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## Technical Change, Non-Tariff Barriers, and the Development of the Italian Locomotive Industry, 1850-1913

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

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ABSTRACT

This paper examines the dynamics of technical change in the Italian locomotive industry in the period 1850-1913. From an historical point of view, this industry presents a major point of interest: it was one of the few relatively sophisticated "high-tech" sectors in which Italy, a latecomer country, was able to set foot firmly before 1913. Using technical data on the performance of different vintages of locomotives, we construct a new industry-level index of technical change. Our reassessment reveals the critical role played by non-tariff barriers for the emergence and consolidation of national manufacturers in this field.

JEL codes: N73, O25.

*1. Introduction*

Following the seminal contribution of Gerschenkron (1962), the relationship between the adoption of new technologies in backward countries and comparative economic development has become one of the liveliest streams of research in economic history. As is well known, Gerschenkron's approach rests on the analytical distinction between countries pushing the technological frontier and countries lagging behind, characterized by various degrees of backwardness (Gerschenkron, 1962, pp. 42-44). For backward countries, the "technology gap" with respect to the technological frontier represents a "great promise", because it provides the opportunity to quickly take over a substantial "backlog of technological innovations" (Gerschenkron, 1962, p. 8). Ultimately, when successful, this process of rapid adoption of new technologies by backward countries will result in a significant acceleration of industrial and overall economic growth ("big spurt"), allowing to "catch-up" with the leading economies.[1] This type of dynamics is supposed to be at the root of the process of convergence of several European countries with Britain during the nineteenth century.[2]

However, Gerschenkron pointed out that the process of diffusion of new technologies to backward countries is by no means automatic. Rather, it requires a significant mobilization of resources, skills, and capitals over a broad front, possibly coupled with the emergence of new "institutional instruments for which there was little or no counterpart in an established industrial country" (Gerschenkron, 1962, p. 7).

Gerschenkron's view of the connection between the diffusion of technological innovations and industrialization has instigated a substantial body of literature devoted to the assessment of the complex array of development strategies adopted by latecomer countries (ranging from trade to industrial policies and other direct forms of State intervention). According to this literature, the key element to evaluate the appropriateness of the "policy mix" implemented by backward countries is precisely their effectiveness in nurturing the "absorptive capabilities" required to adopt and, if necessary, adapt to the local circumstances the new technologies developed abroad.[3]

In this respect, Gerschenkron's assessment of the policy mix adopted by the governments of Italy during the Liberal Age was characteristically blunt, pointing to a generalized "ineptness of government industrialization policies". In particular, in his view, Italian industrialization would have benefited from a more "rationally conceived and executed tariff" (Gerschenkron, 1962, pp. 80-81). Gerschenkron argued that the structure of the tariff (favoring iron and steel in a coal-less country) represented a major impediment to the development of Italy's engineering industry which "was largely left to its own devices" (p. 83). Interestingly enough, with few exceptions, the subsequent literature did not share this perspective. According to Toniolo (1977, p. 672), even if the effective protection rates enjoyed by the engineering industry were negligible, the main culprit for the sluggish development of the industry has to be found in the overall "technical and organizational backwardness of the sector", rather than in mistaken policies.[4]

[1] The influence of the Gerschenkronian framework in the most recent economic history literature is undoubtedly via Abramovitz (1986). Although in Abramovitz's paper, Gerschenkron is not cited (possibly because the paper is devoted to the post World War II convergence) , the influence of the Harvard economic historian is clearly palpable throughout. The intellectual influence of Gerschenkron is explicitely acknowledged in Abramovitz (1989, p. 74).

[2] See Pollard (1981), and the essays collected in Sylla and Toniolo (1992).

[3] See, for instance, David (1975, ch. 2), considering the development of the cotton industry in the United States, and providing an assessment of tariff protection vis-à-vis other policy instruments.

[4] 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 Italian steam locomotive industry. The case is particularly interesting because it may be regarded as one of the few relatively "high tech" sectors in which Italy was able to set foot firmly before 1913. In addition, the development of the industry, in this historical phase, was shaped by a complex mix of policies comprising trade policies, "non-tariff trade barriers" (*i.e.*, peculiar regulations and policies limiting the importation of foreign locomotives), and other discretionary interventions. The locomotive industry constitutes thus 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 for the locomotive industry. We have assembled a new dataset of technical indicators of the performance of different vintages of steam locomotives. The dataset includes some six thousand steam locomotives in operation in Italy during the period from 1839 to the eve of WWI. The dynamic of the index casts doubt on the prevailing view in the literature, according to which the share of the Italian steam locomotive market covered by national producers was severely limited by their technical backwardness. The new quantitative evidence on technical change in Italy's steam locomotives suggests rather the opposite, that the technical capabilities of Italian producers were fully adequate when compared to those of more established foreign producers. Our reconstruction of the broad contours of technical change in the locomotive industry also prompts a comprehensive reassessment of the combination of development policies adopted by the government towards this industry, highlighting the major role played by "non-tariff barriers" (an ingredient of the policy mix that several economic historians seem to have, so far, unduly downplayed).

The organization of the rest of the paper is as follows. The second section provides a short summary of previous research on the steam locomotive industry in Italy. In section 3 we introduce our dataset and discuss the patterns of technical progress in steam locomotives as reconstructed using the proposed index of technological change. In section 4 we reassess the policy mix of tariff and non-tariff barriers towards the steam locomotive industry from 1850 ca. to the nationalization of the railways sector in 1905. In section 5 we examine the new policy mix characterizing the nationalization period. Section 6 concludes.

## *2. The steam locomotive industry in Italy: background and motivation*

The "founding fathers" of the debate on Italian industrialization spilt a good deal of ink 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 overall rate of economic growth (Gerschenkron, 1962). In particular, in the Italian case, Gerschenkron (1962, p. 84) regarded the development of the railway infrastructure as one of the "weakness of Italian industrialization" during the period of the "big spurt" (1896-1908) of the Giolittian period. By that time, according to Gerschenkron, the development of the railroad network was largely completed, so that it failed to provide a significant stimulus to the growth of the industrial sector during that crucial historical phase.

To date the most comprehensive economic appraisal of the relation between railroads and industrial growth in post-Unification Italy is due to Fenoaltea (1983, 2011). Fenoaltea's appraisal of the backward linkages of the railways casts major doubts on Gerschenkron's hypothesis. In fact, Fenoaltea's estimates (Fenoaltea, 2011, p. 177) show that the total amount of railway investment was roughly constant throughout the period 1861-1913 (180 million lire per year at 1911 prices). However, according to Fenoaltea, the composition of investment was more important than its size, an issue neglected by Gerschenkron. In the period 1861-1895 the large bulk of investment was

devoted to construction (mostly using unskilled workers for earthworks and related activities) and only a relatively reduced share (10%) was devoted to the purchase of metalmaking or engineering products. Instead, in the period 1896-1913, the share of investment devoted to metalmaking and in particular to engineering products did rise (to about 30% of the total annual investment). Most importantly, maintenance (both of railway lines and of rolling stock) grew throughout this period so that by the end of the period it was comparable to investment in terms of value added. Remarkably, "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 viewpoint, the steam locomotive represented surely a relatively sophisticated piece of equipment. Steam locomotives are constituted of hundreds of parts, most of them requiring accurate manufacturing and processing. In this respect, Philip Scranton (1997, p. 99) who regards steam locomotives as a quintessential example of nineteenth century "specialty production" has aptly noticed: "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 by individual customers. All this clearly meant that locomotive manufacturers were required to marshal a significant breadth of engineering competences and skills. Furthermore, even if the broad contours of locomotive design were probably firmly established around 1850s, throughout the second half of the nineteenth century, steam locomotives underwent a stream continuous technical improvements which compelled a continuous revision and updating of many details of locomotives design and manufacturing (Sinclair, 1907).[5]

For all these reasons, the steam locomotive provides an interesting perspective on the process of absorption of a relatively "advanced" technology in 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 Belgium, France, United States and Germany. The second wave comprises the period (1880-1920) and, in this phase, we witness the emergence, with varying fortunes, of the manufacturing of steam locomotives in Italy, Russia, Spain and Japan.[6]

So far, the production of steam locomotives in Italy has been investigated by Merger in a series of contributions published during the 1980s (Merger, 1986, 1989), and, more recently, by Ciccarelli and Fenoaltea (2012). The general framework adopted by Merger is that of a latecomer country that initially borrows advanced technologies from abroad and that, subsequently, tries to develop autonomous technological capabilities. It should be noted from the outset, that the main indicator used by Merger for assessing the "performance" of the national producers is simply the number of locomotives produced. In fact, Merger does not consider in detail the technological characteristics of the locomotives produced by Italian and foreign manufacturers. As we shall see, our analysis suggests a rather different interpretation from the one proposed by Merger both in terms of the appraisal of the technological capabilities of the Italian steam locomotive industry and also on the actual effects of specific policy instruments.

[5] 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] In Spain the domestic production of steam locomotives remained limited until the first world war. See Comin et al. (1998, pp. 101-110) and Cayon Garcia and Mayon Rubio (2005) for a useful study of the Spanish locomotive industry in an international comparative perspective and). On the much more successful case of the manufacture of steam locomotive in Japan, see Ericson (1999).

Merger focuses her attention on the connection between trade protection and the development of the steam locomotive industry. In her view, the negative impact of the tariffs on iron and steel imports was somewhat mitigated by an increase in the protection of mechanical engineering products in 1887.[7] Furthermore, in the case of steam locomotives, the impact of the tariff protection on mechanical engineering products was also reinforced by a clause of the Railway Conventions of 1885 establishing that locomotives procurement contracts should have been assigned to national manufacturers if their prices were not higher than the best offer of foreign competitors increased by five per cent. Several contributions have indeed pointed to this "five per cent clause" as a decisve factor accounting for the initial development phase of the Italian production of locomotives after 1885 (Merger, 1986, p. 84, and Federico and Giannetti, 1999, p. 1134). On the other hand, a few dissenting voices have instead suggested that rather than to tariff protection, due attention must be paid on the role of "non-tariff trade barriers" (*i.e.*, peculiar regulations and policies limiting the importation of foreign locomotives) that allowed the creation of a protected space in which Italian manufacturers could move their first steps (Hertner, 1984, pp. 31-32; Calzavarini, 1966, p. 74).

The railway companies operating the different sections of the network were the main purchasers of locomotives and for this reason it is important to bear in mind the institutional arrangements regulating the market in this historical phase. Before the nationalization and the creation in 1905 of the *Ferrovie dello Stato* (a state-owned company), the various sections of the network were operated by private franchise companies. A major reorganization took place with the Railways Conventions of 1885 when the management of the vast majority of the network was assigned to three franchise private companies by means of a renewable contract lasting twenty years. Two major ones, the *Rete Adriatica* (RA) and the *Rete Mediterranea* (RM), covering the peninsula along a west-east divide, and a third one, the *Rete Sicula* (RS), operating in Sicily[8].

## *3. The steam locomotive industry in Italy: new evidence, new conjectures*

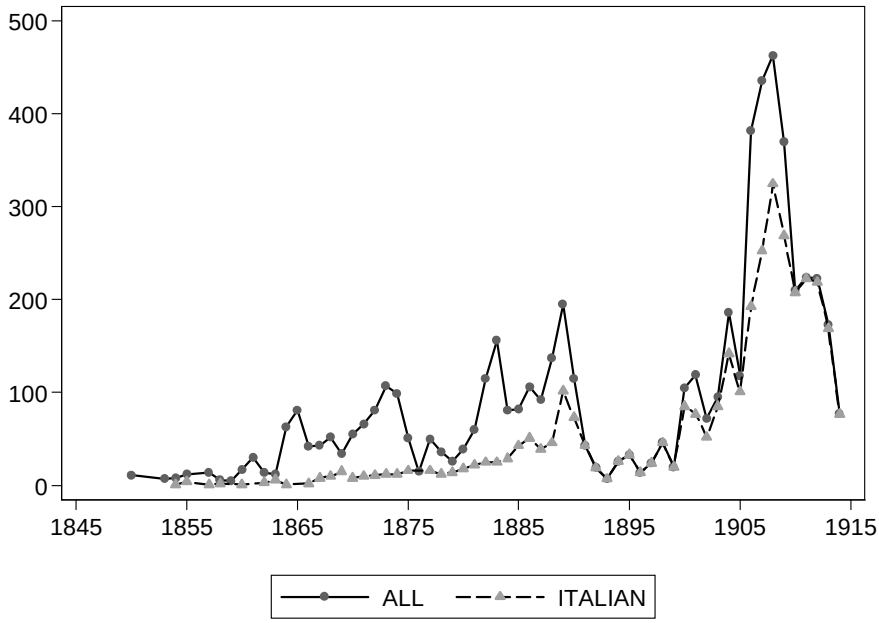
The evidence presented in this paper is largely based on a new locomotives dataset. As described in Appendix, the dataset includes two major components. The first one was obtained using the same sources and adopting much the same approach of Ciccarelli and Fenoaltea (2012) in their statistical reconstructions of the rail-guided vehicles industry in Italy during the Liberal Age. In this way, we were able to gather information on 5,700 locomotives. For each locomotive the sources report the year and place of production, the producer's name, and a numerical identifier. The second component of the dataset is based on the authoritative handbook by Cornolò (1998) representing possibly the definitive account, from the perspective of engineering history, of the development of locomotives in Italy. From this source we have collected a number of indicators of the technical characteristics and performances of the locomotives operating in Italy during the period 1850-1913. By combining the two components of the dataset we are able to chart in detail the technological characteristics of the different segments of the locomotive park installed in each year.

### *3.1 The process of import-substitution*

Figure 1 includes two annual series. The first refers to the total number of locomotives, the second to those manufactured by national producers. The vertical difference between the two series represents thus the number of locomotives by foreign manufacturers.

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

[7] According to Gerschenkron (1962, p. 82), even after the revision of the tariff 1887 the degree of protection of the mechanical engineering industry was too limited to exert major effects.
[8] For a more detailed outline, see the "Supplementary material" section and reference therein.




*Source*: see text.

Figure 1 shows that until mid-1880s, the Italian market is essentially dominated by foreign manufacturers. During the 1890s there is major slowdown during which, Italian producers gain the entire (but indeed limited) national market. Finally, there is a new "growth spurt" during the 1900s. In this phase, Italian producers still maintain the largest share of the market (although it is interesting that in the peak of investment after 1905 there is a significant resurgence of foreign manufacturers).

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

| | (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 |

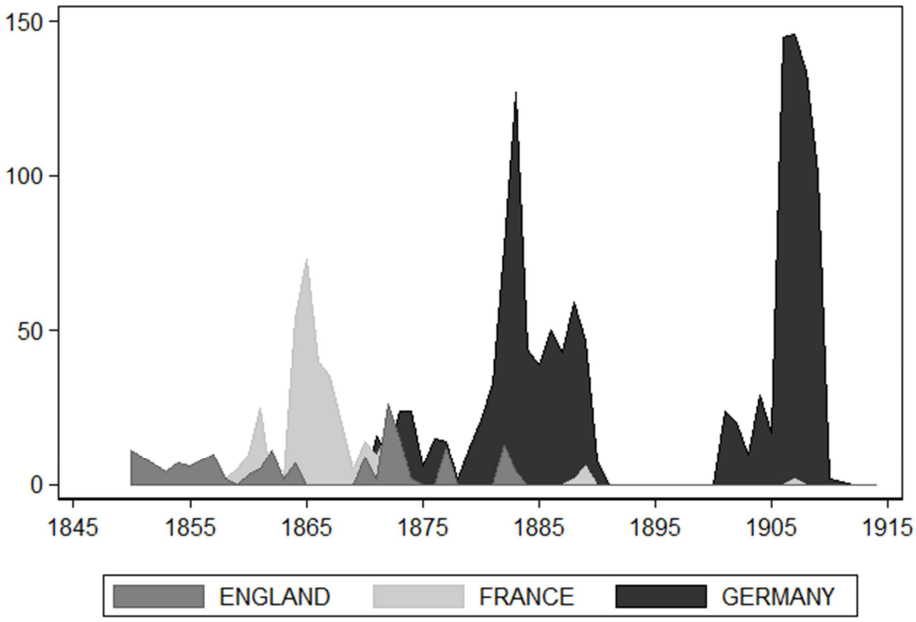
[a] col. (1) = col. (2) + col. (3). Rounding apart, col. (4) = col. (2)/ col. (1) and col. (5) = col. (3)/col.(1).

*Source*: see text.

Table 1 complements Figure 1 by showing the underlying figures grouped by decade. Table 1, cols. 1-3 quantifies the expansion of the 1880s and the upsurge after the turn of the century, a temporal pattern so often recurrent in Italian macroeconomic aggregates of the period. The rising share of national producers (import-substitution) is instead visible in Table 1, cols 4-5-

The interpretation put forward by Merger (1986, 1989) relies, in a substantial way, on the type of evidence presented in Table 1 (and Figure 1). In her account, the limited number of locomotives produced in the period 1861-1885 is due to three concomitant factors: the limited depth of the technological capabilities of the national firms, the lack of specialization (increasing their costs), and the penalties induced by the tariff. After 1885, by virtue of the new Railways Conventions, a new wave of investments took place. In this phase there is an increase of the share of national producers (according to Merger, this may also be due to the role played by public policies in favor of national manufacturers). The ultimate consolidation of the national industry of steam locomotives, according to Merger, takes place after 1905 when the production of national producers is elicited by the wave of investment following the creation of *Ferrovie dello Stato (FS)*.

Figure 2: Locomotives produced for the Italian market: selected countries, 1850-1913 (units).




*Source*: see text.

Figure 2 shows the series of locomotives produced for the Italian market by three major countries (England, France, and Germany). The historical sequence pointed out in Merger's account is also visible in this figure. In an initial phase, the Italian import market is dominated by English producers, in a second phase by French producers, and finally by German manufacturers (for whom, the Italian market was clearly significant).

*3.2 Patterns of technical change*

Our indicator to study the dynamics of technical change in steam locomotives, and to assess the actual gap between Italian and foreign producers, is the traditional weight-to-power ratio.[9] This indicator is widely used in the technical literature on the performance of locomotives (and of other vehicles as well). The weight-to-power (*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.[10] In the celebratory centenary volume of Italian railways (Ferrovie dello Stato, 1940), the weight-to-power ratio is indeed used as a general indicator to chart the progress of the most representative exemplars of steam locomotives constructed in Italy. In the same vein, in a celebratory publication of 1961, the engineer Manlio Diegoli described the evolution of the weight-to-power ratio as a performance indicator that was "a clear expression of technical progress" in steam locomotives (Diegoli, 1961, p. 114). According to Diegoli, this performance indicator was particularly relevant in the Italian context 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 a struggle between the increasing weight of locomotives and rails' – of iron first of steel then – capability to bear it.

The construction of the index of technical change is relatively straightforward. For each locomotive we computed the *whp* ratio using the data from Cornolò (1998) (providing the power in HP and the weight in kg).[11] The *whp* ratio represents therefore our proxy of technical performance of the various "types" of locomotive. 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*. At each moment in time, locomotives of various types and characterized by different *whp* are introduced in the locomotive park. We construct an industry-level index (*WHP)* of technical change as the weighted average of the technical performance of the different locomotive types entering in service in that year:[12]

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

In the above formula *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

[9] This approach is consistent with the paradigm/trajectory framework for the study of technical change proposed by Dosi (1982). In Dosi's terminology the historical evolution of the weight-to-power-ratio represents a "technological trajectory".

[10] 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.

[11] The tender's weight is always omitted from our calculations.

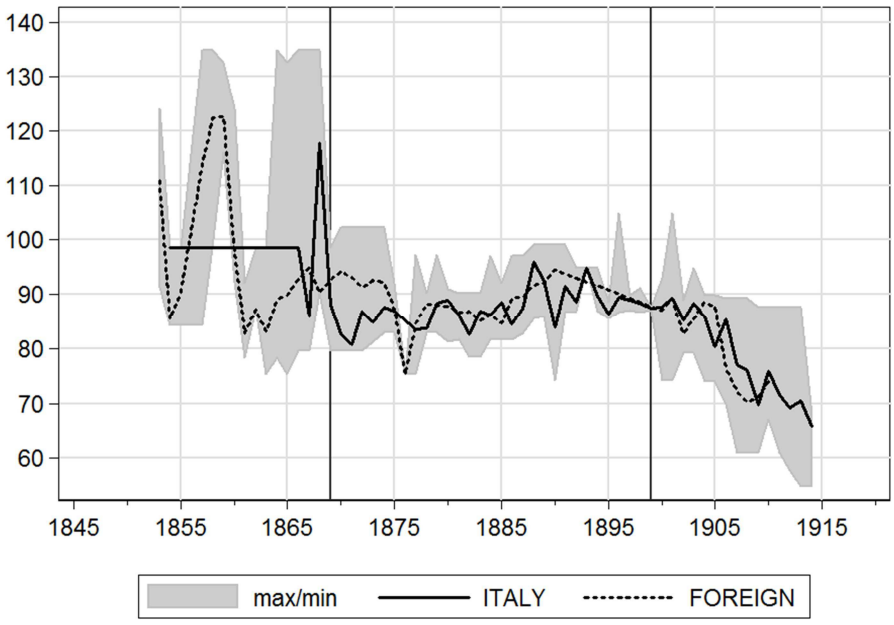
[12] Van Dijk and Szirmai (2006) have constructed a similar index of technical progress for the Indonesian pulp and paper industry.

different types of locomotives introduced in year *t*, and $whp_g$ is the weight-to-power ratio of locomotives of type *g*.[13]

It is important to point out that the proposed index portraits 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 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 3 presents the evolution of the proposed indicator of technical change (WHP) and may be regarded as the core of this paper. The continuous line represents the temporal evolution of the WHP index for Italian manufacturers, whereas the dashed one represents the case of foreign producers. The area shaded in gray is delimited, year by year, by the maximum and minimum sample values of the WHP index.

Figure 3: The weight-to-power index (WHP), 1850-1913.




*Source*: see text.

Overall, in the period in question, the WHP index is clearly characterized by a decreasing trend, reflecting technical progress in steam locomotives. This long-term reduction can be characterized in terms of three major phases. The first (1850-1868 ca) presents some relatively wide fluctuations (which may perhaps be interpreted as a phase of "exploration" of the boundaries of the technological paradigm, or just a consequence of the limited sample size). There is then a phase (1868-1898 ca) of substantial stability with no visible improvements. Finally, there is a phase of

[13] For the sake of illustration, consider a world made up of only two locomotive groups. The first (Group A, including 10 locomotives) with a *whp* index equal to 90; the second (Group B, including 40 locomotives) with a *whp* index equal to 70. In this case *WHP* = 0.2 * 90 + 0.8 * 70 = 74.

rapid acceleration (1898-1914). This pattern is not surprising. Railways, in Italy as elsewhere, were first laid out across the plains. Conquering the mountains was a subsequent step undertaken in the second half of the 19th century. It required more powerful locomotives and better railway infrastructures, including tracks, bridges, and embankments. Accordingly, the last decades of the century represented years of crucial technical progress for the steam locomotives world. 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). A compound locomotive is a steam locomotive which is powered by a compound engine where steam is expanded in two phases. The steam goes first through a (high pressure) cylinder and then it is redirected through a second (low pressure) cylinder, generally of higher diameter. The exhaust steam is eventually expelled out through the chimney. Compounding has two main advantages. The first is that it reduces the consumption of coal and water. The second, mostly relevant here, is that it reduces the weight-to-power ratio due to increased efficiency in the use of steam. Compounding also presents disadvantages such as the increase an increase in the operation and maintenance costs. Compound locomotives were firstly adopted in 1894 by the *Rete Mediterranea* and only later by its *Rete Adriatica* competitor.[14] The technical advantages due to the diffusion of super-heating are somewhat more difficult to describe. The basic idea is as follows. The burning of coal rises the temperature of the water. Once the boiling temperature is reached, the water's temperature ceases to rise. The water goes from a liquid state to a vaporous state. Saturated steam (or "wet steam") is steam in equilibrium with the heated water at the same pressure. At this point, saturated steam can be either injected directly into cylinders or receive an extra amount of heating reducing condensation. This dry steam has, other things being equal, a greater volume than wet steam, resulting in a lower weight-to-power ratio. According to Diegoli superheating was able to increase, other things being equal, the power of a locomotive of about 20-25 percent. In the pre WWI years, the new locomotives introduced in Italy used almost invariantly super-heated steam instead of the more traditional saturated steam.[15] Saturated steam and simple expansion characterized the steam locomotives of "first generation," of the 19th century. Compounding and super-heating were instead the key features of the "second-generation" of steam locomotives. These two innovations were usually considered as alternative ways of increasing locomotives efficiency, although in some cases were adopted simultaneously. Both innovations can perhaps be seen as the response of steam locomotive to the threat coming from an alternative technology, that of the electric locomotives, that after the turn of the century was in its pioneering phase.[16] To summarize, the first conclusion stemming from the analysis of historical trends of the WHP index depicted in Figure 3 is that, during the second half of the 19th century, the steam locomotive world was, from a technological point of view, particularly dynamic.

Figure 3 further contributes to the existing literature by quantifying the extent of the technological gap between Italian and foreign manufacturers for an important segment of the engineering industry. It emerges that, perhaps surprisingly, the performance of Italian and foreign manufacturers is absolutely comparable throughout the entire period considered (including the initial phase). To facilitate comparisons, Table 2 reports, the average WHP index by decade for national and foreign producers.

[14] Further details are given in Appendix A; see also Diegoli (1961), pp. 108-109.

[15] See Diegoli (1961), p. 111.

[16] The homogeneous electrification of Italy's railway network was only accomplished during the 20th century, limiting inevitably the early diffusion of electric locomotives.

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

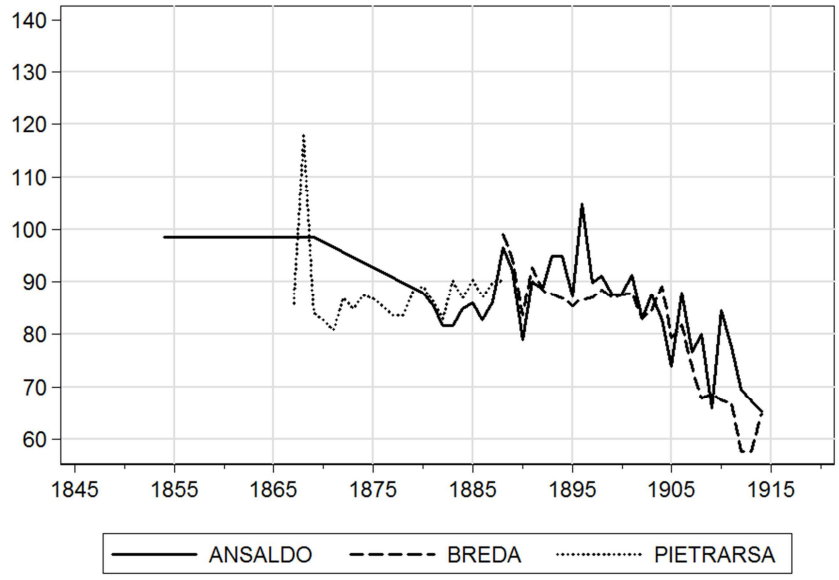
| period | (1) Italian | (2) foreign |
|---|---|---|
| *1850-1860* | 98.56 | 106.25 |
| *1861-1870* | 96.07 | 89.64 |
| *1871-1880* | 85.69 | 88.02 |
| *1881-1890* | 87.43 | 88.63 |
| *1891-1900* | 89.20 | 87.00 |
| *1901-1914* | 77.87 | 79.14 |

[a] The table reports the average value of the WHP distribution.
*Source*: see text.

Again as in Figure 3, throughout the period considered, the average WHP index decreased from about 100 to about 80 with no noteworthy difference between national and foreign producers in each of the three historical phases (roughly 1850-1868, 1868-1898, and 1898-1914) considered before.

Figure 4 complete the picture by reporting the WHP index for the main Italian producers of steam locomotives (Ansaldo, Breda, and Pietrarsa). It is interesting to notice that each producer seems able to manufacture, from a very early stage, locomotives with a performance fully in line with that of foreign producers.

Figure 4: The weight-to-power index (WHP), 1850-1913: main Italian producers.




*Source*: see text.

On reflection, the evidence of Figures 3-4 and Table 2 is not consistent with the accounts prevailing in the literature emphasizing the limited depth of engineering capabilities in Italy. As we have seen, Toniolo (1977) has no qualms in characterizing the entire Italian engineering sector as a backward one. Fenoaltea summarizing the literature, notices that Toniolo's assessment "proved to be an ace: it

has been repeated with approval for example by Luciano Cafagna, then by Vera Zamagni, then again by Jon Cohen and Giovanni Federico". Fenoaltea notices instead, in disagreement with the prevailing view, that at the end of the 19th century Italy was able to export "… major naval vessels, then the very pinnacle of technological sophistication" (Fenoaltea, 2011, p. 150 and citations therein).

In the case of steam locomotives, Merger follows the broad consensus view on the technological backwardness of the Italian engineering sector and points to the restricted base of engineering skills of the country, assuming that it was also characteristic of the steam locomotive industry (Merger, 1986, pp. 76-77). In fact, it is possible to point to shreds of contemporary evidence suggesting that at least since the late 1870s Italian manufacturers were indeed capable of designing and producing steam locomotives of quality fully comparable to that of foreign competitors.

In a conference for the Exposition of Milan of 1881, prof. Leonardo Loria delivered this stark assessment:

> 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).

Another major technical achievement attained in this pioneering phase was the design of the "Mastodonte dei Giovi", a locomotive designed as a combined version of two basic Stephenson locomotives and able to deliver enough power to overtake the steep inclination of the Giovi tunnel passing through the Apennines on the Turin-Alessandria-Genoa line. This locomotive was designed by G. Sommellier, an Italian engineer who supervised the works of the celebrated Mount Cenis/Frèjus tunnel connecting France and Italy through the Alps since 1871. Furthermore, Cornolò mentions, in his detailed historical account, 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.[17]

In our view, these shreds of evidence suggest that the difficulties faced by Italian locomotive manufacturers were more of economic than of technical nature, and strictly connected to the structure of Italy's tariff policy. Interestingly enough, this notion was also entertained in the writings of several authoritative contemporary observers. The next section illustrates the point.

*4. The early policy mix towards the steam locomotive industry*

During the period 1870-1885 ca., several parliamentary select committees (PSCs henceforth) debated alternative forms of State intervention to sustain the development of 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." Much of the discussion focused on the relative protection to be guaranteed to the different industries.

The early 1870s PSC "on industry" (*Comitato dell'inchiesta industriale*) investigated the capacity of the national industry to compete with foreign producers and the possible role played by custom

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

duties in enhancing the competitive potential of national manufacturers.[18] The inquiry considered several industrial sector and the engineering sector was one of the most debated. Many authoritative observers and practitioners (including businessmen, managers, and engineers) were interviewed. The main locomotive producers of the time were Ansaldo (near Genoa established in 1854) and Pietrarsa (near Naples, established in 1842). They were asked to produce evidence of the effects of import duties on the production of steam locomotives in Italy. Both Giovanni Ansaldo and the Pietrarsa's delegates put forward compelling evidence pointing clearly to the negative effect of the tariff's structure on the domestic production.[19] Tables 3 and 4 reproduce the evidence. The tables refer in particular to the Pietrarsa (Naples) and Ansaldo (Genoa) workshops and to the late 1860s and early 1870s period.[20]

Table 3 reports the cost structure of a typical locomotive in the Pietrarsa workshop. Table 3, col. 2 shows that some 70 percent of a "standard" steam locomotive was made of iron, while the remaining 30 percent was made of pig-iron, brass-tubes, copper, steel, and bronze. Total inputs' weight equaled to 43,318 kg. Table 3, col. 4 reports the total cost of production (excluding labor and transport costs), with a breakdown into eight elementary components. The total cost of materials was, import duties apart, equal to 29,610 lire. Once import duties levied on inputs are included, the amount rises to 32,970 lire, corresponding to some 10 percent increase (Table 3, col. 6). The very last line of the table 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 about 40 tons, the import duty amounted thus to 1,600 lire.[21] The tariff's structure, therefore, implied an additional cost of 3,360 lire in case of domestic production and of 1,600 lire in case of acquisition from abroad, resulting, in this way, in a negative protection for Italian locomotive producers.

Table 4 reports similar data provided by Giovanni Ansaldo. The data refer to a locomotive of a "1858 Government type". The basic argument is that total import duties (Table 4, col. 4) of about 2,811.28 lire paid by national producers were well above the 1,570 lire paid as duty to import the same locomotive from abroad. The calculations by Ansaldo are indeed extremely coarse. Inputs weight losses occurring in the production process, and transportation cost – both raising the extent of negative protection – are ignored altogether.[22] Similarly, labor costs are neglected. To summarize, Tables 3 and 4 show clearly that in the early 1870s at least a half of a locomotive was made up of highly-protected-iron, amounting to a negative protection.

[18] 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.

[19] 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 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).

[20] 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.

[21] Early estimates by 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.

[22] The existence of a negative protection on steam locomotives in the early 1870s was appreciated also by other authoritative contemporaries. Pareto (2005) claimed that "after elaborated calculations on the amount of pig-iron, iron, steel, copper, and bronze used to produce a locomotive, one can show that, once import duties are duly accounted for, it would be more convenient to buy the whole locomotive directly from abroad." In a similar fashion, Cognetti de Martis (1877), p. 22 discussed the *protezione a rovescio* ("reverse protection") on the production of steam locomotives in Italy.

Table 3. The negative protection of the Italian steam locomotive industry in the early 1870s: the case of 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 of course 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. The negative protection of the Italian steam locomotive industry in the early 1870s: the case of 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.

The conclusions of the PSC "on industry" concerning Italy's engineering sector were the following: i) "there is no balance between the ("high") tariff on iron and the one ("low") on machines"; ii) "it is necessary to reduce the tariff on iron" iii); "alternatively, it is necessary to raise the tariff on machines" (Comitato della inchiesta industriale, 1874, p. 6). As a matter of fact, both the duties on iron and locomotives were raised over time, a point on which we will return later in this section.

A few years later, in the late 1870s, businessmen, managers, engineers and other experts of the steam locomotive industry were interviewed again by the PSC "on railways" (*Commissione d'inchiesta sull'esercizio delle ferrovie italiane*). Here it suffices to recall the deposition by Pietro Peirano, a manager of Ansaldo. He confirmed that the key factor that had forced his company to give up the production of locomotives was the penalty induced by the tariff, rather than the lack or backwardness of technological competences.[23]

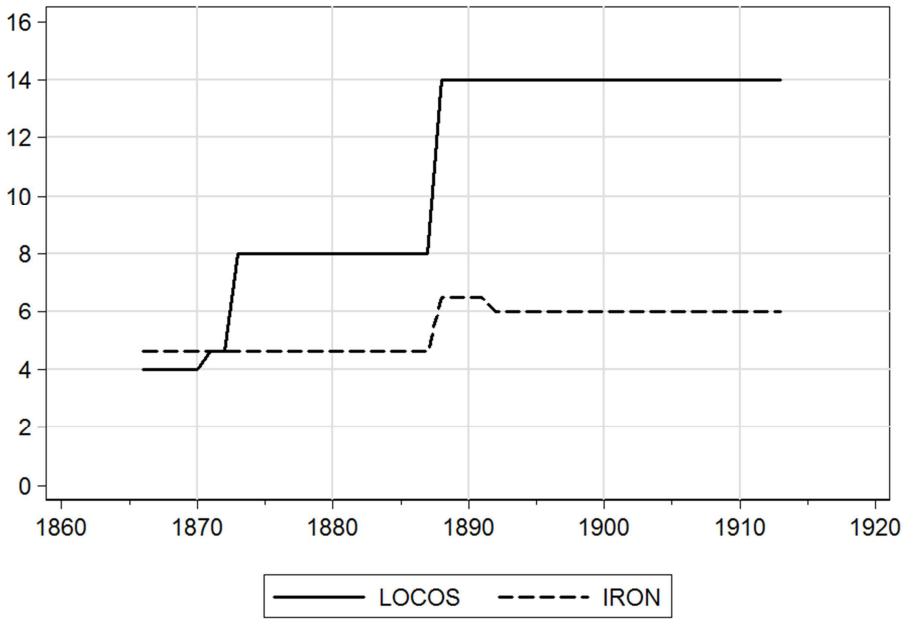
[23] Peirano confidently stated "We could outcompete foreign firms if raw materials were exempted from import duties". Even if self-interested, in our view the statement probably reflects a sincere assessment. In fact in the same interview it is also discussed the special procurement policy practiced by *Ferrovie Meridionali* in favour of Pietrarsa. Clearly, if

The main producers of steam locomotives (including of course Giovanni 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. They largely confirmed the answers given to the previous PSCs of the 1870s: the cost of protecting the metalmaking sector (with high import duties on iron and other production inputs) represented still a much too heavy burden for the engineering sector.[24]

*4.1 Net protection on steam locomotives*

The subsequent tariff reforms – above all that of 1887 – guaranteed gradually a positive protection to Italian producers of machinery (locomotives included), while rising at the same time the protection on iron. Figure 5 summarizes this point.

Figure 5: Import duties on steam locomotives and iron, 1865-1913 (lire per 100 kg).




*Source*: see text.

The continuous line refers to the custom duty (lire per 100 kilograms) on locomotives with separate tender imported from abroad. The dashed line refers to the corresponding duty on iron (lire per 100 kg) imported from abroad. As a result the vertical distance between the continuous and dashed line illustrated in Figure 5 provides a measure of the net-protection on steam locomotives. The measure is clearly rough for several reasons. First, as Tables 3 and 4 show, iron was not the only input in the production of steam locomotive, though it was undoubtedly the most relevant one in terms of weight. Second, import duties were paid in gold so that the evolution over time of the rate of exchange – the lira was "strong" over the 1880s and the 1900s, and "weak" during the 1890s – played an important role in determining the actual effectiveness of protectionist measures. Third,

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).

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

Italian import duties were mainly tied to weight (not to value), and thus the less effective the higher the price of imported goods. Finally, but importantly, the inputs' weight losses occurring during the production process are not considered in Figure 5. Including them would determine an upward shift of the whole dashed curve referring to iron duties possibly of about 20-30 percent.[25] While keeping these important limitations in mind, Figure 5 tentatively suggests that the net protection on steam locomotives turned over time from negative to positive. Interestingly, this outcome was a consequence of the increase, in different proportions, *both* of the import duties on iron and locomotives. Import duties on steam locomotives were raised from 4 lire to 4.62 lire in 1871; from 4.62 to 8 lire in 1873; from 8 lire to 14 from 1888 on (all data refer to lire per 100 kg). Import duties on iron were raised from 4.62 lire to 6.50 in 1888 and then lowered to 6.00 lire from 1892 on (all data refer to lire per 100 kg).[26]

Indeed, the evidence discussed so far suggests a reappraisal of the history of the locomotive industry in Italy, while, at the same time, questioning some elements of the prevailing narrative. In our interpretation, the technical attainments of Italian firms and engineers in the field of locomotive design and production indicate that the structure of the tariff rather than their alleged technological backwardness represented probably the main bottleneck stifling the expansion of the industry during the 1870s and in the first half of 1880s (see again Figure 2). This constraint became less stringent when the effective rate of protection on steam locomotive turned from positive to negative in the late 1880s.[27] Therefore, the evidence on the effective protection rate suggests that, for the period until the late 1880s, the early assessment by Gerschenkron (1962) is fully vindicated. If this is the case, what accounts for the first wave of growth in locomotive investment that, according to our data, took place from 1885? Two key factors have been discussed in the literature. The first factor is the 1887 reform of the tariff that we have just mentioned, raising the import duty on steam locomotives from 8 to 14 lire per 100 kg and thereby ensuring a positive net protection on that segment of the engineering sector.[28] The second factor is the five percent clause introduced by the Railways Conventions of 1885. The clause established that locomotives procurement contracts should have been assigned to national manufacturers if their prices were not higher than the best

[25] 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.

[26] 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.

[27] 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.

[28] 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 distributed over time as follows: 22 units in 1892, 12 units in1898, 28 units in 1899, 16 units in 1900, 35 units in 1901, 24 units in 1902 mainly to the Romanian and Danish States (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 established producers including Beyer & Peacock, Henschel, Maffei, and Wiener Lokomotivfabriks; "exports" to Italian colonies of Libya and Eritrea are documented in Tipi del materiale rotabile (1914) and Gatti (1975).

offer of foreign competitors increased by five per cent. (Ministero dei lavori pubblici, 1901, p. 203-204; see in particular footnote 1). This point remains controversial. According to Gerschenkron (1962, p. 371) the five percent clause was probably too weak to exert a major impact. Similarly, Caizzi (1965, p. 381) and Papa (1973, pp. 50-51) maintain that the protectionist clause introduced in 1885 were of little help to the national industry. On the other hand, the more recent literature, including Merger (1986, p. 84), Giannetti and Federico (1999, p.1134), and Giannetti e Vasta (2012, p. 226), argue instead that the clause had a critical role in accounting for the "take-off" of national production of steam locomotives since 1885.

*4.2 The silent procurement policy of the 1885-1899 period*

There are two features of the Railway Conventions of 1885 that so far have received only limited attention, but are probably far more important that the five percent clause and the revision of the tariff in accounting for the first growth spurt in the domestic production of locomotives. 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 very active procurement policy that was put in place after 1885, which, although not established by law, amounted to a favor to "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).

In fact, 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 procure locomotives directly from the manufacturers. Ministero dei lavori pubblici (1901) contains some aggregate data on the purchase of locomotives for the period 1885-1899 subdivided according to the type of purchase. These data are set out in Table 5.

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.

Two points merit attention. First, as already noted by Gerschenkron, Table 1, cols. 4-5 show clearly that the five per cent clause was by no means sufficient to tilt the price advantage in favor of national manufacturers. The second is that a significant stimulus to the national industry was actually implemented by means of special deals. So far, this procurement policy has received little attention in the literature. Perhaps the major exception is Calzavarini (1966, p. 74) who points to the key role played by "non-tariff trade barriers" in compensating the "the insufficient protection of the trade regime".[29] Calzavarini's appraisal is indeed fully confirmed by the evidence presented in Table 5.

Table 5, cols. 1-2 show clearly that, in the fifteen years from the Railway Conventions of 1885 to the end of the century, the production of steam locomotives for the national market by Italian producers was driven either by national auctions (284 units out of 595) or by private negotiations (311 units out of 595). Given the availability of these preferential channels, international auctions were ignored altogether by national producers. The point, largely overlooked in the current literature, was clear to contemporaries at the point that Lampugnani (1890), p. 745, when referring to Italian producers claims that: " … international auctions were abandoned … and about 1/3 of locomotives orders to Italian producers was agreed with national auctions and about 2/3 through private negotiations". Columns 3-5 of Table 1 are also of some interest, and can be interpreted in two alternative ways. The first is that foreign producers, either because more efficient than Italian producers or just because practicing an aggressive dumping policy, where able to sell steam locomotives at lower prices than the Italian producers; the second, perhaps more plausible, is that

[29] For a general discussion of non-tariff trade barriers, see Baldwin (1970).

the Italian producers exploited direct procurement to fetch a good price in their private negotiations with the Italian government.

A careful analysis of parliamentary proceedings provides a more complete picture of the rising protectionist mood of the time and, more generally, of the various forms of State intervention in the railway sector. Here below, for reasons of space, we can provide just a summary account of these debates.

At close reading, the adoption of stronger protectionist measures to favor Italian producers appears to be a leitmotiv of the parliamentary discussions. A first example is provided by the debate culminated on February 7, 1885 with the rejection by the Chamber of Deputy (188 Deputies against the motion, 127 in favor of it) of the so called "Baccarini motion" (Camera dei Deputati, 1885). The motion proposed that: "Any future acquisition [of rolling stock and other material] by the railway companies should be satisfied through orders to national producers. Only in exceptional cases, after Government approval, orders can be placed to foreign producers."[30] Sure enough, the motion was rejected; but the fact that about forty percent of voters were in favor of excluding altogether foreign producers from the Italian locomotive market clearly shows how rooted was protectionism among policy makers of the time. Another revealing episode is the so called "Colombo-motion" of 1891 (Camera dei Deputati, 1891a, pp. 370-71), from the name of the proponent, Giuseppe Colombo, engineer, entrepreneur, and politician of the time. The motion stated: "The Chambers of Deputies asks the Government to study the proper way to guarantee to the national producers the continuity over time of procurement contracts that the public works ministry and other public agencies will administer […]." The Colombo-motion, approved by the Parliament, might appear a bit vague at a first reading, but is centered on the crucial argument of guaranteeing to the national industry a regular flow of demand. On this specific issue, Vittorio Ellena, chief authority on the matter of Italy's industry and trade policy argued that: "to achieve adequate efficiency a firm should produce one locomotive per week." (Camera dei Deputati, 1891b, p. 278). Finally, about ten years later, the spirit of the "Colombo-motion" of 1891, was recalled in a motion (approved by the Parliament) asking to the Government "… to present a plan [on future acquisitions of rolling stock] to ensure the regular development or railway traffic and … to give full execution to the Colombo-motion of 27 January 1891 asking the Government to guarantee to national producers a regular demand [of locomotives]." ("mozione Ferraris", from the name of the proponent; Camera dei Deputati, 1900, p. 1352).

To summarize, this brief account of the parliamentary debates on locomotives between 1885 and 1900 suggests that: i) the various forms of tariff protection were not believed to be sufficient; ii) the major problem faced by national producers was the irregularity over time of the demand for locomotives with sharp peaks followed by years of relative stagnation, preventing the regular and efficient scheduling of production plans; iii) a different policy-mix assigning greater weight to more direct forms of State intervention was urgently advocated.

*5. The birth of the* Ferrovie dello Stato *(1905) and the new railways policy.*

The late nineteenth-century parliamentary debate on railways produced relevant effects in terms of actual economic policies. Immediately after the turn of the century, and much in line with the content of the Colombo-motion of 1891, the Government presented a plan concerning the acquisition of new rolling stock for the years 1900-1904. It was established that "the quantity, quality, and expenditure … [for new acquisitions] … will be agreed between the State and the operating companies".[31] Furthermore, during the same five year period, the Government provided the operating companies a grant (non-repayable fund) of 28 million lire, reinforcing thus his role of

[30] Alfredo Baccarini, Minister of public works from 1878 to 1883, was surely well informed on Italian railway issues.
[31] Thus article 9 of law no. 57, February 27, 1900.

chief sponsor of the railway sector. [32] It has been noticed accordingly that "the railway plan of 1900 represented the greater State commitment towards railways up to the creation of the *Ferrovie dello Stato* in 1905" (Papa 1973, p. 50). Times were mature for the complete State management of the railway sector and calls for a general reshaping of the system – that is the complex set of relations between the State, the railway companies, and the producers of rolling stocks – gained increasingly momentum. Statements such as "We passed from an insufficient protection to an excessive one. … When the price differential between national and foreign producers reaches level well above 20 percent, as happened in recent years, the protection of the national industry constitutes a burden too heavy for the public budget …." became recurrent in the parliamentary debates.[33] The twenty-year contract between the State and the operating companies (the Railway Conventions of 1885) was, at this point unsurprisingly, not renewed.

The rules of the game were ultimately changed in 1905 when the direct State management of the railway system started with the birth of the *Ferrovie dello Stato* (FS) a fully public company.[34] On the one hand, the protection of the national industry was confirmed and even reinforced. On the other hand, a more rigorous expenditure policy was put in place: "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."[35] Two points deserve attention: i) the tool of direct procurements to assign orders to national producers was explicitly institutionalized, ii) the State intended to use international auctions as an external threat to prevent or at least limit national producers in their attempts to get the highest possible selling prices for their locomotives.[36]

The actual effects of the new FS regime on locomotive acquisitions and related prices is illustrated in Tables 6 and 7. The tables set out quantity and price data as contained in 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). Table 6 col. 2 shows that 291 locomotives were assigned to national producers by means of direct procurement contracts, and 112 to foreign producers of various European countries by means of international auctions.

[32] Thus article 1 of law no. 57, February 27, 1900.

[33] The sentence in the main text refers to the parliamentary speech of April 19, 1905, by Deputy M. Ferraris (Camera dei Deputati 1905, p. 2605).

[34] 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".

[35] Thus article 11 of law no. 137, April 1905. For a critical view see Contento (1905), lamenting the excessive vagueness of the above article 11 when referring to ambiguous concepts such as "whenever necessary" and "fair price of rolling stock." The articles and books review section of the *Quarterly Journal of Economics*, 19, 4, August 1905, p. 663 summarizes Contento's article as follows: "Criticises a protectionist clause in the new State railway legislation, providing that home industries be favored in the purchase of supplies."

[36] 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).

Table 6. Price of 403 locomotives ordered in January 1906 and to be delivered between July 1906 and June 1907, by nationality of the producer.

| producer | (1) FS-group | (2) units | (3) price (lire per kg) |
|---|---|---|---|
| *A. Italians (direct procurement, January 1, 1906)):* | | | |
| 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 | |
| A*verage price*: | | | 1.77 |
| *B. Foreign (international auctions, January 30, 1906):* | | | |
| 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.

*Source*: see text.

The evidence on prices reported in Table 6, col. 3 is more difficult to read. First of all, the average price agreed with national producers at the beginning of January 1906 (1.77 lire per kg, as reported

in Table 6, Panel A, col. 3) represented the maximum level that the State was willing to pay. The actual price paid to national producers was computed by comparing a reference price with the average price of the best offers by foreign producers in the international auction held at the end of January 1906.[37] The reference price was computed as follows. An amount of 0.14 lire per kg, accounting for the tariff on imports of locomotives, was first deducted from the maximum level of 1.77 lire per kg. A further five per cent (to account for the five per cent clause introduced by the Railways Conventions of 1885) was then subtracted from the difference previously calculated. In mathematical terms, the reference price corresponds to 1.77 – 0.14 – 0.05*(1.77-0.14) = 1.77 – 0.14 – 0.08 = 1.55 lire per kg.[38] As anticipated, this is not however the end of the story. To decide the price actually paid to national producers one have to compare the reference price of 1.55 lire per kg with the average price of the best offers presented by foreign producers. In this case, as illustrated in Table 6, Panel B, col. 3, this amount was equal to 1.56 lire per kg. Since the latter is higher than the reference price of 1.55 lire per kg previously calculated, no reduction was applied to the maximum level of 1.77 lire per kg agreed during the private negotiations with national producers.[39]

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 7, col. 2 provides a useful summary view and shows that in 1906 the price gap (about 9 percent) between national and foreign manufacturers was significantly lower than in the previous 1885-1899 period, as documented in Table 5, cols. 3-5.[40] After the turn of the century, with the

[37] As Camera dei Deputati (1906c), p. 13, and article 34 of Law 429 July 7, 1907 on the "State management of the railway sector" report, to evaluate the best offers of foreign producers one has to compute "the average of the lowest prices computed over a half of valid foreign offers. If the number of valid foreign offers is uneven, the average is computed by considering a half plus one."

[38] The calculations concerning the reference price are reported in Camera dei Deputati (1906a), p. 5.

[39] If the reference price happened to be greater than 1.55 lire per kg (say 1.59 lire per kg), then the maximum price previously agreed with national producers (necessarily greater than 1.77 lire per kg) would have been reduced by an amount corresponding to the difference (of 0.03 lire in this case) with the average best offers of foreign producers (1.56 lire per kg), Camera dei Deputati (1906a), p. 5.

[40] 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 obtains 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

birth of the *Ferrovie dello Stato* (FS), the good old times of high prices guaranteed to Italian producers by means private negotiations – compare Table 5, col. 5 and Table 7, col. 3 – seems to be memories of the past.

In 1905, with the creation of the FS, the State was clearly looking for a new policy mix capable to stimulate the national industry, by directly assigning to local producers a great deal of 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. Foreign producers were mainly used as a tool to investigate the price level of locomotives through international auctions and as manufacturers of last resource, in order to absorb demand peaks, above all those occurred in the years 1907-1908 when about 900 locomotives entered the FS locomotive fleet.

The picture we have drawn so far may be further completed by noticing that several informed contemporaries identify in the small and irregular number of orders the main problem affecting the cost competitiveness of national manufacturers (again also in this respect the technological competences of Italian firms were instead deemed as fully comparable to those of foreign producers). Giuseppe Colombo already in 1881 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 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).

More than the need for tariff-based protection (with positive net protection effectively achieved since the late 1880s), the irregularity of demand represented the true leitmotiv anguishing the Italian manufacturers of steam locomotives during the 19th century.[41]

As a final note, to put things in a broader perspective, Table 8, panel A provides a detailed account of government expenditure for the acquisition of various "heavy-engineering" products during the years from 1905 to 1912. Table 8, panel B sets out expenditure on rolling stock, shipbuilding, and artillery and weapons. The table, appended to the celebrated "esposizione finanziaria" of December 7, 1912 made by the Treasury Minister Tedesco to the Italian Parliament in the aftermath of the Italian-Turkish War, distinguishes between supplies by national and foreign producers.

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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.

[41] 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).

Table 8. State expenditure, 1905-1912 (million lire at current prices).[a]

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | railway | | navy | | army | | total | |
| | Italy | foreign | Italy | foreign | Italy | foreign | Italy | foreign |
| *A. Total expenditure* | | | | | | | | |
| 1905-06 | 93 | 52 | 50 | 13 | 54 | 2 | 197 | 67 |
| 1906-07 | 199 | 111 | 52 | 16 | 44 | 12 | 295 | 139 |
| 1907-08 | 242 | 90 | 66 | 13 | 41 | 10 | 349 | 113 |
| 1908-09 | 141 | 37 | 72 | 14 | 63 | 6 | 276 | 57 |
| 1909-10 | 160 | 37 | 90 | 11 | 89 | 14 | 339 | 62 |
| 1910-11 | 142 | 39 | 117 | 9 | 105 | 22 | 364 | 70 |
| 1911-12 | 145 | 44 | 158 | 9 | 119 | 16 | 422 | 69 |
| *total* | *1,122* | *410* | *606* | *85* | *507* | *82* | *2,242* | *577* |
| *B. Selected components of total expenditure* | | | | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | railway: rolling stock | | navy: shipbuilding | | army: artillery | | total | |
| | Italy | foreign | Italy | foreign | Italy | foreign | Italy | foreign |
| 1905-06 | 54 | 31 | 24 | 2 | 6 | 2 | 84 | 35 |
| 1906-07 | 105 | 68 | 27 | 4 | 10 | 11 | 142 | 83 |
| 1907-08 | 142 | 25 | 29 | 6 | 11 | 8 | 182 | 39 |
| 1908-09 | 36 | 0 | 35 | 4 | 10 | 2 | 81 | 6 |
| 1909-10 | 76 | 0 | 47 | 2 | 16 | 11 | 139 | 13 |
| 1910-11 | 61 | 0 | 62 | 3 | 28 | 18 | 151 | 21 |
| 1911-12 | 68 | 1 | 86 | 1 | 37 | 5 | 191 | 7 |
| *total* | *542* | *125* | *310* | *22* | *118* | *57* | *970* | *204* |

[a] Railway: orders by the *Ferrovie dello Stato*; navy: expenditures by the *Ministero della marina*; army: expenditure by the *Ministero della guerra*. Figures in cols. 1, 3, 5, 7 refer to national producers; figures in cols. 2, 4, 6, 8 to foreign producers. Numbers need not to add, due to rounding.

*Source*: Camera dei Deputati (1912), pp. 82-89, Appended Tables 17-20.

While an in-depth analysis is clearly beyond the scope of this paper, three basic facts are however immediately evident. The first is that in an official document by the Treasury minister of the time railways are placed side by side with strategic activities such as the navy and the army. The second is that railways constituted a truly remarkable share of State expenditure (compare cols. 1+2 to cols 7+8). Finally, one may observe that the "national champions" policy was not limited to railways (compare cols. 1 and 2; 3 and 4; 5 and 6). In the light of the above evidence, the impressive State intervention in the railway sector during *the belle époque* can be also considered as part of Italy's attempt to take part in the "great power" politics that ultimately set the stage for the Great War.[42]

## 6. *Concluding remarks*

Our interpretation may be easily summarized. Notwithstanding the limited endowment of the country in terms engineering skills and competences, the Italian steam locomotive industry has in

[42] See Eloranta (2007).

general demonstrated a good performance throughout the entire period in consideration (1850-1913). Italian locomotives were, by and large, of a level of technological sophistication similar to that of foreign exemplars. This was true both in an early phase and also with the acceleration of technical progress brought about by the innovations of compounding and super-heating at the end of the 19th century. Probably to a certain degree, this process of development was disturbed first by the vagaries of the demand which prevented the major national players from planning an ordered expansion of productive capacity and, secondly, by the tariff protecting iron products, which may sound as vindicating a point already made by Gerschenkron a long time ago. On the other hand, from 1885 onwards national manufacturers received a considerable help through a discretionary procurement policy which in practical terms amounted to an effective "non-tariff trade barrier". Hence, on this count Gerschenkron was wrong, since it cannot be said that Italian locomotive manufacturers "were left to [their] own devices".

In a broader perspective, it is interesting to point out that, in the nineteenth century, the design and construction of locomotives were probably among the most sophisticated segments of the mechanical engineering industry. Hence, the fact that Italy was capable to set foot in this sector may appear somewhat paradoxical if one takes into account the bleak performance of other less sophisticated branches. For example, the country was not able to develop any indigenous production in the comparably less sophisticated field of cotton textile machinery (Besso, 1910, pp. 142-143; A'Hearn, 1998). In other branches, the emerging pattern was that of Italian producers focusing on the less sophisticated product niches, leaving to foreign producers the most technologically sophisticated segments of the markets. This is the case described of steam boilers described by Bardini (1997). From this point of view, the successful entry of Italian manufacturers in the production of steam locomotives may be even understood as a case of "technological leapfrogging", in which the backward country is capable to jump directly to the most sophisticated types of technologies (Soete, 1981). Interestingly enough, it is possible also to mention 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 also exported.

If this is the case, the paradox outlined above may be perhaps solved by noting that some of the most sophisticated branches of the mechanical engineering could, at least to a degree, 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.[43]

[43] One of the most forceful critics of the effects of the tariff was Alfredo Cottrau, an engineer who had a firm producing basic and relatively unsophisticated metal components and pieces of machinery (such as truss bridges and roofing). Cottrau was interviewed by several Parliamentary committees. He repeatedly argued against the protection of iron and steel, preventing him to compete adequately in international markets. He also published a small pamphlet on the issue (Cottrau, 1891; on Cottrau see also Fenoaltea 2011, p. 151). Interestingly enough, Vilfredo Pareto in 1891 discussed the effects of the tariff on the mechanical engineering industry fully endorsing Cottrau's analysis (Pareto, 1891).

**Appendix: The steam locomotives dataset.**

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.[44] 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 a series of catalogues portraying the locomotive park of the principal companies operating the railways system at different moments in time. The vast majority of the railway network was assigned in 1885 to three operating companies: the *Rete Adriatica* (RA), the *Rete Mediterranea* (RM), and the *Rete Sicula* (RS). From the late 1880s, these three companies published a series of a catalogues with engineering drawings and lists of the technical characteristics for each type of locomotive in service together with a numerical identifier allowing the precise identification of each vehicle in service, the year of construction, and the name of the building-company.[45] We also used a similar catalogue 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.[46] Our dataset is constructed by merging the relevant quantitative information stored in the above four publications. Luckily enough the sources include a numerical identifier for each locomotive, avoiding the risk of double counting. In this way, we have been able to construct a dataset which includes 5,700 steam locomotives operating in the standard gauge (1,435 meters) Italian railway network during the period 1850-1913. Our sample, limited to the locomotives of the major operating companies, covers about 90% of the total locomotive population.[47]

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 volume is entirely devoted to the detailed technical description of each *Gruppo FS* and represents probably the ultimate account of the development of steam locomotives in Italy from an engineering history point of view. It is worth noting that the historical catalogues also contain similar technical information on locomotives but, to avoid possible inconsistencies arising from collating technical information from different historical sources, we have used Cornolò (1998). In other words, we have chosen to rely on a homogenous secondary source compiled by a truly leading authority in the field.

The WHP calculations in section 3.2 (*Patterns of technical change*) 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.[48] Locomotives in our sample are grouped according to a classification scheme adopted by the *Ferrovie dello Stato* (FS) in 1905. Each locomotive has a

[44] A complete account (in Italian) on sources and methods can be found in Ciccarelli and Fenoaltea (2014).

[45] 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).

[46] Ferrovie dello Stato (1914).

[47] Our dataset does not cover the locomotives of a few private concessionaires (*e.g.*, Ferrovie Nord Milano, or Compagnia Reale Strade Ferrate Sarde). Technical details on steam locomotives used by the Ferrovie Nord Milano are provided by Cornolò (1979). Technical details on steam locomotives used by the Compagnia Reale Strade Ferrate Sarde are provided by the company's annual budget reports. See, for instance, Compagnia Reale delle Strade Ferrate Sarde (1895).

[48] 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).

separated numerical identifier including generally, five or six digits. The first three digits denote typically the group a locomotive belongs to (*Gruppo FS*). The last three digits identify then, within the given group, the specific locomotive. To exemplify, a 120103 identification number would denote the 103th locomotive belonging to FS Group 120.

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 "first-generation" (*i.e.* using single expansion and saturated, or "wet", steam). Panel B refers to groups from 600 to 980, and includes often "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.). Rows contiguity within a given column is generally an indicator of similarity between locomotives of different groups so that, for instance, Gruppo FS 640 shares many features with the Gruppo FS 630. Groups' numbering does not necessarily follow a chronological order and thus, for instance, Gruppo FS 625 was largely inspired by the previous Gruppo FS 640.

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. Going from left to right in panel A, col. 1 to panel B, col. 4, one get a coarse idea of the temporal evolution of locomotive's weight (from about 34,777 kg to 66,531 kg), locomotive's power (from about 378 hp to 932 hp). Power increased more than weight and the average WHP index decreased from about 92 to about 70.[49] A minimum and maximum entry-age, by column, is also reported. Certain locomotive groups deserve a few more words. In our sample, the Gruppo FS 380 includes 50 locomotives. Of these, 20 were built by Vulcan Foundry *(Newton*-le-*Willows*, *Lancashire*, England*)* between 1870 and 1874. The remaining 30 were built by Dübs & Co. (Glasgow, Scotland) between 1871 and 1874. Despite their age, these locomotives were bought in 1906 by the *Ferrovie dello Stato* (FS) from the London Midland Railway.[50] These 50 units represent the only case of second hand locomotives in our sample (comprising 5,700 units) we are aware of. Exceptionally, we attributed these 50 locomotives to the early 1870s, according to their exact year of production, rather than to 1906, when they joined the locomotive fleet operating in Italy.

[49] Table A1, panel B, cols 5-8 report, for the sake of completeness, data on tank-locomotives. These data do not enter the analysis on technical progress carried out in section 3.2.

[50] The average age of a steam locomotive was about 40 years (see, for instance, Ministero dei lavori pubblici, 1901, p. 144.)

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.

**References**

Abramovitz, Moses. “Catching up, forging ahead and falling behind”, *Journal of Economic History* 46, no. 2 (1986): 385-406.

Abramovitz, Moses. *Thinking about growth.* Cambridge: Cambridge University Press, 1989.

Allen, Robert C. “The great divergence in European wages and prices from the Middle Ages to the First World War”, *Explorations in Economic History* 38, no. 4 (2001): 411-447.

A'Hearn, Brian. "Institutions, externalities and economic growth in Southern Italy: evidence from the cotton textile industry, 1861-1914," *Economic History Review,* 51, no. 4 (1998): 734-762.

Baldwin, Robert. *Non-Tariff Distorsions of International Trade*, Washington: Brookings, 1970.

Bardini, Carlo, "I fattori cumulativi nella diffusione di una tecnologia. Le caldaie a vapore in Italia tra la fine del XIX secolo e il 1911," *Rivista di Storia Economica,* 13, no. 1 (1997): 41-74.

Besso, Sabbato. *The Cotton Industry in Switzerland, Vorarlberg and Italy. A Report*, Manchester: Manchester University Press, 1910.

Caizzi, Bruno. *Storia dell' industria italiana: dal XVIII secolo ai giorni nostri*,Torino: Utet, 1965.

Calzavarini Mirella. "Il protezionismo industriale e la tariffa doganale del 1887," *Clio* 2 (1966): 55-93.

Cardwell, Donald. *The Fontana History of Technology.* London: Harper, 1994

Comin, Francisco Comin, Acena, Pablo Martin, Munoz Rubio, Miguel and Javier Vidal Olivares, *150 Anos de Historia de los Ferrocarriles Espanoles*, Madrid, Fundacion de los Ferrocarriles Espanoles, 1998.

Cayon Garcia, Francisco and Miguel Munoz Rubio. "Que fabriquen ellos! La fabricacion de locomotoras de vapor en Espana: una ocasion perdida para la industria" Working Paper, Universidad Autonoma de Madrid, Madrid, 2005.

Ciccarelli, Carlo and Fenoaltea, Stefano. "The rail-guided vehicles industry in Italy, 1861-1913: the burden of the evidence," *Research in Economic History* 28 (2012): 43-116.

Ciccarelli, Carlo and Fenoaltea, Stefano. *La produzione industriale delle regioni d'Italia, 1861-1913: una ricostruzione quantitativa. 2 Le industrie estrattivo-manifatturiere*, Roma: Banca d'Italia, 2014.

Cianci, Ernesto. *Dinamica dei prezzi delle merci in Italia dal 1870 al 1929*, Roma: Istituto Poligrafico, 1933.

Cognetti de Martis, Salvatore. *La rinnovazione dei trattati di commercio. La questione monetaria*, Mantova: E. Segna, 1877.

Colombo, Giuseppe. "Sui progressi compiuti nell'industria delle macchine dall' epoca dell' Esposizione di Firenze ad oggi", in Brioschi, Francesco (ed.), *L' Italia Industriale nel 1881. Conferenze sulla Esposizione Nazionale di Milano,* Milano: Hoepli, 1881.

Cornolò Giovanni. *Cento anni di storia .... delle Ferrovie Nord Milano*, Trento: Globo, 1979.

Cornolò, Giovanni. *Locomotive a vapore.* Parma: Albertelli Editore, 1998 (2nd ed.)

Cottrau, Alfredo. *Le industrie meccaniche e il regime doganale*, Roma: Bertero, 1891.

David, Paul. *Technical choice, innovation and economic growth.* Cambridge: Cambridge University Press, 1975.

Diegoli, Manlio."La trazione a vapore," in Collegio ingegneri ferroviari italiani eds., *Evoluzione tecnica ed economica delle ferrovie nei cento anni dall'Unità d'Italia, 1861-1961*, Rome: Tipografia Pio X: 105-114.

Dosi, Giovanni. "Technological paradigms and technological trajectories" *Research Policy* 11, no. 2 (1982): 147-162.

Eloranta, Jari. "From the great illusion to the Great War: military spending behavior of the great powers, 1870-1913", *European Review of Economic History* 11, no. 2 (2007): 255-283.

Ericson, Steven. "Importing locomotives in Meiji Japan: international business and technology transfer in the railroad industry", *Osiris* 13 (1998): 129-153.

Federico, Giovanni and Giannetti, Renato. "Le politiche industriali" in Amatori, F., Bigazzi, D., Giannetti, R. and L, Segreto, eds. *Storia d' Italia. Annali. L'Industria*, Torino: Einaudi, 1999.

Federico, Giovanni and Tena, Antonio. "Did trade policy foster Italian industrialization ? Evidence from effective protection rates", *Research in Economic History*, 19 (1999): 111-130.

Fenoaltea, Stefano. "Italy" in O'Brien, Patrick, ed. *Railways and the economic development of Western Europe*, pp. 49–120, London: Macmillam, 1983.

Fenoaltea, Stefano. *The Reinterpretation of Italian Economic History*, Cambridge: Cambridge University, 2011.

Hertner, Peter. *Il capitale tedesco in Italia dall'unità alla prima guerra mondiale*. Bologna: il Mulino, 1984.

Gatti, Giorgio. *Le ferrovie coloniali italiane*, Roma: GRAF, 1975.

Giordano, Felice. *L'industria del ferro in Italia; relazione dell'ingegnere Felice Giordano per la Commissione delle ferriere istituita dal Ministero di marina*, Torino: Cotta & Capellino, 1864.

Gerschenkron, Alexander. *Economic Backwardness in Historical Perspective*, Cambridge MA: Harvard University Press, 1962.

Giannetti, Renato and Vasta, Michelangelo. *Storia dell' impresa italiana*, Bologna: il Mulino, 2012.

Greggio, Luciano and Kalla-Bishop, Peter. *Steam locomotives*. New York: Crescent Books, 1985.

Lampugnani, G., "Le nostre industrie meccaniche," *Industria. Rivista tecnica ed economica illustrata* 4, no. 47 (1890): 745-747.

Loria Leonardo. "Il materiale ferroviario" in Brioschi, Francesco (ed.), *L' Italia Industriale nel 1881. Conferenze sulla Esposizione Nazionale di Milano.* Milan: Hoepli, 1881.

Merger, Michele. "Un modello di sostituzione: la locomotiva italiana dal 1850 al 1914", *Rivista di storia economica* 3, no. 1 (1986): 66–108

Merger, Michele. "L'Industrie italienne de locomotives, reflet d'une industrialisation tardive et difficile (1850-1914)," *Histoire, économie et société* 8, no 3 (1989) : 335–370.

Papa, Antonio. *Classe politica e intervento pubblico nell'età giolittiana. La nazionalizzazione delle ferrovie*, Napoli: Guida, 1973.

Pareto, Vilfredo. "Le industrie meccaniche e la protezione", *Giornale degli Economisti* 2 (1891): 308-312.

Pareto Vilfredo. *Vilfredo Pareto. Oeuvres Complètes. XXXII Inédits et Addenda. Ecrits retrouvés, transcrits et annotés par F. Mornati.* Geneve: Droz, 2005: 33-42 (reprint of "Intorno ai trattati di commercio," *L'Economista*, 26 dicembre 1875: 812-817).

Pollard, Sydney. *Peaceful Conquest. The Industrialization of Europe 1760-1970.* Oxford: Oxford University Press, 1981.

Popescu, Ilie. *Căi ferate – transporturi clasice şi moderne*, Bucarest: Editura Stiintifica si Enciclopedica, 1987.

Romeo, Rosario. *Risorgimento e capitalismo*. Bari: Laterza, 1959.

Scranton, Philip. *Endless novelty. Specialty production and American industrialization, 1865-1925*, Princeton: Princeton University Press, 1997.

Sereni, Emilio. *Capitalismo e mercato nazionale in Italia*. Rome: Editori Riuniti, 1966.

Sinclair, Angus. *The development of the locomotive engine.* New York: Sinclair, 1907.

Soete, Luc, "International diffusion of technology, industrial development and technological leapfrogging", *World Development* 13, no. 3 (1985): 409-422.

Sylla, Richard and Toniolo, Gianni. (eds) *Patterns of European Industrialization.* London: Routledge, 1992.

Tey, Giovanni. *La locomotiva a vapore. Storia, sviluppo e perfezionamento al 1910.* Milan: Vallardi, 1910.

Toniolo, Gianni. "Effective protection and industrial growth: the case of Italian engineering," *Journal of European Economic History* 6, no. 3 (1977): 659–673.

Van Dijk M, and Szirmai, A. "Industrial policy and technology diffusion: evidence from paper making machinery in Indonesia," *World Development* 34, no. 12 (2006): 2137–2152

**Official publications**

Camera dei Deputati, *Atti parlamentari. Legislatura XI, Sessione 1871-72, Documenti, Doc. 39-A*, Rome, 1871.

___. *Atti parlamentari. Legislatura XV, 1ª Sessione, Discussioni, Tornata del 7 febbraio 1885*, Rome, 1885.

___. *Atti parlamentari. Legislatura XVI, 2ª Sessione 1887-88, Documenti, Doc. 169, Sub-Allegato 2*, Rome, 1888.

___. *Atti parlamentari. Legislatura XVII, 1ª Sessione, Discussioni, Tornata del 27 gennaio 1891*, Rome, 1891a.

___. *Atti parlamentari. Legislatura XVII, 1ª Sessione, Discussioni, Tornata del 23 gennaio 1891*, Rome, 1891b.

___. *Atti parlamentari. Legislatura XX, 3ª Sessione, Discussioni, Tornata del 3 febbraio 1900*, Rome, 1900.

___. *Atti parlamentari. Legislatura XXII, 1ª Sessione, Discussioni, Tornata del 19 aprile 1905*, Rome, 1905.

___. *Atti parlamentari. Legislatura XXII, Sessione 1904-06, Documenti, Doc. 29*, Rome, 1906a.

___. *Atti parlamentari. Legislatura XXII, 1ª Sessione, Discussioni, Tornata del 15 marzo 1905*, Rome, 1906b.

___. *Atti parlamentari. Legislatura XXII, Sessione 1904-06, Documenti, Doc. 359*, Rome, 1906c.

___. *Esposizione finanziaria del ministro Tedesco fatta alla Camera dei Deputati nella tornata del 7 dicembre 1912*, Rome; (main text also published in Camera dei Deputati, *Atti parlamentari. Legislatura XXIII, 1ª Sessione, Discussioni, Tornata del 7 dicembre 1912*, Rome, 1912).

Comitato dell'inchiesta industriale. *Atti. Deposizioni scritte, categoria 15 § 3. Macchine*, Rome, 1872.

___. *Atti. Deposizioni scritte, categoria 15 § 2. Industrie metallurgiche*, Rome, 1873.

___. *Atti. Riassunti delle deposizioni orali e scritte, categoria 15 § 3. Macchine*, Florence, 1874.

Commissione d'inchiesta per la revisione della tariffa doganale. *Atti. II. Parte industriale. Relazione del deputato Vittorio Ellena*, Rome, 1886.

Commissione d'inchiesta sull'esercizio delle ferrovie italiane. *Atti. Parte I. Verbali delle sedute pubbliche. Volume I*, Rome, 1879.

Compagnia Reale delle Strade Ferrate Sarde, *Relazione e bilancio. Esercizio 1894*, Rome, 1895.

Ferrovie dello Stato. Direzione generale. Servizio trazione. *Locomotive ed Automotrici in servizio e in costruzione al 30 giugno 1914*, Florence, 1914

Ferrovie dello Stato. Direzione generale delle ferrovie dello Stato. *Il centenario delle ferrovie italiane, 1839-19139*, Rome, 1940.

Ministero dei lavori pubblici. Regio ispettorato generale delle strade ferrate. *Relazione sulle costruzioni e sull'esercizio delle strade ferrate italiane per gli anni 1885-1886-1887,* vol. II, Rome, 1889.

___. *Relazione intorno all'esercizio delle strade ferrate delle reti mediterranea, adriatica e sicula dal 1$^{o}$ luglio 1885 al 1900*, parte IV, vol. II, Rome, 1901.

Ministero delle finanze. Direzione generale delle gabelle. *Movimento commerciale del Regno d'Italia nell'anno 1874*, Florence, 1874.

___. *Movimento commerciale del Regno d'Italia nell'anno 1888*, Rome, 1889.

Società Italiana Ernesto Breda, *Per la millesima locomotiva*, Milan, 1908.

___. *La Società italiana Ernesto Breda per costruzioni meccaniche: dalle sue origini ad oggi, 1886-1936*, Verona, 1936.

Società delle Strade Ferrate dell'Alta Italia, *Album delle locomotive*, Turin, 1876.

Società delle Strade Ferrate Romane, *Album delle locomotive*, Florence, 1878.

Società Italiana per le Strade Ferrate Meridionali. Esercizio della rete adriatica, *Tipi delle locomotive e dei tenders. Anno 1887*, s.l., 1887 ca.

Società Italiana per le Strade Ferrate del Mediterraneo, *Album delle locomotive 1888*, Turin, 1888.

Società Italiana per le Strade Ferrate della Sicilia, *Materiale rotabile. Tipi delle locomotive e delle carrozze*, Palermo, 1902 ca.

*Tipi del materiale rotabile in esercizio sulle ferrovie delle colonie libiche e della colonia Eritrea*, Florence, 1914.

**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.[51] 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):[52]

*(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 km), Germany (16,000), Austria (5,800), Spain (2,800), Russia (2,400), World (130,000).[53] 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:

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

[52] 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).

[53] 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.

- *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.[54]
- *Società delle Strade Ferrate Romane (SFR):* This company was managing mostly the lines operating in the previously Papal States.[55]
- *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.[56]

*(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.[57]

*(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.[58]

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

[54] 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).

[55] 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).

[56] "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.

[57] 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 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).

[58] 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.

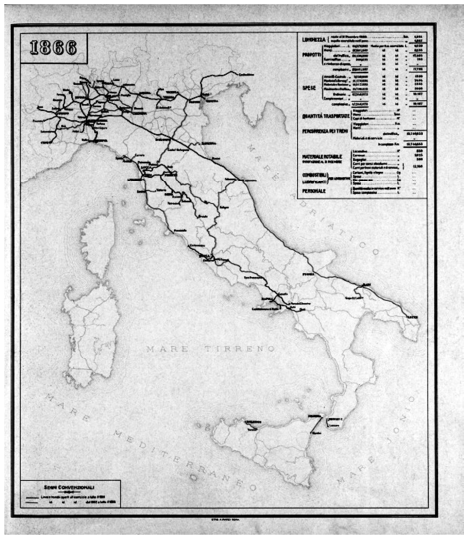
years later, in 1866, the main trunks along the Tyrrhenian and Adriatic coastal plains were terminated.[59] The map for 1886 shows that the main inlands of Sicily and Sardinia had their own network, and that Calabria, in the toe of Italy's boot, was linked to Naples. In 1909, almost at the end of the 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".[60]

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

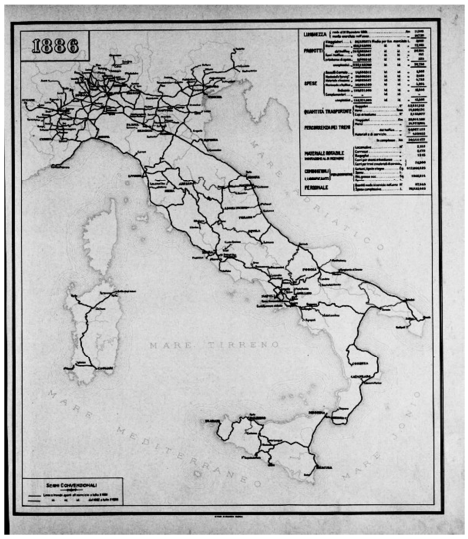
*1861* *1866*

[59]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.

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


*1886*




*1909*


*Source: Ferrovie dello Stato (1911)*

**References (Supplementary materials)**


Cavour C. “Des chemins de fer en Italie.” *La revue Nuovelle, May 1st,* (1846) : 1-36.

Cornolò, G. *Locomotive a vapore FS,* 2a ed. Parma, 1998.

Crispo, A. (1940), *Le ferrovie italiane. Storia politica ed economica*, Milan.

Einaudi M. “Le prime ferrovie piemontesi e il Conte di Cavour.” *Rivista di storia economica*, 3, 1**,** (1938): 1-38**.**

Fenoaltea, S., *The Reinterpretation of Italian Economic History*, Cambridge MA, 2011.

Ferrovie dello Stato. Servizio centrale I$^{o}$. Ufficio statistica. *Ferrovie Italiane, 1861-1909. Riproduzione dei lavori grafici presentati all’Esposizione Internazionale di Torino del 1911,* s. l., 1911.

Guadagno, W. *Ferrovie ed economie nell’ottocento post-unitario,* Rome, 1996.

Kalla-Bishop P.M. *Italian Railways*, Devon, 1971.

Istat (Istituto centrale di statistica), *Sommario di statistiche storiche italiane, 1861-1955*, Rome, 1958.

Ministero dei lavori pubblici. Regio ispettorato generale delle strade ferrate. *Relazione intorno all’esercizio delle strade ferrate delle reti mediterranea, adriatica e sicula dal 1885 al 1900*, parte IV, vol. II, Rome, 1901.

Ministero dei lavori pubblici. Direzione generale delle ferrovie dello Stato, *Relazione a S.E. il Ministro dei lavori pubblici sull'andamento dell'amministrazione delle ferrovie dello Stato nell'esercizio 1905-06*, Rome, 1906.

Panconesi M. *Le ferrovie di Pio IX: nascita, sviluppo e tramonto delle strade ferrate nello stato pontifico (1846-1870),* Rome, 2005.

Società delle Strade Ferrate dell’Alta Italia. *Album delle locomotive,* Turin, 1876.

Società delle Strade Ferrate Romane. *Album delle locomotive*, Florence, 1878.