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DISCUSSION PAPER

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Reversing Fortunes of German Regions, 1926–2019: Boon and Bane of Early Industrialization?

Reversing Fortunes of German Regions, 1926–2019: Boon and Bane of Early Industrialization?*

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This paper shows that 19th-century industrialization is an important determinant of the significant *changes* in Germany's economic geography observed in recent decades. Using novel data on economic activity in 163 labor market regions in West Germany, we establish that nearly half of them experienced a reversal of fortune between 1926 and 2019, i.e., they moved from the lower to the upper median of the income distribution or vice versa. Economic decline is concentrated in North Germany, economic ascent in the South. Exploiting plausibly exogenous variation in access to coal, we show that early industrialization turned from an advantage for economic development to a burden after World War II. The dominant position of heavy industry, supported by the local political-administrative system, limited regional adaptability when the old industries fell into crisis. Today, the early industrialized regions suffer from low innovation and deindustrialization. The (time-varying) effect of industrialization explains most of the decline in regional inequality observed in the 1960s and 1970s and about half of the current north-south gap in economic development.

Keywords: Industrialization, economic development, regional inequality

JEL classification: N91, N92, O14, R12

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1 Introduction

Regional per capita income within advanced economics converged during much of the 20th century (e.g. Barro & Sala-i Martin, 1991; Sala-i Martin, 1996; Persson, 1997). However, there is growing evidence that convergence ended around 1980. Since then, regional disparities have increased again (e.g. Rosés & Wolf, 2018a; Gaubert, Kline, Vergara & Yagan, 2021). This "return of regional inequality" (Rosés & Wolf, 2018b) contributes to growing income inequality and might endanger social cohesion and political stability (Iammarino, Rodriguez-Pose & Storper, 2018; Floerkemeier, Spatafora & Venables, 2021). Of particular concern are declining regions, with their lack of economic opportunity, growing social problems, and rising political tensions (Austin, Glaeser & Summers, 2018; Rodríguez-Pose, 2018). What many of these declining regions have in common is that they had a high share of industrial jobs in the past and are now suffering from the dislocation of deindustrialization (Rosés & Wolf, 2021).

Against this background, the contribution of this paper is two-fold. First, we provide a detailed descriptive analysis of the spatial distribution of economic activity in West Germany over the period 1926-2019. Using a novel data set for 163 labor markets, we study the rise and decline of German regions over the past century and explore trends in regional income inequality. Second, we quantify the effect that early industrialization, measured as the industrial employment share in 1882, had on spatial economic development over time. We then use these results to quantify to what degree regional differences in the early stages of industrialization can explain the changing fortunes of West German labor markets over the past century.

West Germany witnessed a marked reversal of fortune in the 20th century: Historically, North-western Germany was more prosperous than the South. However, the economic balance of power reversed after the Second World War, and today, the North considerably lags behind the South.[1] This reversal makes Germany a particularly interesting case for studying the historical

[1] Appendix Figure A-1 shows the steady relative economic decline of North Germany since 1950. At that time, per capita GDP was about 15% higher in the North than in the South. This lead had vanished by 1980. The past four decades saw a widening gap between South and North Germany. Currently, income per capita is more than

drivers of regional economic decline. After all, economic historians have long argued that the decline of North-western Germany, and particularly the Ruhr region, can be traced back to regional differences in 19th-century industrialization (Abelshauser, 1984; Nonn, 2001; Kiesewetter, 1986).

According to this argument, the reliance of the North on large-scale, capital-intensive firms—often in heavy industries, such as coal, iron, and steel—was conducive to economic development only until the mid-20th century. The heavy industry in the North plunged into crisis after World War II and deindustrialization has impeded economic growth ever since. The most visible signs of decline have been the crisis in the coal industry since 1957, in shipbuilding since the 1960s, and the steel crisis in the 1970s. This paper tests the hypothesis that early industrialization was first conducive and later detrimental for economic development and explores the implications for the marked changes in Germany's economic geography observed in recent decades.

We present three key findings. First, we show that about half of West German labor markets experienced a reversal of fortune between 1926 and 2019, i.e., they moved from the lower to the upper median of the income distribution or vice versa. Economic decline is concentrated in the North: Two-thirds of northern labor markets with above-median per capita incomes in 1926 have below-median income today. We also show that β-convergence ended in 1992. Regional income inequality has increased moderately since 1980, after a sharp decline in the post-war era.

Second, we show that early industrialization after World War II turned from an advantage for economic development to a burden. To establish causality, we instrument a region's industrial employment share in 1882 by its weighted least-cost distance to European coalfields, while controlling for a region's connectedness to other European markets. We exploit the fact that heavy industries, characteristic of Germany's early industrialization process, were dependent on access to coal (Gutberlet, 2014; Ziegler, 2012). Coal, in turn, is found in Carboniferous rock strata, formed hundreds of millions of years ago. Distance to coalfields is thus plausibly exogenous

10% lower in the North than in the South.

to economic development (Fernihough & O'Rourke, 2020). Our 2SLS estimates suggest that a one standard deviation increase in the 1882 industry employment share increases a labor market's rank in the income distribution by 16.8 percentiles in 1957, but decreases the rank by 14.3 percentiles in 2019. We present evidence consistent with the hypothesis that the dominant local position of heavy industry constrained regional adaptive capacity and innovation while generating high adjustment pressure since 1957.

Third, we show that regional differences in 19th-century industrialization are indeed crucial for understanding the reversing fortunes of West German labor markets in recent decades. We quantify the contribution of early industrialization to the North-South gap by predicting the gap for a counterfactual scenario in which regions differ only by their 1882 industrial employment share. Our estimates imply that regional differences in early industrialization can account for almost half of the current North-South gap in per capita income. To quantify the contribution of early industrialization to the evolution in regional inequality, we measure the inequality of a counterfactual income distribution in which all regions are assigned the mean 1882 industrial employment share. We find that the declining positive impact of early industrialization explains well over half of the decline in regional inequality from 1957 to 1980.

Contribution to literature. Our paper contributes to several literature strands. First, we provide new descriptive insights into the evolution of regional economic activity in Germany. Our analysis of 163 labour markets complements previous work on regional development in Germany, conducted at higher aggregation levels (e.g., Kaelble & Hohls, 1989; Frank, 1993; Kiesewetter, 2004). Most closely related to our work is a recent study by Wolf (2018) that describes regional economic development in Germany over the period 1895–2010. The author constructs GDP per capita data for 36 (East and West) German NUTS-2 regions in their 1990s boundaries. We add to Wolf (2018) by presenting evidence for West Germany at a more disaggregated level. In addition, we place a specific focus on transitions between quartiles of the income distribution.

Second, we contribute to an emerging literature that examines the long-term consequences of early industrialization. Franck & Galor (2021) demonstrate that early industrialization has adverse effects on regional economic development in 21st-century France, and Esposito & Abramson (2021) show that former coal-mining regions in Europe have lower GDP per capita today than regions where coal was not previously mined.[2] Both papers attribute the negative long-term effects to adverse consequences for human capital formation.

Our study confirms that early industrialization has negative long-term effects in Germany, where heavy industry played a crucial role in the development process. In contrast to Esposito & Abramson (2021) and Franck & Galor (2021), we find no evidence that early industrialization hindered human capital formation in the long run. This may be because the "educational expansion" of the 1960s and 1970s counteracted the de-skilling effect of early industrialization by establishing new universities in West Germany's industrial heartland. Instead, our results suggest that early industrialization became a drag on economic development because of its negative impact on local innovation and adaptive capacity. The dominant position of large-scale corporations, embedded in a supportive system of corporate relations, preserved local economic structures in an early phase of decline (Grabher, 1993). Today, the old industrial core lacks industry, which in Germany is generally more productive and innovative than the service sector.

Third, we contribute to the ongoing debate on the drivers of the fundamental changes in regional disparities that many advanced economies have experienced in recent decades (Rosés & Wolf, 2018a; Floerkemeier et al., 2021). Our analysis relates the time-varying effects of early industrialization to the marked changes in German economic geography. We show that the decaying effects of early industrialization can explain much of the decline in regional income inequality in the 1960s and 1970s. Similarly, the economic decline of northern Germany is closely related to the legacy of early industrialization. We conclude that differences in 19th-century industrialization are an important determinant of recent shifts in regional economic inequality

[2] Likewise, Matheis (2016) documents negative long-term effects of coal production on the population of US counties. For Western Europe, Rosés & Wolf (2021) document that proximity to coals turns into a burden after the end of the 1970s.

that have received much public attention.

2 Data

This section describes our data. More details on the sources and the definition of all variables can be found in Section A.2 in the appendix.

Unit of analysis. Our unit of analysis is the 163 West German labor markets defined in IfW (1974) based on commuting flows.[3] We aggregate our source data, collected at the level of counties (*Kreise*), to the level of labor markets using Geographical Information System (GIS) software.[4] The fact that we focus on local labor markets rather than counties has two advantages. First, where people live and work often differs at the county level, which poses problems in ranking counties based on their per capita income. In contrast, most people live and work within the same local labor market. Second, territorial reforms led to a sharp decrease in the number of West German counties, especially in the 1970s, making the conversion of data in historical to current county boundaries prone to error. A common reform was to merge urban counties (*Stadtkreise*) with their surrounding rural counties (*Landkreise*). Such reforms do not pose problems at the level of local labor markets, as the latter encompass interconnected rural and urban counties.

GDP per capita, 1926-2019. Our main outcome variable is a labor market's percentile rank in the income distribution of West German labor markets. West Germany's federal statistical office began publishing disaggregated GDP per capita data at the county level in 1957. We digitized the data for 1957-1992 from printed sources. Data are available for eleven years in this period, namely for 1957, 1961, 1964, 1966, 1968, 1970, 1972, 1974, 1978, 1980 and 1992. GDP data for 1992-2019 are available at an annual frequency in electronic form (Arbeitskreis VGR

[3]To the best of our knowledge, the definition in IfW (1974) is the earliest available for West Germany. We exclude the Saarland from our sample, as it did not become part of postwar West Germany until 1957.

[4]The definition of local labor markets is based on county boundaries in 1966. For other years, we overlay maps of historical county boundaries with the base map of local labor markets. We then use the proportion of each historical county's area that belongs to a particular local labor market to aggregate the county-level data.

der Länder, 2021). We proxy regional GDP before 1957 by firm sales, as in, e.g., Vonyó (2012) or Peters (2022). Although firm sales are not a direct measure of the production value, they correlate strongly with local GDP and deliver similar income rankings.[5] We also present evidence for the sub-period 1957-2019, for which income ranks are based on GDP per capita data only.

Industrial employment share 1882. Our main explanatory variable of interest is the share of the local workforce working in industrial occupations in 1882. We thus measure industrialization after Germany's take-off phase, typically dated to 1840-1870s, but before the rise of new industries during Germany's *Hochindustrialisierung* (Ziegler, 2012; Tilly & Kopsidis, 2020). Our measure comes from the first German-wide occupation census that contains results at the county level (Kaiserliches Statististisches Amt, 1884). In a robustness check, we focus only on industrial occupations that have been identified as pivotal for Germany's industrial take-off, namely those in coal mining, iron and metal processing, construction of machines and instruments, and the textile industry.

Distance to European coal fields. Our empirical analysis uses an instrumental variable strategy to identify the causal effect of early industrialization on development. We use the weighted least-cost distance to European coalfields as an instrument for the 1882 employment share in industrial occupations. Access to coal is widely acknowledged as a key factor behind the success of Germany's early industrializing regions, which relied mainly on heavy industries (Fremdling, 1977; Ziegler, 2012). Fernihough & O'Rourke (2020) have recently demonstrated the importance of coal for the European Industrial Revolution in general.

Previous studies have used the proximity to the nearest coal-bearing rock strata as an instrument for the historical use of steam engines (de Pleijt, Nuvolari & Weisdorf, 2020) and coal mining (Esposito & Abramson, 2021). In contrast to these papers, we use the weighted least coast distance to all European coalfields to account for the fact that the closest coalfield is not

[5] The correlation coefficient between a labor market's percentile rank in the 1955 sales per capita and the 1957 GDP per capita distribution is 0.870.

necessarily the one that can be reached with the lowest transportation costs. This modification is important for the German context. In particular, regions in northern and northeastern Germany initially relied primarily on British coal, rather than coal from closer German mines, because of the low cost of river and sea transportation (Fremdling, 1979).[6]

To calculate the instrumental variable, we first divide Europe in a one-by-one kilometer grid. Based on the local geography, we assign each cell a specific transportation cost, which we take from Daudin (2010). We normalize the cost to one for cells that have access to the sea. Cells with access to a major river are assigned a cost value of 1.018, all other cells are assigned Daudin's value for road transport of 2.963.[7] We then calculate the least-cost distance from each labor market to all European coalfields, using the grid as cost surface. The algorithm finds the least-cost path from a region to a coalfield, adding cell-specific costs along the way. The instrument for a given labor market i, C_i, is the sum of the least-cost distances to all coalfields, using the area of coalfields as weights:

$$C_i = \sum_{k=1}^{K} \frac{area_k}{cost_{ik}}, \tag{1}$$

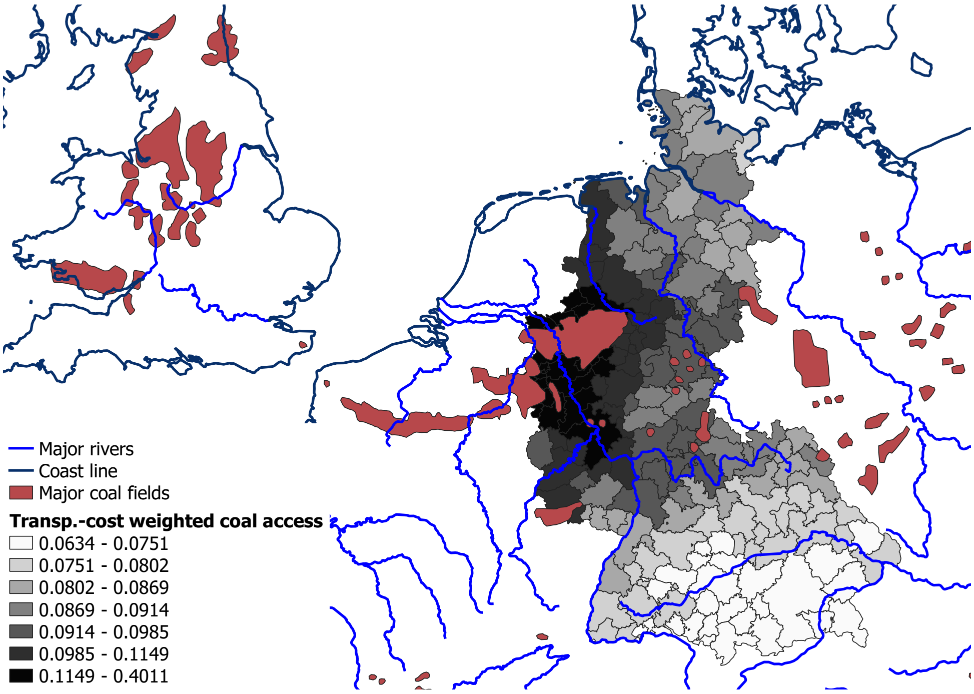
where $cost_{ik}$ is the least cumulative costs from labor market i to coalfield k and $area_k$ is the area of the coalfield polygon in square kilometers. We take the location and extent of European coalfields from Fernihough & O'Rourke (2020).

Figure 1 illustrates the regional variation in the instrument as well as the location of the most important coalfields, coast lines, and major rivers. Higher values indicate more favorable access to coal. Not surprisingly, access is most favorable in the Ruhr region and in regions connected to the Ruhr by rivers. Regions in northern Germany also have relatively favorable access to coal because they can obtain British coal via the North Sea. To ensure that the instrument does not

[6] The relatively low price of English coal in northern Germany was also due to lower production costs in English mines, but this is not accounted for by our instrument.

[7] We take shape files of major European rivers from Fernihough & O'Rourke (2020). The value for rivers is the average of upstream and downstream river transport. We also probe the robustness of our results to alternative costs vectors. In particular, we use squared transport costs and assign higher costs of 2.476 to river and 9.75 to road transport, respectively, following Bairoch (1990). We also restrict the set of rivers to those that are at least 20 meters wide and two meters deep in an additional robustness check.

Figure 1: Weighted least-cost distance to European coalfields



Note: See the main text for details on the construction of the weighted least-cost distance. The transport cost vector is taken from Daudin (2010).

just pick up the connectedness of a labor market within Europe, our empirical analysis controls for a labor market's sum of least-cost distances to all European grid cells on land using the same cost vector as in equation (1) (see Section 4 for details on the empirical specification).

3 The evolution of regional per capita income, 1926-2019

Shifts in the relative position of labor markets. Table 1 documents marked changes in the relative position of West German labor markets over the past 100 years or so. It shows the transitions between quartiles of the income distribution from 1926 to 2019. Change is abound: more than half of the labor markets that were in the bottom quartile of the income distribution in 1926 are now in the top half of the distribution. Conversely, half of the richest labor markets in 1926 are now in the bottom half of the distribution (and 20% of them are even in the bottom quartile). Overall, about half of West German labor markets have experienced a reversal of fortune, i.e., they have moved from the lower to the upper median of the income distribution or vice versa.[8] The correlation between income ranks in 1926 and 2019 is only weakly positive at 0.100 and not statistically significantly different from zero.

Table 1: Transitions between quartiles of the income distribution, 1926-2019 (frequencies, row percent)

		2019				
		Bottom	Second	Third	Top	$\sum$
1926	Bottom	0.244	0.195	0.439	0.122	1.000
		(10)	(8)	(18)	(5)	(41)
	Second	0.342	0.244	0.220	0.195	1.000
		(14)	(10)	(9)	(8)	(41)
	Third	0.220	0.268	0.122	0.390	1.000
		(9)	(11)	(5)	(16)	(41)
	Top	0.200	0.300	0.225	0.275	1.000
		(8)	(12)	(9)	(11)	(40)
	$\sum$	0.252	0.252	0.252	0.245	1.000
		(41)	(41)	(41)	(40)	(163)

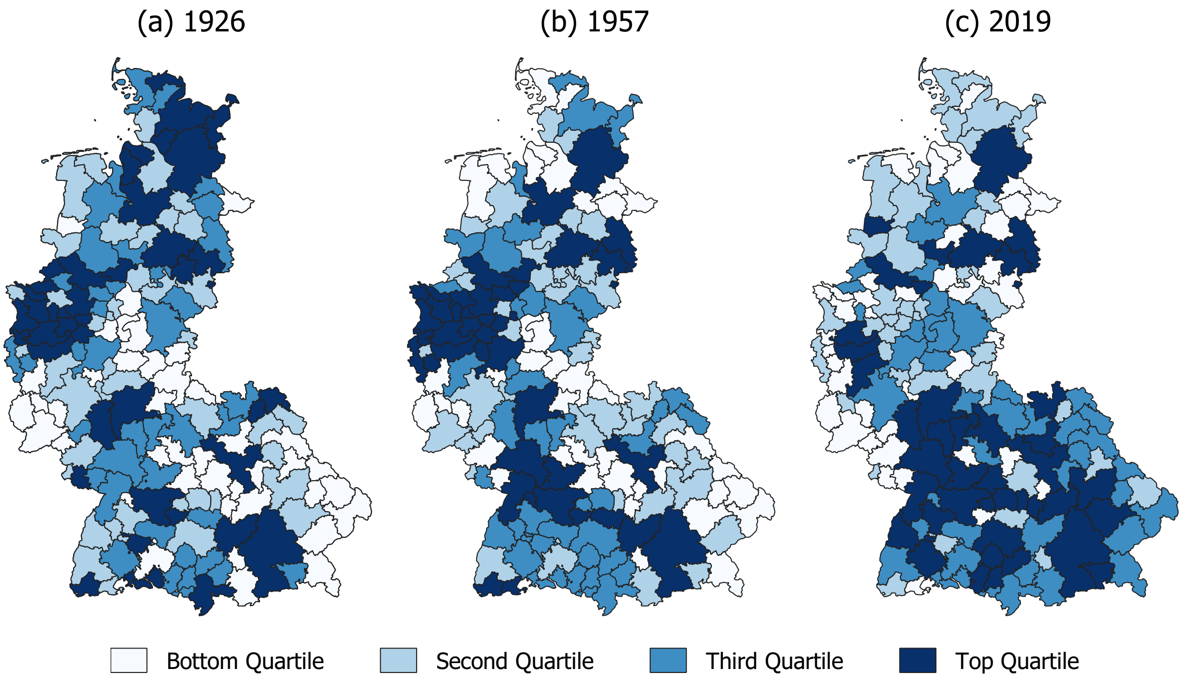
Notes: The table compares positions in the income distribution of West German labor markets in 1926 and 2019. Entries are frequencies, expressed in row percentages. The count for each cell is in brackets. The ranking of labor markets in 1926 and 2019 is based on sales and GDP per capita data, respectively. Cells shaded in green (red) indicate labor markets rising from the bottom (top) to the top (bottom) half of the income distribution.

The maps in Figure 2 illustrate how the economic weights within West Germany have shifted over time. For each West German labor market, the maps show its quartile rank in the income distribution in 1926, 1957, and 2019. In 1926, the economic powerhouses are scattered across the country. They are mainly concentrated in the metropolitan areas in the west (Rhineland, Ruhr region) and north (Bremen, Hamburg). But there are also clusters of rich labor markets in the south, e.g. around Stuttgart or Munich. Poorer labor markets are concentrated in the southeast of West Germany.

In 2019, the regional distribution of incomes has changed significantly. Labor markets in the Ruhr area in particular have slipped in the income ranking. The same applies to some of the

[8] Appendix Table A-1 shows that reversals are only slightly less frequent in 1957-2019 (when we have GDP per capita data also for the initial year).

Figure 2: Regional income in West German labor markets, 1926-2019 (quartile ranks)



Notes: Each map shows the quartile rank in the income distribution of West German labor markets in 1926 (Panel (a)), 1957 (Panel (b)) and 2019 (Panel (c)).

historically rich regions in northern Germany, such as Bremerhaven or Itzehoe. By contrast, only a few of today's poorest labor markets are still to be found in the southeast. Instead, the poorest regions are now concentrated in the far west and northwest of West Germany. Several large centers of the automotive industry (Wolfsburg, Ingolstadt, Munich, Stuttgart and Sindelfingen) top the rankings, accompanied by large cities such as Frankfurt, Düsseldorf and Cologne.

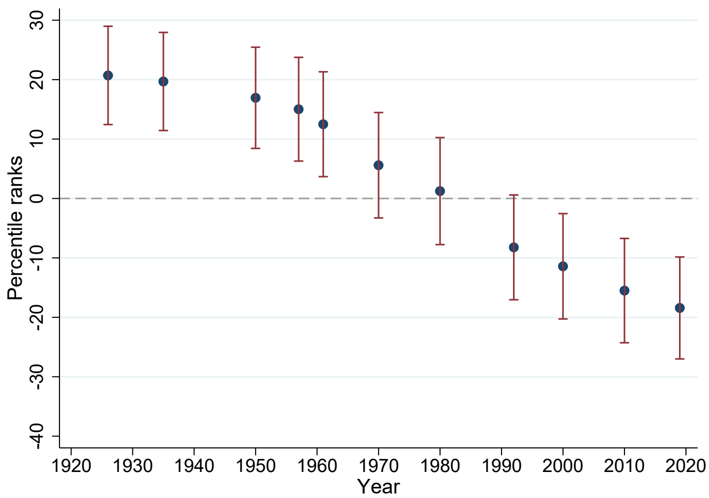
The emerging North-South divide. Figure 2 illustrates that the economic weights within West Germany have shifted significantly over the period 1926-2019. The regions that lost ground in the income distribution were predominantly in the west and north, while the winning regions were predominately in the south of Germany (see Appendix Figure A-3 for a map illustrating the transitions between the top and bottom halves in 1926-2019). The North-South divide, subject of current policy debates (e.g., Schrader & Laaser, 2019), has thus emerged over the past 100 years or so.

We date the emergence of the divide, and quantify its extent, by estimating the following regression for different years:

$$\tilde{y}_{i,t} = \dot{\alpha} + \dot{\beta}_t N_i + \dot{\epsilon}_{i,t}, \tag{2}$$

where $\tilde{y}_{i,t}$ is the percentile rank of labor market i in the income distribution of year t and N_i is a dummy for labor markets located in the North.[9] Parameter $\dot{\beta}_t$ then measures the average difference in percentile ranks between labor markets in North and South Germany at time t.

Figure 3: Percentile rank differences between North and South German labor markets, 1926-2019



Notes: The figure plots the $\dot{\beta}_t$ coefficients from OLS estimations of equation (2). Point estimates are marked by a dot. The vertical bands indicate the 95% confidence interval of each estimate.

Figure 3 plots the estimates of the $\dot{\beta}_t$ coefficient from equation (2). In 1926, northern labor markets ranked, on average, 20.7 percentiles higher than southern ones in the income distribution. After World War II, the North's lead gradually diminished. By 1980, it had disappeared. The

[9] Our baseline definition of northern labor markets adheres to federal states borders. It classifies labor markets located in Bremen, Hamburg, Lower Saxony, North Rhine-Westphalia and Schleswig-Holstein as northern. Southern labor markets are those in Bavaria, Baden-Württemberg, Hesse, and Rhineland-Palatinate (see Appendix Figure A-2 for an illustration). Appendix Figure A-4 shows that the reversal of fortune does not hinge on this specific classification. It remains visible if we also assign the northern parts of Hesse and Rhineland-Palatinate to the North or if we use the latitude as a continuous measure to divide labor markets into northern and southern ones.

North-South gap becomes visible in 1992 and has widened since then. In 2019, northern labor markets rank, on average, 18.3 percentiles below southern ones. In western Germany, then, there has been a reversal of fortune between its northern and southern regions over the past century.

The reversal is also visible in the separate transition matrices for North and South Germany, reported in Table A-2 in the appendix. Positive reversals—with labor markets rising from below- to above-median per capita GDP—cluster in the South (34 out of 40 cases). In contrast, negative reversals are concentrated in the North (31 out of 40 cases). Consequently, northern and southern labor markets drastically changed their overall position in the national income distribution. For example, the share of northern labor markets in the top income quartile fell from 65.0% in 1926 to just 27.5% in 2019. Conversely, the North's share in the lowest income quartile increased from only 14.6% to 61.0%.

The end of convergence. Underlying the marked shifts in the relative position of West German labor markets are regional differences in growth rates. Importantly, we observe β-convergence among West German labor markets only until 1992 but not thereafter. Let $y_{i,t}$ be GDP per capita of economy i at time t. Absolute convergence implies that in a regression of (annualized) growth between time t and time $t+s$ on initial GDP,

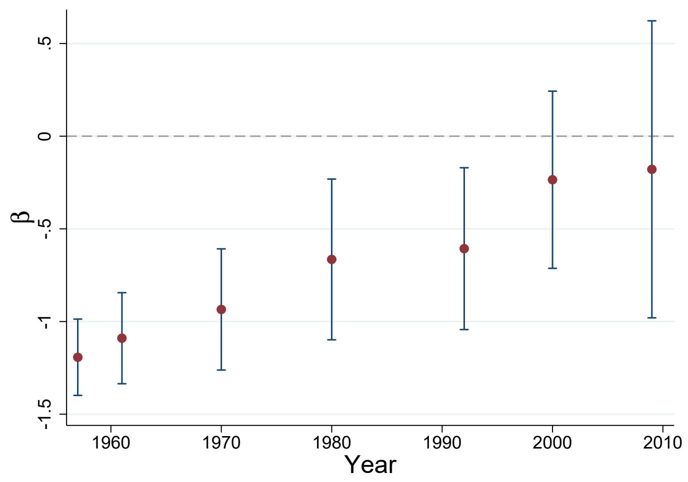
$$\frac{1}{s}\log\left(\frac{y_{i,t+s}}{y_{i,t}}\right) = \alpha + \beta\log\left(y_{i,t}\right) + \epsilon_{i,t+s}, \tag{3}$$

the parameter β is negative (see, e.g., Barro & Sala-i Martin, 1991).[10]

Figure 4 plots estimates of β from OLS regressions of equation (3). Annualized GDP per capita growth, the dependent variable, is calculated from the various start points shown on the x-axis to 2019. The start points include the first year of our GDP data series (1957) and years closest to the end of each subsequent decade. The figure shows that there is β-convergence for start dates between 1957 and 1992 but not thereafter. Thus, poorer labor markets grew faster

[10]Tests of β-convergence are typically motivated by the neoclassical growth model. It predicts that poorer economies with smaller capital stocks grow faster due to diminishing returns. Given access to the same technology, poorer countries then catch up with richer ones as they accumulate capital faster. Another driver of convergence is technology transfers from leader to follower economies (e.g. Abramovitz, 1986).

Figure 4: β-convergence from various starting dates to 2019



Notes: The figure plots the β coefficients from OLS estimations of equation (3). Point estimates are marked by a dot. The vertical bands indicate the 95% confidence interval of each estimate. Each estimate comes from a separate regression. Regressions differ in the starting point for calculating annualized GDP growth. The starting points are 1957, 1961, 1970, 1980, 1992, 2000, 2009. The end point is always 2019.

than richer ones only in the first half of our sample period (when the gap between the North and South narrowed). Appendix Figure A-5 reiterates this point: It shows the unconditional relationship between initial GDP and subsequent annual growth for two sub-periods, 1957-1992 and 1992-2019. A negative relationship is apparent for the earlier period but vanishes for the later one. None of these results are driven by outliers.

In fact, the dispersion of real per capita GDP levels in West Germany has widened since 1980. Table 2 documents how the standard deviation of $\log(y_{i,t})$, σ_{y_t}, has changed over time. The standard deviation decreased markedly between 1957 and 1980, before increasing afterwards (without returning to its 1957 level).[11] We thus observe strong σ-convergence in 1957-1980, followed by moderate σ-divergence.[12] Table 2 also shows that other common measures of regional disparities (coefficient of variation, 90/10 ratio, Gini coeffficient) exhibit similar trends. All

[11] Comparisons of the dispersion over time might be complicated by the fact that the data come from different GDP revisions. However, we find similar patterns when we compare only the dispersion between years for which the data come from the same GDP revision.

[12] See Sala-i Martin (1996) and Young, Higgins & Levy (2008) for a discussion of the concept of σ-convergence and how it relates to β-convergence.

measures declined markedly between 1957 and 1980 but have increased since then. Similar trends in regional inequality have recently been documented also for other advanced economies (Floerkemeier et al., 2021; Rosés & Wolf, 2021).

Table 2: Regional disparities in real GDP per capita, 1957-2019

	1957	1980	2000	2019
σ	0.235	0.162	0.180	0.191
Coefficient of variation	0.242	0.169	0.194	0.208
90/10 ratio	1.799	1.514	1.548	1.581
Gini coefficient	0.132	0.091	0.100	0.107

Notes: The table reports four measures of regional disparities in real GDP per capita. σ is the standard deviation of log real per capita GDP. The coefficient of variation is defined as the standard deviation in GDP per capita divided by its mean. The 90/10 ratio is the ratio of GDP per capita at the 90th to 10th percentile. The Gini coefficient gives equal weights to all regions, i.e., considers each region as an "individual". It ranges from zero (perfect equality) to one (maximal inequality).

4 Early industrialization and economic development, 1926-2019

This section tests the hypothesis that early industrialization was first conducive and later detrimental for economic development, and examines possible channels through which early industrialization might still influence development today.

The effect of industrialization on development, 1926-2019. We estimate the effect of early industrialization on subsequent development using 2SLS. The second stage regression quantifies the effect of the standardized industrial employment share in 1882, $I_{i,1882}$, on a labor market's percentile rank in the income per capita distribution:

$$\tilde{y}_{i,t} = \ddot{\alpha} + \ddot{\beta}_t \hat{I}_{i,1882} + \mathbf{X}_i' \ddot{\gamma}_t + \ddot{\epsilon}_{i,t}, \tag{4}$$

where $\mathbf{X}_i$ is a set of control variables. The first stage regression uses the (log) weighted least-cost distance to European coalfields, C_i, as an instrument for early industrialization (see Section 2 for details on the construction of the instrument):

$$I_{i,1882} = \delta + \zeta \log\left(C_i\right) + \mathbf{X}_i' \eta_t + u_i, \tag{5}$$

where $\mathbf{X}_i$ contains the same control variables as in equation (4).

The key identifying assumption for the 2SLS regression to yield a consistent estimate of our coefficient of interest, $\ddot{\beta}$, is $Cov(C_i, \ddot{\epsilon}_{i,t}) = 0$. The assumption states that (i) there is no unobserved factor that drives economic development and is correlated with C_i and that (ii) C_i affects economic development only through its effect on early industrialization. To rule out that our instrument merely captures favorable location and thus better market access in general, we include the weighted least-cost distance to all European land cells as control variable. Intuitively, the control measures a region's geographic isolation within Europe.[13] We thus exploit only the residual variation in coal access, which is not driven by a region's favorable location in general. Furthermore, we control for the number of towns per square kilometer in 1700, reported in Cantoni, Mohr & Weigand (2020), to capture differences in pre-industrial development.

Table 3 reports OLS and 2SLS regression estimates of the effect of early industrialization on economic development for 1926, 1957, and 2019. These years include the start and end point of our sample period as well as the first year for which we have GDP per capita data. The OLS estimate in Column (1) implies that an increase in the 1882 industrial employment share by one standard deviation improves the rank in the 1926 income distribution by 14.42 percentiles. The 2SLS estimate in Column (2) is only slightly smaller than the OLS estimate. Early industrialization was thus still conducive to economic development in 1926. The same holds for 1957 (see Columns (3) and (4)), just before the coal crisis began with a collapse in demand in the winter of 1957/58.

In 2019, in contrast, early industrialization has an adverse effect on a labor market's ranking in the income distribution. While the OLS estimate in Column (5) is relatively small, the 2SLS estimate is sizable (Column (6)). The latter implies that an increase in the 1882 industrial employment share by one standard deviation decreases a labor market's rank in the income distribution by 14.33 percentiles. The difference between OLS and 2SLS estimates suggests that early industrialization correlates with local characteristics that still foster economic development

[13] Ashraf, Galor & Ömer Özak (2010) establish that, in contrast to conventional wisdom, prehistoric geographical isolation has positive long-run effects on cross-country differences in economic development.

Table 3: Early industrialization and regional economic development

	1926		1957		2019	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
Employment share industry 1882	14.42***	13.19***	18.38***	16.75***	-2.14	-14.33***
	(2.14)	(3.80)	(1.96)	(3.12)	(1.86)	(5.07)
Observations	163	163	163	163	163	163
R-squared	0.217		0.399		0.139	
F-statistic, 1st stage		23.58		23.58		23.58

Notes: The table shows results from OLS (Columns (1), (3), and (5)) and 2SLS (Columns (2), (4), and (6)) regressions of the effect of early industrialization on regional economic development. The ranking in 1926 is based on sales per capita, the rankings in 1957 and 2019 are based on GDP per capita. The 1882 employment share in industry, our explanatory variable of interest, is standardized with a mean of zero and a standard deviation of one. The instrument used in the 2SLS regressions is the log weighted average distance to European coalfields where coalfield sizes serve as weights (see Section 2). All regressions include land accessibility and the number of towns per area in 1700 as control variables. Robust standard errors are in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

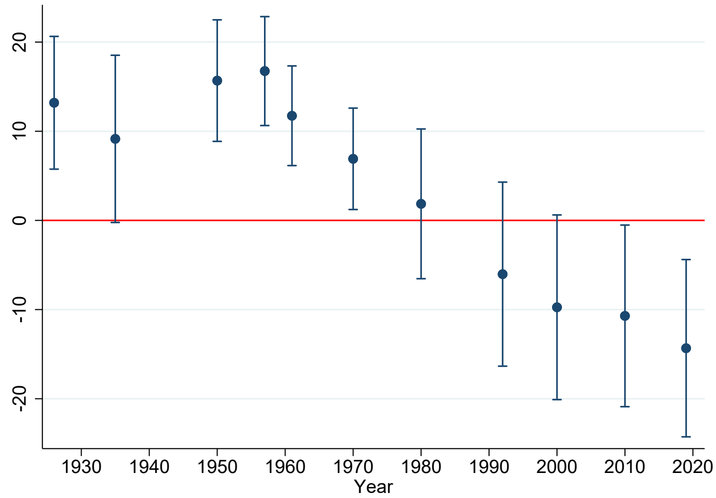
today.[14] The first stage F-Statistic of 23.58 suggests that we do not have a weak instrument problem (see Stock & Yogo, 2005, for critical values).

Overall, our analysis shows that early industrialization had a long-lasting positive effect on economic development, which, however, eventually turned negative. Figure 5 plots coefficient estimates of $\ddot{\beta}_t$ from equation (4) for the years 1926, 1935, 1950, 1957, 1961, 1970, 1980, 1992, 2000, 2010, and 2019. The positive effect of early industrialization is persistent in 1926-1957. If anything, the effect increases from 1935 to 1957, perhaps reflecting the elevated importance of heavy industries for both Germany's war economy and the country's reconstruction efforts after the war.[15] The positive effect of 19th-century industrialization begins to shrink in 1957, in parallel with the onset of the coal crisis. The point estimate turns negative in 1992 and has been declining ever since.

[14] Esposito & Abramson (2021) also find that the adverse effects of historical coal mines on contemporary income are 2-3 times larger (in absolute magnitude) in their IV regressions compared to the OLS estimates. Franck & Galor (2021) show that the early adoption of steam had negative effects on GDP per capita of French departments in 2001-2005. Importantly, their 'IV estimate reverses the OLS estimates [...] from a positive to a negative one'.

[15] The coefficient estimate of $\ddot{\beta}_t$ increases from 9.15 in 1935 to 15.68 in 1950 and 16.75 in 1957. This increase can not reflect the change in the variable used for constructing percentile ranks, as we use sales per capita for both 1935 and 1950.

Figure 5: The effect of early industrialization on the percentile rank in the income distribution



Notes: The figure plots the $\ddot{\beta}_t$ coefficients from 2SLS estimations of equation (4). Point estimates are marked by a dot. The vertical bands indicate the 95% confidence interval of each estimate. The dependent variable is the percentile rank in the income per capita distribution. The 1882 employment share in industry, our explanatory variable of interest, is standardized with a mean of zero and a standard deviation of one.

Robustness checks. We conduct several tests, reported in Appendix Table A-4, to assess the robustness of our results. First, we add a rich set of controls for local geographic and climatic conditions to our baseline specification. Second, we exclude the Ruhr region and Germany's Free Hanseatic cities from our sample. Third, we construct the instrument using alternative cost vectors for the least-cost paths to the coalfields. Fourth, we estimate population- and area-weighted regressions. Fifth, we use log GDP per capita as our dependent variable and only consider the 1882 employment share in core industrial occupations as main explanatory variable. Our key result proves robust in all of these checks: Early industrialization has a beneficial effect on economic development in the medium term, but a detrimental effect in the long term.

Using levels of GDP per capita as dependent variable (rather than ranks) also sheds additional light on the effect size. According to the estimates, a one standard deviation increase in the 1882 industrial employment share increased GDP per capita in 1926 and 1957 by 0.19 and 0.15 log points, respectively. However, it decreases current GDP per capita by 0.09 log points.

Channels. Previous work on the long-term effects of industrialization point to the detrimental effects on human capital as the main channel (Franck & Galor, 2021). Indeed, Esposito & Abramson (2021) find that former coal mining regions in Europe invested less in tertiary education. In the German context, however, it is unlikely that a lack of investment in higher education explains the adverse long-term effects of early industrialization. In the Ruhr region, for example, universities were opened in Bochum (1965), Dortmund (1968), Duisburg (1972), and Essen (1972). Appendix Table A-5 confirms that early industrialized regions do not have a lower share of people with a university degree today. Rather, early industrialization is positively associated with higher education (although the effect is small and not statistically significant).[16]

Why does early industrialization hinder regional economic development in Germany today if it does not impair tertiary education? Economic historians have hypothesized that the high adjustment pressure faced by Germany's early industrial regions after 1957 exceeded their limited capacity for adjustment and innovation (e.g. Grabher, 1993; Hamm & Wienert, 1990; Junkernheinrich, 1989). The resulting deindustrialization and the persistent weakness of innovation are hampering economic development today.

That the old industrial regions were exposed to high adjustment pressure after 1957 is undisputed. Table 4 shows that in 1950, just before the outbreak of the coal crisis, the positive effect of early industrialization on industrial employment was almost entirely due to the coal, iron, and steel industries. A one standard deviation increase in early industrialization increased the industry employment share by 9.6 percentage points in 1950 (Column (1)), of which 8.3 percentage points were attributable to the coal, iron, and steel industries (Column (2)). It was precisely these industries that fell into crisis in the 1960s and 1970s. By 1950, early industrialization had already a negative effect on employment in "modern industries" (Column (3)), such as

[16] We use data on individuals with a university degree from the 1970, 1987, and 2011 censuses. Earlier censuses did not ask about the educational attainment. For none of the three years considered do the 2SLS regressions show a statistically significant effect of early industrialization on the share of individuals with a university degree. The estimated coefficient changes from negative to positive between 1970 and 2011, consistent with the establishment of new universities in former industrial regions after World War II.

Table 4: Early industrialization and industry employment, 1950 & 2019

	Industrial employment share (%)			
	1950			2019
	Total	Coal, iron and steel	Modern industries	Total
	(1)	(2)	(3)	(4)
Employment share industry 1882	9.63***	8.34***	-0.97*	-6.25***
	(1.52)	(1.83)	(0.52)	(1.24)

Notes: The table shows results from 2SLS regressions of the effect of early industrialization on employments shares in industry. The dependent variable is the total industrial employment shares in 1950 (Column (1)) and 2019 (Column (4)), and the 1950 shares in coal, iron, and steel (Column (2)) and "modern industries" (Column (3)). The latter encompass mechanical engineering, road vehicle and aircraft construction, electrical engineering, precision mechanics, optics, the chemical industry and plastics. The 1882 employment share in industry is standardized with a mean of zero and a standard deviation of one. All regressions include land accessibility and the number of towns per area in 1700 as control variables. Robust standard errors are in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

mechanical engineering, electrical engineering, the automobile industry, and the chemical industry. These modern industries continued to flourish after 1945 and are still associated with Germany's economic strength today.

Column (4) of Table 4 shows that Germany's former industrial heartland has failed to revitalize its industrial base in new growth sectors and suffered from deindustrialisation. We find that a one standard deviation increase in early industrialization decreases the employment share in industry by 6.3 percentage points in 2019.[17] Deindustrialization in historically industrial regions hinders local innovation, as patent applications are mainly filed in the industrial sector (Kiese, 2019). Low levels of innovation, in turn, are likely to slow regional economic growth (e.g. Akcigit, Grigsby & Nicholas, 2017). Today, value-added per employee is almost 20% higher in industry than for the German economy as a whole. Deindustrialization and low innovation are thus plausible channels through which early industrialization hinders long-term prosperity.

[17] Appendix Figure A-6 shows that early industrialization has a positive effect on industrial employment only until 1970. The effect then becomes increasingly negative, in line with previous findings for France (Franck & Galor, 2021). The figure also illustrates that the negative effect on industrialization goes hand in hand with positive effects on service employment. In contrast, in the 1950s and 1960s, early industrializing regions had higher employment shares in both industry and services.

We employ the causal mediation framework for linear IV models developed by Pinto, Dippel, Gold & Heblich (2020)[18] to show that the adverse effect of early industrialization is indeed mediated through deindustrialization and the ensuing lack of innovation. Results are in Table 5. Panel A uses patents per capita as mediator variable. Column (1) reproduces our baseline 2SLS results of the effect of early industrialization on per capita income ranks in 2019. The total effect is −14.33 percentiles. Column (2) shows that early industrialization indeed decreases innovative activity. A one standard-deviation increase in early industrialization reduces patents per capita in 2003-2012 by 0.355 log points.[19] Column (3), in turn, suggests that patenting has a positive effect on a labor market's rank in the income distribution (of 30.769 percentiles per log point increase in patents). Therefore, lower innovation activity explains −10.92 (= -0.355×30.70) percentiles–or 76%–of the total effect of early industrialization on economic development. Panel B directly uses industry employment in 2019 as mediator. The analysis suggests that all of the negative long-run effects of early industrialization operates through deindustrialization.[20]

Why have early industrialized regions been unable to maintain, let alone expand, their position in high-growth industries? Possible answers to this question are complex, but usually begin with the lopsided economic structure of early industrialized regions. Most old industrial regions were historically characterized by monostructural agglomerations, typically in heavy and extractive industries (Hu & Hassink, 2016). Large corporations and close interregional business linkages dominated local economies. These tightly knit industrial networks created a "cognitive lock-in" that prevented the regional economy from adapting (Grabher, 1993). Large corporations created a tradition of dependent employment and a corresponding lack of entrepreneurial role

[18]The approach allows us to estimate the proportion of the total treatment effect in linear IV settings that can be explained by a mediator variable without requiring an additional instrument for the mediator. Identification is possible under the so-called partial confounding assumption. This assumption states that confounding variables that jointly cause the treatment and the mediator are independent of the confounding variables that jointly cause the mediator and the outcome. See Dippel, Ferrara & Heblich (2020) for details on the implementation and Dippel, Gold, Heblich & Pinto (2021) for an application.

[19]Data on patent applications to the European Patent Office by NUTS-3 regions come from Eurostat. We average patent applications from the last ten years available.

[20]Unreported regression results also suggest that the adverse effects of early industrialization on current innovation activity indeed operates through deindustrialization.

Table 5: 2SLS mediation analysis

	Panel A. Patents per capita 2003-2012		
	$I_{1882} \rightarrow \tilde{y}_{2019}$	$I_{1882} \rightarrow p_{2012}$	$p_{2012} \rightarrow \tilde{y}_{2019}$
	(1)	(2)	(3)
Employment share industry 1882 (I_{1882})	-14.33***	-0.355***	-3.41*
	(5.07)	(0.101)	(2.02)
Log patents per 1000 persons 2003-2012 (p_{2012})			30.70***
			(8.72)
	Direct effect: -3.41* (2.02)		
	Indirect effect: -10.92** (4.39)		
	Panel B. Industrial employment share 2019		
	$I_{1882} \rightarrow \tilde{y}_{2019}$	$I_{1882} \rightarrow I_{2019}$	$I_{2019} \rightarrow \tilde{y}_{2019}$
	(1)	(2)	(3)
Employment share industry 1882 (I_{1882})	-14.33***	-0.063***	2.42
	(5.07)	(0.012)	(2.55)
Employment share industry 2019 (I_{2019})			267.88***
			(84.74)
	Direct effect: 2.42 (2.55)		
	Indirect effect: -16.75*** (6.25)		

Notes: The table presents second stage results of the causal mediation framework for linear IV models introduced in Pinto et al. (2020). The outcome variable is the GDP per capita rank in 2019. The mediator variable is average patents per capita in 2003-2012 (in logs) and the industrial employment share in 2019 (in %) in Panel A. and B., respectively. Column (1) reproduces, from Column (6) of Table (3), 2SLS regression results of the effect of early industrialization on the outcome. Column (2) shows 2SLS results of the effect of early industrialization on the mediator variable, and Column (3) of the effect of the mediator variable on the outcome (controlling for early industrialization). The indirect effect is the product of the coefficients on early industrialization in Column (2) and on the mediator variable in Column (3). The instrument is the weighted average distance to European coalfields where coalfield sizes serve as weights (see Section 2). All regressions include land accessibility and the number of towns per area in 1700 as control variables. Robust standard errors are in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

models (Stuetzer, Obschonka, Audretsch, Wyrwich, Rentfrow, Coombes, Shaw-Taylor & Satchell, 2016).[21] Corporations were also closely linked to local governments and unions that supported the old mining industrial structures. Large subsidies to the coal, iron, and steel complex maintained outdated structures in Germany's industrial heartland (Hamm & Wienert, 1990; Hassink & Kiese, 2021). In addition, the early industrial regions were not attractive to companies willing to

[21] Equal division inheritance rules, in addition to the lack of coal, favored the emergence of a 'decentralized industrial order' in South-West Germany, dominated by small and medium-sized enterprises (Bartels, Jäger & Obergruber, 2020; Herrigel, 1996).

locate there because heavy industry paid relatively high wages (Junkernheinrich, 1989).

Although a rigorous test is beyond the scope of this paper, we provide evidence consistent with these arguments in Appendix Table A-6. At the beginning of the coal and later the steel crisis, early industrialized regions were indeed characterized by corporate giants, high employment shares in large firms, and high sectoral concentration of employment in industry. Moreover, self-employment rates were low and industrial wages were high when the crisis hit.[22]

As suspected, early industrialization also led to a rigid policy environment. Little political change took place. We find that in the old industrial regions it was less likely that the mayoralty was held by a party other than the dominant one. Of the major parties, the social democratic SPD benefited most from early industrialization, both in local and federal elections. The SPD has traditionally represented the interests of the working class, especially unionized workers. Maintaining the heavily unionized coal and steel sector was in the interest of politicians and unions struggling to defend their political base. Overall, adherence to the existing economic structure was therefore the consensual denominator of local action by companies, politicians, and unions (Grabher, 1993; Junkernheinrich, 1989).

5 Early industrialization, reversal of fortune(s), and changing inequality

To what extent can the blessings and curses of early industrialization explain the changing fortunes of West German labor markets, documented in Section 3? This section considers the role of industrialization for two key empirical patterns: the emerging North-South divide and the fall and rise of regional inequality.

Germany's reversal of fortune(s). Consider first the North-South divide. Table 6 compares the actual divide with the predicted divide resulting from our 2SLS estimates. The latter is the average difference in percentile ranks between northern and southern regions that would

[22] We measure outcomes in 1957 (when the coal crisis began) or just before the crisis began. The local employment share in large firms is available only for 1970. Section A.2 describes the outcome variables in detail.

have resulted if the regions had differed only in their 1882 industrial employment share.[23] As shown, the actual mean difference evolves from +20.71 percentiles in 1926 to −18.42 percentiles in 2019. The mean difference in predicted income ranks follows a similar, though less pronounced, trajectory.

Table 6: Mean differences in income ranks between northern and southern labor markets (in percentiles)

	1926 (1)	1957 (2)	2019 (3)
Actual mean difference	20.71	15.02	-18.42
	(4.22)	(4.45)	(4.38)
Predicted mean difference	8.29	10.47	-8.96
	(2.15)	(2.71)	(2.32)

Notes: The table reports actual and predicted mean differences in income ranks between northern and southern labor markets in 1926 (Column (1)), 1957 (Column (2)), and 2019 (Column (3)). The actual and predicted mean differences are the slope coefficients from a regression of actual and predicted income rank, respectively, on an indicator variable for northern labor markets (see equation (2) for the regression using actual income ranks). We calculate the predicted income rank as $\hat{\ddot{\beta}}_t I_{i,1882}$. Robust standard errors are in parentheses.

Our estimates imply that in 1926, per capita income would have been 8.29 percentile ranks higher in the North than in the South if the regions had differed only in the 1882 employment share in industrial occupations. This northern advantage in predicted income ranks is due to the fact that the average industrial employment share in 1882 was considerably larger in the North than in the South (0.223 versus 0.156) and that early industrialization had a positive effect on economic development in 1926. By 2019, the average differences in predicted income have become negative at −8.96 percentile ranks, reflecting the adverse effect of early industrialization on current development.

A "back-of-the-envelope" calculation suggests that early industrialization explains 48.6% (=8.96/18.42) of the current North-South gap. Therefore, the boon and bane of early industri-

[23]We first use the 2SLS estimate of $\ddot{\beta}_t$ in equation (4) to predict each labor market's income rank, given its 1882 industrial employment share. We then estimate the slope coefficient $\tilde{\beta}_t$ from a regression of the *predicted* income rank on N_i. The estimate yields the mean difference in predicted GDP per capita rank between northern and southern labor markets.

alization contributed significantly to the North-South reversal. Today, the North has a much smaller industrial base than the South after decades of industrial leadership (see Figure A-7 for trends in industrial employment shares over the period 1882-2019). Appendix Table A-7 shows that early industrialization also predicts which individual labor markets experienced a reversal in the 1926-2019 period.[24]

Regional inequality. Consider next the decline and rise of regional inequality. How much of the overall change in inequality can be attributed to regional differences in early industrialization and their differential effect on economic development over time? To answer this question, we decompose the total change in inequality into an "industrialization effect" and a residual. We calculate the industrialization effect as the difference between observed changes in inequality and the counterfactual change in inequality that would have occurred in the absence of differences in early industrialization. The industrialization effect thus measures the contribution of differences in early industrialization to the change in regional inequality.

Let y^c_{it} denote the counterfactual log income per capita of a labor market i in year t, i.e., the income that would result if the 1882 share of industrial employment had been equal to the mean in all labor markets.[25] For the period $t-1$ to t, the contribution of the industrialization effect to

[24]The table presents 2SLS estimates from regressing dummy variables identifying negative and positive reversals on the industrial employment share in 1882 and our standard control variables. The estimate in Column (1) implies that a one standard deviation increase in the 1882 industrial employment share increases the probability of moving from the top to the bottom half of the income distribution by 14.6 percentage points over the 1926-2019 period (from a mean probability of 24.5%). The estimate increases to 22.2 percentage points if we consider reversals in 1957-2019 in Column (2). Conversely, Columns (3) and (4) show that early industrialization markedly decreased the probability of moving up from the bottom to the top half of the income distribution in 1926-2019 and 1957-2019, respectively. The predictive power comes from the fact that early industrialization affects both the initial position in 1926 and the final position in 2019. In unreported regressions, we find that early industrialization still predicts reversals if we restrict the sample to labor markets "at risk" of a reversal (i.e., those in the upper (lower) half of the initial distribution for negative (positive) reversals).

[25]The standardized industrial employment share, $I_{i,1882}$, is then zero. We calculate the counterfactual log income per capita as $y^c_{it} = y_{it} - \hat{\hat{\beta}}_t I_{i,1882}$ where $\hat{\hat{\beta}}_t$ is the 2SLS estimate from the regression model (4) (with log income per capita as dependent variable).

the overall change in σ_{y_t}, the standard deviation of log income per capita, is given by:

$$\begin{aligned} \Delta IND_{t,t-1} &= \overbrace{\left[\sigma_{y_t} - \sigma_{y_{t-1}}\right]}^{\text{Actual change}} - \overbrace{\left[\sigma_{y_t^c} - \sigma_{y_{t-1}^c}\right]}^{\text{Counterfactual change}} \\ &= \underbrace{\left[\sigma_{y_t} - \sigma_{y_t^c}\right]}_{\text{Effect on } \sigma \text{ in } t} - \underbrace{\left[\sigma_{y_{t-1}} - \sigma_{y_{t-1}^c}\right]}_{\text{Effect on } \sigma \text{ in } t-1}. \end{aligned} \tag{6}$$

The second line of equation (6) shows that $\Delta IND_{t,t-1}$ also reflects the difference in the within-year effect of early industrialization on inequality.

Table 7 reports σ_{y_t} and $\sigma_{y_t^c}$ for 1957, 1980, and 2019 and the changes in 1957-1980, 1980-2019, and 1957-2019. The first key observation is that the waning effect of early industrialization explains much of the decline in σ between 1957 and 1980. In 1957, regional differences in early industrialization increased the dispersion of real per capita income by 0.054 log points (the difference between $\sigma_{y_{1957}}$ and $\sigma_{y_{1957}^c}$ reported in the last row). By 1980, however, this effect had declined to just 0.004 points,[26] since early industrialization had no longer a sizeable effect on economic disparity in that year (see Figure 5). Overall, the industrialization effect explains -0.050 (=0.004 – 0.054) log points—or about 69%—of the actual change in σ of -0.073 over the 1957-1980 period.

The second key result from Table 7 is that the industrialization effect cannot explain the increase in regional inequality since 1980. The changes in σ_{y_t} and $\sigma_{y_t^c}$ move largely in parallel over the 1980-2019 period. Therefore, the increase in regional inequality would have occurred even if regions had not differed in their industrialization paths. If anything, regional differences in early industrialization dampened the increase by reducing current inequality. We find that differences in early industrialization reduced the dispersion of real per capita income by 0.013 log points in 2019. Because labor markets with higher counterfactual income per capita tend to have a higher 1882 industrial employment share, a moderately negative effect of early industrialization on economic development compresses the regional income distribution in our specific context.

[26] Earlier work for Germany documented that industrialization increased inequality in the late 19th century (see, e.g., Frank, 1993; Gutberlet, 2014; Braun & Franke, 2022). Together with our results, these findings are consistent with the argument that regional disparities first increase, then stabilize, and finally decline as industrialization progresses (Kuznets, 1955).

Table 7: Components of changes in regional per capita income, 1957-2019

	1957 (1)	1980 (2)	2019 (3)	1957-1980 (2)-(1)	1980-2019 (3)-(2)	1957-2019 (3)-(1)
σ_{y_t}	0.235	0.162	0.191	-0.073	0.030	-0.043
$\sigma_{y_t^c}$	0.180	0.158	0.205	-0.023	0.047	0.024
Δ	0.054	0.004	-0.013	-0.050	-0.017	-0.068

Notes: The table reports σ_{y_t} and $\sigma_{y_t^c}$, the standard deviation of actual and counterfactual log per capita income, for 1957 (Column (1)), 1980 (Column (2)), and 2019 (Column (3)). The last row reports $\sigma_{y_t} - \sigma_{y_t^c}$, i.e., the effect of early industrialization on real per capita dispersion in year t. The last three columns report changes between 1957-1980, 1980-2019, and 1957-2019, respectively. Cells shaded in gray report the industrialization effect, $\Delta IND_{t,t-1}$, as defined in equation (6).

An alternative decomposition isolates the change in inequality that is due to changes in $\ddot{\beta}_t$, the effect of early industrialization on income. Appendix Table A-8 shows that this decomposition[27] delivers even more pronounced results. The waning effect of industrialization—as captured by the decline in $\ddot{\beta}_t$—explains *all* of the decline in regional inequality between 1957 and 1980. What is more, the increasingly detrimental effect of early industrialization between 1980 and 2019 slightly reduced regional inequality over this period. These results imply that without changes in $\ddot{\beta}_t$, regional inequality in West Germany would have increased substantially between 1957 and 2019.

6 Conclusion

In recent decades, the spatial distribution of economic activity has changed fundamentally in many advanced countries. Germany is no exception in this respect. Economic power within the country shifted from the North to the South after World War II. While regional per capita incomes converged strongly in the 1960s and 1970s, regional inequality in West Germany has increased again in recent decades. This paper has shown that these far-reaching changes in

[27]The decomposition is $\overbrace{\left[\sigma_{y_t} - \sigma_{y_{t-1}}\right]}^{\text{Actual change}} = \overbrace{\left[\sigma_{y_t} - \sigma_{y^*}\right]}^{\text{Coefficient effect}} + \overbrace{\left[\sigma_{y^*} - \sigma_{y_{t-1}}\right]}^{\text{Remainder}}$ where $y^* = y_t - (\ddot{\beta}_t - \ddot{\beta}_{t-1})I_{i,1882}$. To obtain y^*, we thus replace the coefficient $\ddot{\beta}_t$ in equation (4) by $\ddot{\beta}_{t-1}$, while holding the effect of other observables and the distribution of residuals fixed. The decomposition is similar in spirit to that proposed by Juhn, Murphy & Pierce (1993). In our context, however, observable characteristics, including $I_{i,1882}$, do not vary over time. See Fortin, Lemieux & Firpo (2011) for an overview of the scope and limitations of different methods for decomposing distributional statistics.

the economic geography of West Germany cannot be understood without accounting for the long-lasting legacy of regional differences in 19th-century industrialization.

We show that early industrialization, measured by industrial employment in 1882, still strongly favored regional economic development in 1957. However, the positive effect diminished between 1957 and 1980, and industrialization became a drag on economic development at the turn of the 21st century. For identification, we exploit variation in access to coal deposits in Europe, while controlling for the connectedness to European markets. Whereas a one standard deviation increase in early industrialization improved a labor market's rank in the West German income distribution by 16.8 percentiles in 1957, it decreases the 2019 rank by 14.3 percentiles.

The initial blessing and later curse of early industrialization strongly influenced trends in regional inequality. We show that the waning advantage of early-industrializing regions markedly reduced regional inequality between 1957 and 1980. Moreover, the gap between North and South Germany, which emerged in the last forty years or so, cannot be understood without recourse to the regions' path to industrialization 140 years ago. Our estimates suggest that differences in early industrialization can explain about half of the current gap between North and South.

Our results have important implications for the policy discourse on regional inequality and economic decline. First, they illustrate that the interpretation of contemporary changes in regional inequality, which have received much attention recently (Iammarino et al., 2018; Floerkemeier et al., 2021), require careful consideration of the past. Development processes not only have lasting effects, but can also bring about future changes. Second, our results show that initial gains from industrialization can come at the expense of long-run losses (see also Matheis, 2016; Franck & Galor, 2021). This inter-temporal trade-off raises the question of whether policy interventions can prevent adverse effects in the long term. Indeed, Germany has managed to avoid the shortage of university graduates in early industrialized regions observed elsewhere in Europe (Esposito & Abramson, 2021), presumably by establishing new universities in its former industrial heartland. Third, our results tentatively suggest that the lopsided economic structure may have favored the negative long-term effects. A more diversified economic structure—as in the Italian industrial triangle of Piedmont, Lombardy and Liguria (Fenoaltea, 2003)—could therefore avoid the adverse long-term effects of industrialization in the first place. After all, Italy's old industrial triangle still generates above-average GDP per capita (e.g. Felice, 2018), in stark contrast to Germany's old industrial heartland.

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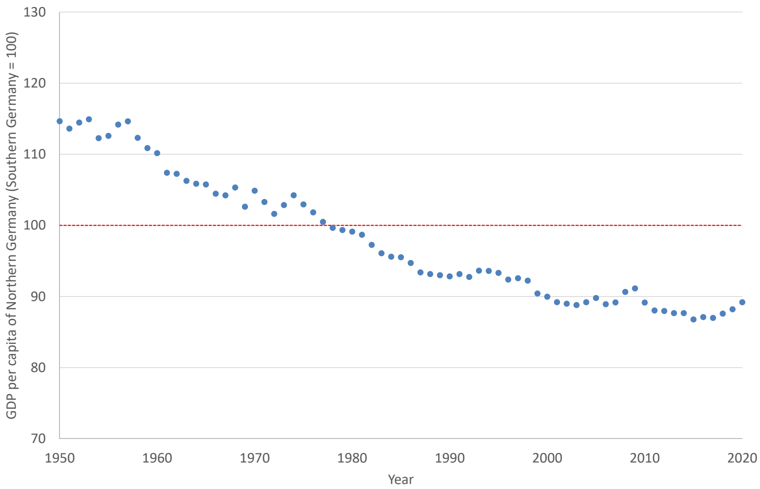
A Online Appendix

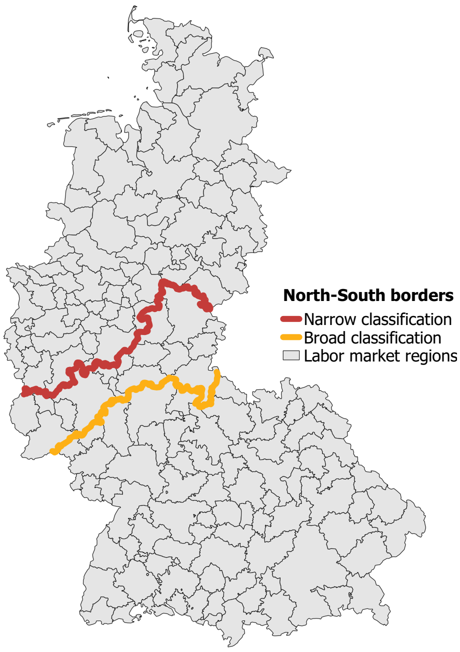
A.1 Background figures and maps

Figure A-1: Normalized GDP per capita of North Germany, 1950-2020 (South Germany = 100)



Notes: The figure depicts the GDP per capita of North Germany relative to that of South Germany. North Germany includes the federal states of Bremen, Hamburg, Lower Saxony, North-Rhine Westphalia, and Schleswig-Holstein. South Germany includes the federal states of Baden-Württemberg, Bavaria, Hesse, and Rhineland-Palatinate.
Source: Arbeitskreis "Volkswirtschaftliche Gesamtrechnungen der Länder"

Figure A-2: Definitions of North and South Germany



Notes: The narrower baseline definition adheres to federal states borders. It classifies labor markets located in Bremen, Hamburg, Lower Saxony, North Rhine-Westphalia, and Schleswig-Holstein as northern. Southern labor markets are those in Bavaria, Baden-Württemberg, Hesse, and Rhineland-Palatinate. The second, broader classification also assigns the northern parts of Hesse and Rhineland-Palatinate to the north.

A.2 Data description and sources

This section provides a detailed description of the data set, the sources, and the construction of variables.

Outcomes:

- *GDP per capita 1957-2019:* West Germany's federal statistical office began publishing disaggregated GDP per capita data at the county level in 1957. We digitized the data for 1957-1992 from printed sources (Statistische Landesämter, 1968, 1973, 1978, 1979, 1998). Data are available for eleven years in this period, namely for 1957, 1961, 1964, 1966, 1968, 1970, 1972, 1974, 1978, 1980 and 1992. GDP data for 1992-2019 are available at an annual frequency in electronic form (Arbeitskreis VGR der Länder, 2021).
- *Turnover 1926, 1935, 1950, and 1955:* We proxy regional GDP before 1957 by firm sales at the county level (Statistisches Reichsamt, 1931, 1939; Statistisches Bundesamt, 1955, 1957a).

Explanatory variables:

Industrial employment share 1882: The share of the local workforce working in industrial occupations in 1882 based on data from the first German-wide occupation census that contains results at the county level (Kaiserliches Statististisches Amt, 1884). The industrial employment share 1882 is defined as industrial employment over total employment. However, due to data availability, the employment share in the core industries of 1882 is defined as the ratio of employees and their dependents to the total population. The core industries include employment in coal mining, iron and metal processing, construction of machines, and the textile industry, but not the home production of textiles.

Distance to European coal fields: We use the weighted least-cost distance to European coalfields as an instrument for the 1882 employment share in industrial occupations. To calculate the instrumental variable, we first divide Europe in a one-by-one kilometer grid, using an Equidistant Conic projection of Europe (ESRI:102031). Based on the local geography, we assign each cell a specific transportation cost, which we take from Daudin (2010). We normalize the cost to one for cells that have access to the sea. Cells with access to a major river are assigned a cost value of 1.018, all other cells are assigned Daudin's value for road transport of 2.963. We take shapefiles of major European rivers (*ne_10m_rivers_lake_centerlines*) and landmass (*ne_50m_admin_0_countries*) from Fernihough & O'Rourke (2020). The shape files are *Made with Natural Earth.* The value for rivers is the average of upstream and downstream river transport. We also probe the robustness of our results to alternative costs vectors. In particular, we use squared transport costs and assign higher costs of 2.476 and to river and 9.75 road transport, respectively, following Bairoch (1990). We also restrict the set of rivers to those that are at least 20 meters wide and two meters deep in an additional robustness check. In doing so, we use the average river bankfull width and depth from the database of Konstantinos, Schumann & Pavelsky (2013). We then calculate the least-cost distance from each labor market's centroid to all European coalfield centroids, using the grid as cost surface. The algorithm finds the least-cost path from a labor market to a coalfield, adding cell-specific costs along the way.

The instrument for a given labor market i, C_i, is the sum of the least-cost distances to all coalfields, using the area of coalfields as weights:

$$C_i = \sum_{k=1}^{K} \frac{area_k}{cost_{ik}}, \tag{A-1}$$

where $cost_{ik}$ is the least cumulative costs from labor market i to coalfield k, and $area_k$ is the area of the coalfield polygon in square kilometers. We take the location and extent of European coalfields from Fernihough & O'Rourke (2020).

Unit of analysis:

Definition: Our unit of analysis is the 163 West German labor markets defined in IfW (1974). The labor markets in IfW (1974) combine counties based on commuter flows. The classification refers to counties in their 1966 borders.

Data aggregation: We aggregate our source data, collected at the level of counties (*Kreise*), to the level of labor markets using Geographical Information System (GIS) software. The definition of local labor markets is based on county boundaries in 1966. For other years, we overlay maps of historical county boundaries with the base map of local labor markets. We then use the proportion of each historical county's area that belongs to a particular local labor market to aggregate the county-level data. Shapefiles on county boundaries are taken from Max Planck Institute for Demographic Research (MPIDR) and Chair for Geodesy and Geoinformatics, University of Rostock (CGG) (2011).

Control variables:

Land access: Land access is measured as the sum of least-cost distances to all European ten-by-ten kilometer grid cells on land, using the same cost vector as in equation (A-1).

Towns 1700: Is defined as the number of towns in 1700 in a given labor market, normalized by area in square kilometers (Cantoni et al., 2020).

Distance to inner-German border: Is defined as the great circle distance between a labor market's centroid and the inner-German border in kilometers.

Location at coast: Is a binary indicator that is one if a labor market is adjacent to the sea and zero otherwise.

Soil quality: We calculate the average soil quality of farmland cells within each labor market based on a 250-by-250 meter raster data set from BGR (2014).[28]

Distance to coast and rivers: Is defined as the great circle distance between a labor market's centroid and the nearest coastline and major river in kilometers, respectively. Shapefiels for coastlines and major rivers are taken from Fernihough & O'Rourke (2020) and are *Made with Natural Earth.*

[28] For the labor market of *Lindau*, we calculate the average soil quality of the neighboring labor markets because the raster data set does not indicate a farmland cell within *Lindau*.

Sunshine hours (mean 1991-2020): We calculate the average annual sunshine in hours within each labor market based on an one-by-one kilometer raster data set of annual average sunshine hours 1991–2020 from Deutscher Wetterdienst (DWD) (2021).

Ruhr valley: Is a binary indicator that is one for the labor markets of Duisburg, Essen, Recklinghausen, Bochum, Dortmund, and Hamm-Beckum.

Free and Hanseatic cities: Is a binary indicator that is one for the labor markets of Bremen, Lübeck, and Hamburg.

Population in 1882: We use county-level population data from the 1882 occupation census (Kaiserliches Statististisches Amt, 1884). In contrast to the 1880 population census, the occupation census does not measure the population at the place of residence (*Wohnbevölkerung*) or whereabouts during the census (*ortsanwesende Bevölkerung*), but at the place of occupation of the provider (*Berufs-Bevölkerung*).

Channels:

Share of people with a university degree 1970, 1987, 2011: Data on population and population by education at the county level are from the corresponding censuses. Earlier censuses did not record educational attainment. The data for 1970 and 1987 are taken from Schmitt, Rattinger & Oberndörfer (1994); 2011 data are taken from `https://www.zensus2011.de`.

Industrial employment share and employment share in services 1882, 1907, 1939, 1950, 1961, 1970, 1987, 1992-2019. Employment shares for the years 1882, 1907 and 1939 are based on the respective occupation censuses (Kaiserliches Statististisches Amt, 1884, 1910; Braun & Franke, 2021). Employment shares for 1950, 1961, 1970 and 1987 come from population censuses and are taken from Schmitt et al. (1994). Since 1992, sectoral employment shares are reported as part of official GDP estimates (Arbeitskreis VGR der Länder, 2021).

Patents 2003–2012: Data on patent applications to the European Patent Office by NUTS-3 regions come from Eurostat (`https://ec.europa.eu/eurostat/web/products-datasets/-/PAT_EP_RTOT`). We average patent applications from the last ten years available.

100 largest firms in 1957: Fiedler & Gospel (2010) list the 100 largest German firms by employment. We match firms to labor markets based on headquarter locations in 1957.

Employment in firms with more than 500 employees in 1970: Shares of employed persons by firm size categories come from the 1970 population census and are taken from Schmitt et al. (1994).

Sectoral concentration of industrial employment in 1950: We measure employment concentration by the Hirschman-Herfindahl-Index (with $\alpha = 2$). The index is calculated as $HHI_i = \sum_{l=1}^{L}(b_{il})^2$, where b_{il} is labor market i's employment share of the (2-digit) industrial sector l in total industrial employment. We multiply the HHI with 100 so that it ranges from $100/L$ (if all sectors have the same employment) to 100 (if all employment is concentrated in one sector). The 2-digit employment data are based on the 1950 occupation census and are taken from several official publications (Bayerisches Statistisches Landesamt, 1952; Hessisches Statistisches Landesamt, 1952; Niedersächsisches Amt für

Landesplanung und Statistik, 1953; Statistisches Landesamt Baden-Württemberg, 1954; Statistisches Landesamt Bremen, 1953; Statistisches Landesamt der Freien und Hansestadt Hamburg, 1953; Statistisches Landesamt Nordrhein-Westfalen, 1952a,b; Statistisches Landesamt Rheinland-Pfalz, 1952; Statistisches Landesamt Schleswig-Holstein, 1953).

Self-employment share in 1950: Defined as the number of self-employed over total employment in 1950. The data are based on the 1950 occupation census and are taken from Braun & Franke (2021).

Average annual earnings in industry in 1951: We calculate the average annual earnings for each labor market as the weighted sum of state-by-sector average annual earnings in 1951 (Statistisches Bundesamt, 1954), using the labor market's sectoral employment shares in 1950 as weights.

Number of years the major was member of the Social Democrats in 1950-1990 and number of years the major was member of the locally dominant party in 1950-1990: We hand-collect names, years in office, and party affiliation of all mayors since 1945 of the main town in each regional labor market. The sources are Wikipedia entries, towns' websites and towns' archives. For each town, we define the dominant party as the party with most years in office (with independent mayors counting for no party).

Vote share of the Socials Democrats in the national election of 1957: Data on election outcomes by counties is available from Statistisches Bundesamt (1957b).

A.3 The evolution of regional per capita income, 1926-2019

Table A-1: Transitions between quartiles of the income distribution, 1957-2019 (frequencies, row percent)

		2019				
		Bottom	Second	Third	Top	$\sum$
1957	Bottom	0.417	0.220	0.293	0.073	1.000
		(17)	(9)	(12)	(3)	(41)
	Second	0.317	0.220	0.268	0.195	1.000
		(13)	(9)	(11)	(8)	(41)
	Third	0.049	0.317	0.293	0.342	1.000
		(2)	(13)	(12)	(14)	(41)
	Top	0.225	0.250	0.150	0.375	1.000
		(9)	(10)	(6)	(15)	(40)
	$\sum$	0.252	0.252	0.252	0.245	1.000
		(41)	(41)	(41)	(40)	(163)

Notes: The table compares positions in the income distribution of West German labor markets in 1957 and 2019. Entries are frequencies, expressed in row percentages. The count for each cell is in brackets. The rankings of labor markets are based on GDP per capita data. Cells shaded in green (red) indicate labor markets rising from the bottom (top) to the top (bottom) half of the income distribution.

Table A-2: Transitions between quartiles of the income distribution, 1926-2019, by region

1926 \ **2019**	Bottom	Second	Third	Top	∑
Bottom	0.028	0.000	0.042	0.014	0.085
	(2)	(0)	(3)	(1)	(6)
Second	0.140	0.099	0.014	0.014	0.268
	(10)	(7)	(1)	(1)	(19)
Third	0.099	0.127	0.014	0.042	0.282
	(7)	(9)	(1)	(3)	(20)
Top	0.085	0.127	0.070	0.085	0.366
	(6)	(9)	(5)	(6)	(26)
∑	0.352	0.352	0.140	0.155	1.000
	(25)	(25)	(10)	(11)	(71)

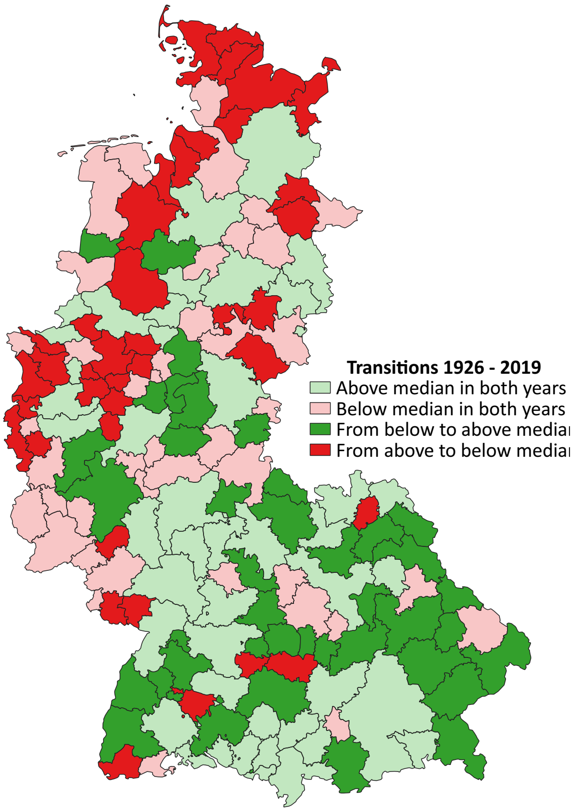
(a) North

1926 \ **2019**	Bottom	Second	Third	Top	∑
Bottom	0.087	0.087	0.163	0.044	0.380
	(8)	(8)	(15)	(4)	(35)
Second	0.044	0.033	0.087	0.076	0.239
	(4)	(3)	(8)	(7)	(22)
Third	0.022	0.022	0.044	0.141	0.228
	(2)	(2)	(4)	(13)	(21)
Top	0.022	0.033	0.044	0.054	0.152
	(2)	(3)	(4)	(5)	(14)
∑	0.174	0.174	0.337	0.315	1.000
	(16)	(16)	(31)	(29)	(92)

(b) South

Notes: The table compares positions in the income distribution of West German labor markets in 1926 and 2019. Panels (a) and (b) show transitions for labor markets located in North and South Germany, respectively. Entries are frequencies, expressed in row percentages. The count for each cell is in brackets. Cells shaded in green (red) indicate labor markets rising from the bottom (top) to the top (bottom) half of the income distribution.

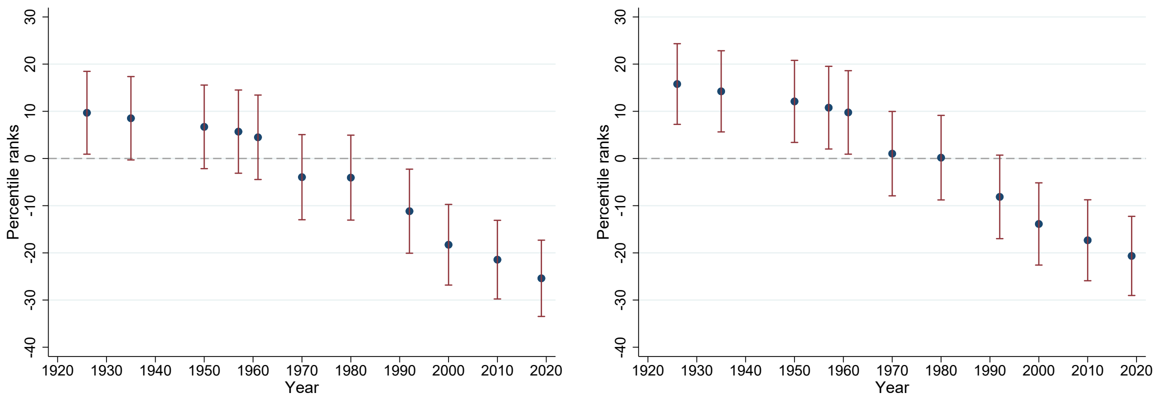
Figure A-3: Changes in the relative income position, 1926-2019



Notes: The figure shows changes in the relative income position between 1926 and 2019. Labor markets shaded in dark green (red) are those rising from the bottom (top) to the top (bottom) half of the income distribution. Labor markets shaded in light green (red) are those that are in the top (bottom) half of the income distribution in both years.

Figure A-4: Percentile rank differences between North and South German labor markets, alternative classifications, 1926-2019

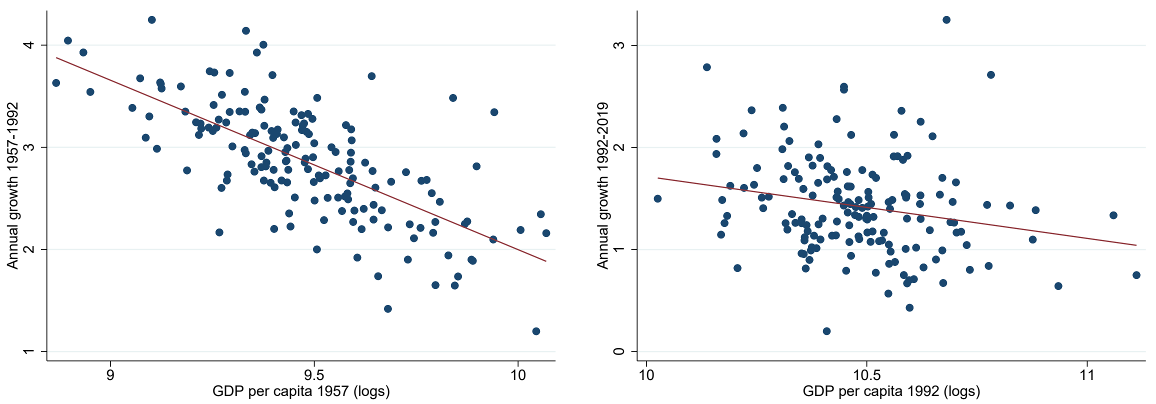
(a) Broad definition (b) Split at medium latitude



Notes: The figure plots the $\dot{\beta}_t$ coefficients from OLS estimations of equation (2). Point estimates are marked by a dot. The vertical bands indicate the 95% confidence interval of each estimate. Panel (a) classifies labor markets located in Bremen, Hamburg, Lower Saxony, North Rhine-Westphalia, Schleswig-Holstein, and the northern parts of Hesse and Rhineland-Palatinate as North Germany. Southern labor markets are those in Bavaria, Baden-Württemberg, and the southern parts of Hesse and Rhineland-Palatinate. Panel (b) uses latitude to assign regions. Those with above-mean latitude are classified as North Germany.

Figure A-5: β-convergence for two sub-periods

(a) 1957-1992 (b) 1992-2019



Notes: The figures plot annual growth in real GDP per capita on the y-axis against initial real GDP per capita, along with the linear regression line. Panel (a) does so for 1957-1992, panel (b) for 1992-2019. Each dot represents a labor market.

A.4 Early industrialization and economic development, 1926-2019

Robustness checks. Table A-4 reports the results of our robustness checks. Panel A reproduces our baseline results on the effect of early industrialization on economic development from Columns (2), (4), and (6) of Table 3.

First, we add additional control variables to our baseline specification (see Panel B). These control variables include distance to the inner-German border, which separated West from East Germany between 1949 and 1990, location at the coast, distance to coast and rivers, soil quality, and average sunshine duration. Geographic and climatic conditions might affect land productivity and thus both the regional industrialization process and aggregate productivity. Second, we vary the estimation sample (Panel C). We exclude the Ruhr region, Germany's old industrial heartland, and the Free Hanseatic cities of Bremen, Hamburg and Lübeck, focal points of the industrialization in northern Germany and federal states in the German Empire. Third, we construct the instrument using alternative cost vectors for the least-cost paths to the coalfields (Panel D). The alternative costs vectors use squared transportation costs, consider only rivers that are at least 20 meters wide and two meters deep, and place higher costs on river and road transport than our baseline vector (following Bairoch, 1990). Fourth, as labor markets vary widely in size, we estimate weighted regressions, using the 1882 population and land area as weights (Panel E). Fifth, we use log GDP per capita as our dependent variable and only consider the 1882 employment share in core industrial occupations as main explanatory variable (Panel F). Core occupations, pivotal for Germany's early industrialization process, include those in coal mining, iron and metal processing, construction of machines, and the textile industry. Our main result proves robust in all of these checks: Early industrialization has a beneficial effect on economic development in the medium term, but a detrimental effect in the long term.

The final robustness check in Panel F sheds additional light on the effect size by using levels of sales (1926) and GDP (1957, 2019) per capita as dependent variables (rather than percentile ranks). According to the estimates, a one standard deviation increase in the 1882 industrial employment share increased 1926 sales per capita and 1957 GDP per capita by 0.19 and 0.15 log points, respectively. However, it decreases current GDP per capita by 0.09 log points.

Table A-4: Robustness checks of 2SLS estimates

	1926 (1)	1957 (2)	2019 (3)	1st stage F-stat. (4)
A. Baseline specification				
Baseline specification	13.19***	16.75***	-14.33***	23.58
	(3.80)	(3.12)	(5.07)	
B. Additional control variables				
...addding distance to inner-German border (logs)	13.62***	15.48***	-15.26***	22.63
	(4.10)	(3.18)	(5.40)	
...adding location at coast (0/1)	13.03***	16.81***	-13.95***	23.45
	(3.69)	(3.14)	(4.98)	
...adding control for soil quality	9.38**	13.72***	-17.78***	22.96
	(4.14)	(3.26)	(5.71)	
...adding controls for log distance to coast and rivers	9.39***	16.22***	-12.96***	31.04
	(2.70)	(2.53)	(4.23)	
...adding control for sunshine hours (mean 1991-2020)	9.38**	13.72***	-17.78***	18.90
	(4.14)	(3.26)	(5.71)	
...all of the controls above	12.09**	15.97***	-15.75**	14.16
	(4.95)	(4.09)	(6.74)	
C. Different samples				
...excluding Ruhr valley	20.34***	19.60***	-19.84**	11.25
	(6.42)	(5.78)	(9.73)	
...excluding Free Hanseatic cities	13.33***	16.69***	-14.58***	23.44
	(3.79)	(3.14)	(5.12)	
D. Alternative cost vectors for the instrument				
...using squared transportation costs	10.34***	14.43***	-18.63***	30.30
	(3.23)	(2.73)	(5.15)	
...considering only rivers at least 20 meters wide and two meters deep	7.26**	14.84***	-14.89***	29.58
	(3.07)	(2.61)	(4.31)	
...based on Bairoch (1990)	6.29**	13.14***	-18.10***	23.75
	(3.08)	(2.60)	(4.83)	
E. Weighted regressions				
...weighted by 1882 population	9.01***	11.21***	-11.79***	46.58
	(3.36)	(3.02)	(4.32)	
...weighted by area	8.25	12.39*	-22.51***	25.83
	(7.27)	(6.91)	(8.71)	
...using Conley SEs (cut-off: 100 km)	13.19***	16.75***	-14.33***	29.13
	(0.45)	(1.47)	(5.26)	
F. Independent and dependent variable				
...1882 employment share in key industries as indep. variable	12.31***	15.95***	-13.65***	19.88
	(4.64)	(3.92)	(5.15)	
...Log turnover/GDP per capita as dep. variable	0.189***	0.145***	-0.088***	23.58
	(0.055)	(0.026)	(0.033)	

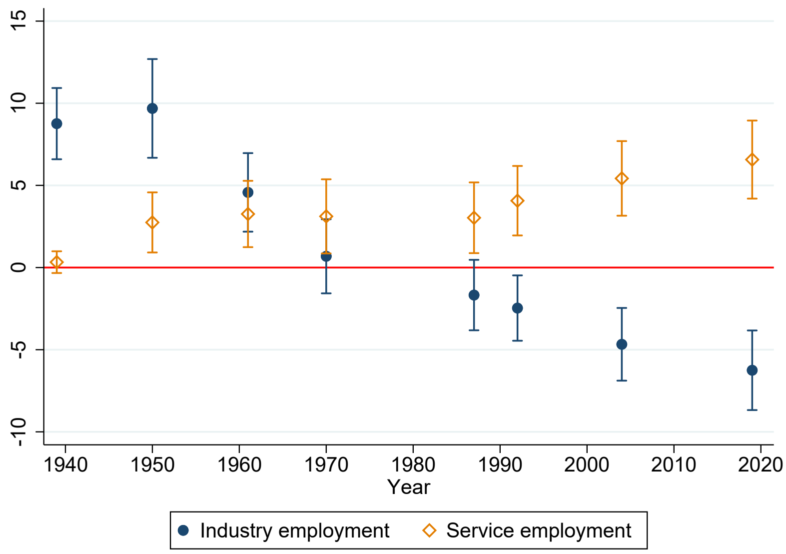
Notes: The table reports 2SLS estimates of the $\ddot{\beta}_t$ coefficient in equation (4). The dependent variable is the percentile rank in the income per capita distribution in 1926 (Column (1)), 1957 (Column (2)), and 2019 (Column (3)). All regressions in Panels A to F include land accessibility and the number of towns per area in 1700 as control variables. Regressions in Panel B add additional variables to our set of controls. Regressions in Panel C vary the estimation sample. Regressions in Panel D vary the cost vectors for sea, river and overland transport used for constructing the instrumental variable. Regressions in Panel E estimate weighted regressions, using population in 1882 and land area as weights. Regressions in Panel F change the dependent and main explanatory variable. Key industries include coal mining, machines, textile, iron and metal processing. Robust standard errors are in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

Table A-5: Effects of early industrialization on tertiary education

	Population share w/ university degree (%)		
	(1)	(2)	(3)
	1970	1987	2011
Employment share industry 1882	-0.138	0.126	0.151
	(0.094)	(0.206)	(0.451)
N	163	163	163

Notes: The table reports results from 2SLS regressions of the effect of early industrialization on the population share with a university degree (measured in percent). The data come from the population censuses 1970, 1987 and 2011. The 1882 employment share in industry is standardized with a mean of zero and a standard deviation of one. All regressions include land accessibility and the number of towns per area in 1700 as control variables. Robust standard errors are in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

Figure A-6: The effect of early industrialization on the employment shares in industry and services, 1939-2019



Notes: The figure plots the coefficient estimates from separate 2SLS regressions of the employment share in industry (blue) and services (yellow) in different years (1939, 1950, 1961, 1970, 1987, 1992, 2004, 2019) on the 1882 industrial employment share (in %). Point estimates are marked by a dot. The vertical bands indicate the 95% confidence interval of each estimate. The 1882 employment share in industry is standardized with a mean of zero and a standard deviation of one. All regressions include land accessibility and the number of towns per area in 1700 as control variables.

Table A-6: Early industrialization, economic structure, and political outcomes

	Economic structure					Political outcomes		
	Location of top-100 firm (0/1) 1957	Empl. share in firms w/ 500+ employees (%) 1970	HHI index of industry concentration 1950	Self-employment share (%) 1950	Avg. annual earnings in industry (100DM) 1951	Years w/ major from dominant party 1950-90	Years w/ Social Dem. major 1950-90	Vote share Social Democrats (%) 1957
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Empl. share industry 1882	0.216***	4.098***	5.658***	-3.006***	4.673***	6.241***	4.687**	3.418***
	(0.0611)	(1.139)	(1.943)	(0.509)	(0.796)	(1.402)	(1.930)	(0.847)

Notes: The table shows the results of 2SLS regressions of the effect of early industrialization on the probability of having at least one of the 100 largest firms in the labor market in 1957 (Column (1)), the share of employment in firms with more than 500 employees in 1970 (Column (2)), the sectoral concentration of industrial employment in 1950 (Column (3)), the self-employment share in 1950 (Column (4)), average annual earnings in industry in 1951 (Column (5)), the number of years the major was member of the locally dominant party in 1950-1990 (Column (6)), the number of years the major was member of the Social Democrats in 1950-1990 (Column (7)), and the vote share of the Socials Democrats in the national election of 1957 (Column (8)). We measure employment concentration by the Hirschman-Herfindahl-Index (with $\alpha = 2$). The 1882 employment share in industry is standardized with a mean of zero and a standard deviation of one. All regressions include land accessibility and the number of towns per area in 1700 as control variables. Robust standard errors are in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

A.5 Early industrialization, reversal of fortune(s), and changing inequality

Table A-7: Early industrialization and reversals of fortunes

	Negative reversal (0/1)		Positive reversal (0/1)	
	1926-2019	1957-2019	1926-2019	1957-2019
	(1)	(2)	(3)	(4)
Employment share industry 1882	0.198***	0.267***	-0.176***	-0.108**
	(0.075)	(0.077)	(0.054)	(0.043)
Outcome mean	0.245	0.209	0.245	0.209

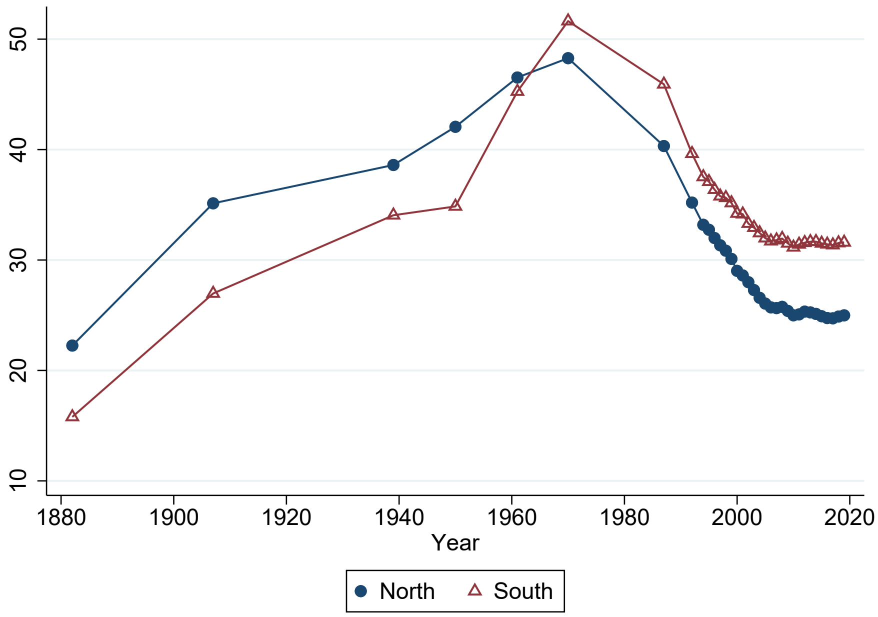
Notes: The table shows results from 2SLS regressions of the effect of early industrialization on the probability of experiencing a reversal of fortune. The dependent variable is a dummy variable indicating a negative (Columns (1) and (2)) or positive (Columns (3) and (4)) reversal. We say that a labor market has experienced a negative (positive) reversal if it moved from the top (bottom) half of the income distribution to the bottom (top) half in 2019. Columns (1) and (3) take the rank in 1926 as the starting point, Columns (2) and (4) the rank in 1957. The 1882 employment share in industry is standardized with a mean of zero and a standard deviation of one. All regressions include land accessibility and the number of towns per area in 1700 as control variables. Robust standard errors are in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% percent level, respectively.

Table A-8: Decomposition of changes in σ_{y_t}, 1957-2019

	1957-1980	1980-2019	1957-2019
	(1)	(2)	(3)
Total change	-0.073	0.030	-0.043
Of which due to:			
change in $\ddot{\beta}_t$	-0.080	-0.018	-0.098
remainder	0.007	0.048	0.055

Notes: The table decomposes the change in σ_{y_t} into two components, the effect of changes in $\ddot{\beta}_t$ and a remainder. See footnote (27) for details.

Figure A-7: Industrial employment shares in North and South Germany (%), 1882-2019



Notes: The figure plots the employment share of the labor force in industry (in %), separately for North and South Germany.

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