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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 where the steam engine powered factory work. The new variable accounts for the main input factor of the 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 infrastructural scarcity and the uneven water endowment, that still today rule the differences between northern and southern Italy, were responsible for the different weight the price of coal had across the country.

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Keywords: Coal; Italy; Provinces; Railways; Infrastructure; Transport costs.

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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 18^{th} 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 many economic historians,[1] 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 the 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). 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. On the other hand, 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, according to Bardini (1997), was the absence of fossil coal in a time when the steam engine was the main technology of the time. According to Allen (2001, 2009), the first British industrial revolution during the second half of the 18^{th} 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

[1] Bardini (1997, 1998), Toninelli (1999, 2010), Malanima and Zamagni (2010), Bartoletto (2013).

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.

This paper contributes to the debate and provides a measure of coal price for the Italian territory at the NUTS3 level. This represents a novelty in the economic history literature: Cianci (1933) provides the price of imported coal in Genoa from 1870 to 1929; more recently, Federico, Tattara and Vasta (2011) presented more detailed data for the period 1862-1921.[2] 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.

The analysis 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 the Italian industrialization and the origin of the North-South divergence represents a pivotal question in the controversial debate about Italy's economic growth. 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 19^{th} 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-size enterprises originates - besides other things - from the need to use more efficiently 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). The measure of coal price constructed in this research involves these disparities. It accounts for the transport infrastructure and the freight charges of the time, shading light on the important role railways had during the second half of the 19^{th} century and on the North-South disparities in terms of infrastructural endowment. On the other hand, an index

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

that varies within country is able also to highlight the geographical differences that typically affect the Italian territory: superior access to the sea in central and southern provinces thanks to the several ports, but a greater connection with foreign trade partners in the North, with the South representing the European periphery. As highlighted by Bartoletto (2004), the transition from an economy based on wood to one based on fossil energy carriers enlarged the provision geography and led to huge import flows, making urban centers dissipate systems characterized by entropy. Moreover, the northern part of the country benefited from an important energy substitute: the availability of water sources for the production of mechanical energy and hydroelectric power.

The historical North-South differences in terms of transport infrastructure endowment and water availability is still a matter nowadays. Ciccarelli and Fenoaltea (2013) argue that the development of railways before and after the Italian unification failed in creating a homogeneous internal economy. The construction of motorways during the 20^{th} century resulted in a dichotomous territory: a developed North-Center and a backward South (Cosci and Mirra, 2018). On the other hand, as observed by A'Hearn and Venables (2013), the proximity of rivers and watercourses gave to northern Italy an additional advantage. These infrastructural and natural resource imbalances persist today. The last part of this paper examines these issues.

Four sections follow. Section 2 discusses the peculiar situation faced by Italy during the 19^{th} century: the need for coal in a territory lacking domestic coal resources. In Section 3 the construction of a new measure of coal price at the NUTS3 level is presented. Section 4 analyzes two important issues linked with the price of an imported factor: the existence of extended transport infrastructure and the availability of an input 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.[3] 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

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

29% of the total industrial consumption (Malanima, 2006).[4]

Coal consumption growth combined with the decreasing availability of traditional sources. As stated by Adami (1886), during the 19^{th} 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. On the other hand, 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.[5] This is shown in Figure 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.[6] The need of importing coal was then a clear consequence of not sufficient domestic resources.

[Figure 1]

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 costly 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.[7]

Import flows increased during the first decades of the 19^{th} century. As stated by Malanima (2006) the reduction of sea transport costs increased coal 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 in Italy was addressed to Genoa also in the following years. Since the large coal shipments arriving in Genoa, the port was organized

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

[5] 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.

[6] Malanima (2006).

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

in two areas: one specific for coal and the second assigned to all other commodities (Corbino, 1922).

The coal urgency 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.

[Figure 2]

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 since the high price of coal paid in Italy once arrived in Genoa and in the other ports.

Italian import ports distinguished 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 the 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 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 Genoa was 40 *Lire*,[8] the cost of transporting coal from Genoa to Turin was 15 *Lire* per ton.[9] The railway transport cost was also subjected 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 tariffs that weighed on coal final price. A further constraint was represented by the unavailability in many provinces of railway lines. Railways expanded over time and in 1881 the kilometers of railways were three and a half times those after Unification. By 1886 the main city center in all provinces was reachable by railways.[10] 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.

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). More recently, Federico, Tattara, Vasta (2011) produced a more reliable estimate. Both contributions provide a country-level indicator: the price of coal at the port of Genoa. This paper makes a step forward estimating a measure at the NUTS 3 level, allowing differences across provinces.

The new measure of coal price has been constructed for all historical Italian provinces for

[8] Source: Federico, Tattara and Vasta (2011).

[9] Indeed, according to different sources, British coal was considered of the best quality compared to the French one.

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

the period 1861-1911.[11] 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.[12]

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.[13] Indeed, as listed in Bollettino Consolare (1883), coal was imported in 26 main Italian ports, as shown previously in Figure 2. Many of these ports belong to the same province; coal was then imported to 17 provinces.[14] However, according to Corbino (1923b; 1923c; 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.

The coal shipping tariff (in Italian *noli del carbone*) is 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.

[11] The price of coal refers to the one imported from Cardiff. 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.

[12] According to the decennial census, Italy counted 59 provinces from 1861 to 1870, and 69 starting from 1871 (Source: Istat). In 1866 territories of north-eastern Italy were annexed to Italy pushing the number of provinces to 68. In 1870, after the annexation of the Papal State, Rome became the 69^{th} province.

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

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

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 tariff 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.[15] For these ports it has been assumed the same transport costs of the nearest port:[16] for Reggio Calabria the same transport cost of Messina, for example.[17] A further assumption regarded the port of Gaeta, at that time included in the province of Caserta.[18] 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 tariffs in all ports vary across years in the same proportion as Genoa coal transport cost does. To express the measure in Italian *Lire*, the exchange rate between the Italian currency and the British one from Spinelli and Toso (1990) has been used. The estimates are presented in Figure 3.

[Figure 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

[15] The bulletin provides the coal transport cost for 11 ports and 9 provinces: Ancona, Brindisi, Cagliari, Genoa, La Spezia, Livorno, Messina, Naples, Palermo, Savona, Venice. Savona and La Spezia belongs 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).

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

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

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

1883 to 1913[19] 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, Tattara, Vasta (2011) about Genoa coal price. Shipping coal tariffs in Genoa from Harley (1989) and transformed above in Italian *Lire* have been subtracted from the Genoa coal price by Federico, Tattara, Vasta (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 Figure 4.

[Figure 4]

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[20] have been used to identify the import port for all 43 (until 1870) and 52 (from 1871 onward) provinces not endowed with a port.[21] In these provinces coal arrived *via* railways or transported through ox- or horse-drawn carts if railway lines were not

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

[20] Corbino (1922; 1923a; 1923b; 1923c; 1924a; 1924b), Bardini (1998), Gazzetta Ufficiale (1935), MAIC (1881), Bartoletto (2004), Deffenu (1914), Garzella *et al.* (2013). When no reference was found, the nearest port rule has been applied: goods were distributed in the province from the nearest import port.

[21] 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.

available. Because of distribution costs, a higher price needed to be paid to use coal in these territories. Therefore, the price of coal in the provinces without a port was equal to the price of coal in the import port plus inland transport costs.

Inland transport costs are determined by the distance from the import port weighted by the tariff 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 19^{th} 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.[22] 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.[23] When no traced roads were available, straight-line distances have been computed.[24] 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 tariffs. 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 tariffs and the terminal component for each transported ton are reported for a wide list of goods - including fossil coal.[25] The information is

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

[23] According to historical sources, during the 19^{th} century, the Italian road network consisted of approximately 3,000 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 19^{th} 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).

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

[25] Ferrovie dello Stato (1912) provides the fixed cost for transporting each ton of fossil coal and the variable

provided for the year 1911. Following the same approach of Missiaia (2016), to project back in time variable and fixed railway tariffs, 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 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 tariffs). Elaborations - presented in Table 1 - are consistent with those by Missiaia (2016) - who estimates average fares for both wheat and coal - with some differences in the variable tariffs due to the inclusion of the sole fossil coal in the present paper's computations.

[Figure 5]

[Table 1]

The tariff for transporting coal by road 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 19^{th} century.[26]

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:

$$coal\ price_{t,p} = coal\ price\ import\ port_{t,p} + (distance_1\ from\ port_{t,p} * km_1\ cost_{t,p}) + terminal_1\ cost_{t,p} + (distance_2\ mid\ point_{t,p} * km_2\ cost_{t,p}) + terminal_2\ cost_{t,p}$$

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; >1,000 *km*.

[26] The fare is consistent with those existing in other countries. Bogart (2013) reports that, during the 19^{th} century, the tariff 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.

The estimated coal prices for provinces with and without a port are presented in Figure 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), for Italy and reported 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 the 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 for fossil fuel.

[Figure 6]

As an imported good, coal price differentials across provinces are affected by the endowment of transport infrastructure - together with market access - and the geographic advantage. These points are discussed in following Section 4.

4 Transport infrastructure and geographic advantage

The coal shortage and the need to provide all the country with the scarce fossil fuel highlight two important issues that still today typify the Italian territory and the difference between North and South: the transport infrastructure endowment and the availability of water sources.

4.1 Transport infrastructure

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.[27] The measurement of coal price

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

can be used as an exercise to answer two different questions: i) What would the price of coal be if we take into account the modern infrastructure? ii) What would the price of coal be if we consider a larger number of provinces?

If in the past railways were the preferred mode of transport to distribute goods across each country, today three-fourth of the European freight transport is performed by truck; in Italy, road transport represents approximately 88% of total freight distribution.[28] Starting from this evidence, but taking into account modern railways[29] and computing the price of coal for all 69 provinces, it emerges that there are not so significant differences between the coal price computed using the transport infrastructure of 1911 and the coal price computed using modern railways.[30] The reason is quite straightforward: in 1911 (last year of the period under scrutiny) all main urban centers were already linked by the railway network. During the 20^{th} century the network has been extended and improved in terms of tracks, speed, trains and locomotives. A larger number of city centers and minor towns have been connected to the network and this has improved the market access of territories that in the past had an unfavorable location. In these terms, if the infrastructural distance is a good indicator for the access to the domestic market in the past, in modern times, instead, the number of tracks, speed, and frequency of trains are more relevant in measuring the connection of the main economic centers. This issue applies less when motorways are considered nowadays. Although almost all main urban centers of the 69 old provinces are linked to their import port by the motorway infrastructure, there are some dissimilarities between North and South. In the North out of 30 provinces, only the province of Sondrio is not connected *via* motorways. In central Italy out of 14, there are 3 provinces not linked by motorways.[31] In the South, instead, the motorway infrastructure does not link the city center of 7 provinces out of 25.[32] The exercise suggests how infrastructural differences have been fundamental in the past in making the coal price higher and lower and in determining dissimilarities between North and South: in Section 3 it emerged how southern provinces, although greater access to the sea, experienced a reduction in the coal price only when railways have been developed. Nowadays, other factors also matter, but differences across

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

[29] The shapefile of modern railways has been sourced from Diva-GIS.

[30] Computations are provided upon request.

[31] Grosseto, Siena, Macerata.

[32] Campobasso, Potenza, Lecce, Catanzaro, Agrigento, Cagliari, Sassari.

northern and southern provinces persist.

The non-significant differences between old and new infrastructure, but the enduring polarization between the North and the South can be better explored if a wider number of provinces is taken into account. On the one hand, the South is characterized by a larger number of ports. On the other, the North has a longer extension of transport infrastructure. The inclusion of a higher number of provinces allows to get rid of the positive geography (greater access to the sea) and to account for the negative geography (mountains) - and therefore a reduced infrastructure endowment. Indeed, the NUTS3 organization in Italy for the period under scrutiny reveals an uneven decomposition of the territory: a higher number of provinces in the North with a smaller surface area compared to the provinces in the Center and the South. To account for a more homogeneous breakdown of the territory, the price of coal is computed using all railway lines present in 1911 but considering the 108 out of the 110 NUTS3 provinces that characterized the Italian administration between 2010 and 2016: the territory of the provinces of Trento and Bolzano in 1911 was not part of Italy.[33] Figure 7 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 by modern provinces is 3.4% higher. The North-East and the South report a higher coal price of 2.3% and 1.5%, respectively. There are no differences for the northwestern provinces, instead.

[Figure 7]

By increasing the number of provinces under scrutiny, it emerges a polarization between the North-West, on the one side, and the rest of the peninsula, on the other side, with islands experiencing the most disadvantaged condition.

4.2 Water sources endowment

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

[33] From 2017 Italy is organized in 107 NUTS3 provinces.

regional disparities and the backwardness of the South can be found in the different geography of the two areas. 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 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.[34]

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. This can be proxied by the number of water mills and hydroelectric plants existing in each province. 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 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 and wind 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

[34] Source: Enel.

changed. Starting from the last decade of the 19^{th} 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 hydroelectricty in Italy began in 1887 and during the beginning of the 20^{th} 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) that provides details about the location (municipality) and the opening year of hydroelectric plants.[35] Figure 8 shows the distribution across the peninsula of both types of water plants.

[Figure 8]

Intuitively, it is easier to define the weight by inverting the number of mills and plants and attributing 1 to the provinces that do not have water energy sources: in these terms, in those provinces, the price of coal weighted by water availability is equal to the simple coal price.[36] Computations are presented in Figure 9. Three facts clearly emerge. First, a huge difference between the effect of the coal price in the South compared to other areas. Second, the South stands out for being the area in which the cost of coal weighs the most and faces the highest cost of the natural disparity. Third, the geographical advantage of the North. The latter is evident by comparing Figure 9 with Figure 6: the North-West and the North-East report a relatively high price of coal when water energy is not accounted for. The absence of water sources in Sicily and Sardinia, instead, does not exacerbate the insular condition and the lack of transport infrastructure: both islands take advantage of having many ports that keep the price of coal low.

[Figure 9]

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

[36] Weighted coal price$_p$ =coal price$_p$ * $\frac{1}{n.mills+n.plants}$

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 tariffs. Shipping costs from the port of Cardiff determined the coal price in the different Italian ports. Inland transport costs and railways tariffs, 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 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, by weighting the measure by the availability of water power allows to account for substitutes and how much the price weighs on the province. This highlights how historical differences between northern and southern territories persist today.

To conclude, the research underlying this paper contributes to the debate on the origins of the regional divide between northern and southern Italy (Cafagna, 1962; 1971; Zamagni, 1987; Russo, 1991; Daniele and Malanima, 2011; Felice, 2013;) and on the importance of coal for the 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 diffrentiated 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). 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 the manufacturing production (Bardini, 1997). The measure of coal price constructed in this paper allows to better address all these issues and to investigate on the regional disparities by using the index in territorial explorations and econometric estimations.

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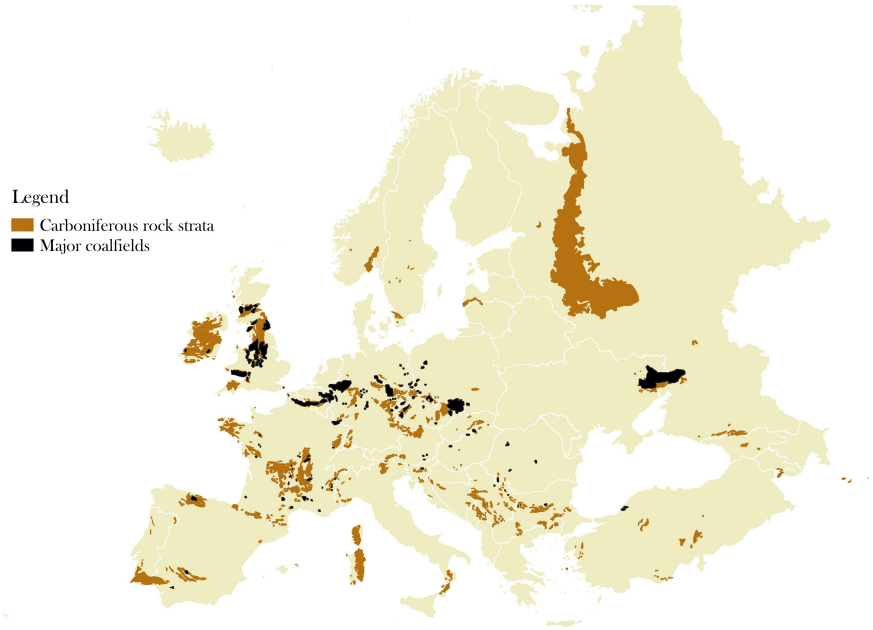
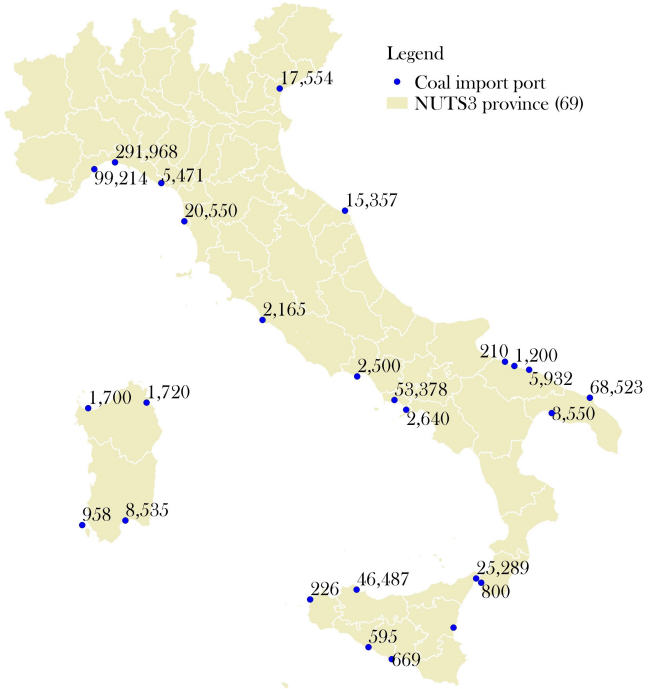
Figures and tables

Figure 1: Carboniferous rocks and major coalfields in 1931 in Europe



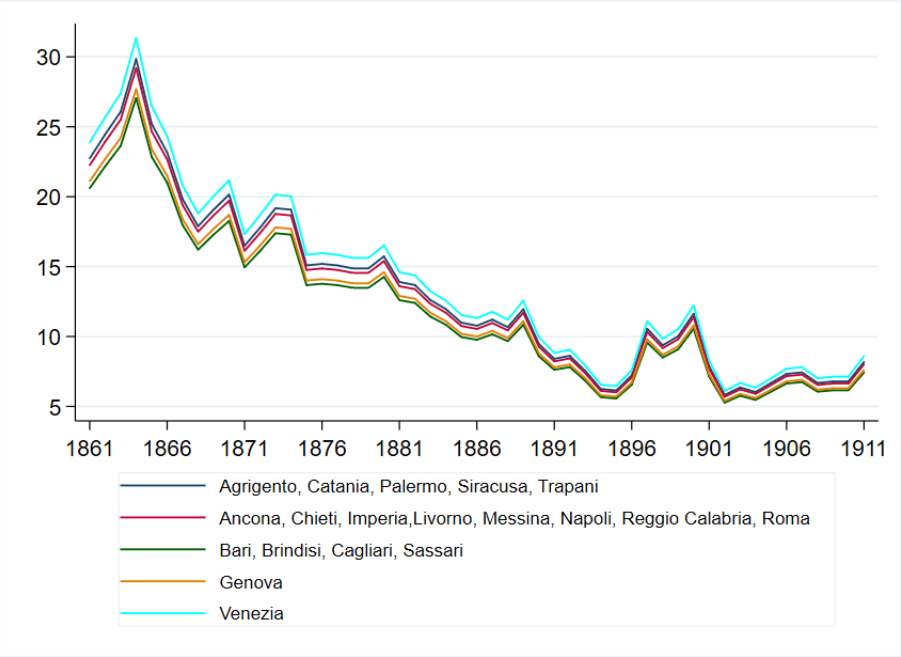
Source: Author's elaborations from Fernihough and O'Rourke (2020) data. Shape file from Carlos Efraín Porto Tapiquén, Orogénesis Soluciones Geográficas (2015)

Figure 2: Coal import ports and imported quantity (tons) in 1882



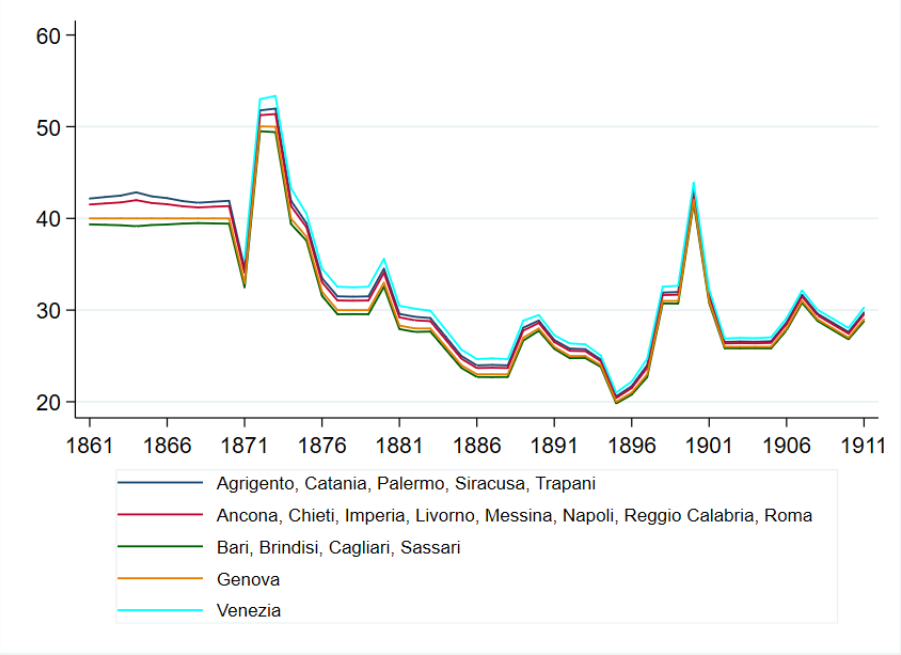
Source: Author's elaborations from Bollettino Consolare (1883) information. Shape file from Istat

Figure 3: Coal shipping transport costs in Italian *Lire*



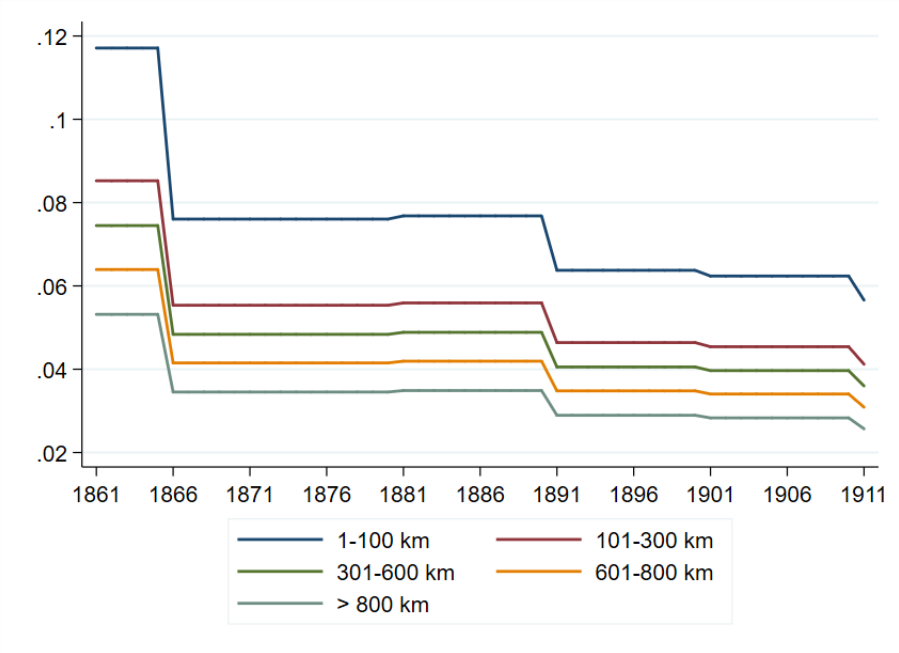
Source: Author's elaborations from Bollettino Consolare (1883) information, Harley (1989), and Spinelli and Toso (1990) data

Figure 4: Coal price in Italian *Lire* in the import ports



Source: Author's elaborations from Bollettino Consolare (1883) information and from Federico, Tattara, Vasta (2011), Harley (1989), and Spinelli and Toso (1990) data

Figure 5: Variable railways tariffs in Italian *Lire* for fossil coal transport



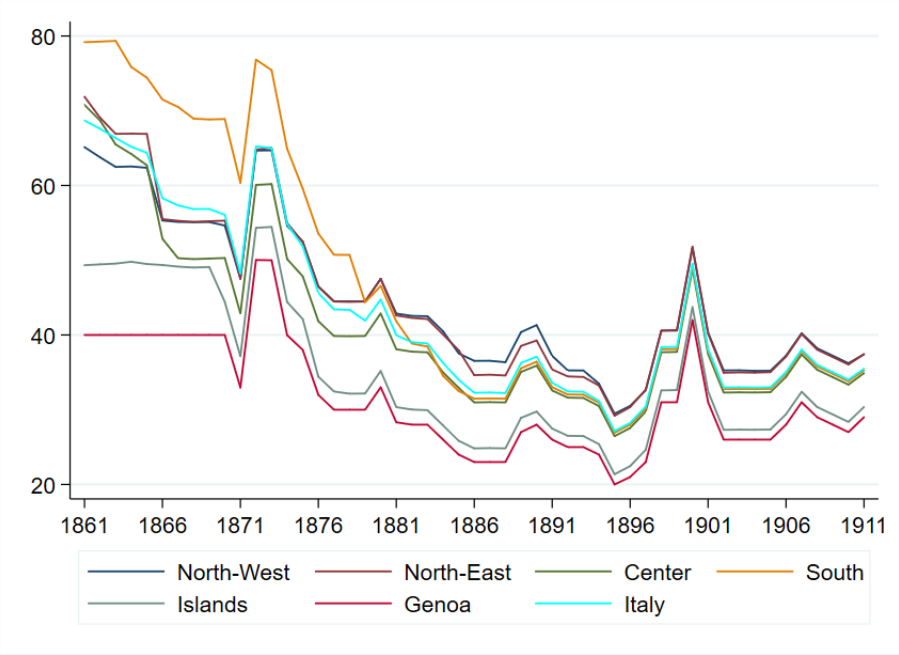
Source: Author's elaborations from Ferrovie dello Stato (1912) and Noyes (1905) data, according to the methodology of Missiaia (2016)

Table 1: Fixed and variable railways tariffs in Italian *Lire* for fossil coal transport

	Years						
	1861-1865	1866-1870	1871-1880	1881-1890	1891-1900	1901-1910	1911
Tariff							
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
901-1,000 *km*	0.0532	0.0345	0.0345	0.0349	0.0289	0.0283	0.0257
$>$ 1,000 *km*	0.0532	0.0345	0.0345	0.0349	0.0289	0.0283	0.0257

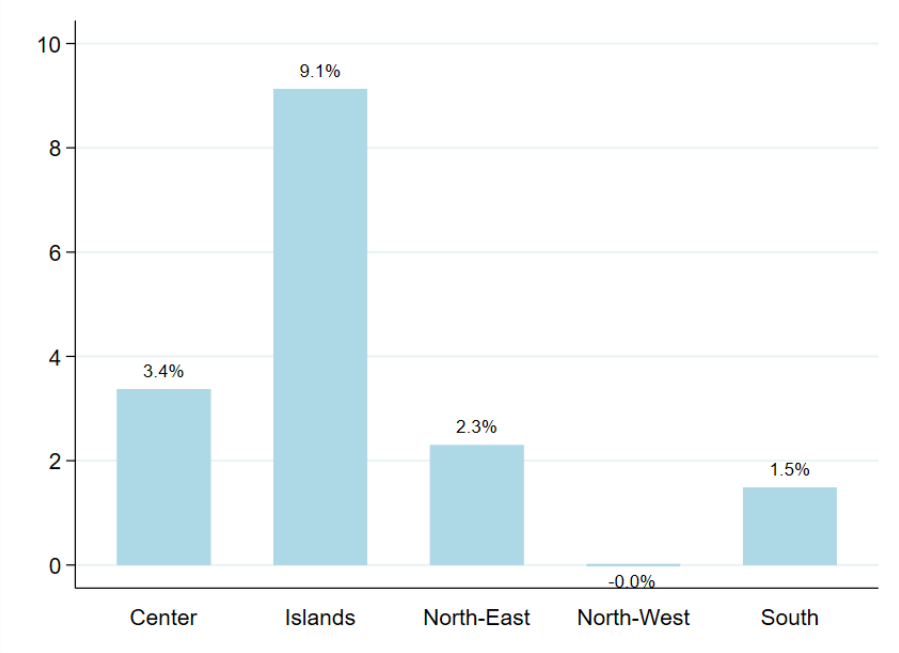
Source: Author's elaborations from Ferrovie dello Stato (1912) and Noyes (1905) data, according to the methodology of Missiaia (2016)

Figure 6: Coal price in Italian *Lire*: averages by area



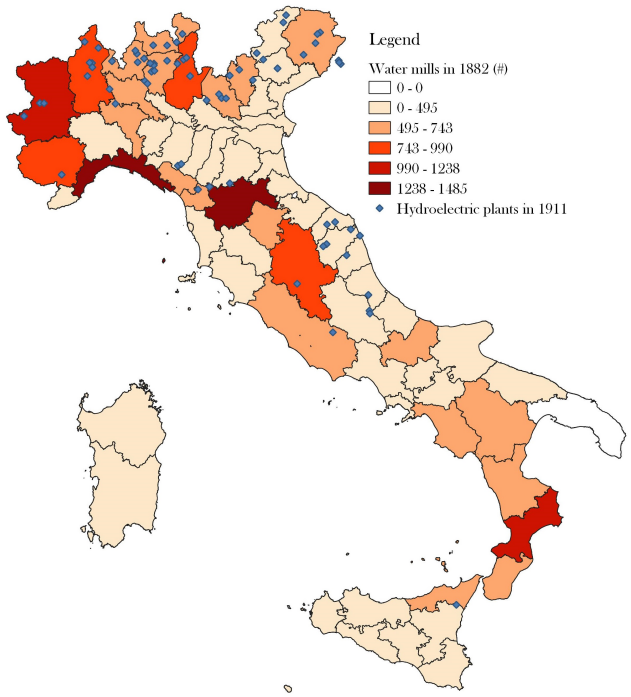
Source: Author's elaborations. See text for sources

Figure 7: Coal price differential (%) with 108 provinces: averages by area



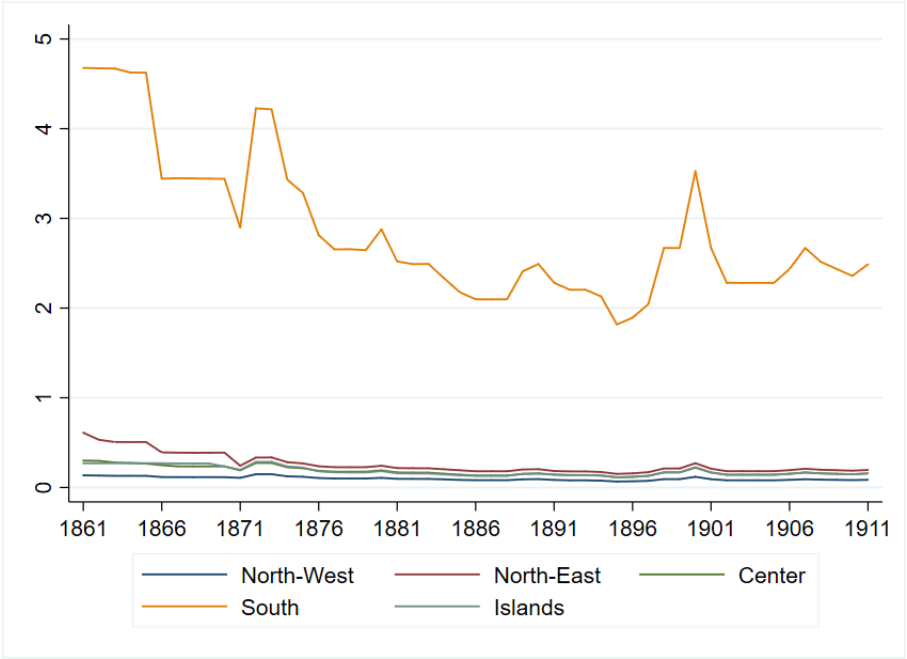
Source: Author's elaborations. See text for sources

Figure 8: 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

Figure 9: Coal price in Italian *Lire* weighted by water energy power



Source: Author's elaborations. See text for sources