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ORIGINAL PAPER

The Italian coal shortage: the price of import and distribution, 1861–1911

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Abstract
This paper estimates a measure of coal price for all NUTS3 Italian provinces between 1861 and 1911. Italy was a latecomer country and its late industrialization was characterized by the absence of coal in a time when the steam engine powered factory work. The new variable accounts for the main input factor of manufacturing production during that period in which the Italian economy registered a long-term growth of GDP and an increase in its industrial activity. The measure allows to speculate on the importance of coal for Italian industrialization and on the origins of the North–South divide.

Keywords Coal · Italy · Provinces · Railways · Infrastructure · Transport costs

JEL Classification N13 · N53 · N73 · N93 · O13 · Q41

1 Introduction

Recently, fossil coal and the demand for fuel are at the center of both political and social attention. The need to develop low-carbon technology to help facilitate the transition to clean energy has become nowadays an urgent imperative of the global agenda. However, less than three hundred years ago coal appeared in history as one of the major characters in what is considered today the main economic and social transformation of modern economies: the Industrial Revolution. At the time no one would have thought that burning fossil fuels would affect climate and global warming. Indeed, during the second half of the eighteenth century having domestic coal made the difference, and its abundance provided a stable source of energy to power new machines.

This paper examines the price of fossil coal and its distribution across the Italian peninsula. Italy lacked domestic coal resources, and according to economic

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historians (Bardini 1997, 1998; Toninelli 1999, 2010; Malanima and Zamagni 2010; Bartoletto 2005, 2013) this was one of the main reasons for the backwardness of its industrial structure. Italy was a latecomer country and experienced an industrial revolution more than one hundred years after the U.K. If for three centuries (from around 1300 to 1600) Italian manufacturing led European production, at the time of its unification (1861) Italy was a relatively underdeveloped area with a slow growth up to the 1880s. The average annual growth rates of GDP and manufacturing remained relatively slow until 1896; it was only during this year that Italy registered growth acceleration (Gomellini and Toniolo 2017).[1] However, the timing and the reason behind Italy's late industrialization are still debated. According to Bonelli (1978) and Cafagna (1972), Italy industrialized before unification. Romeo (1959) dates Italian industrial acceleration during the 1880s after the completion of the main railway network. Gerschenkron (1962) links Italy's industrial revolution to the establishment of universal banks during the 1890s. Consistent with the Kuznets cycle, for Fenoaltea (1988, 2006) the inflow of foreign capitals starting from the 1880s boosted the construction sector, increasing, in turn, the performance of the whole economy. Although these positive figures in its industrial production, Italian manufacturing was still far from the benchmark level reached by the second-comers to industrialization. The most advanced technological sectors didn't exist and many productions were not able to survive without the state's intervention (Bardini 1997). The main reason for this backwardness and slow catching-up was, according to Bardini (1997), the absence of fossil coal in a period when the steam engine was the main technology of the time.

According to Allen (2001, 2011), the first British Industrial Revolution during the second half of the eighteenth century has been possible because the cost of energy (coal) was low and the cost of labor was high: the need to use the most profitable combination of the two input factors was the incentive to invent coal-powered machines that led to the technological transformation of the Industrial Revolution. However, since fossil coal could be imported or substituted, some economic historians denied the importance of domestic coal and its crucial role in the development of an advanced industrial productive structure.[2] If a single-cause explanation is far from being reasonable, the role of coal as a driver, prerequisite, or collateral factor is disputed. For authors like Ashton (1948), Cipolla (1962), Deane (1965), Landes (1966), Wilkinson (1973), Pollard (1981), Braudel (1982), Church (1986), Wrigley (1988, 2010), Pomeranz (2000), Allen (2011) and Kander et al. (2013), the British Industrial Revolution was essentially an energy matter. The switch from a traditional vegetable-based economy[3] to a mineral-based one[4] allowed firms to access cheap and large reserves of energy to power new machines. Work mechanization improved the efficiency of the production processes with resulting industrialization

[1] See Baffigi (2011, 2013) for detailed estimates on historical Italian national accounts.

[2] Clark and Jacks (2007) and Fernihough and O'Rourke (2021) provide a clear summary of the debate.

[3] Wood, animals, water, and wind were the main traditional vegetable energy carriers. See Malanima (2006) for details.

[4] Coal and iron essentially (Deane 1965).

and economic growth. Other scholars like Mokyr (1976, 1990, 2009), McCloskey (1981, 2010), Crafts (1985), Crafts and Harley (1992), Clark and Jacks (2007) and Galor (2011), instead, recognize to coal a small contribution. Technological change was the main actor of the Industrial Revolution and the energy efficiency given by coal usage was the driver for the transformation process. Wright (1990) finds a common ground in the debate, arguing that the geological advantage of coal endowments needed the skills to exploit them. More recently, the role of coal has been empirically tested. Kander and Stern (2014) show that the transition from traditional to modern energy sources, like coal, was a necessary, but not sufficient, condition for industrialization and economic growth in a mostly coal-importing country like Sweden.[5]Matheis (2016) and Hanlon (2020) link long-run negative effects to coal:[6] coal production positively affected the U.S. population growth and the manufacturing activity only in the short run (Matheis 2016). Fernihough and O'Rourke (2021) prove that European urbanization during the Industrial Revolution was boosted by the proximity to coalfields. Using a smaller lens, Crafts and Mulatu (2006) and Gutberlet (2014) study the effect of the coal endowment on the location choices of manufacturing industries in Britain and Germany, respectively. Crafts and Wolf (2014) find that coal proximity did not determine the spatial distribution of cotton mills in the United Kingdom, but coal prices affected the size of the cotton textile industry.[7]

This paper contributes to the debate by providing a measure of coal price for the Italian territory at the NUTS3 level. This represents a novelty in the economic history literature: Cianci (1933) and Vazza et al. (1965) provide the price of imported coal in Genoa from 1870 to 1929 and from 1845 to 1905, respectively; more recently, Federico et al. (2011) present more detailed data for the period 1862–1921.[8] This paper makes a step forward and computes the coal price for the 51 years between 1861 and 1911 for all the Italian provinces of the time.

As pointed out by Farnie (1979) and Crafts and Wolf (2014), a coal price measure at the local level captures the distance from coal reserves and the development of the transport infrastructure. In these terms, it reflects a pure geographic component—the natural endowment—and an institutional one - the prevailing transport costs—suggesting how variation in coal prices originates from two main factors. Both *first-* and *second-nature geography* features allow to assess the local advantage of an area and the agglomeration economies for industries. Moreover, a measure of coal price can be used to empirically test the importance of coal for economic growth and industrial development within-country, acknowledging its role as locally determinant, concomitant, or trivial. However, the analysis here proposed involves important information that allows going beyond a mere economic measure that can be used in empirical analyses and historical investigations. The role of coal—and energy in general—for Italian industrialization and the origin of the North–South

[5] In a similar vein Wrigley (2010) about the British Industrial Revolution.

[6] Coal-generated pollution, decreased employment and urbanization rates in British cities (Hanlon 2020).

[7] Rodgers (1960) recognizes the importance of coal prices on the location of the cotton industry.

[8] The Italian price is the Genoa coal price.

divergence represents a pivotal question in the controversial debate about Italy's economic growth.[9] The energy shortage is an issue that affects Italy since its unification. As stated by Toninelli (2010), modern developed economies stand out for a lower energy intensity: the use of energy per GDP unit decreases with income; in low-income countries, instead, it increases. In Italy, the lack of primary energy carriers might have constrained the innovation frontier: Bardini (1997) highlights how, during the last decades of the nineteenth century, the absence of coal might have forced Italy into a coal-saving innovation path. Toninelli (2008), instead, finds how Italy's dependence on foreign fuel and oil coupled with state intervention, particularly after the oil crisis of 1973. According to Cafagna (1989, 1999) and Toninelli (1999, 2008), among the others, the current Italian industrial organization made up of many small- and medium-sized enterprises originates—besides other things—from the need to save coal. This led to an alternative industrial system characterized by a small-scale production of less technologically sophisticated goods, needing a lower quantity of power, and induced the efficient use of available energy sources, like water.

Water mills, iron, and coal supported the first wave of Italian economic growth together with the transport development and different trends across northern and southern Italy (Malanima and Zamagni 2010). Northern Italy had superior access to transportation and connection with foreign trade partners. Moreover, as observed by A'Hearn and Venables (2013), the proximity of rivers and watercourses gave to northern Italy an additional advantage: the availability of water sources for the production of mechanical energy and hydroelectric power. The historical North–South differences in terms of energy substitutes and transport infrastructure endowment are still a matter nowadays.[10] Ciccarelli and Fenoaltea (2013) argue that the development of railways before and after the Italian unification failed in creating a homogeneous internal economy. Also energy production and use are quite heterogeneous across the country: today the production and adoption of renewable energy sources is essentially a northern Italy's matter. An index that varies within country might be instrumental in shedding light on these geographical imbalances. The last part of this paper examines these issues and provides two simple exercises. It adopts the computed coal prices at the NUTS3 level to explore the role of the transport infrastructure in making the price of coal lower and the proximity to watercourses in being less dependent on coal. Results confirm the advantage of northern territories: the more intricate railway system gave them a *second-nature advantage*, while the greater access to water energy represented a *first-nature advantage*. Minor urban centers in the North could access coal thanks to the developed transport infrastructure, this was less the case in the South. Moreover, thanks to the greater availability of hydro power, the price of coal weighed less on northern provinces since the possibility to substitute coal with water.

[9] See Federico et al. (2019) for a summary of the origins of the regional North–South divide.

[10] The construction of motorways during the 20th century resulted in a dichotomous territory: a developed North-Center and a backward South (Cosci and Mirra 2018).

Four sections follow. Section 2 discusses the peculiar situation faced by Italy during the nineteenth century: the need for coal in a territory lacking domestic coal resources. In Sect. 3 the construction of a new measure of coal price at the NUTS3 level is presented. Section 4 analyzes two issues linked with the price of an imported factor: the existence of extended transport infrastructure and the presence of a coal substitute. Section 5 concludes.

2 The need for coal: import and distribution

For a long time, vegetable sources represented the main energy carriers in Italy. Firewood and food for human and animal work were the principal power fuels, and still in 1861 the country was mostly dependent on traditional sources: coal—the modern energy carrier—represented only 7% of the total consumption.[11] From the 1880s onward, coal consumption accelerated; it became 40% of the total usage on the eve of World War I and in 1911 steam power represented 29% of the total industrial consumption (Malanima 2006).[12]

Coal consumption growth combined with the decreasing availability of traditional sources. As stated by Adami (1886), during the nineteenth century vegetable fuels became sparse and expensive and they were not sufficient to cover the entire demand of energy coming from the metallurgic industry, mines, firms, and needed to power railways, tramways, steamships and to produce gas-lights. Moreover, although from a mere geological point of view, the Carboniferous period dominated also the Italian territory, the rich deposits of coal typical of other European countries (such as the U.K., Belgium, and France) were scarce in Italy with few outcrops of anthracite and lignite.[13] This is shown in Fig. 1: there were no main coalfields and Carboniferous rock strata are mostly concentrated in the island of Sardinia and in the Calabria region. However, coal quarried from the Sardinian mines was few and of poor quality.[14] The need of importing coal was then a clear consequence of insufficient domestic resources.

The scarcity of coal was not a neutral condition for Italy. Bardini (1997) underlines how the high weight of coal, as a bulky commodity, made the import of coal particularly expensive, with high shipping costs weighing on the final price. Compared to the U.K.—its main coal trade partner—the price of fossil coal in Italy was 4–5 times higher and 3–4 times higher compared to other Western Europe economies, like Germany, France, or the U.S.[15]

Import flows increased during the first decades of the nineteenth century. As stated by Malanima (2006), the reduction of sea transport costs increased coal

[11] According to Malanima (2006), total consumption includes both household and industrial usage.

[12] Steam energy accounted for 465,343 CV (i.e. *cavalli vapore*. It is the Italian measure for power, similar to the *horsepower*, HP) out of 1,603,836 total industrial CV (Source: MAIC, Ministero di Agricoltura, Industria e Commercio (1914)).

[13] Bollettino Consolare (1883, p. 38) reports that the lack of fossil coal resources was confirmed by a research conducted by the Committee of Inquiry on the Merchant Navy.

[14] Malanima (2006).

[15] Bardini (1998) compares fossil coal prices in Italy and other countries for the period 1883–1912.

shipping, especially to Genoa. Genoa was the main import port for fossil coal and other goods from abroad. In 1882, 346 out of 430 domestic ships docked at the port of Genoa with an overall dead weight tonnage of 203,707 out of 250,615. Fossil coal represented the majority of traded goods: in 1882, 291,968 out of 677,191 tons of coal were unloaded in the port (Bollettino Consolare 1883). The predominance of Genoa persisted and one-third of total coal imported to Italy was addressed to Genoa also in the following years. Since the large coal shipments arriving in Genoa, the port was organized in two areas: one specific for coal and the second assigned to all other commodities (Corbino 1922).

The urgency to obtain coal and its widespread employment across all the peninsula clearly emerged in the trade bulletins: fossil coal arrived from Cardiff to all main and minor Italian ports. Figure 2 provides a map with the 26 import ports and the quantity of coal imported in 1882. Savona, near Genoa, was the second import port for coal, followed by Brindisi southeasterly, Naples, and Palermo in Sicily.

The need for coal and the provision of fossil fuel that was at the same time of good quality and cheap enlivened the discussions and the research of the time. Because of these two characteristics, British coal was always the favorite in Italy. However, historical reports and bulletins argued for the need of considering other supply sources, other than the British one. Referring to Belgium, Bollettino Consolare (1869) highlighted how the export of Belgian coal was virtually nonexistent: coalfields were far from Antwerp and the port lacked all those facilities needed to load coal into the ships. Transport costs needed to move coal from the pitheads to Antwerp increased the price of coal at the import port. This was not the case in the U.K.: coal basins were close to Newcastle and Cardiff and the ports were equipped with all those technological mechanisms that made loading and unloading easy and fast. However, the bulletin argued how Italian cargo ships that shipped goods from America to Belgium, once arrived in Antwerp needed to ballast the ship and reach the U.K. because no coal was available in the Belgian port. This caused an increase in transport costs and time. The bulletin underlines that, if coal had been available in Antwerp, the higher price of Belgian coal could offset the transport costs to arrive in the U.K., arguing how finding convenient solutions was a serious issue of the time.

Italian import ports differed in terms of coal freight costs (*noli del carbone* in Italian). Shipping costs were responsible for expensive coal prices in Italy and distance was the component that mostly weighed on final sea transports costs. However, goods freight rates were not exclusively fixed according to distances, but also to competition, market factors, and transshipment. Ship companies had to struggle with the prices made by other companies: freight rates in Livorno, despite the greater distance, were lower compared to those in Genoa (Bollettino Consolare 1883).

Once arrived at the port, fossil coal needed to be distributed across the entire peninsula. The distribution of coal across the territory depended on the existence of available transport infrastructure and still in 1886, as acknowledged by Adami (1886), the network was not so developed. Railways were the main transport mode to move coal to industrial areas and urban centers, and distance was the major factor in determining the convenience of fossil fuel for production activities. Abrate (1970) estimates that in 1870 French coal in Turin had a price of 35 Italian *Lire* per

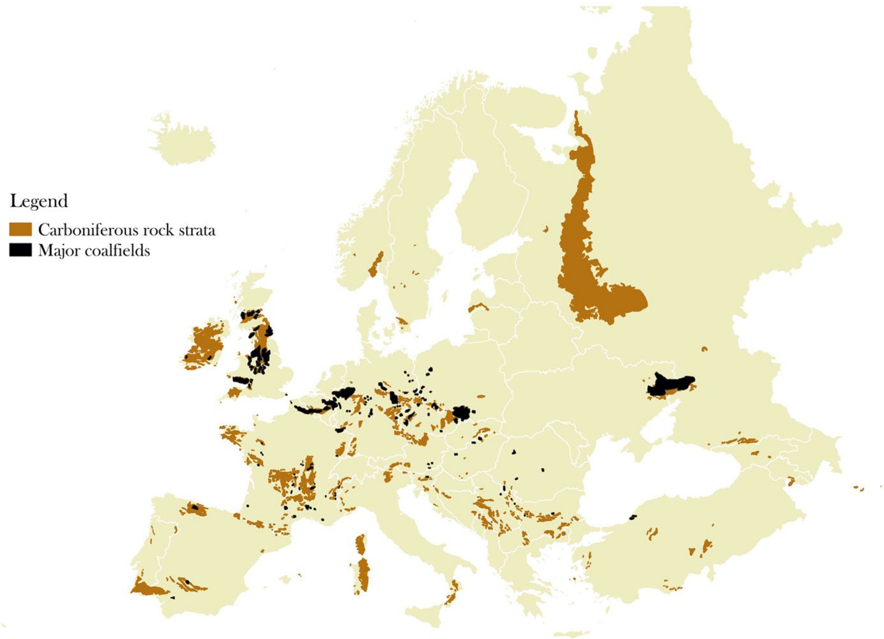

Fig. 1 Carboniferous rocks and major coalfields in 1931 in Europe. *Source*: Author's elaborations from Fernihough and O'Rourke (2021) data. Shape file from Carlos Efraín Porto Tapiquén, Orogénesis Soluciones Geográficas (2015)

ton: 15 *Lire* was the price of coal, 20 *Lire* were the transport costs to deliver coal from St. Etienne by railways. Because of sea shipping costs, British coal, instead, was much more expensive: it arrived at the port of Genoa and was then transported to Turin by railways, with a final price of 55 *Lire*. Considering that in 1870 the price of coal in Cardiff was 12 Italian *Lire*[16] and the price in Genoa was 40 *Lire*,[17] maritime shipping costs amounted to 28 *Lire* per ton, while the cost of transporting coal from Genoa to Turin was 15 *Lire* per ton.[18] The railway transport cost was also subject to the cost of coal itself. Based on the steam engine and representing the fuel to power locomotives, the increase or reduction of the cost of coal, affected also the cost of the railway service. As a commodity, instead, coal was subjected to ad hoc railways fares that weighed on coal final price. A further constraint was represented by the unavailability of railway lines in many provinces. Railways expanded over time and in 1881 the kilometers of railways were three and a half times those

[16] 9.3 shillings per ton (Bollettino Consolare 1883, p. 65), which corresponds to 0.46 pounds per ton. This estimate is consistent with the one by Walters (1975).

[17] Source: Federico et al. (2011).

[18] Indeed, according to historical sources, British coal was considered of the best quality compared to the French one. Therefore, the higher price of British coal in Genoa was compensated by higher quality.

Fig. 2 Coal import ports and imported quantity (tons) in 1882. *Source*: Author's elaborations from Bollettino Consolare (1883) information. Shape file from Istat

after Unification. By 1886 the main city center in all provinces was reachable by railways.[19] When no railways were available, historical sources report that coal was distributed by ox- or horse-drawn carts. However, because of the costs and duration, this mode of transport was not convenient.

[19] The sole province that was not completely linked by railways was Sondrio in Lombardy (North-West of Italy).

3 The coal price measure: data and methodology

A measure of coal price for Italy already exists. Data on the price of coal for the Liberal Age have been firstly collected by Cianci (1933) and Vazza et al. (1965). More recently, Federico et al. (2011) produced a more reliable estimate.[20] All contributions provide a country-level proxy: the price of coal computed at the port of Genoa. Genoa coal price could be used as the Italian indicator for the price of coal, assuming local homogeneity and null distributional costs. This paper makes a step forward and computes a measure at the NUTS3 level, allowing differences across provinces. As highlighted by Bartoletto (2005), the price of coal in the Italian ports was 5–6 times higher than in the British ports, the price was even higher in the internal areas of the peninsula where coal cost 10 times more.

The new measure of coal price is the sum of the price of coal imported from Cardiff[21] and all transport costs to deliver the coal locally. The measure has been constructed for all historical Italian provinces for the period 1861–1911. Data and methodology are described by separating provinces between those with a port and those without a port.

3.1 Coal price in provinces with a port

The initial step consisted in understanding how coal was imported and distributed in each historical province with a port.[22]

40 out of 69 provinces have access to the sea. Among these, those with at least one port are 35. However, not all ports were commercial ports.[23] Indeed, as listed in Bollettino Consolare (1883), coal was imported in 26 main Italian ports, as shown previously in Fig. 2. Many of these ports belong to the same province; coal was then imported to 17 provinces.[24] However, according to Corbino (1923b, c, 1924a), also the ports of Oneglia and Porto Maurizio, Ortona, and Siracusa in the provinces of Imperia, Chieti, and Siracusa, respectively, were coal import ports. In these terms, fossil coal was imported directly from the U.K. to 30 ports and 20 provinces. The computation of the price of coal for provinces with an import port is straightforward: the coal shipping transport cost of each Italian port is added to the price of coal in Cardiff.

[20] Felloni (1957) provides the series of charcoal price in Turin for the nineteenth century.

[21] According to Bollettino Consolare (1883), British coal was of the best quality and the one exported from Cardiff was the cheapest. For these reasons between 1876 and 1882, the amount of coal shipped from the port of Cardiff increased, and in 1881 it reached one-third of the total British coal exported to Italy (633,971 out of 1,727,829 tons). In the port of Cardiff it was always possible for foreign ships to find coal for the outward leg and its location made the approach and docking easy with every kind of weather.

[22] According to the decennial census, Italy counted 59 provinces from 1861 to 1870, and 69 starting from 1871 (Source: Istat).

[23] Corbino (1922, 1923a, b, c, 1924a, b) provides a detailed analysis of Italian ports and their activity.

[24] Genoa, Venice, Livorno, Ancona, Rome, Caserta, Naples, Bari, Lecce, Reggio Calabria, Messina, Catania, Agrigento, Palermo, Trapani, Cagliari, Sassari.

The coal shipping fares (in Italian *noli del carbone*) are reported by Harley (1989) for the sole port of Genoa from 1839 to 1913. The same detail is not provided for all other ports. For the major Italian ports, the information can be sourced from Bollettino Consolare (1883) but only for two years, 1881 and 1882; however, still, some ports are missed. To obtain a long series for all coal import ports, the two sources have been combined and the computation required some assumptions.

To start, the information provided by both sources has been compared. According to Harley (1989) transporting one ton of coal to Genoa costed 13.6 shillings (s.) in 1881 and 12.7 s. in 1882. Bollettino Consolare (1883) reports 13.9 s. and 12 s., respectively. Although not completely identical, the two sources provide similar estimates.

The second step consisted in obtaining the coal rate cost for the 11 ports not listed in Bollettino Consolare (1883) and to consider only the main port for those provinces having more than one.[25] For these ports it has been assumed the same transport costs of the nearest port:[26] for Reggio Calabria the same transport cost as Messina, for example.[27] A further assumption regarded the port of Gaeta, at that time included in the province of Caserta.[28] Since this port—compared to the one of Naples—was a small port with reduced trade flows, it has been assumed that the majority of coal distributed in the province of Caserta had as a starting point the port of Naples.

The third step consisted in computing the percentage differential between the transport cost in Genoa and those in the other Italian coal import ports in 1881 (as reported in Bollettino Consolare (1883)) and applying this differential to the transport cost provided by Harley (1989), obtaining the coal transport cost for all 19 ports/provinces for all years. The solution adopted implicitly assumes that coal shipping fares in all ports vary across years in the same proportion as Genoa coal transport cost does.[29] To express the measure in Italian *Lire*, the exchange rate between

[25] The bulletin provides the coal transport cost for 11 ports and 9 provinces: Ancona, Brindisi (Lecce), Cagliari, Genoa, La Spezia, Livorno, Messina, Naples, Palermo, Savona, Venice. Savona and La Spezia belong to the province of Genoa. It does not list the coal transport cost for the ports of Oneglia-Porto Maurizio (Imperia), Ortona (Chieti), Civitavecchia (Rome), Gaeta (Caserta), Bari, Reggio Calabria, Agrigento, Catania, Siracusa, Trapani, Porto Torres (Sassari).

[26] It can be argued whether this assumption is too strong. As mentioned before, the distance determines transport costs only partially. Transport fares are also the result of competition and market power.

[27] Oneglia-Porto Maurizio (Imperia) has the same transport cost as Savona. Ortona (Chieti) has the same transport cost as Ancona. Civitavecchia (Rome) has the same transport cost as Livorno. Bari has the same transport cost as Brindisi (Lecce). Reggio Calabria has the same transport cost as Messina. Agrigento, Catania, Siracusa and Trapani have the same transport cost as Palermo. Porto Torres (Sassari) has the same transport cost as Cagliari.

[28] Nowadays the port of Gaeta belongs to the province of Latina.

[29] The assumption accommodates the change in time of prices, that is quite homogeneous within country. Bollettino Consolare (1883, p. 66) reports the coal shipping fares in shillings for several foreign ports (including the Italian ports of Ancona, Brindisi, Cagliari, Genoa, La Spezia, Livorno, Messina, Naples, Palermo, Savona, Venice) in two years (1881-1882). As a robustness check, these data have been used to compute the price differential between 1881 and 1882 to verify the suitability of using Genoa's price variation as representative for all Italian ports. Comparing the results, it emerges a similar pattern. All coal shipping fares decrease from 1881 to 1882: on average, Italian ports experienced a reduction of 6.7%. This value is very close to the percentage registered in Genoa: from 1881 to 1882 the cost of transporting

the Italian currency and the British one from Spinelli and Toso (1989) has been used. The estimates are presented in Fig. 3.

The second variable needed to compute the price of coal in the Italian import ports is the price of coal (*free on board*) in the port of Cardiff. The information is provided by Bollettino Consolare (1883) from 1840 to 1882. Bardini (1998) lists the price of coal in the U.K. from 1883 to 1913[30] and the price of coal in southern Wales from 1882 to 1912. However, both prices refer to the price of coal at the pithead. Comparing the data from Bardini (1998) with those from Bollettino Consolare (1883) for the sole year they have in common—1882—it emerges a significant difference between the two prices. Therefore, it is not possible to combine the sources to obtain a unique series. For these reasons, the price of coal in Cardiff has been computed starting from the information provided by Federico et al. (2011) about Genoa coal price. Shipping coal fares in Genoa from Harley (1989) and transformed above in Italian *Lire* have been subtracted from the Genoa coal price by Federico et al. (2011)—also expressed in *Lire*. The information obtained has been compared for the years 1861–1882 with the one provided by Bollettino Consolare (1883), that acted as a benchmark. The computed price of coal in Cardiff, and expressed in *Lire*, has been lastly added to the sea transport costs computed above, obtaining the coal price in the Italian import ports. The estimates are presented in Fig. 4.

Bari, Brindisi (Lecce), Cagliari and Porto Torres (Sassari) stood out for the lowest coal price; in the port of Venice, instead, the price of coal was the highest.

The price of coal in Cardiff is the single coal price considered here. The underlying hypothesis is that the price of coal in Italy was essentially determined by the value of coal in the port of Cardiff, disregarding the effect played by the price of national coal and of coal imported from other countries or shipped from other British ports. This assumption is supported by three main reasons. First, domestic coal—like the one quarried in Sardinia, the region with the major coalfields of the country—was scarce and of poor quality, with a reduced content of carbon and a high concentration of water and volatile materials. Its heating power was low and not suitable for the steel and iron industry. It was mainly used in the island for heating purposes or for steam productions, and until World War I only 25,000 tons per year were extracted on average from the main mine of the island (Benincasa 2015). Sella (1871) argues how local fossil coal could not be compared to the British one. If better quality was the main reason for British coal superiority,[31] the lack of convenient and cheap transport systems in the island did not allow to guarantee a price below the competitive level, making the U.K. coal more attractive also from a mere spending point of view. Second, coal imported from other European countries had not enough power to compete with the one exported from the U.K. ports. During the

Footnote 29 (continued)

coal by sea reduced by 7.0%. A similar trend and not too large differences in percentage values allow taking Genoa's shipping price differentials as a benchmark.

[30] As reported by Bardini (1998), the information has been sourced from the British Parliamentary Papers of 1911 and 1924.

[31] It was established that, under the same conditions, to heat steam boilers the consumed quantity of Sardinian fossil coal and of British one was in the ratio of 42 to 25, respectively (Sella 1871).

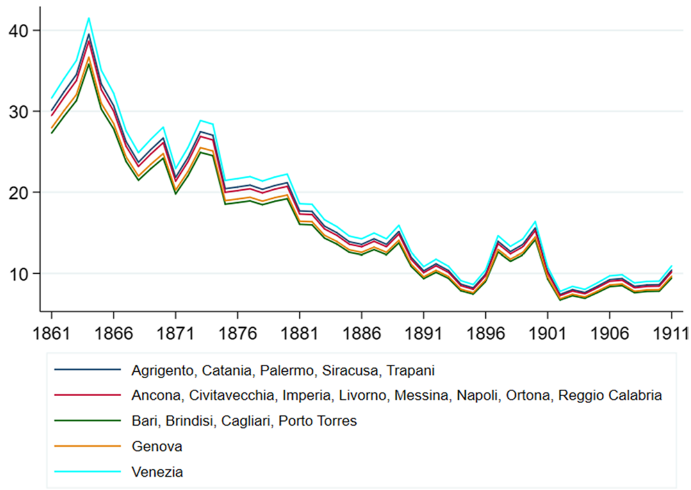

Fig. 3 Coal shipping transport costs (Italian *Lire* per ton). *Source*: Author's elaborations from Bollettino Consolare (1883) information, Harley (1989), and Spinelli and Toso (1989) data

nineteenth century, British coal supplies dominated the world market and they were used to ballast the ships in the outward journey, taking advantage of low transport rates (Jevons 1865). Fremdling (1996) notices how German domestic coal in German, French, and Dutch markets could not overtake supplies from the U.K. reserves. However, with the construction of railways, British coal was replaced in some locations by domestic coal. In India, for instance, foreign coal consumption decreased from 25% in 1890 to 5% in 1899 (Department of Statistics India 1922). Wegerich (2017) shows for different global ports how British coal faced competition from foreign supplies (like Germany or the U.S.), but this happened mainly during the second decade of the 20th century. Third, coal shipped from other British ports had a similar price as the one in Cardiff. Coal prices reported in the British Parliamentary Papers (1913, 1925) for Great Britain show similar series for the North Wales, South Wales, and the U.K. average pithead price. The equalization of the three prices both in level and trend makes the Cardiff price representative for the British coal price. A further point has to do with comparability. Since Cardiff coal was for a long time exported and employed all over the world (southern Europe, North Africa, North and Latin America, India, China, Australia),[32] referring to Cardiff coal prices as a background will allow comparison between Italian provinces and foreign countries or regions.[33]

[32] See Kirkaldy (1914) and Office of Naval Intelligence (1900, 1909) for global ports reached by Welsh coal.

[33] Wegerich (2017) constructs coal price series from 1840 to 1960 for 30 ports and for major exporting countries using the Cardiff coal price as a reference price in his computations and analyses.

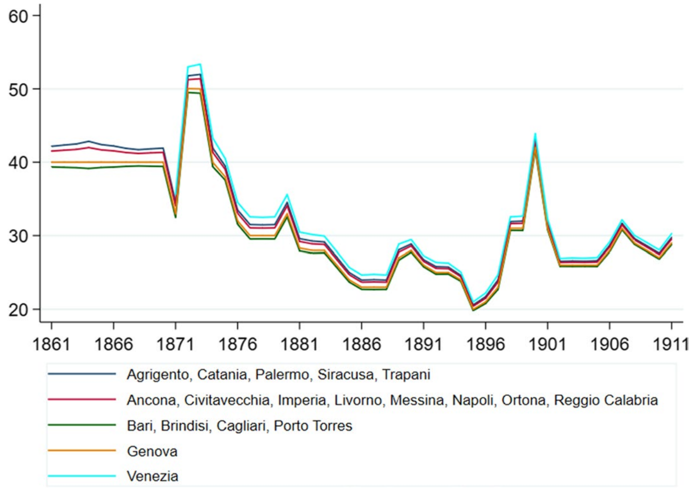

Fig. 4 Coal price in the import ports (Italian *Lire* per ton). *Source*: Author's elaborations from Bollettino Consolare (1883) information and from Federico et al. (2011), Harley (1989), and Spinelli and Toso (1989) data

3.2 Coal price in provinces without a port

Once arrived at the import ports, coal needed to be distributed in those provinces without a port. Several historical sources[34] have been used to identify the import port for all 43 (until 1870) and 52 (from 1871 onward) provinces not endowed with a port.[35] When no reference was found, the nearest port rule has been applied: goods were distributed in the province from the closest import port. Corbino (1923a) explains that Italian ports served mostly the neighboring areas. An investigation of the origins and destinations of the port of Genoa shows that, while the departing wagons do not go, with some exceptions, beyond a distance of 50 kilometers towards Ventimiglia and Pisa, the arriving wagons come from farther distances, that is, as

[34] Corbino (1922, 1923a, b, c, 1924a, b); Bardini (1998), Gazzetta Ufficiale (1935), MAIC (1881), Bartoletto (2004), Deffenu (1976) and Garzella et al. (2013).

[35] 3 out of 20 provinces with a coal import port have their main city center (Caserta, Lecce, Rome) far from the port. From the port of Ancona coal was distributed to the provinces of Ascoli Piceno, Forlí, Macerata, Perugia, Pesaro-Urbino. From the port of Bari coal was distributed to the province of Foggia. From the port of Brindisi coal was distributed to the province of Lecce. From the port of Catania coal was distributed to the province of Caltanissetta. From the port of Ortona (Chieti) coal was distributed to the provinces of L'Aquila and Teramo. From the port of Civitavecchia (Rome) coal was distributed to the provinces of Grosseto and Rome. From the port of Genoa coal was distributed to the provinces of Alessandria, Bergamo, Como, Cremona, Cuneo, Milan, Modena, Novara, Parma, Pavia, Piacenza, Reggio Emilia, Sondrio, Turin. From the port of Livorno coal was distributed to the provinces of Arezzo, Florence, Lucca, Massa-Carrara, Pisa, Siena. From the port of Naples coal was distributed to the provinces of Avellino, Benevento, Campobasso, Caserta, Potenza, Salerno. From the port of Reggio Calabria coal was distributed to the provinces of Catanzaro, Cosenza. From the port of Venice coal was distributed to the provinces of Belluno, Bologna, Brescia, Ferrara, Mantova, Padova, Ravenna, Rovigo, Treviso, Udine, Verona, Vicenza.

far as the cost of railway transport is cheaper than that of transshipment (Corbino 1922). Because of the high inland transport costs and the reduced railway network in the early years after the Italian unification, it was more convenient to distribute coal from the nearest port, reducing inward transportation. For instance, Carrino and Salvemini (2006) observe how during the nineteenth century the lack of a developed railway network between Naples and Reggio Calabria—in the South—was overcome by ship transportation: the sea played a substitute role even for minute trade between places very close as the crow flies and far from the coast. As reported in Gazzetta Ufficiale (1910) the nearest port was customary for moving goods: exports and imports from the island of Sardinia to continental Italy were ruled by the nearest sea route. Low-speed goods shipping, departing from Sardinia, could be routed for a transit other than that determined by the closest route, only if the transport document included all the necessary information about the continental railway lines to deliver the goods to the final destination.

The price of coal in the provinces without a port was, therefore, equal to the price of coal in the import port plus inland transport costs: coal arrived *via* railways or transported through ox- or horse-drawn carts if railway lines were not available.

Inland transport costs are determined by the distance from the import port weighted by the fare for each transported ton of coal. The distance between the port and the main city center of the province has been computed in terms of transport infrastructure. Railways were the main mode to distribute coal and their development in Europe during the nineteenth century allowed the transport of heavy loads of goods across each country. The first Italian railway line was constructed in 1839 and by 1894 all provincial capitals were linked to the main Italian ports.[36] Ciccarelli and Groote (2017) provide the shape file of the Italian railway network for the period 1839–1913. The GIS file has been used to compute the infrastructural distance (km) from the port to the main rail station of each province for each year. Because of the central role railways played in moving coal, they have been assumed as the preferred mode of transport. If railway lines were not available or allowed to travel only a part of the whole route, the distance to the nearest rail station has been computed and the remaining distance has been traced in terms of roads. To account for road distances, the shape file of the Roman road network by McCormick et al. (2013) has been employed. These are all roads constructed by the Romans until 117 A.D. (peak of the Roman Empire) and used as a proxy of existing paths where horse- or ox-drawn wagons could travel to deliver coal.[37] When no traced roads were

[36] By 1886 all but one provincial capitals were connected to the nearest port by railways. Sondrio in Lombardy only by 1894.

[37] According to historical sources, during the nineteenth century, the Italian road network consisted of approximately 3000 km and was in a dilapidated condition. This was a direct consequence of the negligence during the Middle Ages: the almost 19,600 km of Roman roads that existed under Trajan went disrupted. Nevertheless, the main longitudinal and transverse axis were maintained during medieval times and, towards the middle of the nineteenth century, the old Roman road system still represented the foundation of mobility. Modern motorways, railways, and main roads across Italy trace the historical Roman road network (De Benedictis et al. 2021).

available, straight-line distances have been computed.[38] In 1861, 20 out of 43 provinces without a port were linked to the import port exclusively by railways, 13 by both railways and roads, and 10 only by roads.

Beyond infrastructural distance, inland transport costs are increased by fares. These can be variable (i.e. the cost per km) or fixed (i.e. the cost due for using a mode of transport). In Ferrovie dello Stato (1912) railway variable rates and the terminal component for each transported ton are reported for a wide list of goods—including fossil coal.[39] The information is provided for the year 1911. Following the same approach as Missiaia (2016), to project back in time variable and fixed railway fares, the information provided by Ferrovie dello Stato (1912) has been combined with the one in Noyes (1905), who lists for the U.S. and some European countries - including Italy—the average railway rates for different years starting from 1870, and the computations performed by Federico (2007), who computes railway fares for transporting wheat from 1860. Figure 5 shows the estimated cost per km for fossil coal. Fares are constant by decade—as in Federico (2007)—and decreasing in time, with higher fares for shorter journeys. Same computations have been performed for the terminal components (i.e. fixed rates). Elaborations—presented in Table 1—are consistent with those by Missiaia (2016)—who estimates average fares for distributing two representative industrial goods, wheat and coal—with some differences in the variable rates due to the inclusion of the sole fossil coal in the present paper's computations.

The rate for transporting coal by road, instead, has been computed using the information sourced from Sella (1871) who provides details about different journeys by horse- and ox-drawn wagons from the coalfields to the export ports in Sardinia. On average, transporting fossil coal from the pithead to the board of a ship cost 0.59 Italian *Lire* towards the second half of the nineteenth century.[40]

Once computed the price of coal in all import ports and all inland transport costs to distribute coal in each province, the formula used to obtain the price of coal in the latter has been the following:

[38] Straight line distances have been computed in very few cases.

[39] Ferrovie dello Stato (1912) provides the fixed cost for transporting each ton of fossil coal and the variable costs by ton for 12 different journeys: 1–50; 51–100; 101–200; 201–300; 301–400; 401–500; 501–600; 601–700; 701–800; 801–900; 901–1000; >1000 km.

[40] The fare is consistent with those existing in other countries. Bogart (2013) reports that, during the nineteenth century, the fare to transport one ton per mile in the U.K. was 1.46 shillings: this corresponds to about 1.13 Italian *Lire per* ton *per* km. Since by 1886 all but one provincial capitals were connected to the nearest port by railways, there is no need to project the information forward.

$$\begin{aligned} \text{coal price}_{p,t} &= \text{coal price import port}_{p,t} \\ &+ \Big(\sum_{i=1}^{12} \text{distance railways km}_{i_{p,t}} * \text{km cost railways}_{i_t}\Big) + (\text{railways terminal cost}_t * r) \\ &+ \text{distance Roman roads km}_{p,t} * \text{km cost wagon} \\ &+ \text{distance straight line km}_{p,t} * \text{km cost wagon} \end{aligned}$$

$$\text{where } r \begin{cases} 1, \text{ if} \quad \text{distance} \quad \text{railways km}_{i_{p,t}} > 0 \\ 0, \text{ otherwise} \end{cases}$$

The price of coal *per* ton for each year (t) and province (p) is determined by four main components: the price of coal in the nearest import port, the transport costs—if any—of distributing the coal by railways or by land using the path of a historical Roman road or a simple straight line track. The price of coal is equal to the sole price of coal in the nearest import port for those provinces having an import port. For those provinces linked to the import port exclusively by railroads, the price is increased by the distance in km in terms of railways weighted by the cost *per km*—according to the different journey fares (i)[41] displayed in Table 1—plus a terminal cost *per* ton that is fixed. The distributional costs for those provinces connected to the import port by a Roman road or a straight line are obtained by multiplying the land distance in km by the cost of transporting a single ton by cart. In those provinces where more than one transport system is needed to deliver the coal, the price is the sum of two or more distributional costs.

The estimated coal prices for provinces with and without a port are presented in Fig. 6, which shows the trend for the 51 years period. To provide a straightforward picture, NUTS3 level prices are averaged by NUTS1 socio-economic macro-areas (North-West, North-East, Center, South, and Islands). Figure 6 also reports the prices for the port of Genoa. Coal price has overall a decreasing trend, with two main peaks during the 1870s and at the turn of the two centuries. At the beginning of the period, the South registered the highest coal price: although their access to the sea, southern provinces lacked an extended transport infrastructure. With the development of railways and the decreasing of transport costs, the price of coal decreased in the South and from 1879 the northern provinces paid the highest price; however, Fig. 6 shows an equalization of prices at the end of the period.

A deeper view of the geographical variability within the peninsula can be observed in Fig. 7, which shows the price of coal at the NUTS3 level for six selected years. For each year, the coal price is divided in quintiles. In 1861, the price of coal had a high variability: it ranged from 39.3 *Lire*, in the island of Sardinia and Bari (Apulia), to 162.5 *Lire*, in Cosenza (Calabria). In 1871, the South still stood and stuck out for the major and minor prices, with northern territories lying in between. In 1881, the lowest and highest price was 27.9 and 90.2 *Lire*, respectively, with the province of Campobasso, in the South, experiencing the most expensive price. In 1891 and 1901, the coal price variability decreased,

[41] Variable costs *per* ton *per km* are provided for 12 journeys.

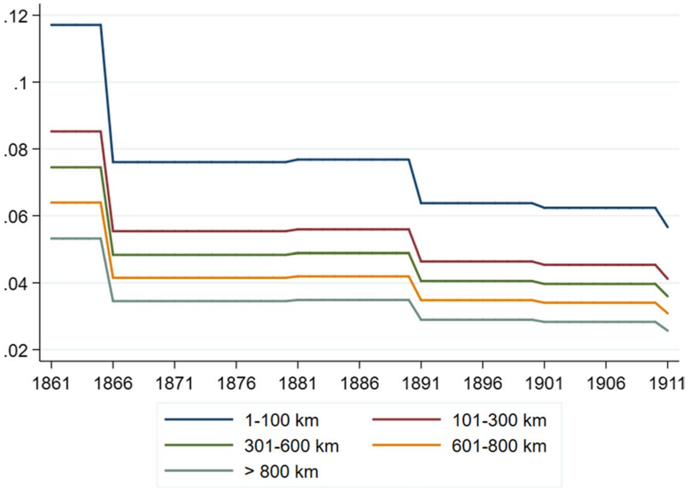

Fig. 5 Variable railways fares for fossil coal transport (Italian *Lire* per ton). *Source*: Author's elaborations from Ferrovie dello Stato (1912) and Noyes (1905) data, according to the methodology of Missiaia (2016)

Table 1 Fixed and variable railways fares for fossil coal transport (Italian *Lire* per ton) *Source*: Author's elaborations from Ferrovie dello Stato (1912) and Noyes (1905) data, according to the methodology of Missiaia (2016)

Fare	Years						
	1861–1865	1866–1870	1871–1880	1881–1890	1891–1900	1901–1910	1911
Fixed	2.6108	1.6953	1.6953	1.7124	1.4211	1.3905	1.2618
1–50 km	0.1171	0.0760	0.0760	0.0768	0.0637	0.0624	0.0566
51–100 km	0.1171	0.0760	0.0760	0.0768	0.0637	0.0624	0.0566
101–200 km	0.0852	0.0554	0.0554	0.0559	0.0464	0.0454	0.0412
201–300 km	0.0852	0.0554	0.0554	0.0559	0.0464	0.0454	0.0412
301–400 km	0.0745	0.0484	0.0484	0.0489	0.0405	0.0397	0.0360
401–500 km	0.0745	0.0484	0.0484	0.0489	0.0405	0.0397	0.0360
501–600 km	0.0745	0.0484	0.0484	0.0489	0.0405	0.0397	0.0360
601–700 km	0.0639	0.0415	0.0415	0.0419	0.0348	0.0341	0.0309
701–800 km	0.0639	0.0415	0.0415	0.0419	0.0348	0.0341	0.0309
801–900 km	0.0532	0.0345	0.0345	0.0349	0.0289	0.0283	0.0257
901–1000 km	0.0532	0.0345	0.0345	0.0349	0.0289	0.0283	0.0257
> 1000 km	0.0532	0.0345	0.0345	0.0349	0.0289	0.0283	0.0257

and in 1911 the range was even shorter: Cagliari, Sassari and Bari still paid the lowest price—28.8 *Lire* for one ton of coal—Cosenza the highest—49 *Lire*. If at the beginning of the period (1860s–1870s) southern and central provinces were those bearing the major costs and northern areas, instead—although lacking access to the sea—could take advantage of the presence of an interconnected

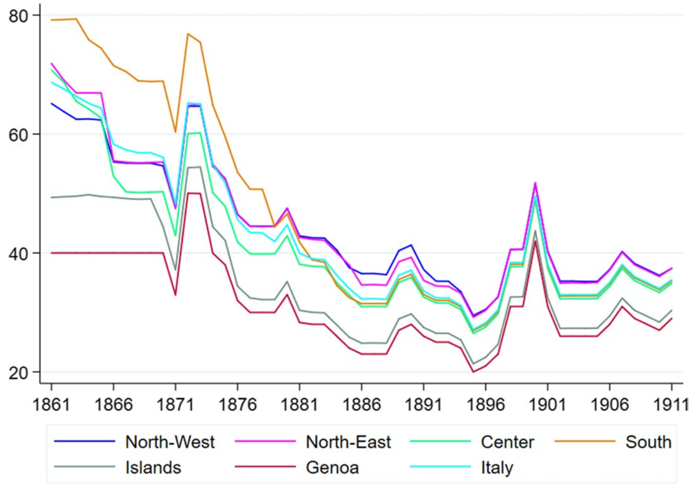

Fig. 6 Coal price: averages by area (Italian *Lire* per ton). *Source*: Author's elaborations. See text for sources

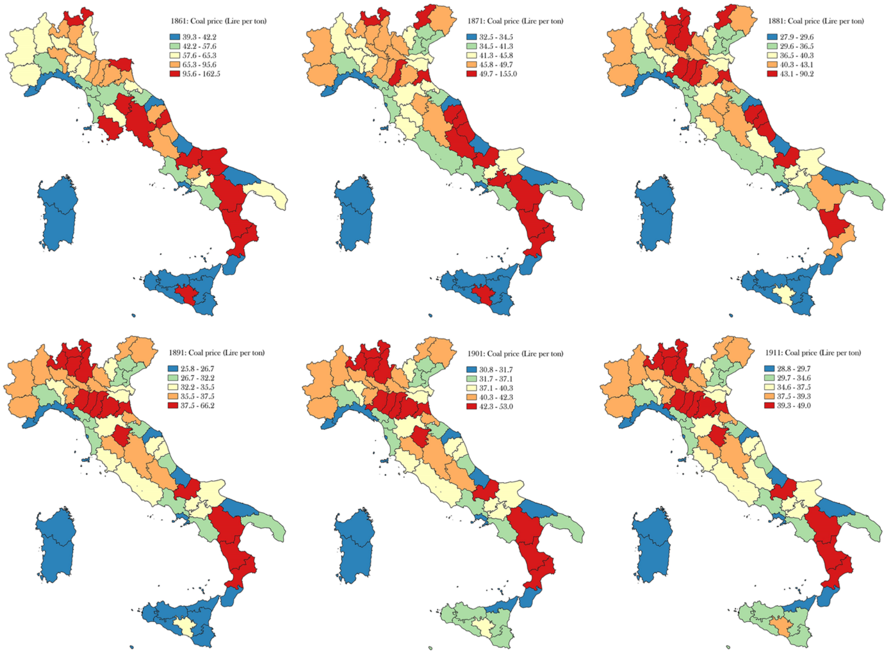

Fig. 7 Coal price in selected years (Italian *Lire* per ton). *Source*: Author's elaborations. See text for sources. Shape files from Istat

railway system, the picture slightly changed over the years. Starting from 1881 the reduction of transport costs lowered prices, with a more homogeneous balance between North and South at the end of the period: provinces in Lombardy and Emilia-Romagna paid between 39 and 44 *Lire* per ton of coal in 1911, but still some southern areas - like Cosenza, Campobasso, Catanzaro, Potenza—suffered from expensive prices.

Although the improved railway system reduced the imbalances between North and South, it did not level out the two areas. The point is examined in next Sect. 4.

4 Coal price and North–South gap

This section aims at using the computed price of coal to explore the Italian North–South divergence in terms of two aspects: transport infrastructure and coal substitutes.

As an imported and intermediate good, transportation costs weighed on the final price of coal. Once arrived at the import ports, the existence of a connected transport infrastructure made the difference in reaching the final destination and making the price lower. Moreover, the heterogeneous Italian geography—on the one side - and the institution's functioning—on the other side—are two key factors that in the past, as well as in present days, rule the development of transport networks. Also the availability of water for the production of hydro energy was—and still is—quite heterogeneous across the country, with the North having a substitute for coal. The analysis here proposed provides two simple exercises to gain insight on these issues.

4.1 Railway infrastructure and the North–South gap

The coal shortage and the need to provide all the country with the scarce fossil fuel highlight the importance of a transport infrastructure endowment.

As a natural resource, the availability of coal favored those areas rich in ore deposits. This was clearly not the case in Italy, where the accessibility of the fossil mineral might be assumed homogeneous across the country. However, it might be argued how differences existed and how these depended on the existence of the transport network.

In the past as today, the extension of the transport infrastructure across the Italian territory is a matter that involves a broad discussion. The uneven construction of railways first and motorways then generated a polarization: the North with an extended and intricate transport system, the South with a backward infrastructural network.[42]

If in the past railways were the preferred mode of transport to distribute goods across each country, today three-fourths of the European freight transport is performed by truck; in Italy, road transport represents approximately 88% of total freight distribution.[43] To deeply examine the role of the historical transport infrastructure on the North–South polarization in terms of coal price, a wider number

[42] See Ciccarelli and Fenoaltea (2013) and Cosci and Mirra (2018).

[43] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Freight_transport_statistics_-_modal_split.

of provinces is taken into account, including also smaller urban centers. The price of coal is then computed using all railway lines present in 1911 but considering the 106 out of the 110 NUTS3 provinces that characterized the Italian administration between 2010 and 2016: the territories of the provinces of Trento, Bolzano, Gorizia, and Trieste in 1911 were not part of Italy.[44] This allows decomposing the territory into finer administrative units in order to better account for the negative geography (mountains), which makes the construction of transport infrastructure particularly difficult. Figure 8 shows the results of this computation by averaging the NUTS3 coal prices at the NUTS1 macro-level. The area that registers the higher differential in coal price is the insular one: for the islands of Sicily and Sardinia, the coal price computed for the new provinces is 9.1% higher than the price of coal measured for the historical provinces. Then come the central provinces for which the coal price in modern provinces is 3.4% higher. The South reports a higher coal price of 1.5%, instead. There are no differences for the northwestern provinces, while in the North-East coal price is 0.4% lower.

By increasing the number of provinces under scrutiny, it emerges a polarization between the North, on the one side, and the rest of the peninsula, on the other side, with islands experiencing the most disadvantaged condition. A finer disaggregation of the territory reveals how differences exist, disparities increase at the local level and imbalances persist in time: in the past, as today, northern provinces were better connected taking advantage of an integrated transport system. The more intricate railway system in the northern provinces gave them a *second-nature geography* advantage, even more when a finer scale is considered: if the main cities had the same access to the transport infrastructure in the North as in the South, the minor urban centers in the southern areas suffered from the lack of an interconnected railway network, corroborating the importance of accounting for these differences with a price varying at the local level.

4.2 Coal substitute and the North–South gap

Among the several explanations for what is known as *Questione Meridionale*, Fenoaltea (2014) and A'Hearn and Venables (2013) focus on the different proximity to water sources between northern and southern Italy. According to this literature, one of the reasons for the large regional disparities and the backwardness of the South can be found in the different geography of the two areas. Basile and Ciccarelli (2018) find that water drove the location of labor-intensive industries between 1871 and 1911. Similarly, Missiaia (2019) reports a positive correlation between industrial location and water power. The northern provinces had a comparative advantage in terms of water energy endowment and the availability of "white coal" from the Alpine region made the North energy-self-sufficient.

Still today the larger water power production in the North is at the core of both economic and political discussions. The process of decarbonizing the economy by

[44] Since 2017 Italy is organized in 107 NUTS3 provinces.

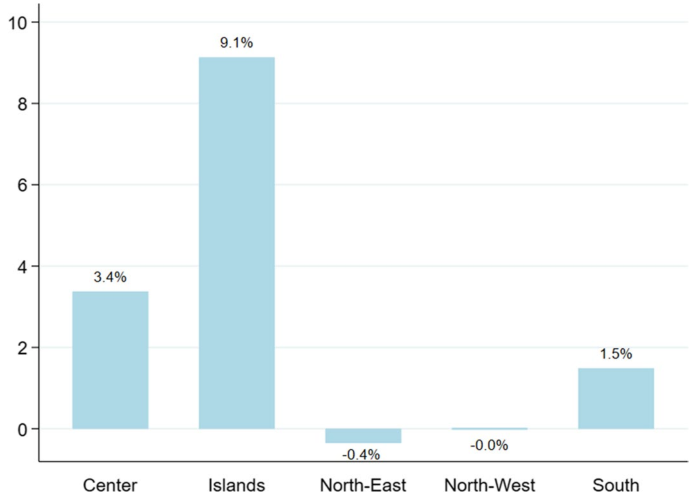

Fig. 8 Coal price differential (%) with 106 provinces: averages by area. *Source*: Author's elaborations. See text for sources

promoting the substitution of conventional sources with the adoption of renewable energy sources becomes essentially a northern Italy's matter. Hydroelectric power plants are mostly located in the northern area of the country and represent 40% of total Italian renewable energy.[45]

Although in Italy it didn't exist a geographic advantage linked to the availability of coal, the natural endowment of water and the differential provision of water energy, as a direct substitute of coal, might have provided the northern provinces with a further additional advantage: the low dependency on external energy carriers.

The measure of coal price at the NUTS3 level discriminates provinces in terms of higher or lower input factor costs. However, it does not account for the reliance on the fossil production factor: the lack of water energy supply made the South more vulnerable to coal imports. To account for the natural advantage given by the water endowment and the availability of a natural substitute, the price of coal can be weighted by the availability of water energy.[46] This can be proxied by the number of water mills existing in each province and by the proximity to hydroelectric plants.[47] The information on the number of water mills by province is sourced from MAIC (1889). Water mills, through a wheel or a turbine, employed mechanical water power

[45] Source: Enel.

[46] Across the centuries, the consumption of wind energy in Italy has always been less than half than hydro power usage. As remarked by Malanima (2006), wind power had a marginal role in the Italian territory. Between 1878 and 1882, wind mills for grounding cereals were only 78; registered water mills were, instead, 29,418.

[47] Basile and Ciccarelli (2018) measure water endowment at the NUTS3 level using the number of rivers flowing in the province and weighting the importance of each river by its length and socio-economic relevance. Missiaia (2019) exploits the production of mechanical water power and hydroelectricity.

to drive a production process, such as grinding flour. As reported in the *Annals of Statistics* by MAIC (1889), coal was a competitor of water energy. Between 1869 and 1882 the number of water and animal-driven mills registered a drop in Italy, while millstones powered by steam power increased. Nevertheless, water mills still dominated the grain industry: steam mills represented only one-sixth of total production and their distribution across the peninsula was opposite to the location of water mills, being predominant in those regions, like Puglia, Basilicata, Campania, and Sicily, where water sources lacked. In 11 provinces steam mills were completely absent and in 34 the production was lower than 100,000 tons. With the spread of technology and the possibility to transmit energy from one place to another, the exploitation of water resources changed. Starting from the last decade of the nineteenth century, the production of hydroelectricity took root in northern Italy. Taking advantage of the steep terrain of the Alpine region and of the Apennines in central Italy, hydropower plants can be considered the first step of Italy's energy transition from fossil fuels towards renewable energy sources. Malanima (2006) reports that the production of hydroelectricity in Italy began in 1887 and during the beginning of the 20th century Italy was the first producer in Europe: in 1911, 942,694 out of 1,603,836 CV used by the Italian industry derived from water power; 465,343 CV from steam power. The information about hydroelectricity is sourced from GSE (Gestore Servizi Energetici) which provides details about the location (municipality) and the opening year of hydroelectric plants.[48] Figure 9 shows the distribution across the peninsula of both types of water plants.

As an exercise, the measure of coal price in Italian *Lire* can be weighted by the possibility to rely on a potential coal substitute. In these terms, those provinces whose availability of water for energy is scarce will have a weighted coal price close to the original (non-weighted) one. In those provinces where the presence of water power plants predominates, instead, the weighted price of coal will be lower than the non-weighted one.[49]

The information on water mills and hydroelectric plants is used to compute two proxies for hydro energy. The first measure accounts for the density of water mills: it is the sum of all water mills existing in the province in 1882 weighed by the land area of the province.[50] The measure has been then re-scaled to vary from 0 to 1, with 0 meaning absence of water mills in the territory. The second variable is the distance in kilometers to the nearest hydroelectric plant in 1911.[51] Analogously to the water mills indicator, the distance has been re-scaled to compute an index that varies from 0 to 1, with 0 this time meaning being close to a hydroelectric plant and 1 absence of hydro power. The newly constructed proxies for water availability are reported

48 https://www.gse.it/documenti_site/Documenti%20GSE/Servizi%20per%20te/GARANZIA%20D'ORIGINE/Altri%20contenuti/Elenco%20impianti%20GO.XLSX.

49 The weighted price of coal is an artificial price expressed in Italian *Lire*. The opportunity to replace coal with hydro energy can be inferred from the difference between weighted and non-weighted price: the higher the difference the higher the availability of water power.

50 The area of all 69 historical provinces is measured in square kilometers.

51 Distances from the centroid of each province to the nearest hydroelectric plant have been computed using QGIS.

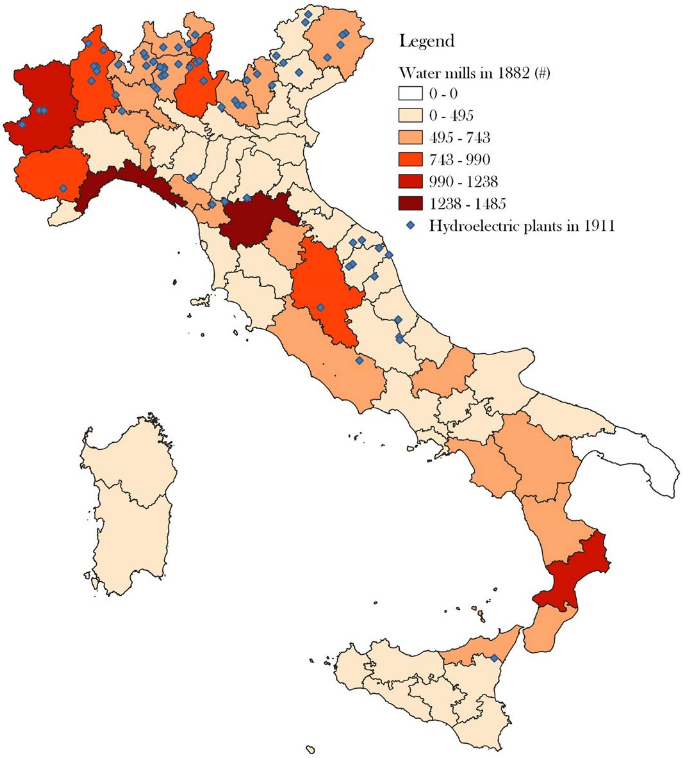

Fig. 9 Number of water mills in 1882 and hydroelectric pants in 1911. *Source*: Author's elaborations from MAIC (1889) information and GSE (Gestore Servizi Energetici) data. Shape file from Istat

in Table 2 which lists the two variables and the corresponding normalized indexes for all historical provinces and by area (North-East, North-West, Center, South, and Islands).

With more than 36 water mills per 100 km^2 and a normalized index of 1, Lucca, in Tuscany, was the province with the highest number of water mills. Lecce, in southern Italy, instead, was the province with the lowest number: there were no water mills in its territory. The macro area having more water mills per 100 km^2 was the North-West, with 15.66 water mills and the corresponding normalized index equal to 0.43. The Center followed with more than 14 water mills and an index of 0.40. In the insular provinces, instead, the density of water mills was of sole 6.23 water mills per 100 km^2.

When focusing on the distance to the nearest hydroelectric plant, the North-West again was the area closer to the centers of hydroelectricity production, with an average distance of 29.68 km and a normalized index of 0.07: this time having a normalized index close to 0 means a higher presence of water since the higher the distance the lower the availability of water power. Then comes the North-East, the Center,

Table 2 Number of water mills per 100 km^2 and distance to the nearest hydroelectric plant *Source*: Author's elaborations from MAIC (1889) information and GSE (Gestore Servizi Energetici) data

Province	Water mills		Hydroelectric plants		Province	Water mills		Hydroelectric plants	
	Number	Index	Distance	Index		Number	Index	Distance	Index
Torino	10.4780	0.2907	3.3866	0.0054	Pisa	15.4909	0.4297	73.4638	0.1690
Novara	11.7495	0.3260	3.1735	0.0049	Arezzo	18.1212	0.5027	88.0353	0.2030
Cuneo	10.8052	0.2998	26.2789	0.0589	Siena	9.5529	0.2650	99.9665	0.2308
Alessan-dria	8.6211	0.2392	58.9947	0.1352	Grosseto	4.2859	0.1189	98.9691	0.2285
Imperia	10.3918	0.2883	37.3990	0.0848	Perugia	9.0517	0.2511	25.0712	0.0560
Genova	32.3758	0.8982	92.2390	0.2128	Roma	4.5449	0.1261	45.5999	0.1039
Como	24.8548	0.6895	16.4478	0.0359	Caserta	7.5212	0.2087	94.5528	0.2182
Sondrio	15.8339	0.4393	15.4074	0.0335	Benevento	10.9989	0.3051	128.0495	0.2963
Milano	16.3627	0.4539	29.2127	0.0657	Napoli	7.8383	0.2174	155.0283	0.3593
Bergamo	20.0494	0.5562	9.1866	0.0190	Avellino	11.9368	0.3311	168.1378	0.3899
Brescia	16.0498	0.4452	7.5113	0.0151	Salerno	12.4746	0.3461	225.0666	0.5227
Pavia	15.4953	0.4299	33.6238	0.0760	L'Aquila	6.9602	0.1931	26.6839	0.0598
Cremona	16.7758	0.4654	57.0969	0.1308	Teramo	10.1313	0.2811	14.9776	0.0325
Mantova	9.4390	0.2619	25.5754	0.0572	Chieti	12.9228	0.3585	42.3438	0.0963
Verona	16.3797	0.4544	3.8226	0.0065	Cam-pobasso	11.8769	0.3295	82.9004	0.1910
Vicenza	19.8428	0.5505	13.8462	0.0299	Foggia	1.4436	0.0400	161.3744	0.3741
Belluno	12.6820	0.3518	23.4324	0.0522	Bari	0.0932	0.0026	268.7779	0.6247
Treviso	13.4285	0.3725	1.0524	0.0000	Lecce	0.0000	0.0000	359.0180	0.8352
Venezia	4.5696	0.1268	36.0901	0.0818	Potenza	5.6686	0.1573	264.5468	0.6148
Padova	11.4732	0.3183	32.2237	0.0727	Cosenza	10.3881	0.2882	213.8759	0.4966
Rovigo	14.8960	0.4132	70.9093	0.1630	Catanzaro	20.2200	0.5609	171.5840	0.3979
Udine	9.2224	0.2558	7.5791	0.0152	Reggio Calabria	17.9422	0.4977	89.0298	0.2053
Piacenza	17.3172	0.4804	62.4858	0.1433	Trapani	2.9103	0.0807	212.3043	0.4929
Parma	12.8319	0.3560	28.0502	0.0630	Palermo	7.7256	0.2143	134.7079	0.3119
Reggio Emilia	12.8757	0.3572	33.9361	0.0767	Messina	17.5746	0.4875	23.4454	0.0522
Modena	18.5754	0.5153	48.5553	0.1108	Agrigento	4.8812	0.1354	150.9824	0.3498
Bologna	10.7890	0.2993	35.2128	0.0797	Caltanis-setta	4.1347	0.1147	100.7939	0.2327
Ferrara	1.3580	0.0377	85.9218	0.1980	Catania	5.3142	0.1474	48.8061	0.1114
Ravenna	4.3482	0.1206	70.9884	0.1632	Siracusa	8.3512	0.2317	99.9996	0.2309
Forlì	11.6349	0.3228	88.7490	0.2046	Sassari	3.2857	0.0911	357.9436	0.8327
Pesaro Urbino	10.8742	0.3017	44.5087	0.1014	Cagliari	1.8633	0.0517	429.6287	1.0000
Ancona	10.3402	0.2869	6.0357	0.0116					
Macerata	8.2394	0.2286	15.2125	0.0330	*Macro area*				

Table 2 (continued)

Province	Water mills		Hydroelectric plants		Province	Water mills		Hydroelectric plants	
	Number	Index	Distance	Index		Number	Index	Distance	Index
Ascoli Piceno	8.6564	0.2401	11.9953	0.0255	North-East	12.01403	0.3333	40.17845	0.0913
Massa Carrara	31.5165	0.8743	21.3750	0.0474	North-West	15.66301	0.4345	29.68097	0.0668
Lucca	36.0469	1.0000	14.3761	0.0311	Center	14.39764	0.3994	49.92049	0.1140
Firenze	25.4092	0.7049	32.7241	0.0739	South	9.276038	0.2573	154.1217	0.3572
Livorno	9.4366	0.2618	121.5536	0.2812	Islands	6.226748	0.1727	173.1791	0.4016

Number in columns 2 and 7 refers to the number of water mills per 100 km^2 in 1882. *Index* in columns 3 and 8 is the corresponding normalized index: the higher the index the denser the water mills in the province. *Distance* in columns 4 and 9 refers to the distance in km to the nearest hydroelectric plant in 1911. *Index* in columns 5 and 10 is the corresponding normalized index: the higher the index the farther the hydroelectric plant

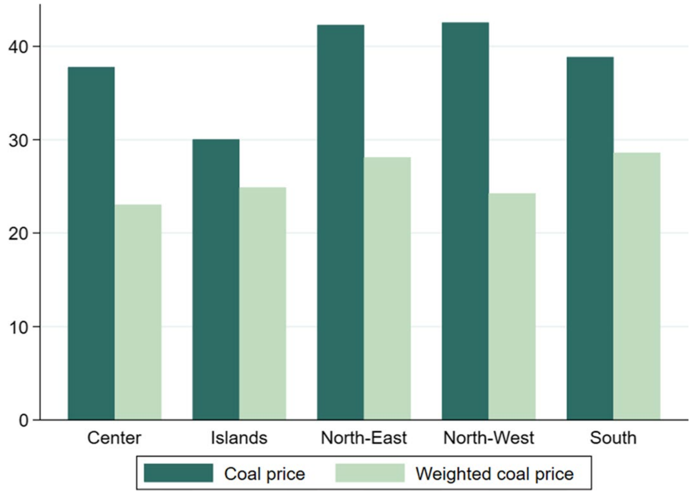

Fig. 10 Coal price and weighted coal price by water power access in 1882 (Italian *Lire* per ton): averages by area. *Source*: Author's elaborations. See text for sources

the South, and the Islands. Treviso being only 1 km far from a hydroelectric center is the province with the lowest index (0). Cagliari, on the island of Sardinia, instead, has an index of 1.

Both indexes are used to compute a weighted price of coal. Since 0 means no availability of mechanical water power and 1 the highest presence of water mills,

Fig. 11 Coal price and weighted coal price by water power access in 1911 (Italian *Lire* per ton): averages by area. *Source*: Author's elaborations. See text for sources

when using the index of the density of water mills, the price of coal is multiplied by 1 minus the index.[52] When using the index of the distance to the nearest hydroelectric plant, instead, the price of coal is directly multiplied by the index since 0 means being close to a hydroelectric center and, therefore, availability of water power, and 1 means being very far from a plant.[53] The results of this exercise are reported in Figs. 10 and 11.

Figure 10 shows the price of coal in 1882 and the corresponding price of coal weighted by the density of water mills. The North-West is the area that reports the largest difference between the non-weighted and the weighted price: 42.55 and 24.24 *Lire*, respectively. The price of coal weighted by water is 43% lower than the non-weighted one. Also for central provinces the artificial weighted price of coal deviates from the real one, confirming how the presence of water mills in the area was quite pervasive at the time. The lack of water in the islands and the South, instead, is proved by the reduced differences in terms of price. The price of coal weighted by water mills is closer to the non-weighted one: the former is 83% and 74% of the latter in the insular and southern territories, respectively.

Analogous results are those emerging from Fig. 11 that shows the coal price in 1911 and the corresponding coal price weighted by the proximity to hydroelectric plants. It is clear how for North-West and North-East areas the difference between the two prices is the largest: one ton of coal in 1911 costed on average 37 *Lire* in both areas,[54] while the weighted price, mimicking the highest availability of

[52] The formula is: weighted coal price$_p$ = coal price$_p$ * (1 – *Index mills*$_p$).

[53] The formula is: weighted coal price$_p$ = coal price$_p$ * (*Index plants*$_p$).

[54] 37.42 *Lire* in North-West and 37.44 *Lire* in North-East.

hydroelectricity, is 2.35 and 3.46 for North-West and North-East, respectively. In these terms, the weighted price is only 6% and 9% of the unweighted one. Also in the Center the artificial price differentiates from the original one: the weighted price is 88% lower than the non-weighted one, confirming the availability of hydroelectric sources. The Southern and insular provinces, instead, are those farther from hydroelectric plants and, therefore, with the smallest deviation in terms of weighted coal price. In these territories, the price of coal weighted by hydro energy availability is on average 38% of the unweighted price.

5 Concluding remarks

This paper has analyzed the construction of a new measure of coal price: the index covers a time-span of 51 years and is computed for all historical provinces existing in Italy between 1861 and 1911.

Coal was the main energy source of the time, the fuel to power steam engines, and the input factor for manufacturing production and industrial activity. Nevertheless, Italy was poor in coal and needed to import it from abroad. Its abundance and high quality made British coal the preferred one. And because of its mechanized ports and the availability of coal for the outward leg, the U.K. was the main Italian trade partner.

As an imported good, the price of coal was strictly driven by transport costs and fares. Shipping costs from the port of Cardiff determined the coal price in the different Italian ports. Inland transport costs and railways rates, instead, further increased the price in those provinces without a commercial port. The decrease in time of global and domestic transport costs balanced the coal price across provinces.

The price of coal at the NUTS3 level reflects, on the one hand, provinces' market access and their geographical advantage. Those provinces with better geography and a more extended transport infrastructure benefited from a lower price of coal. On the other hand, the measure allows to assess some of those imbalances that typically characterize the North–South gap, for instance, the extension of the railway network, providing estimates of these imbalances. The availability of water and the possibility to use hydro energy as a substitute of coal advantaged the northern territories. This issue has been further explored by computing an additional price of coal mimicking the Italian production of water power. In these terms, the research underlying this paper contributes to the debate on the origins of the regional divide between northern and southern Italy (Cafagna 1962, 1965; Zamagni 1987; Russo 1991; Daniele and Malanima 2011; Felice 2013) and on the importance of coal for Italian industrialization (Bardini 1997, 1998; Toninelli 1999, 2010; Malanima and Zamagni 2010; Bartoletto 2013).

Coal shortage involves a lively discussion that goes beyond the mere natural endowment issue. Referring to protectionism, for example, Gerschenkron (1962) argues how the lack of domestic coal should have directed state intervention toward non-coal-intensive productions, rather than in favor of iron and steel industries. However, the central role of firms and how the coal price weighed mostly on them is the issue that mainly links to the debate. The high price of coal in Italy was essentially a firm problem and firms' distance to the nearest port was the crucial variable that differentiated the price across them (Zamagni 1993). Also the well-known dualism between few modern big enterprises and many small firms originated from the need to save coal (Toninelli 1999). The lack of coal forced the Italian industry to a different innovation path from the British one (Bardini 1997) and the diffusion of small- and medium-sized enterprises producing medium high-tech products (Gomellini and Toniolo 2017). Firms invested more in labor-intensive productions and in electric-intensive activities rather than in coal-intensive ones, but, this relative specialization was not fruitful: electric power was a poor substitute of steam energy. The availability of water power, instead, positively affected the need for primary energy in manufacturing production (Bardini 1997). The measure of coal price constructed in this paper allows to better address all these issues and to investigate the regional disparities by using the index in territorial explorations and econometric estimations.

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References

Abrate M (1970) Il Comitato dell'Inchiesta Industriale a Torino (1872). Cronache Economiche 334:27–33

Adami L (1886) I Combustibili Fossili, i Materiali Refrattari e l'Industria Siderurgica all'Espo-sizione Nazionale di Torino nel 1884 con Dati Statistici, Descrittivi e Sperimentali circa le Produzioni in Italia. Roma: Comitato d'Artiglieria e Genio

A'Hearn B, Venables AJ (2013) Internal geography and external trade: regional disparities in Italy, 1861–2011. In: Toniolo G (ed) The Oxford handbook of the Italian economy since unification. Oxford University Press, New York

Allen RC (2001) The great divergence in European wages and prices from the middle ages to the first world. Explor Econ Hist 38(4):411–447
Allen RC (2011) Why the industrial revolution was British: commerce, induced invention, and the scientific revolution. Econ Hist Rev 64(2):357–384
Ashton TS (1948) The industrial revolution, 1760–1830. Oxford University Press, London
Baffigi A (2011) Italian National Accounts, 1861–2011, Banca d'Italia—economic history working papers no. 18
Baffigi A (2013) National accounts, 1861–2011. In: Toniolo G (ed) The Oxford handbook of the Italian economy since unification. Oxford University Press, New York
Bardini C (1997) Without coal in the age of steam: a factor-endowment explanation of the Italian industrial lag before world war I. J Econ Hist 57(3):633–653
Bardini C (1998) Senza Carbone nell'Età del Vapore. Gli Inizi dell'Industrializzazione Italiana. Milano: Mondadori
Bartoletto S (2004) Città e Ambiente - Dalla Legna al Carbon Fossile: i Consumi di Combustibile a Napoli nel corso dell'Ottocento. Mélanges de l'Ecole Française de Rome Italie et Méditerranée 116(2):705–721
Bartoletto S (2005) I Combustibili Fossili in Italia dal 1870 a Oggi. Storia Economica 2:281–327
Bartoletto S (2013) Fossil fuels consumption and economic growth in Italy in the last two centuries. RCC perspectives no. energy transitions in history: global cases of continuity and change, vol 2, pp 37–42
Basile R, Ciccarelli C (2018) The location of the Italian Manufacturing Industry, 1871–1911: a sectoral analysis. J Econ Geogr 18(3):627–661
Benincasa F (2015) Storia dell'Elettrificazione della Sardegna. IBIMET-CNR, Firenze
Bogart D (2013) The transport revolution in industrializing Britain: a survey, WP 121306. University of California-Irvine, Department of Economics
Bonelli F (1978) Il Capitalismo Italiano. Linee Generali di Interpretazione. In: Ruggero R, Vivanti C (eds) Storia d'Italia. Annali 1. Dal Feudalesimo al Capitalismo, Torino: Einaudi
Braudel F (1982) The structures of everyday life: civilization and capitalism, 15th–18th century, vol 1. HarperCollins, New York
Cafagna L (1962) Premessa. In: Cafagna L (ed) Il Nord nella Storia d'Italia. Laterza, Bari
Cafagna L (1965) Intorno alle Origini del Dualismo Economico in Italia. In: Caracciolo A (ed) Problemi Storici dell'Industrializzazione e dello Sviluppo. Argalia, Urbino
Cafagna L (1972) The industrial revolution in Italy 1830–1914. In: Cipolla CM (ed) The Fontana economic history of Europe, vol IV. Glasgow, Collins-Fontana
Cafagna L (1989) Dualismo e Sviluppo nella Storia d'Italia. Marsilio, Venezia
Cafagna L (1999) Contro Tre Pregiudizi sulla Storia dello Sviluppo Economico Italiano. In: Ciocca P, Toniolo G (eds) Storia Economica d'Italia, Vol. 1: Interpretazioni. Roma-Bari: Laterza
Carrino A, Salvemini B (2006) Porti di Campagna, Porti di Città. Traffici e Insediamenti del Regno di Napoli visti da Marsiglia (1710–1846). Quad Stor 121:209–254
Church R (1986) The history of the British coal industry, vol 3, 1830–1913. Victorian Pre-eminence, Clarendon Press, Oxford
Cianci E (1933) Dinamica dei Prezzi delle Merci in Italia dal 1870 al 1929. Istituto Centrale di Statistica, Annali di Statistica, Serie VI, vol 20. Istituto Poligrafico dello Stato, Roma
Ciccarelli C, Fenoaltea S (2013) Through the magnifying glass: provincial aspects of industrial growth in post-unification Italy. Econ Hist Rev 66(1):57–85
Ciccarelli C, Groote PD (2017) Railway endowment in Italy's provinces, 1839–1913. Rivista di Storia Economica 33(1):45–88
Cipolla CM (1962) The economic history of world population. Penguin Books, Baltimore
Clark G, Jacks D (2007) Coal and the industrial revolution, 1700–1869. Eur Rev Econ Hist 11(1):39–72
Corbino E (1922) Il Porto di Genova. Giornale degli Economisti e Rivista di Statistica 63(9):397–460
Corbino E (1923a) I Porti dall'Elba a Napoli. Giornale degli Economisti e Rivista di Statistica 64(3):105–134
Corbino E (1923b) I Porti dell'Italia Meridionale. Giornale degli Economisti e Rivista di Statistica 64(7):345–370
Corbino E (1923c) I Porti di Porto Maurizio-Oneglia, Savona, Spezia e Livorno. Giornale degli Economisti e Rivista di Statistica 64(1):20–45

Corbino E (1924a) I Porti della Sicilia. Giornale degli Economisti e Rivista di Statistica 65(3):160–187
Corbino E (1924b) I Porti di Trieste e Fiume. I Porti della Sardegna. Giornale degli Economisti e Rivista di Statistica 65(6):334–361
Cosci S, Mirra L (2018) A spatial analysis of growth and convergence in Italian provinces: the role of road infrastructure. Reg Stud 52(4):516–527
Crafts NFR (1985) British economic growth during the industrial revolution. Oxford University Press, New York
Crafts NFR, Harley CK (1992) Output growth and the industrial revolution: a restatement of the crafts-Harley view. Econ Hist Rev 45(4):703–730
Crafts NFR, Mulatu A (2006) How did the location of industry respond to falling transport costs in Britain before world war I? J Econ Hist 66(3):575–607
Crafts NFR, Wolf N (2014) The location of the UK cotton textiles industry in 1838: a quantitative analysis. J Econ Hist 74(4):1103–1139
Daniele V, Malanima P (2011) Il Divario Nord-Sud in Italia 1861–2011. Rubbettino, Soveria Mannelli
De Benedictis L, Licio V, Pinna AM (2021) From the historical roman road network to modern infrastructure in Italy, CRENoS WP 2021/02
Deane P (1965) The first industrial revolution. Cambridge University Press, Cambridge
Deffenu A (1976) Sardegna, la Rivista di Attilio Deffenu, edited by M. Gallizzi, Brigaglia, Sassari
Department of Statistics India (1922) Report of the production and consumption of coal in India 1920. Superintendent Government Printing, Calcutta
Farnie D (1979) The English cotton industry and the world market, 1815–1896. Clarendon Press, Oxford
Federico G (2007) Market integration and market efficiency: the case of 19th century Italy. Explor Econ Hist 44(2):293–316
Federico G, Tattara G, Vasta M (2011) Bankit-FTV database. In: Federico G, Natoli S, Tattara G, Vasta M (eds) Il Commercio Estero Italiano: 1862–1950, Collana Storica della Banca d'Italia, Statistiche storiche, IV. Laterza, Rome-Bari
Federico G, Nuvolari A, Vasta M (2019) The origins of the Italian regional divide: evidence from Real Wages, 1861–1913. J Econ Hist 79(1):63–98
Felice E (2013) Perché il Sud è Rimasto Indietro? Il Mulino, Bologna
Felloni G (1957) I prezzi sul Mercato di Genova dal 1815 al 1890. In: Archivio Economico dell'Unificazione italiana. ILTE, Roma
Fenoaltea S (1988) International resource flows and construction movements in the Atlantic economy: the Kuznets Cycle in Italy, 1861–1913. J Econ Hist 48(3):605–637
Fenoaltea S (2006) L'Economia Italiana dall'Unità alla Grande Guerra. Laterza, Rome-Bari
Fenoaltea S (2014) The reinterpretation of Italian economic history. Cambridge University Press, From Unification To The Great War, Cambridge
Fernihough A, O'Rourke KH (2021) Coal and the European industrial revolution. Econ J 131(635):1135–1149
Ferrovie dello Stato (1912) Tariffe e Condizioni pei Trasporti sulle Ferrovie dello Stato. Tipografia Editrice Nazionale, Roma
Fremdling R (1996) Anglo-German rivalry on coal markets in France, the Netherlands and Germany, 1850–1913. J Eur Econ Hist 25(3):599–646
Galor O (2011) Unified growth theory. Princeton University Press, Princeton
Garzella R, Giulianelli G, Petralia G, Vaccari O (2013) Paesaggi e Proiezione Marittima. I Sistemi Adriatico e Tirreno nel Lungo Periodo. Marche e Toscana a Confronto, Centro di Studi Storici Mediterranei, Pisa: Pacini Editore
Gerschenkron A (1962) Economic backwardness in historical perspective: a book of essays. Belknap Press of Harvard University Press, Cambridge
Gomellini A, Toniolo G (2017) The industrialization of Italy, 1861–1971. In: O'Rourke KH, Williamson JG (eds) The spread of modern industry to the periphery since 1871. Oxford Scholarship Online
Gutberlet T (2014) Mechanization and the spatial distribution of industries in the German empire, 1875 to 1907. Econ Hist Rev 67(2):463–491
Hanlon WW (2020) Coal smoke, city growth, and the costs of the industrial revolution. Econ J 130(626):462–488
Harley CK (1989) Coal exports and British shipping, 1850–1913. Explor Econ Hist 26(3):311–338
House of commons, Great Britain (1913) Coal tables. British parliamentary papers, 285, London: Her Majesty's Stationery Office

House of commons, Great Britain (1925) Coal tables. British parliamentary papers, 168, London: Her Majesty's Stationery Office
Istituto Centrale di Statistica del Regno di Italia (1910) Foglio di Supplemento alla Gazzetta Ufficiale, N. 221 del 23 settembre 1910, Tabelle Esplicative Annesse al Decreto N. 211 Pubblicato nella Gazzetta Ufficiale del 24 maggio 1910 N. 121, Roma: Istituto Poligrafico dello Stato
Istituto Centrale di Statistica del Regno di Italia (1935) Supplemento Ordinario alla Gazzetta Ufficiale del Regno d'Italia. Bollettino Mensile di Statistica, N. 44 del 21 febbraio 1935, Roma: Istituto Poligrafico dello Stato
Jevons WS (1865) The coal question. An inquiry concerning the progress of the nation, and the probable exhaustion of our coal-mines, Macmillan, London
Kander A, Stern DI (2014) Economic growth and the transition from traditional to modern energy in Sweden. Energy Econ 46:56–65
Kander A, Malanima P, Warde P (2013) Power to the people: energy and economic transformation of Europe over four centuries. Princeton University Press, Princeton
Kirkaldy AW (1914) British shipping. Kegan Paul, Trench, Trubner &Co, Its History, Organisation and Importance, London
Landes DS (1966) The rise of capitalism. Macmillan, New York
Malanima P (2006) Energy consumption in Italy in the 19th and 20th centuries. A statistical outline, CNR Edizioni
Malanima P, Zamagni V (2010) 150 Years of the Italian economy, 1861–2010. J Mod Ital Stud 15(1):1–20
Matheis M (2016) Local economic impacts of coal mining in the United States 1870 to 1970. J Econ Hist 76(4):1152–1181
McCloskey DN (1981) The industrial revolution, 1780–1860: a survey. In: Floud R, McCloskey D (eds) The economic history of Britain since 1700. Cambridge University Press, Cambridge
McCloskey DN (2010) Bourgeois dignity: why economics can't explain the modern world. University of Chicago Press, Chicago
McCormick M, Huang G, Zambotti G, Lavash J (2013) Roman Road Network (version 2008), DARMC scholarly data series, data contribution series 2013-5
Ministero di Agricoltura, Industria e Commercio (1881) Bollettino Settimanale dei Prezzi di Alcuni dei Principali Prodotti Agrari e del Pane, N. 1, Roma: MAIC
Ministero di Agricoltura, Industria e Commercio (1889) Annali di Statistica. Statistica Industriale. Industria della Macinazione dei Cereali, Fascicolo XIX, Roma: MAIC
Ministero di Agricoltura, Industria e Commercio (1914) Censimento degli Opifici e delle Imprese Industriali al 10 giugno 1911. MAIC, Roma
Ministero per gli Affari Esteri (1869) Bollettino Consolare, vol V. MAE, Fascicolo I, Roma
Ministero per gli Affari Esteri (1883) Bollettino Consolare, vol XIX. MAE, Fascicolo I, Roma
Missiaia A (2016) Where do we go from here? Market access and regional development in Italy (1871–1911). Eur Rev Econ Hist 20(2):215–241
Missiaia A (2019) Market versus endowment: explaining early industrial location in Italy (1871–1911). Cliometrica 13:127–161
Mokyr J (1976) Industrialization in the low countries, 1795–1850. Yale University Press, New Haven
Mokyr J (1990) The lever of riches. Oxford University Press, Oxford
Mokyr J (2009) The enlightened economy: an economic history of Britain, 1700–1850. Yale University Press, New Haven
Noyes W (1905) American railroad rates. Little, Brown and Company, New York
Office of Naval Intelligence (1900) Coaling, docking and repairing facilities of the ports of the world, with analyses of different kinds of coal. U.S. Government Printing Office, Washington
Office of Naval Intelligence (1909) Coaling, docking and repairing facilities of the ports of the world, with analyses of different kinds of coal. U.S. Government Printing Office, Washington
Pollard S (1981) Peaceful conquest: the industrialization of Europe, 1760–1970. Oxford University Presse, Oxford
Pomeranz K (2000) The great divergence: China. Princeton University Press, Europe and the Making of the Modern World Economy, Princeton
Rodgers HB (1960) The Lancashire cotton industry in 1840. Trans Pap (Inst Br Geogr) 28:135–153
Romeo R (1959) Risorgimento e Capitalismo. Laterza, Roma-Bari
Russo S (1991) La Storiografia sul Mezzogiorno nell'Ultimo Quarantennio. In: Cassina C (ed) La Storiografia sull'Italia Contemporanea. Giardina, Pisa

Sella Q (1871) Sulle Condizioni dell'Industria Mineraria nell'Isola di Sardegna. Relazione alla Commissione Parlamentare d'Inchiesta, edited by F. Manconi, Ilisso Edizioni (1999)

Spinelli F, Toso L (1989) Il Tasso di Cambio Settimanale a Breve della Lira nelle Rilevazioni de Il Sole 24 Ore: 1865–1985. In: Spinelli F (ed) Per la Storia Monetaria dell'Italia, vol II. Giappichelli Editore, Torino

Toninelli PA (1999) La Questione Energetica. In: Storia d'Italia. Annali Vol.15: L'Industria, edited by F. Amatori, D. Bigazzi, R. Giannetti and L. Segreto, Torino: Einaudi

Toninelli PA (2008) Energy supply and economic development in Italy: the role of the state-owned companies, WP 2008/146. University of Milan-Bicocca, Department of Economics

Toninelli PA (2010) Energy and the puzzle of Italy's economic growth. J Mod Ital Stud 15(1):107–127

Vazza G, De Petris N, Versetti P, Fornaci T, Agnati A (1965) Il Movimento dei Prezzi in Genova dal 1845 al 1905. Giornale degli Economisti e Annali di Economia 9(10):886–920

Walters R (1975) The economic and business history of the south wales steam coal industry, 1840–1914, PhD thesis, University of Oxford

Wegerich A (2017) Digging deeper: global coal prices and industrial growth, 1840–1960, PhD thesis, University of Oxford

Wilkinson RG (1973) Poverty and progress: an ecological model of economic development. Methuen, London

Wright G (1990) The origins of American industrial success, 1879–1940. Am Econ Rev 80(4):651–668

Wrigley EA (1988) Continuity, chance and change. The character of the industrial revolution in England, Cambridge University Press, Cambridge

Wrigley EA (2010) Energy and the English industrial revolution. Cambridge University Press, Cambridge

Zamagni V (1987) Cuestion Meridional o Cuestion Nacional? Algunas Consideraciones Sobre el Desequilibrio Regional en Italia con Special Referencia a los Años 1861–1950. Revista de Historia economica 1:11–29

Zamagni V (1993) The economic history of Italy 1860–1990. Oxford University Press, New York