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Francesca Polese

The European Educational Journey of the Italian Engineer Giovanni Battista Pirelli, 1870–1871

Considerations on the Swiss Experience

Introduction

The paper aims at contributing to the description of the mechanisms of industrial diffusion and knowledge transmission throughout different European countries and regions during the last third of the 19th century. This was a critical period for the industrialization of continental Europe, since in those years in many areas of the continent industrial activities not only achieved full autonomy from the developments of their British counterparts, but also started to compete with the English manufacturers in various important sectors. Given this wider framework of deep and far-reaching economic transformations, the analysis of the distinctive means by which industrial practices, technical skills and knowledge were transferred across different social and economical environments provides a valuable insight on the dynamics of the spread of modern industry within Western Europe and of the processes through which backward areas managed to fill in the gap that separated them from economically more advanced regions.

The paper approaches these general issues by focusing on a single case: the educational journey across several European countries accomplished by the Lombard engineer and entrepreneur Giovanni Battista Pirelli (1848–1932) in 1870–1871. Pirelli, founder – in 1872 – of the first Italian rubber manufacturing company (G. B. Pirelli & C.) in Milan, became one of the most prominent actors of the country's industrial and political scene of the years between the end of the 19th and the beginning of the 20th century. A brilliant, freshly graduated engineer from Milan's recently founded polytechnic school, Pirelli was encouraged by his teachers to start on a study journey through industrially more advanced areas, with the purpose of acquiring the knowledge and techniques without which the creation of new manufacturing activities in Lombardy was unconceivable. By then, the most modern elements of the region's middle classes were indeed well

aware of the fact that it was critical to exploit the long-standing relationships connecting the Italian region with many of the most developed foreign countries in order to fill in the gap that divided Lombardy from the engines of economic growth. Specifically, Pirelli's journey was aimed at the study of rubber manufacturing, an industry whose importance had progressively grown since the central years of the century and whose absence within Italy was becoming an obstacle to the contemporary development of the region's industrial activities.

The present research is based mainly on a recently recovered document: the manuscript diary written by Pirelli during his travel experience. This source is particularly interesting because it offers a large amount of first-hand descriptions of factories, technical schools and industrial collections written by such an important observer. The diary can be read according to two different although complementary perspectives. On the one hand, Pirelli's records provide a sort of photograph of the degree of development reached by manufacturing activities and industrial works in several European regions at the moment in which the Italian engineer visited them. Such «snapshots» can vary as to sharpness of focus (in some cases Pirelli notes a great amount of information, while in others his observations are limited to rather general facts) and as to angle-shot (at times Pirelli is interested mainly in technical details relating to the machinery, on other occasions he concentrates on the organization of the productive process or on the layout of the plants), yet they are surely an important instrument for the assessment of the limits and features of contemporary industrialization. On the other hand, the diary reflects the interests and the ambitions that moved the main protagonists of that phase of industrial development and sheds light on their concept of «modernization». At the same time, Pirelli's manuscript also illustrates the channels through which these industrialists (entrepreneurs, technicians or engineers) managed to achieve their modernizing projects.

Within the framework of Pirelli's educational journey, the Swiss experience is particularly relevant for several reasons. Firstly, the Lombard engineer devoted more time to the visit of Switzerland than to any other country. Secondly, Pirelli considered the study of the Swiss industries especially worthwhile due to the similarity between Switzerland and Lombardy (and other regions of Northern Italy) as far as natural resources and market size were concerned. In this respect the noticeable goals achieved by the small mountainous neighboring country – to which Lombardy was moreover tied by many long-established commercial and cultural connections – appeared to the most advanced part of Lombardy's industrial community as a sort of model of development that deserved to be reproduced, also because Switzerland had managed to industrialize avoiding the social conflicts that had seriously troubled the industrialization process in Great Britain.

Although limited to a single-voice account, Pirelli's diary can contribute to the understanding of the framework in which Swiss industries started to acquire their modern features. In particular, the Italian engineer's observations provide information on the relative importance of the various sectors within the overall picture of Swiss industry in those years. Moreover, they are useful for assessing some of the main characteristics of the most important Swiss firms, such as their degree of internationalization (especially as far as exports are concerned), their network of commercial and engineering relations with other foreign enterprises, the extent of their competitiveness compared to the principal contenders within each sector. Particularly interesting are the connections between Swiss and Lombard firms (mostly consisting in exports from Switzerland towards the less advanced Italian companies) and the ties linking the engineering communities of the two countries.

While trying to fit the greatest amount of details in the picture of the Swiss industrial world of the last third of the 19th century as provided by Pirelli's diary (especially concentrating on its internationalization and its links with the neighboring Italian region), the paper will also attempt to investigate the problems concerned with knowledge transmission in years of strong industrial expansion. Section One traces a brief portrait of Pirelli's training, while Section Two describes his educational journey. Section Three concentrates on the Swiss experience, outlining the main features of the country's industry as it emerges from the diary. Section Four focuses on the elements of interest of the Swiss experience for the development of industry in Lombardy. The concluding remarks concentrate mainly on the mechanisms of knowledge transmission between the two areas.

Giovanni Battista Pirelli's education

Giovanni Battista Pirelli was born on December 27, 1848 in Varenna, a small village on the Lake of Como, from a family of artisans.¹ In 1861 he moved to Milan in order to continue his studies first at a technical school and later at the faculty of Mathematics and Physics at the nearby University of Pavia. His real ambition was to attend Milan's newly-founded engineering school – the “Istituto Tecnico Superiore” – regarded as an advanced vanguard in the otherwise sluggish world of Italy's technical education institutions of those years.² At 17, Pirelli enrolled at the engineering school. The study-course lasted three years, and after the end of the first one (1867–1868), he decided to leave the civil engineering section and to move to the industrial engineering one. He obtained his diploma on

September 10, 1870 with the highest marks among the nine students that graduated that year in the same section.³

Undeniably, this period was particularly important for the training of the future entrepreneur: in addition to the specific learning related to his professional preparation, the school also introduced Pirelli into a particularly stimulating and dynamic milieu. In the years in which the most advanced Italian regions were moving their first steps in the industrialization process, the “Istituto Tecnico Superiore” stood out as a unique seed-bed of modern industrial projects and entrepreneurial experience. One of the most important animators of this project was Giuseppe Colombo (1836–1921).⁴ Among Italy’s most important engineers and entrepreneurs at the turn of the century, perhaps the most distinctive stimulus that animated Colombo’s multifarious activities was the firm determination to transform Italy into a modern industrialized country. Colombo implicitly considered that backwardness could prove to be an advantage for the late-comers, in that it allowed them to learn from the others’ experience and to avoid their mistakes. Thus, the choices already made by the more advanced industrial regions could offer a solution to some of the problems with which the country had to confront itself in its way towards development. In this sense, Colombo urged Italy to draw on foreign experiences for its own development, although these foreign models needed to be somehow adapted and altered to suit the different economic and social realities of the receiving country.

Pirelli’s journey and his travel diary

Pirelli’s educational journey through various European countries was made possible thanks to a newly-constituted program intended for freshly graduated engineers of Milan’s “Istituto Tecnico Superiore”. The initiative was one of the several instruments conceived in those years by the entrepreneurial community gathered around Milan’s engineering school as a means through which to fuel the region’s economic development and to partly fill in the gap that separated Lombardy from industrially more developed foreign countries. Thus, having obtained the best grades among the students of his section, immediately after his graduation Pirelli was awarded a travel grant. The aim of the “Kramer prize” was to allow the two most brilliant graduates – one from each of the sections of the Milanese engineering school – to achieve some first-hand experience of industrial activity in the more developed European regions. In particular, the regulation explicitly required the industrial engineer (i. e. Pirelli) to “study an industry which in Italy was still regarded as completely new or scarcely diffused”. Pirelli’s

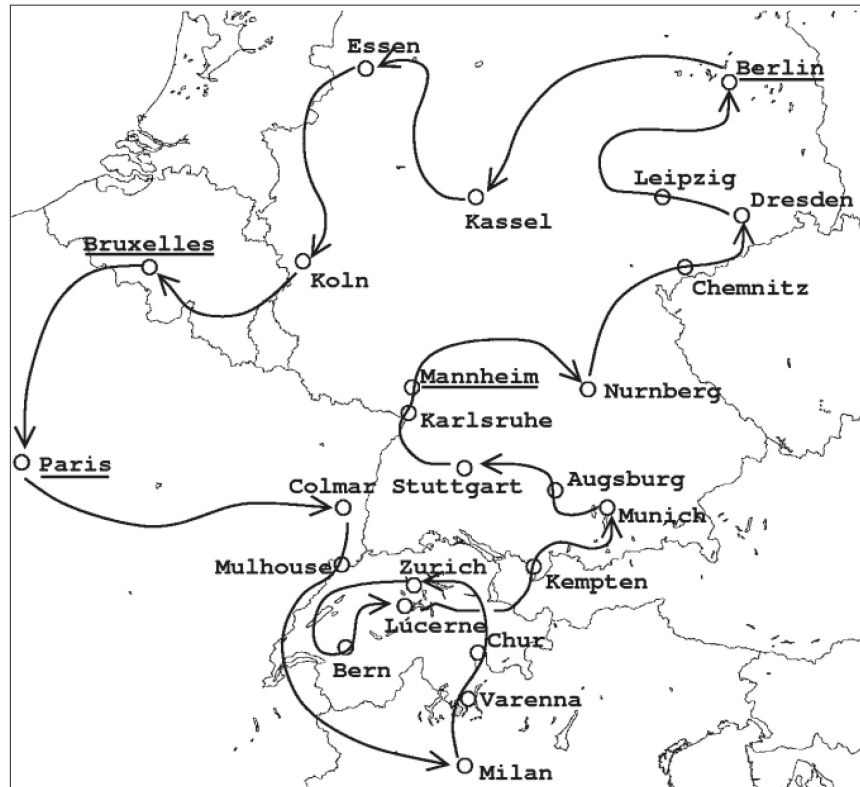


Fig. 1: Piorelli's educational journey, 1870–1871. The cities where Piorelli visited some rubber manufactories are underlined.

journey abroad lasted roughly ten months, from the beginning of November 1870 to the first days of September 1871. In this period, the young engineer travelled more or less extensively through Switzerland, Germany, Belgium, France and Alsace (see fig. 1).

He managed to visit a total of 138 manufactories representative of a very wide variety of industries, ranging from cotton mills and silk dye-works to ironworks and mechanical factories. The firms visited by Piorelli appear significantly different both as far as size and structure are concerned, varying between small artisan workshops to very large fully mechanized industrial plants (table 1, page 196, shows the total amount of plants visited by Piorelli, divided by country

Table 1: *Firms visited by Pirelli during his journey, by country and by industry*

Industry	Switzer- land	Bel- gium	Ger- many	France	Alsace	Total
Cotton mills	14		3		2	19
Wool mills	3		2		1	6
Silk	3		5			8
Mixed textile manufactories	6					6
Mechanical firms	7	5	19		1	32
Railways	4	2	7	1		14
Ironworks			8			8
Industrial exhibitions; technical museums	1		3			4
Rubber		1	3	2		6
Telodynamic Transmissions	2		1		3	6
Water Turbines	5		2			7
Other	8	2	10		2	22
Total	53	10	63	3	9	138

and industry). The overall amount of time Pirelli spent abroad was divided in the following way between the different countries: more than four months in Switzerland;⁵ roughly four months in Germany;⁶ a little more than three weeks in Belgium;⁷ ten days in France.⁸

At first glance, Pirelli's schedule appears quite unreasoned, since it totally left out Great Britain (certainly a first-class destination for a young future entrepreneur, and moreover the European country where the rubber industry in those years was most developed) and it also gave very little importance to France (among the continental European nations, the one where the rubber industry had greatest importance, and where Pirelli could rely on a series of contacts which might be able to introduce him to entrepreneurs of that field; not to mention the fact that French was undoubtedly the foreign language that Pirelli spoke better).

In fact, the choice of this itinerary was largely determined by chance. As far as Great Britain is concerned, even if his teacher, Giuseppe Colombo, had urged him to cross the Channel, the young engineer had deliberately decided not to do so because the money he received from the travel grant proved to be barely enough to cover the expenses of travelling within the continent for those ten months. On the contrary, upon his departure from Italy Pirelli had wished to stay for quite a long while in France, exploiting the contacts that would have probably allowed

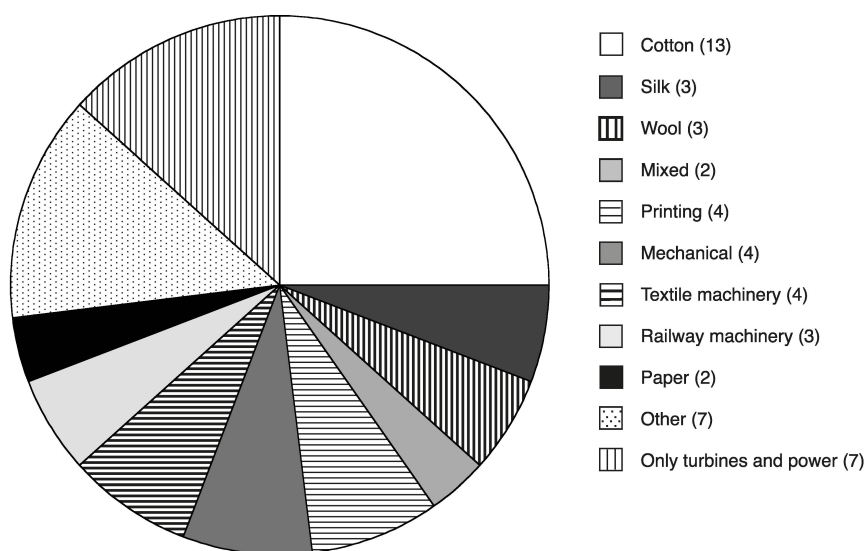
him to visit some important French rubber manufactories. However, initially the French Prussian war and thereafter the Paris Commune induced Pirelli to change his mind. The young engineer was well aware that his decision would have made him skip the visit important factories not only of the rubber industry: “My God! I will be barely able to make a short stop in Paris and then I will have to rush back home! How sorry I will be not to devote some time to the visit to Lorraine and Alsace; especially to the latter region, where I could dream again of water engines and huge cotton and wool factories.”⁹

The Swiss experience: quantitative evidence

The war thus forced Pirelli to protract his sojourn in Switzerland: “There is still no peace between France and Germany and I stopped in Switzerland waiting for it. But in that country there was no rubber industry.”¹⁰ As mentioned above, Switzerland was Pirelli’s first destination and it was the country through which he traveled most extensively. Pirelli’s first stop was Chur, where he visited a paper mill and a railway workshop. From a geographical point of view, although in four months and a half the young engineer covered a wide area, the regions where he spent the longest time (and where he visited the greatest number of factories) are the Zurich area (Pirelli spent a week in town at the beginning of his journey, and later – in the first days of January – spent some more time in the region of the Lake of Zurich), the Winterthur area and the district of Rütli.

The total number of firms Pirelli managed to visit during his sojourn in the country amounts to 53 factories; while he was rejected by other 12 (see the appendix for the complete list of Swiss firms mentioned in Pirelli’s diary). The first instance to which we must point is that as far as his main goal (i. e. the study of the rubber manufacturing industry) was concerned, the Swiss experience was absolutely profitless, since such activity was still completely unknown in the country. However, his journey in Switzerland provided Pirelli with still other teachings that proved to be just as important for his future entrepreneurial career. Figure 2 shows the sectorial distribution of the Swiss firms visited by the Italian engineer. A closer look reveals that the largest amount of factories (25) belonged to the textile sector, being the cotton industry (with 13 mills) the prevalent branch. Another significant feature showed by the diagram is Pirelli’s interest for the problem of power transmission, and especially for the issues related with the industrial exploitation of water power. On the whole, also the mechanical industry accounted for a rather large percentage of the visited firms (22%, i. e. 11 plants), with an equal amount (4 factories each) of firms specialized in the

Fig. 2: Swiss firms visited by Pirelli during his journey (sectorial distribution)



production of textile equipment and factories producing machinery for a wide range of industries.

As far as the number of workers employed in the manufactories is concerned, Pirelli's diary provides only a limited amount of information. The largest firm is without any doubt the mechanical company Sulzer Brothers (Gebrüder Sulzer) of Winterthur, with its 1050–1100 workers. Among the factories with a numerous workforce is also another mechanical company – J. J. Rieter and Co. of Töss – counting more than 700 workers. According to Pirelli's reports, the largest textile company – the firm Graemiger-Müller of Walenstadt, producing dyed cotton goods – employed some 700 workers. In the textile industry, a large amount of the workforce was constituted by women, as in the case of a manufactory producing colored and printed textiles (both wool and cotton) in Azmoos, whose 240 workers were mainly women living in small houses especially built beside the factory.¹¹

Pirelli's diary also provides useful information concerning the channels through which the young Italian engineer was admitted to the factories. Access to the

Table 2: *Reference letters addressed to teachers of the Zurich polytechnic school*

Writer of First Reference Letter	Addressee of First Reference Letter and Writer of Second Reference Letter	Addressee of Second Reference Letter
Giuseppe Colombo	Johann Heinrich Kronauer	Circular letter for several Swiss factories; M. Henggeler (Tiefnau, Bern); Caspar Honegger (Rüti); Schmid (cotton mill in Gattikon)
Giuseppe Colombo	Gustav Zeuner	C. Linde (Munich Polytechnic School); U. Ludewig (Munich Polytechnic School); C. H. Schmidt (Stuttgart Polytechnic School); Böttcher (Gewerbeschule in Chemnitz); Hartig (Dresden Polytechnic School)
Antonio Stoppani	Escher von der Linth	Prof. Geinitz (Dresden); Ing. Rohr (Bureau der Entsumpfungsarbeiten, Bern)
Mr. Villa	Albert Mousson	M. J. Trümpler (Uster); Blumer Brothers (Murg); Gonzembach with Escher (Zurich); Enrico Burkhardt (mines in Käpfnach); Amsler (Schaffhausen)
?	Karl Culman	?

plants was granted thanks to the presentation of a reference letter typically addressed to the owner of the company. The analysis of the letters used by Pirelli sheds some light on the links connecting Milan's emerging industrial and engineering milieu with its Swiss counterpart. In this respect, Giuseppe Colombo played a crucial role, providing Pirelli with letters addressed to three very well-known colleagues of his who taught at Zurich's polytechnic school – Johann Heinrich Kronauer (technology professor), Gustav Zeuner (professor of mechanics and theory of machines, as well as head of the mechanical department and former director of the institution) and, to all appearances, Karl Culmann (from 1855 professor of engineering sciences at the Swiss school). Antonio Stoppani, geologist and professor at Milan's "Istituto Tecnico Superiore", provided Pirelli

with a letter addressed to Arnold Escher von der Linth, one of the time's most prominent geologists and himself teacher at Zurich's engineering school.¹²

As shown in table 2, on their turn these engineers (and scientists) supplied a large amount of reference letters to the young Italian, some of which were directly addressed to entrepreneurs while others were directed to colleagues who, in turn, wrote more reference letters for Pirelli, thus granting him access to a growing number of factories. In this respect, the diary presents evidence of a sort of "domino effect": starting with one contact, a series of subsequent links was established progressively widening the scope of Pirelli's visits.

Moreover, the analysis of the reference letters exploited by the Italian engineer during his travel in Switzerland reveals the connections that in those years bound Zurich's polytechnic school with the country's industrial community.¹³ In fact, this was one of the reasons for which the Swiss engineering school was explicitly chosen as a model by the founders of its Milanese counterpart. One of the staunchest advocates of the Swiss model was the first director of the Milanese school, the mathematician Francesco Brioschi. Brioschi clearly looked at Zurich's polytechnic (founded in 1855) as one of the soundest pillars of Switzerland's industrial development, praising the tight links that connected the school with local industries. Brioschi admired the readiness with which the engineering school satisfied the growing demand of technical specialization produced by the development of industries that were becoming increasingly more complex from a technological point of view. Thus, the connections within the engineering community were added to the other long-lasting ties binding Lombardy and Switzerland.¹⁴

Lessons from Switzerland

A closer investigation of the quantitative data related to Pirelli's educational journey clearly reveals why the Italian engineer considered the visit to Switzerland especially important, thus reinforcing the opinion of other Lombard contemporaries involved in the development of the region's industries. Firstly, the fact that the country's main industry was undeniably the textile one represented a notable similarity with the Lombard situation. As a matter of fact, although Pirelli had left for his journey with the proposal of concentrating on the rubber industry, having spent a little more than two months in Switzerland mostly visiting textile mills, the Italian engineer appeared on the point of abandoning his initial objective, as revealed by this annotation: "I am so enchanted by it [a silk manufactory in Altstetten], that if I were a capitalist I would surely undertake this industry in Italy."¹⁵

From a more general perspective, besides the fact that cotton manufacturing accounted for the largest part of this sector, Pirelli's diary confirms the location of Switzerland's cotton industry especially in the Canton of Glarus (specialized in printing, while cotton spinning was "diffused in all the major German-speaking centers"),¹⁶ whereas silk weaving and mechanical weaving were concentrated in the Canton of Zurich, where they reached "the most advanced development than anywhere else in the world, including Lyons".¹⁷

According to Pirelli's notes, the Swiss textile industry appears overall strongly export oriented, with numerous firms selling their products (mainly high-quality and well-finished goods) to distant markets (Turkey, India and the Far East)¹⁸ and in several cases managing to acquire strong positions even in other European markets. This latter situation is well illustrated by a wool mill in Schaffhausen (owned by Lang and Weidlich), which succeeded in exporting most of its products to Germany, despite the existence of strong protectionist barriers on woolen goods.¹⁹ In one case, Pirelli even reports of a cotton foulard manufactory which managed to export its products to Lyons (a center boasting a long tradition in this field), taking advantage of the French Prussian war.²⁰

In this field, especially in the cotton printing sector, the British appear the main competitors of the Swiss firms: "Their only competitors are the British. They sell their products in Asia, in India and in Africa, and apparently they achieve fabulous revenues. It's an enviable industry."²¹ At times the dependence from the more advanced British counterparts is more evident, as unveiled by the visit to the cotton spinning manufactory (specialized in the production of cotton thread) owned by Escher Hotz (?) in Turgi. In this case, the firm had to face more serious problems than simple market competition. The entrepreneur imputes his difficulties to the absence of technically qualified workers in the area, thus obliging him to hire an expert British worker with the purpose of training the local workforce. However, as in many other cases, the transmission of technical know how from the foreign specialists to the local workers proved to be a quite complex process: "He tried to train one of his most devoted and intelligent workers hiring for the purpose two Englishmen. But loads of troubles occurred, and apparently the two British advanced excuses in order not to show the Swiss all they knew, and eventually they may have even fooled them."²²

In any case, British competition appeared even stronger in the mechanical sector. According to Pirelli's records, the Swiss mechanical industry in those years was undergoing quick and deep changes. If it was undoubtedly still not able of competing with the British, however in several cases it managed to progressively occupy market shares, eventually even giving rise to some export activities. The progress of the textile industry fuelled the development of mechanical firms, the

majority of which produced mainly textile equipment. Yet, during his visits Pirelli still noticed a large amount of British machines working side by side with Swiss and German devices. Quite typical is the case of the above mentioned cotton spinning manufactory of Escher Hotz (?) in Turgi, which employed machines coming from a wide variety of producers: “Generally the machines are bought from Platt [Great Britain], or built autonomously by Escher Hotz (?) copying the English models; some are produced by Harder in Basel.”²³ The Swiss mechanical firms generally appear to lack specialization, producing instead a wide variety of machines according to their individual customers’ orders. This is well illustrated by one of the country’s most successful firms, the J. J. Rieter and C. in Töss (directed by the well known engineer David Heinrich Ziegler). While producing mainly devices used in the cotton spinning industry and water turbines it also built “various machine tools, many of which worked in the factory itself, while others were produced to satisfy the orders of some of their time-honored customers”.²⁴

On the other hand, Pirelli’s visits unveil that some of the Swiss mechanical firms had achieved a leading position in their industrial sectors, not only within the country but also abroad. The already mentioned firm Wegmann and C. in Baden, specialized in the production of machinery for the silk industry “worked for all of Switzerland’s mills, and it is starting to receive orders from Italy as well”,²⁵ the latter country representing a key market due to the overall development of silk manufacturing, especially concentrated in districts such as the Como one. Particularly important was also the mechanical company Caspar Honegger in Rüti (specialized in the production of machines for the cotton industry), which by the time of Pirelli’s visit had undeniably achieved an international reputation: “[...] it’s one of the foreign companies that, due to its branch of activity, is best known in Italy, chiefly in Lombardy and Piedmont – regions with which it commerces very actively [...] It has supplied, and keeps on supplying, the majority of Italian cotton weavers, along with the Swiss ones and a large amount of the Germans.”²⁶ The same applies to the firm Escher Wyss and C. in Zurich, which, at the time of Pirelli’s visit, was building a water wheel ordered by one of Italy’s most important textile industrialists (Eraldo Krumm), for his new plant in Busto Arsizio (near Como). In addition to the production of machine tools and steam engines, Escher Wyss and C. was well known for its steamboats. According to Pirelli’s notes, although within the Swiss market the firm had to face the serious competition of the Sulzer Brothers, abroad the greatest success was reported by Escher Wyss and C., as shown by the fact that it had produced the steamboats used on the Italian Lakes Maggiore and Como.²⁷

As mentioned, figure 2 shows that one of the issues in which Pirelli was most

interested during his visits was the question of power transmission, and especially of the exploitation of water power. The fact that Switzerland could not rely on coal for its industrialization, while it could count instead on a great amount of water power provided by its many Alpine rivers, made Switzerland particularly similar to Lombardy. Moreover, the training provided by Milan's "Istituto Tecnico Superiore" devoted a large amount of lessons to the drawing and project of water turbines. This can explain why nearly in every firm he visited the young Italian engineer recorded (often with detailed sketches) technical specifications and eventual problems faced in the exploitation of water power for industrial activities.

In addition to water turbines, Pirelli was particularly interested in the progress of the so called "telodynamic system". Devised by the Alsatian engineer Gustave-Adolphe Hirn, the system allowed to transfer power originating in one point (namely a river) to factories located at even a considerable distance by means of iron cables.²⁸ Pirelli visited the telodynamic transmission in Sennhof, set up by the mechanical firm J. J. Rieter of Winterthur under the direction of the engineer David Heinrich Ziegler. The system managed to transfer about 90 HP from a water turbine situated in the river Töss to the cotton mill owned by J. H. Bühler located at a distance of 600 meters. Pirelli's description unveils his enthusiasm for the system: "It's one of Switzerland's most beautiful and most successful transmissions. One is marvelled in watching it work without any oscillation nor noise."²⁹ Pirelli also visited the well-known transmission in Schaffhausen, with two water turbines placed in the river Rhein (able to generate up to 500 HP) producing power which was then sold to various firms of the area.³⁰

Conclusions

There can be no doubt about the fact that Pirelli's experience confirms that Switzerland was an important model for the protagonists of Lombardy's industrialization. This is stated quite clearly by Pirelli himself, making his final assessment of his Swiss experience upon his departure for Germany: "Switzerland's industry made such a deep and positive impression on me that I will always bear it in mind. I don't believe that I will see another equally instructive demonstration in any other country. The Swiss seem to be especially made to work in factories, and they cultivate with equal eagerness all the most important varieties of industry [...] One has much to learn from its institutions and from its people and I wish that my country one day will industrially resemble Switzerland. I wish that Lombardy and Piedmont, that are most similar to Switzerland, one day

can take advantage of their proximity and learn the many important lessons coming from that country.”³¹

As mentioned above, Pirelli’s travel diary can be read at two different levels. Firstly, it offers information on the stage of development of Swiss industries at the time of Pirelli’s visit. In this respect, textiles appears unquestionably as the country’s most important industry. Pirelli’s records show that from an international perspective, this industry was overall competitive, managing to export not only in distant markets (mainly Asia and India) but also in other advanced European countries. Within this sector, Great Britain was still undoubtedly the most serious competitor. However, the Swiss firms managed to keep their positions by concentrating on the production of high quality goods – a market on which the British presence was not as dominant.

The diary also provides evidence of the progress experienced by the Swiss mechanical industry in that period. In particular, fuelled by the expansion of textiles the production of textile machines was becoming a branch in which Swiss firms started to distinguish themselves on European markets. However, most of the companies of this sector were still not specialized in a single standardized production but on the contrary counted on the manufacture of a wide range of different machines, built according to the technical specifications required by each individual customer. In any case, Swiss mechanical firms played a crucial role in the industrialization of Lombardy, supplying emergent companies with machines and devices that were overall less expensive than the British ones, and more adequate to meet the specific demand of an area lacking of coal.

On the other hand, Pirelli’s travel diary sheds light on the mechanisms of industrial transfer throughout different nations and varying social and institutional contexts. Pirelli’s case shows that backward countries succeeded in filling up the gap with industrially more advanced nations especially thanks to their ability to learn from more developed countries. As Bengt-Åke Lundvall and Björn Johnson claim, starting from the Industrial Revolution knowledge has become a key economic resource, and thus the ability to learn is critical for development.³² The two scholars identify four different typologies of knowledge which are important for economic development. First of all there is *know what*, that is the knowledge of facts, largely corresponding to information; then comes *know why*, that is the knowledge of scientific rules and technological principles the application of which grants the solution of problems; the third type is *know who*, that is a social and selective kind of knowledge which allows one to know who are the persons who possess the specific skills required to solve particular problems; lastly, there is *know how*, that is the overall skills and capabilities.³³

Although all are somehow present in the case we have studied, Pirelli’s ex-

perience shows that *know who* was particularly critical. Circulation of technical knowledge and industrial information during the last quarter of the 19th century was a rather widespread phenomenon, as demonstrated for example by the success of the international industrial exhibitions in those years. On the contrary, the knowledge of which individuals carried the specific skills or information most useful for the solution for the particular kinds of problems raised by different aspects of industrialization was crucial for the solution of those problems. In this respect the contacts between the Lombard and the Swiss engineering communities proved of great importance in granting Pirelli access to a large amount of firms, as explained specifically in sections 2 and 3. In conclusion, Pirelli's experience shows that industrialization and internationalization can be seen as two aspects of the broader issue of knowledge transmission.

Appendix:

Complete list of Swiss firms mentioned by G. B. Pirelli in his travel diary³⁴

Firm	Location	Sector
Amsler	Schaffhausen	scientific instruments
Beder and C.	Nemünster	textile
Blumer	Murg	textile
Brunner	Glarus	textile
Brunner and Jenny	Schwanden	textile
Caspar Honegger	Rüti	mechanical
Collection of industrial models at the Polytechnic School	Zurich	
Enderlin and Jenny	Ziegelbrücke	textile
Enrico Kunz	Windisch (Brugg)	textile
Enrico Schmid	Gattikon	textile
Escher <Hotz>	Turgi	textile
Escher Wyss and C.	Zurich	mechanical
Fleckstein	Wädenswil (Lake Zurich)	textile
Gebrüder Jenny	Haslen	textile
Gebrüder Sulzer	Winterthur	mechanical
Graemiger-Müller	Walenstadt	textile
Halter and Biedermann	Altstetten	textile
Hefti	Hätzingen	wool-spinning
Henggeler and C.	Baar	textile
Henggeler and C.	Felsenau (Bern)	textile
Hërr and Schmid (formerly Gebrüder Schmid)	Thalwil (Lake Zurich)	textile

Firm	Location	Sector
Hoffman	Chur	textile
Honegger	Siebnen (near Rapperswill)	textile
Honegger-<Amsler>	Rüti	mechanical
J. H. Bühler	Sennhof	textile
J. J. Rieter and C.	Töss (near Winterthur)	mechanical
J. J. Rieter and C.	Nieder-Töss	textile
Jenny and C.	Mollis	textile
Joseph Heer	Glarus	textile
Lang and Weidlich	Schaffhausen	textile
Luisinger-Aebly	Glarus	textile
Mines	Käpfnach (Lake Zurich)	coal mines
Neuhausen foundry	Neuhausen	foundry and ironworks
Oechslin	Schaffhausen	iron wires (for telodynamic transmissions)
Paravicini	Schwanden	textile
Railway workshop	Chur	mechanical
Rauschenbach	Schaffhausen	mechanical
Rigi Railway Construction works	Vitznau	railway construction works
Seidentrocknungs-Anstalt	Zurich	textile
Society for water constructions	Schaffhausen	water turbines and telodynamic transmission
Staebl and Jäggli	Oberwinterthur	mechanical and textile
Swiss Industrial Society	Neuhausen	mechanical
Wegmann and C.	Baden	mechanical
Wingeler	Hirslanden	mechanical
No name	Flums	textile
No name	Landquart	paper
No name	Lauffen	ironworks
No name	near the river Sihl	paper
No name	Olten	mechanical
No name	Sennhof	water turbines
No name	Sennhof	telodynamic transmissions
No name	Zurich	mill
No name	Zurich	municipal water supply system
No name	Zurich	sewers
No name (director: Mr. Stuber)	Azmoos	textile

Firms to which Pirelli was not admitted

Firm	Location	Sector
Balger and Ringwald	Basel	textile
<Bghiner> and Sons	Basel	textile
H. Caspar Escher	Zurich	textile
Hier	Schaffhausen	pottery
H. G. Zuppinger and Sons	Eichthof	textile
<Hisband>	Thalwil (Zurich)	shoe manufacture
Alioth and C.	Arlesheim (Basel)	textile
Maron Boedger	Basel	textile
Scherrer (Escher Wyss)	Hottingen (near Zurich)	textile
Spörri	Flums	textile
Theophil Vischer	Basel	textile
No name	Adliswil (Lake Zurich)	textile

Anmerkungen

- 1 His father, Santino, was a baker and his mother, Rosa Riva, came from a family of house decorators.
- 2 The most qualifying feature of the Milanese engineering school was its section for industrial engineers that represented an exception in Italy, where until that moment as far as engineering was concerned, the only training provided was for civil engineers. On the “Istituto Tecnico Superiore” see, among others: *Il Politecnico di Milano. Una scuola nella formazione della società industriale, 1863–1914*, Milano 1983. Lori, Ferdinando, *Storia del R. Politecnico di Milano*, Milano 1941.
- 3 The documents concerning this period of Pirelli’s training are deposited in the Historical Archives of Milan’s Istituto Tecnico Superiore (now known as Politecnico).
- 4 For a detailed portrait of this unbelievably enterprising engineer see Lacaita, Carlo G., “Giuseppe Colombo e le origini dell’Italia industriale”, in: Colombo, Giuseppe, *Industria e politica nella storia d’Italia. Scritti scelti: 1861–1916*, Milano, Bari 1985, p. 5–86. Borruso, Edoardo, “Il giovane Colombo e la formazione dello sviluppo industriale milanese (1857–1881)”, in *Studi di storia dell’industria “milanese” (1836–1983)*, Milano, 1996, p. 81–145.
- 5 Pirelli’s Swiss sojourn lasted from November 6, 1870 to March 15, 1871.
- 6 During his travel in Germany (March 16– July 28, 1871) Pirelli managed to visit the following states: Bavaria (March 16–25 and April 28–May 3, 1871), Württemberg (March 25–April 16, 1871), Baden (April 17–24, 1871), Hesse (April 25–27 and July 13, 1871), Saxony (May 4–13, 1871), Prussia (May 13–July 11, 1871), Westphalia (June 14–19 and June 28 – July 19, 1871), Rheinland (July 20–27, 1871).
- 7 Pirelli stayed in Belgium from July 29 to August 17, 1871.
- 8 In France, Pirelli visited only Paris (August 21–26, 1871) and then stopped in Alsace (August 27–31, 1871) on his way back to Italy.
- 9 Pirelli, Giovanni Battista, *Viaggio d’istruzione all’estero (premio Kramer). Rassegna di alcuni stabilimenti industriali, manifatture e opere di costruzione varie (1870–1871)* (from now on *Diary*), p. 211.

- 10 Pirelli, Giovanni Battista; Albertini, Alberto, *Appunti biografici*, Archivio Storico Industrie Pirelli 1342.
- 11 Pirelli noted the fact that the presence of lodgings for the workforce was a quite common feature of the Swiss textile manufactories (for example, some of the 430 workers employed by the firm Henggeler and C. near Bern, lived in houses next door to the factory).
- 12 Moreover, Pirelli could count on a letter for Albert Mousson (who taught applied physics at Zurich's engineering school), provided by a Mr. Villa from Milan (of whom at the moment there is no additional information).
- 13 This fact is quite clearly illustrated by the case of the above mentioned Gustav Zeuner. One of the most prominent personalities of the Swiss engineering school, Zeuner devoted a large amount of his studies to the steam engine and to water turbines.
- 14 At least until the end of the century, Zurich's polytechnic attracted a considerable amount of Italian students, some of which occupied crucial positions in Italy's industrial development. According to one version Pirelli himself had attended some lectures at the ETH during his stay in Zurich, even if there is no evidence of Pirelli's presence in the school's Historical Archives (however, the records relating to those years are not totally preserved).
- 15 *Diary* (cf. note 9), p. 46–47.
- 16 *Ibid.*, p. 107.
- 17 *Ibid.*
- 18 Among others, this is the case of a cotton mill in Walenstadt, managed by Graemiger-Müller. The firm produced fabrics for India, other Asian countries and Africa. *Ibid.*, p. 10.
- 19 *Ibid.*, p. 75–76.
- 20 This was the case of the firm Herr and Schmid (formerly Schmid Brothers) in Thalwil. *Ibid.*, p. 30–31. Some firms had also started selling their products in Italy as in the case of the spinning mill Henggeler and C. in Baar. *Ibid.*, p. 89.
- 21 *Ibid.*, p. 23.
- 22 *Ibid.*, p. 92.
- 23 *Ibid.*, p. 91.
- 24 *Ibid.*, p. 60.
- 25 *Ibid.*, p. 76.
- 26 *Ibid.*, p. 93.
- 27 On the production of steamboats by the two companies, see *ibid.*, p. 25 (Escher Wyss and C.) and 52 (Sulzer Brothers).
- 28 Gustave-Adolphe Hirn (1815–1890) has been strangely neglected by historians of technology. See Fox, Robert "Science, Industry and Social Order in Mulhouse, 1798–1871", *British Journal for the History of Science* 17 (1984), p. 127–168.
- 29 *Diary* (cf. note 9), p. 56.
- 30 See *ibid.*, p. 68–69.
- 31 *Ibid.*, p. 107.
- 32 See Lundvall, Bengt-Åke; Johnson, Björn, "The learning economy", *Journal of Industry Studies* 1, n. 2 (1994), p. 23–42.
- 33 *Ibid.*, p. 23–42. For a very interesting application of this theoretical framework to the study of the transfer and adoption of foreign technologies in the 19th century, see Bruland, Kristine, *Skills, learning and the international diffusion of technology. A perspective on Scandinavian industrialization*, in: Berg, Maxine; Bruland, Kristine (ed.), *Technological revolutions in Europe. Historical perspectives*, Cheltenham, Northampton, 1998, p. 161–187. I thank Kristine Bruland for her useful advice in this respect.
- 34 The names in brackets <> are not clearly readable from the manuscript.