest county with population $\geq$ 50K, and share of county employment in manufacturing and in agriculture. Standard errors clustered by state. Dependent variable on Y-axis is change from 1940 to each year in share of total county employment in sector, defined based on industry energy consumption and value-added in 1947 (see text for details).

Table A11. Adding 1949 pipeline robustness check - 2SLS regression of 1940-50 emp. change on $\mathbf{I}(UtilityGas_{1941,c})$ x $PipelineDistance_c$

(a) Top decile energy-intensive manufacturing industries

	Gas		Electricity		Gas or Electricity	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to pipeline	0.001	0.000	0.003***	0.004***	0.003**	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Gas utility in 1941	0.587**	0.384**	-0.195	0.135	0.332*	0.578***
	(0.236)	(0.191)	(0.162)	(0.152)	(0.200)	(0.193)
Gas utility in 1941 x distance to pipeline	-0.004**	-0.004**	-0.003**	-0.003**	-0.006***	-0.006***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
Census Region FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	0.08	0.08	-0.63	-0.63	-0.42	-0.42
1940 Mean Emp %	1.73	1.73	2.51	2.51	3.24	3.24
R-Squared	0.05	0.06	0.06	0.10	0.03	0.06
F-stat	3342.2	3424.6	3342.2	3424.6	3342.2	3424.6

(b) Top quartile energy-intensive manufacturing industries

	Gas		Electricity		Gas or Electricity	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to pipeline	0.004**	0.003*	0.011***	0.012***	0.011***	0.011***
	(0.001)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
Gas utility in 1941	1.008***	0.858***	0.474**	0.776***	1.490***	1.388***
	(0.317)	(0.301)	(0.237)	(0.204)	(0.398)	(0.389)
Gas utility in 1941 x distance to pipeline	-0.009***	-0.008***	-0.013***	-0.012***	-0.017***	-0.016***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.004)	(0.004)
Census Region FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	0.35	0.35	-0.19	-0.19	0.73	0.73
1940 Mean Emp %	3.99	3.99	5.30	5.30	6.26	6.26
R-Squared	0.04	0.04	0.08	0.10	0.05	0.05
F-stat	3342.2	3424.6	3342.2	3424.6	3342.2	3424.6

(c) Other sectors

	Other Manufacturing		Agriculture		Services/Other	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to pipeline	0.008	0.008	-0.025***	-0.025***	0.006	0.007
	(0.005)	(0.005)	(0.009)	(0.009)	(0.005)	(0.005)
Gas utility in 1941	-1.151*	0.216	-1.898*	-4.055***	1.560***	2.451***
	(0.629)	(0.518)	(1.063)	(0.903)	(0.544)	(0.452)
Gas utility in 1941 x distance to pipeline	-0.010**	-0.011**	0.025***	0.025***	0.001	0.001
	(0.005)	(0.005)	(0.007)	(0.007)	(0.005)	(0.005)
Census Region FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	2.74	2.74	-7.89	-7.89	4.42	4.42
1940 Mean Emp %	10.32	10.32	37.47	37.47	45.95	45.95
R-Squared	0.06	0.12	0.15	0.26	0.17	0.20
F-stat	3342.2	3424.6	3342.2	3424.6	3342.2	3424.6

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered by state in parentheses. Sample is 1,246 counties within 250 miles of any wartime pipeline route, including 1949 Tennessee Gas extension line, excluding counties in the three major gas-producing states (LA, OK, and TX).Two stage least squares regression, with second stage results and cluster-robust Kleibergen-Paap Wald rk F statistic from 1st stage reported. Independent variables are full interaction of indicator that county c had gas utility in 1941 and its distance to nearest point on any pipeline route, where latter is instrumented with least-cost/minimum spanning tree optimal pipeline route (in miles). Controls include 1940 log population, log distance to closest county of population $\geq$ 50K, share of total employment in manufacturing or in agriculture, and census region fixed effects. Dependent variables in Panels (a) and (b) are 100 x percentage point change from 1940 to 1950 in employment in top-quantile energy-intensive industries, defined as all types of gas consumed (in million feet^3) per million dollars of value-added and/or cost of purchased electricity as share of value-added. In Panel (c) dependent variables are change from 1940 to 1950 in sector share of county employment

A.6.2 Controlling for initial level of sector employment

Table A12. Controlling for initial sector emp. robustness check - 2SLS regression of 1940-50 emp. change on $\mathbf{I}(UtilityGas_{1941,c})$ x $PipelineDistance_c$

(a) Top decile energy-intensive manufacturing industries

	Gas		Electricity		Gas or Electricity	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to pipeline	0.001	0.001	0.003***	0.004***	0.003**	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Gas utility in 1941	0.203	0.157	0.010	0.192	0.301	0.488**
	(0.157)	(0.131)	(0.173)	(0.160)	(0.218)	(0.191)
Gas utility in 1941 x distance to pipeline	-0.002*	-0.002	-0.004***	-0.004***	-0.006***	-0.005***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)
Initial sector % emp, 1940	0.159***	0.182***	-0.054**	-0.013	0.032	0.099***
	(0.036)	(0.039)	(0.026)	(0.031)	(0.020)	(0.027)
Census Region FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	0.09	0.09	-0.64	-0.64	-0.43	-0.43
R-Squared	0.16	0.18	0.08	0.10	0.04	0.09
F-stat	7492.4	8513.0	7249.4	8325.4	7533.4	9106.5

(b) Top quartile energy-intensive manufacturing industries

	Gas		Electricity		Gas or Electricity	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to pipeline	0.003**	0.004***	0.012***	0.012***	0.011***	0.011***
	(0.001)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
Gas utility in 1941	0.517*	0.549**	0.695**	0.810***	1.276***	1.239***
	(0.277)	(0.243)	(0.298)	(0.218)	(0.451)	(0.393)
Gas utility in 1941 x distance to pipeline	-0.007***	-0.006***	-0.013***	-0.013***	-0.016***	-0.015***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.004)	(0.004)
Initial sector % emp, 1940	0.113***	0.158***	-0.046	-0.014	0.034	0.075
	(0.023)	(0.033)	(0.031)	(0.059)	(0.044)	(0.070)
Census Region FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	0.34	0.34	-0.20	-0.20	0.72	0.72
R-Squared	0.08	0.10	0.10	0.10	0.05	0.06
F-stat	7501.3	9292.3	6351.1	6597.4	6731.4	7356.6

Notes: See next page

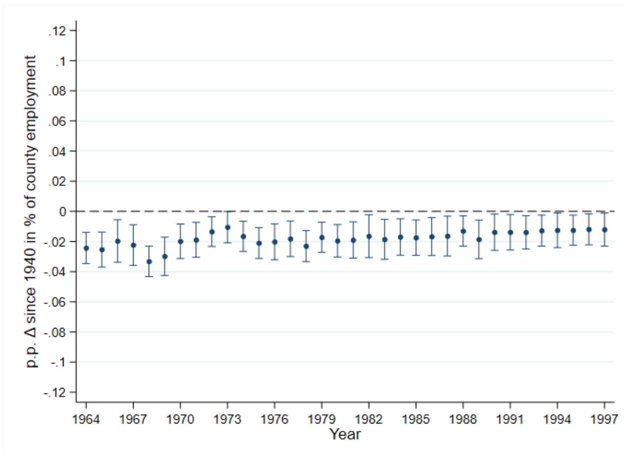
Controlling for initial sector emp. robustness check - 2SLS regression of 1940-50 emp. change on $\mathbf{I}(UtilityGas_{1941,c})$ x $PipelineDistance_c$ (continued)

(c) Other sectors

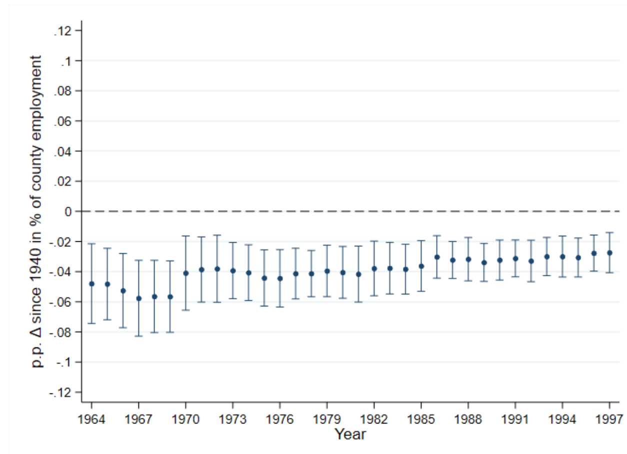
	Other Manufacturing		Agriculture		Services/Other	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to pipeline	0.008	0.008	-0.029***	-0.026***	0.006	0.007
	(0.005)	(0.005)	(0.009)	(0.009)	(0.005)	(0.005)
Gas utility in 1941	-1.128*	0.218	-3.999***	-3.875***	2.407***	2.357***
	(0.616)	(0.511)	(0.884)	(0.920)	(0.461)	(0.448)
Gas utility in 1941 x distance to pipeline	-0.009*	-0.011**	0.025***	0.023***	0.001	0.002
	(0.005)	(0.005)	(0.007)	(0.007)	(0.005)	(0.005)
Initial sector % emp, 1940	-0.028	0.019	-0.111***	-0.133***	-0.071***	-0.079***
	(0.044)	(0.053)	(0.021)	(0.023)	(0.019)	(0.023)
Census Region FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	2.75	2.75	-7.88	-7.88	4.42	4.42
R-Squared	0.06	0.12	0.23	0.26	0.19	0.20
F-stat	7343.5	7356.6	6881.0	7090.2	7509.5	7090.2

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered by state in parentheses. Sample is 1,245 counties within 250 miles of any wartime pipeline route, excluding those in the three major gas-producing states (LA, OK, and TX). Two stage least squares regression, with second stage results and cluster-robust Kleibergen-Paap Wald rk F statistic from 1st stage reported. Independent variables are full interaction of indicator that county c had gas utility in 1941 and its distance to nearest point on any pipeline route, where latter is instrumented with least-cost/minimum spanning tree optimal pipeline route (in miles). Controls include 1940 sector share of county employment, log population, log distance to closest county of population $\geq$ 50K, share of total employment in manufacturing or in agriculture, and census region fixed effects. Dependent variables in Panels (a) and (b) are 100 x percentage point change from 1940 to 1950 in employment in top-quantile energy-intensive industries, defined as all types of gas consumed (in million feet^3) per million dollars of value-added and/or cost of purchased electricity as share of value-added. In Panel (c) dependent variables are change from 1940 to 1950 in sector share of county employment

Figure A3: Controlling for initial sector emp. robustness check - 2SLS regression of 1940-50 emp. change on $\mathbf{I}(UtilityGas_{1941,c})$ x $PipelineDistance_c$

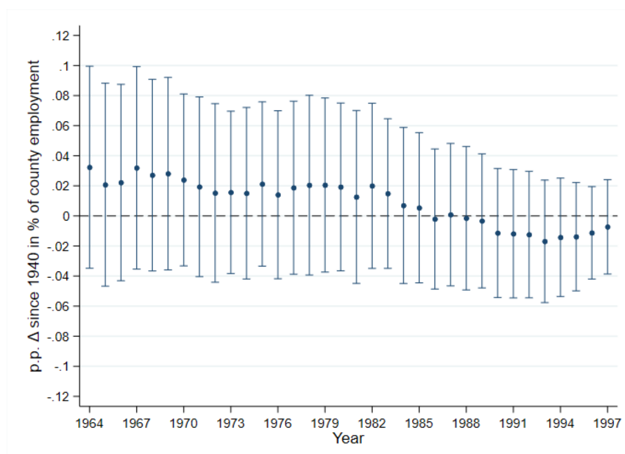


(a) Gas-intensive industries (top quartile)



(b) Electricity-intensive industries (top quartile)

(c) Other manufacturing

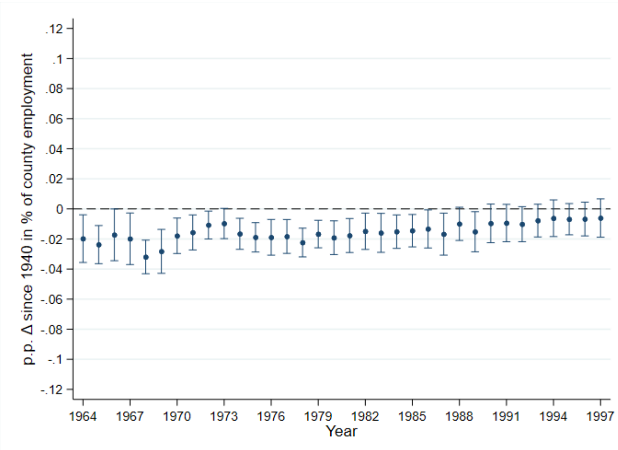


(d) Services and other industries

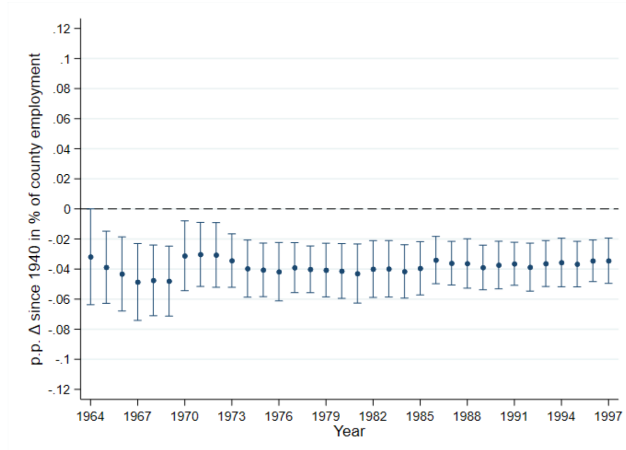
Notes: Sample is 1,246 counties within 250 miles of any wartime pipeline route, including 1949 Tennessee Gas extension line, excluding counties in the three major gas-producing states (LA, OK, and TX).Plot shows the estimated coefficient on the interaction between distance from county c centroid to nearest point on actually-constructed pipeline route and an indicator that county c had a gas utility in 1941, from two stage-least squares regression, with 95% confidence interval. Negative coefficients show increase in employment with decreased distance to pipeline (i.e. increased proximity). Distance to actual pipeline route is instrumented with least-cost/minimum spanning tree optimal pipeline route (in miles). Includes census region fixed effects and controls for 1940 log population, log distance to closest county with population $\geq$ 50 K, and share of county employment in manufacturing and in agriculture. Standard errors clustered by state. Dependent variable on Y-axis is change from 1940 to each year in share of total county employment in sector, defined based on industry energy consumption and value-added in 1947 (see text for details).

A.6.3 Regressions with state fixed effects

Figure A4: State FEs robustness check - Coefficients from 2SLS regression of p.p. change in sector share of total county employment on $\mathbf{I}(UtilityGas_{1941,c})$ x $PipelineDistance_c$ from 1940 to each end-year



(a) Gas-intensive industries (top quartile)



(b) Electricity-intensive industries (top quartile)

(c) Other manufacturing

(d) Services and other industries

Notes: Sample is 1,245 counties within 250 miles of any wartime pipeline route, excluding those in the three major gas-producing states (LA, OK, and TX). Plot shows the estimated coefficient on the interaction between distance from county c centroid to nearest point on actually-constructed pipeline route and an indicator that county c had a gas utility in 1941, from two stage-least squares regression, with 95% confidence interval. Negative coefficients show increase in employment with decreased distance to pipeline (i.e. increased proximity). Distance to actual pipeline route is instrumented with least-cost/minimum spanning tree optimal pipeline route (in miles). Includes state fixed effects and controls for 1940 log population, log distance to closest county with population $\geq$ 50K, and share of county employment in manufacturing and in agriculture. Standard errors clustered by state. Dependent variable on Y-axis is change from 1940 to each year in share of total county employment in sector, defined based on industry energy consumption and value-added in 1947 (see text for details).

Table A13. State FEs robustness check - 2SLS regression of 1940-50 emp. change on $\mathbf{I}(UtilityGas_{1941,c})$ x $PipelineDistance_c$

(a) Top decile energy-intensive manufacturing industries

	Gas		Electricity		Gas or Electricity	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to pipeline	0.001	0.001	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Gas utility in 1941	0.311*	0.206	-0.001	0.197	0.306	0.469*
	(0.175)	(0.142)	(0.142)	(0.145)	(0.245)	(0.240)
Gas utility in 1941 x distance to pipeline	-0.002	-0.002	-0.003**	-0.003*	-0.005**	-0.004*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
State FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	0.09	0.09	-0.64	-0.64	-0.43	-0.43
1940 Mean Emp %	1.73	1.73	2.51	2.51	3.23	3.23
R-Squared	0.10	0.10	0.13	0.16	0.08	0.11
F-stat	3978.9	3876.4	3978.9	3876.4	3978.9	3876.4

(b) Top quartile energy-intensive manufacturing industries

	Gas		Electricity		Gas or Electricity	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to pipeline	0.003	0.002	0.005*	0.004	0.007**	0.007**
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
Gas utility in 1941	0.526*	0.552*	0.411	0.719**	0.820**	0.965**
	(0.305)	(0.290)	(0.307)	(0.287)	(0.397)	(0.386)
Gas utility in 1941 x distance to pipeline	-0.005**	-0.004**	-0.011***	-0.010***	-0.012**	-0.011**
	(0.002)	(0.002)	(0.004)	(0.004)	(0.005)	(0.005)
State FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	0.34	0.34	-0.20	-0.20	0.72	0.72
1940 Mean Emp %	3.98	3.98	5.30	5.30	6.26	6.26
R-Squared	0.08	0.08	0.14	0.17	0.11	0.11
F-stat	3978.9	3876.4	3978.9	3876.4	3978.9	3876.4

(c) Other sectors

	Other Manufacturing		Agriculture		Services/Other	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to pipeline	0.012**	0.011*	-0.026***	-0.024***	0.007	0.006
	(0.006)	(0.006)	(0.008)	(0.008)	(0.005)	(0.005)
Gas utility in 1941	-1.068*	-0.015	-1.586	-3.448***	1.834***	2.498***
	(0.640)	(0.522)	(1.216)	(0.987)	(0.679)	(0.493)
Gas utility in 1941 x distance to pipeline	-0.010*	-0.010**	0.022***	0.020***	0.000	0.001
	(0.005)	(0.005)	(0.008)	(0.007)	(0.005)	(0.005)
State FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	N	Y
Mean p.p. Change in Emp %	2.75	2.75	-7.88	-7.88	4.42	4.42
1940 Mean Emp %	10.32	10.32	37.48	37.48	45.94	45.94
R-Squared	0.13	0.17	0.25	0.34	0.21	0.24
F-stat	3978.9	3876.4	3978.9	3876.4	3978.9	3876.4

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered by state in parentheses. Sample is 1,245 counties within 250 miles of any wartime pipeline route, excluding those in the three major gas-producing states (LA, OK, and TX). Two stage least squares regression, with second stage results and cluster-robust Kleibergen-Paap Wald rk F statistic from 1st stage reported. Independent variables are full interaction of indicator that county c had gas utility in 1941 and its distance to nearest point on any pipeline route, where latter is instrumented with least-cost/minimum spanning tree optimal pipeline route (in miles). Controls include 1940 log population, log distance to closest county of population $\geq$ 50K, share of total employment in manufacturing or in agriculture, and state fixed effects. Dependent variables in Panels (a) and (b) are 100 x percentage point change from 1940 to 1950 in employment in top-quantile energy-intensive industries, defined as all types of gas consumed (in million feet^3) per million dollars of value-added and/or cost of purchased electricity as share of value-added. In Panel (c) dependent variables are change from 1940 to 1950 in sector share of county employment

A.6.4 Cross-county cross-industry regressions

This section provides results from a regression of changes in manufacturing *industry* shares of total county employment from 1940 to 1950 and 1964-1997, leveraging *national* industry-level differences in energy intensity and limited to counties with a pre-war gas utility. Our baseline specification for county c, end year t and 51 IND1950 manufacturing industries i is,

$$\Delta Y_{c,1940-t,i} = \beta_0 + \beta_1(EnergyIntensity_{1947,i} \text{ x } PipelineDistance_c) + \beta_{ct}FE_{ct} + \beta_{it}FE_{it} + \epsilon_{cit} \quad (3)$$

where $\Delta Y_{c,1940-t,i}$ is the change in the share of county employment in industry i from 1940 to year t, $EnergyIntensity_{1947,i}$ is a nation-wide measure of industry gas or electricity intensity as of 1947 (detailed below), $PipelineDistance_c$ is the actual distance from county c to the nearest point along any WW2 pipeline route, and FE_{ct} and FE_{it} are county and industry fixed effects. This regression is based on the cross-county cross-industry design used in Fiszbein et al. (2024) to analyze the productivity impacts of early hydroelectric dams, which follows the cross-*country* cross-industry design pioneered by Rajan and Zingales (1998) and reviewed in Ciccone and Papaioannou (2023). Note that we only include manufacturing industries since data on energy intensity is calculated from the Census of Manufacturing, and therefore not available for industries in the agricultural, services, or other sectors.

$EnergyIntensity_{1947,i}$ measures either all types of gas consumed (in million feet^3) per million dollars of value-added or cost of purchased electricity as a share of value-added (note that a combined 'gas- or electricity-intensive' variable is not possible to calculate with these measures of industry energy-intensity). Table A14 provides results with these measures of energy intensity. These energy intensity measures are highly non-linear across the 51 manufacturing industries in the data—especially gas intensity: while the median industry (Dyeing and finishing textiles, except knit goods) consumed 5.6 million cubic feet of gas per million dollars of value-added in 1947, the top industry (Blast furnaces, steel works, and rolling mills) consumed 898 MF^3/\$M (nearly twice as much as the second-highest, which in turn consumed over twice as much as the next-largest) but the least gas-intensive industry (Tobacco manufactures) consumed only 0.12 MF^3/\$M. There is not nearly as much dispersion in electricity intensity, with the 75th percentile industry consuming only 2.6 times as much as the 25th percentile industry and the 90/10 ratio only 4.6. Therefore, in addition to regressions where $EnergyIntensity_{1947,i}$ is measured as described above, Table A15 also provides results from these cross-county cross-industry regressions where $\ln(EnergyIntensity_{1947,i})$ is used instead.

In both specifications, there appears to be larger employment growth in more energy-intensive industries in counties closer to the wartime pipelines (i.e. a negative coefficient on the interaction of energy intensity and distance to pipeline), though the results are noisy. For the interaction with industry electricity-intensity in Tables A14b and A15b, the coefficient is only statistically significant starting in the late-1960s. There is no significant impact estimated on the coefficient on the interaction with industry gas-intensity interacted with pipeline proximity in Tables A14a and A15a until a positive coefficient is estimated in the mid-1980s onward, likely given the high non-linearity of industry gas-intensity and also consistent with the effects we find of the 1970s energy crisis. These results are generally in line with the results from our baseline sector-level regressions grouping industries into energy-intensity top deciles and quartiles, where we find that counties with better access to pipeline gas had persistent impacts in their share of gas-intensive employment to the mid-1980s but until the late 1990s for the subset of industries intensive in the use of electricity. These cross-county, cross-industry regressions suggest that these results are not driven by the most gas-intensive industries within the top decile or top quartile. They also suggest that our baseline results are not driven by unobserved county or industry characteristics, at least for electricity-intensive industries.

Table A14. Cross-county cross-industry OLS regression of emp. change since 1940 on $PipelineDistance_c$ x $EnergyIntensity_{1947,i}$

(a) Gas-intensive manufacturing industries

	(1) 1950	(2) 1964	(3) 1969	(4) 1974	(5) 1979	(6) 1984	(7) 1989	(8) 1994
Gas-intensity × Distance to pipeline	-0.0000	-0.0000	-0.0000	0.0000	0.0000	0.0000*	0.0000**	0.0000**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
County FE	Y	Y	Y	Y	Y	Y	Y	Y
DV Mean	0.055	0.442	0.435	0.405	0.313	0.244	0.179	0.135
DV Std Dev	0.824	3.144	3.100	2.573	2.340	2.218	2.118	2.066
R-Squared	0.09	0.05	0.07	0.09	0.10	0.10	0.10	0.10
Obs.	38199	38199	38199	38199	38148	38148	38148	38148

(b) Electricity-intensive manufacturing industries

	(1) 1950	(2) 1964	(3) 1969	(4) 1974	(5) 1979	(6) 1984	(7) 1989	(8) 1994
Electricity-intensity × Distance to pipeline	-0.0092	-0.0526	-0.0674**	-0.0626***	-0.0692***	-0.0584**	-0.0655***	-0.0507**
	(0.0056)	(0.0358)	(0.0289)	(0.0205)	(0.0213)	(0.0222)	(0.0213)	(0.0229)
County FE	Y	Y	Y	Y	Y	Y	Y	Y
DV Mean	0.055	0.442	0.435	0.405	0.313	0.244	0.179	0.135
DV Std Dev	0.824	3.144	3.100	2.573	2.340	2.218	2.118	2.066
R-Squared	0.09	0.05	0.07	0.10	0.10	0.10	0.10	0.10
Obs.	38199	38199	38199	38199	38148	38148	38148	38148

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered by state in parentheses. Sample is 1,245 counties within 250 miles of any wartime pipeline route, excluding those in the three major gas-producing states (LA, OK, and TX). OLS regression. Independent variables are interaction of distance from county c centroid to actually-constructed pipeline route (in miles) and industry energy intensityas of 1947. Includes county and industry fixed effects. Standard errors clustered by state in parentheses. Dependent variables is 100 x percentage point change from 1940 to end-year in industry share of total county employment.

Table A15. Cross-county cross-industry OLS regression of emp. change since 1940 on $PipelineDistance_c$ x $\ln(EnergyIntensity_{1947,i})$

(a) Gas-intensive manufacturing industries

	(1) 1950	(2) 1964	(3) 1969	(4) 1974	(5) 1979	(6) 1984	(7) 1989	(8) 1994
ln(Gas-intensity) × Distance to pipeline	-0.0001	-0.0002	-0.0001	0.0001	0.0000	0.0001	0.0002**	0.0003**
	(0.0001)	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
County FE	Y	Y	Y	Y	Y	Y	Y	Y
DV Mean	0.055	0.442	0.435	0.405	0.313	0.244	0.179	0.135
DV Std Dev	0.824	3.144	3.100	2.573	2.340	2.218	2.118	2.066
R-Squared	0.09	0.05	0.07	0.09	0.10	0.10	0.10	0.10
Obs.	38199	38199	38199	38199	38148	38148	38148	38148

(b) Electricity-intensive manufacturing industries

	(1) 1950	(2) 1964	(3) 1969	(4) 1974	(5) 1979	(6) 1984	(7) 1989	(8) 1994
ln(Electricity-intensity) × Distance to pipeline	-0.0002	-0.0007	-0.0009	-0.0009**	-0.0010**	-0.0009**	-0.0010**	-0.0008*
	(0.0001)	(0.0006)	(0.0005)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
County FE	Y	Y	Y	Y	Y	Y	Y	Y
DV Mean	0.055	0.442	0.435	0.405	0.313	0.244	0.179	0.135
DV Std Dev	0.824	3.144	3.100	2.573	2.340	2.218	2.118	2.066
R-Squared	0.09	0.05	0.07	0.10	0.10	0.10	0.10	0.10
Obs.	38199	38199	38199	38199	38148	38148	38148	38148

Notes: * p < 0.10, ** p < 0.05, *** p < 0.01. Standard errors clustered by state in parentheses. Sample is 1,245 counties within 250 miles of any wartime pipeline route, excluding those in the three major gas-producing states (LA, OK, and TX). OLS regression. Independent variables are interaction of distance from county c centroid to actually-constructed pipeline route (in miles) and log of industry energy intensityas of 1947. Includes county and industry fixed effects. Standard errors clustered by state in parentheses. Dependent variables is 100 x percentage point change from 1940 to end-year in industry share of total county employment.