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# Infant company protection in the German semi-synthetic fibre industry: Market power, technology, the Nazi government and the post-1945 world market

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## ABSTRACT

In the 1920 and early 1930s, the German semi-synthetic fibre industry was dominated by a duopoly of two big players. The incumbent firms were not willing to expand their staple fibre capacities to the extent demanded by the new Nazi government, which prepared for autarky and war. Hence the government encouraged other private companies, especially spinning mills, to found eight regional staple fibre plants and protected them against the incumbents who were technologically superior. The Nazis' infant company protection policy enabled the newcomers to become competitive both in economic and technological terms within a few years. After the war and without protection, these firms flourished on the world market. While the big players left the market, two of the newcomers founded in the second half of the 1930s are today the last European producers of staple fibre. We analyse in detail why companies founded for protectionist reasons by a non-benign government became successful firms competing on the world market.

## KEYWORDS

Infant company protection; man-made fibre; viscose; Nazi Germany

## 1. Introduction

The political economy literature offers a wide range of arguments why government intervention on markets is doomed to fail. Even if the central planning agency has benign objectives, it lacks the information to coordinate demand and supply efficiently. Moreover, the planning agency will not have to bear the full consequences if its plans fail. Insofar as government interventions on markets will usually do more harm than good, markets and firms should be left to themselves, and undistorted prices will coordinate supply and demand efficiently (Mankiw, 2014, pp. 187–202).

Economic and business history is full of examples for government interventions that did indeed fail. However, there are positive counter-examples that are usually found wherever some kind of infant industry argument plays a role. Famous examples are the state-supported industrialisation of 19<sup>th</sup> century Germany and especially late 19<sup>th</sup> century Russia, the relationship between tariff protection before the Great War and economic growth in the United

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States, or the mighty MITI agency in Japan (Gerschenkron, 1962; Johnson, 1982; Lehmann & O'Rourke, 2011). In this article, we present a case study for government intervention that certainly was not benign (in the sense of maximising economic or societal welfare), yet nevertheless turned out to be successful although the planners originally had had different objectives in mind. We interpret our findings as an example of what one could call (in analogy to the traditional infant *industry* argument) infant *company* protection where the government supports newcomers in order to break the oligopolistic market power of incumbent firms.

The setting of this case study is the man-made fibre<sup>1</sup> industry which emerged in the late 19<sup>th</sup> century when textile spinners looked for fibres which had better or other material characteristics than natural fibres such as wool, cotton or linen, or were able to substitute for expensive natural fibres such as silk. Right from the start, the production of man-made fibres, which were regarded as a high-technology product in the first half of the 20<sup>th</sup> century,<sup>2</sup> was research and capital intensive which led to a market dominated by a few large players in the business like *Courtaulds* (UK), *Vereinigte Glanzstoff-Fabriken* (Germany) and *Comptoir des Textiles Artificiels* (France) until the Great War.

During the Great War, the production of man-made fibres increased substantially in many countries because they were cut off from cotton imports. The quality of man-made fibre improved considerably so that the market increased. This attracted not only new market entrants like *SNIA Viscosa* (Italy) and *Enka* (The Netherlands), but also existing chemical giants such as *DuPont* (USA), *IG Farben* (Germany), and *ICI* (UK). The importance of patents and economies of scale created high incentives to cooperate and to cartelise the markets. Hence the world's interwar markets for man-made fibres were characterised by a high degree of market power and cartelisation, i.e. market imperfections (see for rayon yarn Cerretano (2011, 2012, 2018)). At the same time the industry was very international in terms of foreign direct investment, cross border cooperation with competitors, and capital ownership (Coleman, 1969, p. 191; Harrop, 2003, p. 944; Langenbruch, 1985, pp. 35–52; Plumpe, 1990, pp. 301–306; Owen, 2010, pp. 23–26; Wicht, 1992, pp. 48–49; Wubs, 2020, p. 103). Many producers were multinationals with affiliates abroad, as the British *Courtaulds* with *American Viscose Corporation* and the German *Glanzstoff* with *American Glanzstoff Corp.* The French *Comptoir des Textiles Artificiels* controlled several rayon companies in different foreign countries. Moreover, joint companies were founded, as in Germany the *Glanzstoff-Courtaulds GmbH* in Cologne. *Glanzstoff* and *Courtaulds* held also shares of the Italian *Snia Viscosa*. In 1921 the Dutch *Enka* and *Glanzstoff* agreed on an exchange of technical information including patents. Eight years later, *Glanzstoff* merged because of financial difficulties with the, in terms of production, much smaller, but financially sound Dutch company into the newly founded *Algemene Kunstzijde Unie (AKU)*, which was registered in the Netherlands (Vaubel, 1986, vol. 1, pp. 11–27; Wicht, 1992, pp. 49–55; Wubs, 2012, p. 19; Wubs, 2020, p. 106).

Since 1931, the German domestic market was dominated by a duopoly consisting of *IG Farben*, for which the production of man-made fibre was just a division of minor importance, and *AKU's* German subsidiary *Glanzstoff*, for which it was the core business (Plumpe, 1990, pp. 306–312). Immediately after the Nazi Party came to power in 1933, the new government strongly pursued autarky policies. Foreign exchange was to be saved for strategic goods that Germany was unable to produce, and import substitution was strongly encouraged. At the time, Germany spent 20% of her foreign exchange on textile and fibre imports, mainly cotton. Accordingly, the man-made fibre industry was an important target for the

government's autarky expansion plans. It encouraged (and sometimes pushed) spinning mills to build up plants for the production of staple fibre, which was a close (but not perfect, as German consumers had already found out during the Great War) substitute for cotton and wool. In doing so, the government broke the duopoly of *IG* and *Glanzstoff*.

In German economic historiography, the projects of the Four Year Plan (1936) are usually judged a failure because these government-financed projects would not have been viable under world market conditions (Kleinschmidt, 2007, pp. 48, 87–88; Mommsen, 1999, p. 13). For the staple fibre market, however, we turn the argument upside down: First, as we will show in the next part of our study, the will of the government to create and co-finance these new suppliers for the purpose of import substitution as well as protecting them during the imitation process was an opportunity for the spinning mills to integrate backwards and to emancipate themselves from their mighty suppliers. Second, the semi-synthetic fibre production capacity created in the 1930s and early 1940s for autarky reasons was not exaggerated. The staple fibre plants created for import substitution became, as we demonstrate in the second part of this article, profitable exporters when foreign trade relations re-liberalized in the late 1940s and 1950s. As we want to assess the long-term outcome of the Nazi government intervention, we trace the industry throughout the rest of the 20<sup>th</sup> century.

The irony of the story is that today, as nearly the whole man-made fibre industry has moved to Southeast Asia and especially China, two of the German regional plants founded on the initiative of the Nazi government in 1935 and 1938, *Kelheim Fibres GmbH* and *Lenzing AG* in Austria, are the last remaining European plants to produce staple fibre (Owen, 2010, pp. 256, 263).<sup>3</sup> In contrast, the former big players have all left the market for reasons we explain below. Therefore, we come to the ironic conclusion that in an industry originally dominated by very large firms and by market imperfections, comparatively small regional plants that were created on the initiative of a non-benign government for the purpose of import substitution became successful players in increasingly globalised markets after World War II.

This study proceeds as follows: In section 2 we describe and analyse the emergence of the German man-made fibre industry in the 1920s and early 1930s. The rules of the game were then changed by the Nazi regime, which intervened strongly in the market (section 3). In the post-World-War-II period, the regional man-made fibre plants built up by the Nazis had to compete on the world markets, which serves us as a kind of benchmark test for the long-term effects of the Nazis' infant company protection (section 4). Section 5 draws the lessons from this case study.

## **2. Technology, collusion and market power in the German semi-synthetic fibre market: the emergence of the duopoly of *IG Farben* and *Glanzstoff***

The importance of textiles for both consumers and producers was much higher in the late 19th century and early 20th century than it is today. Private households spent most of their disposable income on food, followed by clothing and housing. Not by chance did the (cotton) textile industry play a large part in the early industrialisation of England. In other words: textiles were still a very important market at the turn of the 20<sup>th</sup> century. Whoever invented a (semi-)synthetic fibre that was cheaper than the traditional natural fibres of wool, cotton and linen, or had superior textile characteristics like silk, or had properties that none of the existing natural fibres had (e.g. impermeable fibre), could earn a lot of money.

When, after the Great War, the first semi-synthetic fibres entered the markets on a larger scale, chemical firms became interested. Possessing large R&D departments, they had much better opportunities to develop new fibres and patent the product or an important step of the chemical process to produce it. Semi-synthetic fibres like rayon yarn or staple fibre were then products of a high technology industry.

In the industrial organisation literature, technology, especially if it is patentable, is one of the causes why market imperfections may emerge. If potential newcomers do not have access to the new technology or are blocked by high licence fees, they are not able to enter the market. Moreover, in the period before the end of World War II, cartels were legal in many countries. Germany in particular, was notoriously cartel-friendly (Feldenkirchen, 1992). This allowed the incumbents to raise new economic barriers to entry even if the patent protection had expired.

The German semi-synthetic fibre industry of the interwar period is a perfect example of these constellations. The industry produced two types of fibres—rayon yarn and staple fibre (Coleman, 1969, pp. 178–180; 184–187; Völkel, 1942, pp. 27–36; Witt, 1939, pp. 39, 134–135; Zart, 1950, p. 23). While rayon yarn, which was normally based on the viscose process, was mainly used as a substitute for silk in fashion textiles, staple fibre could be used as a wool and cotton substitute or complement.<sup>4</sup> Although staple fibre production is also based on the viscose process, production costs of this fibre were considerably lower than those of rayon yarn. This was partly due to the fact that the number of holes of the spinning nozzles through which the viscose mass had to be squeezed was, in the case of the staple fibre production, up to ten times higher than in the rayon yarn production. This increased the output of spinning machines massively and led to lower unit capital costs. Moreover, the after-treatment of staple fibres required, compared to the rayon yarn production, significantly less factory space and labour. Thus, for the same amount of fibres, labour requirements in the staple fibre production were only 1/4 to 1/3 of that in rayon yarn production.

The production of rayon yarn had expanded significantly since the beginning of the 20th century in most developed countries. In 1929, Germany was one of the biggest producers, surpassed only by the United States and Italy. In 1931, *IG Farben* and *Glanzstoff*, which combined produced about 90% of the German rayon yarn output, co-founded with foreign competitors the German rayon yarn cartel, which fixed output quotas as well as prices (Cerretano, 2012, pp. 609–611; Flügge, 1936, p. 75; Raemisch, 1933, p. 290).<sup>5</sup> In combination with the tight capital controls which were implemented in Germany in 1931, this cartel soon constituted a domestic quasi-duopoly.

In contrast to rayon yarn, the production of staple fibre was still almost negligible during the 1920s. Staple fibre production in Germany had started during the Great War (Bodenbender, 1944, pp. 19–25; Langenbruch, 1985, pp. 22–25; Witt, 1939, pp. 42, 51, 59). Production made up to 8500 tons in 1918, more than in 1934. Yet, after the war, it was abandoned because the quality of the fibres was poor and their production not profitable when imports of natural fibres resumed. Nevertheless, R&D in this field continued. The former explosive cotton (nitro-cellulose) producer *Köln-Rottweil AG* developed a new staple fibre called *Vistra* in 1920, the characteristics of which were substantially improved in the second half of the 1920s with the support of textile producers after *IG Farben* had integrated the *Köln-Rottweil AG* in its concern. The rayon yarn producer *Glanzstoff* had also begun to engage in research on staple fibre once again in 1928 (Bluma, 2004, pp. 125–131; Witt, 1939, p. 77).

At the beginning of the 1930s, rayon yarn producers expected that the production growth rates would, compared to the booming 1920s, slow down in the future (Witt, 1939, p. 71). In contrast to rayon yarn, *IG Farben* and *Glanzstoff* considered, as did their British and American counterparts, staple fibre a product for which demand would strongly expand in the long run (Schermer, 2002, pp. 433–437).<sup>6</sup> Thus, both companies had already agreed to significantly enlarge their staple fibre capacities and to form a German staple fibre cartel before the new Nazi government launched its autarky plans in summer 1934 (Schermer, 2008a, p. 168).

### 3. Infant company protection as a means of Nazi economic policy

When the world economy disintegrated in the 1930s, import substitution became an important issue for the foreign trade policy of many countries. In the summer of 1934, a severe balance of payments crisis led to an intensification of the German import restrictions, which had been implemented in 1931 when Germany had introduced capital controls (Schermer, 2002, 2008b). The scarce foreign currency was to be used for imports, especially of raw materials necessary for rearmament. Thus, the allocation of foreign currency to the textile sector for the import of fibres, in particular cotton, was massively curtailed. Yet, the declining fibre supply threatened the regime's political aims in the long run because a continuation of this policy would have resulted in increased unemployment in the German textile sector which was, in respect to the work force, the largest German industrial sector at the time. In order to deal with this problem, the *Reichswirtschaftsministerium* (RWM, the Reich's ministry of economic affairs) drafted in summer 1934 the National Fibre Program demanding a massive expansion of staple fibre production from 7000 to 100,000 tons annually in order to substitute for cotton and wool. In 1934, 100,000 tons were – given the quality of the staple fibres at the time and the actual German textile fibre consumption – considered the upper limit by which staple fibre could substitute for natural fibres in the domestic market. Yet, overcoming the textile crisis was only one of the two motives for the National Fibre Program. The second motive originated from Nazi Germany's aim to achieve self-sufficiency as a long-run strategy in order to prepare Germany for war. In the following years, the government steadily expanded its capacity objectives due to quality improvements of staple fibres and increasing demands in new fields. At the same time, the Nazi government started to support the expansion of German staple fibre capacities.

Partly due to the import substitution policy in Germany and in other countries, the staple fibre industry's growth during the 1930s was spectacular. World production of staple fibre rose from a mere 3900 metric tons in 1929 to 500,000 tons in 1939 – much faster than that of the less versatile rayon yarn, which increased in the same period by a factor of roughly 2.6 (from 198,000 to 518,000 tons). Whereas staple fibres made up less than 2% of total world semi-synthetic fibre production in 1930, they made up more than 49% only a decade later (*Fibre Organon*, 1962, pp. 33, 18–19 and Table A1 in the appendix). Germany's share of the world's total staple fibre production rose between 1929 and 1939 from 28 to 41%; its share of total semi-synthetic fibre production rose from 14 to 27%, Austria, which was annexed in 1938, not included (*Statistisches Jahrbuch für das Deutsche Reich*, 1938, p. 92\*, 1941/42, p. 92\*, and Table A1 in the appendix). This massive expansion led to considerable savings of scarce foreign currency in Germany by substituting for imported wool and cotton, which still in 1933 accounted for about 20% of German total imports (by value) (Schermer, 2008b,

pp. 871–872; [Table A1](#) in the appendix). In 1939 alone, the savings on foreign currency added to 190 m. RM, whereas the total cost of capacity-enhancing investment in staple fibre between 1935 and 1939 was about 264 m. RM.

During World War II the production of staple fibre increased even more dramatically than it had during the Great War in those countries which were cut off from natural fibre imports, especially of cotton. In Germany, the staple fibre output doubled between 1938 and 1943, cushioning the severe textile crisis in Germany during World War II.

This spectacular output growth of the German staple fibre production during the Nazi period was, as shown by [Table A1](#) (appendix), not primarily carried out by the established companies, i.e. *IG Farben* and *Glanzstoff*, but chiefly by newcomers, the so-called regional staple fibre companies. The first four of these regional plants were founded in 1935 at the initiative of the German government (*Süddeutsche Zellwolle AG*, *Sächsische Zellwolle AG*, *Schlesische Zellwolle AG*, *Thüringische Zellwolle AG*). From 1936 onwards, additional regional fibre plants were founded, as *Rheinische Zellwolle AG*, and, following the annexation of Austria in 1938, *Lenzing AG* (see [Table 3](#) below) (Witt, 1939, pp. 82–85). After the occupation of Poland, a plant was opened in the textile centre Łódź, which started production in 1941, *Zellgarn AG Litzmannstadt* (formerly *Widzewska Manufaktur*) (Blanc, 2016, p. 148; Loose, 2007, p. 262; Zorn, 1980, pp. 61–64). In contrast to the first-wave plants, most second-wave plants produced not only staple fibre but also cellulose, i.e. staple fibre's main upstream product. Most of the capital of these new regional companies was provided by the German textile industry, which had been encouraged (and sometimes pushed) to do so by the government.<sup>7</sup>

Until the end of the 1930s both groups – established companies and the new regional plants – invested heavily. But during the war the production of the established companies remained nearly stable whereas the capacities of the regional plants increased significantly. How can we explain this? Why did the established companies expand their capacities up to the end of the 1930s but stopped to doing so afterwards? And why did the regional companies continue to invest? Furthermore, why were these regional companies founded at all?

When the state launched the National Fibre Program in 1934, the established companies expected that import restrictions on natural fibres would ease in the near future.<sup>8</sup> They expected, too, that in this case the newly founded regional companies would be driven out of the market because of their lack of human capital and experience in production. Given these considerations, it made sense for the established companies to base their expansion plans on their expectations about the domestic demand under normal conditions. These expansion plans, which, as mentioned above, had already been agreed on before the state set up its autarky policy, targeted to expand rayon yarn production to 58,000 tons annually and staple fibre production to between 20,000 (*IG Farben's* estimate) and 40,000 tons (*Glanzstoff's* estimate) annually. In the case of rayon yarn, these estimates relied on the actual per capita consumption in the United States, and in the case of staple fibre on the expectation of large quality improvements, on the assumption of significant cost cuts over the relatively expensive and qualitatively inferior products of the 1920s, and on consumer surveys (Schermer, 2002, pp. 433–437, 2008b). Even though their estimate of the potential domestic market volume far exceeded the quantity of staple fibre actually produced and consumed in Germany in 1934 (7200 tons), all these staple fibre estimates were still significantly lower than the amount requested by the government (100,000 tons). Given that the state was not willing to bear the risk of what the established companies considered an excessive capacity

enlargement, *IG* and *Glanzstoff* were not disposed to invest to the extreme extent requested by the National Fibre Program, even though *IG Farben* expanded its staple fibre production and *Glanzstoff* founded an affiliate, *Spinnfaser AG*, in order to produce more staple fibre.<sup>9</sup> Even the government's threat, put forward in the fall of 1934, to establish regional plants did not change the companies' minds because they expected that import restrictions would be lifted in the medium run, i.e. before newcomers would have been able to become serious competitors.<sup>10</sup> Given this unwillingness, the government encouraged the foundation of regional companies from 1935 on.

In the following years up to the war, the established companies expanded their capacities to an extent which matched the expansion of per-capita semi-synthetic fibre consumption in the U.K. and the U.S., i.e. in countries which they considered as a benchmark and whose per-capita semi-synthetic fibre consumption before the Great Depression had been similar to the German one (Schermer, 2002, p. 444).<sup>11</sup> Moreover, companies in these countries increasingly invested in their staple fibre capacities, a process which was propelled by further quality improvements and decreasing unit costs which improved the competitiveness by price with natural fibres (Coleman, 1969, pp. 322–323, 360–363, 412; *Rayon Organon*, 1941, pp. 128–129; Scherner, 2002, p. 441; Ward-Jackson, 1941, p. 151). Yet, in the late 1930s, *IG* and *Glanzstoff* observed that some of the German newcomers had become increasingly serious competitors because of decreasing unit costs and rising quality and that the regional companies invested massively in R&D.<sup>12</sup> It was thus no longer so clear if the new regional plants would be pushed out of the market once normal conditions returned, and so the established companies stopped investing. Besides, from the late 1930s on, it was clear for both *IG Farben* and *Glanzstoff* that new fully synthetic fibres, which were soon to become market-ready, would become an important field in fibre manufacturing in the near future in addition (and competition) to cellulosic fibres (Langenbruch, 1985, pp. 95–97; Wicht, 1992, vol. 1, p. 76). Given its R&D-lead in the field of polyamides in Germany – *IG Farben* had started R&D in this field in 1928 – and its patents as well as its licence and R&D exchange agreement with DuPont which reserved the German market and the ones of several, predominately southeast European countries to the company,<sup>13</sup> *IG Farben* could expect to get monopoly rents at least for some years.

But given the dominance of *IG Farben* and *Glanzstoff*, why did private investors, mainly spinning mills, found the regional plants in the first place in spite of the fact that the German per-capita production of semi-synthetic fibres from 1937–38 on significantly exceeded that in other countries without import restrictions and in spite of the well-known fact that newcomers faced several barriers of entry? To understand this, we have to take a closer look at the incentive framework created by the state.

First of all, there were investment incentives specifically targeted at spinning mills. Especially from 1936 on, there was a shortage of fibres in Germany with the effect that spinning mills' capacities were underutilised (Höschle, 2004, pp. 74–76). The founding firms of regional plants usually received staple fibre purchase options in relation to their share capital (Schermer, 2008b). Therefore, textile companies that possessed regional plants' shares could utilise their capacity to a greater extent than a company without. In addition, the opportunity costs of investment in staple fibre plants were certainly lower for textile manufacturers than for companies in the chemical industry because after 1934 investments in the textile industry required permission by the government – in contrast to the chemical industry. In other words, spinning mills had fewer investment alternatives. These industry-specific incentives partly compensated for the higher risk of an investment in regional staple fibre



plants due to their lower competitiveness during the first years of production compared with the established companies. Finally, the state's policy of import substitution enabled the customers of the incumbent semi-synthetic fibre producers, spinning mills to integrate vertically and emancipate themselves from their duopolistic suppliers (Streit, 1936, pp. 8, 50–51).<sup>14</sup> In contrast to, e.g. Japan, where many spinning mills were part of large textile concerns that soon after World War I integrated backwards in the man-made fibre industry (Hirano, 2010, p. 70), the German market structure was characterised by small and medium sized enterprises (SME) who lacked the financial and human resources for such a step. Only *Christian Dierig AG* in Silesia, continental Europe's biggest cotton processing group, invested on large scale in the new business, and as late as 1935 (see below).

In addition, investors of the regional companies believed that the support provided by the government would be sufficient to overcome the typical barriers to entry of newcomers in the semi-synthetic fibre industry. The possession of a licence or patent and in particular the human capital endowment was crucial for a marketable semi-synthetic fibre product.<sup>15</sup> However, even when these conditions were met, newcomers still faced an experimental period of production which could last several years, and which required substantial financial means. Thus, potential investors of the regional plants (i.e. mainly spinning mills) who were aware of these problems, clearly emphasised early on that they were only willing to invest if the state created favourable conditions to overcome these barriers to entry (Streit, 1936, pp. 62, 79, 115). And this was precisely what the government did.

First of all, the direct financial support provided by the state was very favourable for the newcomers. The building-up of the regional staple fibre plants was promoted by standardised long-term loans (two thirds of the necessary capital) guaranteed by the government, which lowered investment risks (Schermer, 2008b). However, as long as the loans were not paid back, the government could exert substantial influence. For instance, it had a say with regard to capacity expansion, the type of fibres to be produced (not all were based on viscose), and the location of the regional plants, which had to be built in textile regions with favourable conditions regarding transport costs and access to raw materials. Moreover, the new plants were often erected in backward areas which still suffered from unemployment and thus disposed of labour force reserves (Kaienburg, 1994, p. 15; Phrix GmbH, 1951, p. 71; Witt, 1939, pp. 89–91; Bundesarchiv (BArch) R 8135/4914, Report on Kurmärkische AG, 1938). The government also chose the executive chairmen and was represented on the supervisory board.

In return, the government created favourable macro- and microeconomic conditions for staple fibre production affecting production costs, demand, and prices. The newly founded staple fibre companies were exempt from direct taxes for five years, a standard procedure for investments in the autarky industries (Schermer, 2008a, p. 80). Moreover, they had to pay only a reduced rail freight rate for their supplies.<sup>16</sup> In 1935, import tariffs for semi-synthetic fibres, for which German producers had already lobbied without success in the preceding years, were implemented (Schermer, 2008a, p. 180; Wicht, 1992, p. 41). In the summer of 1935, the cartel price of staple fibre was abolished and replaced by a price fixed by the government. Compared to the respective previous year, the price for standard B-staple fibre, which served as a substitute for cotton (*Baumwolle* in German), was reduced by 18% in August 1935, by 11% in September 1936, and by 9% in September 1937 (Witt, 1939, pp. 126–128). Prices were fixed in a way that allowed regional companies to finance enlargements of their capacity and to invest capital in the second-wave plants (Schermer, 2008a, p. 183). In addition, the

Nazi regime promoted staple fibres in the press in order to overcome consumers' *Ersatzstoffpsychose* (substitute psychosis), rooted in bad experiences during the Great War (Bayerisches Hauptstaatsarchiv, MHIG 5770; Bluma, 2004). Finally, from 1936 on, spinning mills were forced to mix staple fibre with natural fibre in ever increasing proportions.

In order to overcome the knowhow problem, the government approached *IG* and *Glanzstoff* to carry out some sort of technological leadership and to include the planned regional companies in their planned staple fibre cartel (Schermer, 2008a, p. 173, 200). Only when *IG* and *Glanzstoff* refused<sup>17</sup> – fully aware that this complicated imitation for the newcomers – was it clear that the newcomers would have to rely exclusively on their own expertise. The state was reluctant to use §11 of the German patent law which gave the government the possibility to force companies to grant licences (Streit, 1936, p. 79). Only in the case of *Thüringische*, one of the four first-wave regional plants, which the government had chosen for the production of W-staple fibre, i.e. a substitute for wool (*Wolle* in German), did *IG Farben* grant a licence for its *Lanusa* method (Schermer, 2002, pp. 446–447).<sup>18</sup> Yet, this method still was not mature and was only second rate among *IG Farben's* methods for producing W-staple fibre (Kahl, 1964, pp. 106–107; Hoechst-Archiv (HA) ZA 358, Lanusaversuche, Vermerk vom 22.7.1936). In addition, in contrast to normal licence agreements in the field of man-made fibres, an exchange of experiences was not part of the contract (Schermer, 2008a, p. 201).<sup>19</sup>

Given this hostile attitude of the established companies, Hans Kehrl, an ardent Nazi and owner of a textile factory, who since 1935 became the decisive figure in Nazi Germany's cellulose fibre policy, first as member of the staff of Hitler's economic adviser Wilhelm Keppler, later in the Four-Year-Plan administration and the Reichswirtschaftsministerium, and finally in the armament ministry, applied two strategies in order to facilitate a successful imitation. The first strategy consisted in recruiting semi-synthetic fibre specialists (Bode, 2002, p. 191; Kehrl, 1973, pp. 89–90; Plumpe, 1990, p. 314; Schermer, 2008a, p. 201).<sup>20</sup> By doing this, the state ignored existing non-compete clauses and helped hire several actual and former employees from *IG Farben's* and *Glanzstoff's* semi-synthetic fibre production. Only massive protests by the established companies stopped this during 1935. Two of these specialists – chemists Walther Schieber and Richard Dörr – would come to play a crucial role for the development of the regional plants during the Nazi period; Dörr even continued in this role until 1952 (Sandgruber, 2010b, p. 250).

Both Schieber and Dörr were experienced experts in *IG Farben's* semi-synthetic fibre R&D and production. Schieber had initially worked as factory manager of the semi-synthetic production plants of the *IG Farben* in Wolfen, and later in the *IG Farben* plant in Dormagen; Dörr had been involved in the improvement of the *Vistra* staple fibre when he was employee of *IG Farben*.<sup>21</sup> Having worked for *IG Farben* since the early 1920s, Dörr, who disposed of the company's semi-synthetic fibre industry secrets, was fired in May 1933.<sup>22</sup> In 1934 the *RWM* consulted Dörr as an advisor.<sup>23</sup> It was probably Dörr who convinced the government agencies during summer 1934 that newcomers should be able to produce staple fibre of good quality (Streit, 1936, p. 123). After a first visit to Hirschberg (Silesia) in February 1935, where Dörr met industrialists and visited a shut-down rayon yarn plant and a shut-down cellulose plant as a potential location of a staple fibre plant, he set up plans for the new companies which were accepted by the government agencies.<sup>24</sup>

Dörr also played a decisive role in the Nazi government's second measure to overcome the imitation problems of the newcomers: the development of a viable technology for producing B-staple fibre, the most important fibre type. In July 1935, a planning office headed

by Dörr was established in Berlin consisting of engineers and chemists.<sup>25</sup> Shortly afterwards, this office prompted the build-up of a research laboratory and a pilot plant in Hirschberg, which developed and tested a technical process for the production of B-staple fibre and trained workers. This pilot plant benefitted from the fact that it was easy in Hirschberg to hire workers who were experienced in cellulose fibre production, because of the rayon yarn plant which had been shut down during the Great Depression. The laboratory became the core of the *Zellwolle Arbeitsgemeinschaft (ZWAG)*, which was set-up in autumn 1935 as a joint company of the first four regional plants which had been founded in the summer (Witt, 1939, pp. 92–93). The idea was that the regional plants should pool their R&D efforts. Funded by annual contributions of its member companies, the ZWAG was supposed to spend substantial amounts for staple fibre R&D and, indeed, soon attained a level of expenditure similar to *IG Farben*.<sup>26</sup> Further tasks of the ZWAG were to train the workers and to plan the factories, which were to be built according to standardised principles.<sup>27</sup> First wave plants' factory buildings were from the beginning designed in a way that allowed for massive capacity increases in the future.<sup>28</sup> ZWAG was also in charge of the knowledge transfer between the regional plants. The set-up of this cartel-like institutional superstructure of the regional plants was the result of the instigation of both the potential investors and of the former *IG* and *Glanzstoff* employees hired by the government. They were convinced that an organisation carrying out joint R&D and institutionalising an experience exchange was imperative for the success of the projected regional companies.<sup>29</sup>

The cartel-like structure implemented in 1935 in order to overcome the imitation problems of the regional companies was deepened in the following years. In order to further facilitate the knowledge transfer between first- and second-wave regional plants, the government fostered a personal and a capital connection between the plants. First-wave companies had to acquire stock of second-wave plants. In addition, personal links among first-wave and second-wave companies were implemented: Walther Schieber, the chairman of first-wave company *Thüringische*, became chairman of *Lenzing* in 1938 and *Łódź/Litzmannstadt* in 1940; Richard Dörr, chairman of first-wave company *Schlesische*, also became chairman of those second-wave plants, of which *Schlesische* held shares (*Kurmärkische Zellwolle AG*, *Rheinische Kunstseide AG*, *Rheinische Zellwolle AG*, *Zellwolle und Zellulose AG Küstrin*) (Bode, 2002, pp. 191–192; Sandgruber, 2010a, pp. 35, 81–82, 87–99; Sandgruber, 2010b, p. 251). Finally, first-wave companies shared their knowledge with second-wave companies of which they held shares.

Most of these second-wave companies were supposed to produce not only staple fibre but also cellulose. This was the result of government plans made in 1936–7 to expand the German cellulose production. These plans were influenced by the fact that wood had been cut in 1936 far beyond the margins of sustainability of German forests in order to meet the rising German demand and to alleviate the German balance of payments crisis that year. In that year Germany was a net importer of wood, cellulose and pulp combined, which was delivered predominantly (in order of the import value) by the Soviet Union, Sweden, Finland and Czechoslovakia.<sup>30</sup> Moreover, the Nazi autarky policy, which became more comprehensive and accelerated after 1936, aimed to make Germany blockade-safe in the case of war also with regard to the inputs of the semi-synthetic fibre production.<sup>31</sup> Earlier R&D results of fibre producers such as *IG Farben* or *Schlesische* had shown that cellulose out of straw, pine, and beech, which so far had been only used to a very small extent and which were abundant in Germany, could be used for producing cellulose.<sup>32</sup> Consequently, the government had

decided that the regional staple fibre plants should invest in cellulose plants based on these inputs. Because transport costs should be minimised, and because the regional endowment with these inputs differed in Germany, *Schlesische* for example was supposed to invest in plants using straw and pine as inputs. In order to overcome the newcomer problem with regard to cellulose production, the state applied two strategies: first a cooperation with established cellulose and paper producers, and secondly, as in the case of the foundation of the regional staple fibre companies, the hiring of cellulose experts, who previously had worked for established cellulose producers and who were appointed as technical directors for these new plants.<sup>33</sup>

These ownership/R&D-links among first-wave plants and second-wave plants as well as the new production program led to the dissolution of the ZWAG and its substitution with new cartel-like structures along capital connections. It was again the *Schlesische* which set this development in motion. The new second-wave plants, of which the *Schlesische* held shares, had not only to produce cellulose from pines or straw on the basis of technologies developed in the laboratories of *Schlesische*, but had, in contrast to their mother company, to apply a newly developed integrated cellulose and fibre production process.<sup>34</sup> The need of a close cooperation during the implementation of these processes as well as the lack of human capital made a continuation of cooperation in the ZWAG with less cutting-edge companies less desirable.<sup>35</sup> In addition, the capital owners of the *Schlesische* and its ambitious managing director Dörr wished to built-up a staple fibre concern.<sup>36</sup> The biggest shareholder of *Schlesische*, with 49% of the shares, was right from the beginning *Christian Dierig AG* (Schermer, 2008a, pp. 187–188; 2008b, pp. 888–889). The CEO of this large group, Gottfried Dierig, had become increasingly more optimistic about the potential of staple fibre than most of the other established companies in the textile or man-made fibre businesses. This explains why his firm participated in the recapitalisation of the *Schlesische* after 1935, even acquiring the majority of shares in 1936. It was probably Dierig who decided to get rid of state influence by paying back prematurely the government loan in early 1938.<sup>37</sup> This was done with the help of a loan which was provided by textile firms, of which Dierig granted 40%, with the entitlement to convert its loan share into stocks.<sup>38</sup>

For these reasons, the *Schlesische* – together with those regional companies of which it held shares – founded in the spring of 1938 the *Phrix Arbeitsgemeinschaft GmbH*, named after its staple fibre brand 'Phrix' (Schermer, 2008a, pp. 206–207; Witt, 1939, p. 94). The tasks of *Phrix* soon became more comprehensive than those of the ZWAG: they included not only knowledge and technology exchange among its members, but also a centralisation of the sales and marketing organisation, the joint purchase of inputs, and the joint use of patents.<sup>39</sup> Consequently, in the summer of 1938 the *Phrix* members left the ZWAG and Dörr quit his job as managing director of this company.<sup>40</sup> As a consequence, the other regional companies founded the *Deutsche Zellwolle-Ring-Verkaufsgemeinschaft* in the same year, which had the same task as *Phrix* (Witt, 1939, p. 85). It seems that originally the *Deutsche Zellwolle-Ring-Verkaufsgemeinschaft* was supposed to include also the *Phrix Arbeitsgemeinschaft GmbH* and its member firms. Yet, Dörr, if we are to believe his post-war statement, prevented this by threatening to quit the *Schlesische* if the group around the firm should become a part of the *Ring*. Finally, in 1939, the ZWAG was dissolved (Schermer, 2008a, pp. 206–207).

The infant company protection granted by the government-created framework effected a successful imitation process of the first-wave plants producing B-staple fibre. The newcomers were eventually able to manufacture a high-quality product at competitive unit

costs. Yet, this process took some years, as the comparison of costs per kg staple fibre of *Sächsische*, *Süddeutsche* and *Schlesische* on the one hand with those of the *Spinnfaser*, the biggest staple fibre plant of *Glanzstoff*, on the other hand shows. All aforementioned enterprises mainly produced one staple fibre type during this time, namely standard-B-staple fibre. The regional plants, which were founded almost at the same time as *Spinnfaser*, took about a year longer to arrive at a quantitatively appreciable production with fairly tenable costs per kilogram (Schermer, 2008a, pp. 205–206). Up to the late 1930s, the lack of technical knowhow and human capital continued to play a decisive role in these differences. This is suggested by the development of the by far most important cost element in the staple fibre production, namely the cost for raw, auxiliary and working material. This cost element, approximately 60% of staple fibre's production costs, consists mainly of costs for cellulose and various chemicals such as caustic soda. Larger costs for raw, auxiliary and working material per kilogram staple fibre were the consequence of waste production which resulted from imperfect production methods due to the lack of human capital.<sup>41</sup> Yet, in 1939, the difference in this cost element between the regional companies and *Spinnfaser*, which in 1937 had still been substantial, almost totally disappeared – *Sächsische*, *Süddeutsche*, and *Schlesische* had successfully caught up. A further important factor responsible for the higher unit costs of the newcomers (compared to *Spinnfaser*) were the costs of the sales organisation and marketing (Schermer, 2008a, pp. 179–180). In contrast to *Spinnfaser* which could use the sales organisation of *Glanzstoff*, each regional company had to build up its own organisation. Given that the regional plants aimed to establish their products nationally and internationally, they had run expensive marketing campaigns, as *Schlesische* in 1936 for their trade mark 'Phrix'.<sup>42</sup> Yet, as mentioned above, by 1938 the sales organisation and marketing of all regional plants was centralised in the *Deutsche Zellwolle-Ring-Verkaufsgemeinschaft* and the *Phrix-Arbeitsgemeinschaft*, which led to a considerable decrease of this cost component.

Whereas by the end of the 1930s those regional staple fibre plants founded in 1935 that were producing B-staple fibre had become increasingly serious competitors for *IG* and *Glanzstoff* because of decreasing unit costs and rising quality, this process took considerably longer for the *Thüringische*, the only one of the companies founded in 1935 which, based on the *Lanusa*-licence of *IG Farben*, produced W-staple fibre. *IG Farben* had used the *Lanusa* method only on the basis of cotton linter pulp; *Thüringische* had, as stipulated by the government, to apply the method for the first time on the basis of cellulose from beeches.<sup>43</sup> In contrast to lumbers traditionally used for cellulose production, beeches were abundant in Germany. Given these technological challenges, it is maybe not surprising that *Thüringische* for years manufactured a low-quality product at considerable costs (Schermer, 2008a, pp. 209–211). Whereas ideally 1 kg cellulose should suffice for producing 1 kg staple fibre, *Thüringische's* consumption was significantly higher by the late 1930s. This changed only during the war and was probably also caused by a change of the incentive structure. During the 1930s, *Thüringische* was the only large supplier of the *Lanusa*-type W-staple fibre. This implied that the government regularly adapted the prices to the unit costs of *Thüringische*. In other words, the company was in the comfortable position to set cost-plus prices during the 1930s. This was in contrast to all other regional plants founded in 1935, as far as they produced standard B-staple, which faced a price set ex ante by the state. Given this cost-plus pricing, there was no pressing incentive for *Thüringische* to decrease unit costs. This changed only in 1940 because the rationing of inputs during the war demanded a more efficient use of raw materials. The increasing competitiveness of the first-wave regional companies is also

shown by the fact that all of them were able to pay off their loan in advance: the *Schlesische* in 1938, *Süddeutsche* and *Sächsische* in 1940, and *Thüringische* in 1943.<sup>44</sup>

In contrast to these plants, the second-wave companies struggled economically.<sup>45</sup> Even though these companies faced the same input prices and the same selling costs as the plants founded in 1935, and even though a knowledge transfer from the first-wave plants was institutionalised, the second-wave companies faced worse conditions in four respects: First, as mentioned above, some second-wave companies had to implement untested, cutting-edge technologies, which limited the effects of the knowledge exchange. Second, whereas in the start-up period of the first-wave plants, prices for the same type of staple fibre had been fixed by the government on the basis of the unit costs of the least efficient supplier, this was not done in the case of the second-wave companies, which normally produced B-staple fibre. Although the government stopped to further decrease the price after some second-wave companies had started their production in 1937, the second-wave plants incurred substantial losses.<sup>46</sup> Financial difficulties became thirdly a persistent problem for these plants beyond the start-up period because they had not been able to hire sufficient skilled workers at a time of massive and increasing labour shortage in the late 1930s.<sup>47</sup> The lack of experienced personnel in turn led to inefficient production and financial losses. Fourth, to make things worse, these companies had to increase their capacities further during the war in order to meet the staple fibre production objectives of the Nazi regime, exacerbating the human capital problem (BArch R 8119 F/P 180, 145; Kaienburg, 1994, pp. 15, 18–19). Besides, capacity enlargements during the war were more expensive than during the 1930s because construction prices were increasing significantly.<sup>48</sup> In contrast, the re-privatized first-wave regional plants had stopped increasing their capacities since the late 1930s.

In light of these companies' substantial losses and to avoid the necessity of further government guaranteed loans, the state reacted in 1940 and 1941. First, in 1940, it set up for the period of one year, a subsidizing-scheme among the staple fibre producers: established producers (on the basis of capacities erected after 1934) as well as first-wave plants had to subsidise the second-wave plants by providing 7% of their annual revenues as an interest-free loan to the latter.<sup>49</sup> Second, the government backed the deepening of inter-company-cooperation in 1941 in order to create cost-relevant synergies in production and to optimise tax payments.<sup>50</sup> This formalised in some respects the increasing informal inter-company cooperation which had been taken place from 1939 on, and which had been partially triggered by the attempt to overcome the negative impact of military drafting on the human capital endowment of the plants.<sup>51</sup> The *Phrix Arbeitsgemeinschaft GmbH* transformed into a holding company – the *Phrix-Werke AG*.<sup>52</sup> This holding company, led by the *Schlesische* and headed by Richard Dörr, purchased by stock swap the majority of the *Schlesische* and those second-wave staple fibre, rayon yarn and cellulose firms, of which *Schlesische* held shares and which had already been part of the 1938 founded *Phrix Arbeitsgemeinschaft*.<sup>53</sup> The task of the *Phrix-Werke AG* beyond joint marketing and purchase of inputs was to reduce the number of fibre varieties produced by the companies and to identify and implement best-practice methods in the production process of the affiliates.<sup>54</sup> In addition, the *Phrix AG* extended the vertical integration further by founding the *Schlesische Chemie AG* in 1942, which was to provide the chemical raw materials needed for the fibre production (Schermer, 2016, p. 316). The remaining regional companies, as far as they had not paid off their loan, became members of the newly founded *Zellwolle- und Kunstseidenring GmbH (ZKR)*, i.e. *Thüringische*, *Lenzing*, *Zellgarn AG Litzmannstadt*, *Westfälische Zellstoff AG*, *Schwäbische*

*Zellstoff AG* as well as some smaller staple fibre producers such as *Spinnstoffwerk Glauchau AG*.<sup>55</sup> Although the ZKR was formally only a membership association, it constituted in some respects a de-facto holding company: as a so called *Betriebsgemeinschaft* (cooperation of ZKR-member plants), workforce, machinery and raw materials could be exchanged among the member plants, which increasingly produced not only staple fibre, but also cellulose and rayon yarn.<sup>56</sup> This cooperation was facilitated by the fact that Walther Schieber acted as chairman of each of the major ZKR-plants; i.e. *Thüringische*, *Lenzing*, and *Zellgarn* (Sandgruber, 2010a, p. 90). Both the ZKR and *Phrix AG*, produced as much semi-synthetic fibres as *Glanzstoff* and significantly more than *IG Farben*, and was specialised in processing cellulose from different raw materials and thus producing different staple fibre types.<sup>57</sup> Two of the four first-wave plants, *Schlesische* and *Thüringische*, became the centres of the two increasingly forward- and partly also backward-integrated and diversified combines. The other two, *Süddeutsche* and *Sächsische*, chose, after they had paid back the government loans, a different strategy: they decided not to become a member of either concern and to focus on their core business. *Süddeutsche* integrated backwards and in 1937 helped founding the *Schwäbische Zellstoff AG*, acquiring 20% of its shares. This firm supplied *Süddeutsche* with cellulose out of beech and was supposed to start the production of staple fibre.<sup>58</sup> This, however, never materialised because of the war (Burth et al., 1993, p. 204; Handbuch der deutschen Aktiengesellschaften, 1938, p. 6233; Höschle, 2004, p. 205).

This restructuring could not fully solve the economic and financial problems of the second-wave companies.<sup>59</sup> However, the outlook was not as bleak as the financial problems of the second-wave companies might suggest. By the end of the war, all these companies disposed of a competitive technology. At least some companies made substantial progress with regard to more efficient production processes in spite of the unfavourable human capital conditions.<sup>60</sup> Like the established companies, the regional companies had increasingly and successfully developed special staple fibre varieties since the late 1930s (Kaienburg, 1994, p. 17; Phrix GmbH, 1951, pp. 56–57; Scherner, 2008a, pp. 218–219).<sup>61</sup> This technological progress was the result of remarkable research efforts. In the *Phrix*-laboratories at *Schlesische*, 60 chemists were employed in staple fibre research, almost the same number as the giant *IG Farben* employed in this field (Bode, 2002, p. 183; Witt, 1939, p. 76). The R&D expenditure was astonishingly high, even compared with the *IG Farben*: whereas the latter annually spent an average of about 2 million RM for staple fibre R&D between the late 1930s and the end of the war (Scherner, 2008a, p. 218), *Phrix* expenditure in 1941 was significantly larger with about 4 million RM.<sup>62</sup> Given all these considerations, and assuming the financial problems resulting from the specific circumstances since the late 1930s would resolve and the companies would have access to skilled labour once the war was over, it could be expected that they would survive and prosper. This seems especially true, because the regional companies had already made during the early 1940s first steps towards the future production of synthetic fibres by starting, as in the case of *Phrix*, R&D in cooperation with chemical companies (*Deutsche Hydrierwerke AG*, *Böhme Fettchemie GmbH*, and *Henkel*) or by signing a licence and cooperation agreement with the *IG Farben*, as in the case of the ZKR.<sup>63</sup>

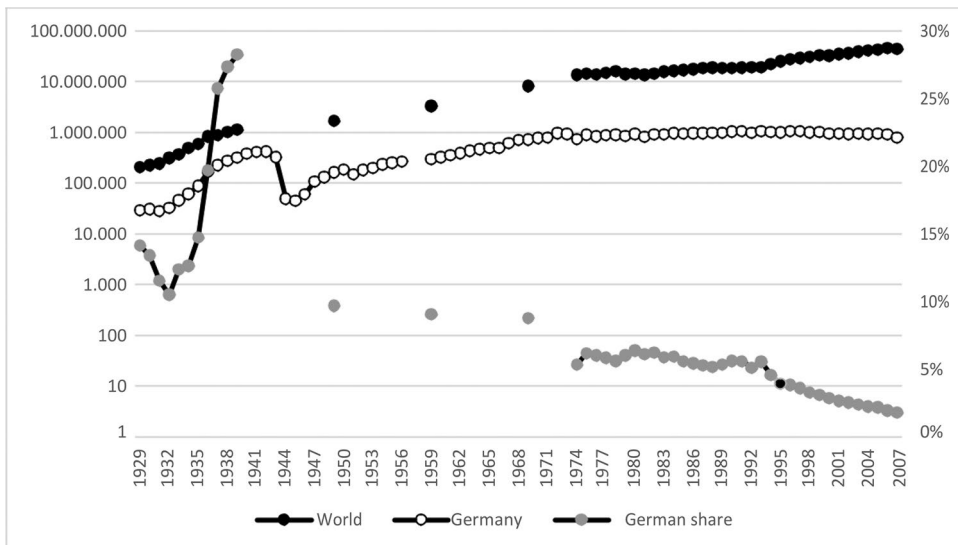
The defeat of Nazi Germany led to the loss of numerous plants. *IG Farben* and *Glanzstoff* lost a number of factories in what was to become the GDR or part of Poland, a fate shared by *Sächsische* and *Thüringische*. The latter's subsidiary, *Lenzing*, was situated in Austria where the new government expropriated the German shareholders and re-privatized the

plant a few years later (Sandgruber, 2010a, pp. 400–415). The subsidiary in Łódź was lost as well. *Phrix* lost all of its staple fibre plants and kept just two plants in Western Germany. However, a large part of the *Phrix* management and the engineers moved from Silesia to the West where they began to rebuild the company. Altogether, a mere 37% of the staple fibre output of 1943 remained in what was to become the Federal Republic of Germany in 1949.<sup>64</sup>

#### 4. After autarky and war: Germany's 'regional' staple fibre plants on the world market

In December 1944, when the military defeat of Germany was just a matter of time, a team in the economic research department of *IG Farben* wrote a memorandum on the future of the man-made fibre industry. After discussing the conditions on the world market, the team concluded that the fact that not only resource-poor countries like Japan, Italy, and Germany, but also countries with access to ample cotton and wool resources had increased their man-made fibre capacities in the last years, indicated 'the high technical perfection and economic competitiveness of the chemical fibre'. They added that after the return to normal market conditions the chemical fibres would not replace the natural fibres, but complement them.<sup>65</sup> After World War II, the industry's optimistic expectations materialised. Figure 1 visualises the enormous growth (note the log-scale) of world production of man-made fibre since 1929.

The graph suggests three phases in the post-war period. As explained in the previous sections, this infant industry experienced tremendous growth rates in the interwar years, which were hardly affected by the Great Depression of the 1930s.



**Figure 1.** World and (West) German production of man-made fibre, 1929 to 2008 (metric tons, share in percent).

Notes: log scale (left). Man-made fibre includes rayon yarn, staple fibre, and synthetic fibres. West Germany between 1950 and 1989. Sources: see Table A1 (appendix).



The second phase lasted from the end of World War II until 1973 and thus paralleled Europe's post-war reconstruction growth phase. While the relative importance of rayon yarn continued to decrease, that of staple fibres continued to increase. Yet, the industry's impressive boom was primarily driven by synthetic fibres like *Nylon* (*DuPont*), *Perlon* (*IG Farben*, then *Bayer*), *Dralon* (*Bayer*), and others. Between 1950 and 1973, the man-made fibre industry grew by an annual average of 7.9% (staple fibre 5.1%). The main input of the synthetic fibres (acrylonitrile) was supplied by the petrochemical industry, and this partially explains why firms of the chemical industry like *DuPont*, *Rhône-Poulenc*, *Monsanto*, *ICI*, *Bayer*, and *Hoechst* became the most important players in the man-made fibre market and also why the industry's growth slowed down after the first oil price crisis of 1973–74. For the rest of the 20<sup>th</sup> century (with few changes until today) the average annual growth rate of man-made fibre production amounted to a mere 3.6% (staple fibre –1.4), which is still a bit more than average GDP growth (Wubs, 2020, p. 113).<sup>66</sup>

In the post-war period, the man-made fibre industry developed a wide range of special fibres that found applications not only in textile production, but increasingly also in other ('non-woven' or 'non-apparel') markets (tyres, furniture, sunshades, convertible tops, sanitary and hygiene equipment, etc.), too. As suppliers of the textile industry, man-made fibre has more or less driven out all natural fibres except cotton, and its importance has thus even exceeded the expectations of the *IG Farben* specialists in 1944. The production of cotton did increase throughout the 20<sup>th</sup> century, while that of wool decreased even in absolute terms. Overall, man-made fibre now accounts for nearly three quarters of the world's textile fibre production (Table 1).

However, technological progress in the man-made fibre markets slowed down. Man-made fibre was no longer a high-tech product and patent protection became less effective. The market became mature, and this meant that producers in West Germany and other European countries soon faced increasing competition from newcomers (Marx, 2017a, pp. 166–167; Owen, 2011, pp. 3–5). In the third phase, i.e. since roughly the 1970s, Western Europe's market share has been in constant decline. The same holds for other highly industrialised countries like the United States and Japan. Nowadays nearly half the world's production is manufactured in mainland China alone (Table 2).

After World War II, West Germany's share shrank roughly in line with that of Western Europe as a whole. The white graph in Figure 1 illustrates the production of (West) German man-made fibre manufacturers, and the grey one their world market share. In the 1950s, West Germany reintegrated into the world economy. Cotton was once more (as it had been until 1931) imported without or just a few restrictions, leaving the man-made fibre industry

**Table 1.** World textile fibre production by products, 1921 to 2018 (per cent of total volume).

	Wool	Cotton	Silk	Man-made fibre
1921	20	79	.7	.5
1939	13	73	.7	13
1950	10	70	.2	19
1963	9	65	0	26
1975	7	49	0	44
1990	5	48	0	47
2018	1	26	0	73

Sources: *Kelheimer Taschenbuch* (1960, pp. 11–12); Bauer (1965, p. 147); Industrievereinigung Chemiefaser (<https://ivc-ev.de/de/weltproduktion-von-fasern-balkendiagramm>, accessed 5 August 2020).

to market forces and hence in a situation which none of the new regional staple fibre plants had ever faced before. The West German man-made fibre industry grew nevertheless in the 1950s and 1960s in line with the world's. Its annual growth rate was even slightly above the world average for the period from 1950 to 1973 (8.2%).

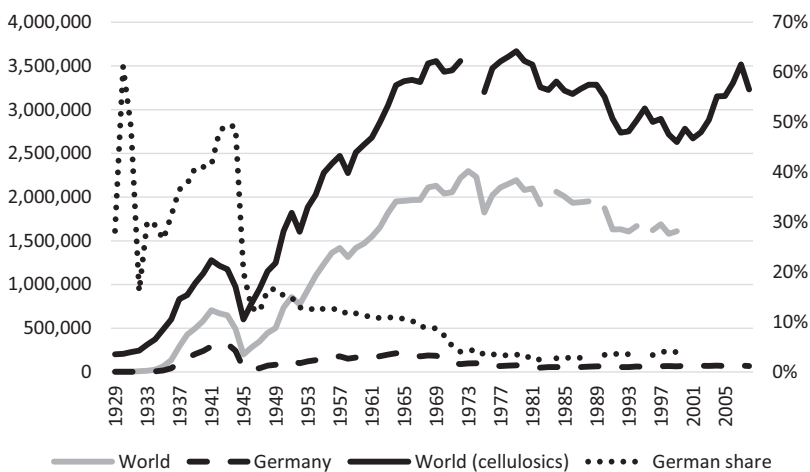
The industry's boom was driven by the new fully synthetic fibres, which disposed of ever improving textile characteristics, e.g. for sportswear (Harrop, 2003, pp. 950–957). In contrast, viscose based fibres like staple fibre and in particular rayon yarn lost importance. In this market the years 1973–74 mark a turning point in the sense that production growth not only slowed down, but even became negative both on a worldwide scale and in Germany. Improved fibre quality characteristics led to a recovery starting in the early 2000s (Figure 2).

**Table 2.** World man-made fibre production by production region, 1930 to 2018 (per cent of total volume).

	Western Europe	of which: Germany	USA	Japan	Rest of the World
1930	58	14	28	8	6
1939	54	27	17	25	4
1950	53	8	19	9	4
1975	25	7	28	13	34
1990	18	5	20	9	53
2018	4	1	3	1	92

Notes: Western Europe includes all European countries except pre-1990 Socialist countries. West Germany between 1950 and 1989.

Sources: *Statistisches Jahrbuch für das Deutsche Reich* (1936), pp. 82–83\*, (1941/42), p. 92\*; *Kelheimer Taschenbuch* (1960), p. 12; Industrievereinigung Chemiefaser (<https://ivc-ev.de/de/chemiefaserproduktion-nach-regionen-balkendiagramm>, accessed 6 August 2020), Table A1 (appendix).



**Figure 2.** World production of cellulose as well as World and (West) German production of staple fibre, 1929 to 2008 (metric tons, percent).

Note: The difference between World cellulose production and World staple fibre production is almost exclusively rayon yarn production. West Germany between 1950 and 1989. Sources: see Table A1 (appendix).

In the following, we will take a closer look at the market structure in West Germany, which, in contrast to the 1930s, cannot be understood if not seen in an international context. Moreover, although we focus on the markets for semi-synthetic fibre, we also have to look at those for synthetic fibres. As described below, *IG Farben* and *Glanzstoff* had dominated the market for semi-synthetic fibres in the early 1930s. In the early 1940s, the unit costs of most second-wave plants had decreased to the level of the plants run by *IG Farben*, *Glanzstoff* and the first-wave regional firms. The imitation process had been largely accomplished. Within the remarkably short period of five to six years, *IG Farben* and *Glanzstoff* had lost their profitable duopoly and their technological advantage to a number of newcomers. One of the latter, the *Phrix AG*, was the unrivalled market leader with a share of roughly 30% in the staple fibre market and 7% in the rayon yarn market.

After the currency reform of 1948 and the foundation of the Federal Republic in 1949, the West German economy boomed. Although there were still import and currency restrictions, the spinning mills were able to acquire foreign raw material, in particular cotton and wool. But compared to the 1920s the quality of man-made fibres had improved considerably. Hence demand for man-made fibres outpaced that for natural fibres (Table 2). Moreover, West German man-made fibre was a successful export product. Production increased even more than domestic consumption, and the export share of the West German man-made fibre production increased from 7% in 1950 to 44% in 1973 (Calculated from *Statistisches Jahrbuch für die Bundesrepublik Deutschland* (1953), pp. 252, 312); (1974), pp. 244, 297).

However, both R&D and production remained costly, so that a concentration process started. The most spectacular case was probably that of *Phrix*. After the war, most of *Phrix'* plants were located in what had either become the Soviet occupied zone or Poland. The company, which had moved its headquarters to Hamburg already in 1941, reorganised its operations. In 1951, *Phrix'* annual fibre output was about 50,000 tons.<sup>67</sup> Within a couple of years, *Phrix'* share of West German semi-synthetic fibre output again made up about one third in the early 1950s (*Phrix GmbH*, 1951, p. 56). This success was facilitated by continuities. Dörr remained chairman and most other managers and researchers, and hence their experience and knowledge, had relocated to the West (*Phrix GmbH*, 1951, p. 11, 24, 56, 100, 111). *IG Farben*, who also had had most of its staple fibre capacity in the East, was divided into its original firms, mainly *Bayer*, *BASF*, and *Hoechst* (1952).

Those few regional plants which were located in West Germany (*Süddeutsche* in Kelheim, and a *Phrix* plant at Siegburg) survived, although partly damaged by bombing. *Lenzing* in Austria, the largest of the regional plants, remained fully intact (Sandgruber, 2010a, pp. 14, 313). Table 3 illustrates in which post-1945 countries the plants of the German staple fibre industry were located.

As in the 1930s, the production of staple fibre grew more than that of rayon yarn. The development of synthetic fibres, however, changed the market dramatically. Before World War II, the booming man-made fibre market had been dominated for quite some time by large manufacturers like the German *Glanzstoff*, the British *Courtaulds*, the French *Comptoir* group and the Dutch *AKU*. Now their suppliers became attracted by the business. The only large chemical firm active in the German semi-synthetic fibre market had been *IG Farben*. After the war, other chemical giants either entered the market directly or sold pre-products to downstream firms producing the new synthetic fibres. It was in this new field that large profits could be reaped. The R&D costs were immense, so that the independent firms came

**Table 3.** Staple fibre plants in Germany, 1944–45.

Location		Main owner 1944	Capacity 1938–39 (tons per day)	Foundation	Production start staple fibre
Heinsberg- Oberbruch	W	<i>Glanzstoff</i>	10	1891	1916
Premnitz	E	<i>IG Farben</i>	<i>n.a.</i>	1920	<i>n.a.</i>
Bitterfeld-Wolfen	E	<i>IG Farben</i>	<i>n.a.</i>	<i>n.a.</i>	1932
Burghausen	W	<i>IG Farben</i>	3	1914	1934
Freiburg im Breisgau	W	<i>Rhodiaseta (Rhône- Poulenc group)</i>	10	1927	1934
Kassel- Bettenhausen	W	<i>Glanzstoff</i>	90	1935	1935
Ludwigshafen- Oppau	W	<i>IG Farben</i>	<i>n.a.</i>	<i>n.a.</i>	1935
Berlin-Zehlendorf	W	<i>Spinnstoffabrik Zehlendorf, independent</i>	10	1919	1936
Kelheim	W	<i>Süddeutsche Zellwolle, wave 1</i>	60	1935	1936
Plauen	E	<i>Sächsische Zellwolle, wave 1</i>	35	1935	1936
Rudolstadt- Schwarza	E	<i>Thüringische Zellwolle, wave 1</i>	60	1935	1936
Hirschberg/Jelenia Góra	P	<i>Phrix, wave 1</i>	60	1935	1936
Glauchau	E	<i>Spinnstoffwerk Glauchau, independent</i>	10	1923	1937
Siegburg	W	<i>Phrix, wave 2</i>	40	1936	1938
Küstrin	P	<i>Phrix, wave 2</i>	60	1938	1938
Wittenberge	E	<i>Phrix, wave 2</i>	55	1937	1939
Lenzing	A	<i>Thüringische Zellwolle, wave 2</i>	50	1938	1939
Litzmannstadt/Łódź	P	<i>Thüringische Zellwolle, wave 2</i>	70	1940	1940

Notes: Political location after 1945 in Austria (A), East Germany (E), Poland (P), or West Germany (W). Capacity Litzmannstadt/Łódź as of 1944. Regional plants of first and second wave. The three *IG Farben* plants without individual capacity data had a joint capacity of 137 tons per day.

Source: authors' compilation.

under increasing pressure. Besides those based on polyamide or acrylonitrile, Britain's *ICI* developed during World War II a third synthetic fibre, polyester ('*Terylene*'). After the war, *ICI* licenced the production to *Glanzstoff* ('*Diolen*') and *Hoechst* ('*Trevira*') (Bauer, 1965, pp. 106–113, 127–130; and for *Hoechst*: Marx, 2013, p. 254). Nevertheless, demand for both rayon yarn and staple fibre continued to increase. *Glanzstoff*, for example, invested heavily in both fields. Its production peaks were in the staple fibre business around the mid-1960s and in the rayon yarn business around the early 1970s, in both cases exceeding the war peaks by about 50% (Langenbruch, 1985, pp. 121–123).

*Bayer* developed a new synthetic fibre based on acrylonitrile, which it marketed as *Dralon* from 1954 onwards. *BASF*, another successor of *IG Farben*, started to think about entering the fibre market in 1962, which complicated its long-standing relation to its second largest customer, *Glanzstoff*. *BASF* proposed a joint venture, but *Glanzstoff's* main shareholder, the Dutch *AKU*, disliked the idea, and the cooperation talks ceased in 1965. *BASF*, eager to get a foot in the business, set up a joint venture in 1966 with *Dow Chemical* in the US where *Dow Badische Chemical Company (DB)* opened a new factory for the production of nylon fibres and polyester fibres in Anderson, South Carolina. *Dow* brought in a factory for acrylic fibre in Williamsburg, Virginia (Abelshausen, 2004, pp. 517–527).

After the cooperation talks with *Glanzstoff* failed, *BASF's* second choice in Germany was the ailing *Phrix AG*, which it took over in January 1967, a step that increased the competition

on the West German man-made fibre market (Marx, 2017b, pp. 9–10). In 1968, *Dow* acquired a stake in *Phrix* from *BASF*. Both firms joined their fibre interests in the newly formed *DB-Phrix Group*. After *Bayer* and *Hoechst*, *BASF* was now the last of the three German chemical giants being present at the man-made fibre market which soon began to suffer from overcapacity. *BASF*'s strategy was to survive on the market until 1980, by which time the top management expected there would be only a few giant manufacturers of synthetic fibres left on the world market. The question was whether the *DB-Phrix Group* would be among those who would survive the concentration process to come. Yet, the takeover of *Phrix* turned out to be a disaster. The firm was still focussed on the production of viscose-based semi-synthetic staple fibre and had missed the trend towards synthetic fibre of which it produced only minor quantities. *Phrix* incurred high losses, which were further increased by the revaluation of the West German mark in October 1969. Both *Dow* and *BASF* did not want to let a joint subsidiary go bankrupt. But the sequel of *Phrix* factory closures in 1970 and 1971, which in the end cost the jobs of 3000 employees, received much more attention in the public than *BASF* had hoped for (Abelshauer, 2004, pp. 551–560).

In contrast to *Phrix*, the *Süddeutsche Zellwolle AG* in Kelheim (Bavaria) did improve its product portfolio in time. The *Süddeutsche*, one of the earliest Nazi regional plants, was fully independent and most of its shareholders were still the South German spinning mills which had founded the company in 1935. The firm was quite successful in producing and selling staple fibre with an ever-rising export share. But as world market prices fell due to increasing competition, *Süddeutsche* realised that it had to find a second pillar which was obviously in the synthetic fibre market. The firm managed to develop a new synthetic fibre by the late 1950s based on acrylonitrile without violating the patent rights of its large competitors. Producing both staple and synthetic fibre ('*Danufil*' and '*Dolan*'), *Süddeutsche* remained very profitable. But throughout the 1960s it became clear that in order to survive in an ever more competitive market, the firm had to invest on a scale which its shareholders were not able to finance. Since 1958, the West European (and German) textile industry was in a deep structural crisis, which in the end it would not survive. For *Süddeutsche*'s main shareholders the company's dividends were a welcome cash-flow which covered their own operational deficits. These spinning mills were certainly not in the position to finance further investments. So *Süddeutsche* looked for a larger player who could take over. As *Süddeutsche*'s synthetic fibre sold very well and with profit, several chemical firms offered high bids. Finally, it was *Hoechst* who won the takeover competition. *Süddeutsche*'s product portfolio seemed to fit nicely into *Hoechst*'s. When *Süddeutsche* became subsidiary of *Hoechst* (1968), the last of the regional staple fibre plants of the 1930s which were located in West Germany had lost its independence (Spoerer & Götz, 2017, pp. 84–96). In the wake of the first oil price crisis, the German man-made fibre industry was completely in the hands of the chemical giants *Bayer*, *BASF* and *Hoechst* or part of the Dutch *Akzo* group (*Glanzstoff*), the successor of *AKU* which had merged with the Dutch chemical firm *KZO* in 1969. As the three aforementioned giant firms were *IG Farben*'s successors, one could argue that the old oligopoly of the early 1930s was restored. But, in stark contrast to autarchic Nazi Germany, the opportunities to control the markets became ever more difficult in globalising fibre markets and all the more as important patents for synthetic fibres expired in the 1960s.<sup>68</sup> Moreover, Western Germany was an attractive location for foreign direct investment. Both *Dupont* and *ICI* erected synthetic fibre plants and had in

1968 shares in the West German man-made fibre market of 12.5 and 6.9%, respectively (Wubs, 2012, p. 36).

Faced with the same world market conditions, the fate of the plant in Lenzing (Austria) in the 1950s and 1960s was similar to that of *Süddeutsche*. With 100 tons a day, the plant had been Europe's largest in 1943, but was on the verge of bankruptcy in 1945–46. Although the capacity was far beyond the demand of Austrian textile mills, the government decided that the plant should be re-started. As early as 1948, it became profitable and soon started to export on a large scale (Sandgruber, 2010a, pp. 68, 77–78, 108, 112, 317, 323, 341–342). In terms of production, both *Lenzing* and *Süddeutsche* ranked in 1964 among the world's largest producers of cellulose-based fibres. Table 4 is a snapshot of the world's largest Western man-made fibre producers at the heyday of the industry.<sup>69</sup>

Another similarity to the *Süddeutsche* is that the management did not fully rely on staple fibre, but diversified its products by taking up the production of fully synthetic fibre (*Nylon*, *Perlon*, and since 1968 *Trevira* in cooperation with Hoechst) in 1960 and developed high-quality fibre types, which the growing number of competitors was not able to copy immediately. The main difference to the *Süddeutsche* was the ownership structure. *Lenzing*, which was able to acquire a cellulose plant next to its own plant in 1968–69, was dominated by public banks who protected the firm from foreign takeover bids until the 1990s.<sup>70</sup>

However, in the third phase after 1973 the world market share of Western European manufacturers fell dramatically. The oil price crisis of 1973 hit the chemical industry and especially the man-made fibre markets, but the giant firms which were active in this business were able to offset the losses of their fibre divisions. In addition to the oil price shock, the European man-made fibre industry was subject to a structural crisis. In the 1960s and 1970s, many cellulose-based and synthetic fibres became a commodity. Market segments which were technologically mature were taken over by low-cost producers in the Eastern bloc and later in Eastern Asia (Steffen, 2008, pp. 44–46). Moreover, the industry's main customer, the textile industry, was in a deep structural crisis. After the War, when private consumption resumed, Europe's textile industry had experienced its last boom period. But spinning and

**Table 4.** Leading Western man-made fibre producers in 1964 (1000 tons).

Firm		Cellulose-based (semi-synthetic) fibres	Synthetic fibres	Man-made fibres
DuPont	US	25	374	399
Aku/Glanzstoff	NL/D	279	102	381
Courtaulds	UK	356	20	376
Rhône-Poulenc	F	200	140	340
Celanese	US	190	23	213
Snia Viscosa	I	138	30	168
Chemstrand/Monsanto	US	5	145	150
ICI	UK	0	114	114
Phrix	D	68	5	73
Lenzing	A	57	–	57
Süddeutsche Chemiefaser (Kelheim)	D	55	2	57
Union Chimique	B	38	7	45
Svenska Rayon	S	34	0	34
Saeteri	FIN	25	0	25
Borregaard	N	23	0	23

Source: Owen (2010, p. 60). The source he relies on does not give data for the large Japanese producers, which were Asahi Kasei, Kanebo, Kurabo, Kuraray, Mitsubishi Rayon, Nichibo, Nisshinbo, Nippon Rayon, Teijin, Toray, and Toyobo, see *ibid.*, pp. 259–261.

weaving, and all the more cloth production, is comparably labour-intensive, and the transport of textiles is cheap. Hence the textile industry in developed countries came under pressure from competitors in the European periphery, in the Mediterranean, and finally in South and Southeast Asia. The textile crisis of 1958 had been the first crisis indicator. Ever more spinning and weaving mills in the developed countries closed their factory gates. The new textile firms in developing countries covered their demand of man-made fibres increasingly from East European or Asian low-cost suppliers.<sup>71</sup>

Other structural disadvantages for the European industry that increased costs stronger than in the less developed world were government and organized-labour market regulations which the industry regarded as restrictive, and wage increases (Steffen, 2008, p. 24). Moreover, since the famous Club of Rome's report on the 'Limits of growth' (1972), European societies were increasingly in favour of regulation for the protection of the environment. This was a problem for the chemical industry as a whole, but for the synthetic fibre and especially the environmentally very problematic viscose fibre producers in particular (Spoerer & Götz, 2017, pp. 104–112). For both plants in Kelheim (formerly *Süddeutsche*) and Lenzing, the adaptation to new, much tighter environmental standards raised concerns about the viability of the plants. Since 1980, Kelheim was (and still is) the last (West) German producer of staple fibre. In both cases, the firms decided to invest heavily in new technology, which reduced the pollutant emissions considerably. In this respect, *Lenzing* bought in 2004 the *Iyocell* ('*Tencel*') business originally built up by *Courtaulds* which relied on much more environment friendly viscose processing than that for the conventional viscose fibres (Owen, 2010, pp. 135, 156–157, 238–239, 281–282).

Because of its low profitability and uncertain business prospects, Kelheim was split off from the *Hoechst* group in 1994 and became part of the *Courtaulds* group. When *Courtaulds* was taken over by *Akzo Nobel* in 1998, Kelheim was brought into a newly founded fibre subsidiary, *Acordis*. The fact that the plant had been forced to adopt advanced environment standards already in the late 1970s and 1980s allowed it to win the intra-group location competition with two other *Acordis* viscose-based fibre plants in the UK (Grimsby) and the US (Mobile). These plants produced at lower costs than Kelheim, but to continue production would have required huge investment in environment friendly technology – which Kelheim already had. Hence Grimsby and Mobile were closed in 2001 and the technology was transferred to Kelheim. In 2004, the Kelheim plant was sold to a holding in which *Lenzing* had stakes and became formally independent as *Kelheim Fibres GmbH*. In 2008 *Kelheim Fibres* sold its synthetic fibre plant, also located in Kelheim, to *Lenzing*. A complete takeover of *Kelheim Fibres*, i.e. the viscose fibre production, by *Lenzing* was ruled out by the German Federal Cartel Office in 2012. Since then, *Kelheim Fibres* is independent again and continued its focussing on specialty viscose fibres for which it today claims to be the world's leading manufacturer.<sup>72</sup> *Lenzing* always remained independent (a planned takeover by a private-equity holding in 2001 failed) and is since the 1980s one of the world's leading viscose producers with man-made fibre plants in Austria, the UK (Grimsby), the United States (Mobile), Indonesia, and China. *Lenzing's* Indonesian subsidiary *South Pacific Viscose* is the world's largest producer of viscose fibre.<sup>73</sup>

While there are still a few European plants producing synthetic fibres today, there are only two left which produce viscose staple fibre: *Kelheim Fibres*, formerly *Süddeutsche*, and *Lenzing AG*, both founded as part of the Nazi infant company protection policies in the 1930s. Being infant companies protected by the Nazi economic policy, both profited enormously

from the technology transfer in the Third Reich and, in contrast to other staple fibre firms, used this knowhow in the afterwar period to diversify their product range by starting to develop viscose fibre for other markets (e.g. tampons, dressing, and other hygiene or medical products) and to produce synthetic fibres. By doing so they emancipated themselves from the classical textile markets. While all other European staple fibre plants died away along with their main customer, the textile industry, those two plants diversified successfully, survived (so far), and even became world leaders in niche or even commodity markets.

While forward-looking management and sheer luck, especially in the case of Kelheim (Spoerer & Götz, 2017, pp. 123–124) were certainly important factors that contributed to firm longevity and survival, Geoffrey Owen has convincingly argued that ‘varieties of capitalism’ (Hall/Soskice) played a role as well. In Anglo-Saxon countries the crisis of the man-made fibre business coincided with the trend to a more pronounced financial market capitalism. Since the early 1990s, financial investors were ready to take over firms whose market value suffered from poor results of certain divisions (such as the fibre business) and split them up. In the end, this was the fate of once famous giant firms such as *ICI* and *Courtaulds*. This narrowed the managers’ room for manoeuvre and induced them to act and plan on a more short-term basis. In corporatist countries like Austria and Germany, shareholders were not the only stakeholders. On the one hand, the employed and with them the politicians of the region, in which the plants were located whose existence was at stake, were in the position to put pressure on the management. On the other, politicians were willing to support and sometimes subsidise the process of restructuring. In these countries, managers remained in the position to plan on a long-term basis, restructure their business, and nurse it back to health (Owen, 2011). This was the case for the former *Süddeutsche* plant in Kelheim, for example, which was taken up and sold off by *Hoechst*, the untypical (and very unlucky) pioneer of shareholder value in Germany (Marx, 2017b, pp. 15–17) (1968/1994), *Courtaulds* (1994/1998), and *Akzo Nobel* (1998/2004). Hence non-financial stakeholders certainly contributed to the longevity and survival of both Kelheim and of *Lenzing*, where the Austrian state (indirectly) had an important financial stake since 1949 (Owen, 2010, pp. 280–283).

## 5. Conclusion and outlook

The general question whether and under what circumstances protecting infant industries or companies might be a sensible policy is far beyond the scope of this study. It is often argued that the beneficiaries of such a policy use their room for manoeuvre in prolonging their privileges rather than improving their competitiveness – which is the very rationale of the policy. There are many examples, especially of state-run enterprises, which are in line with this sceptical reasoning.<sup>74</sup> We illustrate a counter-example in which infant company protection indeed strengthens the beneficiaries of such a policy against incumbent duopolists in the sense that the new firms acquire knowhow and capacities that enable them to succeed even when the protection ends and they are left to the forces of the market. The success of the policy is underlined by the ever-increasing export share of these plants’ production after World War II and their longevity.

In this sense, the foundation and subsequent support of the regional companies in Nazi Germany during the second half of the 1930s is an example of successful government



intervention. Ingredients for this success were on the one hand the active infant company protection policies the government granted to these companies – profitable prices, reduced taxes and freight rates, a de facto granted demand for their output, and state guaranteed loans at favourable conditions. Yet, this by and large financial support was not alone sufficient for the successful imitation by the regional plants and therefore their survival under free market conditions after the war.

A successful imitation also required that the newcomers had to develop a viable technology and that they had to acquire non-patentable knowledge which was crucial in this industry. Thus, the Nazi government implemented an institutional and personal superstructure for the regional plants which facilitated the knowledge transfer among the plants and especially between first-wave and second-wave companies. Generally, more and more activities of the companies were centralised over time exploiting synergies (as sales organisation and marketing, purchase of raw materials, R&D, patent questions). This process, including almost all regional companies, culminated in 1941, when the holding company *Phrix AG* and the de-facto holding *ZKR* were set up and operated as two new big players in the German cellulose-based, i.e. semi-synthetic fibre market. By 1943, both produced as much cellulose-based fibres as *Glanzstoff* and exceeded *IG Farben's* output significantly.

The case presented here is all the more stunning because making German firms competitive in free world markets was certainly not on the agenda of Nazi policy makers. There is evidence that exporting staple fibre was regarded as a useful by-product of the massive capacity enlargement in the course of the autarky policy. But the main motive was import substitution. As the Nazi government was reluctant to force the incumbent firms – in fact, duopolists – to undertake capacity increases which they regarded as too optimistic, the government planners encouraged the incumbents' customers to erect new plants. It was two of these new plants, *Kelheim* and *Lenzing*, fully protected by the government until 1945 but only on a comparably small scale thereafter, which survived the stiff post-war competition process and are today the last European viscose-based fibre producers.

## Notes

1. Man-made fibre is the generic term for semi-synthetic fibres (almost exclusively cellulose) and (fully) synthetic fibres. Semi-synthetic fibres are mainly produced from cellulose which is made of wood pulp. When processed, a viscose filament results which is either 'endless' (rayon) or cut down (staple fibre, today known as viscose staple or viscose fibre). Throughout the 20<sup>th</sup> century, viscose, rayon, and staple fibre were often synonyms. In order to differentiate between the two types of fibre, we call 'endless' viscose filament 'rayon yarn' and filament which was cut down 'staple fibre'. The first was a substitute for silk, the latter for cotton or sometimes wool. Nylon was the first fully synthetic fibre for textiles. See for the taxonomy Owen (2010, pp. 308–309).
2. See Blanc (2016, pp. 134–135), who also stresses the enormous health risks for workers exposed to carbon disulfide vapors in viscose-spinning departments, then and now.
3. The annual fibre production capacity of the Lenzing plant in 2019 made up to 358,000 tons, that of Kelheim 90,000 tons (<https://www.lenzing.com/investors/facts-and-figures/factsheet/> and <http://kelheim-fibres.com/en/company/about-us/>, both accessed 14 August 2020). – After ailing for many years, a third European plant run by *Sniace* in Torrelavega (Spain) ceased production in February 2020, see *ABC* 13 February 2020 (<https://www.abc.es/economia/abci->

sniace-cesa-actividad-y-cierra-fabrica-torrelavega-no-poder-afrontar-pagos-202002132213\_noticia.html?ref=https:%2F%2Fwww.google.com%2F, accessed 13 August 2020).

4. For the different rayon yarn types and their production processes, see Coleman (1969, pp. 172–180) and Owen (2010, pp. 308–313).
5. For the first attempts to create a German cartel in 1926 and the aftermath, see Cerretano (2012, pp. 600–601).
6. For the expectations in the UK and the US, see Coleman (1969, p. 270) and Avram (1929, pp. 119, 128–129).
7. For details, see Scherner (2008b). See also for the case of the *Süddeutsche Zellwolle AG: Streit, Gründung*, p. 8.
8. For the following see Scherner (2002, pp. 445–447). For several examples of German companies, which had this normalization expectation with regard to foreign trade during the 1930s, including *IG Farben* and *Glanzstoff*, see *ibid.*, Wicht (1992, p. 65), and Scherner (2008a, pp. 86, 279–280). See also Ebi (2004, pp. 192–193).
9. For a detailed account of the foundation of *Spinnfaser AG* and the capacity enlargement of *IG Farben* in 1934–35, see Scherner (2008b, pp. 874–884). See also for *Spinnfaser AG*, Langenbruch (1985, pp. 69–71).
10. Consequently, the established companies campaigned against the newcomers, trying to convince investors that it would not be possible to produce staple fibre without the patents held by *IG Farben* and *Glanzstoff*, and that the plans to produce staple fibre from cellulose out of straw or pine would not be feasible. Privataarchiv Richard Eugen Dörr, *Phrix-Novelle*, chap. 5, pp. 26–27.
11. Note that the precise allocation between staple fibre and rayon yarn under this counterfactual is negligible, since, as mentioned above, the production of staple fibre and of rayon yarn only differed in some of the last production steps. This means that companies which had experience in the production of both fibres could have switched the production relatively cheaply.
12. See for example Rheinisch-Westfälisches Wirtschaftsarchiv (RWVA) 195/B 6-0-5, Memorandum of Herrmann, 29 Sept. 1937; Vaubel, 1986, vol. 1, 60.
13. On the research of *IG Farben* in the field of fully synthetic fibres, see for example Plumpe (1990, pp. 318–325, Bode (2002, pp. 190–191), and Coleman (2003, p. 945). On the agreement with *DuPont*, which reserved the German market to *IG Farben* see, Plumpe (1990, p. 321) and Bode (2002, pp. 176–178); 'Nylon: Von Perlon spricht man nicht', in: *Spiegel* 14 March 1950 (<https://www.spiegel.de/spiegel/print/d-44447617.html>, accessed 5 August 2020).
14. Before the government launched the National Fibre Program, some spinning mills had approached – without success – *Glanzstoff* to establish a staple fibre plant as a joint venture, see Scherner (2008b).
15. Cerretano (2011, pp. 207, 211–212; 2018, p. 552). For the respective contemporary perception, see Boeddinghaus (1931, p. 27); Flügge (1936, pp. 22–24); Privataarchiv Richard Eugen Dörr, *Phrix-Novelle*, chap. 3, p. 10.
16. Witt (1939, pp. 106–107, 129); Bayerisches Wirtschaftsarchiv, F 21/249, Aktennotiz über die 55. ordentliche Mitglieder-Versammlung der Industrie- und Handelsbörse Stuttgart am 5.2.1936.
17. Even government officials expected this, see Streit (1936, p. 62), Letter Kehrl to Köhler 18 Feb 1935.
18. According to statements made after the war, *IG Farben* had been forced to grant the Lanusa license to *Thüringische Zellwolle AG*. See Hayes (1987, p. 187).
19. For the contract see, BArch R 8128/15330, Lizenzvertrag IG Farben AG und Thüringische Zellwolle AG, 18.5.1936.
20. On Kehrl, see Müller (1999).
21. Privataarchiv Richard Eugen Dörr, Dörr, *Die Phrix-Story*, August 1970.
22. Privataarchiv Richard Eugen Dörr, IG Farben AG an Staatspolizeistelle Halle, 21.7.1933; Dörr, Lebenslauf, 2.5.1945. Dörr himself speaks of an intrigue against him (*ibid.*).
23. Privataarchiv Richard Eugen Dörr, Dörr, *Die Phrix-Story*, August 1970; Dörr, *Phrix-Novelle*, chap. 3, p. 4.
24. Dörr, *Phrix-Novelle*, chap. 3, pp. 11–14a.

25. BArch R 8120/47, Geschäftsbericht der Schlesischen Zellwolle AG für das Jahr 1935; Dörr, *Phrix-Novelle*, chap. 3, p. 18; chap. 5, pp. 9–10, 17–21.
26. BArch R 2/1503, note, 26.7.1935, fol. 70. On *IG Farben's* R&D expenditure, see BASF Archiv, IG-Bestand, T 1305/1.
27. See for example BArch R 8135/428, Report on Sächsische, 1937, p. 18.
28. Dörr, *Phrix-Novelle*, chap. 5, p. 34.
29. BArch R 2/15304, Keppler to Reich finance minister, 31.7.1935, fol. 6–7; Dörr, *Phrix-Novelle*, chap. 3, pp. 4, 18.
30. BArch R 2/17794, note, July 1936; Speech of Löb, 20.10.1937; Kehrl, *Krisenmanager*, pp. 95–96. On German net imports, see *Statistisches Jahrbuch für das Deutsche Reich* (1937), p. 255.
31. Privatarchiv Richard Eugen Dörr, Dörr, *Phrix-Novelle*, chap. 5, pp. 34–35, 41–42.
32. For the R&D of *Schlesische* on straw and pine, see Privatarchiv Richard Eugen Dörr, Dörr, *Die Phrix-Story*, August 1970; Dörr, *Phrix-Novelle*, chap. 5, pp. 35, 43.
33. BArch R 2/15286, note, 18.12.1937, fol. 19; note, 13.1.1938, fol. 20; BArch 8135/4002, report on Zellstoff-Fabrik Küstrin AG 1936; report on Zellstoff-Fabrik Küstrin AG 1938; BArch 8135/4914, report on Kurmärkische Zellwolle und Zellulose AG 1938.
34. This integrated production flow was supposed to reduce, after starting problems, the unit costs of staple fibre by some percent. BArch R 2/15303, note, February 1938, fol. 276; Witt (1939, p. 85). Similar technological progress with regard to produce cellulose from German raw materials and with regard to a continuous cellulose-fibre production flow was also carried out by the established companies (Bodenbender, 1944, p. 32; Witt, 1939, pp. 58, 75, 78).
35. BArch R 8119F/P 2009, Dresdner Bank, 28.8.1941, fol. 6; BArch R 8135/6153, report on Zellwolle Arbeitsgemeinschaft 1938. See also Witt (1939, p. 93); Privatarchiv Richard Eugen Dörr, Dörr, *Die Phrix-Story*, August 1970.
36. Privatarchiv Richard Eugen Dörr, Dörr, Lebenslauf, 2.5.1945.
37. BArch R 8119F/P181, Dresdner Bank to Deutsche Bank, 28.3.1938, fol. 144. According to Dörr, this happened without having asked the state in advance. Privatarchiv Richard Eugen Dörr, Dörr, Lebenslauf, 2.5.1945.
38. BArch R 8135/453, Report on Schlesische 1938.
39. See for example BArch R 8119F/P 2009, Dresdner Bank, 28.8.1941, fol. 6–7.
40. BArch R 8135/6153, Report on Zellwolle Arbeitsgemeinschaft 1938.
41. The purchase of cellulose was more favorable for *Spinnfaser* than for the regional staple fibre plants. However, this lower input price can only explain a small share of the higher variable cost of the newcomers. About the cellulose prices see BArch R 8135/3583 Report on Sächsische, 1939, 5; BArch R 8135/2704 Report on Spinnfaser, 1937, 8.
42. This brand name was chosen because *Schlesische's* management believed that it would be more marketable in foreign countries than a German name. Privatarchiv Richard Eugen Dörr, Dörr, *Phrix-Novelle*, chap. 5, p. 46.
43. Piorkowski (1938, p. 2). Moreover, *Thüringische* had his own research laboratory. *Ibid.*, p. 4.
44. BArch R 8135/3001 Report 1940; BArch R 8119 F/P 181, 16; Kahl (1964, p. 89).
45. Moreover, see BArch R 8119 F/P 185 note Deutsche Bank, 21.1.1941.
46. BArch R 13 XII/422 Schreiben des Beauftragten für den Vierjahresplan an die Fachgruppe Chemische Herstellung von Fasern vom 26.8.1937, fol. 60a.
47. See for example BArch R 2301/6580, note, economic department of the Reichsbank, 25.1.1937, fol. 62; Sandgruber (2010a, p. 70); Kaienburg (1994, p. 13).
48. On construction prices, see Scherner (2010, p. 466). In the case of *Lenzing*, higher investment expenditures were also caused by bad planning; Sandgruber (2010a, p. 70).
49. BArch R 2/15303, note, 8.7.1940; note 7.6.1940.
50. For details see, BArch 8119 F/P 2009, Dresdner Bank, note, 17.4.1941, fol. 13–16.
51. Privatarchiv Richard Eugen Dörr, Dörr, *Phrix-Novelle*, chap. 6, pp. 14–18. Consequently, in the late 1930s, the German press described the companies being member of the *Phrix GmbH* as a 'concern'. BArch R 2/15303, fol. 15.
52. BASF-Archiv, A 41 Entwicklung der Phrix-Werke AG, p. 3; BArch R 8135/5964 Bericht über die Phrix-Werke AG, pp. 1–6.

53. BArch R 8119 F/P 179, fol. 9; BArch R 8119 F/P 180, fol. 7.
54. BASF-Archiv, A 41 Entwicklung der Phrix-Werke AG, p. 4; BArch R 8135/5964 Bericht über die Phrix-Werke AG, p. 7.
55. For the list of members see BArch R 1828/20084, Vertrag IG und ZKR über die Zusammenarbeit auf dem Gebiet der vollsynthetischen Hochpolymeren, 3.6.1942, p. 15.
56. This cooperation started already in late 1939, see Sandgruber (2010a, p. 119).
57. In 1943, the *Phrix AG* had a workforce of about 22,000 and a production capacity for 105,000 tons of fibres and 90,000 tons of cellulose. Privatarchiv Richard Eugen Dörr, Dörr, *Die Phrix-Story*, August 1970.
58. The plant is still today producing cellulose out of beech. See <https://www.sappi.com/de/ehingen-mill>, accessed 5 August 2020.
59. See for example BArch R 8119 F/P 174, fol. 1; BArch R 8119 F/P 179, fol. 7; BArch R 8119 F/P 180, fol. 1–2; BArch R 8119 F/P 197, fol. 270; Sandgruber (2010a, p. 112).
60. In the case of the *Kurmärkische*, the cellulose input per kg staple fibre decreased from 1.11 to 1.03 between 1940 and 1942 as well as the share of waste from 8.6% to 2.8%. BArch R 8135/4884, Report on *Kurmärkische* 1940; BArch R 8135/4217, Report on *Kurmärkische* 1941; Report on *Kurmärkische* 1942. The *Lenzing AG*, another second-wave company, made increasing profits per kg staple fibre between 1941 and 1943. This process was interrupted only in the last phase of the war. For data on revenue and costs per kg, see Sandgruber (2010a, p. 74). Only one second-wave company, the *Rheinische*, had persistent problems and had even an increasing share of waste between 1940 and 1942, see Scherner (2008a, pp. 215–216).
61. For an example, see BArch R 8135/4217 Report on *Kurmärkische*.
62. BArch 8119 F/P 2009 Dresdner Bank, note, 17.4.1941, fol. 13–16.
63. For Phrix, see Bode (2002, p. 183). After the war, *Phrix* produced its own synthetic fibre brand *Phrilon* (Phrix GmbH, 1951, p. 84). For ZKR's license and cooperation agreement, see BArch R 1828/20084, Vertrag IG und ZKR über die Zusammenarbeit auf dem Gebiet der vollsynthetischen Hochpolymeren, 3.6.1942. Shortage of steel, however, prevented the build-up of large capacities during the war. *IG Farben's* output remained, compared with *DuPont*, small. BArch R 8128/19060, IG an Reichsamt für Wirtschaftsausbau, 11.12.1943; Plumpe (1990, pp. 322–323).
64. Calculated from Gleitze (1956, p. 208), and the figures in Table 3 above.
65. 'Chemische Fasern', Report by Economic Research Dept. of IG Farben, 8 Dec 1944, fol. 15, BArch R 3101/32128 (our translation). For similar statements made by *Glanzstoff* only a week later and briefly after the war, see Kleinschmidt (1998, pp. 175–176), and RWWA 195/B 5-1-11, minutes of the *Glanzstoff* supervisory board meeting, 28 June 1946.
66. Growth rates calculated from data kindly supplied by Industrieverband Chemie, published in Spoerer and Götz (2017, pp. 134–135). Viscose-based fibre production (rayon yarn and staple fibre) increases again since the early 2000s.
67. 'Phrix-Konzern', in: *Spiegel*, 2 September 1953 (<https://www.spiegel.de/spiegel/print/d-25657461.html>, accessed 6 August 2020).
68. See for the notorious chemical fibre cartel in the 1970s Schröter (2012) and Marx (2017a). On patents, see Opitz (1980, p. 94).
69. At the time, most developed world markets were controlled by market agreements between the leading firms. Japanese exports to the Western markets were minimal, see Opitz (1980, pp. 86–87, 100) and Schröter (2012, p. 91). – Note that Owen states that *Lenzing* did not produce synthetic fibres in 1964. In fact, *Lenzing* did produce *Nylon* and *Perlon* since late 1960, see Lackinger (2010, p. 195). *Süddeutsche* had just started the production of its synthetic fibre '*Dolan*' and increased it in the second half of the 1960s, see for production data Spoerer & Götz (2017, pp. 97, 134–135).
70. Lackinger (2010, pp. 195, 225–226); Sandgruber (2010a, pp. 330, 344–345); <https://www.lenzing.com/lenzing-group/history/> (accessed 13 August 2020).
71. *Süddeutsche Zellwolle AG*, Financial reports 1957 and 1961, Company Archive Kelheim Fibres.
72. Spoerer and Götz (2017, pp. 113–125, 132–133); <http://kelheim-fibres.com/en/company/about-us/> (accessed 20 August 2020); Marx (2016, pp. 208, 216).

73. Lackinger (2010, p. 329); Blanc (2016, pp. 200–201); <https://www.lenzing.com/lenzing-group/locations/> (accessed 20 August 2020).
74. In its first years, *Lenzing* fits perfectly into this picture, see Sandgruber (2010a, pp. 69–72).

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No potential conflict of interest was reported by the authors.

## Notes on contributor

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## Appendix

Table A1. Cellulosics and synthetics production in Germany and the World, 1929–2008.

	Regional plants											
	Staple fibre		Rayon yarn		Cellulosics		Synthetics		Man-made fibre		World	
	Germany	World	Germany	World	Germany	World	Germany	World	Germany	World		
1929	1,089	0	3,856	197,585	27,578	201,440	0	0	27,578	0	201,440	
1930	1,996	0	3,266	204,343	29,347	207,609	0	0	29,347	0	207,609	
1931	1,996	0	4,082	224,075	30,572	228,157	0	0	30,572	0	228,157	
1932	1,361	0	8,437	236,095	28,213	244,532	0	0	28,213	0	244,532	
1933	4,037	0	13,381	28,848	299,462	312,843	0	0	32,885	0	312,843	
1934	7,167	0	24,403	348,813	46,221	373,216	0	0	46,221	0	373,216	
1935	17,191	0	64,818	424,426	61,779	489,245	0	0	61,779	0	489,245	
1936	43,001	6,521	137,438	45,495	88,496	601,327	0	0	88,496	0	601,327	
1937	106,322	38,198	291,433	58,060	164,382	834,156	0	0	164,382	0	834,156	
1938	160,708	69,640	426,422	65,771	226,479	878,926	0	0	226,479	0	878,926	
1939	204,570	n.a.	499,813	73,709	278,279	1,017,362	0	0	278,279	0	1,017,362	
1940	240,132	147,183	585,316	79,787	319,919	1,127,313	0	5,000	319,919	0	1,132,313	
1941	292,567	191,160	706,198	90,265	382,832	1,277,679	0	n.a.	382,832	0	n.a.	
1942	322,413	223,442	668,641	89,403	411,817	1,215,582	0	n.a.	411,817	0	n.a.	
1943	320,826	223,397	648,047	96,162	416,987	1,173,988	0	n.a.	416,987	0	n.a.	
1944	241,311	n.a.	492,420	84,595	325,906	974,498	0	n.a.	325,906	0	n.a.	
1945	40,052	n.a.	200,125	9,525	49,578	601,146	0	n.a.	49,578	0	n.a.	
1946	36,061	n.a.	280,774	8,890	44,951	784,261	0	n.a.	44,951	0	n.a.	
1947	41,776	n.a.	346,998	18,643	60,419	948,915	100	n.a.	60,519	100	n.a.	
1948	73,074	n.a.	445,881	35,652	108,726	1,153,032	200	n.a.	108,926	200	n.a.	
1949	83,506	n.a.	502,127	47,355	130,861	1,246,018	400	n.a.	131,261	400	n.a.	
1950	112,718	n.a.	737,541	49,442	162,159	1,611,614	900	69,000	163,059	900	1,680,614	
1951	127,777	n.a.	856,382	56,382	184,159	1,818,905	3,000	n.a.	187,159	3,000	n.a.	

(Continued)



Table A1. Continued

1952	99,382	n.a.	772,468	45,042	830,528	144,424	1,602,995	4,000	n.a.	148,424	n.a.
1953	121,563	n.a.	937,122	54,250	947,101	175,812	1,884,223	5,400	n.a.	181,212	n.a.
1954	134,399	n.a.	1,100,869	60,237	926,236	194,636	2,027,104	7,400	n.a.	202,036	n.a.
1955	156,852	n.a.	1,236,039	68,130	1,042,355	224,982	2,278,394	11,600	n.a.	236,582	n.a.
1956	171,322	n.a.	1,361,231	68,356	1,021,036	239,678	2,382,267	14,100	n.a.	253,778	n.a.
1957	178,353	n.a.	1,418,837	71,622	1,052,334	249,975	2,471,171	19,300	n.a.	269,275	n.a.
1958	151,137	n.a.	1,314,964	64,501	959,348	n.a.	2,274,312	n.a.	n.a.	n.a.	n.a.
1959	166,196	n.a.	1,418,837	72,847	1,092,704	n.a.	2,511,541	n.a.	n.a.	n.a.	n.a.
1960	168,419	n.a.	1,468,732	74,571	1,131,259	248,200	2,599,991	50,800	702,000	299,000	3,301,991
1961	166,423	n.a.	1,547,204	75,432	1,134,888	254,500	2,682,092	72,350	n.a.	326,850	n.a.
1962	179,577	n.a.	1,654,705	77,610	1,201,566	260,800	2,856,271	93,900	n.a.	354,700	n.a.
1963	198,492	n.a.	1,819,359	78,653	1,231,503	281,500	3,050,862	109,500	n.a.	391,000	n.a.
1964	213,143	n.a.	1,949,994	78,335	1,329,026	297,200	3,279,019	139,800	n.a.	437,000	n.a.
1965	207,428	n.a.	1,956,344	78,426	1,368,942	290,800	3,325,286	178,200	n.a.	469,000	n.a.
1966	202,000	n.a.	1,965,915	77,927	1,374,702	279,000	3,340,617	213,000	n.a.	492,000	n.a.
1967	178,000	n.a.	1,967,366	65,726	1,346,761	245,000	3,314,127	251,000	n.a.	496,000	n.a.
1968	190,000	n.a.	2,109,885	71,350	1,418,338	260,000	3,528,223	361,000	n.a.	621,000	n.a.
1969	185,000	n.a.	2,129,888	77,428	1,425,006	262,000	3,554,894	453,000	n.a.	715,000	n.a.
1970	149,000	n.a.	2,041,529	76,839	1,391,667	226,000	3,433,195	497,000	n.a.	715,000	n.a.
1971	106,000	n.a.	2,054,300	75,070	1,396,611	181,000	3,450,911	604,000	4,818,000	723,000	8,251,195
1972	90,000	n.a.	2,217,100	70,600	1,337,599	160,200	3,554,699	640,800	W	785,000	n.a.
1973	98,000	n.a.	2,298,200	71,100	1,664,000	168,400	n.a.	812,600	n.a.	801,000	n.a.
1974	99,000	n.a.	2,229,900	69,400	1,668,000	166,000	n.a.	812,600	n.a.	979,000	n.a.
1975	63,000	n.a.	1,823,500	48,800	1,120,000	112,000	3,201,000	626,000	10,625,000	738,000	13,826,000
1976	72,000	n.a.	2,021,900	66,300	1,380,000	138,000	3,473,000	764,000	11,101,000	902,000	14,574,000
1977	68,000	n.a.	2,108,900	63,700	1,330,000	132,000	3,551,000	707,000	10,350,000	839,000	13,901,000
1978	73,000	n.a.	2,151,100	59,700	1,330,000	133,000	3,605,000	740,000	11,321,000	873,000	14,926,000
1979	76,000	n.a.	2,194,900	58,100	1,340,000	134,000	3,669,000	769,000	12,428,000	903,000	16,097,000
1980	73,000	n.a.	2,081,000	65,200	1,380,000	138,000	3,557,000	717,000	10,625,000	855,000	14,182,000
1981	50,712	50,712	2,099,900	65,000	1,460,000	146,000	3,516,000	786,000	11,101,000	932,000	14,617,000
1982	48,076	48,076	1,916,700	61,000	1,430,000	143,000	3,256,000	687,000	10,350,000	830,000	13,606,000
1983	55,676	55,676	n.a.	n.a.	1,520,000	152,000	3,224,000	752,000	11,321,000	904,000	14,545,000
1984	56,505	56,505	2,060,800	61,000	1,630,000	163,000	3,322,000	762,000	12,428,000	925,000	15,750,000
1985	56,761	56,761	2,006,900	64,000	1,690,000	169,000	3,218,000	801,000	13,118,000	970,000	16,336,000
1986	54,934	54,934	1,935,400	n.a.	1,610,000	161,000	3,178,000	779,000	13,676,000	940,000	16,854,000
1987	54,871	54,871	1,941,200	n.a.	1,620,000	162,000	3,236,000	803,000	14,476,000	965,000	17,712,000
1988	60,551	60,551	1,950,400	n.a.	1,710,000	171,000	3,284,000	807,000	15,232,000	978,000	18,516,000
1989	64,595	64,595	n.a.	n.a.	1,790,000	179,000	3,284,000	804,000	15,718,000	983,000	19,002,000
1990	64,213	64,213	1,872,700	n.a.	1,800,000	180,000	3,145,000	810,000	15,374,000	990,000	18,519,000
1991	60,412	60,412	1,629,400	n.a.	1,890,000	189,000	2,897,000	857,000	15,727,000	1,046,000	18,624,000

1992	56,891	56,891	1,631,000	182,000	2,737,000	886,000	16,336,000	1,068,000	19,073,000
1993	57,152	57,152	1,606,900	177,000	2,752,000	805,000	16,522,000	982,000	19,274,000
1994	62,883	62,883	1,668,500	197,000	2,877,000	876,000	16,445,000	1,073,000	19,322,000
1995	58,040	58,040	n.a.	200,000	3,014,000	816,000	19,160,000	1,016,000	22,174,000
1996	55,174	55,174	1,620,700	202,000	2,859,000	791,000	22,486,000	993,000	25,345,000
1997	66,404	66,404	1,689,500	196,000	2,896,000	874,000	25,020,000	1,070,000	27,916,000
1998	67,219	67,219	1,578,900	208,000	2,716,000	844,000	26,589,000	1,052,000	29,305,000
1999	63,761	63,761	1,609,800	189,000	2,629,000	818,000	28,214,000	1,007,000	30,843,000
2000	70,249	70,249		182,000	2,781,000	844,000	30,288,000	1,026,000	33,069,000
2001	70,361	70,361		183,000	2,671,000	756,000	30,316,000	939,000	32,987,000
2002	70,540	70,540		184,000	2,742,000	752,000	32,323,000	936,000	35,065,000
2003	68,385	68,385		190,000	2,883,000	739,000	33,769,000	929,000	36,652,000
2004	72,182	72,182		202,000	3,152,000	738,000	36,074,000	940,000	39,226,000
2005	67,286	67,286		199,000	3,154,000	727,000	38,157,000	926,000	41,311,000
2006	74,263	74,263		200,000	3,306,000	736,000	39,772,000	936,000	43,078,000
2007	74,439	74,439		202,000	3,517,000	703,000	42,890,000	905,000	46,407,000
2008	67,157	67,157		193,000	3,231,000	608,000	41,398,000	801,000	44,629,000

Notes: It is common practice in the man-made fibre industry to add production data of all kinds of cellulose-based fibre (rayon yarn, staple fibre) and synthetic fibres. Of course, the finished products vary in value terms. Metric tons. Germany without Austria, which was part of Germany between 1938 and 1945. Her staple fibre production never exceeded 20,900 tons (rayon yarn 3200 tons). West Germany between 1946 and 1990. German figures for staple fibre and rayon yarn do not add up to cellulose since 1960 because of other viscose-based fibres such as cellulose acetate etcetera.

Sources: *World Fibre Organon* 1962/1, pp. 17–21 (1929–1950), 1968/6, pp. 97, 104–105 (1951–65), 1973/6, pp. 80–81 (1966–1970), 1978/6, pp. 80–81 (1971–1975), 1983/6, pp. 87–88 (1976–85), 1989/6, pp. 110–111 (1984–1988), 1995/6, pp. 28–29 (1990–1994), 2000/6, pp. 9–10 (1996–1999), Owen, (2010, pp. 314–315); *Germany Statistisches Jahrbuch für das Deutsche Reich* (1929, 1934, 1936, 1938, 1941/42); *Kelheimer Taschenbuch* (1960), p. 10 (1940–1949); data kindly supplied by Dr. Wilhelm Rauch of Industrievereinigung Chemiefaser (cellulose and synthetic fibres 1960–2008).