



The European coal curse

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Abstract

In this paper we examine the impact of natural resource wealth by focusing on historical coal-mining across European regions. As an exogenous source of variation in coal extraction activities, we rely on the presence of coal-deposits located on the earth's surface, which historically facilitated the discovery and extraction of coal. Our results show that former coal-mining regions are substantially poorer, with (at least) 10% smaller per-capita GDP than comparable regions in the same country that did not mine coal. We provide evidence that much of this lag is explained by lower levels of human capital accumulation and that this human-capital effect is concentrated in men. Finally, we provide suggestive evidence that the persistently lower levels of human capital in coal mining regions that we document result from the crystallization of negative attitudes towards education and lower future orientations in these regions.

Keywords Mines · Coal · Resources · Minerals · Resource curse · Universities · Human capital · Long-run development · Gender gap · Male achievement gap

JEL Classification O13 · Q35 · N13 · I25 · O10

1 Introduction

A substantial body of work finds that natural resource abundance can have adverse effects on growth and development. While scholars have extensively explored its short-run effects, typically with data from the post-war period, extant evidence on comparatively longer term consequences is limited. Indeed, although short-term negative effects can be assessed with little delay and, eventually, may be mitigated by dedicated policies, effects over broader spans of history are much more difficult to evaluate since, by construction, they take a time to materialize. Nevertheless, studying these effects and their drivers is crucial, especially if they can be difficult to undo when ameliorative policies are implemented only belatedly.

In this paper we investigate the effects of resource wealth by focusing on the impact of historical coal-mining across European regions, where coal was mined for centuries but its

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extraction has been minimal for several decades. To this end, we collect data on coalfields discovered in Europe by the early twentieth century.¹ In order to examine the effects of coal abundance, we exploit within-country variation to compare coal-mining regions to non-coal-mining regions in the same national context. Since more technologically advanced regions were also those most likely to search for and extract coal, we exploit differences in underlying geological surface conditions to obtain plausibly random variation in the location of mining activity. European coal seams occur most extensively in rock strata originating in the Carboniferous period and thus, given the position of the latter in the geological time scale, tend to be located deep underground. However, in some places, erosion and tectonic movement brought Carboniferous strata to the surface, making easier the discovery and extraction of coal. As such, we exploit the location of coal-deposits within carboniferous surface geology to obtain plausibly exogenous variation in the likelihood of coal having been discovered and extracted.

Our results show that regions that produced coal have an (at least) 10% smaller per capita GDP than comparable regions in the same country that did not mine coal. Our results are robust to the inclusion of a large set of geographical and location-based controls and a set of alternative measures of historical coal extraction. They are also consistent in magnitude across regions of the continent—despite large heterogeneity in economic, institutional, and historical contexts.²

In order to exclude the possibility that Carboniferous surface geology might be associated with a particularly disadvantaged geography, we examine the effect of having surface geological strata that strictly preceded and followed the Carboniferous Period, the Permian and Devonian Periods, respectively. Because of the temporal proximity of these eras on the geologic time scale, comparable earth movements and erosion should have brought them close to the surface and thus made such areas similar in terms of geographical characteristics. Regions with Carboniferous, Permian, and Devonian surface geology are therefore likely to share similar bio-geographic features while being, nevertheless, considerably different with respect to coal richness. We employ these facts in a falsification exercise, which shows that coal geology affected present-day development through the historic presence of coal mines, and not due to features characterizing areas with similar geographies and geological histories.

Next, we show that the European “coal curse” we identify has been, to a large extent, a human capital curse, demonstrating that coal-mining had a large negative effect on human capital accumulation. We show that, today, regions that historically mined coal have a 20% lower share of people with a university education. Given that coal-mining has been an almost entirely male-dominated profession, we then explore whether the depressed human capital accumulation we observe disproportionately impacted men, and document a substantial male achievement gap in coal-mining regions. Based on coefficient estimates, the European male achievement gap in tertiary education would nearly disappear in the absence of a Carboniferous geography.

In the last part of our analysis we shed light on the drivers of this human capital curse. We present evidence consistent with two possibly complementary mechanisms. First, we

¹ We follow Fernihough and O’Rourke (2014) and use data on historical coalfields as measured in the early twentieth century in Pol et al.’s (1931) Atlas. While Fernihough and O’Rourke (2014) exploit the proximity of cities to coalfields to proxy for city availability of coal, we are instead primarily interested in measuring where coal mines were located.

² In particular, the same picture emerges in Northern, Southern, and Eastern Europe.

find evidence suggesting that when coal-mining employed a large share of the labor force of coal-mining regions, the continued demand for low-skilled labor depressed investment in human capital accumulation. Here, we focus on public investment in higher education and construct a dataset that maps European universities over time and space. From the mid-nineteenth century on (but not before), considerably fewer universities were established in regions with a history of coal mining. While coal-mining regions partially caught up, a gap in human capital accumulation nevertheless persists. We provide suggestive evidence that this is because of the preferences devaluing/stigmatizing education that the history of coal engendered. Second, we find evidence suggesting that differences in health and life expectancy were potentially important and complementary drivers of lower human capital in European mining regions. Unhealthy and unsafe working conditions in the mines, as well as a greater degree of environmental degradation, may have resulted in worse health and substantially lower life expectancies through the present. In turn, we show that this may explain a lower propensity to invest for the future, possibly depressing incentives for the accumulation of human capital.

We evaluate and find no support for several other conjectured potential mechanisms linking resource abundance to diminished human capital accumulation and lower incomes. We find that neither institutional dysfunction nor weak or corrupt governments play a role in explaining our findings. Similarly, we show that selective migration of foreigners with low preferences for human capital does not drive our results.

Last, we assess the degree to which our findings are specific to coal or generalize to other natural resources with a shorter history of extraction, such as oil, or resources with a much lower spatial concentration of workers, like gold. We do not find evidence that these resources are associated with lower incomes or educational attainment, historical public under-investment in university education, or gender disparities in tertiary education. Besides its longer extractive history, coal-mining differs from present-day petroleum extraction in its history of a driver of early industrialization in Europe. Because they are currently in decline, industries that exploited coal as an energy input during the initial phases of industrialization, steel and iron production, for example, are concentrated in former coal-mining regions. As such, we explore whether the effects of coal abundance can also be attributed to the declining fate of the industries that it fostered.³ To accomplish this we present new data on historical iron, steel, steam, and textile production sites across European regions and show that the presence of these industries was, indeed, associated with coal and Carboniferous geography. However, our results indicate that these historical areas of production were not associated with lower public investment in university education or with gender-heterogeneous educational achievement, patterns that are, instead, specific to former coal-mining regions.

1.1 Related literature

In the substantial body of empirical work exploring the effects of natural resource wealth, short-term consequences have (mostly) monopolized scholars' attention.⁴ This literature has focused mostly on oil, exploiting price variation or oil discoveries in the period

³ A negative effect of early industrialization on income and human capital has been similarly documented by Franck and Galor (2019). See below for a discussion of the relevant literature.

⁴ Following Sachs and Warner (2001), a wide range of empirical studies have investigated the causes and consequences of this "resource curse." For comprehensive reviews of the literature see, among others, Torvik (2009), Van der Ploeg (2011), Ross (2015), and Venables (2016).

following the Second World War to detect effects that materialize over, at-most, a half-century. Within this body of scholarship, our empirical strategy most closely matches the set of papers that exploit within-country and sub-national variation. Most studies have focused upon sub-national variation in oil (or gas) discoveries and prices, exploiting county and other low-level data in the United States (Michaels 2011; Jacobsen and Parker 2016; Allcott and Keniston 2017) and abroad (Caselli and Michaels 2013; Cavalcanti et al. 2019). Most of these studies suggest positive effects on employment and income per capita, with the exception of Jacobsen and Parker (2016) that find a negative long-term effect on these outcomes.

Still, while petroleum is certainly a central energy input in all modern economies, it has only been intensively extracted since the mid-twentieth century. By contrast, European coal has been mined in large quantities since the early nineteenth century and in Europe it lost occupational relevance around 1960s. This allows us to document comparatively longer-run effects and to trace the impact of resource wealth on norms and preferences that are comparatively inert over the short run. In this vein, we contribute to a small literature taking a longer-term view on the resource curse, which has mostly focused on violence and crime as outcomes (Couttenier et al. 2017; Buonanno et al. 2015; Uribe-Castro 2018).⁵ Our results suggest that much of the negative impact of coal has, in the long-run, been a consequence of depressed investment in human capital.

Our paper also contributes to the empirical scholarship on the effect of natural resource wealth on human capital. Cross-country analyses based on late twentieth century data find that public expenditure on education and school enrollment tend to be inversely related with resource wealth (Gylfason 2001; Papyrakis and Gerlagh 2004). Examining the impact of major oil discoveries on income and years of schooling in a panel of countries, Smith (2015), by contrasts, finds positive effects on income and years of schooling. More closely related to our approach are a series of papers that carry out empirical case studies exploiting within-country variation. Black et al. (2002, 2003, 2005), for example, examine cycles of coal booms and busts in Appalachia and show that during boom years, the levels of schooling (in addition to welfare expenditure and participation in disability programs) for low-skilled men are significantly lower.⁶

With respect to this literature, our comparatively longer-run perspective allows us to shed light on the important roles played by preferences for education and future orientation, showing how these may result in long-term underinvestment in human capital. Moreover, given the well-established centrality of human capital for economic growth, our results are salient for studies exploring the deep geographical determinants of human capital formation (Galor et al. 2009; Galor and Özak 2016).⁷

In particular, we contribute to the recent line of research exploring the long-run (de)skilling effect of early industrialization initiated by Franck and Galor (2019). Our findings

⁵ Couttenier et al. (2017) provide evidence of a “homicide curse” in US counties that discovered minerals before formal institutions were established. In the same spirit, Buonanno et al. (2015) document the impact of sulfur mining on the emergence of organized crime in Sicily after the collapse of the Bourbon regime. Uribe-Castro (2018) shows that counties more suitable for growing coffee had a smaller share of the population employed in manufacturing in 1945.

⁶ See also the recent study by Ahlerup et al. (2016), who focus on gold mines in Africa and demonstrate that individuals whose adolescence was spent in mining districts tend to have lower levels of schooling.

⁷ Galor et al. (2009), for example, document the role of land inequality as a driver of human-capital promoting institutions and long-term growth. Similarly, Galor and Özak (2016) show that agro-climatic characteristics conducive to higher returns increased individuals’ long-term orientation and, as a consequence, investment in human capital.

on coal, a fundamental energy input for early industrialization, coincide with their results on income and education, extending the evidence to 31 countries and confirming their hypothesis in institutionally and culturally variegated settings as different as Northern, Southern, and Eastern Europe.⁸ Finally, insofar as coal-mining represented a large sector during the industrialization of Europe, the new findings documented in this paper are also relevant to this literature. First, we show that coal mining reduced historical public investment in education, with up to 2 missing universities per coal-mining region. Second, former coal-mining regions display a gender-heterogeneous stigmatization of education, helping to explain the male achievement gap affecting coal-mining regions today. Third, as findings from Franck and Galor (2017, 2019) indicate, short-term and longer-term effect might well differ. Looking at the historical effects of coal availability, Fernihough and O'Rourke (2014), in fact, document that in the short-run proximity to coal increased city population size from 1800 onward.

To the best of our knowledge, our study is also the first to document a male achievement gap related to historical mineral abundance. In this way, we uncover a primary geographical driver of well-documented gender differences in educational attainment and labor market advancement (see, among others, Autor and Wasserman 2013; Bertrand and Pan 2013; and Chetty et al. 2016).⁹ In parallel, we contribute to a small but growing literature on the gendered effects of mining.¹⁰ While most papers in this vein have focused on the welfare of women, documenting effects on female labor supply and economic opportunity (Ross 2008; Khattar and Grosjean 2013; Kotsadam and Tolonen 2016; Aragón et al. 2018), the main novelty here is our finding that, in the long run, is it male welfare that may be more at risk.

The remainder of this paper is organized as follows. In Sect. 2, we summarize the key elements of historical coal extraction in Europe. We then discuss the original data collected for this project and our empirical strategy in Sect. 3. Section 4 presents long-term results on income, while Sect. 5 explores the effect on human capital accumulation. Section 7 assesses other potential reinforcing drivers of the coal curse. The final section concludes.

⁸ To the degree that coal mining in Europe is an example of a declining industry, we also contribute to the literature on industrial decline (see David et al. 2013; David and Dorn 2013).

⁹ In the United States, women have already surpassed men in terms of high school and college graduation rates by the cohort born in the 1950s (Autor and Wasserman 2013). Bertrand and Pan (2013) highlight the role of family influence on the gender gap and boys' disruptive behavior. Chetty et al. (2016) document that this gap is relevant for poorer families and varies substantially across counties and commuting zones. Fortin et al. (2015) show the existence of an underlying GPA gap. Autor et al. (2019) emphasize the negative welfare consequences of industrial decline for young adult males in affected regions.

¹⁰ Our results also broadly relate to the paper of Alesina et al. (2013), which highlights how different technologies of production can lead to long-lasting and persistent differences in gender attitudes and norms.

2 Background

2.1 Coal-mining in Europe

While it has been mined in small amounts since ancient times, coal was only an occasional source of heat up until the 18th century.¹¹ Over the course of the subsequent century it slowly began to be used in England as fuel in industrial processes. The mining of coal then spread to Belgium, in the Valenciennes area, and subsequently to the famous Western coal basin between 1842 and 1914. In the second half of the 18th century, the first small-scale mines appeared in Germany, when mining of exposed coal seams in the Ruhr, Inde, and Wurm river valleys began. As Fig. 1 shows, by the mid-19th century coal use as a source of energy had spread to the most advanced European countries. Indeed, from the onset of the industrial revolution up until the mid-twentieth century coal was the dominant source of energy in Europe. Coal consumption (and production) then began to rapidly decline in the second half of the 20th century, as it was largely substituted by oil.¹² While some of the last European coal mines closed only in the mid-1980s, in terms of labor force participation the coal-sector entered decline decades earlier.¹³

2.1.1 Labor intensity and spatial concentration

Coal-mining was, and to an extent still is, a labor-intensive industry. Even when compared with oil and other manufacturing sectors. Coal-mining employed huge numbers of workers and its costs were largely composed of wages.¹⁴ Further, it was mechanized relatively late: in 1913 in the UK less than 10% of coal was cut by machine. In 1923—at the peak of coal employment in the UK—1.2 million people were employed in coal mining.

What is more, European coal-mining was a heavily concentrated industry. As Supple (1992) puts it: “... given the size of the industry, towns and whole counties were dominated by coal-mining and its labor force.” About one in three inhabitants in the County of Durham, were, for example, employed in the mining sector.¹⁵ Similar figures are found in other European countries. In the Belgian mining region of Borinage, at the peak of coal production, one-fifth of the inhabitants of the area were miners (Lambert and Boulanger 2001). In

¹¹ In the late 17th century England, coal began to supplant timber for home-heating, as the latter had become exhausted as a source of fuel.

¹² Appendix Figure 8 tracks the evolution of world coal production, showing how its decline took place in conjunction with the increase in oil production.

¹³ With regard to labor force participation, the UK represents a fairly standard example. In 1923, 1.2 million people were employed in coal mining, out of a total population of about 38 million people. After nationalization, in 1945, the number dropped to 702,000 but remained stable until 1960. By the 1980s, however, when the last of the British coal mines were about to be closed, only two hundred thousand people remained employed in coal-mining.

¹⁴ Supple (1992) estimates that wages for the British coal industry between the wars accounted for two-thirds to three-quarters of the total production costs. Coal-mining remains today among the more labor-intensive extractive industries. For contemporary estimates of the labor/capital ratio comparing coal-mining with other mining sectors and industries and its evolution over time, see, for instance: “A Detailed Analysis of the Mining Industry: Preferences and Interpretation,” September 2009, Centre for the Study of Living Standard; “Productivity in the Mining Industry: Preferences and Interpretation,” December 2008, Australian Government Productivity Commission.

¹⁵ Source: A vision of Britain through time and the NETSFIELD project.

the German Ruhr valley, as late as 1957, more than 10% of the population was employed in the mining sector.

The concentration of coal production and its workforce in specific areas, where families of miners passed their occupation from one generation to the next, fostered inward communities with deep ties. Such towns were “... relatively homogeneous, self-contained... these places owed their existence to coal and the coal-mining occupations.”¹⁶ The stability, homogeneity, and separation of these communities favored the emergence of a specific coal-mining identity, resulting in strong local norms and shared preferences (Stanley et al. 2008).

Finally, coal-mining has traditionally been a male-dominated industry.¹⁷ Historical accounts for various countries confirm that European coal miners were mostly men, and that women typically did not work in underground mining or coal washing. Gender norms and conceptions of appropriate behavior for men and women, together with images and stereotypes of the male breadwinner prevailed in coal-mining communities, and have been documented by a large qualitative literature.¹⁸

2.1.2 Coal-mining and education

Despite requiring substantial on-the-job training, coal-mining required relatively few skills and little to no formal education. Anecdotal evidence and historical narratives detail the stunningly low level of literacy and schooling that characterized mining regions. Table 1 reports average literacy rates for several occupational groups in 19th century England. In the first half of the century, only one in five miners was literate. This figure stands out as particularly striking in comparison to the average literacy rate of metalworkers, potters, and textile workers, all of which were between two and three times higher. Even workers classified as “unskilled” had a higher average literacy rate than miners. A similar picture emerges for other European countries; in 1866 in the Belgian mining area of Borinage, the average literacy rate was two-thirds that of the national average (Lambert and Boulanger 2001). These low levels of schooling were partly a consequence of, among other things, the reliance on child labor in the mines (Nardinelli 1980; Humphries 2003).¹⁹

While the rate of schooling in coal-mining regions has increased since the 19th century, evidence still points to an underlying gap. To this regard, a broad literature in sociology and educational studies has documented that a disaffection with schooling, fear of academic success, and negative expectations for the future remain prevalent in the former coal-mining regions of Europe and the United States.²⁰ The strong community ties characterizing coal-mining areas made these norms prevalent also among those that did not have

¹⁶ See the report “Coalfields regeneration: dealing with the consequences of industrial decline,” Bennett, Beynon and Hudson, Bristol: Policy Press, March 2000.

¹⁷ Aragón et al. (2018) document that in 1984 in England and Wales, 84% of workers in primary sectors (thus including mining, but also agriculture, energy, and water supply) were men.

¹⁸ While far from an exhaustive list, relevant accounts of gender norms in mining communities are discussed in Hall (2001) and Parry (2005) for Great Britain before and after the closure of mines; Beckwith (2001) for Pennsylvania; and Brown (2006) for Nigeria.

¹⁹ Since coal-mining required a relatively long period of on-the-job training, children and young adults were hired more frequently than in other occupations (Mitch 1999). Moreover, the physically small constrained spaces in which miners were required to work often made child-labor particularly valuable.

²⁰ See, for instance, Rasheed Ali and Saunders (2009), Gore et al. (2011) and Bright (2011).

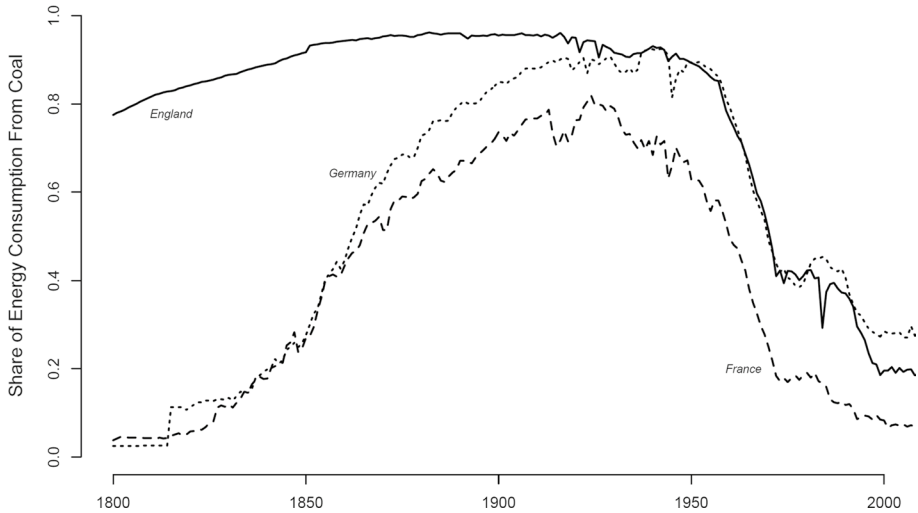


Fig. 1 Share of total energy consumption from coal. Coal Consumption in England & Wales, France, and Germany data from Kander et al. (2014)

relatives employed in the industry, and persistent even after coal-mining was no longer a possible career trajectory.

3 Data and empirical strategy

Our empirical analysis focuses on European regions, with all data measured at the European region level (NUTS2). We construct and combine data from a number of different sources.²¹ Overall, our analysis covers regions across 31 European countries for which information on historical coal-mining could be assembled.²² In this section, we describe our measures of historical coal-mining. Next, we discuss our empirical strategy, which relies on geological characteristics as exogenous source of variation in coal extraction. Last, we present our main outcome variables of interest. Full details on data sources, description of controls, and additional variables employed in the analysis are reported in Appendix, Section A.

3.1 Historical Coal-mining in Europe

3.1.1 Historical coalfields

There is not, to our knowledge, any systematic mapping of historical coal mining across European regions. To proxy for the historical presence of coal mines, we follow Fernihough

²¹ NUTS2 stands for Nomenclature of Territorial Units for Statistics, which are geographic subdivisions of countries constructed for statistical purposes by the European Union.

²² The final sample includes the EU-27 countries, as well as Croatia, Norway, and Turkey. In our sample, NUTS2 regions have an average size of about 18 thousand square kilometers.

Table 1 Literacy rate of miners and other occupational groups in England

	Male literacy rate			
	1839	1844-9	1854-9	1864-9
Professional occupations	100	96	96	100
Managerial/Technical occupations	90	91	91	90
Skilled occupations				
Textile	63	58	70	85
Potters	58	50	56	61
Metalworkers	53	60	61	79
Miners	21	20	30	47
Partly-skilled	58	62	66	71
Unskilled	27	31	41	51

The table summarizes literacy rates for five main occupational groups in England. Data from Vincent (2000)

and O'Rourke (2014) who collect information from a historical atlas of European coalfields describing areas where coal was mined.²³ This Atlas, the *Atlas Chatel and Dollfus: Les Houillères Européennes* (1931), is to our knowledge the most complete attempt to map 19th and early 20th century European coalfields and contains information on locations where coal had been searched for, found, and extracted by 1931. Yellow polygons in Fig. 2, left panel, map their distribution. Thanks to subsequent research and technological advancement, today we have a complete mapping of coal deposits worldwide. The black triangles in Fig. 2, right panel, depict major coal deposits in Europe based on the data of Thomas and Thomas (2002). The picture visually demonstrates that coal deposits are much more widespread throughout the continent and go beyond the coal fields that had actually been mined by 1931.

With the digitized borders of historical coalfields, we create an indicator variable taking on the value of 1 if a coalfield (any portion of it) is located in the region—we name this variable (Historical) Coalfields. About one-third of European regions had historical coalfields defined as such.²⁴ As expected, this share is higher in Northern Europe (about half of the regions had a historical coalfield) and lower in Southern Europe (only 20% of regions had one).

3.1.2 Historical coal-mines

Our map of historical coalfields based on Pol et al. (1931) has the unique advantage of providing systematic and comparable evidence on the location of historical coal mining over time and space. The criteria for the mapping are identical across all countries in the sample and the presence of coal fields is captured at the same exact historical moment. The main disadvantage of this data is that it represents a very rough proxy of the intensity of actual coal extraction. A coal field could in fact exist, be known, and be mined more or less

²³ Certain sources define coalfields as areas rich in coal deposits. The historical map of coalfields we use is furthermore informative as to where coal was searched, found, and extracted at the time.

²⁴ The yellow polygons in Fig. 2 map the geographical distribution of historical coalfields and contains 130 polygons/coalfields, spanning across 104 regions. On average, one third of European regions had a historical coalfield (with a standard deviation of 0.47).

intensively. In other terms, this source of data is not informative of the actual number of collieries and miners associated to the mapped coalfields.

As an alternative measure, we rely on information from the European Route of Industrial Heritage (ERIH) database. The project censuses historical industrial heritage sites across 44 countries in Western Europe, Eastern Europe, and the Balkans.²⁵ Based on this source, we create this measure of historical coal mining by counting the number of coal mines listed among these heritage sites. The right panel of Fig. 2 shows that the presence of historical coalfields and historical coal mines tend to coincide.

We use the Pol et al. (1931) measure as our primary explanatory variable and replicate the full analysis with the ERIH data.

3.2 Empirical strategy: the geology of coal

The nature of our question suggests a comparison between regions that had coal-mines and regions that did not. Yet relying on cross-sectional variation in historical coal-mining poses several threats to identification. First off, the choice to mine is non-random. As we expect actors located in regions with initial technological and economic advantages to have selected into coal-mining, estimates based upon a simple comparison of outcomes across coal-mining and non-mining regions are likely biased. Moreover, non-classical measurement error in our proxy for historical coal-mining might further bias such a naive comparison. To obtain an exogenous source of variation in the presence of coal-mines, we exploit the underlying geological features that facilitate the extraction of coal to predict where coal extraction was more likely to occur.

3.2.1 Instrumental variable #1: carboniferous surface

Coal is a sedimentary rock (deposited over 300 million years ago) found in layers called seams. In Europe, coal seams occur most extensively in rock strata originating in the Carboniferous Period, a geologic era that spans from the end of the Devonian Period (about 350 million years ago) to the beginning of the Permian Period (about 270 million years ago), see Speight (2012) among many others.²⁶ Because of their age, these seams are often found deep underground, but earth movements or erosion may bring them close to the surface. Historically, the proximity of coal to the surface facilitated the discovery and extraction of coal.²⁷

Given that coal is very often found in carboniferous strata, and that having carboniferous strata closer to the surface simplified the discovery and extraction of coal, we exploit

²⁵ Information on these sites covers 236 regions of the 31 countries in our analysis, related to sectors such as textiles, iron and steel, transport, etc.

²⁶ In common classifications, the Carboniferous Period is usually broken down into the Mississippian (between 305 and 350 million years ago) and Pennsylvanian Subperiods (between 270 and 305 million years ago). While there is some variation across continents, European coal has almost exclusively been found in rock sediments from the Carboniferous Period. As Speight (1994) points out, “Commercially important strata are not usually found in strata older than the ... [Carboniferous]... age, although Devonian coals have been mined in Europe.”

²⁷ “Early miners first extracted coal exposed on the surface of the land...” (UK National Coal-Mining Museum). The technological development of the mining industry (with the use of the bell/pit technology, the horse and gin etc...) allowed over time to reach always deeper seams, as well summarized by Appendix Figure 3.

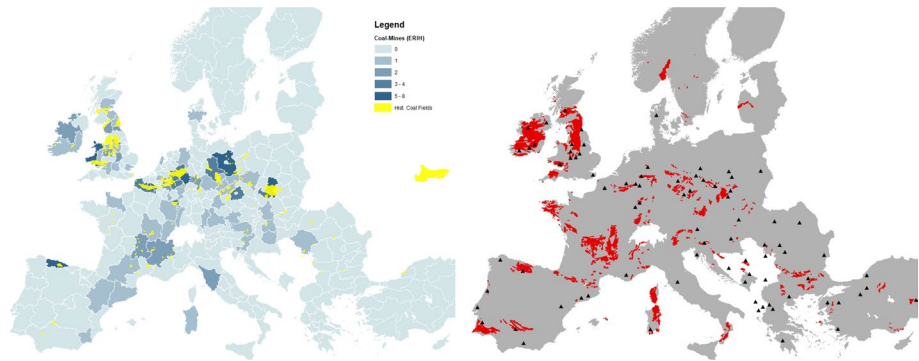


Fig. 2 Geological maps and carboniferous surfaces. *Left Figure*: Historical Coalfields, in yellow, are digitized from The Atlas *Les Houillères Européennes*, by Pol et al. (1931). Different shades of blue indicate the number of historical coal-mines as documented by the ERIH Project. *Right Figure*: Red polygons map carboniferous surfaces from the geological map of Asch (2007). Black triangles represent major coal-deposits in Europe, based on data from Thomas and Thomas (2002)

the presence of carboniferous surface geology in a region to predict the historical presence of coal-mines. Geological maps summarize the composition and age of surface geological materials (rock and sediment) in an area. From the geological map of Asch (2003), we retrieve information on the distribution of surface geological strata in each region in the form of polygons (see Appendix Section A.2 for further details). Following these insights, we expect to find historical coal mines predominantly in regions with Carboniferous geological strata located on the surface, therefore, we instrument our measures of historical coal-mines with a variable taking on value 1 if carboniferous surfaces are present in the region.

3.2.2 Instrumental variable #2: coal-deposits on carboniferous surfaces

Areas with carboniferous surfaces might also share a similar geography, having potentially been exposed to similar tectonic movements and erosion. Such shared features could thus represent omitted characteristics of these areas, biasing our results. As such, we adopt a second instrumental variable strategy that attempts to compare, to the extent possible, areas with similar geographical and geological profiles.

As mentioned, coal seams are often found in areas with carboniferous surface strata. Many coal deposits, however, are not located in areas where carboniferous strata lie on the surface. In many areas, for instance, coal-seams are buried deeper down, complicating the process of extraction. We hypothesize that where coal deposits are located within a carboniferous surface strata, their discovery and extraction is cheaper and thus more probable.

We therefore use the presence of coal deposits within carboniferous surface geology as a predictor of historical coal mines. In doing so, we can also condition on the total share of carboniferous surface geology in a region and on the presence of major coal deposits in a region. In this way, we hold constant the carboniferous geology and coal richness of the region.

Figure 3 shows how we operationalize this strategy. Given that the polygons of carboniferous surface strata are often very tiny and may have been digitized with error, we draw buffers of 40 km around each polygon (as a robustness check, we replicate with buffers of

30 and 50 km). In addition, we digitized locations of major European coal deposits using a map by Thomas and Thomas (2002) (see Appendix Figure 4). Again, since that the digitization of coal deposits might slightly misplace their actual location, we draw a 40 km buffer around the digitized points. We consider a coal deposit to have been located within a carboniferous surface strata whenever this buffer intersects the polygon describing the carboniferous surface geology.

Among the regions with a major coal deposit (27% of our sample), 56% of such deposits are located within carboniferous surface strata. Note, however, that out of the regions with carboniferous surface strata (51% of the sample), 62% do not have a coal deposit, as shown using the Thomas (2013) data. All in all, 21% of our regions have a coal deposit located within a carboniferous surface strata. While this second strategy allows us to directly control for the actual presence of a coal deposit and for the size of carboniferous surface strata, it is also much more demanding in terms of residual variation used for estimation. We therefore implement the latter only for outcomes for which the sample is sufficiently large.

3.3 Main outcome variables

3.3.1 Per capita income and tertiary education

Our primary outcomes are taken from Eurostat (2017) regional variables. The natural logarithm of GDP per capita measures the regional purchasing power adjusted level of income per capita in 2010. The share of people with tertiary education measures the contemporary share of people (age 25 to 64) with a tertiary degree. As the same information is available for the population of males and females, we construct a measure of the male tertiary education gap subtracting the share of women with a tertiary education from the share of men with a tertiary education. In our sample, 23.4% of females (age 25 to 64) and 22.6% of males have a tertiary degree. This implies that, on average, the male achievement gap in tertiary education is close to zero (-0.81 as average, with a standard deviation of 5.65). From Eurostat, we also retrieve information on secondary education, and life expectancy of males and females.

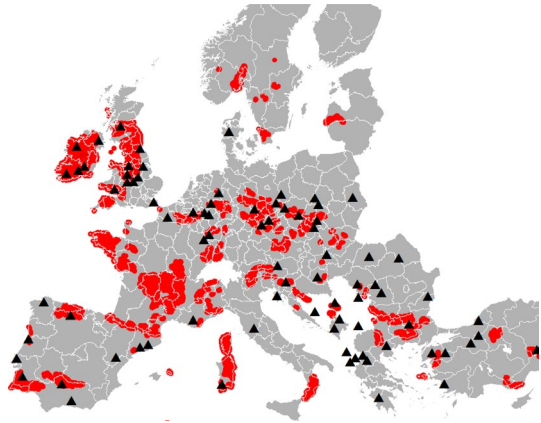
3.3.2 Prevalence of universities

To measure historical public investment in tertiary education, we conduct a historical census of European universities, collecting information on the establishment date, name, and location of universities and other recognized institutions of higher education. In doing so, we adopt two strategies. As baseline, we rely on the extensive coverage of universities provided by Wikipedia and extract the relevant information (name, location, and establishment date) through a web-based automated text extraction exercise.²⁸ To verify that our results do not depend on non-random selection of universities included in the Wikipedia country lists, we collect similar information exploiting university rankings.²⁹ We then use

²⁸ We restrict our sample to 26 countries that share similar layouts for the provided information, thus ensuring the data is comparable across countries. Appendix Figure B13 maps the location of universities scraped from the Wikipedia pages, while Appendix Section A.4 provides further details on the automated text extraction exercise.

²⁹ Given that available rankings do not report the founding date of the institution (which must be retrieved manually), we focus on the top 500 European universities according to the “Webometrics Ranking of World Universities,” a composite index measuring the quality of universities around the world. For these universi-

Fig. 3 Geological maps and carboniferous surface strata. Red polygons represent buffers around carboniferous surfaces strata retrieved from Asch (2007). Black triangles map major European coal-deposits from Thomas and Thomas (2002)



these sources to reconstruct, for each half-century, a variable indicating the total number of universities present in the region.³⁰ Reassuringly, while the census of Universities through Wikipedia allows us to include more institutions, the variables produced with these two different sources are highly correlated (0.56).

3.3.3 Attitudes towards education and patience

To elicit information regarding preferences and norms towards education, we rely on the European Social Survey (ESS). In the third wave (2006) of the ESS, respondents are asked at what age they consider an individual too young to leave full-time education. While the mode is 16 years old, a surprisingly high number of respondents (around 15%) claim that it is “Never too early to leave full-time education.” We take this extreme response as a symptom of strong disaffection towards and/or general devaluing of formal education. Note that, on average, there is no difference in the share of males and females claiming that it is never to early to leave full-time education. Responses are available for 144 regions located in 20 different countries. To further evaluate the role of attitudes and preferences, we complement ESS data with preferences taken from Global Preferences Survey by Falk et al. (2018), which also includes important information on subjective math skills and other traits that have been found to be relevant for human capital accumulation such as time preferences (Galor and Özak 2016).

Footnote 29 (continued)

ties we retrieve the establishment date and location of each institution so to replicate in spirit the measure constructed via automated text extraction from the Wikipedia pages.

³⁰ Note that both variables are constructed based on universities that are still functioning today, and thus may ignore institutions that existed in the past but then had to shut down. If coal-mining regions had universities that closed as a consequence of specialization into mining, this would attenuate the effect that we estimate.

4 Historical coal-mining and income: a long-term course

4.1 Estimating equations

4.1.1 Baseline specification

In order to explore the local effects of resource extraction, throughout the analysis we exploit within-country variation in historical mines. More formally, we estimate variations of the following equation:

$$\text{LnGDP}p_{i,c} = \beta_0 + \beta_1 \text{Historical Mine}_{i,c} + \mathbf{X}'_{i,c} \beta_2 + \mu_c + \epsilon_{i,c}$$

where i stands for region and c for country. Our baseline specification includes the full set of country fixed effects μ_c , netting out the role of possible confounders that operate at the country level. In this way our empirical approach allows us to focus on the sub-set of political and economic channels most closely linked to the local/regional impact of coal-mining, abstracting from mechanisms that operate at the national level such as currency appreciation or elites' extractive behaviors. We thus explore local variation in resource abundance following the rich literature of within county studies already discussed in Sect. 1. At the same time, we retain the advantage of a multi-country setting by focusing on 31 countries. In this way, our approach is similar to that of Berman et al. (2015), facilitating the plausible identification of causal effects while preserving a degree of external validity.

We control for a number of exogenous covariates, $\mathbf{X}_{i,c}$. First, to exclude the possibility that a peculiar geography associated with coal-mining areas may confound our results, we collect information on the geography and climate of each region, recording measures of average ruggedness, elevation, soil suitability, average and standard deviation of temperature and precipitation.³¹ Additionally, we record for each region a full set of distance measures (from each centroid to the coast, to the country border, to rivers, from country capitals) and a dummy variable for the presence of ports. Last, we include location controls (latitude, longitude, and the interaction of latitude and longitude). Maps in Figure B3 provide a visual representation of the residual variation of the variables Carboniferous Surfaces and Deposits on Surfaces after accounting for country fixed effects and baseline geoclimatic and location controls.

We account for spatial correlation in the errors in two ways. First, we compute Conley (1999) standard errors adjusted for two-dimensional spatial dependence. To be as conservative as possible, following Colella et al. (2019), we select the cutoff values providing the largest confidence intervals for our baseline specification. The selected cutoffs correspond to 100 km, as documented by Appendix Figure B1. Moreover, we verify our results also reporting standard errors clustered at country level.

4.1.2 Instrumental variable strategies

The first instrumental variable strategy we propose exploits the presence of carboniferous surfaces to predict historical coal-mining. We therefore estimate the following first stage equation:

³¹ We take averages and averages of standard deviation of monthly climate with data from 1900 to 1960.

$$\text{Hist. Mine}_{i,c} = \gamma_0 + \gamma_1 \text{Carb. Surface}_{i,c} + \mathbf{X}'_{i,c} \gamma_2 + \mu_c + \epsilon_{i,c}$$

where for i region in country c , $\text{Carb. Surface}_{i,c}$ is an indicator variable taking on value 1 if a carboniferous surface (of any size) is present in the region. As an extended specification, in order to compare as much as possible areas sharing similar geological features and coal abundance, we estimate the following alternative first stage equation:

$$\begin{aligned} \text{Hist. Mine}_{i,c} = & \gamma_0 + \gamma_1 \text{Deposit on Surface}_{i,c} + \theta_1 \text{Carb. Surface Share}_{i,c} + \theta_2 \text{Deposit}_{i,c} \\ & + \mathbf{X}'_{i,c} \gamma_2 + \mu_c + \epsilon_{i,c} \end{aligned}$$

where our variable of interest is $\text{Deposit on Surface}_{i,c}$, taking on value 1 if a major coal-deposit is located within a carboniferous surface. This specification allows us to control directly for the carboniferous geology of the region by including $\text{Carb. Surface Share}_{i,c}$ —which corresponds to the share of the region occupied by Carboniferous surfaces—and $\text{Deposit}_{i,c}$, which takes on value 1 if a major coal deposit is located in the region. Our coefficient of interest is γ_1 , which measures the likelihood of having a mine if in the region a coal-deposit is located within a carboniferous surface, while keeping constant the total share of carboniferous surfaces of the region and the availability of coal deposits.

First stage estimates, reported in Table 2, show that both instruments are powerful predictor for the presence of mines. Top panel estimates indicate that the presence of a Carboniferous surface is a strong predictor of historical coal-mining: a standard deviation increase is associated with a 0.41 standard deviation increase in the likelihood of having a coal mine, measured as historical coal-field. If we look at historical coal-mines (ERIH data), having a carboniferous surface brings about a 31% increase in the number of collieries. In the bottom panel of Table 2, we present first stage estimates exploiting the second instrumental variable strategy. Having a coal-deposit within a carboniferous surface—keeping constant carboniferous share and coal-deposit—is also a powerful encouragement for the presence of historical mines: a one standard deviation increase brings about a 0.33 standard deviation increase in the likelihood of historical coal-mines. Standard tests show that the instrument is sufficiently strong, and extremely stable, across most specifications.³²

4.2 Historical coal-mining and income

Table 3 summarizes estimates of the effect of historical coal-mining on present-day income. The table presents ordinary least square estimates (OLS) in column 1 of the effect of a historical coal mine; columns 2 and 4 report the reduced-form effect of both instruments (coal surface strata and the presence of a coal deposit within the carboniferous surface); and columns 3 and 5 report instrumental variable (IV) estimates using both of our instruments, respectively. The main parameter of interest, β_1 , measures the average difference in income per capita between regions that had coal fields in the 19th century and those that did not. The OLS estimate (columns 1) shows that historical coal-mining regions have, on average, an income per capita that is around 10% lower than other regions in the same country.

³² The only exceptions is represented by regression looking at the effect of deposits on carboniferous surfaces on historical coal-mines, these parts of results will therefore be taken with caution. The F-statistics presented refers to estimation with standard errors clustered at the country level.

Instrumental variable estimates (Columns 3 and 5) confirm the negative effect of historical coal extraction on present-day income. In absolute values, our instrumental variable estimates tend to be two to three times larger than those estimated via OLS. This is expected. First, regions that were more likely to benefit from cheap energy due to early industrialization were more likely to seek to mine coal, if there is some persistence in development, comparing coal-mining and non-coal-mining regions will underestimate the true effect of coal extraction.³³ Second, since our setting features a dichotomous dependent variable and a dichotomous instrument, measurement errors of non-classical form can also concur to the difference between OLS and IV estimates.³⁴ To be as conservative as possible, we can use OLS and IV estimates as lower and upper bound of the true coefficient. Focusing on estimates in column 1 and 5, we can take home a negative effect of historical coal-mines on income ranging between 10% and 25%. Appendix Table B1 replicates baseline estimates using historical coal-mines from the ERIH database. When looking at the number of coal-mines, in terms of magnitude, a one standard deviation increase in the log-number of mines would bring about a decrease in income of 0.29 standard deviations (column 5).

4.2.1 Permian and devonian geography: a falsification exercise

Carboniferous surface strata might share peculiar geo-climatic features that, in turn, might impact present-day incomes.³⁵ As such, baseline specifications control for a rich set of climatic, geographic, and location characteristics.³⁶ Relatedly, if Carboniferous surfaces were associated with poorer or less urbanized areas before coal extraction took off, we should observe lower overall urbanization even before coal started to be intensively mined. Appendix Figure B5 shows that areas with a carboniferous surface strata were no different from other regions in terms of average population, city population and average number of cities with more than 12 thousand people before the peak decades of coal extraction. If anything, carboniferous regions tended to have a slightly higher population than other regions in the same country.³⁷

³³ It is also possible that, since our measure of historical coalfields maps coalfields active in the 19th century and early decades of the 20th century, our measure may not capture additional negative effect of coalfields that had yet to be discovered and exploited, including in the “control” group of regions units that were, in reality, treated. Further, the compliers are mostly located in regions in Northern and Eastern Europe, as only 3 southern European countries had historical coal-mines.

³⁴ In these cases, a specific type of misclassification of the endogenous variable might imply a downward bias of the OLS coefficient and an upward bias in the IV coefficient. This bias is a function of the difference in the share of mining units erroneously classified as non-mining and the share of non-mining units erroneously classified as mining. In all these circumstances, OLS and IV estimates could still be used to bound the true coefficient. Notice also that the analysis conducted using $\text{Ln}(\text{Coal-Mines})$ does not suffer of this type of bias and provide results that are very much in line with the ones discussed above.

³⁵ Strata from the Carboniferous period emerged roughly when the supercontinent Pangea started to form, between 354 and 290 million years ago. Originally located in the Southern hemisphere, Pangea underwent a long series of decompositions, shifts, and radical climatic changes before giving origin to today’s continents. Still, the random decomposition of Pangea might have accidentally lead to the concentration of Carboniferous rocks in areas with a peculiar climate or geography.

³⁶ Figure B4 in the Appendix plots the cross-region relationship between several geographical features and share of Carboniferous strata. Regions high in Carboniferous tend to be slightly more rugged and to have a lower average temperature.

³⁷ As a robustness analysis, we borrow the methodology of Conley et al. (2012) to assess the robustness of our instrumental variable strategy to potential violation of the exogeneity of the instrument.

Table 2 Historical coal-mining and carboniferous surfaces

	Coal fields			Ln (Coal mines)		
	(1)	(2)	(3)	(4)	(5)	(6)
Carboniferous surface	0.410*** (0.105) [0.055] {0.433}	0.391*** (0.114) [0.055] {0.413}	0.385*** (0.115) [0.055] {0.406}	0.302*** (0.078) [0.056] {0.323}	0.310*** (0.080) [0.059] {0.333}	0.311*** (0.082) [0.062] {0.334}
<i>Controls</i>						
Geographic		Y	Y		Y	Y
Location & distances			Y			Y
Country FE	Y	Y	Y	Y	Y	Y
R-squared	0.46	0.48	0.49	0.26	0.26	0.27
1st stage F-stat	15.14	11.73	11.11	14.86	14.88	14.37
Deposit on surface	0.345*** (0.084) [0.083] {0.300}	0.364*** (0.085) [0.083] {0.316}	0.379*** (0.101) [0.083] {0.329}	0.346*** (0.113) [0.113] {0.305}	0.351*** (0.114) [0.113] {0.310}	0.357*** (0.119) [0.115] {0.315}
<i>Controls</i>						
Geographic		Y	Y		Y	Y
Location & distances			Y			Y
Carb. geography	Y	Y	Y	Y	Y	Y
Coal deposits	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y	Y
R-dquared	0.45	0.48	0.50	0.36	0.37	0.37
1st stage F-stat	16.85	18.28	14.21	9.37	9.47	9.05
Observations	306	306	306	306	306	306
Number of clusters	31	31	31	31	31	31
Average dep. var.	0.34	0.34	0.34	0.23	0.23	0.23

OLS estimates. The unit of observation is the NUTS2 European region. The dependent variable, in columns 1–3, is the variable Historical Coalfields, an indicator variable taking on value of 1 if a historical coal-field is located in the region; in columns 4–6, the dependent variable is Historical Coal-Mines, the natural logarithm of the number of coal-mines in the region. Carboniferous Surface is an indicator variable taking on value of 1 if a carboniferous surface is present in the region. Deposit on Surface is a dummy variable taking on value of 1 if a coal-deposit localized on top of a carboniferous surface is present in the region. Carboniferous Geography measures the share of a region area that is occupied by a Carboniferous surface. Coal Deposit is an indicator variable taking on value of 1 if a coal-deposit is located in the region. Robust standard errors clustered at the country level in round brackets, Conley standard errors (100 km degrees cut-off) in square brackets, standardized beta coefficient in curly brackets. ***, **, * indicate significance at 1-, 5-, and 10-% level, respectively, relative to robust standard errors clustered at the country level

Furthermore, given the proximity in geological time of Permian, Carboniferous and Devonian strata, we should expect areas where earth movements and erosion brought them close to the surface to share many observable and unobservable geographical features. Despite these potential geographical similarities, we expect relatively few coal mines to be located in regions with Devonian surface geology and little or no mines in areas with Permian. Simple correlations are in line with our predictions: the variable

Table 3 Historical coal-mining and income per capita in 2010

	Ln (Income Per Capita)				
	OLS	Carboniferous surface		Deposit on surface	
		Red. form	IV	Red. form	IV
Coal fields	– 0.101*** (0.029) [0.038]		– 0.348*** (0.114) [0.086]		– 0.254** (0.099) [0.123]
Instrument		– 0.134*** (0.037) [0.031]		– 0.096** (0.035) [0.042]	
<i>Controls</i>					
Carb. geography				Y	Y
Coal deposits				Y	Y
Geographic	Y	Y	Y	Y	Y
Location & distances	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y
Beta coef.	– 0.108	– 0.152	– 0.375	– 0.090	– 0.273
Average dep. var.	9.93	9.93	9.93	9.93	9.93
Number of clusters	31	31	31	31	31
Observations	306	306	306	306	306
R-squared	0.77	0.78		0.77	
1st stage F-stat			11.11		14.21

OLS, Reduced-form and IV estimates. The unit of observation is the NUTS2 European region. The dependent variable is the natural logarithm of GDP per capita in 2010 (purchasing power-adjusted). Coalfields is an indicator variable taking on value of 1 if a historical coal-field is located in the region. The instrument is Carboniferous Surface in columns 2 and 3, Deposit on surface in columns 5 and 6, where Carboniferous Surface is an indicator variable taking on value of 1 if a carboniferous surface is present in the region; while Deposit on surface is a dummy variable taking on value of 1 if a coal-deposit localized within a carboniferous surface is present in the region. Robust standard errors clustered at the country level in round brackets, Conley standard errors (100 km degrees cut-off) in square brackets. ***, **, * indicate significance at 1-, 5-, and 10-% level, respectively, relative to robust standard errors clustered at the country level

Historical Coal Fields has a correlation of 0.69 with the variable share of Carboniferous strata, 0.14 with the variable share of Devonian strata, and 0.04 with Permian strata.

Figure 4 shows that our intuition is correct, and that Carboniferous, Devonian, and Permian strata are very often contiguous and similarly distributed.³⁸

However, the results, summarized in Table 4, show that Permian and a Devonian surface geology are not associated with lower income once we control for the presence of Carboniferous surface strata.

³⁸ The correlation between Carboniferous Strata and Permian Strata is 0.37, between Carboniferous Strata and Devonian Strata is 0.46.

4.2.2 Robustness and additional results

Figure 5 presents scatter plots and indicates that our findings are not driven by outliers. Appendix Figure B8 replicates our baseline results, splitting the sample into 3 different groups of countries: Northern, Eastern and Southern Europe. Across all the regions, the negative effect of carboniferous surface geology is confirmed. Further, results do not depend on the unit of observation used in the baseline analysis. In Appendix Table B9, we zoom-in and explore within-country variation in England, taking English Local Authority Districts as our units of observation. Our results are very similar in size to our baseline effects. Furthermore, the richness of the micro-data allows us to examine the negative effect on income across income deciles. We show that all income groups are negatively affected by historical coal-mining (Figure B9). As a further alternative to the regional-level analysis in our baseline, we replicate the analysis at grid-cell level of 0.5×0.5 degrees of size. To measure income per capita at this disaggregate level, we use the global gridded Gross Domestic Product (GDP) of Nordhaus and Chen (2016). Table B6 shows that, despite being less precisely estimated (probably because of the measurement error in the gridded GDP data), the negative effect on income established in our baseline analysis is confirmed. In Appendix Table B2 and Table B3 we present results including distance to carboniferous surface strata and the standard deviation of elevation as controls. In table B4 we consider possible heterogeneities in the effect related to distance from rivers and coasts. All in all, our results point to a substantial negative effect of a history of coal extraction on income providing evidence of a very sizable “European coal curse.”

5 Historical coal-mining and human capital

Beyond uncovering a direct negative impact of historical coal-mining on present-day incomes, our next empirical findings indicate that former coal-mining regions are also characterized by significantly lower levels of human capital.

5.1 Coal-mining and tertiary education

To start, we provide evidence of a large negative effect of historical coal mining on the share of people with a tertiary education. In Table 5 we show that having had a historical mine decreases the share of individuals (age 25 to 64) with a tertiary degree by 2–4% points relative to other non-mining regions in the same country, which implies a 10–20% reduction compared to the regional average. The IV estimates are about two times larger than those derived from OLS, again suggesting that a selection into historical coal-mining obscures the effect that emerges from a naive comparison between coal-rich regions and other, non-mining, regions. While the IV coefficient using the Deposit on Carboniferous surface strata instrument (column 6) is not precisely estimated, it is virtually identical to our IV estimate using Carboniferous surface strata as our instrument (column 3).

Regression results treating historical coal-mines as the explanatory variable (Appendix Table B7) and in binned scatter plots (Appendix Figure B10) confirm the results presented here. Similarly, in Table B8 we present a falsification exercise looking at Permian and Devonian strata. In Appendix Table B9 we show that there is no sizable negative effect of historical coal mines on the share of people (age 25 to 64) with a secondary degree. These

Fig. 4 Carboniferous, Permian and Devonian Surfaces. The polygons map the geological surfaces from the Carboniferous (red), Devonian (purple) and Permian (orange) periods. From the geological map by Asch (2007), digitized by the authors

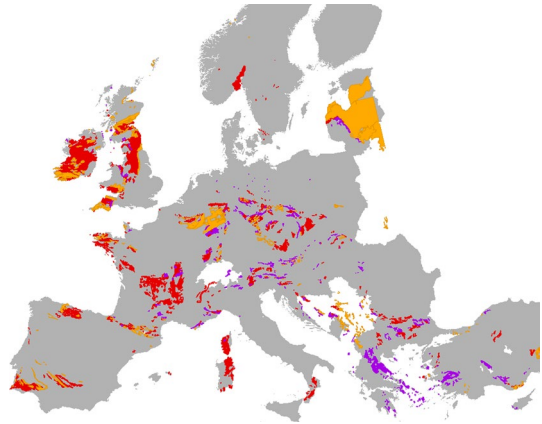


Table 4 Falsification exercise—permian and devonian surfaces

	Ln(Income per Capita)					
	(1)	(2)	(3)	(4)	(5)	(6)
Permian surface	− 0.085** (0.040) [0.031] {− 0.094}	− 0.045 (0.044) [0.030] {− 0.050}			− 0.070 (0.044) [0.032] {− 0.077}	− 0.043 (0.048) [0.031] {− 0.047}
Devonian surface			− 0.070** (0.029) [0.030] {− 0.075}	− 0.020 (0.027) [0.028] {− 0.022}	− 0.051 (0.032) [0.030] {− 0.055}	− 0.012 (0.032) [0.029] {− 0.013}
Carboniferous surface		− 0.122*** (0.039) [0.031] {− 0.139}		− 0.127*** (0.040) [0.032] {− 0.144}		− 0.118*** (0.041) [0.032] {− 0.134}
<i>Controls</i>						
Geographic	Y	Y	Y	Y	Y	Y
Location & distances	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y	Y
R-squared	0.76	0.78	0.76	0.78	0.77	0.78
Observations	306	306	306	306	306	306
Number of clusters	31	31	31	31	31	31
Average dep. var.	9.93	9.93	9.93	9.93	9.93	9.93

OLS estimates. The unit of observation is the NUTS2 European region. The dependent variable is the natural logarithm of GDP per capita in 2010 (purchasing power-adjusted). Permian (Devonian) Surface strata is an indicator variable taking on value of 1 if a Permian (Devonian) surface strata is present in the region. Robust standard errors clustered at the country level in round brackets, Conley standard errors (100 km degrees cut-off) in square brackets, standardized beta coefficient in curly brackets. ***, **, * indicate significance at 1-, 5-, and 10-% level, respectively, relative to the Conley Standard Errors

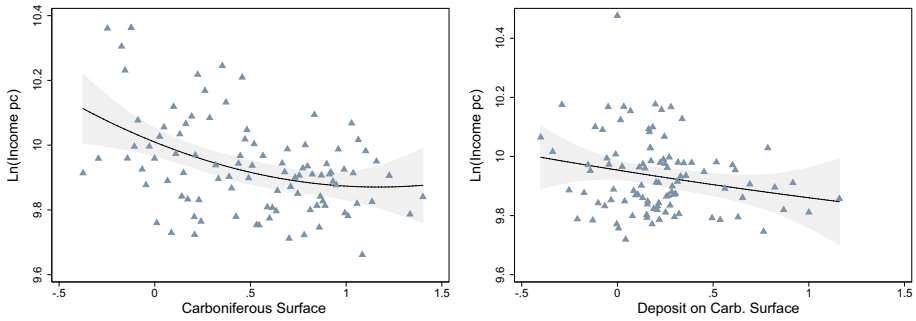


Fig. 5 Historical Coal-Mining, Carboniferous Surface and Income—Binned Scatterplots. Binned scatterplots of the reduced form relationship between income per capita and carboniferous surfaces (*Left Figure*). Binned scatterplots of the reduced form relationship between income per capita and deposit within carboniferous surfaces (*Right Figure*)

Table 5 Historical coal-mining and tertiary education in 2010

	Tertiary education				
	OLS	Carboniferous surface		Deposit on surface	
		Red. form	IV	Red. form	IV
Coal fields	- 1.919*** (0.697) [0.690]		- 3.894** (1.606) [1.710]		- 3.897 (2.417) [2.405]
Instrument		- 1.602** (0.714) [0.711]		- 1.423* (0.784) [0.858]	
<i>Controls</i>					
Carb. geography				Y	Y
Coal deposits				Y	Y
Geographic	Y	Y	Y	Y	Y
Location & distances	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y
Beta coef.	- 0.100	- 0.087	- 0.203	- 0.065	- 0.203
Average dep. var.	23.02	23.02	23.02	23.02	23.02
Number of clusters	31	31	31	31	31
Observations	293	293	293	293	293
R-squared	0.78	0.78		0.78	
1st stage F-stat			15.93		12.88

OLS, Reduced-form and IV estimates. The unit of observation is the NUTS2 European region. The dependent variable is the share of individuals (24–65 years) with a tertiary degree, 2006–2010 average. Coalfields is an indicator variable taking on value of 1 if a historical coal-field is located in the region. Carboniferous Surface is an indicator variable taking on value of 1 if a carboniferous surface is present in the region. Deposit on surface is a dummy variable taking on value of 1 if a coal-deposit localized on top of a carboniferous surface is present in the region. Robust standard errors clustered at the country level in round brackets, Conley standard errors (100 km degrees cut-off) in square brackets. ***, **, * indicate significance at 1-, 5-, and 10-% level, respectively, relative to robust standard errors clustered at the country level

results indicate that the coal history of these regions has a specific impact on the choice to pursue an advanced education and, today, it is not binding for lower levels of education. When we look at overall years of schooling over time, as in Figure B12, we see that coal-mining regions had lower average years of schooling already by 1960. This figure plots the trajectories of income per capita and years of education over time. The graphs show that average years of schooling in coal-mining regions were lower before income started to decline. Furthermore, when we subset to the sample of regions for which we have data across the entire period of inquiry, we see that levels of education remained comparatively lower in coal-mining regions through the 2000s.

5.1.1 Closed and open mines

To get a sense of whether our baseline effect is mostly driven by mines that closed in the distant past or mines that have closed more recently, we extend our analysis to include information about whether a mine was closed and, if so, when it closed (see Section A.3 for data construction details). Figure 6 plots coefficients and standard errors obtained from a regression including three indicator variables: an indicator variable taking on value 1 if in the regions there are mines that closed before 1960, an indicator variable taking on value 1 if in the regions there are mines that closed after 1960, an indicator variable taking on value 1 if in the region there are still open coal mines. These data reveal that the presence of all three types of mines decreases the share of individuals with tertiary education, with the effect of mines that closed after 1960 not as precisely estimated. Interestingly, even regions with open coal-mines have lower levels of tertiary education.

5.2 The male achievement gap in tertiary education

Since, almost exclusively, coal-mines employed men, we might expect that the negative disincentive for human capital accumulation we document might have been comparatively large for men in former coal-mining regions. As such, we examine whether the effect on human capital that we observe today is disproportionately concentrated in men. We find that, indeed, carboniferous geology and historical coal-mining tend to depress tertiary educational attainment in men more than women. These results, summarized in Table 6, show that the presence of a historical mine is associated with a reduction in tertiary education for men that is roughly double than that for women, yielding a share of men with tertiary education between 10 and 25% lower than in non-mining regions.

In fact, we observe the existence of a sizable male university gap, measured as the share of men with a university education minus the share of women with a university education. Figure 7 plots the non-parametric relation between the (residuals) of the university gender gap and Carboniferous surface (left) and Deposit on Surface (right). Appendix Table B10 presents the full set of OLS, Reduced-form and IV estimates. In terms of size, in coal mining regions the male achievement gap is four times the average gender gap in Europe. As a way of highlighting the size of the estimated coefficient, we propose a thought experiment where we set to 0 all regions with a Carboniferous surface in the sample. We find that, in the absence of Carboniferous surface geology, the European male achievement gap in tertiary education would nearly disappear.

In Appendix Table B12, we control (badly) for tertiary education of males in the region and find that the residual effect of historical coal-mining on income is halved, providing suggestive evidence that the gender achievement gap is a key mechanism driving our

baseline results that link a history of coal mining to lower incomes today. In, Table B13, we analogously control (badly) for the tertiary education of women. Its inclusion brings about a markedly smaller—but still relevant—decrease in the negative effect of historical coal-mining.³⁹

6 Drivers of lower human capital

Next, we find evidence consistent with two, possibly complementary, drivers of lower human capital in mining regions. First, we show that regions that historically mined coal invested less in education and provide evidence consistent with the fact that this historical public under-investment left a persistent legacy in terms of educational achievement. Second, we show that individuals in coal-mining regions have lower life expectancies—especially men—and possibly as a consequence, a significantly lower future orientation, potentially driving the lower levels of human capital we observe today.

6.1 Historical public investment in education: the founding of universities

We first provide evidence that coal-mining is at the root of historical public under-investment in university education. In the absence of historical regional data on public investment in education, we rely on a raw but indicative proxy, the presence of universities.⁴⁰ With these data we reconstruct the evolution of universities over time and show that coal abundance is not associated with a differential history before the intensification of coal-mining in the 19th century. Only after coal became central to the European economy does the effect we identify materialize.

In Fig. 8 we plot the total number of universities over time, comparing coal-mining regions with non-coal-mining regions located in the same country. Here, we look at the time-varying effect of Carboniferous surfaces strata (left figure) and deposit on surface (right figure). In Appendix Figure B14 and B15 replicate the same graphs as above using universities per capita and our alternative, rankings based, measure of universities as the outcome, respectively. Appendix Tables B15, B16, B17 give an extensive set of specifications (OLS, Reduced-form and IV) for the years 1950 and 2000, treating universities and universities per capita as the outcome.

Figure 8 shows that areas with a greater underlying propensity to mine coal had the same number of universities as other regions in the same country through the beginning of the 19th century. After this, the number of universities declined in these coal-rich regions in comparison to other regions. Across empirical strategies and data, coal-mining regions differed markedly in terms of universities founded by 1950. These results are precisely estimated and consistent in magnitude across empirical specifications and different outcome variables. Coefficients suggest that coal-mining regions had between 0.5–2 universities less than other regions in the same country. The coefficients in 1950 and 2000 tend to be similar

³⁹ In a Mincerian spirit, Appendix Table B14, presents estimates using Carboniferous surface strata as an instrument of Tertiary Education of males.

⁴⁰ Note that public under-investment in universities could be the consequences of both a lower supply and a lower demand of universities in a region. We are interpreting the presence of a university as local public investment in education because, *de facto*, regions without a university receive fewer resources for tertiary education than regions with a university.

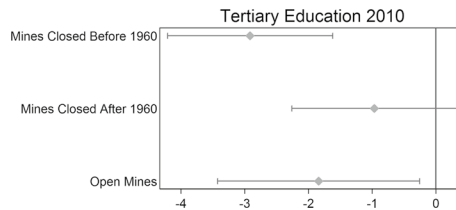


Fig. 6 Old Mines, Closed Mines and Open Mines. The graph plots OLS estimates of a regression using as outcome variable the share of individuals with a tertiary education and including three indicator variable. Mines Closed Before 1960 is an indicator variable taking on value 1 if in the regions there are mines that closed before 1960. Mines Closed After 1960 is an indicator variable taking on value 1 if in the regions there are mines that closed after 1960. Open Mines is an indicator variable taking on value 1 if in the region there are still open coal mines

in size but estimates for 2000 are more noisily estimated, suggesting a partial catch-up of former coal-mining regions.

In Appendix Table B19 we replicate results using 0.5 x 0.5 grid cells as units of observation. These results allows us to rule out that the choice of the region, as unit of observation, is driving our findings. In Appendix Table B18 we present a falsification exercise looking at the effect of Devonian and Permian surfaces.

Historical human capital shocks persist over time (Caicedo 2018; Waldinger 2016; Chen et al. 2017). While coal-mining regions may have, partially, caught up in terms of public investment in education, we provide suggestive evidence, consistent with existing findings on the legacies of human capital shocks, that the historical under-investment in education drives present-day lower levels of human capital accumulation. In Appendix Tables B20 and B21 we show that once historical under-investment in education—measured as total number of universities in 1950—is accounted for, the direct effect of historical coal-mining on tertiary education and income—today—shrinks substantially.

6.1.1 Channels of persistence: attitudes toward education

We find support for a related mechanism through which a history of coal-mining impacts present-day levels of education. We show that a history of mining engendered deep-seated attitudes and social norms, resulting in a general devaluation of higher learning. Using data from the European Social Survey, we examine individuals' opinions on school-leaving, where our dependent variable takes on the value of one if the individual considers it to be never too early to stop formal education. We take this response as evidence of a strong disaffection towards education. In order to avoid responses that simply reflect the educational level or the occupational status of the respondent, in the even columns we include dummies for educational level and occupation, effectively comparing the responses of individuals with the same level of education and with the same occupation across historical mining and other regions.

These results are summarized in Table 7 and show that individuals living in coal-mining regions are more likely to have negative views of formal education. Using OLS and IV estimates to bound the effect, having an historical coal mine brings about an increase in the share of people that devalue formal education between 0.4 and 5.7% (columns 2 and 6). Appendix Table B22 replicates these results using the alternative measure of historical coal-mines. Table B23 and B24 presents result for people younger and older than

Table 6 Historical coal-mining, tertiary education and gender in 2010

	OLS	Carboniferous Surface		Deposit on Surface	
		Red. Form	IV	Red. Form	IV
<i>Tertiary education and gender male</i>					
Coal fields	– 2.094*** (0.698) [0.719]		– 5.273*** (1.483) [1.751]		– 5.749** (2.287) [2.372]
Instrument		– 2.169*** (0.736) [0.729]		– 2.099*** (0.748) [0.760]	
Beta coef.	– 0.112	– 0.121	– 0.283	– 0.098	– 0.308
Average dep. var.	22.62	22.62	22.62	22.62	22.62
R-squared	0.76	0.76		0.77	
<i>Tertiary education and gender female</i>					
Coal fields	– 1.769** (0.806) [0.742]		– 2.488 (1.898) [1.851]		– 2.044 (2.754) [2.956]
Instrument		– 1.023 (0.820) [0.766]		– 0.746 (0.995) [1.090]	
Beta coef.	– 0.083	– 0.050	– 0.116	– 0.031	– 0.096
Average dep. var.	23.43	23.43	23.43	23.43	23.43
R-squared	0.80	0.79		0.80	
Number of clusters	31	31	31	31	31
Observations	293	293	293	293	293
1st stage F-stat			15.93		12.88
<i>Controls</i>					
Carb. geography				Y	Y
Coal deposits				Y	Y
Geographic	Y	Y	Y	Y	Y
Location & distances	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y

OLS, Reduced-form and IV estimates. The unit of observation is the NUTS2 European region. The dependent variable is the share of males and females (24–65 years) with a tertiary degree (2006–2010 average). Coalfields is an indicator variable taking on value of 1 if a historical coal-field is located in the region. Carboniferous Surface is an indicator variable taking on value of 1 if a carboniferous surface is present in the region. Deposit on surface is a dummy variable taking on value of 1 if a coal-deposit localized on top of a carboniferous surface is present in the region. Robust standard errors clustered at the country level in round brackets, Conley standard errors (100 km degrees cut-off) in square brackets. ***, **, * indicate significance at 1-, 5-, and 10-% level, respectively, relative to robust standard errors clustered at the country level

40, respectively, and show that coefficients, although not always precisely estimated, are extremely similar.

Given that our results on tertiary education reported in Sect. 5 suggest a stronger effect on men, it is natural to expect heterogeneity across genders in attitudes towards formal education. As before, we treat the share of individuals who view it as never too early to leave

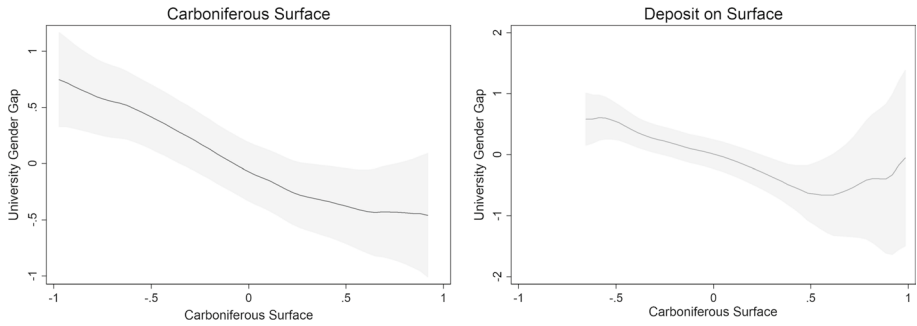


Fig. 7 Carboniferous Surface and the University Gender Gap in 2010—Local Polynomial Smooth. Local polynomial smooth of the university gender gap in 2010 on carboniferous surfaces (*Left Figure*) and deposit within carboniferous surfaces (*Right Figure*), after controlling for country, geographic, location and distance controls

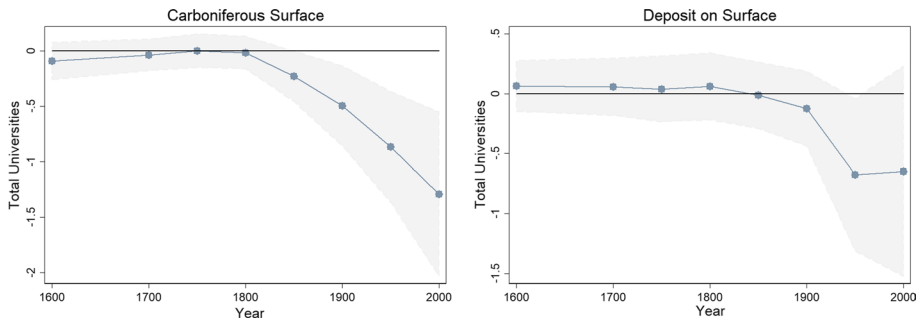


Fig. 8 Carboniferous Surface and Prevalence of Universities over Time. The graph plots estimates of the coefficient Carboniferous surface (*Left Figure*) and Deposit within Carboniferous surface (*Right Figure*) on the number of universities in the region over time

formal education as our dependent variable. Here, we examine separately preferences for education of men and women and find that our previous result on education, which aggregates across genders, masks substantial heterogeneity across male and female respondents. Table B25 (columns 1–3 for males, columns 4–7 for females) shows that the coefficient for men is almost 2 times larger in absolute terms than that for women, and is also statistically indistinguishable from zero. It is important to note, however, that standard errors on these estimates are large and we can only take these differences as suggestive evidence of heterogeneity. Interestingly, and somewhat surprisingly, the same gender heterogeneity in attitudes towards higher education does not emerge when looking at respondents older than 40 (see Appendix Table B26). Overall, older cohorts also show higher disaffection towards formal education, but older men do not devalue formal education more than older women respondents. These age differences might reflect gender-specific variations in attitudes toward education over the course of the life cycle. Or, alternatively, it could reflect that comparatively higher (lower) disaffection for formal education of young males (females) might have emerged only recently among younger generations. Given that responses to this question are only available for a single survey year (2016), we cannot distinguish between these explanations.

Table 7 Historical coal-mining and attitudes towards school

	Never too young to leave full-time education					
	OLS		Reduced form		IV	
Coal fields	0.005 (0.012) [0.012]	0.008 (0.011) [0.011]			0.065* (0.034) [0.038]	0.057* (0.033) [0.036]
Carboniferous surface			0.024** (0.012) [0.013]	0.021* (0.012) [0.012]		
<i>Controls</i>						
Geographic	Y	Y	Y	Y	Y	Y
Location & distances	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y	Y
Individual	Y	Y	Y	Y	Y	Y
Education/occupation FE		Y		Y		Y
Beta coef.	0.007	0.009	0.033	0.029	0.080	0.071
Average dep. var.	0.15	0.15	0.15	0.15	0.15	0.15
Number of clusters	144	144	144	144	144	144
Observations	36378	36378	36378	36378	36378	36378
R-Squared	0.10	0.11	0.10	0.11		
1st Stage F-Stat					19.24	19.62

OLS, Reduced-form and IV estimates. The unit of observation is the European Social Survey respondent (2016, 3.6 Edition). The dependent variable is a dummy variable taking on value 1 if the respondent consider that it is never too early to leave full-time education, 0 otherwise. Coalfields is an indicator variable taking on value of 1 if a historical coal-field is located in the region. Carboniferous Surface is an indicator variable taking on value of 1 if a carboniferous surface is present in the region. Robust standard errors clustered at the country level in square brackets, Robust standard errors clustered at the NUTS2 level in round brackets, Conley standard errors (100 km degrees cut-off) in square brackets. ***, **, * indicate significance at 1-, 5-, and 10-% level, respectively, relative to robust standard errors clustered at the country level

In addition, we explore whether part of the underlying gap in tertiary educational attainment might be related to broader attitudes towards gender in former coal-mining regions. To gain a sense of this we examine two additional questions from the European Social Survey that ask: i) whether men have more of a right to jobs than women, and ii) whether women should focus on family and cut down on paid work. Results, reported in Appendix Table B28, show that indeed former coal-mining regions tend to have more traditional attitudes towards gender on the role of men in the labor market and in society. However, coefficients are fairly small and not precisely estimated.

6.2 Life expectancy, time preferences and human capital

6.2.1 Health

Coal mining, especially during the 19th century, resulted in extreme levels of pollution, with severe consequences for mortality and health (Bailey et al. 2016; Beach and Hanlon 2018). It is possible that historical pollution and environmental degradation has negatively affected the general health status of individuals in former coal-mining regions and reduced

average life-expectancy for adults through the present. In Appendix Table B29, we look at the self-reported health status of ESS survey respondents and find, indeed, even today respondents in coal mining regions report lower average health. Importantly, this is not true for respondents younger than 40 (Appendix Table B30), possibly indicating that older individuals, including those that were still alive while the last coal-mines were active, are those reporting worse health statuses.

To further assess the role of health in human capital accumulation, we focus on present-day life expectancy: Table 8 shows that individuals in former coal-mining regions have notably lower life expectancy at birth, between 0.55 and 1.75 years shorter. All coefficients are very precisely estimated and consistent across empirical strategies. Results from a falsification exercise looking at Permian and Devonian strata, Appendix Table B32, provides further evidence in support of our identification assumptions.

In line with the Ben-Porath hypothesis, historically lower life expectancy could have contributed to lower investments in human capital. Indirect evidence of the complementary relationship between life expectancy and human capital is presented in Table B34. Once we account for life expectancy, the effect of historical coal mining on tertiary education disappears. In line with our results on the gendered impact of coal-mining, the life expectancy of males is more negatively affected (Appendix Table B33) than that of women.

6.2.2 The role of time preferences

Historical lower life expectancies might have depressed incentives to accumulate human capital by lowering future orientation in mining regions. We evaluate this possibility by exploring data from the Global Preferences Survey by Falk et al. (2018), which includes measures of survey respondents' future orientation. According to our estimates, one standard deviation increase in the likelihood of having mines brings about a 0.14 standard deviation reduction in patience. We do not observe a significant difference in this effect between men and women.

Further tests of this hypothesis would require historical data on life-expectancy. However, there are not, to our knowledge, such data available for our sample. Data constraints, therefore, prevent us from further assessing the role of historical life expectancy. Available evidence, however, suggests that the role of historical life expectancy might have been relevant in shaping the rate of time-preferences, which has been demonstrated a pivotal factor for human capital formation (Galor and Özak 2016). In the case of coal-mining, lower life expectancy might have impacted on the prevalence of long-term orientation and thus on human capital investment. At the same time, it is important to note that time-preferences could themselves be shaped by decades of under-investment in human capital. Still, given the stickiness of these traits, their coincidence may explain why the negative impact of coal-mining has on human capital that we document is so difficult to ameliorate.

7 The specificity of coal

In this section we investigate whether other extractive industries, oil and gold, are similarly associated with such negative developmental outcomes. In addition, we explore whether the observed patterns in educational investment—and its gendered dimension—are also explained by patterns of industrialization engendered by coal-mining. Finally, we examine the role that other potential reinforcing mechanisms—institutional quality, migration,

Table 8 Historical coal-mining and life expectancy

	Life expectancy, 2010				
	OLS	Carboniferous surface		Deposit on surface	
		RF	IV	RF	IV
Coal fields	– 0.550*** (0.149) [0.123]		– 1.283*** (0.432) [0.345]		– 1.750*** (0.427) [0.385]
Instrument		– 0.473*** (0.162) [0.133]		– 0.637*** (0.088) [0.094]	
<i>Controls:</i>					
Carb. geography				Y	Y
Coal deposits				Y	Y
Geographic	Y	Y	Y	Y	Y
Location & distances	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y
Beta coef.	– 0.098	– 0.090	– 0.229	– 0.098	– 0.313
Average dep. var.	79.63	79.63	79.63	79.63	79.63
Number of clusters	31	31	31	31	31
Observations	300	300	300	300	300
R-squared	0.91	0.91		0.92	
1st stage F-stat			10.80		13.92

OLS, Reduced-form and IV estimates. The dependent variable is life expectancy at birth (Eurostat) in 2010. Robust standard errors clustered at the country level in round brackets, Conley standard errors (100 km degrees cut-off) in square brackets. ***, **, * indicate significance at 1-, 5-, and 10-% level, respectively, relative to robust standard errors clustered at the country level

conflict, present-day pollution and environmental degradation—play in explaining our findings. We find no supporting evidence for any of these outcomes.

7.1 Oil, gold, and early industrialization

7.1.1 Oil and gold extraction

As discussed in Sect. 1, most scholarly literature has focused on the consequences of oil extraction. European oil extraction has a much more recent history and, as discussed in Sect. 2, differs from historical coal mining in its spatial concentration. Gold extraction has, by contrast, a much longer and spatially dispersed history but differs from coal extraction as it traditionally employed many fewer workers. We explore whether areas with petrol fields and gold deposits in Europe experienced similar trajectories as coal mining regions. Our results show no sign, however, that oil or gold impart a “curse” like coal. Regions with petrol fields or gold deposits, respectively, do not have lower average incomes or lower levels of tertiary education. Furthermore, they do not exhibit a gender gap in university education and have, on average the same number of universities as other regions (see Appendix Table B39 & Figure B16).

7.1.2 Early industrialization and manufacturing

The impact of coal may further differ from that of other resources by virtue of its unique role in the early industrialization of Europe and, more generally, the potential spill-overs it had on the location of manufacturing and other tradeable sectors. The large literature on the resource curse has put forward two possible mechanisms linking access to resources and manufacturing. On the one hand, resource abundance might have had strong agglomeration effects by stimulating investment in complementary sectors (Duranton and Puga 2004; Glaeser and Gottlieb 2009). In the case of coal, we expect very strong agglomeration effects, especially for industrial sectors that developed during a period when the transportation costs of coal were high.⁴¹ Furthermore, given the important role of coal in the Industrial Revolution, easy access to it may have coincided with the early industrialization of certain areas.⁴² On the other hand, classical “Dutch disease” effects suggest that the resource sector might crowd out non-extractive sectors that produce tradable goods, for instance manufacturing. If the former effect prevailed in European coal-mining areas—in the medium and long run—it may explain the empirical patterns we observe.

To evaluate this potential channel, we focus on the following sectors: iron, steel, steam, and textiles. We employ data on the distribution of these industries as derived from the European Industrial Heritage Project. Our results (Appendix Tables B42 and B43) show that coal is in fact highly correlated with historical iron, steel, steam but less so with textile production. However, none of these industries are associated with income or tertiary education. Furthermore, we do not observe the same historical underinvestment in universities in regions with these industries (see Appendix Figure B17). Finally, while we observe a negative effect on the university gender gap, the coefficient is not precisely estimated and, in standardized terms, it is orders of magnitude smaller than the coefficient obtained from historical coal mining.⁴³

7.2 Alternative drivers of the European coal curse

A host of additional channels might have contributed to or reinforced the negative effects of historical coal. In what follows, we briefly address each, summarizing results provided in much greater detail in Appendix Section C.2.3.

⁴¹ The paper of Fernihough and O’Rourke (2014), indeed, finds evidence that cities that were proximate to coal grew faster in terms of population during the 19th century.

⁴² The decline of European industrial regions has been sizable, as documented empirically by Franck and Galor (2019). In line with anecdotal accounts describing the demise of formerly prosperous industrial centers like the Ruhr valley in Germany or the English Midlands, Franck and Galor (2019) exploit variation in the introduction of the steam engine across French provinces and find that regions that adopted industrial technology earlier have lower standards of living when compared to otherwise similar regions in the present.

⁴³ Note, however, that these results should be viewed with some caution, as these variables are measured with error and we do not have an exogenous source of variation to obtain our estimated effects of historical industrialization.

7.2.1 Institutional quality

A substantial body of scholarship has found that resource wealth can lead to underdevelopment through its impact on various types of institutional dysfunction.⁴⁴ Rent-seeking politicians and extractive or corrupt institutions may impede farsighted investment in human capital as well as depress incomes, leading to the results we document. To evaluate this we compare present-day measures of institutional quality using rich information from the European Quality of Government Index (EQI) (Charron et al. 2014), allowing us to look at corruption, impartiality in public good provision, and average quality of the public sector. All in all, we find no evidence of a resource curse associated with historical coal mining that operates through institutional quality.

7.2.2 Conflict

Similarly, we verify whether coal-mining regions were more exposed to conflict. We examine the number of interstate disputes per region (using data from Militarized Interstate Disputes, 1816–2010) and the intensity of aerial bombing during the Second World War. We find that former coal-mining regions were not more involved in military disputes nor were they exposed to more allied bombings during the Second World War (see Appendix Tables B56 and B57).

7.2.3 Selective migration

Anecdotal evidence suggests that mining regions may have experienced historically large migration inflows (to fill labor demand in the coalfields). The observed patterns of university education and related preferences could thus be due to substantial in-migration of foreign workers with very low levels of formal education. In Tables B50, B51, and B52, we explore differences in the share of individuals born in the country, with their father born in the country, and older individuals with their father born in the country. These results indicate that former coal-mining regions had, and still have, a lower share of foreigners than other regions in the same country. Still, foreign migrants with lower preferences for human capital may have selected into former coal-mining areas, with (larger flows) of migrants with high preferences for human capital opting for other locations in the same country. In Appendix Table B27 we explore attitudes towards formal education among ESS respondents with a father born abroad. Although our results should be viewed with caution as we are left with a relatively small sample (141 regions are covered in this restricted sample), the coefficients are very close to zero. All in all, our results do not support the view that the migration of foreigners with low human capital has driven our results.

The evolution of population over time, summarized in Figure B5, suggests, however, that former coal-mining regions have experienced a comparative reduction in population over the second half of the 20th century. To gain a more complete picture, we focus on present-day migratory balances, measuring the difference between the number of individuals who entered and left each region. Appendix Table B53 indicates that former coal-mining

⁴⁴ See Mehlum et al. (2006), Robinson et al. (2006), Besley and Persson (2008), Vicente (2010), Brollo et al. (2013), Jensen and Wantchekon (2004), Berman et al. (2015), Caselli et al. (2015), Monteiro and Ferraz (2012), Couttenier et al. (2017), Buonanno et al. (2015).

regions have a more negative total migratory balance, in principle due to higher out-migration and, potentially, lower in-migration (compared to other regions in the same country). In Tables B54 and B55 we then differentiate between external and internal migratory balances. While the coefficients are not precisely estimated, the largest effect of historical coal mining, if anything, is on the external migratory balance, compatible with the hypothesis that the relatively lower population is related to the lower influx of foreign workers both in the present and past.

7.2.4 Fertility transition

Because of the continued demand for low-skilled labor that mines fostered, coal-mining areas may have maintained comparatively high fertility levels at the turn of the twentieth century, when a broad demographic transition towards lower fertility occurred across the continent. As a consequence, compared to other regions in the same country, coal-mining areas may have experienced a delay in the demographic transition towards lower fertility levels and higher investment in human capital. This delay could lie behind the long-term within-country divergence in educational and income levels documented in this paper. Appendix Tables B66, B67, and B68 summarize the effect of historical coal-mining on total fertility in 1870, 1900, and 1930 respectively. Results, indeed, indicate higher fertility levels for coal-mining regions, especially in 1930. Coefficients are, however, never precisely estimated.

7.2.5 Air and water pollution

If places that mined coal in the past are also those using more coal today, the long-term effects we identify may operate through pollution and related health consequences. In Tables B58 to B63, we explore whether historical coal mining is associated with higher levels of present-day air pollution, measured as number of days with SO_2 above threshold levels, and in microgram per cubic meter of PM_{25} , PM_{10} , O_3 , NO_2 and BAP : former coal-mining regions do not differ from other regions in any of these dimensions. Appendix Table B64 shows that former coal-mining regions do not exhibit higher levels of water pollution measured through the Ecological Quality Ratio. We also find no difference in the waste treatment practices of former coal-mining regions, measured using data from Eurostat in Appendix Table B65.

8 Conclusion

The extant literature on the resource curse, by virtue of its emphasis on the impact of petroleum wealth in the post-war period, has documented short-run effects of natural resource wealth. Since it was the dominant source of energy in the European economy for much of the nineteenth and early twentieth centuries, the history of coal allows us to trace a comparatively longer-run impact of natural resource wealth. To provide credible inference, we exploit the relative location of coal deposits as a plausible source of exogenous variation in presence of historical coal mines. Our baseline results indicate that former mining regions are, at a minimum, 10% poorer than otherwise comparable regions within the same country. Besides providing results that quantify coal's persistent effect on incomes, we have presented evidence that indicates that much of this effect operates through the impact of

coal extraction on human capital, specifically in tertiary education. Coal mining regions both have fewer universities and a lower proportion of individuals with university education. What is more, individuals in these regions hold attitudes that are much more negative towards formal education and are less future oriented. In sum, our results suggest that natural resources without the associated human capital investments do not produce long-run prosperity, at least when it comes to coal in Europe.

Additional empirical work is necessary to shed further light on the “curse” we identify. First, historical data mapping the evolution of incomes, education, health, and life expectancy over time would provide greater insight with respect to the temporal dynamics of our results. Second, more complete information on historical industrialization might help to further understand the degree to which the effects we uncover are related to coal mining or to the industries that coal-abundance fostered. Finally, while foreign migration does not explain our results, it is possible that past internal migration contributed to the distributions of preferences for human capital that we observe today. Dedicated data collection effort on within-country migration patterns might help shed light on this potentially important dimension.

Supplementary information **Supplementary Information** The online version contains supplementary material available at <https://doi.org/10.1007/s10887-021-09187-w>.

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