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De-Industrialization, Local Joblessness and The Male-Female Employment Gap

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Abstract

Across industrialized countries, regional disparities in labor market outcomes and income have increased in recent decades. This paper investigates how one of the largest localized labor demand shocks tied to the beginning of de-industrialization- the decline of the mining industry between 1960 and 2010 - affects labor market outcomes in the long run. The analysis relies on a new panel data set based on digitized census records from Belgium, France, the UK, and Germany that allows tracing labor market adjustments over 60 years for the male and female working-age population separately. For the causal estimation, I use an IV-shift share approach that exploits exogenous variation in the shifts induced by increased seaborne trade of energy substitutes and the share given by geological rock strata to predict mining activity. The male population disproportionately suffered under this (early) de-industrialization shock and the subsequent job loss. For the male population, the employment-population ratio has not yet recovered resulting in persistent local joblessness. In contrast, the female working-age population experienced a strong catch-up in employment and participation. I find that at the aggregate level, a substantial, albeit time-lagged population response paired with a strong increase in female participation rates fully compensates for the loss of male jobs over the decades. As a consequence, the male-female employment gap shrinks over time.

JEL Classification:

Keywords: Structural change, local labor markets, regional disparities

1 Introduction

Regional economic disparities in income and labor market outcomes within advanced economies have been on the rise since the early 1980s (Roses and Wolf (2021) and Moretti (2011)). Regionally concentrated structural change which especially affects the labor demand for low-skilled workers, as well as an overall slowdown in migration to high-income places due to idiosyncratic preferences or limited housing supply, have contributed to these disparities (Ganong and Shoag (2017) and Diamond (2016)). Recently, local joblessness has increasingly replaced real wages as a measure of regional welfare differentials for two reasons. First of all low employment levels entail next to the high economic costs additional social costs such as higher mortality and crime rates (Austin et al. (2018) and Rice and Venables (2021)) spurring political discontent in declining regions (Dijkstra et al. (2020)). Second, recent theoretical advances in spatial equilibrium theory show that changes in the employment-population ratio can be directly mapped to changes in welfare levels across space (Amior and Manning (2018)).

This paper shows to what extent current disparities in regional labor market outcomes across Belgium, France, the UK, and Germany can be traced back to localized labor demand shocks tied to the beginning of the de-industrialization. The labor demand shock to the mining industry- driven by increased import competition from alternate fossil fuels after the reopening of the Suez Canal in 1957- was not only the first but also one of the largest shocks de-industrializing the economy in recent history. The subsequent decline in mining jobs started ten years before the overall manufacturing decline set in. While the employment share in the coal mining industry in 1960 in the four countries under consideration amounted on average to only 2 % nationally, former mining regions faced on average a 8 % employment loss between 1960 and 2010 due to the high spatial concentration. This paper revolves around two major research questions: First, how does the labor demand shock to the mining sector affect local labor markets in the long run? Second, what are the mechanisms of adjustment? To answer these questions, I have constructed a new panel data set based on digitized national census records for the main coal-producing countries Belgium, France, England (with Wales), and (West-)Germany allowing to track labor market outcomes at the NUTS3 level from 1950 until today. So far, there did not exist a harmonized dataset on local labor market outcomes neither for these countries individually let alone spanning the entire EU for this time-period ¹.

Methodologically, I construct a shift-share variable in a similar vein to Autor et al. (2013) that exploits the exogenous increase in import penetration in the energy sector over time to instrument for the regional decline in mining jobs. Following the recent discussion on causal inference with Bartik shift-share variables (Goldsmith-Pinkham et al. (2020)

¹Eurostat offers some relevant outcomes at the more aggregate NUTS1/NUTS2 level starting 1980, but unfortunately does not provide information on gender-specific outcomes.

and Borusyak et al. (2022)), my identification strategy relies on both the exogeneity of the shift and the share as I use geological rock strata instead of lagged employment shares to predict regional mining activity. To stress the exogeneity of the shifts, I show that the decline in the mining industry was to a large extent driven by globalization shocks that eventually led to the loss of comparative advantage in the energy sector. Whereas before the 1960s domestic coal was the primary source of energy consumption, the pattern changed dramatically in the subsequent decades. Starting in 1957 with the reopening of the Suez Canal, oil from the newly discovered oilfields in the Middle East and North Africa was increasingly used as a substitute for domestic coal due to the lower market price. After the two oil crises between 1974 and 1979, large-scale seaborne coal trade became feasible and cheaper import coal gradually replaced the remaining domestic coal production. In both cases the increased foreign competition was driven by supply-side factors in the new trading partners' economic environment and, most importantly, a rapid decline in transportation costs.

This paper finds that regions that experienced a one standard deviation increase in shock exposure between 1960 and 2010 display a 10 % lower employment growth and 11 % lower population growth until today. At the aggregate level, within 30 years after the initial shock, the adjustment of local labor markets is completed as there is no longer a differential growth of the employment-population rate. Even though the shock to the mining industry affected the male labor force only, the adjustment of the local labor markets is entirely driven by the female labor market. A further contribution of this paper is therefore to highlight the importance of the expansion of female labor force participation and thus compositional changes in the labor force as an important adjustment mechanism in response to de-industrialization shocks. The connection between de-industrialization and female labor force participation is still understudied. The mining industry (like most manufacturing industries) provided relatively low educated manual workers with high wages and secure labor market conditions. This changed rapidly after 1960 with the decline of this industry. Within two decades the female labor force participation increases rapidly. A one standard deviation increase in shock exposure leads to a 9 % stronger increase in the female employment-population ratio between 1960 and today. The increase in the female employment-population ratio does not only offset the decrease in the male employment-population rate, it also substantially narrows the male-female employment gap. For the male working-age population, on the other hand, the shock turns out to be persistent in the long run. A one standard deviation increase in jobs lost leads to a 2 % stronger decrease in the employment-population rate until today.

The persistence in labor market outcomes in response to past labor demand shocks—such as the permanent decline of the male employment-population rate—is puzzling from a theoretical perspective. Within the framework of classical spatial equilibrium models

in the tradition of Rosen-Roback (Rosen (1979) and Roback (1982)) a negative demand shock to a local labor market results in a decline of wages (and to a lesser extent a fall in prices) whereas unemployment remains unaffected in the short run. The lack of an employment response in the short run which is due to the assumption of a inelastic labor supply and friction-less labor markets is neither supported by the results of this paper nor in line with the existing empirical evidence. The modified framework by Amior and Manning (2018) and Beaudry et al. (2014) allows labor supply to be elastic in the short run. As a consequence, an adverse demand shock reduces the labor supply resulting in a lower employment-to-population ratio ². In the long run, however, both frameworks predict that population adjustments (or new job creation) should equalize existing regional differences in employment rates and real wages.

Starting with the seminal papers by Blanchard and Katz (1992) and Bartik (1991), a large body of literature in urban as well as in labor economics has tested these theoretical predictions empirically- mostly for the U.S. setting. These papers typically rely on employment change or generic Bartik IVs as an explanatory variable and are therefore agnostic about the type and the exogeneity of the shock. This paper contributes to this strand of the literature by concentrating on the causal identification of a specific shock and thereby providing evidence of how labor markets adjust in the European setting in the very long run. Whereas earlier studies for both the US and Europe generally find that labor market adjustment is completed within 10 years after the change in labor demand due to strong population response (compare Blanchard and Katz (1992), Feyrer et al. (2007) and Decressin and Fatás (1995)), more recent studies tend to find more persistent effects (compare Amior and Manning (2018), Rice and Venables (2021) and Charles et al. (2019)). There is a handful of studies within this literature that specifically deals with the consequences of declining mining employment on labor market outcomes limited to either the U.S. (Black et al. (2005), Black et al. (2003) and Autor et al. (2021)) or the UK setting (Aragón et al. (2018), Beatty and Fothergill (1996)). These studies do not offer a causal identification and the time frame of the empirical analysis extends only to 1980, and therefore 20 years after the European regions were first exposed to the shock.

The second strand this paper contributes to is the literature dealing with the impact of globalization shocks on local labor markets following the seminal paper by Autor et al. (2013). Most of this literature focuses on the question of how local labor markets adjust to increased import competition from China between 1990 and 2010. Whereas studies for the U.S. generally find strong adverse effects on local labor markets (compare also Pierce and Schott (2016), Acemoglu et al. (2016)), the evidence in the context of Western Europe is mixed at best (Malgouyres (2017) and Dauth et al. (2014)). The few existing studies extending the perspective to other globalization shocks show that the impact differs im-

²The extent of the reaction of wages as opposed to employment rate depends on the elasticity of labor supply and existing wage rigidity on the market.

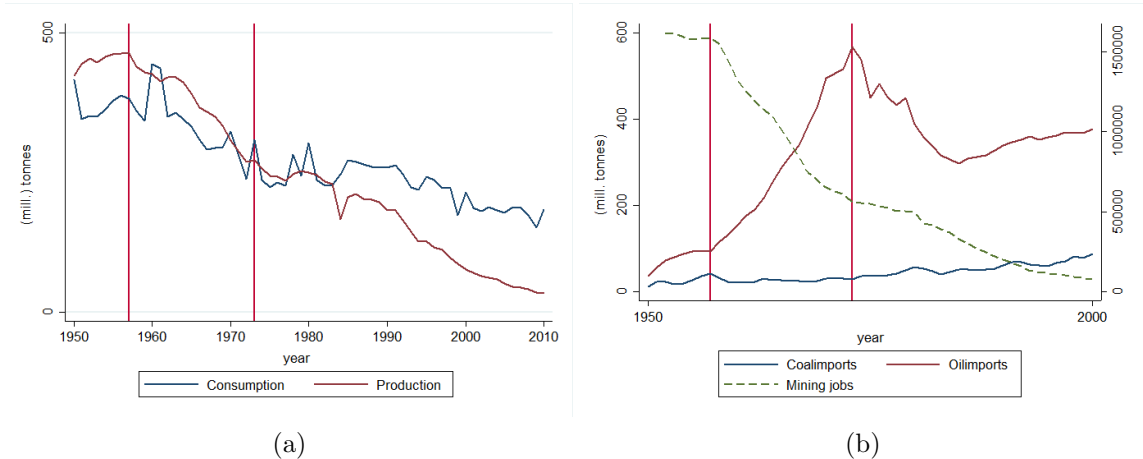
mensely depending on the specific context and timing. Eriksson et al. (2021) contrast the China shock to earlier trade shocks induced by the rising imports from Japan a decade earlier (1975-1985) and find no impact on employment rates. Bräuer and Kersting (2023) analyze the historical trade shock of the so-called grain invasion on economic outcomes across Prussian counties between 1895 and 1910 and find that labor markets adjust very efficiently due to very high mobility of workers. The findings of this paper therefore broaden the understanding of the impact of and adjustment to globalization shocks more generally. The size of the effect on the male population of the import shocks studied here is substantially larger than the aggregate effect of the China shock in the U.S. and thus of greater importance for the European setting. At the same time, the adjustment to the shock studied in this paper is much more rapid due to a strong population response and the expansion of female labor force participation. Hence, the findings of this paper point to the importance of accounting for gender-specific responses and compositional changes in explaining aggregate labor market outcomes.

Third, this paper therefore also contributes to the literature focusing on the increase in female participation that has been documented for many industrialized countries after World War II (compare Olivetti and Petrongolo (2016) and Goldin (2006)³). Despite the general increase, there are still considerable differences across countries and also within countries⁴. Whereas changes in specialization patterns such as the growth of non-manual occupation and an expanding service sector shape female labor market participation (Olivetti and Petrongolo (2016) and Ross (2008)), past specialization patterns might still matter through the inter-generational transmission of gender norms (Alesina et al. (2013) and Wyrwich (2017)). A subset of the literature focuses specifically on the importance of exogenous shocks such as economic crises or violent conflicts in spurring changes in female labor force participation. In order to smooth consumption within the household, women of men struggling on the labor market increase their labor supply. This so-called added worker effect goes back to the seminal work by Mincer (1962) and Lundberg (1985). Accordingly, Bellou and Cardia (2021) find that female labor force participation increased more rapidly in U.S. states that were more severely affected by the Great Depression. A related, albeit special setting is the mobilization of males during in times of war. The incidence of these male labor shortages increased women’s employment

³According to the seminal work of Goldin (2006) and Boserup (1970) female labor force participation follows an u-shaped pattern along the development process. This hypothesis holds well in the specific context of industrialized countries in the 20th century but yields conflicting evidence when tested with cross-sectional and panel data (compare Gaddis and Klasen (2014)). One potential explanation is that the rise in female labor force participation decisions is shaped by both rising income levels and the specific type of structural change prevailing.

⁴Surprisingly, empirical evidence on the potential causes of this variation is still relatively scarce- especially within countries. Next to economic reasons, a range of cultural and political determinants have been discussed in the literature such as the type of religion or policy regimes (Feldmann (2007), Kreibaum and Klasen (2015)), commuting time within cities (Black et al. (2014)), as well as the specific welfare regime such as the tax system have been found to be relevant (Alesina et al. (2011)).

Figure 1: The decline of the coal industry



Notes: Panel (a) shows the total hard coal production and consumption in Belgium, France, the UK and Germany between 1950 and 2010. Panel (b) depicts the evolution of oil imports (in million tonnes hard coal equivalence) and hard coal imports in million tonnes (left axis) and the total number of mining jobs (right axis). Sources: See data Appendix.

opportunities in nations such as the U.S. and Vietnam at least in the short run. In the long run however, these studies find only a modest effect on female participation as most of the women drop out of the workforce upon the return of the men (compare Goldin (1991), Goldin and Olivetti (2013), Kreibaum and Klasen (2015) and Rose (2018))⁵. This paper adds to this literature by causally showing how a gender-biased labor demand shock persistently increases female labor force participation over time, thereby shedding light on both the importance of the added worker effect and prevailing structural change.

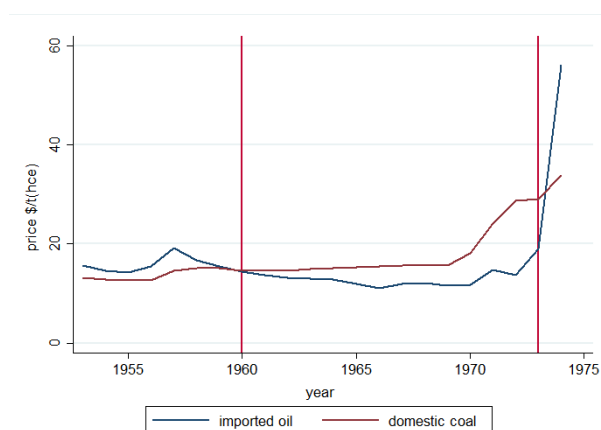
2 Empirical Strategy and Data Sources

2.1 Energy shocks and the emergence of seaborne trade

Coal used to be the dominant energy source in Western Europe ever since the Industrial Revolution until the mid-1960s when the industrialized countries faced the "second major energy transition" in history (Kander et al. (2013)). After the end of the second world war income growth boosted energy demand. As a consequence, coal production as well as employment in mining expanded. In 1957 domestic coal production in the UK, France, Belgium and (West-)Germany reached a peak with 490 million tonnes of coal produced (compare figure 1a), and the number of workers employed climbed to 1.6 million (compare figure 1b). In 1950 above 80% of all primary energy used in the four countries in the sample came from (domestically) produced hard coal. This changed rapidly in the next decades

⁵Goldin and Olivetti (2013) and Rose (2018) find that half of all women in the U.S. that entered the workforce during WWII, do not stay in the workforce. Fernandez et al. (2004) find a long-run impact of WWII on female participation for the post-war generation. They argue that due to the formation of preferences and norms during childhood, wives of men whose mothers worked are themselves significantly more likely to work.

Figure 2: The evolution of energy prices



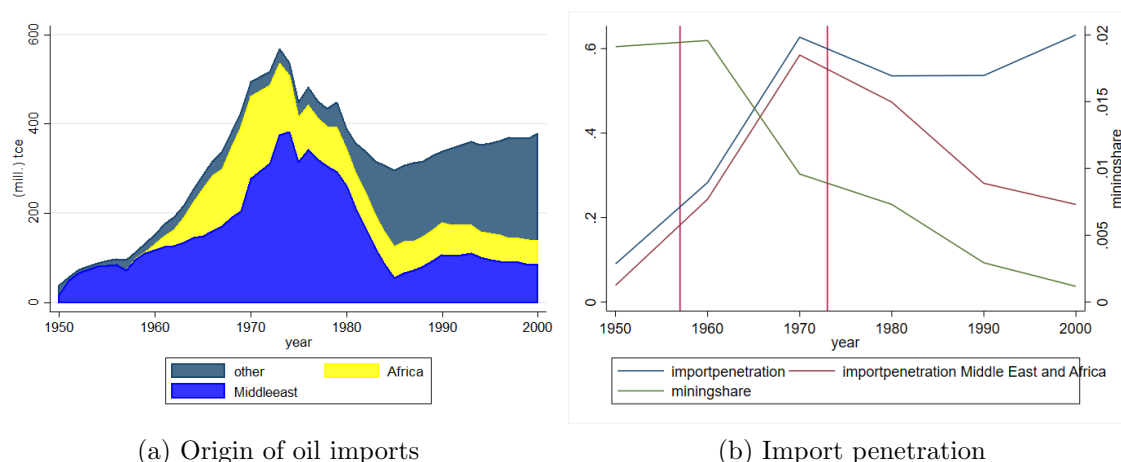
Notes: This figure depicts the evolution of the US dollar price per 1 million tonnes hard coal equivalent for imported oil and domestic coal for France, Germany and Belgium. The UK is excluded due to missing data. Sources: Own illustration based on data provided by Statistical Office of the European Communities (1975), for details see data Appendix.

with the share of coal dropping to less than 40% in 1970, until below 20% today (compare figure B.7a). The decline of the coal industry can be subdivided into two distinct although related phases. Common to both phases of decline is that increased globalization pressure due to a fall in overseas freight rates combined with the expansion of export capacities from new market entrants led to the loss of the comparative advantage in the energy market. As a result, domestic coal is substituted with imported energy sources.

The first phase of decline began in 1957 with the reopening of the Suez Canal and the liberalization of the energy markets in Western Europe. Growing market integration within Europe with the formation of the ECSC (European Coal and Steel Community) in 1951 and later the European Economic Community (EEC) in 1957 as well as economic considerations linked to the cost advantage of oil as a cheap energy source put political pressure on governments to liberalize the energy market. As a result import duties on oil were canceled and the fixing of domestic coal prices was abandoned (Nonn (2001)). Due to the political instability following the Suez crisis and the temporary closure of the Suez Canal in 1956/57 oil prices remained constant and even increased until 1957 as seen in Figure 2. The reopening of the Suez Canal marks the important turning point that allowed oil prices to fall substantially. Freight rates for ships carrying oil to Europe from the expanding oil fields in the Middle East and North Africa did not just drop to the pre-closure levels but much beyond: During the closure investments in a new type of very large crude carriers (VLCC) were made to allow the cost-efficient transportation around Cape of Good Hopes (Pfister (2010)). This new technology enabled the transport of much larger quantities and therefore reduced the tonne per mile transport costs (compare Lundgren (1996)).

The import penetration of oil measured as the share of imported oil in overall coal and oil supply (domestic production+imports-exports) increased from less than 10% in

Figure 3: Import penetration of crude oil



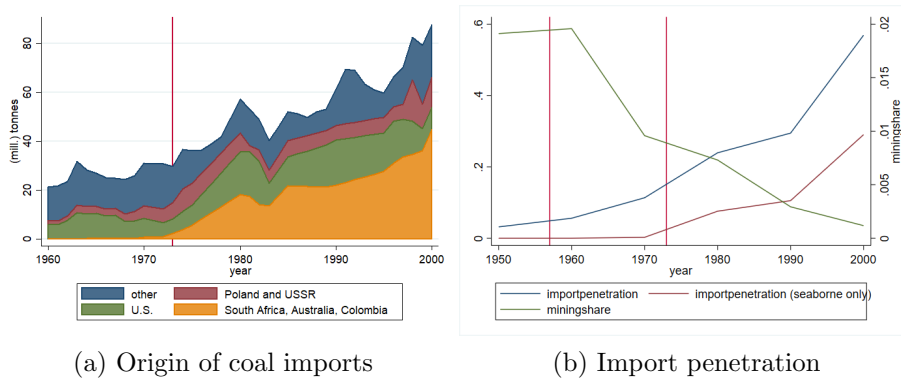
Notes: Panel (a) shows total oil imports converted to million tonnes hard coal equivalents by country of origin for all countries in the sample. Panel (b) compares the evolution of the national employment share in the mining sector (y-axis to the right), to the import penetration of oil imports coming from the Middle East and Africa and overall oil import penetration. Sources: See data Appendix.

1950 to over 60% in 1970 (see Figure 3b). The share of oil in the overall energy mix increased from less than 20% to 60% as depicted in Figure B.7a and B.6. Figure 3a shows that the increased import penetration was entirely driven by shipments from the Middle East and Africa, which started to rise very rapidly after the re-opening of the Suez Canal in 1957. As a consequence, the demand, production, and employment in the domestic hard coal sector was reduced by roughly one-half (compare Figure 1). The absolute decline in coal consumption is remarkable because the overall energy demand increased rapidly until the late 1990s. Oil imports did not just account for the increased energy demand, they also replaced coal in all sectors of final energy consumption (for more details see the historical background section B in the Appendix).

This first phase ended with the first oil crisis in 1973. The oil trade prior to the first oil crisis in 1973 was dominated by large (state-owned) American and European companies which induced in the early 1970s Middle Eastern governments to put upward pressure on the oil prices . After the outbreak of the Yom Kippur War in 1973 the Middle Eastern states within the OPEC imposed an oil embargo on Western countries which resulted in an oil price explosion. Oil prices quadrupled and peaked during the second oil crisis in 1979 (see figure 2). As a consequence oil demand in all sectors (except for transportation) declined and never reached the pre-crisis level again (compare Figure 3). It also spurred the development of oilfields, especially in the UK, and subsequent downward pressure on oil world prices due to diversification. As a consequence of the oil price explosion, the price of coal became competitive again as it fell below the level of oil prices in 1973 (compare figure 2) ⁶. The period between the first and second oil crises is marked by relative stability in both domestic coal demand and supply.

⁶For the UK, the oil to coal price ratio dropped from previously 1.13 to 0.79 in the year 1973, and furthermore dropped to 0.58 in the wake of the Iranian crisis in 1979 (Sill (1984)).

Figure 4: Import penetration coal



(a) Origin of coal imports

(b) Import penetration

Notes: Panel (a) shows total coal imports in million tonnes hard coal by country of origin for all countries in the sample. Panel (c) compares the evolution of the overall employment share in the mining sector (y-axis to the right), to the the overall and seaborne import penetration for all countries in the sample. Sources: See data Appendix.

The second phase of decline began after the second oil crisis in 1979 and lasted until the late 1990s. Due to high transportation costs before 1970, just a small share of coal was traded, and if so mostly across land and short distances rather than across sea. In the early 1970s, the "third revolution in merchant shipping" with the introduction of specialized dry bulk carriers enabled for the first time large-scale seaborne trade. The freight rates for coal dropped from the 1950s to the 1990s by 70 % (Lundgren (1996))⁷. In response to the increased oil prices and the generally expected increase in demand for coal in the future, new coal overseas exporters entered the global market⁸. The new entrants quickly gained a comparative advantage in coal production due to better geological conditions such as the existence of open-cast mines (Australia), lower wages (South Africa), or less labor protection (U.S.) but most importantly the reduction in freight rates for sea-borne trade. As seen in figure 4a, starting in 1973, coal imports increased substantially in size. The increase is driven by South Africa, Columbia, and Australia all of which first entered the Western European coal market during this time. Together, they account for 80% of the overall increase in coal imports. As a consequence the import penetration within the western European coal market increased from less than 10% in 1960 to almost 60% in 2010, and seaborne trade by the new entrants increased from zero to almost 40% as depicted in figure 4b). Whereas until the first oil crisis in 1993 domestic coal production and demand dropped at the same rate, in following decades there is an increasing gap between these two indicators. Whereas coal demand is declining at a very slow rate, domestic production falls very steeply starting in the early 1980s. The decline in domestic production is mirrored

⁷This is comparable to the switch from sailing to steam vessels in the late 19th century. The advances in this new shipping technology are linked to the earlier technological advances in the size of tankers during the Suez Crisis (see above). In proportions and hydrodynamics, the dry bulk carriers are similar to the tankers although dry carriers generally are of a smaller size (Corlett and National Maritime Museum (1981), pp 24-32))

⁸(Moncur and Jones (1999) for example describes for South Africa how mining facilities and transportation devices were expanded in reaction to the first oil crisis and revived demand for coal.

by a decline in mining jobs, indicating that productivity advances in the coal sector are not the underlying driving force. Even though as early as 1970, European coal was no longer competitive, coal imports increased only gradually. The governments of all four countries in the sample shielded domestic coal production from the increased international competition. In the face of the increasing price gap between domestically produced coal and the international market, politics secured the coal demand especially in the electricity generation market by enforcing agreements between power plants and coal mines. The intensity of the protection and timing of the subsequent liberalization differs widely among the four countries depending on the strength of trade unions, social concerns, and energy security. Notwithstanding, the growing price gap between imported coal and domestically produced coal in all countries inflated the financial means necessary to shield domestic production. In the end, the national protection policy could not withstand the increased financial pressure, resulting in the eventual phase-out of the coal industry.

2.2 Measuring the shock

The analysis is based on all NUTS3 regions in current (2016) boundaries of the four main coal-producing European countries: England (with Wales), (West-) Germany, Belgium, and France. The current NUTS3 regions correspond to the administrative units of counties in the UK, Departments in France, Arrondissements in Belgium, and Kreise in Germany. To measure each region's exposure to the adverse labor demand shock in the mining industry between 1960 and 2010, I construct a Bartik shift-share variable that projects the changes in mining employment at the national level to the regional level by using the regional employment shares in mining as of 1950 (for sources see Data Appendix C). I use ten-year lagged employment shares to avoid capturing a decline in mining shares due to the *anticipation* of the shock of forward-looking agents.⁹ The shock is therefore defined as :

$$\Delta Shock_{it} = \frac{L_{mi_{t-1}}}{L_{i_{t-1}}} \frac{\Delta L_{mjt}}{(L_j 1950)} \quad (1)$$

$L_{mi_{t-1}}$ is the employment in mining in region i in 1950, $L_{i_{t-1}}$ is the overall employment in regions i , whereas $\frac{\Delta L_{mjt}}{(L_j 1950)}$ is the change in national mining employment as a share of overall employment in 1950. The Bartik shift-share variable abstracts from any idiosyncratic region-specific component that links a more rapid regional decline in mining jobs to adverse regional labor market outcomes. Nonetheless, running a simple OLS regression

⁹In principle, the exposure to the shock could be more directly measured by the number of jobs lost in mining between 1960 and 2000 as a fraction of initial jobs in that region. The change in mining employment at the regional level is digitized from census records. Due to changes in industry definitions over time, the data most likely suffers from measurement error (compare data Appendix). Furthermore, defining the shock in this way leads to a reversed causality issue. The decline in mining jobs could be the result rather than the driver of adverse economic conditions. A region already in decline is more likely to close down production sites and reduce employment.

using the demand shock as defined in (1) still suffers from several potential endogeneity issues as discussed in section 2.3. The estimation of a causal effect therefore requires a credible IV approach. I exploit the fact that the decline in mining is not driven by a decrease in domestic productivity but rather by the loss of comparative advantage due to the decline in transportation costs and a subsequent foreign supply shock. Therefore, I isolate the exogenous variation in the timing and intensity of the shock that can be explained by the rise in import penetration in the energy sector:

$$IV1 : \Delta \hat{E}X P_{it} = \frac{L_{mi_{t-1}}}{L_{i_{t-1}}} \frac{\Delta IMP_{jt}}{(Y_{jt-1} + IMP_{jt-1} - EX_{jt-1})} \quad (2)$$

More precisely, I compute the change in national oil imports between 1960 and 1970 coming from the Middle East and Africa ΔIMP_t as a fraction of the initial (1950) industry absorption of oil and coal which equals the primary energy supply, defined as total production (Y_{t-1} plus all imports IMP_{t-1} minus exports EX_{t-1}). All sources are listed in Appendix C. As in (1), the national changes in import penetration are regionally distributed using lagged regional employment shares in mining $\frac{L_{mi_{t-1}}}{L_{i_{t-1}}}$. After the first oil price crisis in 1973, oil imports were no longer competitive and did not exert any additional pressure on the coal market. Instead, starting in 1970, seaborne coal trade became feasible, and imported coal was increasingly used as a substitute for domestically produced coal. For the years 1970 to 2010 I therefore use the increase in coal imports shipped from overseas as a fraction of coal use in primary energy supply to measure the exposure to the shock. Due to the specific geological conditions necessary to extract coal the following identification strategy can rely additionally on the exogeneity of the shares. Instead of using the regional employment shares as of 1950 to define the exposure to the treatment, I employ the share of land area with below-surface carboniferous strata in a region. The access to below surface Carboniferous- coal-bearing- rock strata increases the likelihood of a region engaging in coal mining (compare Fritzsche and Wolf (2023) for an extended discussion). Carboniferous strata that is covered by a mountain massif is excluded since the lack of accessibility hinders large-scale mining activity ¹⁰. The IV as introduced in (2) is therefore modified as follows:

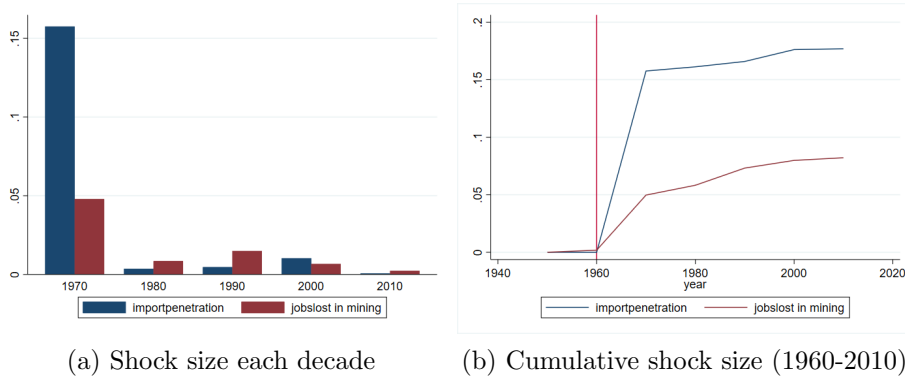
$$IV2 : \Delta \hat{E}X P_{it} = \frac{Carbarea_i}{Area_i} \frac{\Delta IMP_{jt}}{Carbarea_j} \quad (3)$$

$\frac{Carbarea_i}{Area_i}$ is the share of land area covered by carboniferous strata in region i and $Carbarea_j$ is the sum of all carboniferous strata existent in country j . Since the share is now based on area measures, the denominator of the shift also needs to be expressed in terms of area.

Figure 5a illustrates the evolution of the average jobs lost as defined in equation

¹⁰To derive a region's coverage with carboniferous strata, I use the shapefiles provided by Asch (2003). For information on the location of mountain massifs, I rely on shapefiles provided by Kapos et al. (2000)

Figure 5: Correlation between Jobs lost in mining and import penetration

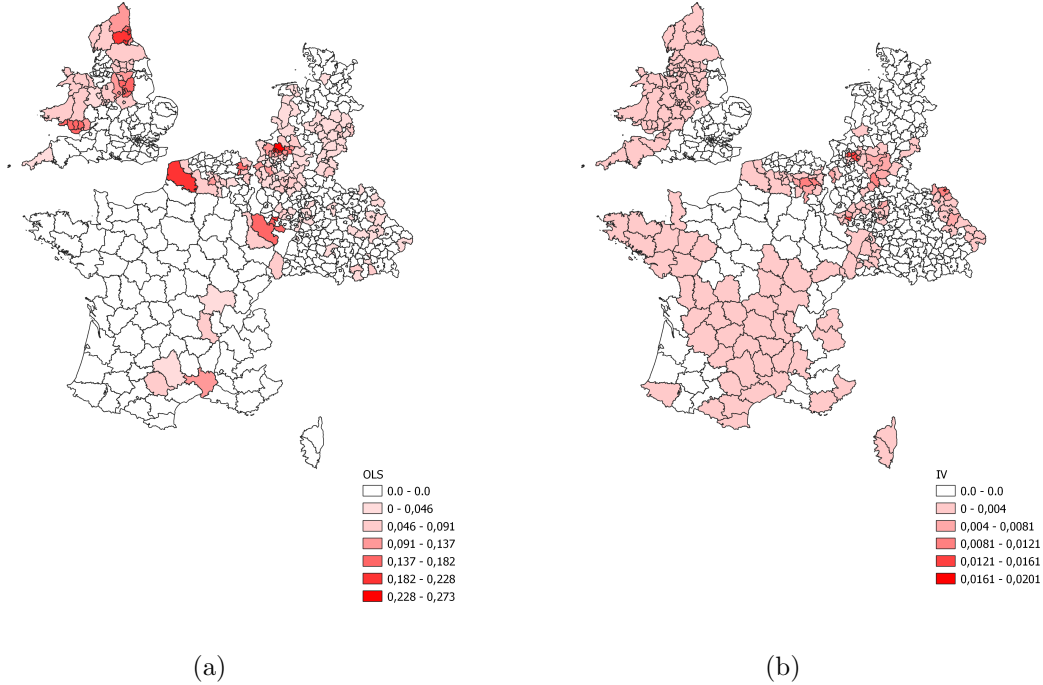


Notes: Panel (a) illustrates the evolution of the average jobs lost as defined in equation 1 and import penetration as defined in equation 3 for all treated regions (regions that have a positive mining share in 1950). Panel (b) shows the cumulative average jobs lost in mining and the import penetration for the average treated region over time. For the computation of averages, the regions' share in the national working-age population as of 1960 is used as weights. For Source: See text and data Appendix.

(1) and import penetration as defined in equation (3) for all treated regions, meaning all regions that have a positive mining share in 1950. The shock exposure as measured with the explanatory variable jobs lost is highly correlated with the IV. Between 1960 and 1970 during the oil invasion, in the following referred to as the oil shock, the exposure is most intense. The average mining region experiences a job loss of 5 % points within one decade. In the subsequent decades between 1970 and 2010 the shock is entirely driven by the rise in seaborne coal trade. The coal shock is substantially smaller in size: the additional number of jobs lost each decade amounts on average only to 0.8 percentage points (compare also Table A.2 in the Appendix) and therefore to only one-sixth of the original shock size.

The shocks to the mining industry in the decades between 1970 and 2010 are naturally not independent from the initial oil shock. The regions exposed to import shocks in later decades might still be in recovery from the employment decline they experienced in the previous decade. As detailed in the next section, I account for the dynamics of the adjustment by running additional specifications using as an explanatory variable the cumulative shock over time. Figure 5b shows the cumulative evolution of jobs lost in mining and the import penetration for the average treated region over time. The shock is most pronounced between 1960 and 1970 during the oil invasion. Between 1970 and 1980 there is only very small additional pressure from import competition and therefore the number of additional jobs lost is negligible. Between 1980 and 1990 the shocks intensity increases once more before gradually fading out and reaching final plateau in 2000. Depending on the timing of closure of the last mine, there is some variation across countries: For Belgium, the shock reaches its maximum cumulative intensity between 1990 and 2000, in France maximum intensity is reached in 2000. Figure 6 shows the geographical distribution of exposure to the cumulative shock between 1960 and 2010 for all NUTS3 regions in the sample. The left panel shows the exposure measured with the main explanatory variable jobs lost as defined in equation 1, whereas the right panel shows the exposure measured

Figure 6: The spatial distribution of the exposure to the shock



Notes: Panel (a) shows the exposure to the cumulative shock between 1960 and 2010 measured with the main explanatory variable as defined in equation 1 for all NUTS3 regions in the sample. Panel (b) shows the exposure to the cumulative shock between 1960 and 2010 measured with the IV as defined in equation 3. Sources: See text and data Appendix.

with the IV given by equation 3. There is a high spatial correlation between these two variables. The most affected regions are located in North England, North France, and the Western part of Germany. At the same time, the exposure is not limited to a few clusters but rather spread out geographically.

2.3 Empirical Strategy

This section presents the empirical strategy to measure the impact of the labor demand shocks on local labor markets outcomes. In a first step I use a stacked first difference model to estimate the effect of the shock in 1, instrumented by 3 on the decadal change in the outcome variable between 1960 and 2010:

$$\Delta \ln(Y)_{it} = \gamma_j + \alpha_t + \beta_1 \Delta EXP_{it} + \beta_2 X_{it} + \epsilon_{it} \quad (4)$$

where $\Delta \ln(Y)_{it}$ is the change in the dependent variable for region i , γ_j is a country fixed effect and α_t is a separate time dummy for each decade. In all specifications, I use the regions' share in the national working-age population as regression weights. The vector X_{it}

controls for a variety of observable confounders that potentially impact the labor market conditions of a region either through amenity-driven supply changes or productivity-driven demand changes. I include first-nature geographical indicator variables for being a coastal or mountain region as well as a variable capturing the soil quality, mean temperature, and mean rainfall in a region. As second nature geography controls, I include the proximity to the next border, the population density lagged by ten years, as well as the degree of urbanity of a region and a dummy variable indicating the status as a capital city. The definitions of the variables and information on data sources are listed in the Data Appendix C. Depending on the specification, I also include different variables capturing the initial composition of the labor force such as the educational level, foreign population, industrial structure as well as female participation, all collected and digitized from census records (for a full list of control variables see Table A.3 and for sources see Data Appendix C). All controls are fixed to their pre-shock level and interacted with time dummies to allow a different impact over time.

The Bartik shift-share variable as defined in 1 abstracts from any idiosyncratic region-specific component that links a more rapid regional decline in mining jobs to adverse regional labor market outcomes. Nonetheless, running a simple OLS regression using the demand shock as defined in 4 still suffers from several potential endogeneity issues. Mining regions could be affected by unobserved trends that are related to their initial conditions. The decline of the mining industry could be a symptom of general decline *common to all* mining regions rather than the cause of it. Potential confounders such as unobserved adverse amenity or productivity shocks could affect both the decline in mining employment and at the same time overall labor market conditions. The estimation of a causal effect therefore requires a credible IV approach. For the identification strategy to be valid, the residual must be orthogonal to the Instrument. This condition is satisfied if either the national level instrument - the shift- or the regional employment level in mining -the shares- or both are uncorrelated to unobserved shocks (see for an extended discussion Goldsmith-Pinkham et al. (2020), Borusyak et al. (2022) and Adão et al. (2019)). The IV as defined in equation 3 exploits the fact that the decline in mining is not driven by a decrease in domestic productivity but rather by the loss of comparative advantage due to a foreign supply shock and the subsequent decline in transportation costs. The focus on a single industry and the absence of a large number of independent shocks make it difficult to provide empirical proof that the identifying assumption related to the exogeneity of the shift, holds. A negative productivity shock or technological change towards automation especially affecting mining regions could in theory also result in higher imports and a decline in both mining and overall employment. However, this scenario seems rather unlikely given the exact timing of the shock as discussed in section 2.1. This argument is furthermore supported by the evidence shown in Figure A.1 in the Appendix. Productivity, measured as the output per (mining) worker is increasing over time. A positive

technology shock in mining could potentially reduce labor input in this industry but it cannot explain neither the rise in prices, as seen for Germany in Figure B.8, nor the decline in production shown in Figure 1. Due to the specific geological conditions necessary to extract coal the following identification strategy can rely additionally on the exogeneity of the shares. The access to below surface Carboniferous- coal-bearing- rock strata increases the likelihood of a region engaging in coal mining (compare Fritzsche and Wolf (2023) for an extended discussion). By exploiting the exogenous variation provided by the regions' geology to predict mining activity, I rule out the possibility that regions selected into mining based on unobserved characteristics that also affect labor market outcomes today. Regions that started to engage in coal mining activity in the 18th and 19th century are not likely to be randomly selected. The demand for coal was probably higher in more urban and densely populated areas. Due to high transport costs, coal production might have been located closer to pre-industrial urban agglomerations. The presence of (unobserved) regional characteristics that were favorable to the specialization into coal production at the beginning of the Industrial Revolution and which are still affecting current economic development today, will introduce a positive selection bias. Finally, as a direct consequence of the mining activity itself, treated regions might have *acquired* characteristics that are very different to other regions i.e. lower human capital or less diversified business structure. Conceptually it is not clear whether potential impacts on labor market outcomes of these acquired characteristics should be distinguished from the ones of mining activity itself. It is however true, that the presence of such characteristics challenges the external validity of the results. If for example, human capital is systematically lower in former coal regions, job creation in growing skill-intensive industries as a channel of labor market recovery becomes less feasible. The adjustment of regions with high human capital endowment hit by a shock of similar size could therefore be much smoother.

To assess the validity of the identifying assumption for the exogeneity of shares, I undertake several robustness exercises as suggested by Goldsmith-Pinkham et al. (2020). First of all, following the simple Diff-in-Diff approach, I test in all main specifications for parallel pre-trends, ensuring that the shock indeed caused a change in the changes of outcomes. Second, I show in Appendix table A.1 the correlation of the mining share and the shock as measured in equation 1, 2, and 3 with pre-shock regional characteristics. A correlation with characteristics that might at the same time predict changes in labor market outcomes potentially violates the exclusion restriction and results in biased shock estimators. Indeed, Table A.1 shows that a relatively high share of of the variation in jobs lost and the exposure to the shock can be explained by initial characteristics, indicated by the R-squared. The shocks as measured in equation 1 and 2 are negatively correlated with the employment share in other manufacturing industries, the female participation rate in 1960, and the population share with a college degree in 1970. There is a significant positive correlation between the level of urbanity and industry diversity in 1960 as measured

with the Herfindahl Index. Interestingly, the shock is not correlated with initial human capital as proxied with university density in 1945. The IV based on carboniferous strata as defined in 3 is substantially less correlated with regional characteristics. The R-square drops from 0.46 to just 0.16 and there remains only a weak correlation between the female participation rate in 1960 and population density in 1950. Again, the lower female participation rate and the higher population density of mining regions are direct consequences of the specialization in mining and the correlation is therefore not surprising. Nonetheless, to isolate the impact of these potentially mediating variables, I run robustness checks for the main result in table 4, including as controls the educational attainment, initial industry and labor force composition.

Equation 4 treats the shock as being independent and therefore does not account for sluggish response to the shock in previous decades. Thus, the changes in outcome in each sub-period are assumed to be independent of former adjustments. During the second period of trade invasion marked by the coal import shock, labor market outcomes are the results of both the impact of the ongoing shock and the lagged adjustment of the previous decades. In a second step, I account for these dynamics in the adjustments to the shock. To estimate the effect of the cumulative shock between 1960 and 2010, I use the following first difference approach over successively longer periods, running separate regressions for each decade:

$$\Delta \ln(Y)_{it+l} = \gamma_j + \beta_0 + \beta_1 \Delta EXP_{it+l} + \beta_2 X_{it} + \epsilon_{it} \quad (5)$$

where $\Delta \ln(Y)_{it+l}$ is the change in the dependent variable for region i over the period t to l (with $t_0 = 1960$ and $t_l = 2010$) and ΔEXP_{it+l} is the change in the trade shock in the same period. As controls I use country-fixed effects as well as the range of start-of-the-period geographical and amenity controls X_{jt} as described above.

If a region is hit by a labor demand shock different adjustments can take place measured by the outcome variable Y . Lower wages (or a larger pool of unemployed workers) attract new firms to the regions or provide an incentive for existing firms to expand. To the extent that this new job creation offsets the job loss, we should observe no adverse effect on employment (or population) after ten years. Since this analysis uses panel data based on decadal census data, there are data points only every ten years. This analysis therefore abstracts from short-term effects. The net employment loss after ten years, defined as the reduction in the number of residents employed, is going to be the starting point of this

analysis ¹¹. The net employment loss can be decomposed into two components:

$$\Delta emp = \Delta \frac{emp}{pop} * \Delta pop \quad (6)$$

A net employment loss after ten years is reflected either by a decline of the employment-population ratio and or a population decline. As a channel of adjustment workers move from declining places to places with better employment opportunities and higher wages. If the population response is as large as the employment loss, we observe a perfect adjustment meaning that the shock does not affect the employment-population ratio after ten years. If however, the population response is sluggish or insufficient to offset the employment loss, the shock has persistent effects on the employment-population ratio. The employment-population ratio is the key outcome variable in this paper since it shows the race between employment and population. In equilibrium employment-population ratio should return to its original level all else equal- persistent spatial differences indicate welfare differentials as shown in Amior and Manning (2018). Introducing the more realistic assumption of an elastic labor supply in the short run, changes in labor demand have simultaneous effects both on real wages and the employment rate. Changes in the employment rates are then sufficient to derive welfare differentials without the need for regional wage or price data which is not available for such a long time horizon. The employment-population ratio measures how many of the working-age population contribute to generating measurable value added in the economy. Thereby, it abstracts from the participation decision of individuals and only reflects realized employment. The employment-population ratio can therefore be in a second step decomposed into the participation rate and the employment rate (the inverse of the more commonly used unemployment rate):

$$emp = \frac{emp}{part} * \frac{part}{pop} * pop \quad (7)$$

Transforming the decomposition in logs we get the following expression:

$$\log(emp) = \log(emprate) + \log(partrate) + \log(pop) \quad (8)$$

Taking first differences, equation 8 is modified to:

$$\Delta \log(emp) = \Delta \log(emprate) + \Delta \log(partrate) + \Delta \log(pop) \quad (9)$$

Facing adverse labor market conditions individuals that do not leave react either by staying in the labor market and become unemployed (the employment rate decreases) or they withdraw from the labor market entirely (decline in the participation rate) due the lack

¹¹An additional implicit adjustment channel is increased out commuting. Since all labor market outcomes are measured at the place of residence, the net employment loss is taking realized employment outside of the region of residence into account.

of individual prospects- the so-called discouraged worker effect.

2.4 Descriptive statistics: Labor market outcomes

This paper is based on a new regional panel data set allowing to trace labor market outcomes for male and female separately from the 1950s until today covering all NUTS3 regions across Belgium, France, Germany, England and Wales. There does not exist a harmonized dataset on local labor market outcomes neither for the countries individually let alone spanning several countries going back to 1950. Eurostat offers some relevant outcomes at the more aggregate NUTS1/NUTS2 level starting 1980 but unfortunately does not provide information on gender-specific outcomes. One of the contributions of this paper is to fill this data gap. The main outcome variables of interest are, as detailed in the previous section 2.3, the headcounts for employment, labor force participation, and (working-age) population for males and females separately. If not indicated otherwise, all labor market outcomes and weights are based on the working-age population instead of the overall population. Table 1 gives an overview of all collected and harmonized (labor market) outcome variables as well as socio-demographic variables (fixed to the pre-shock level) added as controls. The data is derived from census data records and therefore it

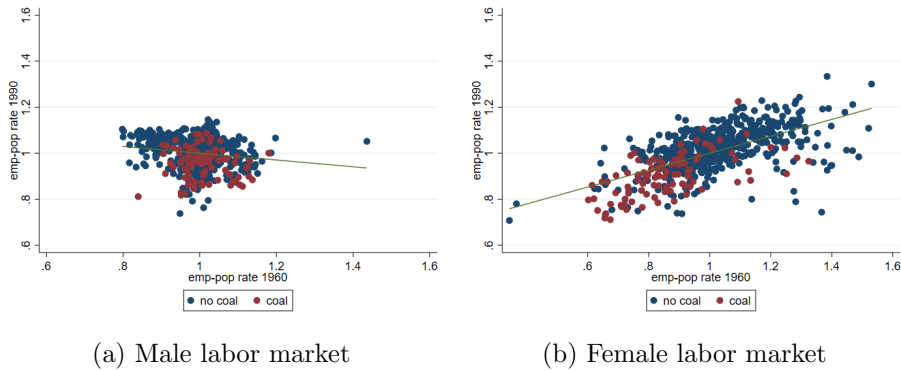
Table 1: Data Overview

variables	1950	1960	1970	1980	1990	2000	2010
population (at the place of residence)	✓	✓	✓	(✓)	✓	(✓)	✓
population (at the place of residence), male/ female	✓	✓	✓	(✓)	✓	(✓)	✓
working age population (15-64)	✓	✓	✓	(✓)	✓	(✓)	✓
working age population (15-64), male/ female	(✓)	✓	(✓)	(✓)	✓	(✓)	✓
active population	✓	✓	(✓)	(✓)	✓	(✓)	✓
active population, male/ female	(✓)	✓	(✓)	(✓)	✓	(✓)	✓
employment (at the place of residence)	(✓)	✓	✓	(✓)	✓	(✓)	✓
employment (at the place of residence), male/ female	(✓)	✓	✓	(✓)	✓	(✓)	✓
foreign population		✓	✓	(✓)	✓	(✓)	✓
population with a tertiary degree			✓	(✓)	(✓)	(✓)	✓
non-school going population			✓	(✓)	(✓)	(✓)	✓
self employment	✓	✓					
owner-occupied housing	✓	✓					
employment (at the workplace)	(✓)	✓	✓	✓	✓	✓	✓
sector-specific employment (at the workplace)	✓	✓	✓	✓	✓	✓	✓

Notes: ✓ data for all countries available and in dataset included; (✓) data for single countries imputed, for more information see figure C.13.

provides data points for every decade. If there was no census in a given country in the respective year, the closest available data point was taken instead. Germany is a special case since after 1970, census data is available for roughly every 20 years and thus data for 1980 and 2000 had to be imputed. For all other countries, there is missing data for only very few data points and if so mostly relevant for the measurement of pre-trends. Figure C.13 offers an overview for which years and which country imputations have been necessary.

Figure 7: The persistence in employment-population ratios (1960-1990)

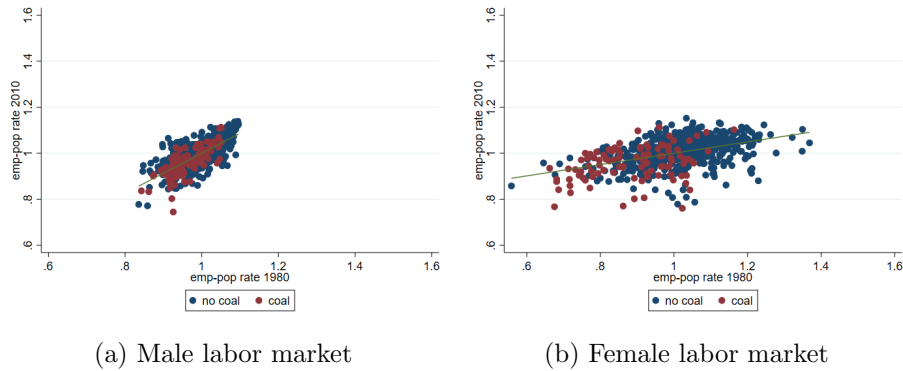


Notes: Panels (a) and (b) plot the male and female employment-population rate ($\frac{employment}{working-age-population}$), as defined in equations 6 and 8, in 1990 against the employment-population rate in 1960. Treated regions (coal regions) are highlighted in red color. Sources: See text and data Appendix.

For details on the imputation see the country-specific data sections in in the Appendix C. Administrative boundaries changed over time and the mapping of historical data into current NUTS3 boundaries is based on assumptions as outlined in the Data Appendix C for each country separately. All variables listed above are constructed from country-specific census records that are in detail listed in the Data Appendix C. The only exceptions are the data points for the variables employment and sector-specific employment at the place of work starting 1980 which are taken from the ARDECO database (ARDECO database) published by the European Commission. It is naturally very challenging to harmonize census data sets over time for single countries and even more so across countries. Data on industry-specific employment, self-employment, and the number of foreign population is only available for all countries starting in 1960. Data on educational attainment is only available for all countries starting in 1970 (data is missing for Germany and the UK before that). For a few variables, definitions across countries vary. Since all specifications include country-fixed effects, these differences in definition should not influence the results. In very few cases, definitions of variables change over time within single countries. The general level effects are captured by the inclusion of time-fixed effects. Furthermore, results are only biased if the changes in definitions affect the control and treatment groups to a different extent (for details see Data Appendix C).

Figures 7 and 8 show the persistence in the employment-population ratio for both genders for two distinct periods, 1960 to 1990 and 1980 to 2010. The employment-population ratio is normalized by each country's mean rate in the specific year to account for level differences due to country-specific characteristics. The persistence of the male employment-population ratio has clearly increased over time. Between 1960 and 1990, as de-industrialization and subsequent structural change reach their peak intensities, there is a negative relationship between male employment-population rate levels. A high employment-population ratio in 1960 does not predict a higher employment-population

Figure 8: The persistence in employment-population ratios (1980-2010)

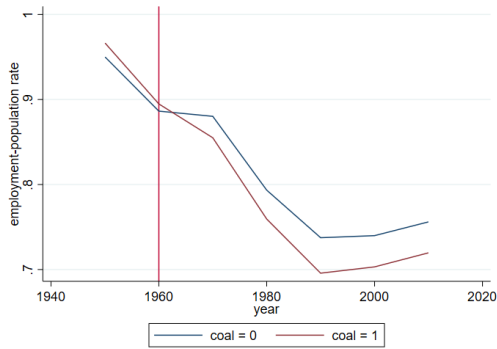


Notes: Panels (a) and (b) plot the male and female employment-population rate, as defined in equations 6 and 8, in 2010 against the employment-population rate in 1980. Treated regions (coal regions) are highlighted in red color. Sources: See text and data Appendix.

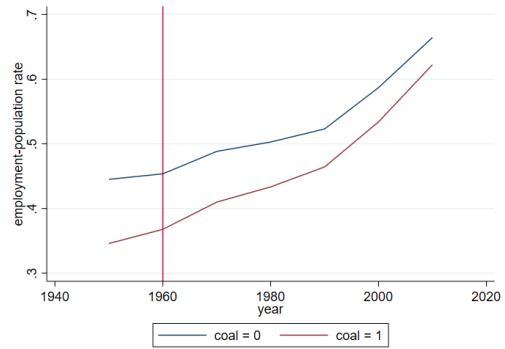
ratio thirty years later. Between 1980 and 2010, however, the persistence becomes strong, meaning that the relative performance of regions over time is no longer changing. It is striking, that the patterns in the female labor market follow the exact opposite trend: persistence has decreased over time. This indicates that any dynamics in the labor market in recent decades are mostly driven by the catch-up of female labor force participation in regions with a low initial level. Turning to the specific performance of the former coal regions compared to all other regions figure 7 illustrates that between 1960 and 1990 the relative position of coal regions in the male employment-population rate decreased considerably and dropped below the countries' average (compare figure 8). Both in 1980 and 2010 coal regions are still below the average. For the females the opposite is true: Whereas in 1960 the former coal regions have a below-average employment-population rate, the relative position is clearly improving over time.

Figure 9 Panel a) to f) compares directly the evolution of the main outcome variables over time for the treatment (Coal regions) and control group (Regions without coal) for males and females separately. The vertical line indicates the timing of the oil invasion- and therefore divides each graph into a pre and post-shock period. Figure 9 panel a) illustrates the rapid decrease in the male employment-population ratios for both coal and non-coal regions over the last 70 years. In 1950 over 90 % of the male working-age population used to be in employment whereas in 2010 this is true for only 75 %. In coal regions the employment-population ratio is higher compared to other regions until 1960, indicating favorable labor market conditions before the crisis. After 1960, a reversal of fortunes takes place as the employment-population ratio starts to drop for coal regions below the level of all other regions they increasingly fall behind. Figure 9 panel b) shows that the female employment-population ratio increases strongly over the same period for all regions. Between 1950 and 1960, the ratio increases only very moderately for both coal regions and all other regions. After 1960 female employment starts to rise much more rapidly for coal

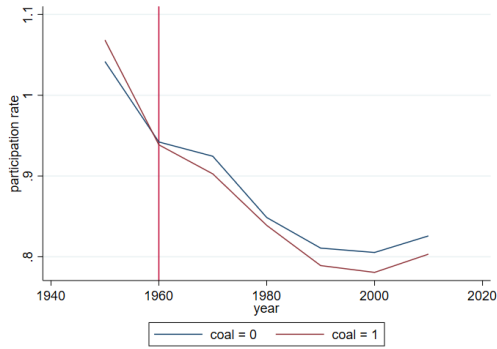
Figure 9: Labor Market Outcomes



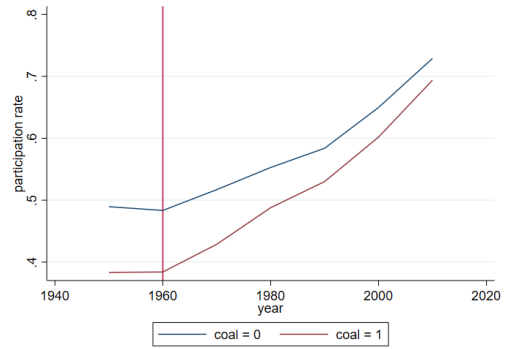
(a) employment-population ratio (male)



(b) employment-population ratio (female)



(c) Participation rate (male)



(d) Participation rate (female)



(e) Employment rate (male)



(f) Employment rate (female)

Notes: Panel (a) to (e) compare the employment-population rate, the participation rate and the employment rate as defined in equations 6 and 8 for regions within the treatment group with an above median exposure (jobs lost in mining > 0.05 %) to all other regions. Sources: See text and data Appendix.

regions, narrowing the gap to all other regions markedly. In 1960 only 45 % (35 % in former coal regions) of all working-age females are in employment, in 2010 the ratio rises to above 60 %. Panel c) and Panel d) highlight that the differences in the employment-population ratios are to a large extent driven by differences in participation rates. Despite the strong convergence in female participation rates after the shock, the levels in former mining regions are still lower today. The lower participation rates of females in mining regions historically and still today are striking. A plausible explanation for this pattern could be that specialization in activities requiring heavier manual work excluded females from the labor market since men had a comparative advantage over women within this sector (Hall (2013)). At the same time, it reduces employment opportunities in other sectors due to the Dutch Disease mechanism (compare Ross (2008)). Panel e) and f) depict the evolution of the employment rates which is here defined as the inverse of the unemployment rate (employment/active population). Both the male and female employment rates are higher in coal regions in 1960 indicating favourable labour market conditions. Starting in 1960, this pattern changes as now the male and female employment rate in coal regions start to fall in relative and absolute terms. The rate falls below the level of all other regions and permanently stays at this lower level.

3 Results

3.1 The effect of the trade shock on aggregate labour market outcomes

In this section, I concentrate on three sets of outcomes following equation 6: Overall employment growth, population growth as well as the ratio of these two. As described above, the employment-population ratio indicates how well labor markets adjust and it serves as a measure for welfare changes. Table 2 shows the effect of jobs lost in the mining industry on employment and population growth as well as the ratio of these two in a stacked first difference approach as specified in equation 4. The first two columns show the estimates for the entire period 1960-2010, whereas columns (3) and (4) provide estimates for the oil import shock (1960-1970) and the coal import shock (1970-2010) separately. A concern to the analysis is that the import-driven decline in mining jobs could be the consequence of prior decline in economic activity rather than the cause of it, or that both are symptoms of a common third cause. In column (5) I conduct the falsification exercise by testing whether future jobs lost in mining, instrumented by future import competition, predict past changes in our main outcome variable. More specifically, I run a regression of the jobs lost in mining between 1960 and 1970, instrumented by the increase in oil imports over the same period, on the changes in employment, population, and the employment-population ratio between 1950 and 1960. The resulting point coefficients for all three variables are not significant, demonstrating that the regions more exposed to the shock

Table 2: Overall response

	Entire period 1960-2010		Sub-period I 1960-1970	Sub-period II 1980-2010	Pre-period 1950-1960
	(1)	(2)	(3)	(4)	(5)
Panel A: Employment					
shock (current period)	-0.697*** (0.145)	-1.953*** (0.462)	-1.322*** (0.455)	-7.432*** (2.449)	
shock (1960-1970)					-0.265 (0.676)
Panel B: Population					
shock (current period)	-0.657*** (0.124)	-1.302*** (0.328)	-0.664* (0.339)	-1.717*** (0.237)	
shock (1960-1970)					-0.625 (0.601)
Panel C: Emp-Pop Ratio					
shock (current period)	-0.040 (0.047)	-0.651*** (0.199)	-0.659*** (0.197)	1.332 (0.894)	
shock (1960-1970)					0.360 (0.260)
controls	✓	✓	✓	✓	✓
Observations	2975	2975	595	2380	594
KP (F-stat)		29.06	24.73	20.01	24.73

Notes: This table reports the β_1 coefficient of jobs lost in equation (4). Columns (1) show the OLS result, whereas (3)-(5) report the IV estimates. For 1950 data is missing for the German state Saarland which reduces the number of observations in column (5) by 7. All regressions include country and time dummies as well as time-invariant first and second nature controls interacted with time dummies and by one decade lagged population density. Models are weighted by the regions' share of the national working-age population in 1960. Robust standard errors in parentheses are clustered on regions.*** indicate significance at the 1 % level, ** at the 5 % level and * at the 10 % level.

starting in the 1960s, were on the same growth trajectory as all the other regions before the shock.

For all three outcomes, the IV estimates (column 2) yield higher results compared to the simple OLS regression (column 1). This indicates that the OLS estimates suffer from an upward bias, probably due to a positive selection into mining as described above. The F statistic is for all periods well above ten indicating that the IV based on the carboniferous strata and the import shock is a relevant IV for the jobs lost in the mining sector. Over the entire period, the shock amounts on average to 0.4 percentage points each decade, with a standard deviation of 1.5 percentage points (compare Table A.2 column (3)). A one standard deviation increase in jobs lost in mining decreases employment growth by $(e^{(-0.70 \cdot 0.015)} - 1 =)$ 1 %. For the IV estimates the implied reduction amounts to $(e^{(-1.96 \cdot 0.015)} - 1 =)$ 3 % each decade. The population grows by 1 % and 2 % less for the OLS and IV estimation respectively during the same period for each standard deviation increase in jobs lost. The population response does not keep up with the employment response and therefore the employment-population ratio is declining. To test the robustness

of the results, I re-run the regression (Panel C, column 2) adjusting the standard errors for serial and spatial correlation. Table A.5 in the Appendix shows how the standard errors change for different distance cut-offs (50-200 km) using Conley standard errors and allowing for autocorrelation within the panel units (with a lag of 2 to 5 decades). Since observations are not weighted by working-age population the negative coefficient becomes larger. The standard errors increase if allowing for correlation across space and time, but leave the significance of the results unchanged.

Columns (3) to (4) display that the effects on employment and population are negative and significant for both sub-periods. The population response - given the employment loss- is however considerably stronger in the second period. In the first period, a one standard deviation increase in shock size translates into a $(e^{(-1.332*0.03)} - 1 =)$ 4.2 % decrease in employment and a $(e^{(-0.664*0.03)} - 1 =)$ 2.2 % lower population growth, leading to 2 % less growth in the employment-population ratio. In the second period, a one standard deviation increase in jobs lost suppresses employment growth by $e^{(-7.432*0.006)} - 1 =$ 4.5 % but leads to a population response of 5.4 %. As a result, the employment-population ratio in the second period is no longer declining - indicating a complete adjustment within ten years. Therefore the decline in the employment-population ratio is entirely driven by the first period 1960-1970.

Table 2, Panel A shows that the net employment loss after ten years exceeds the initial decline in mining jobs in both sub-periods. In the first ten years, the shock therefore did not induce new job creation but rather job destruction in other sectors of the local economy. Table 3 shows to what extent the shock to the mining sector triggered spill-overs to related industries. In the first period, a one standard deviation increase in the exposure to the shock reduces employment in the construction sector by 3 % and in trade and transport services by 4 %. In the second period a one standard deviation increase in the exposure to the shock decreases construction employment by 12 %, employment in trade and transportation by 8 %, and employment in other services by 6 %. Other manufacturing employment remains unaffected. This finding is in line with earlier findings of Black et al. (2005) for the U.S. which also find spillovers to other sectors such as local services.

Finally, in table 4 column (1) - (7) I re-estimate the effect of jobs lost in mining on the employment-population ratio by adding stepwise a range of demographic and labor-market specific controls. Including these variables ensures that the shock is not capturing the impact of some initial characteristics of mining regions that could potentially differ from other regions. Since changes in these variables over time could be directly affected by the shock, I fix all variables to the pre-shock level in 1960. Reassuringly, the point estimate for jobs lost remains negative and highly significant for all specifications and is therefore robust to adding these potential confounders. Column (2) adds the employment share in manufacturing in 1960 (excluding mining), the share of the foreign-born population in

Table 3: Change in industry-specific employment

	(1) agric.	(2) manuf.	(3) constr.	(4) trade and trans.	(5) fin. services	(6) other services
1960-1970						
shock (current period)	-1.787 (1.884)	-0.628 (1.419)	-1.008** (0.470)	-1.327*** (0.357)	-0.414 (0.567)	-0.464 (0.482)
controls	✓	✓	✓	✓	✓	✓
Observations	595	595	595	595	595	595
Regions	595	595	595	595	595	595
KP (F-stat)	24.60	24.60	24.60	24.60	24.60	24.60
1970-2010						
shock (current period)	-9.444 (9.988)	-0.432 (4.635)	-18.402*** (7.125)	-12.320*** (3.727)	-3.679 (4.562)	-10.140*** (3.576)
controls	✓	✓	✓	✓	✓✓	✓
Observations	2380.000	2380.000	2380.000	2380.000	2380.000	2380.000
Regions	595	595	595	595	595	595
KP (F-stat)	19.588	19.588	19.588	19.588	19.588	19.588

Notes: This table reports the β_1 coefficient of jobs lost in equation (4) on log employment growth in six different industries excluding mining. All regressions include country and time dummies as well as time-invariant first and second nature controls interacted with time dummies and by one decade lagged population density. Models are weighted by the regions' share of the national working-age population in 1960. Heteroskedasticity-robust standard errors in parentheses are clustered on regions.*** indicate significance at the 1 % level, ** at the 5 % level and * at the 10 % level.

1960, and the university density in 1945 to the regression. Including these initial characteristics increases the negative effect of job lost in mining on the employment-population ratio slightly. The initial employment share in other manufacturing is added to the regression to address the concern that the observed adverse labor market outcomes are driven by correlated de-industrialization shocks related to other manufacturing industries rather than mining itself. Figure A.3a in the Appendix shows the manufacturing decline (excluding mining) in coal and non-coal regions over time and provides descriptive evidence that there were no major differences in the timing and intensity of decline. Column (1) shows that controlling for confounding de-industrialization shocks increases the negative effect of jobs lost, hinting at the existence of a positive bias. A 1 % point increase in the initial manufacturing employment share depresses the growth in the employment-population rate by 0.05 %. Given that across the entire sample the mean manufacturing rate in 1960 amounts to 37 %, the predicted differential decline in the employment-population ratio is 2 % each decade. Column (2) furthermore adds the share of foreign-born residents to control for confounding changes in the labor supply of a region. A higher share of foreign-born residents could potentially predict stronger future population growth (and employment growth) since new migrants might be attracted to those places where already a large migrant community exists. For this reason, many studies use the location of historical migrant enclaves to build shift-share IVs for migration inflows going back to Altonji and Card (1991) and Card (2001). On the other hand Borjas (2001) and Cadena

and Kovak (2016) argue that labor markets with a high share of foreign-born adjust more smoothly due to a higher mobility which implies a stronger supply elasticity. After World War II, a large number of guest workers were drawn into the expanding Western European economies by bilateral agreements. Depending on the host country these workers came mostly from Mediterranean countries such as Italy and Greece but also from Portugal, Turkey, and North Africa and were employed in low or semiskilled occupations. Between 1960 and 1980 an increasingly large number of guest workers were attracted to work in the mining sector, increasing the share of foreign-born workers both within the mining sector and in the local population. The share of foreign workers employed in mining varies considerably between countries. In Germany, the share amounts to 2 % in 1960, in France to 18 and in Belgium to 42 % (Statistical Office of the European Communities (1975))¹². Accordingly, mining regions in France and Belgium have an above-average share of foreigners in the overall population, whereas in the UK and Germany, it is below average. Column (2) highlights that the foreign rate has a negative, albeit not significant effect on the growth of the employment-population ratio due to the very large standard error. The effect becomes only significant in column (7) when controlling for the initial employment-population rate and education. Column (3) adds controls for the industrial concentration outside of mining as measured with the Herfindahl-Hirschmann-Index (HHI) across six industries outside of mining and the share of self-employed in overall employment. The HHI has a negative but only marginally significant effect on future employment-population rate growth. Interestingly, a higher concentration turns into a positive and significant effect when controlling for initial employment levels and education in column (7). The number of self-employed in overall employment has a strongly positive effect indicating that a more wide-spread entrepreneurial base encourages future employment growth. Column (4) controls for the importance of education and initial human capital levels (compare Fritzsche and Wolf (2023)). Data for the population share with tertiary education is only available for all regions starting in 1970 and might thereby be affected by the shock. The share of the population with tertiary education has a strongly significant positive effect on future growth of the employment-population ratio but reduces the coefficient of interest only very slightly. Surprisingly, the university density in 1945 has a negative effect on the growth of the employment-population ratio. This might be explained by the larger number of students that have reached working age but are not part of the workforce due to ongoing education. Last but not least I control for the effect of unobserved historical shocks by conditioning on the initial employment-population ratio. The employment-population ratio in 1960 has a strong negative effect on the future growth of the same variable, pointing to the strong beta convergence. A one percentage point higher initial

¹²The absolute number of foreign mining workers increased further between 1960 and 1965, whereas the absolute number of workers was falling. This furthermore increased the share of foreign workers in mining to 7 % in Germany, 22 % in France, and 51 % in Belgium.

Table 4: Employment-population response (1960-2010)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
shock	-0.651*** (0.199)	-0.676*** (0.180)	-0.624*** (0.173)	-0.604*** (0.173)	-0.906*** (0.224)	-0.858*** (0.218)	-0.920*** (0.227)
emp(%) in manuf 1960		-0.051*** (0.008)	-0.037*** (0.013)	-0.037*** (0.013)	-0.026*** (0.009)	-0.028*** (0.011)	-0.026*** (0.009)
pop (%) foreign 1960		-0.026 (0.039)	-0.038 (0.040)	-0.042 (0.045)	-0.073** (0.037)	-0.070** (0.034)	-0.075** (0.036)
hhi1960			-0.041* (0.024)	-0.028 (0.023)	0.034* (0.019)	0.028 (0.020)	0.038** (0.019)
selfemprate1960			0.082*** (0.022)	0.081*** (0.019)	0.023 (0.021)	0.217*** (0.019)	0.072*** (0.026)
unidensity 1945				-0.010*** (0.002)	-0.004** (0.002)	-0.001 (0.002)	-0.003 (0.002)
pop(%) coll degr 1970				0.243*** (0.052)	0.196*** (0.047)	0.161*** (0.051)	0.182*** (0.047)
emp-pop rate 1960					-0.295*** (0.033)		-0.238*** (0.037)
female part rate 1960						-0.147*** (0.017)	-0.041*** (0.016)
controls	✓	✓	✓	✓	✓	✓	✓
Observations	2975	2975	2970	2970	2970	2970	2970
Regions	595	595	594	594	594	594	594
R	0.68	0.69	0.69	0.70	0.70	0.70	0.70
KP (F-stat)	29.06	31.78	30.07	28.98	24.21	24.20	23.77

Notes: This table reports the β_1 coefficient of jobs lost in equation (4). Column (1)- (7) report the IV estimates. All regressions include country and time dummies as well as time-invariant first and second nature controls interacted with time dummies and by one decade lagged population density. Models are weighted by the regions' share of the national working-age population in 1960. Column (3) to column (7) miss one observation, the British county of Portsmouth (UKJ31), due to missing data on self-employment. Heteroskedasticity-robust standard errors in parentheses are clustered on regions.*** indicate significance at the 1 % level, ** at the 5 % level and * at the 10 % level.

employment-population ratio implies a differential employment-population rate decline of 0.30 % over the subsequent decade. Controlling for the initial employment-population ratio augments the negative effect of the shock. Coal regions have on average a lower employment-population ratio in 1960 which is entirely driven by the lower female participation rate (compare table A.3 in the Appendix). Section 3.4 will show that the recovery of the employment-population rate is driven by the expansion of the female labor supply. Hence, adding the female participation rate in 1960 directly into the equation increases the negative effect of the shock on the growth rate of the employment-population ratio.

3.2 Heterogeneity in the population response

In the following section, I am going to investigate the heterogeneity in the population response across different subgroups. This is interesting for three reasons. First, if the subgroups that are more affected by the shock respond less, labor markets are less quick to adjust (Cadena and Kovak (2016)). Second, if mobility varies along socio-demographic

Table 5: Heterogeneous population response

	(1) pop	(2) pop (15 – 65)	(3) pop (< 15& > 65)	(4) foreign	(5) native	(6) without college	(7) with college
1960-1970							
shock	-0.553 (0.370)	-0.514 (0.391)	-0.657* (0.371)	-0.153 (2.368)	-0.097 (0.412)		
controls	✓	✓	✓	✓	✓		
Observations	594.000	594.000	594.000	592.000	592.000		
Regions	594	594	594	594	594		
KP (F-stat)	28.142	28.142	28.142	27.350	27.350		
1970-2010							
shock	-10.553*** (2.261)	-11.162*** (2.222)	-9.062*** (3.160)	-19.917*** (6.393)	-9.059*** (2.028)	-4.849** (2.147)	-30.251*** (9.461)
controls	✓	✓	✓	✓	✓	✓	✓
Observations	2376	2376	2376	2376	2376	2376	2376
Regions	594	594	594	594	594	594	594
KP (F-stat)	22.24	22.24	22.24	22.24	22.24	22.24	22.24

Notes: This table reports the IV β_1 coefficient of jobs lost in equation 4. All regressions include country and time dummies as well as time-invariant first and second nature controls interacted with time dummies, by one decade lagged population density as well as the employment share in manufacturing in 1960. Models are weighted by the regions' share of the national population in 1950. All regressions exclude the county of Portsmouth (UKJ31) due to the missing population share in 1950. Heteroskedasticity-robust standard errors in parentheses are clustered on regions.*** indicate significance at the 1 % level, ** at the 5 % level and * at the 10 % level.

dimensions, the change in the composition of the population affects productivity differentials. If for example, the high skilled and working-age population is more likely to migrate, leaving the less educated behind, the average productivity of a region declines. Third, selective migration has important distributional consequences. Those that stay behind bear the incidence of the shock and inequality between groups increases. Due to the lack of data, I follow the indirect migration approach as often used in the literature. It is therefore beyond the scope of this paper to investigate whether this population response is due to increased outflows of population from affected areas or a decline of (internal) inflows. However, there is a growing body of evidence for the U.S. that migratory responses to local shocks tend to be driven by diverted in migration rather than increased out-migration (compare Monras (2018), Dustmann et al. (2017) and Amior (2021)).

Table 5 shows the population response to the oil import shock (1960- 1970) and the coal import shock (1970-2010) separately for different demographic subgroups. Results differ slightly from the ones presented in table 2 because as additional control the share of manufacturing employment in 1960 is used and regressions are weighted by the region's share in the national population as of 1950 instead of the working-age population. Columns (2) and (3) show that in the second period, the reaction of the working-age population is considerably larger than for the non-working-age population, whereas in the first period,

the reverse is true. A one standard deviation increase in the exposure to the coal import shock decreases non-working-age population growth by $e^{(-9.062*0.006)} - 1 =$ or 5,6 % and working-age population by 6.9 %. Between 1960 and 1970 a standard deviation increase in jobs lost in mining leaves the working-age population unaffected and decreases the non-working-age population by $e^{(-0.657*0.0295)} - 1 =$, by 2%.

Columns (4) and (5) highlight that between 1970 and 2010 the population adjustments are driven by both the native population and the foreign population. The response of the foreign population is however substantially stronger: a one standard deviation increase in shock exposure reduces the foreign population by 13 % and the native population by 5 %. Since the average share of foreigners is only 8% in 1970 increasing to 11% in 2010 (compare Figure A.3b in the Appendix), the strong population response is still to a large extent driven by the native population. The stronger propensity to migrate for the foreign population is still striking and stresses the important role of immigration in the efficient adjustment of labor markets. The findings are also in line with evidence previously presented for the U.S. (compare Cadena and Kovak (2016), Autor et al. (2021) and Amior (2021). Cadena and Kovak (2016) for example finds that the migration response to labor demand shocks in the U.S. during the Great Recession is strongest among low-skilled Mexican workers. Amior (2021) finds that new immigrants account for 40 % of the population adjustments to labor demand shocks across the U.S. regional labor markets, but at the same time crowd out the mobility response by natives.

Columns (6) and (7) differentiate the population response by the educational level of the (adult) population. Population growth declines more strongly for the educated population. A one standard deviation increase in the exposure to the coal shock decreases the growth of the population with a college degree by $e^{(30.251*0.006)} - 1 =$ 20 % whereas the population without a college degree grows only 3 % less. The finding that lower educated workers are less likely to respond to an adverse shock is in line with the finding by Bound and Holzer (2000) and Notowidigdo (2020) for the U.S.¹³ Evidence provided for the China shock on the other hand points at a stronger mobility response by the young male and uneducated population (Greenland et al. (2019)). This paper finds that the group most exposed to the shock, i.e. miners without a college degree, are less responsive than less exposed groups. This supports the descriptive evidence provided by Hollywood (2002). Focusing on the migration decision of miners in the UK, she finds that they have a much lower migration propensity compared to the rest of the population. There might be several reasons why miners do not migrate despite being affected by shocks. Next to the high economic costs of moving and poor employment prospects in other industries, generous

¹³Bound and Holzer (2000) more carefully analyze the population response to demand shocks and find that lower educated as well as black workers are less likely to move due to higher migration costs. Notowidigdo (2020) offers an alternative explanation for the lower mobility response of low-skilled workers: He finds that low-skill workers are disproportionately compensated during adverse labor demand shocks, rather than facing higher out-migration costs.

Table 6: Decomposition of labor market adjustments during the oil shock (1960-1970)

	(1)	(2)	(3)	(4)	(5)
	$\Delta \ln emp$	$\Delta \ln pop$	$\Delta \ln emp pop rate$	$\Delta \ln emp rate$	$\Delta \ln partrate$
Panel A: Full sample					
shock	-1.405*** (0.522)	-0.720* (0.415)	-0.686*** (0.186)	-0.244*** (0.093)	-0.442*** (0.116)
Panel B: Male sample					
shock	-1.736*** (0.556)	-1.160** (0.452)	-0.576*** (0.196)	-0.242*** (0.092)	-0.334*** (0.114)
Panel C: Female sample					
shock	-0.756 (0.562)	-0.277 (0.410)	-0.479 (0.312)	-0.347*** (0.133)	-0.133 (0.220)
controls	✓	✓	✓	✓	✓
Observations	595.000	595.000	595.000	595.000	595.000
KP (F-stat)	28.031	28.031	28.031	28.031	28.031

Notes: This table reports the IV β_1 coefficient of jobs lost in equation 4. All regressions include country and time dummies as well as time-invariant first and second nature controls interacted with time dummies, by one decade lagged population density as well as the employment share in manufacturing in 1960, the share of foreign population in 1960 and the university density in 1945. Models are weighted by the regions' share in the national working-age population in 1960. Heteroskedasticity-robust standard errors in parentheses are clustered on regions. *** indicate significance at the 1 % level, ** at the 5 % level and * at the 10 % level.

compensation mechanisms or a strong attachment to the local community could be important. The finding that high skilled working-age population displays a higher propensity to move thereby reducing the skill level in the local labor market implies that next to employment also productivity levels are affected. Skilled-biased migration contributed to the decline in mining regions and therefore supports the argument made by Fritzsche and Wolf (2023).

3.3 Decomposition results: gender-specific outcomes

We have seen in Table 2 that the employment-population ratio decreases in the first period and has no additional effect in the second period despite both a strong employment and population response. The next section discusses in more detail the mechanisms of adjustment with a special emphasis on differences in outcomes based on gender. The shock was gender-specific as it only affected the male labor market directly. The share of female employees in the coal sector was negligible. Hence, we expect that the adverse labor market outcomes at the aggregate level should be driven by the male labor force. The effect on the female labor market is from a theoretical standpoint a priori unclear and depends on subsequent changes both on the demand and supply side of female labor.

The descriptive statistics presented above indicate that Coal mining regions had especially low female participation rates in 1960. The mining sector itself - like other

Table 7: Decomposition of labor market adjustments during the Coal shock (1970-2010)

	(1)	(2)	(3)	(4)	(5)
	$\Delta \ln emp$	$\Delta \ln pop$	$\Delta \ln emp \cdot poprate$	$\Delta \ln emprate$	$\Delta \ln partrate$
Panel A: Full sample					
shock	-7.822*** (2.214)	-9.172*** (1.778)	1.350 (0.890)	-0.394 (0.817)	1.744* (0.985)
Panel B: Male sample					
shock	-10.634*** (2.579)	-9.379*** (1.895)	-1.255 (0.925)	0.732 (0.700)	-1.988** (0.946)
Panel C: Female sample					
shock	-3.105 (2.021)	-9.017*** (1.688)	5.912*** (1.405)	-1.714 (1.124)	7.626*** (1.845)
controls	✓	✓	✓	✓	✓
Observations	2380.000	2380.000	2380.000	2380.000	2380.000
KP (F-stat)	26.064	26.064	26.064	26.064	26.064

Notes: This table reports the IV β_1 coefficient of jobs lost in equation 4. All regressions include country and time dummies as well as time-invariant first and second nature controls interacted with time dummies, by one decade lagged population density as well as the employment share in manufacturing in 1960, the share of foreign population in 1960 and the university density in 1945. Models are weighted by the regions' share in the national working-age population in 1960. Heteroskedasticity-robust standard errors in parentheses are clustered on regions. *** indicate significance at the 1 % level, ** at the 5 % level and * at the 10 % level.

heavy and manual industries - required very challenging manual work, making it less attractive for the female part of the population to enter this sector. At the same mining used to be well paid, reducing the incentive for women married to miners to enter the labor market (Hall (2013)). Due to the Dutch disease mechanism, specialization in mining might additionally lead to a crowding out of economic activity in other sectors with higher female employment (Ross (2008)). The sudden and very rapid decline in the mining sector challenged the prevalent male breadwinner model within affected regions. The "added worker effect", going back to the seminal work by Mincer (1962) and Lundberg (1985), suggests that women increase their labor supply in reaction to the men struggling in the labor market in order to smooth consumption within the household. This mechanism is of course not restricted to married couples but might also apply to other female dependents. Hence, in response to the shock, females could react by entering the labor market as secondary workers thereby shifting the female labor supply outwards. We should, however, expect female employment to decline in response to the shock in the presence of positive spillover effects that reduce the labor demand in related industries with a high female employment share. In addition, increased labor market tightness i.e. oversupply of labor for the given demand, could lead to a crowding-out of female labor from the few remaining job opportunities. If labor demand is biased towards the male labor force due to limited substitutability between male and female labor or differential gender norms this becomes more likely.

Table 6 and table 7 decompose the overall labor market outcomes presented above by splitting the working-age population into subgroups based on gender. The overall effects on employment and population are therefore the group size-weighted average of the outcomes of the female and male subgroups. We can see that the share of males in the working-age population is plotted in figure A.2 in the appendix. The share of males in the working-age population over time is stable at 50 % level. Therefore, the relative contribution is driven by the strength of the reaction rather than by group-size changes.

We first concentrate on the outcomes for the male working-age population- which is the group directly exposed to the shock. Table 6, Panel B shows the effect of jobs lost on the labor market outcomes for the male population between 1960 and 1970 following the full decomposition in equation 9. In the first period, the negative employment response is substantially larger than the population response, indicating a very sluggish adjustment. A region experiencing a one standard deviation increase in jobs lost faces in the next decade a 5.3 % larger employment decline, whereas the population grows by 3.5 % less. As a result, the employment-population ratio declines by 1.8 % more. The decrease of this ratio could be either driven by lower participation rates indicating that fewer working-age men are willing to participate in the labor market or by a lower employment rate indicating that for those that are willing, there is not a sufficient number of jobs. Column (4) and (5) decomposes the employment-population ratio in its two components, indicating that results are driven almost equally by a stronger decline in the employment rate and the participation rate. Table 7 Panel B focuses on the second subperiod. In the second period, there is an additional net employment loss: a one standard deviation increase in the exposure to the coal import shock leads to a differential employment growth of 7 % and a differential population growth of 6 %. The effect on the employment-population rate is negative, albeit not statistically significant. Interestingly, the participation rate continues to decline, whereas the employment rate remains unchanged. This shows that in line with the discouraged worker effect, male working-age men exit the labor market in response to the depressed labor market conditions rather than becoming unemployed. The distribution of early retirement packages to miners might furthermore increase the exit rate.

Table 6 Panel C analyses the effect on the female labor market. Between 1960 and 1970 there is a negative effect on female employment growth, population growth, and employment-population ratio, albeit not being statistically significant. Nonetheless, the labor market is deteriorating for the female working-age population as there is a statistically significant reduction in the growth of the employment rate. This reduction is even larger compared to the male one hinting at a biased labor demand towards male employment and a crowding out of females from the remaining positions. In the second subperiod, there is still no significant negative employment response for working-age fe-

males. At the same time, there is a substantial population response that matches the male one. As a result, there is a strong positive effect on the female employment-population ratio. A one standard deviation increase in the shock size leads to a 4 % decadal growth in the employment-population ratio. The strong population response of females, despite not being directly affected, could indicate that females are more responsive compared to men towards adverse labor market conditions. The more likely explanation is that moving is a decision made by households rather than individuals. Due to the lack of microdata, it is beyond the scope of this paper to assess the interdependence of decision-making within households. At the same time, the female participation rate increases by 5 %, indicating that of the remaining working-age women a growing share enters the workforce and takes up employment. This evidence is supportive of the added worker effect outlined above. The labor market now absorbs the additional female employment as the employment rate is unaffected. Thus, whereas the decline of the employment-population ratio between 1960 and 1970 is entirely driven by the male segment of the labor market, the recovery thereafter is driven by the female one. On the male labor market, the employment loss exceeds the population adjustments in both periods. In the second period, the expansion of female labor supply paired with the strong female population response compensates for the loss of male employment.

3.4 Dynamic response: Are the outcomes persistent?

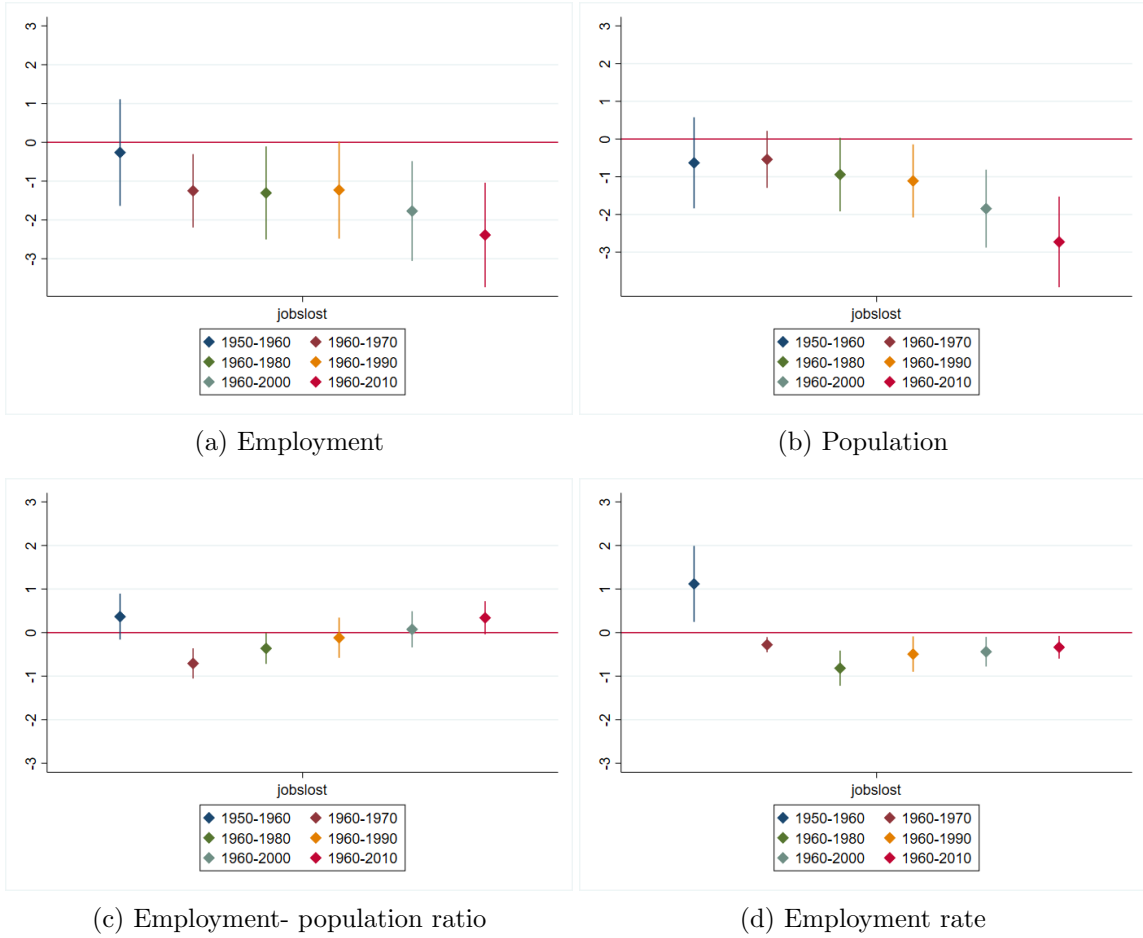
This section uses specification 5 to test the impact of the decline in mining jobs in the long run. As plotted in figure 5b the trade shock was most pronounced between 1960-1970 and continued to increase very gradually until 2000 and reaches a plateau thereafter. By extending the time period of analysis to 2010, outcomes can be observed one decade after the shock reached full intensity. Thus, I estimate how the cumulative shock between 1960 and 2000 affect the labor market outcomes between 1960 and 2010. Figure 10 displays the cumulative effects for each decade for employment growth, population growth, and the change in the employment-population ratio. Each panel shows seven different regressions for successively longer periods. The vertical bars indicate the 95 % confidence interval for each point estimate. The first point estimate shows the effect of the cumulative shock on the changes in outcomes between 1950 and 1960, the decade prior to the shock, and therefore tests for the existence of differential pre-trends. Figure 10c shows the effect on the employment-population ratio, indicating how rapid and to what extent the population reacts to employment changes. Before the shock, the treatment and control group are on the same growth trajectory. Between 1960 and 1970 the estimated impact of the shock on the employment-population ratio is turning negative to -0.7. Over the subsequent decades, however, the point estimates return to zero indicating that the labor market adjustment is completed within 30 years after the initial shock. After an initial sluggishness, the

population response is slowly catching up and is fully compensating for the employment loss. Regions that experienced a one standard deviation increase in shock exposure between 1960 and 2010 display a 10 % lower employment growth and 11 % lower population growth until today (compare Figure 10a and 10b). As shown by Amior and Manning (2018), the change in the employment-population ratio is in equilibrium a sufficient statistic to approximate changes in real income. Hence, from an aggregate perspective, this indicates that there are no persistent adverse effects on welfare. The equalization of the employment-population ratio looking at the aggregate labor market is not reflected by a recovery of the employment rate. Equalization happens despite persistently higher unemployment growth (compare figure 10d). In the pre-period, between 1950 and 1960, the employment rate grew more strongly compared to all other regions, between 1960 and 1970 however the trend reversed itself. The estimated impact on the employment rate is -0.3 between 1960 and 1970 and then increases to -0.8, before slowly attenuating back to -0.3 in 2010. A one standard deviation increase in shock exposure between 1960 and 2010 therefore depresses the growth rate of the employment rate by 1.4 %.

Due to compositional changes in the labor force, there are strong long-term effects for the different subgroups, implying important distributional consequences. Figure 11 depicts the effect of the shock on the male and female employment-population ratio as well as the male-female employment gap. Figure 11a illustrates that the male labor force experiences a persistent decline in the employment-population ratio in response to the shock. The estimated impact of the shock amounts to -0.6, reaches a slump between 1970 and 1980 with -0.8, and then slowly attenuates to -0.5 until 2010. A one standard deviation larger exposure to the shock between 1960 and 2010, depresses growth in the male employment-population ratio by 2 % until 2010. For the average coal region, the employment-population ratio therefore declines by 4 % more compared to all other regions until 2010. Hence, for the group most affected - the male labor force - there has never been a full recovery from the shock and the adverse impact on the labor market is still visible today. To gauge the overall economic magnitude of the effect, I do a simple back-of-the-envelope calculation comparing the shock-induced reduction in the male employment-population rate to the observed reduction between 1960 and 2010. The employment-population rate declines across all regions on average by 17 % over this period. As the average exposure to the cumulative shock across all regions amounts to 2 percent (compare Table A.2), the predicted shock-induced decline amounts to 1 % and thus explains 6% of the overall decline nationally.

Figure 11b shows that the opposite is true for the female labor market. There is a large positive effect on the female employment-population rate that becomes stronger and more significant over time. As discussed in the previous section, the increase of the female employment-population ratio increasingly compensates for the persistent decline of the male one and results in the equalization of employment-population growth rates between

Figure 10: Testing for persistence



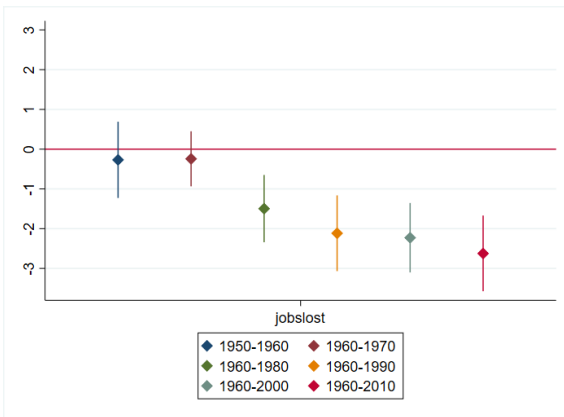
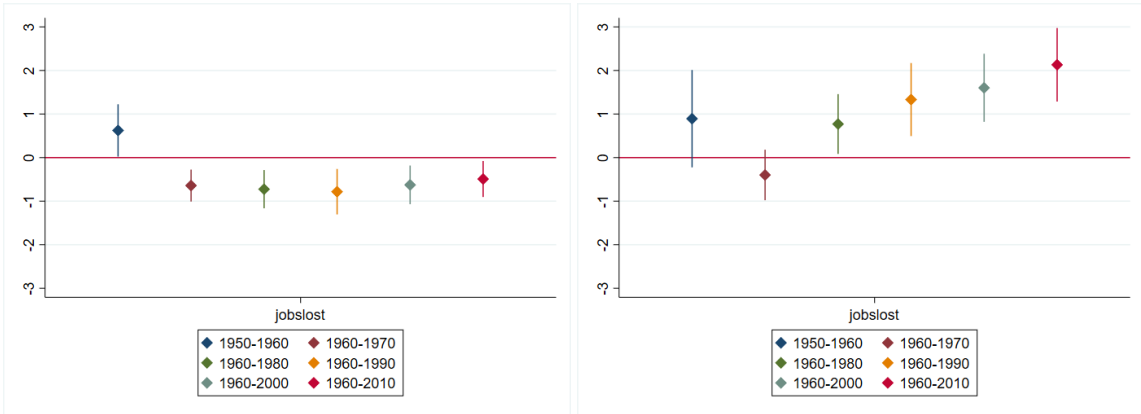
Notes: This figure reports the IV β_1 coefficients of jobs lost in equation 5 and their 95 % confidence-intervals. All regressions include country dummies as well as time-invariant first and second nature controls, by one decade lagged population density as well as the employment share in manufacturing in 1960, the share of foreign population in 1960, and the university density in 1945. Models are weighted by the regions' share in the national working-age population in 1960. The regression output is given in the Appendix Tables A.6 - A.10.

treated and non-treated regions as early as 1990. A one standard deviation increase in the exposure to the cumulative shock leads to a 9 % stronger growth of the employment-population ratio between 1960 and 2010. For the average coal region, the employment-population ratio therefore increases by 18 % more compared to all other regions until 2010. Over the entire period, the female employment-population rate grew by 42 %. Thus, the shock investigated in this paper can account for roughly 10 % of the overall increase. Figure 11c directly illustrates how the employment composition changes over time in response to the shock. The figure shows the estimated effect of the shock on the male-female employment gap measured as the ratio of the male to the female employment rate. The employment gap closes considerably faster for former mining regions. A one standard deviation larger increase in the exposure to the shock reduces the gap by 11 % more. Interestingly, the effect continues to grow over time, indicating that the adjustment is not yet completed.

How does the impact of the shock studied here compare to the estimates provided for the China shock in the U.S.? In a very similar specification to equation 5, Autor et al. (2021) test for the persistence of the China shock by extending the analysis done by Autor et al. (2013) by one decade to 2019. They find that ten years after the shock reached its peak intensity in 2019, the impact estimate for the wage and salary employment rate persists at -1.74 (Autor et al. (2021), Figure 5c). Thus, a one standard deviation increase in import penetration of 0.59 (Autor et al. (2021), Table 1) decreases the employment-population rate by 1.03 %age points after 20 years. Interestingly, there is no significant negative effect within the first decade. As described above, I find that that a one standard deviation increase in jobs lost decreases the employment-population ratio by 2.8 % after ten years and 1.6 % after 20 years which equals a decline of 1.8 and 1.04 %age points respectively. Thus, after 20 years the effect of both shocks are strikingly similar in size. The definition of the employment-population rate in Autor et al. (2021) differs from the one used here as they exclude the employment effects on all self-employed. This should be, however, of no major importance in this context, as the wage and salary employees are the ones affected by the lay-offs. The other main difference is that in the context of the China shock, both male and female workers are affected and therefore they do not account for gender-specific responses. Comparing their estimates to the response I measure on the male labor market only shows that the energy import shock has a stronger and more lasting impact in the context of Western Europe. I find that a one standard deviation increase in jobs lost decreases the male employment-population ratio by 2 % which equals a decline of 1.78 %age points. Thus, for the male population, the effect is 60 % larger compared to the China shock.¹⁴ Interestingly, in the U.S., there is no statistically significant population

¹⁴In the same paper Autor et al. (2021) compare the China shock to the decline in mining jobs between 1980 and 2000 in the U.S. extending the analysis of Black et al. (2005). They find for the U.S. a negative and significant effect on the wage and salary employment rate after 20 years: an average exposure to the

Figure 11: Testing for persistence: Males vs. Females



Notes: This figure reports the IV β_1 coefficients of jobs lost in equation 5 and their 95 % confidence-intervals. All regressions include country dummies as well as time-invariant first and second nature controls, by one decade lagged population density as well as the employment share in manufacturing in 1960, the share of foreign population in 1960, and the university density in 1945. Models are weighted by the regions' share in the working-age population in the national working-age population in 1960. For panels (a) and (b) the regression output is given in the Appendix tables A.6 - A.10.

response to the China shock. Hence, the effect on the employment-population ratio in Europe is stronger despite a substantial population response.

4 Conclusion

The decline of the mining industry starting in the late 1950s marked the beginning of the de-industrialization in Western Europe. The decline was triggered by the feasibility of importing cheaper energy substitutes and led to a permanent shift in economic activity across space. After initial sluggishness, the negative population response to the shock is

shock of 0.22 percentage points yields a decline of the employment-population rate by 0.11 percentage points. After 30 years the adjustment is completed as there is no longer any statistically significant effect on the employment-population ratio. Hence, the effect in the U.S. amounts to only a fraction of the one in (Western-)Europe due to both the lower average shock intensity and the lower impact coefficient.

sufficiently large to catch up to the employment response. As a consequence, 30 years after the initial oil shock the employment-population rate is no longer growing at a differential pace in former coal regions compared to all other regions. Against the theoretical backdrop of spatial equilibrium models, this indicates a return to the equilibrium as the growth path of welfare levels is equalized across space. However, and this a main finding of this paper, the adjustment at the aggregate level hides important differences across groups. The male working-age population, being the group most affected by the shock, suffers from persistent joblessness. The male employment-population rate in former mining regions has declined by 4 % more compared to all other regions from 1960 until 2010. This is driven both by a decline in the male participation rate and a rise in the unemployment rate. This points to a misallocation of male labor across space resulting in a potential reduction of aggregate output. Furthermore, recent research suggests that economic distress in the male labor market entails high social and political costs. On the contrary, for the female working-age population the shock turned out to be beneficial in the long run. The decline of the mining industry initiated a strong catching-up process for female employment, closing the initial large employment gap between males and females in these regions. After the shock, the female employment-population ratio increased 18 % more strongly for former coal regions compared to other regions. The increase in female labor force participation fully compensated for the loss in the male employment-population ratio in the long run. The very strong response of the female participation rate in response to the deteriorating situation on the male labor market hints at the importance of the added worker effect. It would be worthwhile for future research to investigate whether increased female employment share translates into higher income and female empowerment along other dimensions.

Can we therefore conclude that the adjustment was successful at the aggregate level redistributing welfare from the male to the female working-age population? This is not the case if the compensating effect of female labor force participation observed at the aggregate level does not apply to the household level. Due to the lack of microdata that is unfortunately not available for the time frame and scope of the analysis, this study focuses on individual outcomes. It does not account for the household as a utility-maximizing unit. labor market decisions of individuals within households depend on each other. Therefore, future research using microdata is needed to shed light on compensating mechanisms within households. Next, it is important to keep in mind that the employment-population ratio is measured at the extensive margin and therefore does not take into account the number of hours worked. The share of female employment increased more strongly in coal regions and females exhibit a higher propensity to work in part-time employment. Using hours worked as a measure would most likely amplify the differences between treated and non-treated regions. Related to this, the type of employment and sector of activity of the remaining jobs matter for the productivity and wage growth of

a region. In a companion paper by Fritzsche and Wolf (2023), we find persistent lower growth rates in GDP per capita for former mining regions. Given that this paper finds an equalization of employment-population rates, differences in income must be driven by growing productivity differentials measured as the output per worker. Despite the large population response at the aggregate level, the heterogeneity in the population response shown in this paper has important compositional consequences. The younger and more skilled move away from affected regions, leaving the rest behind. Skill-biased migration amplifies productivity differentials between regions whereas the costs of adjustment within regions are disproportionately paid by the (male) low-skilled population that is comparably immobile.

The topic of de-industrialization has recently gained new attention as industrialized economies face the challenge of adapting to a new energy transition away from fossil fuels towards renewable energies. The mechanisms of labor market adjustments shown in this paper are informative for the expectations of future adjustments. Similar to other de-industrialization or globalization shocks studied previously, former mining regions differ from other regions as they exhibit lower human capital, a higher population density, and, most importantly, a lower female participation rate. Nonetheless, the findings remain robust when controlling for these initial characteristics. The strong persistence in economic outcomes as highlighted in this paper stresses the importance of implementing policies that aim to reduce the impact on spatial inequality. Based on the findings presented here, the following policy implications can be derived: First, mobility between places in Europe is still a large equalizing force. To facilitate a more rapid adjustment, especially for the low-skilled, barriers to migration such as limited housing supply or information deficits should be removed. Second, activating unused labor force potential is crucial for alleviating the negative consequences of economic transitions. Albeit being quantitatively of less importance in the future, there is still room for further expansions of the female labor force. Additionally, this can be extended to other marginalized groups within the labor force such as migrants. Last but not least, the groups most affected by the job loss should be targeted with qualifying measures to ease job transition. Market forces are likely not strong enough to allocate work efficiently across space. The longer it takes for an economy to adjust, the higher the adjustment costs.

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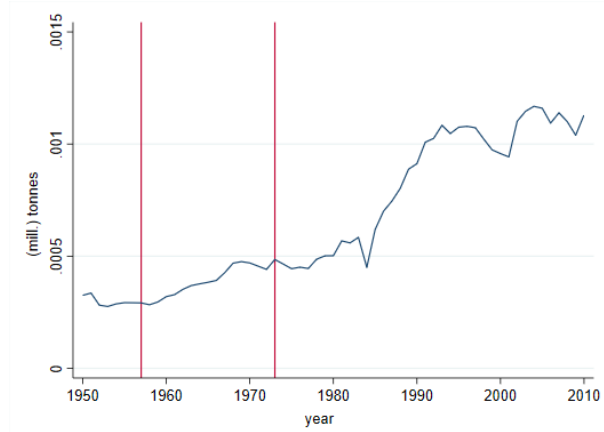
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Appendix

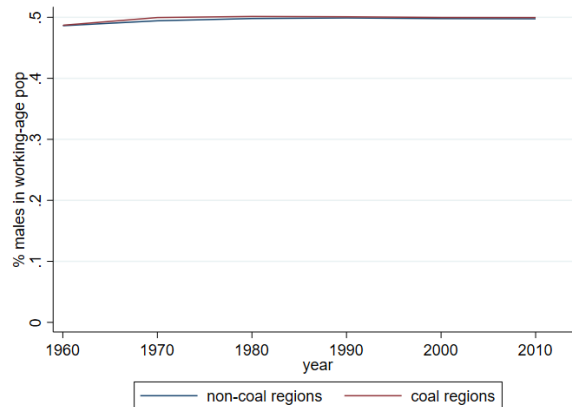
A Figures and Tables

Figure A.1: Output per worker



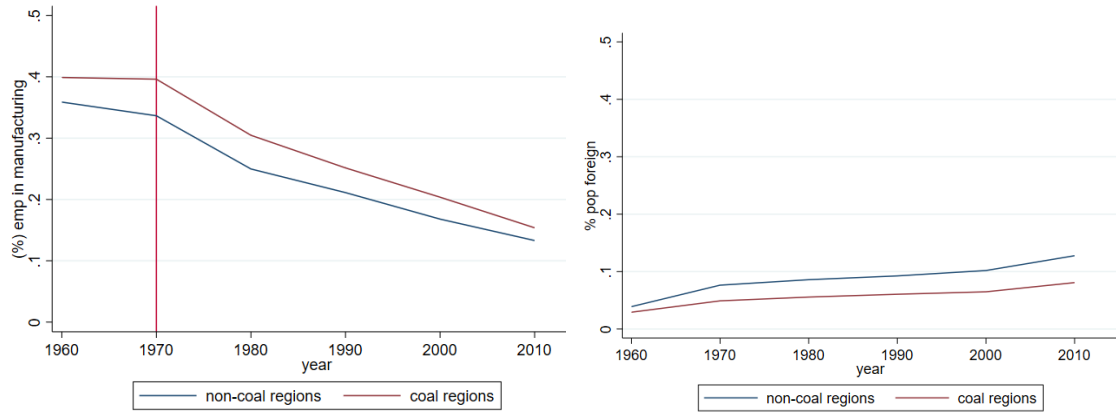
Notes: This figure depicts the output per worker, defined as the national coal production divided by the number of workers, for Belgium, France, the UK, and (West-)Germany between 1950 and 2010. Sources: See data Appendix.

Figure A.2: Male share in working-age population



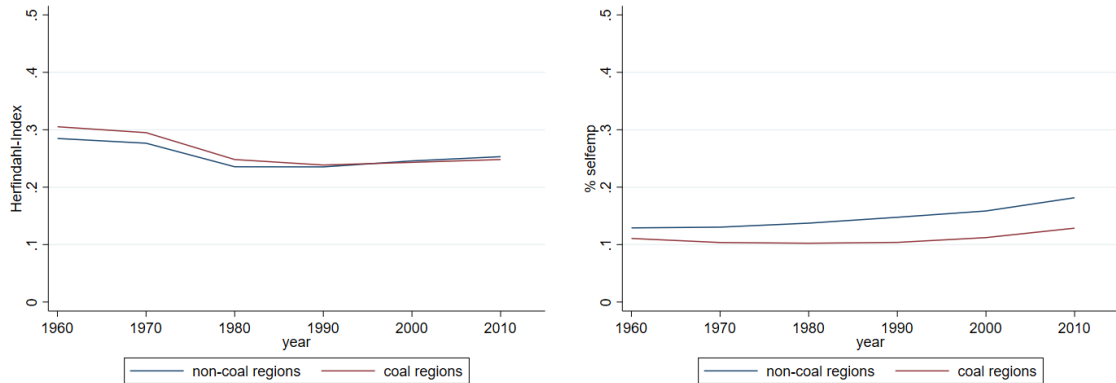
Notes: This figure depicts the share of the males in the overall working-age population between 1960 and 2010 for the treatment group (coal regions, N=168) and the control group (Non-coal regions, N= 427). Sources: Census data, see data Appendix.

Figure A.3: Main Control variables



(a) Manufacturing decline

(b) Foreign population



(c) Industry concentration

(d) Self-employment

Notes: Panel (a)- (d) depicts the share of manufacturing employment in over all employment, the share of foreign population in overall population, the industry concentration outside of mining as measured with the Herfindahl-Index and the share of self-employed in overall employment between 1960 and 2010 for the treatment group (coal regions, N=168) and the control group (Non-coal regions, N= 427). Sources: Census data, see data Appendix.

Table A.1: Relationship between initial characteristics and the shock exposure

	(1) miningshare1950	(2) Bartikum	(3) installcum	(4) installcarb cum
pop (%) foreign 1960	0.175 (0.151)	0.039 (0.129)	0.018*** (0.007)	-0.004 (0.004)
emp(%) in manuf 1960	-0.196*** (0.051)	-0.112*** (0.031)	-0.003** (0.001)	-0.002 (0.002)
hhi1960	0.305*** (0.089)	0.204*** (0.057)	0.005** (0.002)	0.007** (0.004)
selfemprate1960	0.115 (0.076)	0.114** (0.052)	0.003* (0.002)	0.002 (0.002)
selfownedrate1960	-0.079 (0.049)	-0.085** (0.041)	0.000 (0.001)	-0.000 (0.001)
pop(%) coll degr 1970	-0.928*** (0.209)	-0.569*** (0.170)	-0.027*** (0.008)	-0.009** (0.005)
unidensity 1945	0.006 (0.009)	0.004 (0.007)	0.000 (0.000)	0.000 (0.000)
female partrate 1960	-0.486*** (0.049)	-0.364*** (0.039)	-0.013*** (0.002)	-0.007*** (0.002)
urban	0.022*** (0.008)	0.016*** (0.006)	0.001** (0.000)	-0.000 (0.000)
controls	✓	✓	✓	✓
Observations	569.000	569.000	569.000	569.000
R	0.460	0.444	0.421	0.164

Notes: This table reports the coefficients of running a simple OLS regression of the different shock measures on initial characteristics. Column (1) is the employment share in mining in 1950, column (2) refers to the shock as defined in equation 1, column (3) to equation 2 and column (4) to equation 3. Heteroskedacity-robust standard errors clustered at the level of observations are reported in parentheses. Regressions are weighted by the regions' share of national working-age population in 1960.

Table A.2: Descriptive statistics shock size

	(1) Oilshock (1960-1970)	(2) Coalshock (1970-2010)	(3) Av. shock (1960-2010)	(4) Cumm. shock (1960-2010)
All regions				
Bartik	0.0141 (0.0295)	0.0024 (0.00639)	0.0047 (0.0151)	0.0242 (0.0498)
installcarb	0.0636 (0.180)	0.0019 (0.00787)	0.0142 (0.0843)	0.0712 (0.202)
N	595	2380	2975	595
Mining regions				
Bartik	0.0479 (0.0366)	0.0081 (0.00961)	0.0161 (0.0244)	0.0822 (0.0607)
installcarb	0.1576 (0.285)	0.0048 (0.0124)	0.0354 (0.142)	0.1769 (0.320)
N	168	672	840	168

Notes: This table reports the mean and standard deviation (in parentheses) for the shock as defined in equation 1 and the IV as defined in equation 3 for different sub-periods. Statistics are weighted by the regions share of national working-age population in 1960.

Table A.3: Descriptive statistics initial characteristics

	(1)	(2)
	Non-coal regions	Coal regions
pop (%) foreign 1960	0.0389 (0.0340)	0.0293 (0.0308)
hhi1960	0.2848 (0.0585)	0.3053 (0.0567)
selfemprate1960	0.1291 (0.0604)	0.1107 (0.0541)
selfownedrate1960	0.2052 (0.154)	0.1830 (0.139)
pop(%) coll degr 1970	0.0532 (0.0320)	0.0427 (0.0248)
unidensity 1945	0.2613 (0.459)	0.1375 (0.211)
emp-pop rate 1960	0.6670 (0.0570)	0.6301 (0.0572)
female emp-pop rate 1960	0.4569 (0.0809)	0.3844 (0.0758)
male emp-pop rate 1960	0.8880 (0.0687)	0.8878 (0.0658)
female participation rate 1960	0.4846 (0.0931)	0.4096 (0.0897)
Observations	427	168

mean coefficients; sd in parentheses

Notes: This table reports the mean and standard deviation (in parentheses) of all main control variables for the start of the period level (1960). Statistics are weighted by the regions share of national working-age population in 1960.

Table A.4: Descriptive statistics outcomes

	(1)	(2)	(3)		
	1960	2010	$\Delta 1960 - 2010$		
Non-coal regions					
emp (log)	12.1068	(1.204)	12.3827	(1.174)	0.2759 (0.300)
female emp (log)	11.0487	(1.239)	11.6285	(1.188)	0.5798 (0.352)
male emp (log)	11.6720	(1.195)	11.7465	(1.161)	0.0745 (0.301)
working-age pop (log)	12.5155	(1.172)	12.7412	(1.212)	0.2257 (0.244)
female working-age pop (log)	11.8490	(1.166)	12.0528	(1.220)	0.2038 (0.260)
male working-age pop (log)	11.7939	(1.179)	12.0431	(1.205)	0.2492 (0.231)
emp-pop rate (log)	-0.4087	(0.0873)	-0.3586	(0.119)	0.0502 (0.156)
female emp-pop rate (log)	-0.8004	(0.191)	-0.4243	(0.118)	0.3760 (0.207)
male emp-pop rate (log)	-0.1219	(0.0795)	-0.2966	(0.122)	-0.1747 (0.159)
employmentrate rate (log)	-0.0588	(0.0702)	-0.0977	(0.0457)	-0.0390 (0.102)
female employmentrate rate (log)	-0.0561	(0.0796)	-0.1005	(0.0467)	-0.0444 (0.114)
male employmentrate rate (log)	-0.0599	(0.0680)	-0.0953	(0.0455)	-0.0354 (0.0972)
participation rate (log)	-0.3499	(0.0826)	-0.2608	(0.0812)	0.0891 (0.0866)
female participation rate (log)	-0.7443	(0.205)	-0.3239	(0.0792)	0.4204 (0.182)
male participation rate (log)	-0.0620	(0.0507)	-0.2013	(0.0859)	-0.1393 (0.0808)
male-female employment gap (log)	0.6785	(0.197)	0.1278	(0.0326)	-0.5507 (0.189)
foreign population (log)	9.2703	(1.874)	10.8784	(1.630)	1.6090 (0.688)
native population (log)	12.9037	(1.153)	13.0327	(1.159)	0.1284 (0.274)
population with college degree (log)	9.3251	(1.854)	11.4362	(1.459)	2.3212 (0.620)
population without college degree (log)	13.1187	(1.344)	12.2817	(1.114)	-0.0752 (0.237)
Observations	427		427		427
Coal regions					
emp (log)	11.9297	(0.823)	12.1198	(0.757)	0.1902 (0.275)
female emp (log)	10.7521	(0.811)	11.3530	(0.763)	0.6009 (0.297)
male emp (log)	11.5538	(0.840)	11.4949	(0.753)	-0.0589 (0.296)
working-age pop (log)	12.3955	(0.809)	12.4879	(0.815)	0.0924 (0.227)
female working-age pop (log)	11.7276	(0.798)	11.7956	(0.819)	0.0680 (0.239)
male working-age pop (log)	11.6756	(0.821)	11.7939	(0.811)	0.1183 (0.220)
emp-pop rate (log)	-0.4659	(0.0894)	-0.3681	(0.128)	0.0978 (0.156)
female emp-pop rate (log)	-0.9755	(0.199)	-0.4425	(0.133)	0.5329 (0.205)
male emp-pop rate (log)	-0.1218	(0.0755)	-0.2990	(0.126)	-0.1772 (0.157)
employmentrate rate (log)	-0.0606	(0.0611)	-0.0997	(0.0498)	-0.0390 (0.0983)
female employmentrate rate (log)	-0.0587	(0.0696)	-0.0995	(0.0514)	-0.0408 (0.109)
male employmentrate rate (log)	-0.0607	(0.0584)	-0.0999	(0.0492)	-0.0392 (0.0943)
participation rate (log)	-0.4052	(0.0895)	-0.2684	(0.0828)	0.1368 (0.0867)
female participation rate (log)	-0.9168	(0.222)	-0.3430	(0.0868)	0.5737 (0.191)
male participation rate (log)	-0.0611	(0.0537)	-0.1991	(0.0818)	-0.1380 (0.0754)
male-female employment gap (log)	0.8537	(0.196)	0.1435	(0.0353)	-0.7102 (0.192)
foreign population (log)	8.8343	(1.548)	10.2964	(1.039)	1.4621 (0.887)
native population (log)	12.7919	(0.803)	12.8550	(0.788)	0.0631 (0.219)
population with college degree (log)	8.8403	(0.845)	10.9459	(1.030)	2.0924 (0.534)
population without college degree (log)	13.0085	(0.785)	12.1369	(0.765)	-0.0930 (0.242)
Observations	168		168		168

Notes: This table reports the mean and standard deviation (in parentheses) of all main outcome variables for the start of the period level (1960), the end of the period level (2010), as well as the change over time. Statistics are weighted by the regions share of national working-age population in 1960.

Table A.5: Overall response- accounting for spatial and serial correlation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
shock	-1.493*** (0.279)	-1.493*** (0.569)	-1.493** (0.642)	-1.493** (0.662)	-1.493** (0.644)	-1.493** (0.647)	-1.493** (0.648)
distance cut-off (km)	0	200	100	50	100	100	100
number of lags	0	2	2	2	3	4	5
controls							
Observations	2975	2975	2975	2975	2975	2975	2975
Regions							
R	0.68	0.72	0.72	0.72	0.72	0.72	0.72
KP (F-stat)	183.27	183.27	183.27	183.27	183.27	183.27	183.27

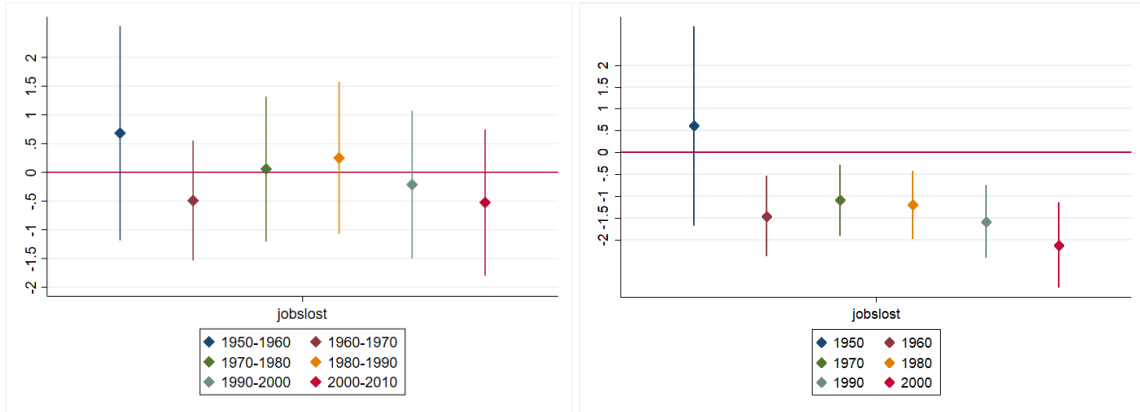
Notes: This table reports the β_1 coefficient of jobs lost in equation (4) based the IV-estimation using HAC-standard errors (Heteroscedasticity, Autocorrelation, and Conley robust standard errors) for different distance cut-offs and different time cut-offs for autocorrelation within panel units. All regressions include country and time dummies as well as time-invariant first and second nature controls interacted with time dummies and by one decade lagged population density. Models are not weighted. *** indicate significance at the 1 % level, ** at the 5 % level and * at the 10 % level.

Table A.6: Decomposition 1960-1970

	(1) Δemp	(2) Δpop	(3) $\Delta empporate$	(4) $\Delta emprate$	(5) $\Delta partrate$
Panel A: Full sample					
jobslost	-1.249*** (0.482)	-0.540 (0.386)	-0.708*** (0.177)	-0.279*** (0.089)	-0.429*** (0.109)
Panel B: Male sample					
jobslost	-1.628*** (0.513)	-0.986** (0.414)	-0.642*** (0.187)	-0.282*** (0.087)	-0.360*** (0.109)
Panel C: Female sample					
jobslost	-0.491 (0.532)	-0.092 (0.391)	-0.399 (0.296)	-0.360*** (0.126)	-0.040 (0.211)
controls					
Observations	595.000	595.000	595.000	595.000	595.000
R	0.495	0.463	0.554	0.567	0.692
KP (F-stat)	29.964	29.964	29.964	29.964	29.964

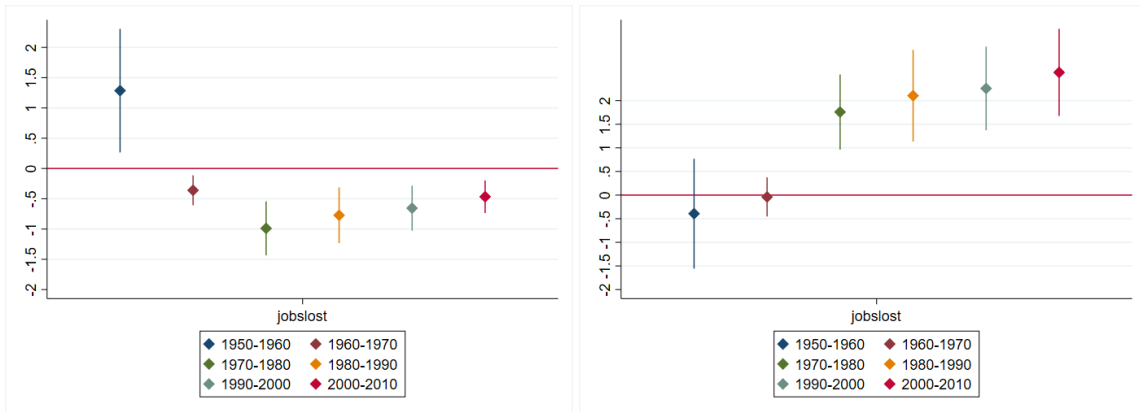
Notes: This table reports the IV β_1 coefficient of jobs lost in equation 5. All regressions include country dummies as well as time-invariant first and second nature controls, by one decade lagged population density as well as the employment share in manufacturing in 1960, the share of foreign population in 1960 and the university density in 1945. Models are weighted by the regions share in working-age population in national working-age population in 1960. Heteroskedasticity-robust standard errors in parentheses are clustered on regions. *** indicate significance at the 1 % level, ** at the 5 % level and * at the 10 % level.

Figure A.4: Comparing former coal-producing and non-coal producing regions (females)



(a) Employment

(b) Population

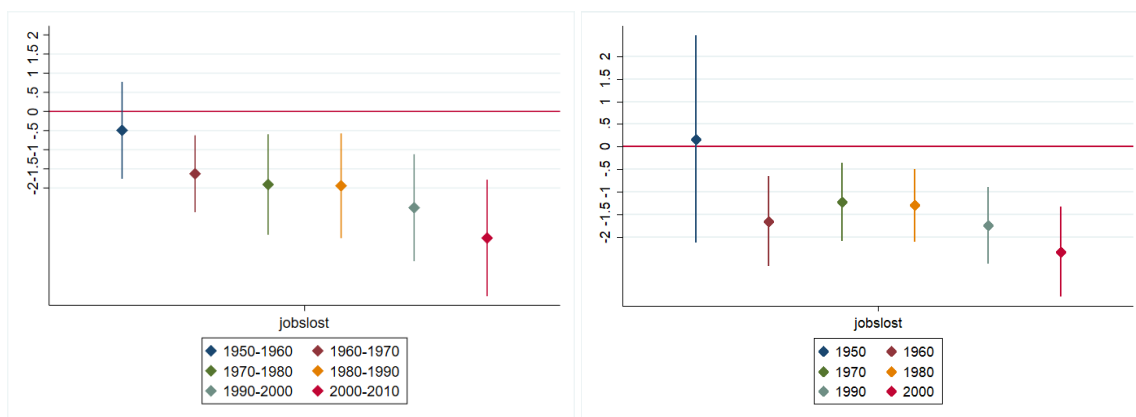


(c) Employment rate

(d) Participation rate

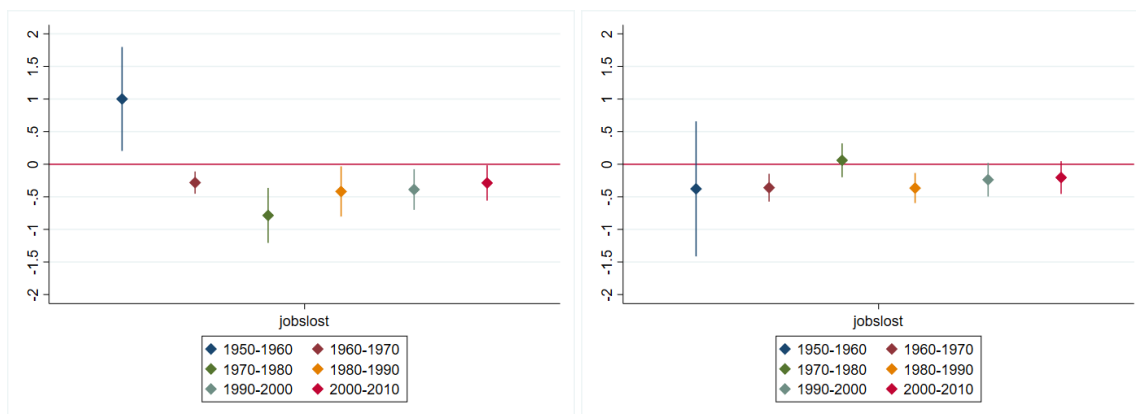
Notes: N=595; This figure reports the IV β_1 coefficient of jobs lost in equation 5. All regressions include country dummies as well as time-invariant first and second nature controls, by one decade lagged population density as well as the employment share in manufacturing in 1960, the share of foreign population in 1960 and the university density in 1945. Models are weighted by the regions share in working-age population in national working-age population in 1960. Heteroskedasticity-robust standard errors in parentheses are clustered on regions.*** indicate significance at the 1 % level, ** at the 5 % level and * at the 10 % level.

Figure A.5: Comparing former coal-producing and non-coal producing regions (males)



(a) Employment

(b) Population



(c) Employment rate

(d) Participation rate

Notes: N=595; This figure reports the IV β_1 coefficient of jobs lost in equation 5. All regressions include country dummies as well as time-invariant first and second nature controls, by one decade lagged population density as well as the employment share in manufacturing in 1960, the share of foreign population in 1960 and the university density in 1945. Models are weighted by the regions share in working-age population in national working-age population in 1960. Heteroskedasticity-robust standard errors in parentheses are clustered on regions.*** indicate significance at the 1 % level, ** at the 5 % level and * at the 10 % level.

Table A.7: Decomposition 1960-1980

	(1) Δemp	(2) Δpop	(3) $\Delta emppoprate$	(4) $\Delta emprate$	(5) $\Delta partrate$
Panel A: Full sample					
jobslost	-1.305** (0.612)	-0.942* (0.498)	-0.363** (0.182)	-0.817*** (0.206)	0.454*** (0.142)
Panel B: Male sample					
jobslost	-1.909*** (0.669)	-1.184** (0.523)	-0.725*** (0.224)	-0.785*** (0.215)	0.060 (0.132)
Panel C: Female sample					
jobslost	0.057 (0.643)	-0.713 (0.483)	0.771** (0.350)	-0.988*** (0.228)	1.759*** (0.405)
controls					
Observations	595.000	595.000	595.000	595.000	595.000
R	0.550	0.603	0.499	0.676	0.601
KP (F-stat)	28.717	28.717	28.717	28.717	28.717

Notes: This table reports the IV β_1 coefficient of jobs lost in equation 5. All regressions include country dummies as well as time-invariant first and second nature controls, by one decade lagged population density as well as the employment share in manufacturing in 1960, the share of foreign population in 1960 and the university density in 1945. Models are weighted by the regions share in working-age population in national working-age population in 1960. Heteroskedasticity-robust standard errors in parentheses are clustered on regions.*** indicate significance at the 1 % level, ** at the 5 % level and * at the 10 % level.

Table A.8: Decomposition 1960-1990

	(1) Δemp	(2) Δpop	(3) $\Delta emppoprate$	(4) $\Delta emprate$	(5) $\Delta partrate$
Panel A: Full sample					
jobslost	-1.230* (0.639)	-1.112** (0.494)	-0.118 (0.236)	-0.494** (0.207)	0.376** (0.170)
Panel B: Male sample					
jobslost	-1.942*** (0.699)	-1.158** (0.507)	-0.784*** (0.266)	-0.418** (0.196)	-0.366*** (0.118)
Panel C: Female sample					
jobslost	0.251 (0.675)	-1.081** (0.485)	1.332*** (0.427)	-0.772*** (0.234)	2.105*** (0.495)
controls					
Observations	595.000	595.000	595.000	595.000	595.000
R	0.629	0.637	0.565	0.712	0.610
KP (F-stat)	27.979	27.979	27.979	27.979	27.979

Notes: This table reports the IV β_1 coefficient of jobs lost in equation 5. All regressions include country dummies as well as time-invariant first and second nature controls, by one decade lagged population density as well as the employment share in manufacturing in 1960, the share of foreign population in 1960 and the university density in 1945. Models are weighted by the regions share in working-age population in national working-age population in 1960. Heteroskedasticity-robust standard errors in parentheses are clustered on regions.*** indicate significance at the 1 % level, ** at the 5 % level and * at the 10 % level.

Table A.9: Decomposition 1960-2000

	(1)	(2)	(3)	(4)	(5)
	Δemp	Δpop	$\Delta emppoprate$	$\Delta emprate$	$\Delta partrate$
Panel A: Full sample					
jobslost	-1.771*** (0.656)	-1.846*** (0.527)	0.075 (0.212)	-0.439** (0.173)	0.514*** (0.175)
Panel B: Male sample					
jobslost	-2.515*** (0.713)	-1.889*** (0.538)	-0.626*** (0.226)	-0.388** (0.159)	-0.238* (0.132)
Panel C: Female sample					
jobslost	-0.214 (0.656)	-1.817*** (0.520)	1.602*** (0.399)	-0.655*** (0.189)	2.257*** (0.451)
controls					
Observations	595.000	595.000	595.000	595.000	595.000
R	0.623	0.579	0.615	0.748	0.521
KP (F-stat)	28.866	28.866	28.866	28.866	28.866

Notes: This table reports the IV β_1 coefficient of jobs lost in equation 5. All regressions include country dummies as well as time-invariant first and second nature controls, by one decade lagged population density as well as the employment share in manufacturing in 1960, the share of foreign population in 1960 and the university density in 1945. Models are weighted by the regions share in working-age population in national working-age population in 1960. Heteroskedasticity-robust standard errors in parentheses are clustered on regions.*** indicate significance at the 1 % level, ** at the 5 % level and * at the 10 % level.

Table A.10: Decomposition 1960-2010

	(1)	(2)	(3)	(4)	(5)
	Δemp	Δpop	$\Delta emppoprate$	$\Delta emprate$	$\Delta partrate$
Panel A: Full sample					
jobslost	-2.388*** (0.688)	-2.728*** (0.614)	0.340* (0.194)	-0.336** (0.133)	0.676*** (0.177)
Panel B: Male sample					
jobslost	-3.306*** (0.777)	-2.814*** (0.627)	-0.492** (0.211)	-0.287** (0.138)	-0.205 (0.128)
Panel C: Female sample					
jobslost	-0.525 (0.650)	-2.656*** (0.605)	2.131*** (0.431)	-0.466*** (0.137)	2.597*** (0.470)
controls					
Observations	595.000	595.000	595.000	595.000	595.000
R	0.616	0.523	0.682	0.789	0.512
KP (F-stat)	28.750	28.750	28.750	28.750	28.750

Notes: This table reports the IV β_1 coefficient of jobs lost in equation 5. All regressions include country dummies as well as time-invariant first and second nature controls, by one decade lagged population density as well as the employment share in manufacturing in 1960, the share of foreign population in 1960 and the university density in 1945. Models are weighted by the regions share in working-age population in national working-age population in 1960. Heteroskedasticity-robust standard errors in parentheses are clustered on regions.*** indicate significance at the 1 % level, ** at the 5 % level and * at the 10 % level.

B Historical background: Energy shocks and the emergence of seaborne trade

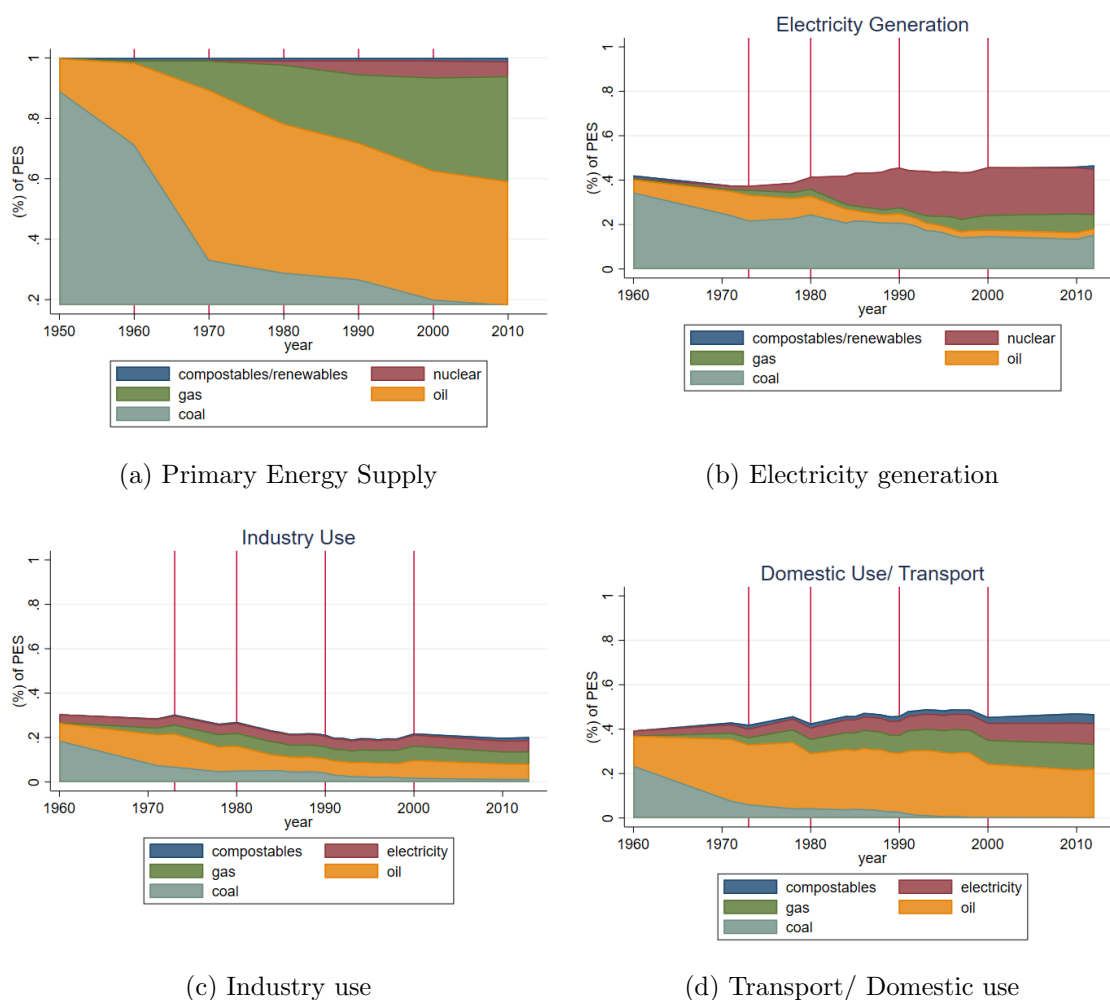
The oil invasion (1957-1973)

The increasing energy demand in industrialized countries after World War II induced the large European and American oil firms in cooperation with the national governments in oil-producing countries to drill for new oil reserves. As a consequence, large new oilfields in the Middle East and North Africa were discovered during the 1950s and increasingly exploited¹⁵. Until the mid-1950s national governments were focused on the protection of the domestic coal market to avoid growing foreign energy dependency, stabilize the balance of payments, and secure employment opportunities. However, growing market integration within Europe with the formation of the ECSC (European Coal and Steel Community) in 1951 and later the European Economic Community (EEC) in 1957 as well as economic considerations linked to the cost advantage of oil as a cheap energy source put political pressure on governments to liberalize the energy market¹⁶. As a result import duties on oil were canceled and the fixing of domestic coal prices was abandoned (Nonn (2001)). Due to the political instability following the Suez crisis and the temporary closure of the Suez Canal in 1956/57 oil prices remained constant and even increased until 1957 as seen in Figure 2. The reopening of the Suez Canal marks the important turning point that allowed oil prices to fall substantially. Freight rates for ships carrying oil to Europe from the expanding oil fields in the Middle East and North Africa did not just drop to the pre-closure levels but much beyond because during the closure investments in a new type of very large crude carriers (VLCC) were made to allow the cost-efficient transportation around Cape of Good Hopes (Pfister (2010)). This new technology enabled the transport of much larger quantities and therefore induced a drop in the tonne per mile transport costs (compare Lundgren (1996)). Subsequently, in the next decade, the share of oil in the overall energy mix increased from less than 20% to 60% as depicted in Figure B.7a and B.6. The import penetration of oil measured as the share of imported oil in overall coal and oil supply (domestic production+imports-exports) increased from less than 10% in 1950 to over 60% in 1970 (see Figure 3b). Figure 3a shows that the increased import penetration was entirely driven by shipments from the Middle East and Africa, which started to rise very rapidly after the re-opening of the Suez Canal in 1957. Oil imports did not just account for the increased energy demand, they also replaced coal in all sectors of final energy consumption. In both the industry sector as well as in the domestic, service, and transport sectors, coal use declined rapidly in relative and absolute terms until the mid-1970s (compare Figures B.7c and B.7d). Within the domestic use and service sector, coal was substituted by imported oil especially for the heating of office and domestic spaces (Haugland et al. (1998)). Oil use in the transport sector increased mostly due to the fuel consumption of (private) cars and to a lesser extent due to the switch from coal to diesel-fueled or electric locomotives in the national railway systems. The absolute decline in coal in both sectors is remarkable because the overall energy demand increased

¹⁵According to Pfister (2010) the oil reserves in the Middle East increased from 28 billion barrels to 367 billion barrels between 1948 and 1972. Ghawar (discovery in 1948, production from 1951), Safaniya (1951, 1957) in Saudi Arabia, Zelten/ Nasser (1956/ 1961) in Libya, and Edjeleh (1956/1960) and Hassi Messaoud (1956/ 1958) in Algeria are notable examples.

¹⁶Cheap energy was considered to be beneficial for strengthening the Western European position as an exporter of higher value manufacturing goods and improving its competitive position towards the U.S.

Figure B.6: Energy use across different industries by source



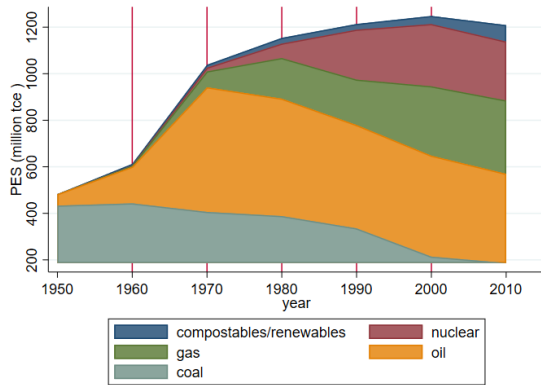
Notes: This figure depicts the overall energy use (as a %age of Primary Energy Supply) by energy source (type of fuel) for the different end-uses. Own illustration, based on data published by International Energy Agency and Organisation for Economic Co-operation and Development (2015), International Energy Agency and Organisation for Economic Co-operation and Development (1996) and ?. For details, see data appendix.

until the late 1990s¹⁷. In the industry sector, on the other hand, overall energy demand started to fall in the 1970s (compare B.7c) due to the re-allocation of energy-intensive industries to countries outside Europe with cheaper energy prices as well as an increase in energy efficiency due to advanced technologies¹⁸. The overall decline in coal use in final energy consumption was not compensated by an increased use in electricity generation. During the 1970s power plants were increasingly fueled by cheaper oil and in later decades by natural gas and nuclear energy. The absolute use of coal in electricity generation remained nevertheless stable until the 1990s.

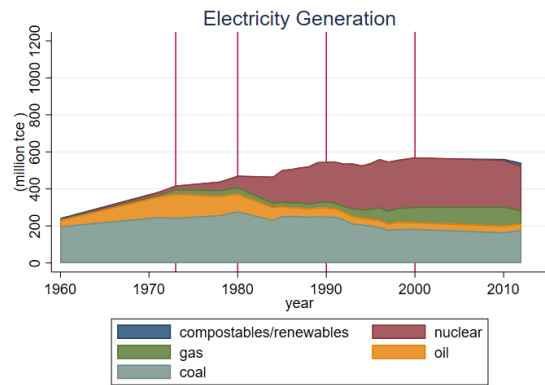
¹⁷This is due to the shift to commercial services as well as increased heating demand for spaces and the increased fuel consumption of (private) cars

¹⁸The comparatively high energy prices especially in Germany induced by the regulative policies in hard coal energy market furthermore enforced the structural change (compare Haugland et al. (1998), p.29ff.).

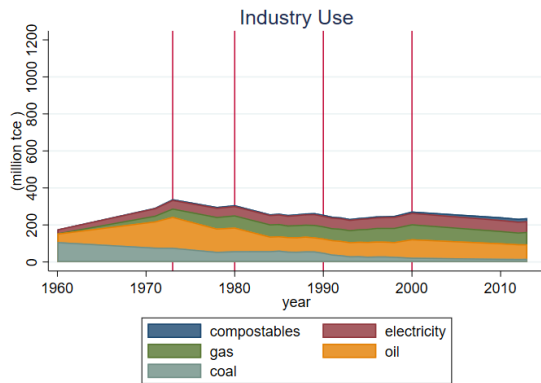
Figure B.7: Coal use in different sectors



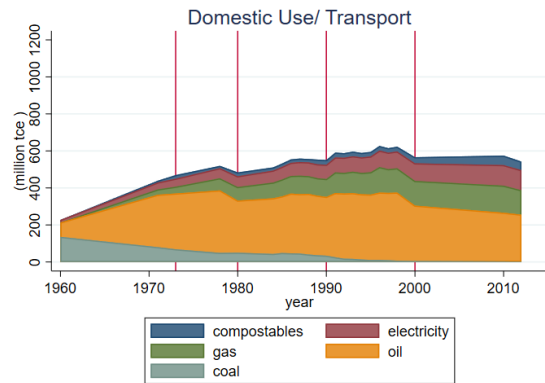
(a) Primary Energy Supply



(b) Electricity generation



(c) Industry use



(d) Transport/ Domestic use

Notes: This Figure depicts the overall energy use (in million tonnes hard coal equivalents) by energy source (type of fuel) for the different end-uses. Source: Own illustration, based on data published by International Energy Agency and Organisation for Economic Co-operation and Development (2015), International Energy Agency and Organisation for Economic Co-operation and Development (1996) and ?. For details, see the data Appendix.

The first and second oil crisis and the rehabilitation of coal

The oil trade prior to the first oil crisis in 1973 was dominated by large (state-owned) American and European companies which induced in the early 1970s Middle Eastern governments to put upward pressure on the oil prices (see figure 2). After the outbreak of the Yom Kippur War in 1973 the Middle Eastern states within the OPEC imposed an oil embargo on Western countries which resulted in an oil price explosion. Oil prices quadrupled and peaked during the second oil crisis in 1979. As a consequence oil demand in all sectors (except for transportation) declined and never reached the pre-crisis level again (compare Figure 3). It also spurred the development of oilfields, especially in the UK, and subsequent downward pressure on oil world prices due to diversification. As a consequence of the oil price explosion, the price of coal became competitive again as it fell below the level of oil prices in 1973 (compare figure 2) ¹⁹. Oil-fueled power plants were replaced by coal-fueled ones. At the same time, the industry demand e.g. in the chemical industry increased again as new technologies were developed to increase the potential use of coal such as the synthetic production of fuels (Hall (1981)). Although national governments reacted to the new energy insecurities by reinvesting in domestic coal mining facilities (see for example the Coal Plan 1974 in the UK), the domestic coal production did not manage to expand in response to the demand increases. This was partly due to the major run-down of capacity and lack of investments in the previous decade but especially due to the increased competitive pressure arising from the sea-borne coal trade. Production, consumption, and employment remained relatively stable until after the second coal crisis in 1979 whereas much of the increased demand for coal in the EEC since the mid-1970s has been met by extra-community imports (Sill (1984), Hall (1981)).

The emergence of seaborne coal trade

In response to the increased oil prices and the generally expected increase in demand for coal in the future, coal overseas exporters entered the global market and rapidly gained a large market share ²⁰. The new entrants quickly gained a comparative advantage in coal production due to better geological conditions such as the existence of open-cast mines (Australia), lower wages (South Africa), or less labor protection (U.S.) but most importantly the reduction in freight rates for sea-borne trade. Due to high transportation costs prior to 1970, just a small share of coal was traded, and if so mostly across short distances and across land routes rather than across sea. In the early 1970s, the "third revolution in merchant shipping" with the introduction of specialized dry bulk carriers enabled for the first time large-scale seaborne trade. The freight rates for coal dropped from the 1950s to the 1990s by 70 % (Lundgren (1996)) ²¹. As seen in figure 4a, starting in 1973; coal imports increased substantially in size. The increase is driven by South Africa, Columbia, and Australia all of which first entered the Western European coal market during this time. Together, they account for 80% of the overall increase in coal imports. As a consequence the import penetration within the western European coal

¹⁹For the UK, the oil to coal price ratio dropped from previously 1.13 to 0.79 in the year 1973, and furthermore dropped to 0.58 in the wake of the Iranian crisis in 1979 (Sill (1984)).

²⁰(Moncur and Jones (1999) for example describes for South Africa how mining facilities and transportation devices were expanded in reaction to the first oil crisis and revived demand for coal.

²¹This is comparable to the switch from sailing to steam vessels in the late 19th century. The advances in this new shipping technology are linked to the earlier technological advances in the size of tankers during the Suez Crisis (see above). In proportions and hydrodynamics, the dry bulk carriers are similar to the tankers although dry carriers generally are of a smaller size (Corlett and National Maritime Museum (1981), pp 24-32))

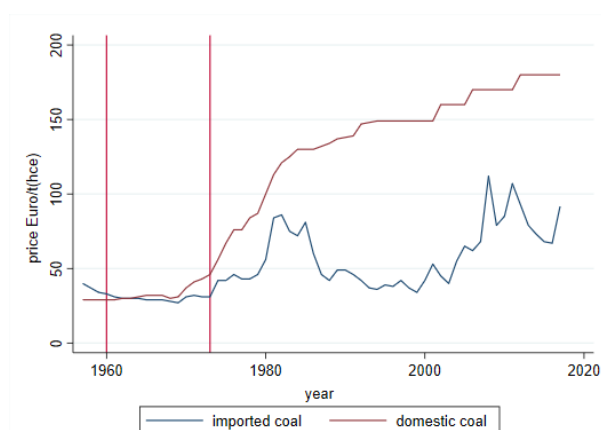
market increased from less than 10% in 1960 to almost 60% in 2010, and seaborne trade by the new entrants increased from zero to almost 40% as depicted in figure 4b). Whereas until the first oil crisis in 1993 domestic coal production and demand dropped at the same rate, in following decades there is an increasing gap between these two indicators. Whereas coal demand is declining at a very slow rate, domestic production falls very steeply starting in the early 1980s. The decline in domestic production is mirrored by a decline in mining jobs, indicating that productivity advances in the coal sector are not the underlying driving force. Despite the fact that as early as 1970, European coal was no longer competitive, coal imports increased only gradually. The governments of all four countries in the sample shielded domestic coal production from the increased international competition. In the face of the increasing price gap between domestically produced coal and the international market, politics secured the coal demand especially in the electricity generation market by enforcing agreements between power plants and coal mines. Power plants were obliged to purchase a fixed amount of domestic coal whereas, at the same time, a quota on coal imports from non-EC countries was introduced. The price difference to the international coal price was compensated by direct subsidies paid by the national government ²².

The intensity of the protection and timing of the subsequent liberalization differs widely among the four countries depending on the strength of trade unions, social concerns, and energy security. Notwithstanding, the growing price gap between imported coal and domestically produced coal in all countries inflated the financial means necessary to shield domestic production. In the end, the national protection policy could not withstand the increased financial pressure, resulting in the eventual phase-out of the coal industry. The French coal market was the least regulated and coal imports increased rapidly already in the 1970s. In the late 1980s due to the increased use of nuclear energy, coal imports started to decline again. The French government encouraged imports of cheaper foreign coal by expanding and investing in coal ports and transportation infrastructure. The phaseout of the nationalized coal industry was however guided by social considerations as it was set up in line with the age developments of the workforce to allow for voluntary retirement. The last mine closed in 2004. In Belgium, similar to the French case, coal imports were allowed to increase in the 1970s. At the same time, however, financial support for domestic coal mines increased massively since coal prices on the international markets dropped and no productivity gains for domestic mines were realized. In 1986, the Belgian government decided the national phaseout of coal mining and in 1992 production ceased ²³. For the UK, the turning point in the protection policy of the national coal industry was marked by the Thatcher government taking over power in 1979. The Thatcher government aimed to reduce state subsidies and state intervention in general pushed the privatization of both the coal and electricity industry, and announced the end of price support for domestically produced coal. In 1983/84 the announcement of subsequent mine closures resulted in the one-year-long miners' strike which eventually ended in a defeat for the trade unions. To counterbalance the shortfalls in coal supply, especially for

²²In Germany the use of domestic coal for electricity generation was secured by the so-called "Jahrhundertvertrag" which was signed in 1980. The growing price gap to internationally produced coal was directly compensated by a levy paid by all electricity consumers, the so-called "Kohlepfennig". In the UK, British Coal and the Central Electricity Generating Board entered "The Joint Understanding" in 1979. All costs not covered by revenues from the coal sales were financed through a direct government subsidy. Likewise in France, state-owned Charbonnages de France (CdF) was directly subsidized by the national government and entered an agreement with Electricite de France ensuring a commitment to purchase domestic coal (IEA, 1988, Coal Prospects and Policies in IEA countries (1987 Review)).

²³Subsidies provided by the Belgian government were comparable high due the the low productivity of domestic coal production.

Figure B.8: The evolution of the coal prices 1958-2020



Notes: This figure depicts the evolution of the price for imported hard coal and domestically produced hard coal for (West-)Germany. Source: Own illustration, based on Verein der Kohleimporteure e.V. (2018)

electricity generation, import coal was allowed to enter the market. Imports continued to increase thereafter which was mirrored by the strong decline in coal production and coal employment. In Germany, the fate of the national coal industry changed in 1994 with the Constitutional Court ruling against the levy paid by all electricity consumers, the so-called "Kohlepfenning". The Kohlepfenning was replaced by direct state subsidies. The growing inability of German coal to compete internationally and increasing political pressure from the European Commission resulted in the liberalization of the coal market. Figure B.8 compares the price evolution for imported coal and domestically produced coal for (West-)Germany. The Price gap started to emerge during the 1970s and continued to grow thereafter. As a consequence, coal imports started to increase rapidly in the 1990s.

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C Data and sources

Employment and population outcomes at the NUTS 3 level

The variables covering demographics (population in different age brackets, nationality, gender), home ownership, employment (overall and in different sectors), unemployment, labor force participation, type of employment (self-employment), the number of people that completed tertiary education and the number of people that has left education is derived from digitized census records. Employment (at the workplace) and industry-specific employment (at the workplace) are for the years 1950 to 1970 derived from census records and thereafter matched to the ARDECO database (ARDECO database) on regional employment published by the European Commission (https://knowledge4policy.ec.europa.eu/territorial/ardeco-database_en). All other variables are measured at the place of residence. It is naturally very challenging to harmonize the census data sets over time for single countries and even more so across countries. Due to boundary changes, the data is re-estimated for the current 2016 NUTS 3 boundaries. Data is collected for the years 1950, 1960, 1970, 1980, 1990, 2000, and 2010. If there was no census in a given country in the respective year, the closest available data point was taken instead. Germany is a

²⁴The German Coal Commission stated in a Report in 1990 the inability of German coal to compete internationally and reports that the costs of coal production are three times above the international level.

Figure C.9: Data overview- missing value

	1950	1960	1970	1980	1990	2000	2010
population (at the place of residence)	✓	✓	✓	DE	✓	DE	✓
population (at the place of residence), male/ female	✓	✓	✓	DE	✓	DE	✓
working age population (15-64)	✓	✓	✓	DE	✓	DE	✓
working age population (15-64), male/ female	FR	✓	BE	DE	✓	DE	✓
active population	✓	✓	DE	DE	✓	DE	✓
active population, male/ female	DE	✓	DE	DE	✓	DE	✓
employment (at the place of residence)	BE	✓	✓	DE	✓	DE	✓
employment (at the place of residence), male/ female	BE	✓	✓	DE	✓	DE	✓
foreign population		✓	✓	DE		DE	✓
population with a tertiary degree			✓	DE	ENG	DE	✓
non-school going population			✓	DE	ENG	DE	✓
self employment	✓	✓					
owner-occupied housing	✓	✓					
employment (at the workplace)	BE	✓	✓	✓	✓	✓	✓
sector-specific employment (at the workplace)	✓	✓	✓	✓	✓	✓	✓
	✓	data available		DE	Germany		
		Imputed		ENG	England with Wales		
		not used		BE	Belgium		
				FR	France		

special case since after 1970, census data is available for roughly every 20 years and thus data for 1980 and 2000 had to be imputed. For all other countries, there is missing data for only very few data points and if so mostly relevant for the measurement of pre-trends. Figure C.13 offers an overview for which years and which country imputations have been necessary. For details on the imputation see the country-specific data sections below. Data on industry-specific employment, self-employment and the number of foreign population is only available for all countries starting in 1960. Data on educational attainment is only available for all countries starting in 1970 (data is missing for Germany and the UK before that). Owner-occupied housing and self-employment are in some specifications used as controls fixed to their pre-shock level. Self-employment is measured at its 1960 level for France, Belgium, and Germany and at its 1950 level for England. Owner-occupied housing is measured at its 1960 level for all countries except Germany where it is measured at its 1950 level. Across countries definition of single variables within the census data may vary: Non-school going population for Belgium is published whereas for all other countries is measured as the population aged 15 years and above minus the number of students in each region. The definition of self-employment differs in France from the one employed in all other countries as self-employment within agriculture is not included. Since all specifications include country-fixed effects, these differences in definition should not influence the results. In very few cases, definitions of variables change over time within single countries. The general level effects are captured by the inclusion of time-fixed effects. Results are only biased if the changes in definitions affect the control and treatment group to a different extent. The base for the measurement of education in the UK changes after 1970, and the definition of employment changes in the German Census data between 1950 and 1960 (for details see country-specific data sections below).

France

Census Data is available from different sources and published every 6 to 9 years between 1954 and 2016. If there was no census in the year of interest, the closest available data point was taken instead. Data for the year 1950 is taken from the census of 1954, data for the year 1960 is taken from the year 1962, data for 1970 is taken from the census in 1968 and 1975, data for the year 1980 is taken from the census in 1982, data for the year 1990

Figure C.10: Data overview France

	1950	1960	1970	1980	1990	2000	2010
population (at the place of residence)	✓	✓	✓	✓	✓	✓	✓
population (at the place of residence), male/ female	✓	✓	✓	✓	✓	✓	✓
working age population (15-64)	✓	✓	✓	✓	✓	✓	✓
working age population (15-64), male/ female		✓	✓	✓	✓	✓	✓
active population	✓	✓	✓	✓	✓	✓	✓
active population, male/ female	✓	✓	✓	✓	✓	✓	✓
employment (at the place of residence)	✓	✓	✓	✓	✓	✓	✓
employment (at the place of residence), male/ female	✓	✓	✓	✓	✓	✓	✓
foreign population	✓	✓	✓	✓	✓	✓	✓
population with a tertiary degree			✓	✓	✓	✓	✓
non-school going population			✓	✓	✓	✓	✓
self employment		✓					
owner-occupied housing		✓					
employment (at the workplace)	✓	✓	✓	✓	✓	✓	✓
sector-specific employment (at the workplace)	✓	✓	✓	✓	✓	✓	✓
	✓	data available					
		imputed					
		not used					

is taken from the census in 1990, data for the year 2000 is taken from the census in 1999. The gender-specific number of the working-age population in 1950 is missing. The data is imputed, assuming the same female/male share in the overall working-age population as in 1960. The definition of self-employment used for France differs from that used for the other countries in the sample. The variable is constructed based on the Catégories socioprofessionnelles (CSP) as defined and published by INSEE and includes the following categories: 2 "Artisans-commerçants-chefs d'entreprises" and 3 "Cadres et professions intellectuelles supérieures". This means that self-employment within agriculture is not included whereas the following additional groups are included: "Professeurs; Professions littéraires et scientifiques; Ingénieurs; Cadres administratifs supérieurs". The industry-specific employment in 1960 and 1970 is not measured at the place of residence. County boundaries have changed only very moderately over time. For details see the next section. For counties within the NUTS2 regions, FRBO and FRM0 data points are missing for 1960. In these cases, the data is imputed using a linear projection between the 1950 and 1970 values.

Data Sources:

- Census 1900:
 - Résultats statistiques du recensement des industries et professions (Dénombrement général de la population du 29 mars 1896) . Tome III , Région de l'Ouest au Midi (45 départements) ,table I and III, <https://bibnum-patrimoniales.univ-grenoble-alpes.fr/items/show/1>.
 - Chiffres détaillés - Séries historiques de population (1876 à 2017). Insee, Recensements de la population, <https://www.insee.fr/fr/information/2414405>.
- Census 1950:
 - Tableaux de l'économie française [Texte imprimé] / Institut national de la statistique et des études économiques ; dir. publ.Paris : INSEE, 1956, <https://gallica.bnf.fr/ark:/12148/bpt6k6478595s/f18.item>.
 - Recensement de 1954. Population de la France. Institut National de la Statistique et des etudes économiques.
 - Recensement General de la Population de mai 1954. Resultats du Sondage Au 1/20eme. Volume A. Population active. Institut National de la Statistique et des etudes économiques, <https://www.bnsp.insee.fr/bnsp/>.

- Census 1900: Data digitized from scanned census records provided by KU Leuven, Project Belgian Historical Censuses, accessed via <https://bib.kuleuven.be/english/ebib/project-historical-census>
 - Recensement général des industries des métiers (31 octobre 1896). (1900). Hayez.
 - Statistique de la Belgique: Population. Recensement général au 31 décembre 1900. (1903). Lésigne.
- Census 1950- 1980: Data digitized from scanned census records provided by KU Leuven, Project Belgian Historical Censuses, accessed via <https://bib.kuleuven.be/english/ebib/project-historical-census>
 - Recensement général de la population, de l'industrie et du commerce au 31 décembre 1947. (1949). Institut National de Statistique.
 - Recensement de la population 1961.(1963). INS.
 - Recensement de la population - 31 décembre 1970. (1973). Institut national de statistique.
 - Algemene volks- en woningtelling op 1 maart 1981: algemene resultaten. (1982). NIS.
- Census 1990-2011: requested via Statbel or accessed via <https://statbel.fgov.be/fr/propos-de-statbel/que-faisons-nous/recensement-census>

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Germany

Census data is available for the years 1951, 1961, 1970, 1987 and 2011. Due to the time gaps between 1970 and 2011, the data for 1980 and 2000 is imputed using a linear projection. The definition of the labor force (active population) changed between 1950 and 1960. In 1950, only those who were employed and earned an income from it or usually employed (currently unemployed) were counted as the labor force. From 1960 onward, all persons working for gainful purposes are taken into account, irrespective of the earnings or time spent on work. The German Statistical Office estimated that on average the change of the definition leads to a 2 percent increase in the labor force (for women more than for men). The gender specific active population in 1950 is missing. To impute the missing values, the share of males and females in employment is used to subdivide the overall active population. Overall active population as well as gender-specific active population for 1970 is missing and subsequently imputed in the following way: The regions (and gender) specific growth rates of working age population and employment are computed between 1960 and 1980 and averaged. The average of these two growth rates is then applied to the value gender-specific active population in 1960. For the German state of Saarland data is published in the German census only after 1957 when it joined the Federal Republic of Germany. For the year 1951 because it The number of owner-occupied housing for 1960 is not available, the number of owner-occupied housing in 1950 is used instead. County boundaries have changed considerably over time. For details see next section.

Data Sources:

- Census 1900: Berufszählung des deutschen Reiches 1995, Galloway, Patrick R., 2007, "Galloway Prussia Database 1861 to 1914", www.patrickgalloway.com.

Figure C.12: Data overview Germany

	1950	1960	1970	1980	1990	2000	2010
population (at the place of residence)	✓	✓	✓		✓		✓
population (at the place of residence), male/ female	✓	✓	✓		✓		✓
working age population (15-64)	✓	✓	✓		✓		✓
working age population (15-64), male/ female	✓	✓	✓		✓		✓
active population	✓	✓			✓		✓
active population, male/ female		✓			✓		✓
employment (at the place of residence)	✓	✓	✓		✓		✓
employment (at the place of residence), male/ female	✓	✓	✓		✓		✓
foreign population		✓	✓				✓
population with a tertiary degree			✓		✓		✓
non-school going population			✓		✓		✓
self employment		✓					
owner-occupied housing	✓						
employment (at the workplace)	✓	✓	✓	✓	✓	✓	✓
sector-specific employment (at the workplace)	✓	✓	✓	✓	✓	✓	✓
	✓	data available					
		imputed					
		not used					

- Census 1950- 1987:

- Schmitt, Karl; Rattinger, Hans; Oberndörfer, Dieter (1994): Kreisdaten (Volk-
s-
zaehlungen 1950-1987). GESIS Datenarchiv
- Braun, Sebastian T. and Richard Franke (2021). A County-Level Database
on Expellees in West Germany, 1939-1961. Vierteljahrschrift für Sozial- und
Wirtschaftsgeschichte 108(4): 522-540.
- Die Wohnbevölkerung nach der Erwerbstätigkeit in Nordrhein-Westfalen. Beiträge
zur Statistik des Landes Nordrhein-Westfalen / Sonderreihe Volkszählung 1950,5,a.
1952
- Gemeindestatistik des Landes Nordrhein-Westfalen. Ergebnisse der Volks-,
Berufs-, Wohnungs-, und Arbeitstättenzählung 1950 und der landwirtschaftlichen
Erhebungen von 1949/50. Statistisches Landesamt Nordrhein-Westfalen, Düssel-
dorf 1952.
- Fachserie : A, Bevölkerung und Kultur : Volks- und Berufszählung vom 6. Juni
1961. Heft 2. Ausgewählte Bevölkerungsgruppen. deutsche Bevölkerung und
Ausländer. Stuttgart 1967. Kohlhammer.
- Statistisches Bundesamt Wiesbaden: Fachserie A. Bevölkerung und Kultur.
Volkszählung vom 6. Juni 1961. Vorbericht 12. Wohnbevölkerung nach der
Beteiligung am Erwerbsleben, Altersgruppen und überwiegenden Lebensunter-
halt.

- Census 2011: https://www.zensus2011.de/DE/Home/home_node.html

United Kingdom

Census data is available every ten years from 1951 to 2011. All Scottish counties are excluded from the analysis due to missing data and the dataset is therefore limited to England and Wales only. Within the census data, the measurement of educational attainment changed over time. Whereas in 1970 the headcount of persons with completed tertiary education share is based on employed persons only, it is based on all persons thereafter. Subsequently, to construct the share of persons with tertiary education the number of all employed persons in 1970 is used. The data on educational attainment for 1990 is missing. The data is imputed for 1990, assuming that the share of persons with tertiary education changed linearly over time. The number of self-employed persons for 1960 is not available, the number of self-employed persons in 1950 is used instead.

Figure C.13: Data overview England (with Wales)

	1950	1960	1970	1980	1990	2000	2010
population (at the place of residence)	✓	✓	✓	✓	✓	✓	✓
population (at the place of residence), male/ female	✓	✓	✓	✓	✓	✓	✓
working age population (15-64)	✓	✓	✓	✓	✓	✓	✓
working age population (15-64), male/ female	✓	✓	✓	✓	✓	✓	✓
active population	✓	✓	✓	✓	✓	✓	✓
active population, male/ female	✓	✓	✓	✓	✓	✓	✓
employment (at the place of residence)	✓	✓	✓	✓	✓	✓	✓
employment (at the place of residence), male/ female	✓	✓	✓	✓	✓	✓	✓
foreign population		✓					
population with a tertiary degree			✓	✓		✓	✓
non-school going population			✓	✓		✓	✓
self employment	✓						
owner-occupied housing		✓					
employment (at the workplace)		✓	✓	✓	✓	✓	✓
sector-specific employment (at the workplace)		✓	✓	✓	✓	✓	✓
	✓						

data available
imputed
not used

County boundaries have changed considerably over time. For details see the next section.

Data Sources:

- Census 1901:
 - Lee, Clive Howard. 1979. British Regional Employment Statistics. 1841-1971. Cambridge: Cambridge University Press.
- Census 1951-1971:
 - Lee, Clive Howard. 1979. British Regional Employment Statistics. 1841-1971. Cambridge: Cambridge University Press.
 - Census of England and Wales 1951. Occupation Tables. Laid Before Parliament Pursuant to Sect. 4(1) Census Act 1920. 1956. London: Stat. Off. Tables 20 and 21
 - Census 1951 England and Wales: General Tables Comprising Population Ages and Marital Condition Non-Private Households Birthplace and Nationality Education ; Laid Before Parliament Pursuant to Sect. 4(1) Census Act 1920. 1956. London: Stat. Off.(Table 35, Tables 30 and 31)
 - General Register Office. 1966. Census 1961 England and Wales : Workplace Tables. Part III. (Laid Before Parliament Pursuant to Section 4(1) Census Act 1920). London: Stat. Off.(Table 1)
 - General Register Office. 1966. Census 1961 England and Wales : Workplace Tables (Laid Before Parliament Pursuant to Section 4(1) Census Act 1920). London: Stat. Off.(Table 1)
 - Census 1961: Office of National Statistics, accessed via <https://www.nomisweb.co.uk/Nomis>.
 - Census 1971 for England Wales (and Scotland): UK data Service, Caseweb, <https://casweb.ukdataservice.ac.uk/> shapefiles accessed via
- Census 1981 and 1991:
 - for England Wales and Scotland: Office of National Statistics, accessed via <https://www.nomisweb.co.uk/Nomis>.
- Census 2001 and 2011:

- for England Wales (not Scotland): Office of National Statistics, accessed via <https://www.nomisweb.co.uk/Nomis>. Data is provided in current NUTS3 boundaries.
- for Scotland: Scotland’s Census National Records of Scotland, accessed via <https://www.scotlandscensus.gov.uk>

Regional mining employment in 1950 and 1960

- Germany
 - 1950: Braun, Sebastian T. and Richard Franke (2021). A County-Level Database on Expellees in West Germany, 1939-1961. *Vierteljahrschrift für Sozial- und Wirtschaftsgeschichte* 108(4): 522-540.
 - 1960: Industrie und Handwerk. Regionale Verteilung der Industriebetriebe und deren Beschäftigte nach Industriegruppen. Reihe 4. Sonderbeiträge zur Industriestatistik. Statistisches Bundesamt Wiesbaden. Verlag W.H. Kohlhammer.(1958, 1962, 1974)
- Belgium
 - 1950 and 1960: Data digitized from scanned census records provided by KU Leuven, Project Belgian Historical Censuses, accessed via <https://bib.kuleuven.be/english/ebib/project-historical-census> (for details see above)
- France
 - 1950: Tableaux de l’économie française [Texte imprimé] / Institut national de la statistique et des études économiques ; dir. publ.Paris : INSEE, 1956.<https://gallica.bnf.fr/ark:/12148/bpt6k6478595s/f18.item>
 - 1960: Réseau Quetelet. lil-0351: Recensement de la population 1962 : tableaux standards par communes. 1962 (INSEE).
- United Kingdom
 - 1950: Lee, Clive Howard. 1979. British Regional Employment Statistics. 1841-1971. Cambridge: Cambridge University Press.
 - 1960: Census 1961: Office of National Statistics, accessed via <https://www.nomisweb.co.uk/Nomis>

National level Energy data

Primary energy supply

Data on the primary energy supply (consumption), and the use in different sectors is digitized from different publications from the International Energy Agency (IEA):

- International Energy Agency (1996). Oil information. issn: 1683-4259.
- International Energy Agency and Organisation for Economic Co-operation and Development (2000-2015). Energy balances of OECD countries. IEA statistics. International Energy Agency: Paris [France] .
- International Energy Agency, Secretariat and Organisation for Economic Co-operation and Development (1986-2016, various issues.). Coal Information. OECD/IEA: Paris. isbn: 9789264258624

- For Germany, energy consumption and primary energy supply differentiated for (East-) and (West-)Germany was taken from: Arbeitsgemeinschaft Energiebilanzen <https://ag-energiebilanzen.de/daten-und-fakten/zeitreihen-bis-1989/>

Coal production, consumption and employment

Specific information about the coal industry such as production, consumption and employment at the national level are digitized from the Energy Statistics published by Statistical office of the European communities, and later by Eurostat, as well as several additional national data sources:

- Statistical Office of the European Communities (1950-1975). “Energiestatistik. Jahrbuch.” (Various issues).
- Eurostat and Europäische Kommission (1984-1997). “Energy. Statistical Yearbooks.” (Various issues).
- For the UK, the number of employees in mining between 1853-2018 were downloaded from: Department for Energy Security & Net Zero (DESNZ), Historical data on coal: coal production, availability and consumption 1853 to 2022, Digest of UK Energy Statistics (DUKES), annual data, <https://www.gov.uk/government/statistical-data-sets>.
- For (West-)Germany, the number of employees in mining between 1950-2018 were downloaded from: Statistik der Kohlewirtschaft e.V., <https://kohlenstatistik.de/downloads/steinkohle>.

Energy import data

Data on overall import quantities of crude oil and hard coal as well as quantities imported from each partner country were also taken from Energy Statistics published by Statistical office of the European communities, and later by Eurostat, as well as several additional national data sources:

- Statistical Office of the European Communities (1950-1975). “Energiestatistik. Jahrbuch.” (Various issues).
- Eurostat and Europäische Kommission (1984-1997). “Energy. Statistical Yearbooks.” (Various issues).
- For the UK, data on oil imports by origin prior to 1973 were used from Energy Security & Net Zero (DESNZ), Historical crude oil and petroleum data: production, imports and exports, Digest of UK Energy Statistics (DUKES), annual data, <https://www.data.gov.uk/dataset>
- For the UK, information on coal imports by country of origin since 2002 data was downloaded from the National Statistics publication Energy Trends produced by the Department for Energy Security & Net Zero (DESNZ): <https://www.gov.uk/government/organisations/department-for-energy-security-and-net-zero/about/statistics>
- For (West-)Germany, coal imports by origin since 2003 were downloaded from: Statistik der Kohlewirtschaft e.V. <https://kohlenstatistik.de/downloads/steinkohle>,

Energy price data

- The price for domestic coal and imported oil between 1950 and 1975 is taken from the Statistical Office of the European Communities (1950-1975). “Energiesstatistik. Jahrbuch.” (Various issues).
- For Germany, price data for domestic and imported coal was digitized from: Verein der Kohleimporteure e.V. 2018. ‘Jahresbericht 2018 - Fakten und Trends 16/17’. Hamburg, Germany, <http://www.kohlenimporteure.de/publikationen/jahresbericht-2018.html>.

First and second nature controls

- Average soil productivity of croplands (soil quality): Joint Research Centre, European Commission https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Agri-environmental_indicator_-_soil_quality
- Average temperature and mean rainfall: Angelova, Denitsa; Blanco Lupio, Norman (2020), “Meteorological indicator dataset for selected European NUTS 3 regions”, Mendeley Data, V2, <https://data.mendeley.com/datasets/sf9x4h5jfk/2>
- Indicator for being a coastal region (coast): Eurostat <https://ec.europa.eu/eurostat/web/coastal-island-outermost-regions/methodology>. A Nuts 3 regions is classified according to one of the following three criteria: any NUTS level 3 region with a sea border (coastline) (1) ; any NUTS level 3 region that has more than half of its population within 50 km of the coastline, based on population data for 1 km² grid cells (2); No coastline (3)
- Indicator for the degree of urbanity (urban), following the Eurostat rural-urban typology. For more information see (<https://ec.europa.eu/eurostat/web/rural-development/methodology>).
- Dummy for being a border region: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Territorial_typologies_manual_-_border_regions Eurostat identifies border regions in the European Union (EU) as those regions with a land border, or those regions where more than half of the population lives within 25 km of such a border.
- Indicator for being a mountain region (mount): Eurostat https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Territorial_typologies_manual_-_mountain_regions#Published_indicators. A Nuts 3 regions is classified according to one of the following four criteria: any NUTS level 3 region where more than 50 % of the surface is covered by topographic mountain areas (1); any NUTS level 3 region where more than 50 % of the regional population lives in topographic mountain areas (2); any NUTS level 3 region where more than 50 % of the surface is covered by topographic mountain areas and where more than 50 % of the regional population lives in these mountain areas (3); no mountain area (4).
- Log Population density (lnpopden): Constructed from population size (see sources for population above) and area of NUTS 3 regions (derived via GIS from shapefiles provided by Eurostat <https://ec.europa.eu/eurostat/web/nuts/nuts-maps>)

- University density in 1945 (number of universities divided by total area): The European Tertiary Education Register (n.d.). ETER database, <https://eter-project.com/project-description/using-eter-data/>.
- Herfindahl-index 1960 (hhi 1960) is based on the employment shares in six different industries (agriculture, manufacturing, construction, trade and transport, financial and business services, as well as public and other services). This index is intended to capture the industry mix of regions in the pre-shock period in 1960 outside of mining and therefore mining employment is excluded and subtracted from overall the employment figure. Employment shares are based on census data as outlined above.

C.1 Data set harmonization: Boundary changes over time

United Kingdom

The Local Governemnt Act of 1974 (becoming effective in 1974) was a major local government reform reorganizing districts and counties. All existing administrative counties, county boroughs, urban districts, and rural districts were abolished. In their place, new metropolitan and non-metropolitan counties were created and these counties were in turn divided into districts. Under these changes, the number of districts was reduced from 1756 to 379. Data until 1971 is either reported in historical county boundaries or historical district boundaries. The data is therefore re-estimated into current boundaries with population weights based on historical districts' population sizes in 1961. Shapefiles for district and county boundaries for 1961 are extracted here: [https://geoportal.statistics.gov.uk/search?collection=Dataset&sort=name&tags=all\(BDY_CEN_1961\)](https://geoportal.statistics.gov.uk/search?collection=Dataset&sort=name&tags=all(BDY_CEN_1961)). Shapefiles for district and county boundaries starting 1971 are extracted here: https://borders.ukdataservice.ac.uk/easy_download_data.html?data=England_dt_1971. Each historical county j can be expressed as a sum of historical districts k . Likewise each modern county i (NUTS3 region) can be expressed as the sum of historical districts k . In some cases the former districts are not perfectly overlapping with current NUTS 3 regions²⁵. In these cases, a constant population density within historical districts k is assumed, and the district level data is distributed across NUTS 3 regions i based on the areashare of the overlap:

$$Y_i = \sum Y_k * \frac{area_{ik}}{area_k}$$

In a few cases, the relevant data is only provided at the more aggregate level of historical counties (number foreign population 1960 and mining employment in 1950). This data gets re-estimated into current boundaries by constructing populations weights based on historical districts. In a first step, we derive the sum of the population over all historical districts k that are both within old county boundaries j and new county boundaries i . If historical districts k are overlapping with several new counties i , the areashare of the overlap is used to map the historical population of each district k to the current NUTS 3 areas i :

$$pop_{ijk} = \sum pop_{jk} * \frac{area_{ijk}}{area_{kj}}$$

In a next step, we take the share of the population in historical county j that lives in the part of that lies within the new county boundaries i to derive population weights:

²⁵85 % of all historical districts have at least a 90 % overlap with a current NUTS 3 region

$$popweight_{ij} = \frac{\sum pop_{ijk}}{pop_j}$$

In a final step, these population weights are used to map data provided at the historical county level j to current NUTS 3 regions i :

$$Y_i = \sum Y_j * popweight_{ij}$$

Germany

Census data is available for the years 1951, 1961, 1970, 1987 and 2011. Due to the time gaps between 1970 and 2011, the data for 1980 and 2000 is imputed using a linear projection. County boundaries have changed considerably over time. Shapefiles for the county boundaries for the years 1896-1987 are taken from censusmosaic <https://censusmosaic.demog.berkeley.edu/data/historical-gis-files>, shapefiles for the current NUTS 3 regions in the version of 2016 are provided by Eurostat <https://ec.europa.eu/eurostat/de/web/gisco/geodata/reference-data/administrative-units-statistical-units/nuts>. The county-level data in the boundaries of 1896-1971 are therefore recalculated for the current county-boundaries (NUTS 3 regions in the version of 2016) using GIS data. Between 1965 and 1978, major land reform acts across all federal states reduced the number of counties from 564 to 442 (328 NUTS3 regions today). The census data used is provided at the historical county level. In order to re-estimate the data for the current NUTS 3 boundaries, historical population data at the current municipality level is used provided by Felix Roesel (2022): German Local Population Database (GPOP) (Version 1.0). https://leopard.tu-braunschweig.de/receive/dbbs_mods_00071017. In a first step, for each historical county j the area overlap with the current municipality l is calculated. Within municipalities a constant population density is assumed. In a next step, these area weights are used to derive the proportion of the historical population within current municipality borders l that lives in the part that is overlapping with the historical county j . Current counties i are the sum of several municipalities l . Therefore, we aggregate the area weighted historical population within the current municipalities l that are overlapping with historical counties j to the current county level i by summing over all municipalities l that belong to current county i :

$$pop_{lij} = \sum_{lij} pop_l * \frac{area_{lj}}{area_l}$$

Pop_{lij} is therefore historical size of the population of each historical county j that lives within the boundaries of county i . To construct population weights, we then use the population share of historical county j that lives within the boundaries of county i :

$$popweight_{ij} = \frac{pop_{ijl}}{pop_j}$$

In a final step, these population weights are the used convert data available only for counties in historical boundaries to current boundaries according the following expression:

$$Y_i = \sum Y_j * popweight_{ij}$$

Belgium

County boundaries (Arrondissement) stayed constant over the entire period of interest with only few exception: Arr. Halle-Vilvoorde (BE241) and Arr. Bruxelles-capitale (BE100) were founded in 1963 from the the Arr. Brussel pheripque; Arr Mouscron (BE324) was founded from parts of Arr Ypres (BE253) and Arr Countrai (BE254). These changes occurred in 1963 when the linguistic border was created. For these cases, data of the affected counties has been aggregated.

France

In France, the county boundaries (Departments) stayed constant over the entire period of interest with a few exceptions: The historical Department Seine-et-Oise was subdivided into the new Departments of Essonne, Val-d'Oise and Yvelines in 1968; Seine was subdivided into Hauts-de-Seine, Seine-Saint-Denis Val-de-Marne and Paris in 1968. For the analysis, we aggregate the new departments according to the old boundaries which reduces the number of observations but does not require any information about the distribution within the old counties. These new departments all belong to the metropolitan area /agglomeration Paris and therefore form an integrated labor market.