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Makiko HINO[†] and Mototsugu FUKUSHIGE[‡]

Abstract

We estimate the stocks of patents and their growth rates in the Italian textile and chemical industries between 1904 and 1937. The stocks and growth rates by nationality are estimated for Italy, France, Germany, the UK, Switzerland, and the USA. The Italian patent stock in the textile industry followed and attempted to catch up with the stock of the leading countries; by contrast, that in the chemical industry fell behind during that period. Although growth rates were similar, Italy's growth rates fell into the lower group before and after World War I. Our results indicate that not all Italian industries succeeded in catching up with the leading countries.

Keywords: technological progress, patent, textile, chemical, Italy

JEL Classification: N62, N63, O31

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1 Introduction

The Kingdom of Italy was a state founded in 1861 as a result of the unification of states previously fragmented across the Italian peninsula. Compared with Germany and the UK, Italy had been a less technically developed country up until World War I (WWI).[1] However, according to Zamagni (1993), Italy's technical development had caught up with Germany and the UK in the textile industry by the late 1920s, and in the chemical industry by the early 1930s; thereafter, it started to industrialize intensively. Figure 1 indicates that the amount of silk yarn and cotton yarn production—the main products of the textile industry—were stagnant or flat. Nevertheless, the view of Zamagni (1993) that rayon production developed rapidly in the 1930s (Figure 1) and that nitric acid as a flagship product in the chemical industry increased dramatically (Figure 2) is persuasive to a certain extent.[2]

However, the increase of production volume does not mean simultaneous technical development in the abovementioned industries. For example, Young (1994, 1995) pointed out that total factor productivity (TFP) growth rates of Asian newly

[1] According to Maddison (1995), there are major differences in GDP between Italy and five countries: Italian per capita GDP in 1990 evaluated by the 1990 price index was 1746 compared with Germany at 3134, France at 2849, UK at 4593, Switzerland at 3531, and the USA at 4096 (all in $US). As well as the estimate by Maddison (1995), there are new estimates by Fenoaltea (2005, 2006) and comparisons by Cohen and Federico (2001) and Prados De La Ecosura (2000) that merely modify Maddison (1995). Therefore, no estimate denies Italy's backwardness.

[2] Data source for rayon yarn is obtained from *Annuario statistico italiano* (Ministero d'agricoltura, industria e commercio) in each year and data sources for other products are from *Confederazione fascista degli industriali,annuario staitistico per le industrie chimiche 1938* (Confederazione fascista degli industriali, 1939) in Figure 1 and 2.

industrialized countries were not particularly high compared with Japan in its high-growth era.

When considering the pathway from developing country to advanced country, we usually focus on the level of per capita GDP. However, because in our study period (1904–1937) transportation systems had not developed adequately, there are many studies showing regional gaps in economic growth within a country. These regional growth gaps could be attributed to regional differences in industrial growth, which also suggest the presence of differences in interindustry growth. In this study, we deal with the textile and chemical industries as representative Italian industries and discuss the growth difference for each industry.[3] Regrettably, because there are no specific data regarding labor input and capital input for the respective industries, it is not easy to analyze TFP growth for each industry in this period. Therefore, we study the number of patents issued as a variable that is barely affected by TFP change at a country and industry level. This approach is inspired by Madsen (2008) who shows that patent stock contributes to TFP growth for each country.[4] We selected the textile and chemical industries partly because of their importance in the period, but mainly because of the number of patents applied for and issued, which appears to be related to the international diffusion of technology.

In an analysis of the number of patents issued and the stock in the first half of the twentieth century, it should be recalled that the Paris Convention for the Protection of Industrial Property was signed in 1883 by 11 countries. This was one of the first

[3] Von Tunzelmann (2000) shows the difference between technological change and productivity change in the USA, the UK, and Germany, but we focus only on technological change.

[4] According to Madsen (2008), international patent stock contributes to TFP growth of respective OECD countries.

intellectual property treaties and is still in force in 2014 (Lerner, 2000).[5] We must look carefully to distinguish patents in Italy not lodged by Italian inventors and Italian companies. In other words, patentees include many economic agents in the USA and other European countries; therefore, we cannot measure the level of technology at the time by simply analyzing the number of patents issued and their stock. We therefore look at the nationality of the patentees of patents issued in Italy, along with our comparison of countries' issuance and stocks of patents.[6] We consider the following six countries: Germany, France, the UK, Switzerland, the US, and Italy.[7]

Taking into account that Italy had by 1930's caught up economically with Germany and the UK, the acquisition of Italian patent rights by foreign companies and individuals can be explained as preventing losses from imitation by Italian companies. Analyzing the nationality of the patentee in Italy may account for the capacity for technological development of each country in an indirect way. In other words, paying attention to the nationality of the Italian patentee makes it possible to compare the capacity of industrial technological development of the six countries included in this study.

The aim of this paper is to compare the quality of industrial development in Italy with five countries by analyzing the nationality of patentees in the representative Italian textile and chemical industries between 1904 and 1937. The paper is structured as follows.

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[5] Nevertheless, even today, the intellectual property protection system of any specific country does not provide automatic protection for intellectual property internationally (Lerner, 2000).

[6] Nicholas (2011) points out the importance of domestic patents for technological modernization in Japan.

[7] We are not concerned here with Austria, because it is difficult to make a comparison of changes before and after WWI.

Section 2 surveys the relevant literature on the relationship between the Italian economy and patent rights in the period. Section 3 describes our data and explains the method of calculating the patent stock. Section 4 calculates the growth rate of the patent stock in two periods: before and after WWI, and finds a proxy variable for the technological development of each country, based on the estimated patent stock in Section 3. The technological level and growth of Italy compared with the other five countries in this study are examined in Section 5. Section 6 concludes and identifies remaining issues for future study.

2 Literature survey

Aftalion (2001) provides a historical explanation of the general technology of the chemical industry examined in this paper. According to Streb, Baten and Yin (2006), technological transfer to Italy and other countries in the textile and chemical industries occurred in the first half of the twentieth century, with dyes from 1887 to 1896 and chemicals more generally from 1897 to 1902 to Germany. Richter and Streb (2011) analyzed the presence of a patent lag for machine toolmaking in Germany compared with the USA, the leading country for international technological transfer in this period. This is a helpful reference for our study on the relationship between Italy and more developed countries. Streb, Wallusch and Yin (2007) also examined knowledge spillovers in the textile and chemical industries in Germany.

For Italy's economic history at the time we refer to Zamagni (1993), Cohen and Federico (2001) and Fenoaltea (2011). For the first half of the twentieth century, Maddison (1995) presents historical GDP statistics for Italy, as well as other European

countries and the USA. Following Gerschenkron's (1962) view, several researchers analyzed Maddison's data or others' to study economic backwardness.

Some previous studies analyzed the effect of the unification of Italy in 1861 on Italy's process of catching up with developed countries. Esposto (1992) examined the differences between regions' speeds of catching up. Ciccarelli, Fenoaltea and Proietti (2010) analyzed the effect of the unification of Italy on regional convergence. Bardini (1997) points out that the process of catching up in this period was delayed by a lack of energy sources, in particular, a dependence on imports of coal. Furthermore, according to Tortella (1994), levels of education and literacy rates were important factors. Mattesini and Quintieri (1997) examined the cause of the Great Depression in the interwar period, concluding that in Italy it was due to the increase of real wages rather than the financial system.

For studies of TFP, Rossi and Toniolo (1992) analyzed TFP from 1895 to 1947 using national data for capital and labor input. Broadberry, Giordano and Zollino (2011) examined TFP between 1861 and 2010; however, their analysis was limited to macroeconomics by their Banca d'Italia data. Amidei, Cantwell and Spadavecchia (2011) used patent data to study the relationship between foreign technology and the development of domestic technology in Italian industries, including patents issued abroad by Italian applicants. In this study, they analyzed technology importation, foreign direct investment and research or development as a general analysis of technological development and technology importation from foreign countries.[8] However, because their study covers a much longer period than the first half of the twentieth century, there

[8] In this study, they examined industrial designs and trademarks as well as patenting activity.

is insufficient emphasis on the period of our study. A further difference is that Amidei, Cantwell and Spadavecchia (2011) analyzed the technological level, based on a revealed technological advantage index calculating the share of patents issued to Italian applicants by the United States Patent and Trademark Office (USPTO); by contrast, we examine the patent stock and its growth rate. Their index allows comparison of the growth rate of technology of different countries with respect to the growth rate of technology in US.

Sella and Marchionatti (2012) show that the Italian economy before WWI suffered large economic fluctuations. Giannetti, Federico and Toninelli (1994) analyzed industry-level growth rates, showing that these differences related closely to technological development. Further, Fenoaltea (2003) explains that the textile industry was seven times as large as the chemical industry in 1861, but only about twice as large in 1961; thus, the difference between the textile and chemical industries lessened as a result of the rapid growth of the chemical industry. According to Felice and Carreras (2012), the textile industry's output increased from 8.6% of Italy's total productions in 1911 to 10.9% in 1938; by contrast, the chemical industry (including rubber) grew rapidly from 3.4% to 12.9% of GDP.

3 Data and imputation

We use the number of patents issued and the nationality of applicants obtained from XIX Filature, tessile e industria complementare and XXIV Industrie chimiche diverse in the *Bollettino della proprietà industriale* (Ministero d'agricoltura, industria e commercio) in each year. This provides data on the number of patent applications in Italy by applicant nationality. The years 1909 and 1910 are absent, as are data for German nationals between 1917 and 1919.

We can first assume that patent applications were not made by Germans for the three years (1917–1919) during WWI and its aftermath, because Germany was a belligerent country. Second, we interpolate the number of patents issued to foreigners of each country for 1909 and 1910, based on the share of foreign-filed patents in Italy in 1908 and 1911, as follows. Let $y(i)_j$ be the number of patents issued of the *i*th nationality in j year for a specific industry, and let Y_j be the total number of patents issued for this industry in Italy; then the number of such patents in 1909 is

$$\mathrm{y(Italy)}_{1909} = \mathrm{Y}_{1909} \times \frac{\mathrm{y(Italy)}_{1908} + \mathrm{y(Italy)}_{1911}}{\mathrm{Y}_{1908} + \mathrm{Y}_{1911}}.$$

Figures 3 and 4 show the number of patents issued in the textile and chemical industries, respectively, including the interpolated data for 1904–1937. They clearly show a spike in the number of patents issued in 1923 and 1924, after WWI. We believe that this spike derives from a concentration of applications from ex-belligerent countries and from the postwar changes in the region, including newly independent countries. For this reason, we do not examine the change in the number of patents issued each year, but the stock of patents based on the number issued to foreign applicants. One reason is that temporary delays or retarding of issuance has little effect on the growth rate of the stock. It is possible that this would result in the period following this concentration being underestimated. We will refer to this point again in Section 4.

The stock of patents issued to each country's applicants up to 1904 must be estimated to analyze the patent stock and its growth rate. These data are not available for the textile and chemical industries before 1903. Therefore, we estimate pre-1903 patents by the ratio of patents issued by each country for the abovementioned industries to the

number of patents issued in Italy between 1904 and 1908 from the *Bollettino della proprietà industriale* each year. Let Z_j be the number of patents issued in Italy to Italian applicants for all industries; for example, the number of patents issued to Italian applicants in 1900 is

$$y(\text{Italy})_{1900}=Z_{1908}\times\frac{\sum_{t=1904}^{1908} y(\text{Italy})_t}{\sum_{t=1904}^{1908} Z_t}.$$

Because Z_j is available from 1886, we examine the number of patents issued in each country from 1886 to 1903.

The patent depreciation rate is required to estimate the patent stock. Because patent duration at this time was no longer than 15 years, we assume a 10% residual after 15 years, while the annual depreciation rate is 14.23%. We assume the patent stock to be zero at 1885 and the patent stock in *i* country in *t* year is $s(i)_t$, so the stock of patents to Italian applicants in *t* year is

$$s(\text{Italy})_t = y(\text{Italy})_t + s(\text{Italy})_{t-1}\times(1-0.1423),\ t = 1986 \text{ to } 1937.$$

This may be an underestimate given that the patent life is at most 15 years. However, the depreciation rate may be overestimated in the few years after the Italian patent system was instituted, when no patents were depreciating. We tested some alternative values for the depreciation rate, but the results were little changed. Furthermore, because the 18 years from 1886 to 1904 are longer than the patent life, the post-1904 stock will be little affected by the 1886 stock of patents. Figures 5 and 6 show the available patent stocks in the textile and chemical industries, respectively, from 1904 to 1937 based on our

estimates. We have used a logarithmic transformation for the ordinate axis to show growth rates. Our estimation method for the patent stock is the same as that of Hall, Jaffe and Trajtenberg (2005); however, they use a depreciation rate of 15% as is conventional. When we select the 15% rate, our results in the following sections are hardly affected.

4 Growth rate estimation

Before we analyze Figures 5 and 6 using the patent stock estimates in Section 3, we first examine the average growth rate of the stock. As shown in these figures, the patent stock fell drastically from 1914 to 1920 because of WWI. We believe that this fall was temporary. We divide our period into two: the 11 years from 1904 to 1914, and the 14 years from 1924 to 1937. We ignore the intervening period as too disrupted by WWI. Figures 5 and 6 show these two periods clearly and illustrate our reason for excluding the middle period. We transform the time trend logarithmically to analyze growth rates of the patent capital stock. The time variable, $TREND_t$, takes the value of the year, that is, it takes the value 1904 in the year 1904. The average Italian growth rate is then

$$s(\text{Italia})_t = \alpha+\beta*TREND_t+\varepsilon_t, \quad t = 1904, \dots, 1914 \ \& \ t = 1924, \dots, 1937.$$

The average growth rate of the first period and the second period, (β), is analyzed; the error term is ε_t. The results are shown in Tables 1 and 2 and we discuss these growth rates in the next section. Most results are statistically significant; however, the Durbin–Watson ratio (DW) suggests the presence of serial correlation in the error term. To obtain the average growth rate in this period, it is not important to have an efficient estimator of the regression coefficient.

5 Comparisons of technological growth

We compare technological progress using the above graphs (Figure 5 and 6) and our estimates of patent stocks. First, the number of patents issued to Italian applicants in the textile industry is not far short of the number issued to German applicants before WWI as shown in Figure 3. This appears to continue after WWI. When we compare patent stocks, we can see that the number issued to Italian applicants caught up with the number issued to German applicants in 1917 and remained higher until 1937 (Figure 5). However, because Germany has the higher growth rate, it is implied that the stock issued to German applicants caught up with that of Italian applicants by 1937. It is easy to assume that the growth rate issues to German applicants maintained a high level of about 8.0% in the first period and about 6.3% in the second period. On the other hand, the growth rate issues to Italian applicants were about 6.1% in the first period, but decreased drastically to 3.0% in the second period. The growth rates in the number of patents issued and stock issues to German applicants maintained a high level, while those to applicants from the USA, Switzerland, and the UK also maintained a high level in the second period; in particular, the growth rate issues to UK applicants exceeded the growth rate of those to US, Swiss, and Italian applicants (Figure 5, Table 1). The growth rate of issues to French applicants was much lower than that to Italian applicants, resulting in an almost zero growth rate in the second period (Table 1). Our conjecture is that these results show stagnant technological progress.

On the other hand, it is clear that the number of patents issued to Italian applicants in the chemical industry was much lower than that to German applicants in 1910 (Figure 4), and the difference between these countries disappeared after 1929. In the case of the stock of patents issued, we find that the stock issued to Italian applicants

caught up with the stock issued to German applicants because of the disruption of WWI; however, after 1925, the level of the stock issued to Italian applicants stagnated and Germany overtook Italy. We can see that the growth rate of German applicants was as high as 8.8% in the first period and about 8.4% in the second period (Table 2), while the growth rate of Italian applicants stagnated, at about 3.5% in the first period and at about –0.5% in the second period.

When we examine the growth rate of issues to Italian applicants, only the number of patents issued and their stock remained high. While the growth rates of applicants from countries such as the USA, Switzerland, and the UK were slow, they maintained growth rates from 2.1% to 5.7%. This result represents the steady development of the chemical industry in the abovementioned countries in contrast to stagnation in Italy. For the other stagnating country, France, the growth rate is estimated at –1.0% in the second period, as is the case for Italy.

When the number of patents issued in the textile and chemical industries in Italy is examined, the large number by Italian applicants might be expected. Nevertheless, we should not overlook the share of patents issued to German applicants who had the latest technologies and knowledge. Based on the growth rate, Italy ranked fifth or sixth of the six countries in both the textile and chemical industries, in both our first and second periods. These results indicate that the textile industry in Italy followed the German trend in the number of patents issued and the stock issued to Italian applicants; however, in the chemical industry, Germany extended its strong lead on Italy. In particular, after WWI, technological stagnation in the chemical industry is evident, while the growth rate of the textile industry is much the same as in the UK, Switzerland, and the USA. These results clearly contrast with each other. The level of the growth rate depends on the depreciation

rate used for estimating the patent stock, but when each country has a nearly identical depreciation rate, the ranking of the growth rates and level trends are largely similar.

6 Conclusion

We examined the technological development of the textile and chemical industries in six countries including Italy, based on the number of patents issued in Italy to applicants from six developed countries. For the six countries in this study, our estimated growth rates show a low ranking of technological development of the textile and chemical industries in Italy before and after WWI. It is clear that Italy was inferior to Germany in the growth rates of both industries. Furthermore, while the textile industry maintained a certain growth and level even after WWI, in the chemical industry, only France failed to prevail against Italy. Germany exercised a preponderant influence on Italy, one that was far greater than the other five countries.

Thus, we can confirm that Italy was not a high-growth country among the target six counties in terms of technological development. We can conclude from our results that Italy was a less developed country at that time. In particular, the stagnation of the chemical industry was quite serious by comparison with the textile industry. Hence, in Italy, not all Italian industries promoted technological catch-up to the leading countries. It is clear that the Italian textile industry attempted to catch up with Germany as well as other developed countries. On the other hand, the Italian chemical industry fell behind the leading country, Germany, as well as the other countries. The circumstances of the two industries were different. Quah (1997) showed that some countries succeeded in catching up with developed countries while others failed. Our study has shown that Italy over our time period is a case where there were industries that were technologically

developing and others that stagnated. Of course, we have only compared two industries. Therefore, when the technological trends of all Italian industries are examined, or other industries are analyzed using our method, these cases might differ from the results of this study. Furthermore, this study of patent issuance has not yet led to the analysis of the effect of the patent stock on growth in each industry and economic growth at the national level. It is important to examine the effect of patents on the economy specifically. For example, Pistoresi and Rinaldi (2012) show that Italy ran large trade deficits from 1900, which increased until the second half of the 1930s when the trade balance improved. The question is whether there is a relationship between technological development and the trade balance. Finally, this analysis is heavily dependent on the stock of patents. The accuracy of our estimates may be critical to our results.

These issues should be addressed by using other data over a long period or analyzing the number of patents in each industry of other countries.

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Table 1 Estimation results for the textile industry

Countries	Period	α	s.e. of α	β	s.e. of β	R^2	DW	Difference in β
Italy	1904–1914	5.39945**	0.02388	0.061221**	0.003521	0.9711	1.092	–0.0308
	1924–1937	5.82002**	0.08435	0.030392**	0.003035	0.8931	1.280	
Germany	1904–1914	5.44584**	0.02603	0.079726**	0.003838	0.9796	1.226	–0.0164
	1924–1937	4.62375**	0.14216	0.063326**	0.005115	0.9274	0.7654	
France	1904–1914	4.98084**	0.01699	0.060730**	0.002505	0.9849	2.372	–0.0680
	1924–1937	5.72074**	0.09604	–0.0007258	0.003455	0.0037	1.160	
UK	1904–1914	4.81357**	0.02978	0.021365**	0.004391	0.7246	1.033	0.0187
	1924–1937	4.51522**	0.18385	0.040107**	0.006615	0.7539	0.649	
Switzerland	1904–1914	4.24071**	0.04032	0.086863**	0.005946	0.9595	0.811	–0.0374
	1924–1937	4.21817**	0.17577	0.049426**	0.006324	0.8358	0.624	
USA	1904–1914	4.19055**	0.01902	0.064586**	0.002805	0.9833	1.968	–0.0279
	1924–1937	4.38656**	0.21138	0.036715**	0.007605	0.6601	0.532	

Note 1. ** means statistically significant at 1% and s.e. of β and DW mean standard error of estimated β and Durbin–Watson ratio, respectively.

Note 2. Difference in β means difference between estimated β from 1904–1914 to 1924–1937.

Note 3. Largest order of β 1904–1914: Switzerland, Germany, the USA, Italy, France, and the UK; 1924–1937: Germany, Switzerland, the UK, the USA, Italy, and France.

Table 2 Estimation results for the chemical industry

Countries	Period	α	s.e. of α	β	s.e. of β	R^2	DW	Difference in β
Italy	1904–1914	5.96554**	0.02961	0.035101**	0.004365	0.8778	0.936	–0.0407
	1924–1937	6.75914**	0.09557	–0.0055927	0.003438	0.1806	1.186	
Germany	1904–1914	6.04826**	0.02891	0.088305**	0.004262	0.9795	1.052	–0.00388
	1924–1937	4.88380**	0.15099	0.084429**	0.005432	0.9527	0.720	
France	1904–1914	5.07454**	0.03434	0.052815**	0.005064	0.9236	1.494	–0.0631
	1924–1937	6.37502**	0.08578	–0.010332	0.003086	0.4829	0.920	
UK	1904–1914	4.33957**	0.027815	0.065629**	0.004101	0.9660	0.717	–0.0448
	1924–1937	5.11036**	0.1248	0.020832**	0.004489	0.6422	0.760	
Switzerland	1904–1914	3.36926**	0.03653	0.113663**	0.005386	0.9802	1.628	–0.0591
	1924–1937	3.82234**	0.1410	0.057525**	0.005071	0.9147	0.820	
USA	1904–1914	4.05592**	0.033845	0.055935**	0.004990	0.9332	3.006	–0.00883
	1924–1937	4.63237**	0.1205	0.047107**	0.004334	0.9078	0.918	

Note 1. ** means statistically significant at 1% and s.e. of β and DW mean standard error of estimated β and Durbin–Watson ratio, respectively.

Note 2. Difference in β means difference between estimated β from 1904–1914 to 1924–1937.

Note 3. Largest order of β 1904–1914: Switzerland, Germany, the UK, the USA, France, and Italy; 1924–1937: Germany, Switzerland, the USA, the UK, Italy, and France.

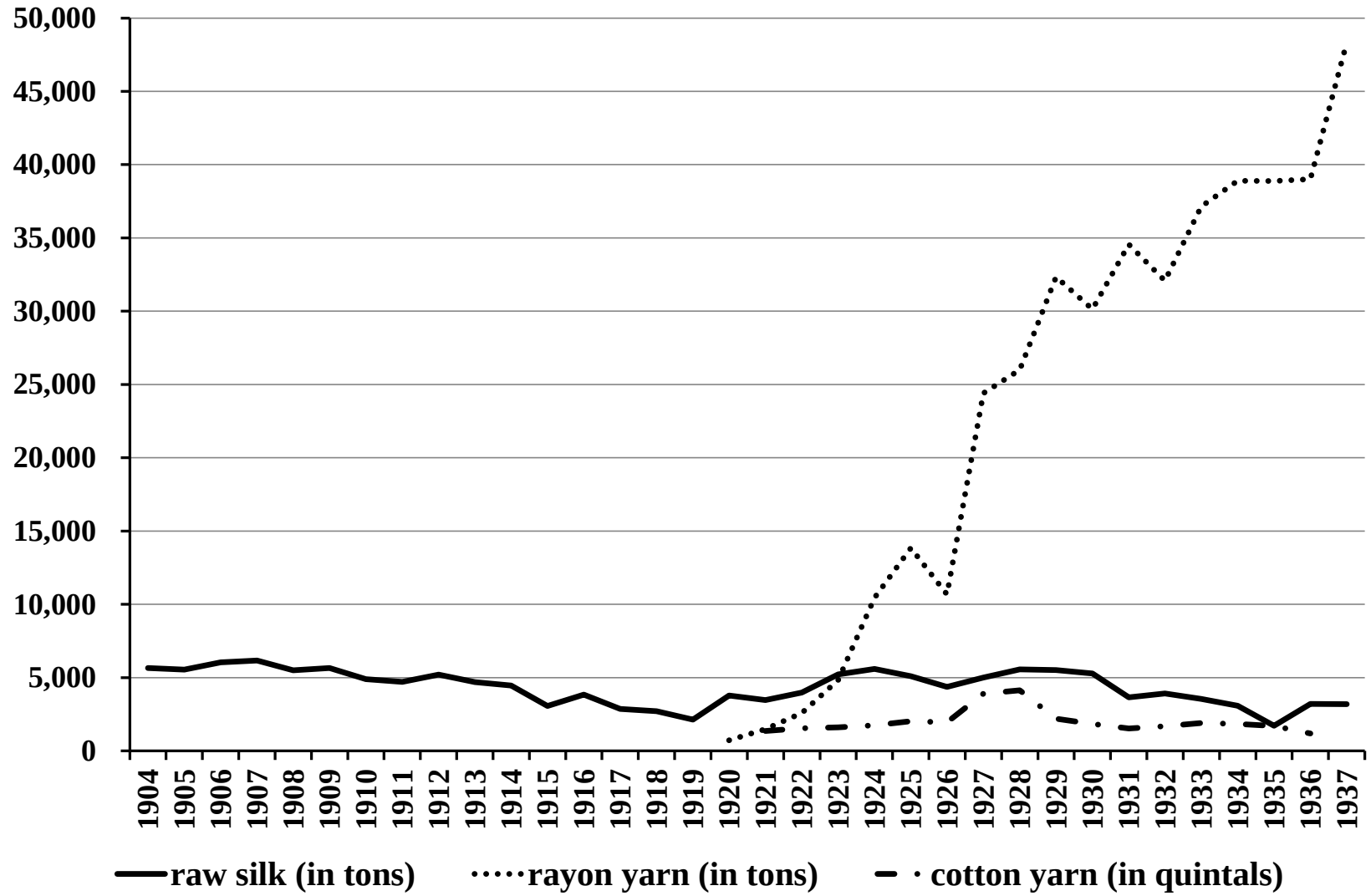

Figure 1 Trend in some products of the textile industry in Italy

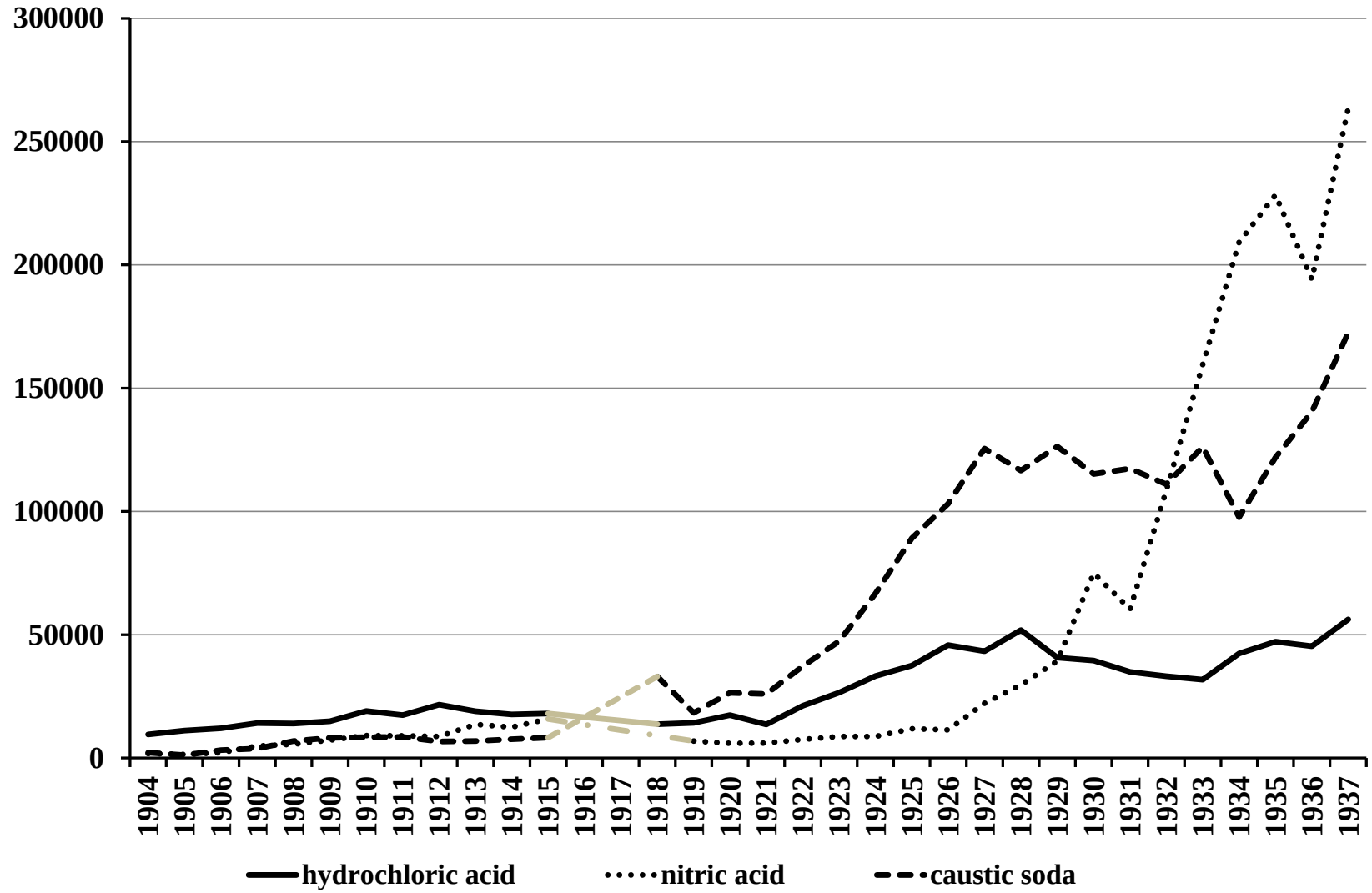

Figure 2 Trend in some products of the chemical industry in Italy

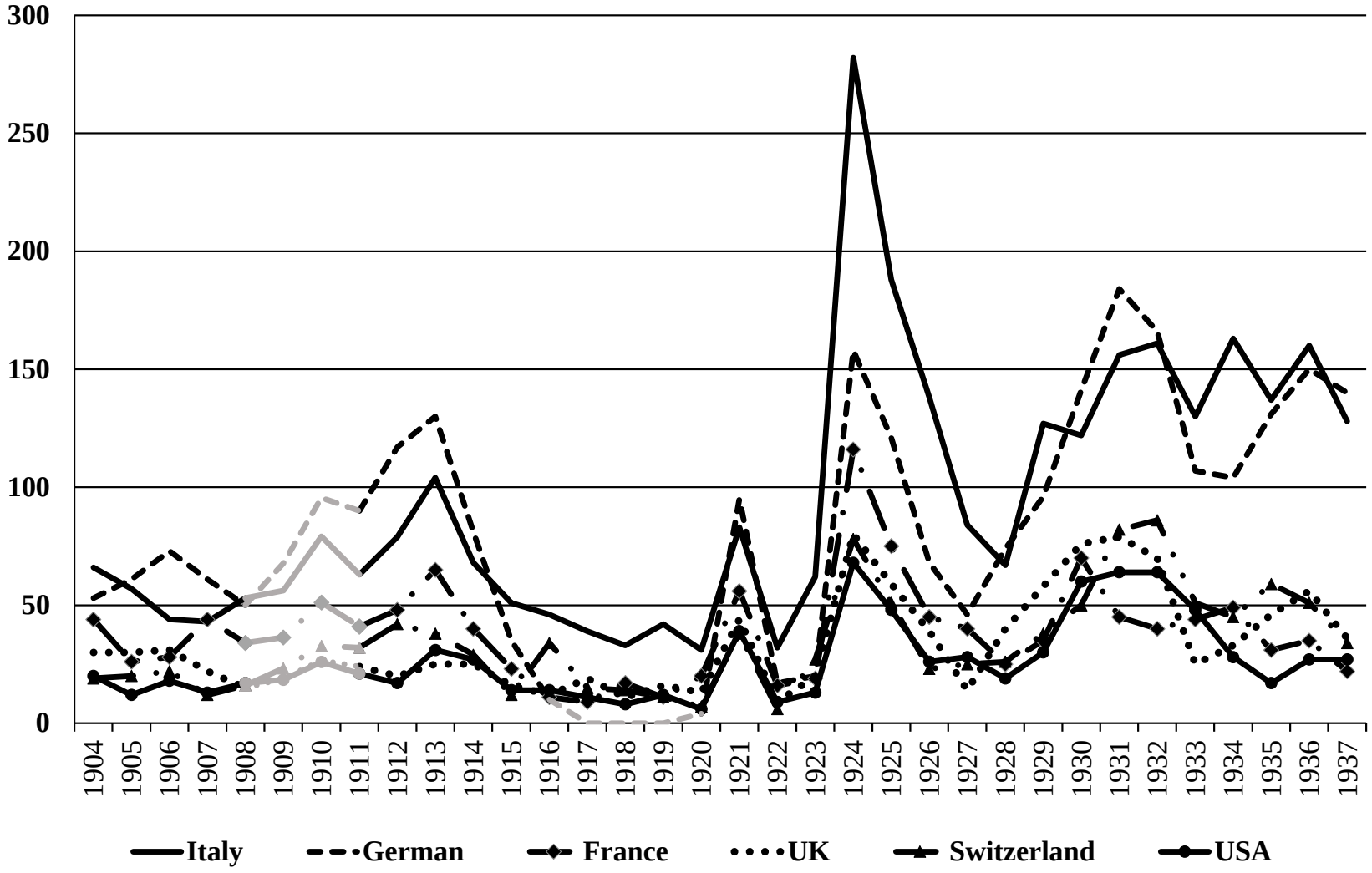

Figure 3 Number of patents of the textile industry

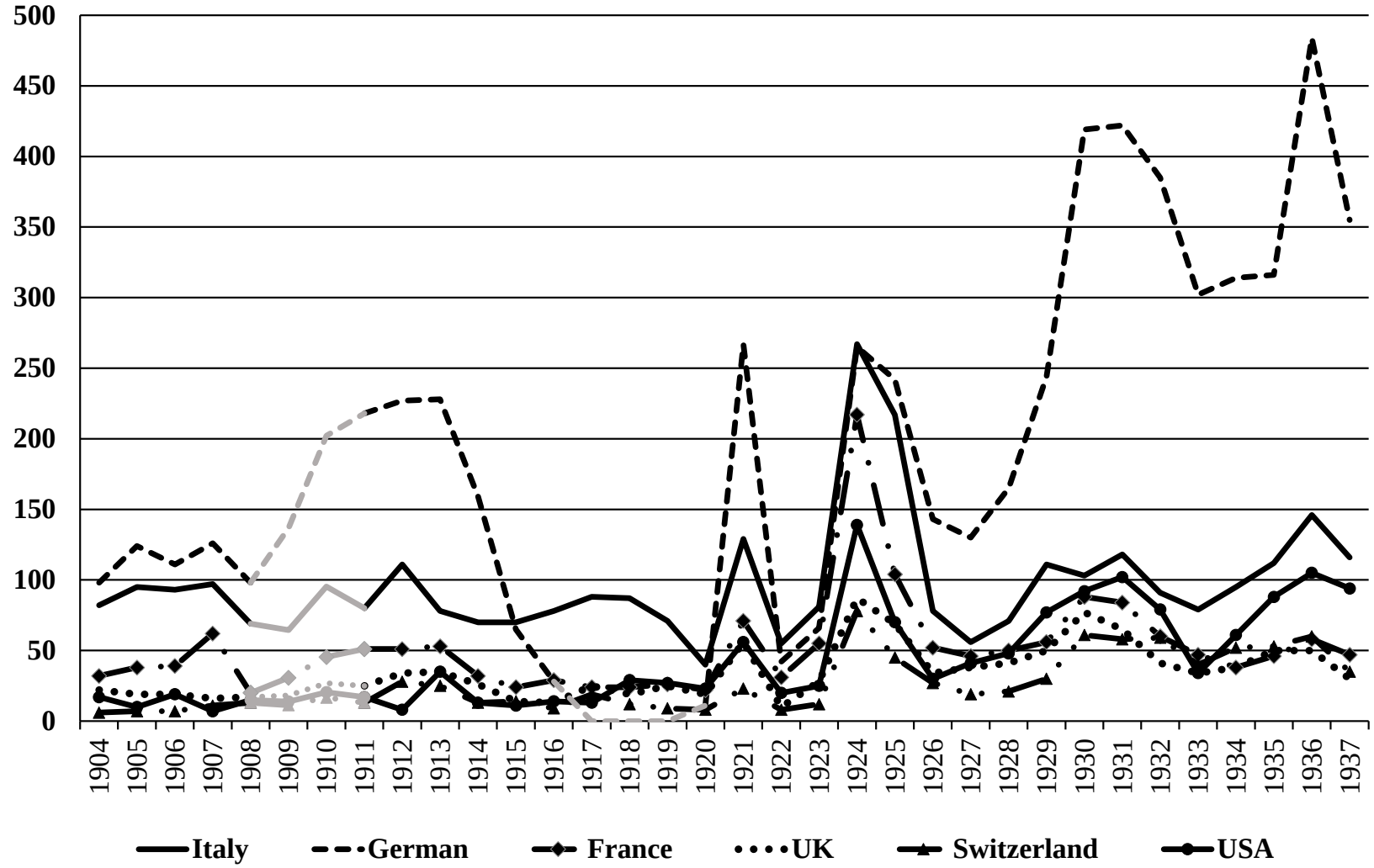

Figure 4 Number of patents of the chemical industry

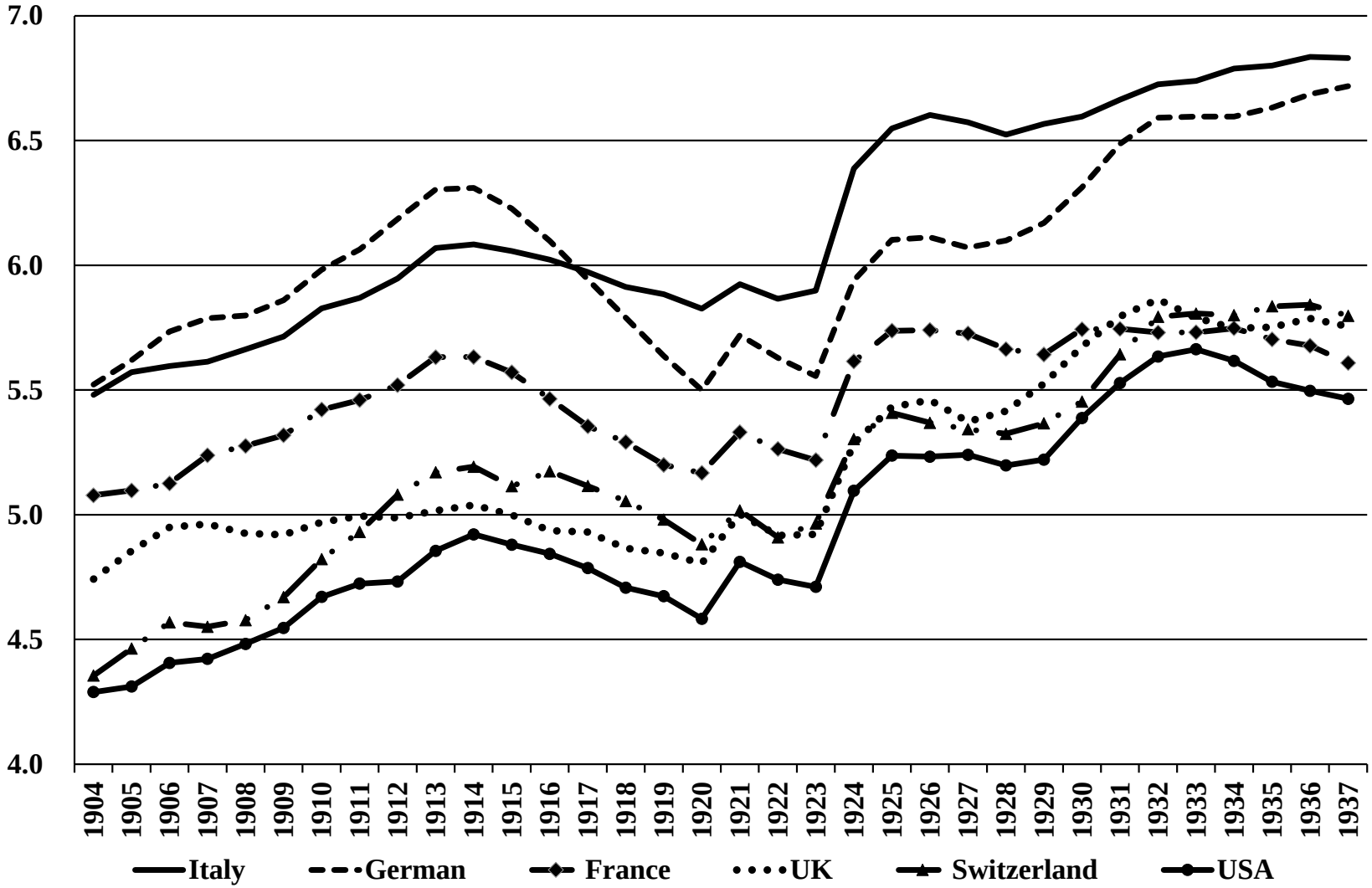

Figure 5 Trend in the number of patents of the textile industry

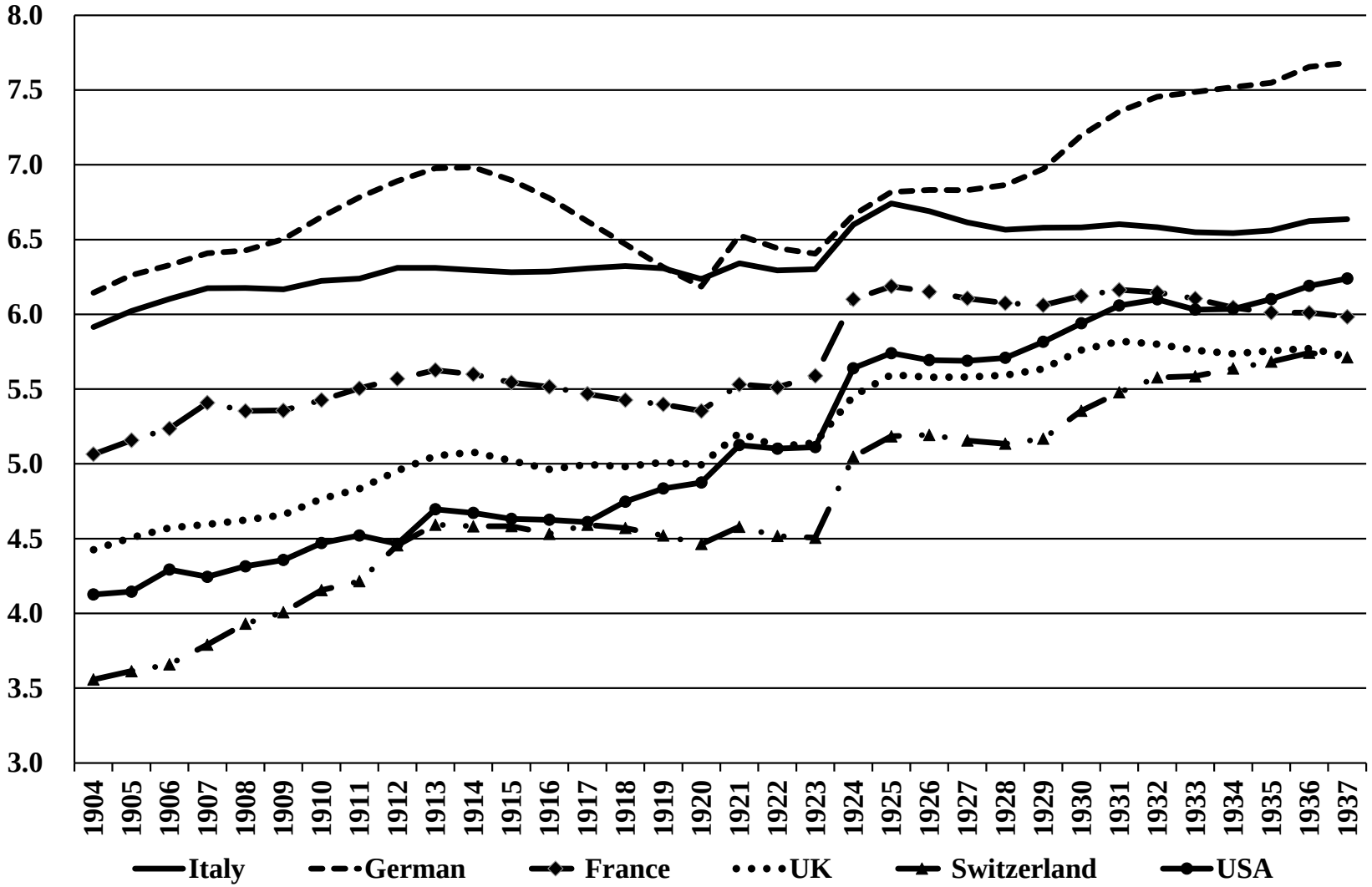

Figure 6 Number of patents of the chemical industry