The JOURNAL of ECONOMIC HISTORY

CAMBRIDGE UNIVERSITY PRESS

PUBLISHED FOR THE ECONOMIC HISTORY ASSOCIATION

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Journal:	*The Journal of Economic History*
Manuscript ID:	JEH-OA-14-Feb-0035.R3
Manuscript Type:	Original Article - Jean-Laurent Rosenthal
Era(s):	Nineteenth century
Primary Topic:	Technology, Industry
Additional Topics:	

TECHNICAL CHANGE, NON-TARIFF BARRIERS, AND THE DEVELOPMENT OF THE ITALIAN LOCOMOTIVE INDUSTRY, 1850-1913

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ABSTRACT

The locomotive industry was one of the relatively sophisticated "high tech" sectors in which Italy, a late industrializer, was successful before 1913. Using technical data on the performance of different vintages of locomotives, we construct a new industry-level index of technical change. We also study the impact of different policy instruments (import duties, non-tariff trade barriers, and other discretionary interventions) in shaping the development of the industry. Our reassessment reveals not only the sound technological performance of Italian locomotives and successful industry growth, but also the critical played by non-tariff barriers for the development of the industry.

Acknowledgements: We would like to thank Alberto Dalmazzo, Giovanni Federico, Stefano Fenoaltea, Alfredo Gigliobianco, Piero Muscolino, Tommaso Proietti, Gianni Toniolo, and Michelangelo Vasta for helpful discussions and suggestions. This paper has also benefited from the comments of two anonymous referees and of the participants at the economic history seminars at the Bank of Italy, and at the University of Siena.

INTRODUCTION

The relationship between the adoption of new technologies in developing countries and comparative economic development continues to generate considerable research in economics and economic history.[1] In his work, Alexander Gerschenkon noted that the "technology gap" with respect to the technological frontier provides developing countries with the opportunity to quickly absorb the "backlog of technological innovations" of advanced countries and catch-up with them (1962, p. 8). This process of international technology diffusion is purported to be at the root of convergence with Britain by several European countries during the nineteenth century (Landes, 1969). However, catching up is by no means automatic. Rather, it requires a significant mobilization of resources, skills, and capitals over a broad front, often coupled with a complex "mix" of policy interventions towards infant industries, ranging from trade and industrial policies to other forms of government actions.[2]

In his assessment of the policy mix adopted by Italian governments in the second half of the nineteenth century, Gerschenkron was characteristically blunt, pointing to a generalized "ineptness of government industrialization policies". In particular, he argued that Italian industrialization would have benefited from a more "rationally conceived and executed tariff". The structure of the tariff, favoring iron and steel in a coal-less country, represented a major impediment to the development of the Italian mechanical engineering industry which "was largely left to its own devices" (Gerschenkron, 1962, pp. 80-83). Other historians have instead argued that the sluggish development of the industry lay in the overall "technical and organizational backwardness of the sector" and not in mistaken policies.[3]

[1] See Fagerberg (1988) for a useful survey.
[2] For a recent compact treatment see Allen (2011). For a classical analysis of the case of South Korea, see Amsden, (1989).
[3] According to Toniolo (1977), p. 672, a more favorable tariff could have resulted in an increase of some 50% of the mechanical engineering industry, which in turn would have amounted to an increase of some 7% in aggregate industrial production in 1908.

This paper sheds new light on these issues by reassessing the case of the steam locomotive industry, one of the few relatively "high tech" sectors in which Italy was successful before 1913. The development of this industry was shaped by a complex mix of policies comprising trade policies, "non-tariff trade barriers", and other discretionary interventions. The locomotive industry, thus, constitutes a useful vantage point to reconsider the general effectiveness of the different types of interventions adopted by the Italian governments in the period 1850-1913.

Our analysis relies on a new index of technical change based on technical indicators of the performance of different vintages of steam locomotives. The dataset includes some six thousand steam locomotives in operation in Italy from 1839 to 1913. The index casts doubt on the prevailing view that the market share of Italian steam locomotive manufacturers was severely limited by their technical backwardness. On the contrary, the new quantitative evidence on technical change suggests that the technical capabilities of Italian producers were fully adequate when compared to those of foreign producers. Efficient production required then an annual production of about fifty locomotives per firm. Tariff-based protectionism, with positive net protection in force since the mid-1880s, was not sufficient to reach this goal. Rather, this production level was achieved through specific procurement policies assuring regular orders to national producers. It was these non-tariff barriers that played a critical role for the development of the Italian locomotive industry.

THE STEAM LOCOMOTIVE INDUSTRY IN ITALY: BACKGROUND

At the point of political unification of Italy in 1861, the railway network was limited with about 3,900 km in 1864, against 18,000 km in UK, 16,000 km in Germany, and 12,000 km in France and the system had an eminently local character, as a result of the uncoordinated investments of the different pre-unitarian states in railway infrastructure. Political unification provided a major stimulus towards the expansion of the network, so that by 1910 the network comprised about 15,300 km. However, even after unification, various sections of the network were operated by several private franchise companies. A major reorganization took place in 1885 with "Railways

Conventions" assigning the management of the network to three major private franchise companies under a renewable contract: the *Rete Adriatica* (RA) and the *Rete Mediterranea* (RM) covering the peninsula along a west-east divide, and, the *Rete Sicula* (RS), operating in Sicily.[4] In 1905 the operation of the railway network was nationalized and taken over by the Ferrovie dello Stato (a big state-owned company with about 100,000 workers).

Debates on Italian industrialization initially focused on the relation between railway extension and market unification (Romeo, 1959; Sereni 1966) and on the connection between the development of the railway network, the demand for industrial products, and the rate of economic growth (Gerschnekron, 1962). To date, the most comprehensive economic appraisal of the relation between railroads and industrial growth in post-Unification Italy is Fenoaltea (1983, 2011). Fenoaltea's appraisal points to the importance of the composition of investment. From 1861-1895, investment was devoted to construction of railway tracks (mostly using unskilled workers for earthworks and related activities) with a relatively reduced share (10%) devoted to the purchase of metalmaking or engineering products. From 1896-1913, the share of investment devoted to engineering products rose to about 30% of the total annual railway investment. Most importantly, maintenance (both of railway lines and of rolling stock) grew throughout this period so that by 1913 it was such that, "on a value added basis, the maintenance of [rolling stock] was as important as their initial fabrication and, unlike the latter, it was immune from foreign competition" (Fenoaltea, 1983, p. 49).

From an engineering standpoint, the steam locomotive is a sophisticated piece of equipment, comprising hundreds of parts, most of them requiring accurate manufacturing and processing. Philip Scranton (1997, p. 99) regards steam locomotives as a quintessential example of nineteenth century "specialty production": "no specialty product was then more complicated than a railway engine and few were as heavily taxed in use". Mass production was not feasible: steam locomotives were manufactured in small batches and they often had to incorporate particular specifications requested

[4] For a more detailed outline of the historical evolution of the railway system in Italy, see the "Supplementary material" section and reference therein.

by individual customers. This meant that locomotive manufacturers had to marshal a significant breadth of engineering competences and skills. Even if the broad contours of locomotive design were established by the 1850s, throughout the second half of the nineteenth century, steam locomotives underwent a stream of technical improvements which compelled a continuous revision and updating of many details of locomotives design and manufacturing.[5]

For these reasons, the steam locomotive provides an interesting perspective on the absorption of an "advanced" technology by latecomer countries. In comparative perspective, it is possible to distinguish two main "waves" in the international diffusion of the steam locomotive. During the first wave (1830-1860), the manufacturing of steam locomotives became established in England Belgium, France, United States and Germany. During the second wave (1880-1920), we witness the emergence, with varying success, of the manufacturing of steam locomotives in Italy, Russia, Spain and Japan.[6]

THE STEAM LOCOMOTIVE INDUSTRY IN ITALY: NEW EVIDENCE, NEW CONJECTURES

The evidence presented in this paper is largely based on a new dataset described in the Appendix. It comprises two major components. The first one includes information on 5,700 locomotives both domestic and foreign.[7] For each locomotive we know the year and place of production, the producer's name, and a numerical identifier. The second component is based on the authoritative handbook by Cornolò (1998) providing technical characteristics and performances of the

[5] See Sinclair (1907). According to Greggio and Kalla-Bishop (1985, p. 99), "It was not until 1890 that fundamental design theory could be said to be settled, for what was decided then lasted until the end of steam". Analogously, Cardwell (1994, p. 348) regards the end of the nineteenth century as the moment in which the locomotive had reached "a point of near- perfection".

[6] The domestic production of steam locomotives in Spain remained limited until the first world war. See Comin et al. (1998,) and Cayon Garcia and Mayon Rubio (2005). On the more successful Japanese case, see Ericson (1999). In the Italian case, the production of steam locomotives has been investigated by Merger, (1986, 1989), and, more recently, by Ciccarelli and Fenoaltea (2012). The works by Merger are mainly concerned with the production of national manufacturers in quantitative terms and do not consider in detail the technological performance of the different models of locomotives. Ciccarelli and Fenoaltea (2012) presents annual estimates for the rail-guided vehicles industry both at the national and regional level.

[7] Sources and methods of the locomotive data-set are described in Appendix.

locomotives for the period 1850-1913. By combining these two components we can chart in detail the technological characteristics of the different locomotives operating in each year.

The process of import-substitution

The development of Italy's locomotive market is described in Figure 1 and Table 1 illustrating both the total number of locomotives and those produced domestically.

Until mid-1880s, domestic production was limited and the market was dominated by foreign manufacturers. The Italian import market was initially dominated by English producers, then by French producers, and finally by German manufacturers for whom, the Italian market was particularly significant. The *Maschinenfabrik Esslingen*, among the leading German producer of steam locomotives, exported during the period 1883-1887 about a half of its production in Italy (Hertner 1984, p. 30). Furthermore, as noted by Schram (1997, p. 61) German banks backed the Rete Mediterranea, and the Railways Conventions of 1885 marked the beginning of German investments in Italy. During the 1890s few locomotives were purchased, but, after 1900, demand resumed with Italian producers substantially increasing their market share.

Using data on the number of locomotives, Merger (1986, 1989) argues that the limited production of Italian manufacturers during the period 1861-1885 is due to three concomitant factors: the limited depth of technological capabilities of national firms, a lack of specialization leading to increasing costs) and the penalties induced by the tariff on iron. After 1885, with the new Railways Conventions, a new wave of investments took place. In this phase Merger argues that the increased domestic production was a result of the public policies favoring national manufacturers, in particular Pietrarsa, Ansaldo and Breda.[8] The ultimate consolidation of the national industry of steam locomotives, according to Merger, takes place after 1905 when the production of private national producers is elicited by a new wave of investment following the creation of *Ferrovie dello*

[8] These companies had been able to develop a certain base of engineering capabilities in locomotive building by virtue of different channels of knowledge transfer (recruitment of foreign personnel, travels abroad and licensing of foreign patents), see Merger (1986) and Vasta (2002).

Stato (FS), the new public operating company managing the entire main network (including both new construction and maintenance of the railway lines, and the maintenance of rolling stock). However, the increase in the number of domestically-produced locomotives tells us little about their technical quality.

[Figure 1 about here]

[Table 1 about here]

Patterns of technical change

We assess the dynamics of technical change using the traditional weight-to-power (*whp*) ratio, a synthetic indicator that is widely used in the engineering literature and represents "a clear expression of technical progress" in steam locomotives (Diegoli 1961, p. 114). The *whp* ratio provides a measurement of the performance of the locomotive in a metric which is independent of its size, facilitating thus comparisons across different models and designs.[9] For each locomotive we computed the *whp* ratio using the data from Cornolò (1998). The *whp* ratio represents, therefore, our proxy for the technical performance of the various "types" of locomotive with lower values denoting better performance and thus improved technology.[10] The different "types" of locomotives (*Gruppi FS*) were classified in 1905 by the engineers of the newborn *Ferrovie dello Stato*. Locomotives belonging to the same group are very similar in terms of technical characteristics. As Appendix A details, our sample includes more than 100 *Gruppi FS*. We construct an industry-level

[9] The *whp* ratio, as any other synthetic indicator of technological performance, has of course its own limitations. First, it is a ratio, so it is not directly telling on locomotive weight and power, each per se relevant. Second, the *whp* is not particularly informative on other technological characteristics such as locomotive top-speed, fuel efficiency, etc.

[10] An increase in locomotive power (due to the introduction of, say, a bigger boiler) leaving unaltered the whp ratio is not interpreted here as technological progress. The whp ratio is a performance indicator that seems particularly relevant in the Italian context also because "The Italian lines had numerous metal girders of moderate resistance, so the locomotives had to be of reduced weight, both per axle and per linear meter; as a consequence [Italian locomotives] were forced to have a particularly high power." (Diegoli, 1961, p. 108). From this point of view the evolution of Italy's steam locomotive sector during the 19th century can be understood as struggle between the increasing weight of locomotives and rails' – of iron first of steel then – capability to bear it

index (*WHP)* of technical change as the weighted average of the technical performance of the different locomotive types entering in service in that year:[11]

$$WHP_t = \sum_{g=1}^{G_t} s_{gt} whp_g \quad (1)$$

Where *t* represents time (year), and $s_{gt} = n_{gt} / N_t$ is the share of locomotive of type *g* introduced in year *t,* (with n_{gt} and N_t indicating respectively the number of locomotives of type *g*, and the total number of locomotives, introduced in the year *t*); G_t denotes the number of the different types of locomotives introduced in year *t,* and whp_g is the weight-to-power ratio of locomotives of type *g*.[12] This index comprises only the locomotives introduced in a given year. While the sources indicate systematically the year in which a locomotive entered in operation, the information about the year in which it was scrapped is not systematic. This prevents us for constructing the index for the composition of locomotives in operation in a given year. The index of technical change, therefore, should be regarded as an index representing the level of technological performance of the investment in locomotives in a specific year.

Figure 2 shows the evolution of the WHP index for Italian and foreign manufacturers. The area shaded in gray is delimited, year by year, by the maximum and minimum sample values of the WHP index. Interestingly enough, after 1870, it is not uncommon to find Italian manufacturers among the best performers (locomotives with minimum value of the whp ratio in each year).

The WHP index is characterized by a decreasing trend, reflecting technical progress for both domestic and foreign locomotives. The first period (1850-1868) has wide fluctuations which is an outcome of the limited sample size. The three decades from 1868 to 1898 shows substantial stability, with a rapid acceleration from 1898 to 1913. This pattern is not surprising. Railways, in

[11] Van Dijk and Szirmai (2006) have constructed a similar index of technical progress for the Indonesian pulp and paper industry.

[12] For example: if Group A includes 10 locomotives with a *whp* index of 90, and Group B includes 40 locomotives with a *whp* of 70, then *WHP* = 0.2 * 90 + 0.8 * 70 = 74.

Italy as elsewhere, were first laid out across the plains. Conquering the mountains required more powerful locomotives and better railway infrastructures, including tracks, bridges, and embankments. The rapid acceleration observed in this last phase is concomitant with the introduction of two major technical innovations: compounding and super-heating (Tey, 1910, pp. 28-36; Diegoli, 1961, pp. 108-109). Both of which reduced the weight-to-power ratio. Compounding and super-heating were the key features of the "second-generation" of steam locomotives.[13] Compound locomotives were adopted in 1894 by the *Rete Mediterranea* and only later by its competitor, *Rete Adriatica*. Table 2 complements Figure 3 by reporting the average WHP by decade separately for foreign and domestic producers; figures on the main Italian producers of the time are also reported in columns 3-5.

[Figure 2 about here]

[Table 2 about here]

The evidence presented so far is not consistent with the limited engineering capacity suggested by the prevailing literature (on this point see Fenoaltea 2011, p. 150). Rather it supports contemporary views arguing that, at least from the late 1870s, Italian manufacturers were indeed capable of designing and producing steam locomotives of quality fully comparable to that of foreign competitors, or, more precisely, of the models of locomotives that English, French and German manufacturers were importing in Italy. For example, at a conference for the 1881 Milan Exposition, Professor Leonardo Loria stated:

> The national locomotives are perfectly equal, both in terms of manufacturing and assembling of components, to the best foreign locomotives … . Our locomotives are not anymore mere imitation of foreign locomotives, manufactured assembling a number of components imported from abroad, rather they are locomotives fully adapted to the special conditions of our railway network, almost completely manufactured by us, where our engineers introduce important innovations … . And, as far as the cost of production is concerned, today we are not far away from foreign firms. (Loria, 1881, pp. 76-77).

[13] Both innovations can been seen as the response to the threat of the electric locomotives in its pioneering phase after 1900.

Additional corroboration of this point can be found in the detailed account of Cornolò who mentions, other models of locomotives (such as the "Ariosto" or the "Frescot") designed during the 1870s and early 1880s that were crowned with critical acclaim at international exhibitions and in the engineering literature.[14]

Government policy

The domestic production of locomotives increased over the nineteenth century. In this section, we examine the impact of government policy on the growth of the industry. Interestingly, from 1870 to 1885, several parliamentary select committees (PSCs) debated alternative forms of State intervention to sustain the national industry. Of particular relevance here are the early 1870s PSC "on industry", the late 1870s PSC "on railways", and the mid-1880s PSC "on the revision of trade tariff."

The PSC "on industry" (*Comitato dell'inchiesta industriale*) investigated the capacity to compete with foreign producers and the ways in which custom duties increased domestic competitiveness.[15] The engineering sector was one of the most debated with many observers and practitioners (including businessmen, managers, and engineers) interviewed. The main locomotive producers were Ansaldo (near Genoa, established in 1854) and Pietrarsa (near Naples, established in 1842). They were asked about the effects of import duties on the domestic production of steam locomotives. Both Ansaldo and the Pietrarsa argued that the then tariff's structure worked against the domestic production.[16] Tables 3 and 4 reproduce the evidence referring to the Pietrarsa (Naples) and Ansaldo (Genoa) workshops.[17]

[14] See in particular Cornolò (1998), p. 31.

[15] The board was promoted by Luigi Luzzatti, an economist and politician of the time, appointed Prime Minister in 1910. Luzzatti and Vittorio Ellena exerted a major influence on the diffusion of protectionism in Italy through the tariff reforms of 1878 and 1887. Pareto itself used to refer to the 1887 protectionist reform as the "Ellena-Luzzatti" tariff.

[16] As already noticed by Ciccarelli and Fenoaltea (2012), Felice Giordano – in his 1864 appraisal of the iron and metal working industry in Italy – argued convincingly that the engineering establishments of Naples and Genoa could potentially produce locomotives at prices that were similar to that of foreign ones. The argument made by Giordano

Table 3 reports the cost structure of a typical locomotive in the Pietrarsa workshop. Column 2 shows that some 70 percent of a "standard" steam locomotive was made of iron, while the remaining 30 percent was of pig-iron, brass-tubes, copper, steel, and bronze. Column 4 reports the total physical cost of production (excluding labor and transport costs). The total cost of materials was 29,610 lire, and 32,970 lire once import duties are included (corresponding to a 10 percent increase). The last line shows that the import duty on a steam locomotive considered as a finished product amounted to 4 lire per 100 kg. With a total weight of 40 tons, the import duty amounted to 1,600 lire.[18] The tariff's structure, therefore, implied an additional cost of 3,360 lire for domestically-produced locomotives relative to 1,600 lire for imported locomotives, resulting in a negative protection for Italian locomotive producers.

Table 4 reports similar data provided by Ansaldo. For a standard "1858 Government type" locomotive, the import duties on raw materials were 2,811 lire, well above the 1,570 lire paid as duty to import the same locomotive from abroad. Although the calculations by Ansaldo are extremely coarse, they show that in the early 1870s at least a half of a locomotive was made up of highly-protected-iron, amounting to a negative protection.

[Table 3 about here]

[Table 4 about here]

The PSC "on industry" concluded that: "there is no balance between the ("high") tariff on iron and the one ("low") on machines"; therefore "it is necessary to reduce the tariff on iron," or "alternatively, it is necessary to raise the tariff on machines" (Comitato della inchiesta industriale,

refers to *total* cost of production, so that while iron was surely more expensive in coal-less Italy, labor was there relatively cheaper than in other countries (Giordano, 1864, pp. 102, 359).

[17] The sources report an import duty on steam locomotives of 4 lire per 100 kg in one case (Pietrarsa), and 4.62 lire per 100 kg in the other (Ansaldo). From that evidence one can infer that in one case (Pietrarsa) the data refer to some year between 1866 and 1870, while in the other case (Ansaldo) to either 1871 or 1872.

[18] Giordano (1864), p. 349 reports an input weight loss that may reach some 25 percent for certain materials. As a result, the negative protection illustrated in Tables 3-4 is surely underestimated.

1874, p. 6). In fact, both the duties on iron and locomotives were raised over time. In the subsequent PSC "on railways" (*Commissione d'inchiesta sull'esercizio delle ferrovie italiane*), Pietro Peirano, a manager of Ansaldo confirmed that the key factor forcing his company to give up the production of locomotives was the penalty induced by the tariff rather than the lack or backwardness of technological competency.[19] Ansaldo and Pietrarsa's delegates were also consulted by the PSC on "the revision of international trade tariff" *(Commissione d'inchiesta per la revisione della tariffa doganale*) instituted in the mid-1880s and reaffirmed that the cost of protecting the metal-making sector (with high import duties on iron and other production inputs) represented a still too heavy burden for the engineering sector.[20]

Net protection on steam locomotives

As shown in Figure 3, subsequent tariff reforms – above all that of 1887 – gradually ensured a positive protection to Italian producers of steam locomotives.

[Figure 3 about here]

The vertical distance between the continuous and dashed line provides a measure of the net-protection on steam locomotives. Obviously the measure is rough for several reasons. Iron was not the only input in the production of a steam locomotive, though most relevant in terms of weight. Second, Italian import duties were mainly tied to weight (not to value), and thus less effective the higher the price of imported goods. Finally, but importantly, the inputs' weight losses occurring during the production process are not considered. Including them would shift the dashed line upward perhaps by as much as 20-30 percent.[21] Despite these limitations, Figure 5 tentatively suggests that the net protection on steam locomotives became positive over time: a consequence of

[19] Peirano confidently stated "We could outcompete foreign firms if raw materials were exempted from import duties". Even if self-interested, in our view the statement probably reflects a sincere assessment. In the same interview it is also discussed the special procurement policy practiced by *Ferrovie Meridionali* in favour of Pietrarsa. Clearly, if Peirano had not been intimately convinced of the critical role of the tariff, the best course of action would have been to advocate for the extension of a similar procurement policy rather than the revision of the tariff (Commissione d'inchiesta sull'esercizio delle ferrovie italiane, 1879, pp. 371-372).

[20] Commissione d'inchiesta per la revisione della tariffa doganale (1886), p. 423-433.

[21] This percentage is suggested by the early calculations reported in Giordano (1864), p. 349, and confirmed by the more detailed tables reported in the later Camera dei Deputati (1888), pp. 52-54.

the increase, in different proportions, *both* of the import duties on iron and locomotives. Import duties on steam locomotives were raised from 4 to 4.62 lire in 1871; 4.62 to 8 lire in 1873; 8 lire to 14 from 1888. Import duties on iron were raised from 4.62 lire to 6.50 in 1888 and then lowered to 6.00 lire from 1892).[22]

To sum up, the evidence we have discussed so far suggests that the structure of the tariff rather than alleged technological backwardness represented the main bottleneck stifling the expansion of the industry up to mid-1880s (Figure 2).[23] This became less stringent as the effective rate of protection on steam locomotive rose in the late 1880s.[24] The growth in production after 1885 is generally seen as the result of two policy changes. The first is the aforementioned 1887 reform of the tariff that, raising the import duty on steam locomotives from 8 to 14 lire per 100 kg.[25] The second is the five percent clause introduced by the Railways Conventions of 1885 which required that locomotives procurement contracts should be assigned to national manufacturers if their prices were less than 5 percent higher than the best offer of foreign competitors.[26] This is point of contention in the literature: several historians argued that the five percent clause was probably too weak to exert a major impact (Gerschenkron 1962, p. 371; Caizzi 1965, p. 381; and Papa 1973, pp. 50-51), but the

[22] Annual data on import duties are from the Movimento commerciale del Regno d'Italia, the official historical source on Italy's commercial flows. Data for the year 1874 are, for instance, from Ministero delle finanze (1875), p. 54 (locomotives), and p. 61 (iron). Data for year 1888 are, for instance, from Ministero delle Finanze (1889), p. 218 (iron), and p. 256 (locomotives). Data on steam locomotives are separately identified starting with 1886. In the preceding years the duty on steam locomotives were reported within the more general category of "steam machines". Data on iron refer to "ferro di prima fabbricazione" for the years 1866-1874, to "ferro laminato o battuto o in verghe di più di 5 millimetri di diametro" for the years 1870-1884, and to "ferro e acciaio laminato o battuto o in verghe, spranghe o barre sagomate - non aventi in sezione alcun diametro o lato di 7 millimetri o meno" for the years after 1885. Luckily enough, overlapping retrospective figures are regularly reported in the source, allowing the reconstruction of plausible time-homogeneous series of import duties. Import duties for the years before 1865 were *ad valorem* and thus, for the sake of simplicity, here ignored.

[23] Thus confirming the intuition in Ciccarelli and Fenoaltea (2012), pp. 55-56.

[24] Federico and Tena (1999) have produced a detailed set of estimates of "effective rates of protection" by using the technical coefficients of three input-output tables (one for UK in 1907, one for Italy in 1911, and one for Italy in 1950). Their estimates suggest that the effective protection rate for the mechanical engineering was probably not very different from zero or marginally positive over the period 1889-1913. Their estimates are therefore broadly consistent with the views of informed contemporaries discussed here.

[25] The 1887 tariff reform raised import duties on both iron and machines (including locomotives). Still the main Italian producers of steam locomotives were for the first time able to export their products. A possible explanation is that starting with late 1880s exporters were exempted from the payment of duty on iron. According to Società Italiana Ernesto Breda (1908), p. 50, Breda exported in the 1892-1902 decade 137 steam locomotives mostly in Romania and Denmark (Società Italiana Ernesto Breda (1936), p. 66; Popescu (1987), p. 333). It may worth noting that the Romanian market of the time was dominated by major producers such as Beyer & Peacock, Henschel, Maffei, and Wiener Lokomotivfabriks.

[26] Ministero dei lavori pubblici, 1901, pp. 203-204; see in particular footnote 1.

most recent contributions such as Merger (1986, p. 84), Giannetti and Federico (1999, p.1134), and Giannetti e Vasta (2012, p. 226) claim rather that the clause played an important role in the "take-off" of domestic production of steam locomotives after 1885.

The silent procurement policy, 1885-1899

There are, however, two other features of the Railway Conventions of 1885 that have received only limited attention in the literature, but are possibly far more important than the five percent clause and the revision of the tariff in accounting for the expansion of the domestic production. The first is the special endowment of 15 million lire granted, with the reorganization of the railway system in 1885, to the three major operating companies to purchase railway equipment and material and also to renew their locomotive fleet (Merger, 1986, p. 81). The second is the active procurement policy that was put in place after 1885, which, although not established by law, amounted to favoritism of "national champions" well beyond the preference arising from the five per cent clause.

The point is clearly stated in an official publication of the "public works" ministry explicitly acknowledging that a segment of the Italian market for locomotives was to be reserved for national manufacturers:

> In the case of locomotives the protection afforded by the aforementioned article [*i.e.*, the five per cent clause], was not sufficient to allow national firms to win procurement contracts and, even a higher protection would have not been enough. Hence, in order to encourage the Italian locomotive industry, which is still in its infancy and it is practiced by very few firms that are now constructing the plants necessary to win against foreign competition, several procurement contracts have been assigned to these firms by means of private deals, fixing prices in such a way to allow these firms to manufacture locomotives without making losses and not making a too heavy burden for the State (Ministero dei lavori pubblici, 1889, pp. 501-502).

The five per cent clause introduced by the Railway Conventions of 1885 was to be applied to contracts assigned by means of formal competitive calls ("licitazione"), but the franchise companies

could also procure locomotives directly from the manufacturers outside of the competitive system as seen in Table 5.

[Table 5 about here]

Two points merit attention. Columns 4 and 5 show clearly that the five per cent clause was insufficient to tilt the price advantage in favor of national manufacturers. Second, a significant stimulus to the national industry was implemented by means of special deals.[27] In particular, from the Railway Conventions of 1885 to 1900, the domestic production of steam locomotives was assigned either by national auctions (284 units out of 595) or by private negotiations (311 units out of 595). To be sure, the price of foreign locomotives was lower than national ones. Particularly so in the case of locomotive awarded through direct procurement contracts (about 74 thousands lire against about 48 thousands lire). Most likely, this price differential reflected both the possible higher efficiency of foreign over national producers, but also the existence of implicit agreements guaranteeing high prices to Italian producers.

The adoption of stronger protectionist measures to favor Italian producers appears to be a leitmotiv of the parliamentary discussions.[28] Despite various calls to exclude foreign locomotives, the government rejected such outright protection. However, the government agreed that, while the various forms of tariff protection were not sufficient, the most critical issue was the irregularity of demand. Informed contemporaries identify in the small and irregular number of orders the main problem affecting the cost competitiveness of national manufacturers. In 1881 Giuseppe Colombo wrote:

> The convenient manufacturing of steam locomotives requires a demand of at least 50 units per year, and a workshop with the most sophisticated and specialized machinery. Two such workshops would probably suffice to supply the needs of whole Italian railway network. Given the methods of locomotives production prevailing

[27] Calzavarini (1966, p. 74) points to the key role played by "non-tariff trade barriers" in compensating the "the insufficient protection of the trade regime". Calzavarini's appraisal has been largely neglected by the subsequent literature. For a useful discussion of non-tariff barriers, see Baldwin (1970).

[28] An account of the passionate parliamentary debates on the locomotive industry at the turn of the century, not reported here for reasons of space, can be found in Ciccarelli and Nuvolari (2014).

> today also in the major foreign firms, where many components are directly purchased by iron producers or other specialized manufacturers and … given the proved ability of Italian producers in both new productions and maintenances … the success of such undertaking in Italy would be, no doubt, possible (Colombo 1881, p. 67).

A similar point was also stressed, a quarter century later, in the 1908 celebratory volume for the 1,000th locomotive constructed by Breda:

> The technical difficulties that Breda had to face daily were exacerbated by two key factors: the fierce competition from foreign producers, and the irregular and discontinuous nature of the orders (Società Italiana Ernesto Breda, 1908, p. 22).

These statements suggest that more than the shield of tariff-based protection (with positive net protection effectively achieved from the late 1880s), it was the irregularity of demand that stymied the Italian manufacturers of steam locomotives during the 19th century.[29]

In this context, the Railway Conventions of 1885 played a critical role in reassuring the two main national manufacturers (Ansaldo and Breda) that the new political environment was going to be quite favorable to domestic producers of locomotives. This resulted in an expansion of the productive facilities of both firms so that domestic production increased relatively swiftly from a few units to more than hundred units.[30]

THE BIRTH OF THE FERROVIE DELLO STATO (1905) AND THE NEW RAILWAYS POLICY

The late nineteenth-century parliamentary debates on railways had important consequences in terms of actual economic policies. The government presented a plan concerning the acquisition of new rolling stock for the years 1900-1904. It was established (article 9 of law no. 57 of February 27,

[29] The highly irregular nature of the demand was not only a feature of the Italian market. For a discussion of the "feast-or-famine" nature of locomotive demand in this period in different countries, see Ericson (1998, pp. 133-134).
[30] On the investment in production capacity (in particular in that related to the production of locomotives) in the pioneering years of Breda, see Licini (1994).

1900) that the quantity, quality, and expenditure for new acquisition of locomotives had to be agreed between the State and the operating companies. Furthermore, during the same five year period, the Government provided the companies a non-repayable grant of 28 million lire, reinforcing thus its role as chief sponsor of the railway sector. Not surprisingly, it has been remarked that the railway plan of 1900 represented the greater State commitment towards railway since the unification (Papa 1973, p. 50). In 1905, the twenty-year contract between the State and the operating companies (the Railways Conventions of 1885) was not renewed and the State assumed the direct management of the railway system through the creation *Ferrovie dello Stato* (FS), a fully public company.

The rules of the game were changed considerably. The new legislation established that "the Government will assign the production of new rolling stock to national manufacturers … safeguarding, other things being equal, a fair distribution among the various producers" and "whenever necessary … the executive manager [of the newborn FS] can disregard open and national call and use private negotiations …", but importantly, "in case of collusive behavior or any kind of fraud by national manufacturers to the detriment of the railway administration [that is the FS], or when it will not be possible for national producers to guarantee a fair price of rolling stock, according to the prevailing market conditions, then … [the Government] … will order new rolling stock to foreign producers".[31] Two points deserve attention. The first is that the tool of direct procurement to assign orders to national producers was explicitly institutionalized. The second is that the State intended to use international auctions as a threat to limit "extortionary" pricing by national producers.[32] While the protection of the national industry was thus confirmed and even reinforced, a more rigorous expenditure policy was put in place.

[31] The framework of the new policy regime was established by law no. 137, April 1905 on "the public management of the railway sector", and by law no. 429, July 1907, on "the State management of railways not licensed to private firms". The citation refers to article 11 of law no. 137, April 1905.

[32] Direct procurement contracts were rarely used to import locomotives from abroad. The Minister of public works Carmine mentions for instance the case of "unusual" private negotiations with foreign producers concerning 25 locomotives (Camera dei Deputati 1906b, p. 6652).

Tables 6 and 7 document the effects of the new FS regime on locomotive acquisitions and prices. Table 6 provides quantity and price data from an official 1906 report.[33] A total of 291 locomotives were assigned to national producers by direct procurement contracts and 112 to foreign producers though international auctions. Table 7 provides an assessment of the price gap between national and foreign manufacturers in 1906. It shows that by 1906 the price gap was only about 9 percent, significantly lower than in the 1885-1899 period.[34]

[Table 6 around here]

[Table 7 around here]

To summarize, with the creation of the FS in 1905, the State implemented a new policy mix capable to stimulate the national industry, by directly assigning to local producers new locomotive orders, and, at the same time, to safeguard the State budget by linking the price effectively paid to national producers to the best offers of foreign producers.[35] Foreign purchases were used to investigate the price of locomotives and to absorb demand peaks such as occurred in 1907-1908 when about 900 locomotives entered the FS locomotive fleet.

CONCLUDING REMARKS

Notwithstanding the limited endowment of the country in terms of engineering competences, the Italian steam locomotive industry achieved a level of technological sophistication in line with that of foreign producers by the beginning of the twentieth century.. The early development of the industry was slowed both by the vagaries of the demand which prevented the major national players

[33] The report of March 1906 to the Parliament by the Minister of public works Pietro Carmine (the so called "Carmine-report", Camera dei Deputati 1906a).

[34] The price ratio between national and foreign locomotives reported in Table 7 can be used to perform a tentative estimation of the TFP gap in steam locomotives production between Italy and Germany around 1906. We use the formula $\frac{A}{A^*} = \frac{(W/W^*)^{\alpha}(R/R^*)^{\beta}(C/C^*)^{\gamma}}{P/P^*}$, where A = TFP levels; W= real wages; R = rental cost of capital; C = raw materials and α, β, and γ are the shares of labor, capital, and raw material in total costs. The suffix * indicates the foreign country. Assuming that the rental cost of capital was the same in the two countries, using the data in Table 3 to estimate cost shares, data on real wages from Allen (2001), and on the price of iron (which approximates the raw materials) from Cianci (1933, pp. 329-330), one gets that the level of TFP in Italy was about 85% of the German level. Taking into account the crude nature of the data, the assumptions made, and that the extent to which the prices reported in Table 7 were subjected to political manipulation remains uncertain, these estimates provide only a very rough indication of the TFP gap between the two countries.

[35] For a more detailed discussion on the procedures to determine the price of steam locomotives after 1905 see Ciccarelli and Nuvolari (2014).

from planning an ordered expansion of productive capacity and, secondly, by tariff protection on iron products, which resulted in a cost disadvantage. From 1885 onwards national manufacturers received considerable support through a discretionary procurement policy which in practical terms amounted to an effective "non-tariff barrier" and to a more regular demand for their products, tied to the spread of the railways network leading to greater economies of scope.

The design and construction of locomotives were probably among the most sophisticated segments of the nineteenth century mechanical engineering industry and it is instructive to compare the performance of the locomotive industry with other less sophisticated branches such as cotton textile machinery where the country was unable to develop any autonomous production. (Besso, 1910, pp. 142-143; A'Hearn, 1998) Yet , there were also other complex engineering products in which Italy was also able to deliver a very good performance, such as the production of war-ships (Fenoaltea, 2011, p. 150), some of which were even exported. This somewhat paradoxical outcome can be explained taking into account that some of the most sophisticated branches of the mechanical engineering could endure the negative effects of the tariff, by virtue of non-tariff trade barriers such as public procurement, subsidies, and other similar policies, whereas the less sophisticated branches had to bear its full burden.

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APPENDIX: THE STEAM LOCOMOTIVES DATA SET

The steam locomotives dataset is based on two major components. The first one is constructed with the same approach and sources used in Ciccarelli and Fenoaltea (2012) for their statistical

reconstruction of Italy's rail-guided vehicles industry.[36] The second component is entirely new and covers indicators of technical characteristics and performances of locomotives.

The main source for the first component of the dataset is constituted by the catalogues of the principal companies operating the railways system at different moments in time. Catalogues of this kind were published from the late 1880s by three main operating companies (*Rete Adriatica* (RA), the *Rete Mediterranea* (RM), and the *Rete Sicula* (RS)). [37] A similar catalogue was published in 1914 by the *Ferrovie dello Stato* (FS), providing an exhaustive list of locomotives in operating service at the date of June 30, 1914.[38] The catalogues set out the technical characteristics of each type of locomotive in service together with a numerical identifier, the year of construction, and the name of the building-company. Our dataset is constructed by merging the relevant quantitative information stored in these four publications.

The second component of the dataset concerns technical features. For each locomotive model (*Gruppo FS*) we have retrieved the information on locomotives' weight and power (measured in HP) from Cornolò (1998), pp. 584-599.

The WHP calculations presented in the previous *Patterns of technical change* section refer to 4,432 steam locomotives with separated tenders; the remaining 1,268 tank-locomotives (locomotives carrying water and coal on board instead of pulling them behind in a separated tender), with a WHP far higher and well above 100, are excluded.[39] Locomotives in our sample are grouped according to a classification scheme adopted by the *Ferrovie dello Stato* (FS) in 1905.

Table A1 illustrates the distribution of locomotives in our sample by (104) locomotive groups. The table includes two panels. Panel A includes locomotive groups from 100 to 560; these are mostly of

[36] A complete account (in Italian) on sources and methods can be found in Ciccarelli and Fenoaltea (2014).
[37] Società Italiana per le Strade Ferrate Meridionali. Esercizio della Rete Adriatica (1887 ca), Società Italiana per le Strade Ferrate del Mediterraneo (1888), and Società italiana per le Strade Ferrate della Sicilia (1902 ca).
[38] Ferrovie dello Stato (1914).
[39] We do not consider in our sample tank-locomotives because they are typically of reduced size and weight, and often operating in *narrow gauge* lines (Ministero dei lavori pubblici, 1901, pp. 200-201, where the tank-locomotives are classified as a category apart, with an average price well below that of standard locomotives).

"first-generation" (*i.e.* using single expansion and saturated, or "wet", steam). Panel B refers to groups from 600 to 980, and includes mostly "second generation" locomotives (*i.e.* adopting super-heating and/or double-expansion). The table's columns are numbered as follows. Odd numbers refer to locomotive groups. Even numbers refer to the units of locomotives within a given group. Locomotive groups included in the same column are similar in terms of technical characteristics (speed, power, weight, wheels arrangement, etc.). The bottom part of Table A1, panels A and B report the average sample weight, the average sample power, and the power-to-weight-ratio evaluated at the sample average.

[Table A1 panel A about here]

[Table A1 panel B about here]

Table 1. Estimated acquisitions of steam locomotives: total, domestic, and foreign production, 1850-1913.

	(1)	(2)	(3)	(4)	(5)
		units		percentages	
period	total	Italian	foreign	Italian	foreign
1850-1860	80	9	71	11	89
1861-1870	426	53	373	12	88
1871-1880	570	121	449	21	79
1881-1890	1,139	455	684	40	60
1891-1900	337	317	20	94	6
1901-1914	3,148	2,393	755	76	24
1850-1914	5,700	3,348	2,352	59	41

Source: see text.

Table 2. The weight-to-power index (WHP), 1850-1913.[a]

	(1)	(2)	(3)	(4)	(5)
			main Italian producers		
period	foreign	Italian	Ansaldo	Breda	Pietrarsa
1850-1860	106.25	98.56	98.56	-	-
1861-1870	89.64	96.07	98.56	-	92.61
1871-1880	88.02	85.69	87.97	-	85.72
1881-1890	88.63	87.43	85.58	92.35	88.00
1891-1900	87.00	89.20	91.65	87.81	-
1901-1914	79.14	77.87	78.07	73.63	-

[a] The table reports the average value of WHP. The dash denotes missing data in our sample. Breda was only created in mid-1880s, Pietrarsa switched from new production to maintenance in the 1890s

Source: see text.

Table 3. Import duties in the early 1870s: Pietrarsa (Naples).

(1) product	(2) weight (kg)	(3) unit cost (lire/kg)	(4) tot. cost[a] (lire)	(5) unit import duty (lire/100kg)	(6) total import duty[b] (lire)
Inputs:					
from Marseille:					
iron (plates)	10,852	0.432	4,688.06	4.62	501.36
iron (plates)	8,959	0.283	2,533.61	4.62	413.91
from England:					
fabricated metal	11,022	0.865	9,534.03	11.55	1,273.04
steel	1,498	0.970	1,453.06	13.86	207.62
copper	1,580	2.270	3,586.60	13.86	218.99
bronze	819	2.170	1,777.23	4.62	37.84
brass tube	3,059	1.820	5,567.38	23.10	706.63
pig-iron	5,529	0.085	469.97	exempt	0.00
Total	43,318[c]		29,609.94		3,359.39
Final product:					
Steam locomotive	40,000[c]			4.00	1,600.00

[a] Col. 4 = col 3 * col. 2. Once labor costs (21,974.45 lire) and transport costs (2,172.51 lire) are included, total costs amount to 53,752 lire. [b] col. 6 = col. 2 * col. 5 / 100. [c] The number of kilograms reported in the table (43,318 kg) refers to the weight of the inputs used to build a "standard" locomotive. Given the loss of weight of materials tied to the production process (called *sfrido* in the technical jargon) the final weight of the locomotive is lower than 43,318 kg. For the sake of simplicity, the sources typically omit to consider the *sfrido*.

Source: Comitato dell'inchiesta industriale (1872), p. 58; Camera dei Deputati (1871), p. 112

Table 4. Import duties in the early 1870s: Ansaldo (Genoa).

(1) product	(2) weight (kg)	(3) unit import duty (lire/100kg)	(4) total import duty[c] (lire)
Inputs:			
iron (bars)	20,000	4.62	924.30
copper (fused)	1,500	4.62	69.30
copper (bars)	560	13.86	77.62
copper (plates)	1,475	9.24	136.29
copper (layers)	400	9.24	36.96
tin (rods)	200	9.24	18.48
steel (bars)	500	13.86	69.30
steel for wheels	3,225	23.10	744.97
steel for springs	990	34.45	344.03
brass (tubes)	1,670	23.10	385.77
brass (for seals)	60	9.24	5.55
pig-iron	3,450	exempt	0.00
Total	34,030		2811.28
Final product:			
Steam locomotive	34,030	4.62	1572.18

Source: Comitato dell'inchiesta industriale (1873), p. 43.

Table 5: Acquisitions of new locomotives: expenditure and average price by types of procurement, 1885-1899.

(1) Type of procurement contract	(2) Number of locos	(3) Tot. expend. (lire)	(4) Aver. price per loco[a]	(5) National/ foreign price[b]
Open calls[c]				
to foreigners	291	17,299,848	59,449.65	
to Italians	0	0		
National calls[d]:	311	24,892,467	80,040.09	1.346
Direct procurement:				
to foreigners	46	2,217,898	48,215.17	
to Italians	284	21,112,045	74,338.19	1.541
Total	932	65,522,258		
to foreigner	337	19,517,745	57,916.16	
to Italians	595[c]	43,392,879	77,074.39	1.331

[a]Col. 4 = col. 3/col. 2; [b] the national to foreign price ratio was obtained (rounding errors apart) as follows: (80,040.09/59,449.65) = 1.346; (74,338.19/48,215.17)=1.541; (77,074.39/57,916.16)=1.331. [c] Open calls ("licitazioni internazionali") were opened to both foreign and Italian producers; [d] National calls ("licitazioni nazionali") were reserved for Italian producers. [c]The figure (595) also includes 32 locomotives built by the Mediterranea (30) and Adriatica (2) in their own workshops, accounting for a total value of 2,611,631.62 lire.

Source: Ministero dei lavori pubblici (1901), pp. 202-209.

Table 6 Domestic and foreign prices of 403 locomotives ordered in January 1906, by nationality of the producer.

producer	(1) FS-group	(2) units	(3) price (lire per kg)
A. Italians (direct procurement)			
E. Breda Milano	640	20	1.78
E. Breda Milano	320	52	1.73
E. Breda Milano	835	10	1.73
OM Milano	320	20	1.73
OM Milano	851	26	1.77
OM Saronno	600	38	1.79
Giovanni Ansaldo Genova	600	20	1.79
Giovanni Ansaldo Genova	630	25	1.80
Giovanni Ansaldo Genova	640	9	1.78
Giovanni Ansaldo Genova	870	40	1.85
Giovanni Ansaldo Genova	910	30	1.78
E. Breda Milano		6	NA
Giovanni Ansaldo Genova		10	NA
Total units[a]:		291	
Average price:			1.77
B. Foreign (international auctions)			
Maffei – Monaco[b]	851	16	1.43
Ungarische S.B. Budapest	600	9	1.48
Sigl, Wiener Neustdat	600	24	1.65
Hartmann – Chemnitz	600	12	1.65
Società Alsaziana Grafenstadt	600	9	1.68
M. Fabrik Esslingen	600	9	1.68
Schwazkopff – Berlino	600	9	1.70
Energie Marcinelle	600	12	1.72
Henschel – Cassel	630	12	1.72
Total units:		112	
Average price:			1.63
Average price of best offers[c]:			1.56

[a] The total does not include one locomotive ordered to Breda and one to Ansaldo to be exhibited during the Milan 1906 exposition (Camera dei Deputati, 1906a, p. 11) [b]A few locomotives were sold by Maffei at the price of 1.50 lire per kg (Camera dei Deputati, 1906a, p. 12). [c]Following Camera dei Deputati, 1906c, p. 13, and article 34 of Law 429 July 7, 1907 on the "State management of the railway sector") the average price of best offers is equal to 1.56 lire per kg and computed as (1.43+1.48+1.65 +1.68)/4.

Table 7: Price of 403 locomotives ordered in January 1906, and to be delivered between July 1906 and June 1907.

	(1) price (lire per kg)	(2) national/foreign price
Italian locomotives (via direct procurement)	1.77	
foreign locomotives (via open calls)	1.63	1.086

Source: Camera dei Deputati (1906a), p. 5.

Table A1. Steam locomotives operating in Italy, 1850-1914, by group.[a]

A. FS Groups 100-500: first generation machines

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
locomotives with separated tender									
group	units	group	units	group	units	group	units	group	units
100	12	200	56	310 C	69	400	13	500	18
102	8	206	64	320	201	410	25	510	142
103	5	215	394	380	50	420	293	530	72
111	8	255 C	6	385	19	450	8	540	18
112	8	260	24	388	3	451	72	545	46
113	25	265	30	390	9	470	143	550	18
116	5	268	10	391	28	499	6	552	36
118	7	269	6	395	5			560	31
120	156	270	130	396	5				
136	27	290	338	397	3				
140	70								
155	39								
164	25								
170	73								
180	4								
183	12								
185	41								
190	97								
asw[c]	34,777		41,273		41,357		60,304		44,255
ashp[c]	378		461		457		711		529
whpas[c]	92		90		90		85		84
min year[d]	1853		1861		1857		1853		1878
max year[d]	1889		1913		1908		1912		1901

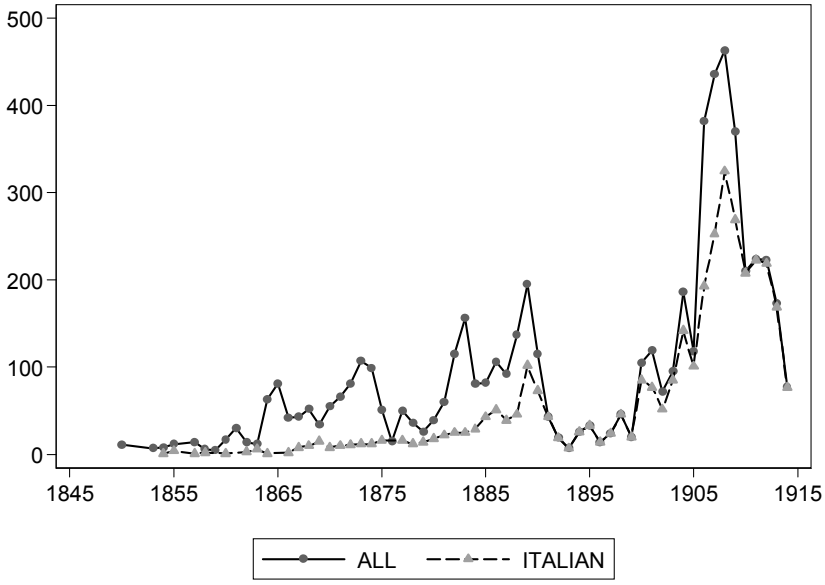
Table A1, *cont.*
B. FS Groups 600-900: second-generation machines

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
locomotives with separated tender				tank-locomotives[b]			
group	units	group	units	group	units	group	units
600 C	248	720	10	800	18	900	18
625 S	98	730 C	190	801 C	9	902	12
630 C	100	740 S	135	802	3	905	84
640 S	169	745 S	4	803	6	910 C	54
650	55	750 C,S	40	805	46	950	6
656 C	25			810	13	980 C	12
660 C	51			813	12		
666 C	10			815	2		
670 C	43			816	38		
680 C,S	151			817	4		
685 S	66			820	1		
690 S	24			821	4		
				822	2		
				825	12		
				827	20		
				829	6		
				830	44		
				835	286		
				848	2		
				849	2		
				850	5		
				851	207		
				870	168		
				875	55		
				885 C	16		
				895	89		
				898	5		
				899	7		
asw[c]	60,179		66,531		43,044		58,857
ashp[c]	860		932		380		576
whpsa[c]	69		71		113		102
min year[d]	1884		1902		1850		1886
max year[d]	1914		1914		1914		1913

[a] The table includes 5,700 steam locomotives operating in the standard-gauge (1,435 meters) Italian railway network. The C and S letters attached to groups' number denote respectively double-expansion and super-heating. The remaining cases consist of more traditional locomotives using saturated steam and simple expansion. [b] Groups FS 800 to 899 and 900 to 980 only include tank-locomotives (for a total of 1,268 units) and are not included in the evaluation of the WHP index illustrated in section 3.2. [c] *asw*: average sample weight; *aswp*: average sample horse power; *whpsa*: weight-to-power ratio evaluated at sample average. [d] *min year*: first entry year in the sample; *max year*: last entry year in the sample.

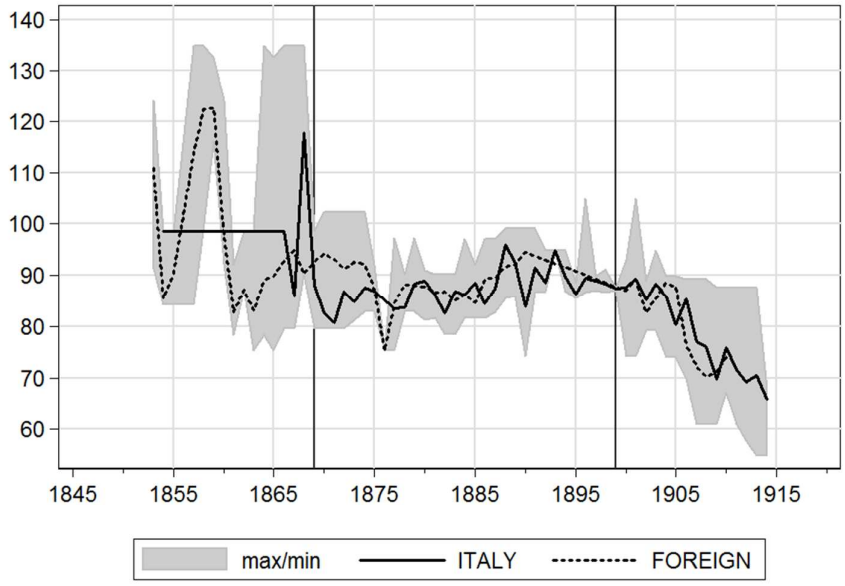
Source: see text.

Figure 1: Estimated acquisitions of steam locomotives in Italy, 1850-1913 (units).



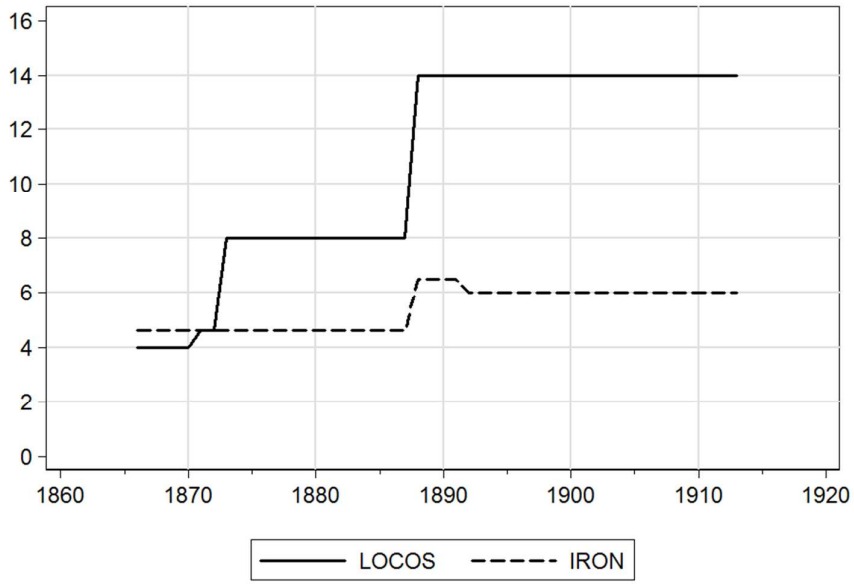
Source: see Appendix.

Figure 2: The weight-to-power index (WHP), 1850-1913.



Source: see text.

Figure 3: Import duties on iron and steam locomotives: 1865-1913 (lire per 100 kg).



Source: see text.

Supplementary material. The evolution of the railways in Italy during the Liberal Age

The text below provides a brief account of the evolution of the Italian railway network from its origins (1839, when the short trunk connecting Naples to Portici was opened) to the eve of WWI.

The pre-Unitarian period, 1839-1860

Cavour, the main architect of Italy's Unification, was a great supporter of railways, considering them as a source of civilization. His 1846 *Des chemins de fer en Italie,* written when he was member of Piedmont's parliament, had a certain resonance among European elites.[1] The 1846 Cavourian piece was mainly written against the Austrian plans for the future development of Northern Italy's railways *(*Lombardy and Venetia, including of course Trieste and its port, were then part of the Habsburg Empire). The Austrian policy aimed to strengthen the commercial relation between Wien and Trieste, and its port on the upper Adriatic sea, and, at the same time, to downsize Genoa's commercial ambitions, tied naturally to the development of its port in the upper Mediterranean sea. A few years later, as Prime Minister, Cavour was able to pursue effectively his ideas on railways and Italian unification. The opening in 1853 of the line connecting industrial Turin to Genoa and its port, represented the first achievement of his railway policy. In 1854, the "Sampierdarena" – the first hundred-per-cent Italian steam locomotive, named after the place of production near Genoa – was produced by the new born Ansaldo factory. The development of an important engineering company in Genoa was part of the Cavourian project too.

In the pre-Unitarian period the extension of the railway network was limited and the system had an eminently local character as a result of the uncoordinated installation of railways by pre-Unitarian states. The railway lines were typically built by a large number of concessionaires. Numerous individual lines, of full or narrow gauges, were in private hands and the management of the network reverted to the State only in subsequent years. We refer the reader to Kalla-Bishop (1971), pp. 11-30 for a more complete treatment of the early development of the railway network in pre-Unification Italy, and of the leading actors of the time – Cavour, Metternich, Pius IX, and, especially so, the Rothschilds.

The post-Unitarian period, 1861-1913

A useful point of departure to approach the study of the steam locomotive industry is the outline of the institutional evolution of the railway system in post-Unification Italy. In this respect, it is possible to distinguish four major phases (Cornolò, 1998):[2]

(a) The Railways Conventions of 1865 (1865-1876)

The extension of the Italian network in 1864 amounted to some 3,850 kilometers. As a term of comparison, the situation elsewhere was the following: USA (56,000), UK (18,000) France (12,000

[1] Cavour (1846). On Cavour and early development of Italian railways see M. Einaudi (1938).

[2] Fenoaltea (2011) suggests a somewhat different periodization which is essentially based on the different waves of construction of the railway network, rather than on the institutional arrangements. A detailed account of the evolution of the Italian railways system can also be found in Crispo (1940), and Guadagno (1996).

km), Germany (16,000), Austria (5,800), Spain (2,800), Russia (2,400), World (130,000).[3] A certain number of regions (including Basilicata, Calabria, and Umbria in mainland Italy, and the two big islands of Sicily and Sardinia) were in 1864 still without rails. After the country's Unification (1861), the law no. 2279 of 1865 established that four major private "franchise" firms should be appointed for the operation of the existing railway systems and for the construction of new ones. The companies to whom the Railway Conventions of 1865 entrusted the management of the network were:

- *Società delle Strade Ferrate dell'Alta Italia (SFAI):* This company was under the control of the Rotschilds until 1878 and was managing mostly the network in Northern Italy, as the name suggests.[4]
- *Società delle Strade Ferrate Romane (SFR):* This company was managing mostly the lines operating in the previously Papal States.[5]
- *Società Italiana delle Strade Ferrate Meridionali (SFM):* This company was managing the lines along the Adriatic coast from Bologna to Otranto plus an additional trunk connecting Foggia to Naples.
- *Società Strade Ferrate Vittorio Emanuele* (then *Società per le Strade Ferrate Calabro-Sicule, SFCS*), operating mainly in Sicily.

(b) "Indirect" State control (1876-1885)

This is a rather obscure phase in which, due to the financial difficulties of the "franchisee" companies, the State was forced to take gradually back their control.[6]

(c) The Railways Conventions of 1885 (1885-1905)

After a decade of "indirect" State management (1876-1885) the system underwent a major reform in 1885, when the management of the vast majority of the railway network was assigned to three operating companies by means of a twenty year renewable contract. Two major ones, the Rete Adriatica (RA) and the Rete Mediterranea (RM), covered the peninsula along a west-east divide, and a third one, the Rete Sicula (RS), operated in Sicily.[7]

[3] Giordano (1864), p. 93. The numbers referring to Italy also include Venetia and Latium only annexed to the country respectively in 1866 and 1870. According to Istat (1958, p. 137) the extension of the Italian network was of 8 km in 1839 (from Naples to Portici), about 1,200 in 1855, about 2,400 in 1860, about 6,400 in 1870, about 9,100 in 1880, about 12,200 km in 1890, about 14,400 in 1900, about 15,300 in 1910, about 16,200 in 1920, about 16,900 in 1930, about 17,000 in 1940, and, finally, about 16,700 in 1955.

[4] Starting with 1867, after the annexation of Venetia to the country, the management of the Venetian railway network passed from Südbahn to SFAI. Technical details on the SFAI's locomotive fleet are in Società delle Strade Ferrate dell'Alta Italia (1876).

[5] A detailed account of the railways system in the Papal States during the Pio IX *era* is in Panconesi (2005). Technical details on the SFAI's locomotive fleet are in Società delle Strade Ferrate Romane (1878).

[6] "Eventually, in 1868 the company ran out of money and went bankrupt. Willy-nilly, the state took over the planned ù system, calling it the Calabria-Sicilian Railroads."(Kalla-Bishop 1971, p. 46). The sentence refers specifically to the *Società Strade Ferrate Vittorio Emanuele,* but it is more generally representative of the financial difficulties of various Italian railway companies of the time.

[7] The full name of the three companies is *Società italiana per le strade ferrate meridionali*, operating on the *Rete Adriatica*, the *Società italiana per le strade ferrate del Mediterraneo*, operating on the *Rete Mediterranea*, and the *Società italiana per le strade ferrate della Sicilia,* operating on *the Rete Sicula.* When referring to the three companies the historical sources often use the shorter labels "Rete Adriatica", "Rete Mediterranea", and "Rete Sicula", or even the RA, RM, and RS acronyms used by the companies to mark their locomotives. According to Ministero dei Lavori pubblici. Regio ispettorato generale delle strade ferrate (1901), pp. 123-124, the existing stock of 1,789 locomotives was assigned in June 1885 to the three newborn companies in the following way: 760 were given to the RA; 920 to the

(d) The creation of the Ferrovie dello Stato *(1905-1913)*

Finally from 1905, at the end of the twenty year contract with the three operating companies previously mentioned, the railways system was directly managed by the State through the newborn *Ferrovie dello Stato* (FS) a fully public company.[8]

Figure 1 illustrates the extension of Italy's railroads in selected years from 1861 to 1909. In 1861 there was no "national" network yet, although Milan and Ancona (on the Adriatic coast) were connected by a line passing through Bologna and other urban centers of the broad Po valley. A few years later, in 1866, the main trunks along the Tyrrhenian and Adriatic coastal plains were terminated.[9] The map for 1886 shows that the main inlands of Sicily and Sardinia had their own network, and that Calabria, in the toe of Italy's boot, was linked to Naples. In 1909, almost at the end of the period here considered, the vast majority of the network was built, and included a relevant numbers of lines crossing the Apennines, with gradients of a certain relevance requiring particularly powerful locomotives. After all, it has been noticed, "the familiar boot-shaped peninsula of Italy … is not particularly kind to railways on the ground".[10]

RM; 109 were finally assigned to the RS. The 1,789 locomotives were inherited from *Alta Italia-SFAI* (976), *Romane-SFR* (320), *Meridionali* (296), and *Calabro-Sicule* (197).

[8] According to Ministero dei Lavori pubblici. Direzione generale delle ferrovie dello Stato (1906), p. 95, in July 1905 the newborn Ferrovie dello Stato inherited from the existing major companies a total of 2,664 locomotives (including the 1854 *Sampierdarena*). The company-by-company breakdown is as follows: 1,617 from the RM, 877 from the RA, and 170 from the RS.

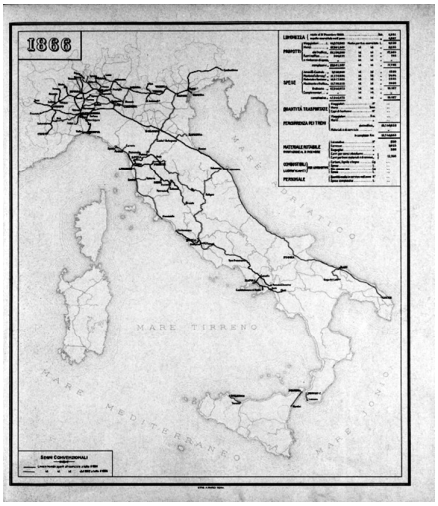
[9] The rapid network extension in the aftermath of the country's Unification (1861) had probably more to do with the necessity of rapidly moving the troops across the territory (to prevent or repress insurrections) than with economic reasons.

[10] Kalla-Bishop (1971), p. 11.

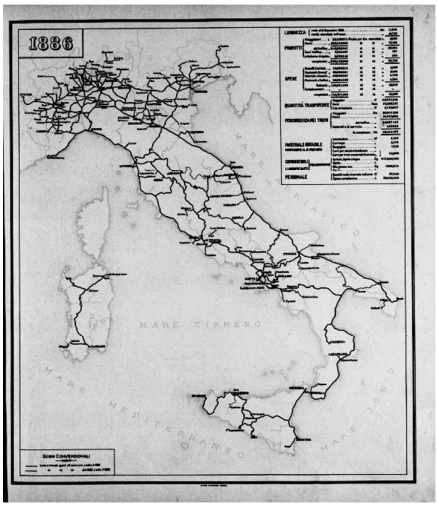
Figure 1. The evolution of the Italian railways, selected years.

1861

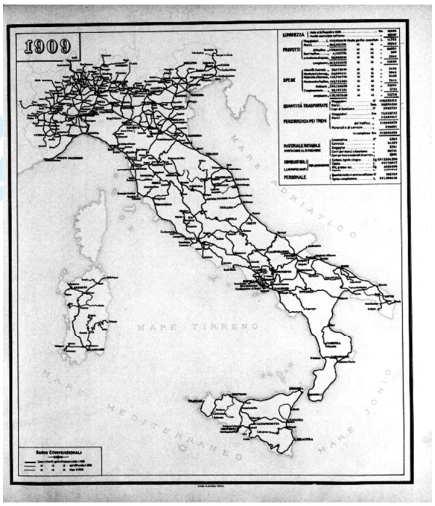
1866



1886



1909



Source: Ferrovie dello Stato (1911)

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