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European Cartels and Technology Transfer: the experience of the rayon industry, 1920 to 1940

ABSTRACT

Business historians generally agree that European cartels, while proliferating after 1918, favoured the international spread of technology. Moving along similar lines, economist Baumol has argued that big firms sell proprietary technology and cooperate on the technological front with the double fold aim to make a profit and to internalise knowledge spillovers. This article qualifies both claims suggesting a less optimistic view about the effects of the visible hand of international cartels. The history of the rayon industry, a high-tech sector until 1940, shows that cartels tended to inflate the price of borrowed technology and to influence the direction of technology flows. Another important conclusion is that the successful adoption of technology did not necessarily translate into expansion for the receptor firms since the cartel leaders, i.e., the licensors, tended either to retain vital information or to check the growth of the licensees by attaching certain commercial limitations to the sale of know-how.

Introduction

The view that European cartels facilitated the international diffusion of technology came to be widely held in the interwar era. During the negotiations surrounding the shape of the post-1945 global economic order, Anglo-American planners rejected schemes for the international extension of the Sherman Act on the grounds that the complete banning of international cartels would hamper the interchange of technology between Europe and the United States. Through cross-licensing and other cartel understandings, and irrespective of growing international political strains, this interchange had in effect taken place in most innovative, high-tech industries (some of which were of the highest military importance) from the early 1920s well into the war years. Yet despite its importance, the technological dimension of international cartels has generally been overlooked in post-war scholarship. Only in the past two decades has it begun to receive renewed scholarly attention.

1 I would like to thank Roger Horowitz and the Hagley Museum and Library, Wilmington, Delaware, which generously supported my research work back in 2007. Heartfelt thanks also go, of course, to Maria Adorante.
5 For an up-to-date review of the debate on...
Because it was one of the fastest growing high-tech innovative sectors of the interwar era, the rayon industry offers rich insights into the theme at hand. A fibre spun out of melted wood-pulp, rayon was the first of a large and ever growing family of man-made fibres. The industry made its appearance at the turn of the 19th and 20th centuries, experiencing impressive growth after the First World War. As Coleman pointed out, one crucial factor behind this growth was the international spread of rayon know-how in the years immediately after the conflict. The industry’s main protagonists from the industry’s beginnings in 1895 included the British concern Courtaulds, the German firm Vereinigte Glanzstoff-Fabriken (VGF), and the French conglomerate the Comptoir des Textiles Artificiels (Comptoir), and these three firms remained key players for some time thereafter. They were joined soon after the First World War by a number of fast-growing firms in Holland and in the USA, but also in low-wages economies, such as Italy and Japan. These new firms began to challenge the position of the first movers. More importantly, while entering this business, before and once again after the conflict, the leading rayon firms set up a European cartel, cooperating on the technological front. They jointly developed a viable spinning system before 1914, and continually exchanged know-how until the late 30s.

What accounted for the international spread of rayon technology after 1918? And, how did the European rayon cartel shape this process? In attempting to answer these questions, Coleman and later Jones suggested that the expiry of the basic viscose rayon patents in 1919, the so-called Müller patents taken out in 1905, represented the main factor behind the diffusion of this trade. Important as it was, however, patent ownership alone did not ensure the successful launch of new rayon businesses. This remained a rapidly evolving industry with high entry barriers until the 30s. As a consequence, would-be rayon-makers needed know-how from the few older established firms in order to succeed. Coleman and Jones underestimate this fact, considering the post-war European rayon cartel an attempt by the pioneer firms, primarily Courtaulds and VGF, to regain control over the industry. The history of this trade shows, however, that new-comers and old-established firms alike were willing to participate in cartelization in order to have, among other things, access to new advances. Another point escaping the attention of Coleman is that technology transfer within this industry took the shape of two-ways flows (from the proprietor to the recipient firm and back from the latter to other firms). This fact had important implications. One of these was that rayon, to adapt Allen’s notion to an international context, was to some extent a «collective invention», namely the outcome of the cooperation among the leading European firms, with two important qualifications: in the case of rayon, know-how did not belong to any specific national context; and, secondly, technology transfer was not costless for receptor firms.
Cooperation not only offered access to information and know-how. It also fostered economic integration. The fact that international cartels – the majority of which were established in Europe – underpinned the economic integration of Europe (the European Coal and Steel Community, for example, was an outgrowth of the European coal and steel cartel of the 30s) has largely been established. A similar effect is apparent in the case of rayon: against a backdrop of rapid fragmentation of the global economy, the main actors into the industry kept close ties with one another and maintained global governance mechanisms of the industry until the outbreak of the Second World War. Moreover, the history of this trade confirms that governments sponsored international cartels in an attempt to facilitate technological interchange. As will be seen below, when entering the war in 1940, the Fascist government did not sequestrate the stake that Courtaulds had in the Italian rayon-maker Snia Viscosa as enemy property because links between these and other companies along with European cartels facilitated the acquisition of foreign know-how.

The history of this trade seems also to corroborate Mansfield and Baumol’s claim that cooperation results mostly from the inefficacy of the international patent system. This does not guarantee a monopoly over proprietary technology – so argue Mansfield and Baumol – so much that the owners of technology prefer to make a profit from its sale (this is the trade off for the loss of the monopoly over proprietary technology), while «internalising knowledge spillovers» by collaborating with their competitors. After 1914 and immediately after the end of the conflict, there was little or no patent protection in Europe, and the pioneer rayon firms temporarily abandoned a concerted commercial and technological policy. As will be seen here, along with the high profits deriving from the sale of patents and know-how, these facts had a weight in the diffusion of rayon technologies outside Germany and France in particular. These facts, and especially the temporary absence of a common patent policy of the pioneer firms, help to explain more particularly why this industry spread towards countries such as Italy and Japan, where labour was cheaper and demand for rayon almost non-existent.

This article, then, lends substance to the claim that European cartels were vehicles for technology transfer. Yet it qualifies Baumol’s rosy picture of the effects of the visible hand of cartels on the spread of industry. As will be seen here, patent and technological understandings tended, first, to lift entry barriers to outsiders (especially chemical
firms), and, second, to influence the direction of technology flows. Within the European rayon cartel, moreover, there seemed to be a trade-off between access to know-how and output growth.\textsuperscript{16} The Italian experience, in particular, shows that the labour costs of the receptor firms (and their ability to depress world prices) increased the price of borrowed technology, a point overlooked by Mansfield and Teece.\textsuperscript{17} This experience also demonstrates that the government was instrumental in smoothing technology transfer while avoiding a dramatic limitation of output, a fact that Petri has probably underestimated in his analysis of the German-Italian petrochemical industry in the 30s, in which the transfer of know-how from Germany to Italy, it should be stressed, was sponsored and supervised by the Italian government.\textsuperscript{18}

This article proceeds as follows. After briefly reviewing the history of the industry after 1918, it analyses the technology interchange taking place between the largest European rayon firms. Before a conclusion is drawn, a third section considers the role of the Italian government in the transfer of technology from Britain and Germany to Italy.

The collapse of the pre-war European rayon cartel and the diffusion of technology after 1918

How impressive the growth of the rayon industry after the First World War was can be gauged from Figures 1 and 2.\textsuperscript{19} These also say something about the spread of the industry outside the initial core producing countries, i.e. Britain, France and Germany. After an initial lead, both France and Britain declined in relative terms, whereas Italy and more particularly the USA rapidly emerged as important producing countries after 1918. In contrast to Britain and France, moreover, Germany remained a leading producer throughout the interwar era and particularly in the latter half of the 30s, when import-substitution policies and then rearmament boosted a new upsurge.\textsuperscript{20} As for Japan, the quasi-exponential expansion of rayon output began just as Europe and the USA saw their output grow less quickly than in the 20s as a result of a significant drop in demand. Three interconnected factors were at work behind this trend: first, cheaper labour (eight times cheaper than in Britain in 1930) and higher labour productivity; second, closer integration between rayon, chemical and silk, as well as cotton, spinning firms (the former were an extension of the latter); lastly, the occupation of large swaths of China (which along with India constituted the largest export outlet after the closing up of the US market in 1930 by virtue of protectionism) and related

\textsuperscript{17} Mansfield, International technology transfer (cf. n. 12), 373f.; David J. Teece, Technology Transfer by Multinational Firms: The Resource Cost of Transferring Technological Know-How, in: Economic Journal 87 (1977), 242-261.
\textsuperscript{19} Coleman, Courtaulds (cf. n. 6), vol. II, 171-204.
Figure 1: World rayon output by main producing countries, 1921 to 1929


Figure 2: World rayon output by main producing countries, 1930 to 1941

import-substitution policies during the 30s that provided outlets for growing domestic output.21

Underpinning these developments was the soaring number of rayon firms after 1914. Coleman calculated that there were fewer than ten of them before 1914 as opposed to 120 in 1931.22 Of the newcomers, however, only a few became leading players into the industry. These included the Dutch N.V. Nederlandsche Kunstzijde Fabriek (Enka); the U.S. chemical concern Du Pont; the German giant chemical firm IG Farben; Snia Viscosa, Châtillon and Cisa in Italy; and a plethora of smaller Japanese concerns, of which Teikoku Jinzo Kenshi Kaisha Ltd (the Teikoku Artificial Silk Co. Ltd) became the most prominent in terms of output and output capacity by the 30s.

Two crucial questions should thus be posed at this juncture: why did the industry begin to spread mostly after 1918? And, how did the newcomers manage to obtain rayon know-how?

There is no single answer to these questions. The migration of skilled workers previously employed by the pioneer firms did have a role in the diffusion of trade secrets and non-patentable knowledge. The best known cases were those of Jacques Coenraad Hartogs and Marco Biroli. The former launched Enka in 1913 after some training in Courtaulds’ plant at Coventry in the 1900s, while Marco Biroli, the motivating spirit behind Châtillon, had been a distinguished chemist of Cisa, the Italian subsidiary of the Comptoir.23

The inconsistencies and loopholes of the international patent system were also of some importance in this process, however.24 After 1914, patents and assets were sequestered and new competitors had entered business under the shelter of import-substitution policies. This was the case, in particular, of a number of German chemical firms, notably AGFA, Bayer and Köln Rottweil AG, which started rayon production in 1915 and merged into IG Farben in 1926. Moreover, international patent protection, which was traditionally guaranteed by commercial treaties, continued to remain partially if not wholly ineffective immediately after the war as the stipulation of new commercial ententes was delayed, first, by European inflation and, above all, by the suspension of Germany’s commercial sovereignty, which lasted until 1925. These facts facilitated the entry into business of newcomers outside Germany. Châtillon, to quote one example, operated on the basis of patents – the so-called Biroli patents registered in Italy and in the USA in 1919/20 – which clearly infringed the Müller and other German patents.25

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22 Coleman, Courtaulds (cf. n. 6), II, 189f.
23 Cerretano, The European rayon industry (cf. n. 16), 162f.
24 Ibid., 56-65.
25 Ibid.
The old-established firms and in particular VGF did start legal action against some of the newcomers after 1925. Yet, while lengthy and expensive, legal action failed to uproot new competition. The pioneer firms, especially VGF, instead used legal action as a bargaining counter in cartel negotiations. In 1924/25, VGF, for example, dropped all lawsuits against IG Farben after that the latter firm undertook to join a domestic price cartel and significantly to curtail its rayon output.26 In 1930, using similar tactics, it dropped legal action against Châtillon, which then finally joined a cartel limiting exports from Italy into Germany.27

Important as they were, however, neither the migration of skilled workers from one company to another, the expiry of patents, nor their illegal acquisition alone can account for the impressive diffusion of rayon know-how after the conflict. The most successful newcomers, it should be stressed, obtained licenses and know-how from the pioneer firms. Still an infant industry in the early 20s, rayon-making posed formidable financial and technological problems for would-be rayon firms, a fact explaining why newcomers sought support from well-established rayon concerns as they entered this business.

However, if this fact encouraged newcomers to seek the cooperation of the pioneer firms, the reasons which motivated the latter to provide assistance to new competitors were less straightforward. Pursuit of profit was clearly a major factor at work here: high rayon prices, high profit margins, and the small number of patent holders in the first half of the 20s increased both royalties and the price of this technology. The temporary lack of patent and commercial coordination among the pioneer firms, however, also contributed to this outcome and to the rapid spread of this industry in the early 20s.

Under the leadership of Courtaulds and VGF, the pioneer firms had formed a European cartel prior to 1911. Although it collapsed in 1914, it was re-established after 1925.28 Less tightly organised than the pre-war cartel which envisaged, among other things, a common European sales agency, the interwar European rayon cartel was, to use Fear’s typology, a hard core price cartel.29 In these cartels, however, it was difficult to draw a sharp line between patent- and market-sharing agreements, for these complemented each another in the regulation of competition and in the creation of domestic monopolies. In relation to this, it is worth noting that before 1914 the pioneer firms, through concerted action, had avoided licensing technology to strong firm, notably chemical concerns, which, although lacking the textile expertise, had a competitive edge when it came to the provision of heavy chemicals, caustic soda, and sulphuric acid, which were all heavily employed in rayon manufacture. When licensing occurred, the licensees were usually financially weak, with little in-house capabilities and not in a position to increase output dramatically.30 A case in point is the Italian Cisa, a small and troubled celluloid manufacturer established in 1901 which, as a result of this exchange, came to be controlled by the French firm.31

The posture of the pioneer firms changed dramatically after 1918. To Baumol, technology-sharing cartels, which provide little or no incentive to cheating, are much more

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26 Ibid.
27 Ibid., 183-196.
28 Coleman, Courtaulds (cf. n. 6), II, 76-103.
29 Fear, Cartels (cf. n. 5), 272, Fig. 12.1.
30 Coleman, Courtaulds (cf. n. 6), II, 76-103.
31 Ibid.
stable than market-sharing cartels. The rayon cartel, which to a great extent was a technology-sharing cartel, did not, however, survive the stresses of the war (notably, the strains among firms created by asset and patent sequestration). A common patent policy failed to materialise immediately after the war as relations between the leading firms continued to be strained and profit margins remained high. Another contributing factor to this outcome, however, was the fact that numerous interests which had amassed immense fortunes during the war were now able, more than in the past, to lure patent holders, particularly the Comptoir and VGF, with huge sums of money.

Soon after the war, the Comptoir and VGF attempted to re-establish a European cartel. In particular, they settled patent disputes, reviving a «community of patents» in May 1920. Despite these attempts, however, both firms sold their know-how independently to new competitors. Early in 1920, the Comptoir licensed, among others, DuPont and Snia Viscosa. Two years later, VGF set up a firm in Japan in conjunction with Japanese businessman Nogushi Yun and his Asahi Chemicals. In the cases of the Japanese and Italian investment, however, both VGF and the Comptoir subjected technology transfer to output and sales limitations (the licensors were not allowed to make their sales in a number of markets, including of course the licensors’ domestic markets) and to the free acquisition of advances originating in the new plants.

High rental rates and high profits, as already mentioned, but also probably a lack of financial resources, were the key factors encouraging VGF and the Comptoir to license outsiders. As we have seen, however, these firms sought to discriminate against certain potential new entrants. When early in 1922 news broke that VGF was about to establish a joint venture in Japan, the Comptoir protested to VGF in the following terms:

«We have rejected negotiations with the Japanese, who made very favourable proposals […] during our meeting [in Cologne in May 1920] we agreed that the idea of providing this support to as dangerous people as the Japanese must be abandoned altogether […]».

These words testified to the fact that the profit deriving from the sale of know-how was probably not the only factor governing technology trading. The «dangerous people» to whom the Comptoir referred were the firms and interests with large financial resources, no home market, and cheap labour which were likely to become a threat in export markets.

32 Baumol, *Horizontal Collusion* (cf. n. 15).
33 Letter of Alfred Bernheim (the Comptoir) to Fritz Bluethgen (VGF), 10 August 1922;
Zusammenkunft zwischen Bernheim, Dietz, Jordan und Bluethgen, Koeln, 8./9. Mai 1920, in: VGF Archives, Wuppertal [hereinafter VGF A], Frankreich-CTA, E 5-o-2, E 5-1-3 bis 19. Please note that, since consulted, this archive has now been moved to Cologne and was subject to a new classification system. See also Theodor Langenbruch, *Glanzstoff, 1899-1949*, Elberfeld-Wuppertal 1985, 85.
36 Letter from Alfred Bernheim (Comptoir) to Fritz Bluethgen (VGF), 24 March 1922, in:
VGF A, E5-o-2, E5-1-3 to 19.
More than VGF, however, the Comptoir was the pioneer firm which most helped new interests to enter into this business. In April 1920, the French firm set up Du Pont Fibersilk, with works at Buffalo, New York, in conjunction with US chemical giant Du Pont. Of the new company’s starting capital (four mill. US-Dollar), 60 percent went to Du Pont, and the remainder to the French (including 24 percent for their know-how). In 1925, Du Pont Fibersilk changed name into the Du Pont Rayon Company (which, in 1930, became wholly controlled by Du Pont, and in 1936 became the Du Pont Rayon Department) and set up new plants at Old Hickory, Tennessee, and in Richmond, Virginia in 1929. Du Pont expanded considerably in the 20s, becoming as early as 1924 the second largest US rayon producer after the American Viscose Corporation. As Hounshell and Smith underlined, rayon soon became the largest branch of the company, absorbing a good portion of Du Pont’s output of heavy chemicals.

Du Pont remained dependent on European know-how until 1930. In that year, however, it purchased the Comptoir’s minority stake, becoming the only full-fledged big U.S. rayon company. The chemical company nevertheless maintained close relations with the Comptoir until 1939 (they had cross-licensing and market-sharing agreements while making joint direct investments in Argentina and Mexico). With regard to the limitations imposed on licensees, it is also worth noting that in exchange for know-how Du Pont refrained from invading European markets.

Of far-reaching consequence for the industry as a whole was the support that the Comptoir provided to Snia Viscosa. This was because Du Pont was a high-cost producer which expanded mostly within the domestic market, whereas the latter posed a direct threat to the old-established firms in export outlets. In the years 1920 to 1922, the Comptoir sold Snia Viscosa the Italian rights to the Müller patents along with a number of small rayon plants previously belonging to the Cisa group. The French firm, as already mentioned, sought to use technology transfer to exert some control over the industrial policy of Snia Viscosa. However, Snia Viscosa soon expanded output beyond the agreed limits (about 3,000 metric tons a year) undercutting the Comptoir and other pioneer firms in all markets, particularly Britain and the USA. As early as 1924, Snia Viscosa had overtaken Courtaulds and VGF in terms of output, accounting for about 70

37 Final agreement between Comptoir and Du Pont, 7 July 1920, in: Du Pont Archives, Hagley Library, Wilmington DE [hereinafter DPA], 1771, Box 82.
40 Hounshell/Smith, Science and Corporate Strategy (cf. n. 38), 161-182; Taylor/Sudnik, DuPont (cf. n. 38), 118.
percent of Italian exports, and eleven percent of the world’s output of rayon.43 The reasons behind the failure of the Comptoir to check the expansion of the Italian firm must be found in the factors allowing the latter to grow rapidly: not only inflation, currency depreciation, and cheap labour, but also the U.S. and British boom in demand for poor quality rayon were important. In fact, the Italian firm, unable to produce good quality yarn until 1930, soon became entrenched in this poor quality rayon market. With regard to this, it should be emphasised that, as an authoritative source noted in the early 40s, this boom was largely occasioned by a lack of price coordination by the pioneer firms and more particularly by the price cuts that Courtaulds and its subsidiary the American Viscose Corporation executed in 1919/20 with the aims of bringing rayon prices into line with rapidly falling cotton prices and also of keeping new competitors at bay.44

Coleman concluded that the «most evident contribution» of the pre-war European rayon cartel «arose from technical collaboration and patent exchanging. Without these measures the industry would have advanced less rapidly than it did; the effect was to ease the dissemination of knowledge rather than to restrict it».45 As we have mentioned in this section, however, the European rayon cartel ensured the diffusion and exchange of rayon technology mostly within the cartel network, raising its costs for outsiders.

In connection with this, it should be said that economists and economic historians tend to consider, although implicitly, technology transfer a costless process, which is then substantially unaffected by the market power of the firms holding proprietary technology.46 Largely as a consequence of this, they also tend to establish, once again implicitly, an equation between the acquisition of borrowed technology and unrestrained growth.47 With regard to this, Mansfield and Teece have however established that the price of «borrowed technology» is a negative function of both its age and the number of patent-holders.48 To quote a well-known example, Snia Viscosa, between 1920 and 1931, spent about 240 mill. lira or the equivalent of about 25 percent of the company’s share capital in 1925 in the acquisition of patents and know-how from the Comptoir, VGF, and Courtaulds.49 Moreover, the transfer of technology was subject to output limitations, the costs of which are not immediately quantifiable.50 Against this background, it seems reasonable to suggest that had pre-war conditions prevailed, the diffusion of rayon know-how, given its high transfer costs and the small number of patent

43 Cerretano, *The Benefits of Moderate Inflation* (cf. n. 16).
45 Coleman, *Courtaulds* (cf. n. 6), II, 102.
49 Cerretano, *The Benefits of moderate inflation* (cf. n. 16); Cerretano, *The European rayon industry* (cf. n. 14), 10-111.
50 Ibid.
holders, would scarcely have taken place or would have been subjected to major output limitations. It can safely be stated, in conclusion, that the international spread of this expensive technology and the parallel growth in rayon output after the First World War was to a great extent the outcome of unique circumstances: the temporary collapse of the European rayon cartel; excess war profits; high profit margins in this industry; inflation; and lack of patent protection.

The European rayon cartel and technology exchanges after 1918

We have mentioned that the pre-war European cartel, while envisaging the sharing out of markets, stipulated the pooling of patents and know-how. These aspects were strictly interconnected since cross-licensing, while subject to certain limitations with regard to sales and prices in third markets, guaranteed domestic monopolies to the patent-holders. However, the gist of the agreements signed in 1911 was that all major rayon concerns – from Courtaulds, to VGF, to the Comptoir – shared the Müller and other basic patents and undertook to pool future advances originating in the plants of all cartel members. As Coleman has shown, visits to foreign plants were regularly undertaken and information exchanged in the early days of the industry. However, technological exchanges and the supervision of arrangements remained strictly bilateral.

This «pair-wise mode of operation», to borrow Baumol’s notion, also characterised the post-war period. The members of the European rayon cartel, in other words, exchanged know-how or information bilaterally without resorting to a coordinating body or general meeting. This way, however, innovations were potentially available to all. Of particular importance after 1918 were the technological exchanges taking place between the Comptoir and Du Pont; between VGF and the Comptoir (especially in the field of acetate rayon); and between VGF, Courtaulds, and Snia Viscosa. Here attention will focus on the exchanges taking place within the latter group of firms between 1927 and 1940.

At this juncture, it should be said that Courtaulds and VGF in 1927 jointly bought a controlling interest in Snia Viscosa, after the Italian firm had broken off relations with the Comptoir and found itself in financial need in mid-1926. This move was instrumental in VGF and Courtaulds’ cartel strategy, which aimed at dramatically curtail Italian exports of rayon. The Courtaulds-VGF-Snia Viscosa compact (taken together, the firms controlled more than 50 percent of world’s output in 1930) that ensued in effect gave a major boost to post-war European cartelization. On the other hand, while facing financial collapse, Snia Viscosa accepted a limitation of output in exchange for financial aid and, above all, in exchange for Courtaulds and VGF’s know-how.

51 Coleman, Courtaulds (cf. n. 16), II, 76-103.
52 Ibid.
53 Ibid.
54 Ibid.
56 The Benefits of Moderate Inflation (cf. n. 16); Coleman, Courtaulds (cf. n. 16), II, 275-288.
57 Coleman, Courtaulds (cf. n. 16), II, 275-288; Cerretano, The European rayon industry (cf. n. 14), 44-111.
58 Cerretano, The Benefits of moderate inflation (cf. n. 16).
In the 20s, the primary concern of Snia Viscosa was, as with other newcomers, to develop a viable spinning process. The development of that system after 1927 was, however, marred by strong disagreements between Italian and German technologists, who pursued a dramatic reduction of output. The reason why VGF, more than Courtaulds, was charged with the industrial reconstruction of Snia Viscosa was that the German company operated on the basis of a spinning system, namely the «bobbin spinning», similar to the one that the Italians had begun to develop under the direction of the Comptoir. German plans for a dramatic reduction of output were abandoned in the end (see below). Some of the advances introduced by VGF engineers were, however, kept. As a leading Italian engineer recalled, their most significant contributions to Snia Viscosa’s spinning system were changes and improvements in the filtration systems of the viscose solution (a crucial operation in the making of viscose rayon), improvements in the filtration of the spinning bath, the introduction of the «gear-pump» (another technical breakthrough introduced in the late 20s) and «candle-filter» in the spinning machines, and the establishment of textile and chemical laboratories in all the company’s factories (on the various stages of rayon-making see Figure 3). Even Snia Viscosa’s new – and to a considerable extent ground-breaking – spinning machine, the Silm 81, was largely modelled on the VGF’s von Hamel machine (on this see below). In addition, Snia Viscosa combined these new advances with Courtaulds’ innovative bleaching system.59

A leading director of Courtaulds noted in late 1930 that the outcome of these technical developments was the elaboration of a competitive bobbin system.60 One important element of this system was the use of aluminium bobbins of 90 mm diameter, larger than those employed by VGF (70 mm diameter) and allowing a reasonable compromise between quality, which was now good enough to support vast markets in the various weaving trades, and greater economies of scale (100 grams of yarn could be spun in one twist, against the mere 45 grams of the VGF 70 mm bobbins or 55 grams the Courtaulds Topham boxes). Another feature was the use of the Silm 81 itself, for which a patent was taken out in Italy, in Germany, and in Britain late in 1930.61 The Silm 81 marked a significant advancement in bobbin spinning technologies, for it allowed the automatic changeover of bobbins, meaning that, when the first series of bobbins was filled, the machine switched over automatically to the second series. This limited the handling of bobbins (thus allowing improvements in quality) when filaments were still wet, and, as a result, the amount of waste and time due to the manual change of bobbins (so-called «doffing») (see Figure 3).

The spinning system of Snia Viscosa was one of two methods adopted at the time, the other being the box or centrifugal spinning system, in use in Courtaulds and the American Viscose Corporation’s plants. Coleman maintains that the gap in costs be-


60 Memorandum by Ernst Lunge (Courtaulds) regarding Snia Viscosa, 22 September 1930, in: Courtaulds Archives, Coventry [hereinafter CA], JHW.16.

61 British Patent 3,4446 («Improvements in spinning machine»).
tween box and bobbin spinning was bridged by the mid-1900s, and that the employment of these systems, which produced yarns of differing characteristics, depended much on the end-uses of the yarns. Yet bobbin spinning techniques made great headway in the late 20s, becoming more amenable to greater economies of scale. Unsurprisingly, then the methods developed in Snia Viscosa’s plants and in Cologne (i.e. VGF and Courtaulds’ joint plant) drew the attention of Courtaulds. With regard to this, it should be noted that the employment of bobbin spinning was interconnected with wider discussions within the British concern’s board of the British on how to expand outlets of rayon, whether through high quality or through low prices. Between 1928 and 1930, Italian engineers and chemists paid regular visits to the continental subsidiaries of Courtaulds in Calais and in Cologne, collaborating with their technical staff. While proving crucial to the improvement of Snia Viscosa’s spinning methods, these exchanges also allowed Courtaulds and its continental plants finally to master up-to-date bobbin spinning technology.

The development of staple fibres technology proved more important still. Essentially yarn cut at regular lengths, staple fibres constituted the most important breakthrough in this industry after 1918, mostly because they were cheaper than traditional yarns and could be more easily spun in combination with natural fibres, wool, and then cotton. Mass production of staple fibres, besides extending the end-uses of rayon, was behind the upsurge in rayon output in the latter half of the 30s (see Table 1). More importantly, it took off mostly in countries which adopted extensive import-substitution and autarkic policies, i.e. Germany, Japan, and Italy (see Table 2).

Snia Viscosa initially obtained patents for staple fibres from the Comptoir, and later developed some of ideas introduced by VGF during the war. To be more specific, the Italian company introduced a staple fibres cutting machine (patented under the name of Antonio Beria in 1927 and in 1928) which developed Pellerin’s idea of collecting fibres from a spinning jet with a great number of holes (as many as 1,200 against 35 or 70 in the case of yarns) in the form of a thick tow or bundle, which went first through a funnel and then through blades. One feature of this machine was the rapidity with which it could cut the rayon tow. Snia Viscosa surrendered in 1932 this machine to Courtaulds which began the mass-production of staple fibres under the trademark of “Fibro” in 1936, and to American Viscose Corporation as well as Courtaulds’ subsidiary at Calais in 1934 and in 1935. Likewise, in April 1935 the Italian conglomerate sold staple fibres know-how to VGF, undertaking to assist the latter firm in the development of the Blaschke machine, a staple fibres machine which was more compact and potentially more efficient than the Beria machine.

Connected with the commercialisation of staple fibres was the mass production of wood-pulp from reed and beech – to acquire sufficient raw materials, Snia Viscosa made huge investment by 1935 to substitute for North American and Scandinavian

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62 Coleman, Courtaulds (cf. n. 16), II, 51.
64 Memorandum by Ernst Lunge (Courtaulds) regarding Snia Viscosa, 22 September 1930, in: CA, JHW.16.
65 Cerretano, The European Rayon Industry (cf. n. 14), 159-175.
Table 1: Rayon yarns and staple fibres: global output, 1929 to 1941
(1,000 metric tons)

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<th>Yarn</th>
<th>Staple fibres</th>
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<td>1929</td>
<td>197.8</td>
<td>98.2</td>
<td>3.6</td>
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<tr>
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<td>204.6</td>
<td>98.5</td>
<td>3.2</td>
</tr>
<tr>
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<td>224.1</td>
<td>98.2</td>
<td>4.1</td>
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<td>236.3</td>
<td>96.6</td>
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<td>24.5</td>
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<td>86.7</td>
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<td>77.1</td>
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<td>517.6</td>
<td>50.8</td>
<td>499.9</td>
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<tr>
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<td>542.0</td>
<td>48.1</td>
<td>585.1</td>
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<tr>
<td>1941</td>
<td>571.5</td>
<td>44.7</td>
<td>706.3</td>
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Table 2: Italy, Germany, Japan: shares of world output of staple fibres, 1929
(1,000 metric tons)

<table>
<thead>
<tr>
<th></th>
<th>Italy</th>
<th>Germany</th>
<th>Japan</th>
<th>World output</th>
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<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
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<tr>
<td>1929</td>
<td>0.8</td>
<td>1.1</td>
<td>30.6</td>
<td>3.6</td>
</tr>
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<td>0.3</td>
<td>2.0</td>
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<td>3.2</td>
</tr>
<tr>
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<td>2.0</td>
<td>48.8</td>
<td>4.1</td>
</tr>
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<td>1.4</td>
<td>17.1</td>
<td>0.3</td>
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<td>43.0</td>
<td>31.3</td>
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<td>240.1</td>
<td>41.0</td>
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<tr>
<td>1941</td>
<td>124.7</td>
<td>292.6</td>
<td>41.4</td>
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</table>

Source: See Table 1.
spruce by using these lower quality sources. The diversification into this industry was occasioned by two interrelated factors: first, currency scarcity and import-substitution policies; and, secondly, growing prices of imported, high-quality wood pulp. Of inferior quality, the reed and beech wood pulp could however be employed in the production of staple fibres, which were of much lower quality than yarns. Although production began in 1939 and was interrupted as early as 1943, the Italian firm developed sophisticated wood pulp technology, which Courtaulds acquired in the early 50s.

The Cerini soda recovery process was also of some importance. By the mid-20s, pressures from price decreases for finished product on the one hand and surging production costs on the other triggered a search for processes of recovery of heavy chemicals (sulphuric acid and caustic soda). The contribution of Snia Viscosa to this field of research was the Cerini process, a cheap and efficient dialyser for the recovery of the so-called «press lye», which was mostly composed of caustic soda. The process could recover up to 85 percent of the caustic soda from it. Snia launched the Societa Italiana Recupero Soluzioni Impure (hereinafter SIRSI) in 1930 in conjunction with Cerini in order to exploit the patent worldwide. After rejecting the Heibig process employed in VGF’s plants, Courtaulds, Courtaulds Canada, the British Cellophone, and the American Viscose Corporation acquired the British, Canadian, and American rights to the Cerini process in the years between 1931 and 1933. Courtaulds and AVC acquired 66 and 127 plants respectively from SIRSI, building approximately 478 other recovery plants on their own respectively between 1931 and 1937. This system was disclosed to VGF and other European rayon firms, as well as to Du Pont.

Less important but worth mentioning, finally, was the Ferretti process for the production of Lanital, a casein fibre. Developed in the mid-30s in an attempt to substitute decreasing wool imports, this proved a fiasco outside of Italy because of its poor strength and dyeing properties. In summer 1937, Courtaulds, however, acquired the patent rights for Britain and Canada and marketed it as «Fibrolan», while agreeing to pool advances with Snia Viscosa. The American Viscose Corporation and Du Pont became for some time interested in this process between 1936 and 1937. Yet the unclear patent position of Lanital in the USA, the high price of the patent (two mill. US-dollars), and the uncertainty surrounding the commercial success of the fibre led these firms to abandon plans for its mass production.

A director of Courtaulds recalled in 1931 that «the only technical assistance subsequently exchanged between Courtaulds and Snia was that given by Snia [Viscosa] to us, when they gave us the Sniafil machine and facilities to learn bobbin spinning practice» [italics in the original]. In effect, on balance, the British firm gained greater benefits from these technological interchanges in the time period under consideration.

67 Cerretano, The European rayon industry (cf. n. 14), 204ff.
68 Coleman, Courtauld’s (cf. n. 10), III, 112ff.
70 Cerini Dyalisers, 6 October 1937, in: CA, JHW 57.
71 Ibid.
72 Agreement on Lanital, 7 July 1937, in: CA, AGR 31.
74 Cable of Samuel Salvage to John Hanbury-Williams, 9 June 1937, in: CA, JHW 3.
75 Ernst Lunge (Courtaulds), Memorandum to Samuel Courtauld, Rapallo, 11 April 1931, in: VGF A, E7-1-10 bis 14.
That said, however, Snia Viscosa, besides the assistance for the development of a viable spinning system, also secured important innovations from Courtaulds and from VGF. One of these was the Lilienfeld process. Originated in the VGF works, this patent covered the use of certain chemical compounds for the making of high-tenacity yarns employed in the making of tyres. Another important technological breakthrough of the 30s, high-tenacity yarns found vast outlets in tyre manufacture initially in the USA and subsequently in Europe, where their application of took only place as a result of cotton shortages late in the 30s. Snia Viscosa began experimentation with the Lilienfeld process in 1930, purchasing the rights for Italy in 1934. Snia Viscosa obtained box-spinning machines employed by the VGF Cologne factory from the German firm in exchange for staple fibres technologies. The Italian firm completed the set of box-spinning technologies with the acquisition of «cake-washing» machines – another important innovation of the 30s – from Courtaulds in 1939.

Of greater importance were the innovations that Snia Viscosa secured from Courtaulds soon after 1945. These included the Continuous Spinning System, acetate rayon know-how, the so-called hot stretch process for high-tenacity rayon and, most importantly, Nylon 66, the first truly synthetic fibre that began to be marketed after the Second World War. It should be noted that Courtaulds in its turn obtained these advances from firms with which it had cross-licensing agreements, including the US firm Industrial Rayon Corporation, ICI, the Comptoir, and Du Pont.

National governments, corporate cooperation and technology transfer: the Italian case

The Italian government and economic nationalism played an important, although often indirect, role in the process by which Snia Viscosa successfully adopted foreign know-how. As with other European governments, the Fascist regime did not hinder cooperation between national and foreign firms. It did, however, seek to ameliorate the trade off between access to foreign know-how and output limitation.

We have seen in the previous section that Courtaulds and VGF came to control Snia Viscosa in 1927/28. The British and the Germans initially entrusted a VGF director, Karl Scherer, with the technical as well as financial restructuring of the company. While implementing a dramatic reduction of output, Scherer ousted Riccardo Gualino, the founder of the company, appointing Senatore Borletti as the company’s new chairman. These were major developments when considering that Gualino was not only one of the most prominent Italian businessmen, but Snia Viscosa was also by the mid-20s the largest Italian company by capital and furthermore that this took place in the context of growing economic nationalism during the late 20s. The weight of Courtaulds and VGF

76 Coleman, Courtaulds (cf. n. 16), II, 351.
77 Transfer of box-spinning technologies from Cologne was, obviously, also agreed with Courtaulds; Letter of Conrad Hermann (VGF) to Franco Marinotti, 5 April 1935, in: VGF A, SV 179.
78 Extract from minutes of Board Meetings Courtaulds, 10 March 1939, in: CA JHW.4.
79 On cake-washing systems see Coleman, Courtaulds (cf. n. 16), II, 187f.
70 Cerretano, The European rayon industry (cf. n. 14), 217-222.
80 Ibid.
in Snia Viscosa’s governing bodies was not entirely clear in Italy until the early 30s, and raised criticism from influential economic and political circles. Early in 1931, a Courtaulds’ liaison officer in Snia Viscosa stated that Scherer «has a very bad reputation in Northern Italian Fascist circles owing to […] his insistence some months ago that production should be very much reduced».81 A few months later, an anonymous commentator remarked to Mussolini that «thanks to foreign intervention, the financial problems [of Snia Viscosa] can be considered solved, and yet it is difficult not to feel, when one possesses self esteem, the humiliation of this intervention».82 Similar sentiments seemed to have gained currency in the midst of the depression as the measures of economic nationalism (which, among other things, impeded the launch of Ford’s subsidiary in Italy) that Mussolini implemented in «defence of national industry» in 1930 seemed to indicate.83 A stance of economic nationalism was also taken by the state agency Istituto per la Ricostruzione Industriale (Istituto) created in 1933 when opposing the merger between Snia Viscosa, Châtillon (controlled by the Istituto from 1933), and the Comptoir-owned firm Cisa throughout the 30s. The argument was that a merger between those firms would create a domestic monopoly controlled by foreign interests.84 A memorandum that the Istituto circulated in late 1933 put it this way:

«[Senatore Borletti] […] has been warned about the preoccupations of national character inherent in the strengthening up of [Snia Viscosa’s] majority voting pool, which seems to be controlled by foreigners […] Senatore Borletti has denied this control […] in order to prove this, he has shown the statutes of Safra and Sagepi […] it must be noted that the exceptional formulas used in the statutes of these holding companies confirm the widely shared view that the controlling interest of Snia Viscosa is in the hands of foreign groups.»85

In effect, Safra and Sagepi, which were established in 1933, were companies holding the German and British interests in Snia Viscosa. Yet their launch marked the separation between the ownership and management of the company, putting an end to Courtaulds
and VGF’s direct control over the management of Snia Viscosa. Growing poor relations between VGF and Courtaulds played a part in these developments. But political factors and economic nationalism seemed to have had an even greater role. Explained Borletti to the managing director of VGF in spring 1931 that «these changes [...] have been imposed by factors, I would say, of political [...] order [...] these changes have been proposed merely to moralise [...] the situation». Against that backdrop, it comes as little surprise that Scherer’s schemes for a dramatic limitation of output were abandoned altogether between 1931 and 1933.

Yet, while putting a brake on foreign influence at Snia Viscosa, the regime did not press the Italian firm to sever links with their foreign rivals entirely. After the entry of Italy into war in 1940, Mussolini intervened personally to avoid the sequestration of Courtaulds’ interest in the company. One of the reasons for this move can be found in a memorandum of 1941 by the Italian Ministry for Finance. This read:

«[...] in this industry, international technical collaboration has brought important results [...] through the utilisation of technical resources available in each single country [...] the financial participation of foreign groups in national companies have always been considered favourably to facilitate technical and commercial collaboration. This opinion was also shared by representatives of the German [rayon] industry [...] according to the Ministry for Finance the foreign interests in Snia Viscosa should not be eliminated [...]».

Thus, two points may be drawn from what has been said so far on the role of the government. The first is that this fostered economic integration and international cartel agreements not only to mitigate the shortcoming of credit scarcity after 1927, but also to facilitate technology exchanges. The second point is that the regime, although favouring co-operation between Snia Viscosa and its rivals, impeded the dramatic downsizing of the company while smoothing the acquisition of foreign know-how.

86 Coleman, Courtaulds (cf. n. 16), II, 378; Cerretano, The European rayon industry (cf. n. 14), 175-183.
87 Ibid.
88 In the original: «Ces modifications n’ont pas été faites pour le goût de changement, ni pour faire de la théorie inutile, mais se sont imposées pour des raisons, voudrais je-dire, politique et d’ordre général [...] cette modification a été proposée uniquement pour moraliser, pour ainsi dire un peu la situation [...]». Letter of Senatore Borletti to Fritz Bluethgen (VGF), 29 May 1931, in: VGF A, E7-1-22 to 34.
89 Coleman, Courtaulds (cf. n. 16), III, 109.
90 In the original: «[...] In questa industria, la collaborazione tecnica a carattere internazionale, ha portato sempre risultati positivi nel miglioramento produttivo ed economico, attraverso lo sfruttamento delle risorse tecniche via affioranti in ogni Paese, come pure gli accordi con i gruppi ed i Sindacati nazionali dei vari Paesi produttori, hanno permesso una armonica e progressiva affermazione nel mondo delle fibre sintetiche. Accanto a queste necessità, è sempre stata ritenuta opportuna la partecipazione finanziaria di gruppi stranieri nelle imprese nazionali dei vari Paesi, e questo per maggiormente facilitare la collaborazione tecnica e commerciale [...] il Ministero delle Finanze ritiene che le partecipazioni estere della Snia non debbano essere eliminate.» In Considerazioni e premesse per l’unificazione dei piú importanti organismi Italiani per la produzione dei tessili artificiali, undated but 1941, in: ACS, IRI, SR: Fasc. Châtillon – Trattative di cessione.
Conclusion

It can safely be concluded then that the European rayon cartels before and after the First World War were also technology-sharing cartels and that, as such, they offered to all cartel members a potential access to, and information about, new advances. While proving crucial to the early development of the industry, these cartels eased the diffusion and exchange of technology within the cartel network and within the countries where the cartel members operated. The history of the rayon industry thus confirms the claim that European cartels were important conduits for technology transfer, accounting to a great extent for the co-evolution of both firms and industrial systems, itself an aspect of economic integration. Nevertheless, the evidence presented here also demonstrates that, while access to technology was a matter of death or life for newcomers, the cartel tended to lift entry barriers by regulating the patent and commercial policy of its members. The pursuit of profit did drive the transfer of technology, but the leading firms, via cartel agreements, were also able to influence the direction of technology flows. One point of some importance is that the transfer and successful adoption of technology did not necessarily translate into expansion for the receptor firms since the licensors tended either to retain vital information or to limit the growth of the licensees. The history of this trade shows that the impressive diffusion of rayon technology taking place soon after 1918 was attributable, among other things, to a lack of coordination among the leading firms. This history also suggests that governments had a role in ensuring that technology was effectively transferred and in avoiding a dramatic limitation of output growth.

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