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Patent Applications – Structures, Trends and Recent Developments 2016

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0 Summary

Transnational Patent Filings

At the international level, the US is and remains the largest technology providing country in absolute terms, followed by Japan and, with a given distance, Germany and China. In terms of patent intensities, i.e. patent filings per one million employees, however, rather the smaller countries like Switzerland, Sweden and Finland are at the top of the list of the analyzed technology-oriented countries. Japan scores fourth and Germany fifth, respectively. Per capita, the USA is in the midfield, together with France and Great Britain as well as the EU28 on average.

A closer look at high-tech patent filings reveals a rate of about 63% of high-technology patents in total worldwide patenting in the year 2014, with a rather steady growth up to 2008. Germany has lost ground in high-tech shares since then, which is mostly a result of stagnation in the recent years, while other countries have expanded their high-tech patent activities. Yet, Germany, Japan, Korea, Italy and Denmark, but also Brazil and India, are the countries that show the strictest focus on high-level technologies, while most of the other countries are more active in leading-edge technologies.

When looking at Germany's country-specific technology profiles according to the NIW/ISI/ZEW list of research-intensive industries and goods (Gehrke et al. 2013), comparative advantages in three main areas can be found: transport (automobiles and engines as well as rail vehicles), machinery and some areas of electrical engineering like power machines and power generation.

Structures in International Co-Patenting

The shares of international co-patents have constantly increased over the last twenty years for most of the countries in our analysis – with the exception of the large Asian countries China, Japan and Korea. Since 2007, however, stagnation in worldwide co-patenting shares can be observed. Since 2011, even a decrease for some European, countries e.g. Switzerland, Sweden, Great Britain and France, as well as the US can be found. The country-by-country trends reveal that the US is the most important collaboration partner for most of the countries in our analysis, directly followed by Germany, implying a strong international position as a partner in innovation collaborations.

The field specific trends reveal that some fields, mostly within chemistry, are generally more cooperation intensive than others, i.e. all countries show comparably large shares of co-patents within these fields, whereas in other fields, mostly related to mechanical engineering, the cooperation intensity is generally lower. Another interesting trend is that smaller fields in terms of absolute patenting figures are more cooperation-intensive than larger ones. Since there are fewer national partners in smaller fields, international partners have to be found in order to generate innovative results that cannot be carried out without an external partner.

Germany shows especially high shares of co-patents within the chemistry related fields, while the lowest shares can be found in the fields of "weapons", which, however, is true for all countries, "nuclear reactors and radioactive elements", "electrical equipment for internal combustion engines and vehicles" and "automobiles and engines".

Patent Activities of the German Federal States

The analyses of patent filings by German federal states shows that Bavaria and Baden-Württemberg file the largest number of patents at the transnational level, and, together with North-Rhine Westphalia, account for about two thirds of all German transnational filings. Generally, it can be stated that the Southwestern German federal states have larger filing numbers than the Northern and Eastern states. With regard to the growth rates only moderate growth in patent filings can be found. The only states that show significant growth in patent filings between 2003 and 2013 are Brandenburg, Berlin and Bavaria. It is thus two of the Northeastern countries that have managed to increase their amount of filings in the last decade. When taking a look at the technology field specializations of the federal states, it can be revealed that the German focus on mechanical engineering is mostly resembled in the profiles of the Southwestern states, while in the Northeastern parts of Germany chemistry and electrical engineering play a larger role. The highest internationalization rates in our comparison can be observed for Brandenburg, followed by Rhineland-Palatinate, Hesse and Saxony.

Patenting Trends in Public Research

The analyses of patent filings by universities and public research organizations (PROs) in Germany shows that patenting has become more and more important for universities and PROs over the last 10 years. However, the analyses of academic patents reveal that at least part of the growth in university filings after the abolishment of the Hochschullehrer-privileg" in 2002 can be attributed to the fact that universities more often show up as patent applicants on patent filings, while the actual research output of universities has not grown exceptionally.

Since 2010, however, declining patent numbers by universities and PROs can be observed. This is also reflected in the patent intensities, i.e. the number of transnational patent filings per 1,000 R&D employees, of universities and PROs. Especially in the recent years the patent intensities have been decreasing. Though the patent intensities of universities have risen in the course of the 2000s, PROs still are far more patent intensive than universities are. Among the PROs, the Fraunhofer Society is responsible for the largest share of patent filings, followed by the Helmholtz Association, the Max-Planck Society and the Leibniz Society.

The field specific patent shares of universities and PROs reveal that universities and most of the more fundamental research oriented PROs have a focus on chemistry, while especially the Fraunhofer focuses on electrical engineering. Mechanical engineering, however, where the German industry has its strengths, is less reflected in the focal points of Germany's public research.

Trademarks

The general trends in trademark filings show an increase in CTM filings between 2002 and 2015 with slowdowns visible during the economic crises in 2000/2001 and 2008/2009. Germany is by far the largest trademark applicant at the OHIM with more than 20,000 filings in 2015, followed by the US, Great Britain and France. Great Britain has managed to catch-up with the US in terms of trademark filings but also China and Korea have shown large growth rates especially in the last few years.

Overall, non-European countries show a larger share of product marks than their European counterparts. The only exception is the US, where a comparably large share of mixed and service marks can be observed. In terms of trademark intensities, i.e. trademark filings per million employees, the smaller economies like Austria, Sweden, Denmark and Finland show the highest values. The differentiation by NICE classes reveals that Germany's large shares in CTMs are not due to major shares in only few classes but are spread across the whole range of NICE classes. Germany thus shows positive specialization values in most of the fields but still a rather clear specialization to the fields related to machines and metals can be observed.

1 Introduction

The technological performance of countries or innovation systems is mostly measured by patent applications as well as patent grants, which can be seen as the major output indicators for R&D processes (Freeman 1982; Grupp 1998). Patents can be seen and analyzed from different angles and with different aims and the methods and definitions applied for analyses using patent data do differ (Moed et al. 2004). A technological view allows prior art searches as well as the description of the status of a technology. Seen from a micro-economic perspective, the evaluation of individual patents or the role of patent portfolios in technology-based companies might be in focus. A macro-economic angle offers an assessment of the technological output of national innovation systems, especially in high-tech areas.

In this report, we focus on the macro-economic perspective by providing information on the technological capabilities and the technological competitiveness of economies as a whole. As already mentioned, patents are used as an output indicator of R&D processes. However, R&D processes can also be measured by the input – for example, in terms of expenditures or human capital. In order to achieve a more precise approximation of the "black box" of R&D activities (Schmoch and Hinze 2004), both perspectives – i.e. input and output – are needed. The input side, however, has been widely analyzed and discussed in other reports, also in this series (e.g. Schasse et al. 2016). Here, we therefore strictly focus on patents as an indication of output (Griliches 1981; 1990; Grupp 1998; Pavitt 1982).

This report gives a brief overview of the developments of transnational patent applications since the early 1990s. However, we especially focus on the recent trends and structures. In this year's report, we will further focus on analyses of international cooperation structures in terms of co-patents. Moreover, we will provide a differentiated look at the German technology landscape at the level of regions, i.e. the German "Bundesländer", and we will analyze patents by German universities and public research institutes to gain insights into the technological performance of the German science system. Finally, as a complementary innovation indicator to patents, we analyze trademark filings in an international comparison.

Section 2 first of all presents the data and methods applied for the analyses in the following chapters. Section 3 focuses on transnational patent applications and discusses total trends, growth rates, intensities (patents per 1 million workforce) and specialization indices, which are designed to reflect patent structures beyond size effects of countries and technology fields. Section 4 will provide the analyses on international co-patenting structures and in section 5 we will show the differences in patenting behavior across the German federal states. In section 6, we will take a closer look at patents from German universities and public research institutes. Finally, section 7 presents the analyses on structures and trends in Community Trademark filings.

2 Basic Methodological Remarks

The patent data for this study were extracted from the "EPO Worldwide Patent Statistical Database" (PATSTAT), which provides information about published patents collected more than 80 patent authorities worldwide. The list of research-intensive industries and goods (NIW/ISI/ZEW-Lists 2012) will be used for the differentiation of 38 high-technology fields (Gehrke et al. 2013). By using PATSTAT as the basis of our analyses, we are able to apply fractional counting of patent filings. We do this in two dimensions: on the one hand, we fractionally count by inventor countries and, on the other hand, we also fractionally count by the 38 technology fields of the high-tech list, implying that cross-classifications are taken into account. The advantages of fractional counting are the representation of all countries or classes, respectively, as well as the fact that the sum of patents corresponds to the total, so that the indicators are simpler to be calculated, understood, and therefore also more intuitive.

The patents in our analyses are counted according to their year of worldwide first filing, which is commonly known as the priority year. This is the earliest registered date in the patent process and is therefore closest to the date of invention. As patents are in this report – first and foremost – seen as an output of R&D processes, using this relation between invention and filing seems appropriate.

At the core of the analysis, the data applied here follows a concept suggested by Frietsch and Schmoch (2010), which is able to overcome the home advantage of domestic applicants, so that a comparison of technological strengths and weaknesses becomes possible – beyond home advantages and unequal market orientations. In detail, all PCT applications are counted, whether transferred to the EPO or not, and all direct EPO applications without precursor PCT application. Double counting of transferred Euro-PCT applications is thereby excluded. Simply speaking, all patent families with at least a PCT application or an EPO application are taken into account.

In addition to the absolute numbers, patent intensities are calculated, which ensures better international comparability. The figures for the patent intensity are calculated as the total number of patents per 1 million workers in the respective country.

For the analyses of patents in different technological fields, patent specializations are calculated. For the analysis of specializations, the relative patent share (RPA[1]) is estimated. It indicates in which fields a country is strongly or weakly represented compared to the total patent applications. The RPA is calculated as follows:

$$RPA_{kj} = 100 * \tanh \ln [(P_{kj}/\sum_j P_{kj})/(\sum_k P_{kj}/\sum_{kj} P_{kj})]$$

where P_{kj} stands for the number of patent applications in country k in technology field j.

1 Revealed Patent Advantage.

Positive signs mean that a technology field has a higher weight within the country than in the world. Accordingly, a negative sign represents a below-average specialization. Hereby, it is possible to compare the relative position of technologies within a technology portfolio of a country and additionally its international position, regardless of size differences.

3 Trends in Transnational Patent Filings

Within this section, the recent trends of transnational patent filings since the beginning of the 1990s will be described. The analyses will be carried out for a selected set of technology-oriented countries[2], although, for reasons of presentation, not every country is displayed in each figure. Besides a country-specific view, we will provide a distinction between low- and high-technology areas. High-tech is defined as technologies for which usually an average investment in R&D of more than 3% of the turnover is required (Gehrke et al. 2013). High-tech will further be differentiated by high-level and leading-edge technologies. While high-level covers technologies that require R&D expenditures between 3% and 9%, the leading-edge area covers technologies that are beyond 9% investment shares (Gehrke et al. 2013). In section 3.1, we will firstly discuss some broader country as well as technology-specific trends, while the differentiation of national technology profiles of Germany – looking at a list of 38 technology fields – will be presented in section 3.2.

3.1 Country Comparisons

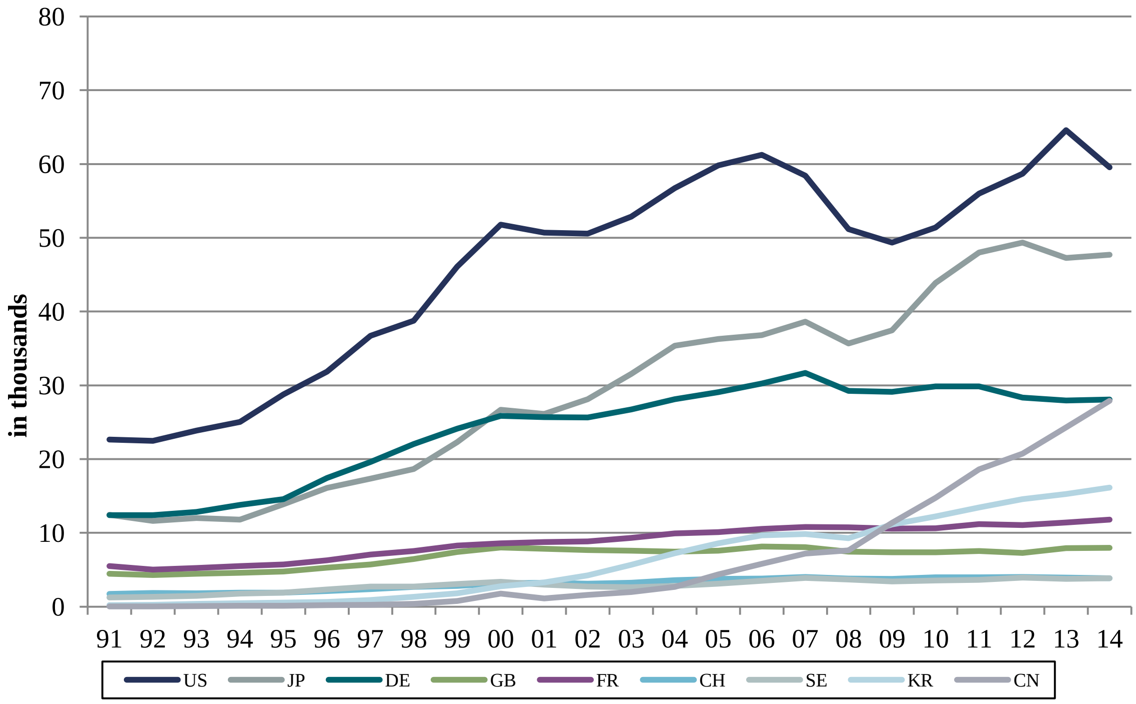
The absolute number of transnational patent applications by inventor countries is displayed in Figure 1. At the international level, the USA is the largest technology-providing country with nearly 60,000 filings in 2014. It is followed by Japan with nearly 50,000 filings in the same year. Since patent filings from the US grew at a quicker pace than the filings originating from Japan, at least until 2013, the distance between the two countries increased in the last years. In 2014, however, a decrease in the number of filings from the US can be observed, which can be explained by the coming into force of the Leahy-Smith America Invents Act (AIA) in 2013. In the run up to the AIA deadline, an unprecedented number of US priority applications were filed since the changes of the AIA were regarded by many as introducing less favorable conditions for applicants. In turn, this lead to a corresponding spike in PCT filings until 12-months later. Consequently, changes in U.S. patent law in contributed to the temporary surge of filings seen in the priority year 2013 (WIPO 2016b).

The next two countries in the ranking are China and Germany, both with about 30,000 filings in 2014. In this year's report, however, it is the first time that China is nearly at the same level as Germany within this ranking. On the one hand, this is a result of the massive growth of filings from China since 2008, but also of stagnation in German patent filings

2 These are: Belgium, Denmark, Germany, Finland, France Israel, Italy, Japan, Canada, Korea, The Netherland, Austria, Poland, Sweden, Switzerland, Spain, United Kingdom, USA, Brazil, Russia, India, China, South Africa as well as the group of EU-28 member states.

during the last few years. Following behind these four countries, there is a large group led by Korea, followed by France and Great Britain. Sweden and Switzerland follow Great Britain with about 4,000 transnational filings in 2014. With regard to Germany, several effects could serve as an explanation for the stagnation in patent filings, although business R&D expenditures have still been growing in the recent years (Schasse et al. 2016). The Fraunhofer ISI is just analyzing this within an ongoing project for the Federal Ministry of Education and Research. One of the explanations is that the stagnation in filings might be a consequence of a stronger concentration of patent filings to large firms, making it even harder for SMEs to enter certain markets. Yet, it could also be as this is merely an effect of a small percentage of very large firms that have changed their patenting strategies or a more general shift in strategies for IP protection. Finally, it might be an effect of decreasing marginal effects for R&D expenditures in Germany. However, at this stage, these explanations remain speculative and further analyses are necessary to get deeper insights into these effects.

Figure 1: Absolute number of transnational patent applications for selected countries, 1991-2014



Source: EPO – PATSTAT; Fraunhofer ISI calculations

The absolute data that has been presented so far, however, is affected by size effects. To adjust for these size effects, patent intensities, i.e. patents per one million employees, were calculated. These are displayed in Table 1. This size adjustment sheds new light on the country ranks. Though the USA is the largest country in absolute terms, it only scores thirteenth within our country set in terms of patent intensities. At the top of the list, rather the smaller countries like Switzerland, Sweden and Finland can be found. Japan, Germany and South Korea are first among the larger countries in terms of patent intensities. Japan ranks fourth on this indicator, directly followed by Germany and Israel. On the one hand, this resembles a strong technology orientation and technological competitiveness. On the other hand, it is also a sign of a clear and strict international orientation and an outflow of the export activities of these countries as patents can be seen as an important instrument to secure market shares in international technology markets (Frietsch et al. 2014). Within the perspective of this indicator, France, Great Britain and the EU-28 are in the midfield together with the USA, Italy and Belgium. The BRICS countries, i.e. China, South Africa, Russia, Brazil and India, score on the lower ranks on this indicator.

Table 1: Patent intensities (patent applications per 1m employees) and shares of technological areas, 2014

		Total	Less R&D-intensive		High-Tech of which are:		Leading-edge technologies		High-level technologies	
1	SUI	850	423	50%	459	54%	155	18%	304	36%
2	SWE	807	258	32%	576	71%	319	40%	257	32%
3	FIN	802	342	43%	465	58%	269	34%	196	24%
4	JPN	751	298	40%	468	62%	170	23%	298	40%
5	GER	704	322	46%	398	57%	124	18%	275	39%
6	ISR	633	214	34%	428	68%	243	38%	185	29%
7	KOR	631	231	37%	411	65%	195	31%	217	34%
8	DEK	630	254	40%	379	60%	129	21%	250	40%
9	AUT	591	314	53%	282	48%	92	16%	190	32%
10	NED	535	263	49%	275	52%	138	26%	137	26%
11	FRA	447	191	43%	266	59%	120	27%	146	33%
12	BEL	427	197	46%	234	55%	105	25%	129	30%
13	USA	407	145	36%	267	66%	136	33%	132	32%
14	EU-27/28	345	156	45%	196	57%	78	22%	119	34%
15	GBR	260	109	42%	157	60%	76	29%	81	31%
16	ITA	244	134	55%	118	48%	31	13%	87	36%
17	CAN	192	77	40%	117	61%	61	32%	56	29%
18	ESP	147	73	50%	76	52%	31	21%	45	30%
19	POL	48	23	47%	26	54%	11	23%	15	31%
20	CHN	36	10	28%	27	74%	17	46%	10	27%
21	RSA	22	13	57%	9	39%	4	16%	5	23%
22	RUS	16	7	45%	9	55%	4	28%	4	27%
23	BRA	7	4	53%	3	50%	1	13%	3	37%
24	IND	5	2	33%	4	69%	2	32%	2	37%

Source: EPO – PATSTAT; OECD, The World Bank, Fraunhofer ISI calculations

Note: In a few cases, shares of patents in certain IPC-classes are assigned to leading-edge as well as high-level technologies, which might lead to double-counts. The shares therefore might slightly exceed 100%.

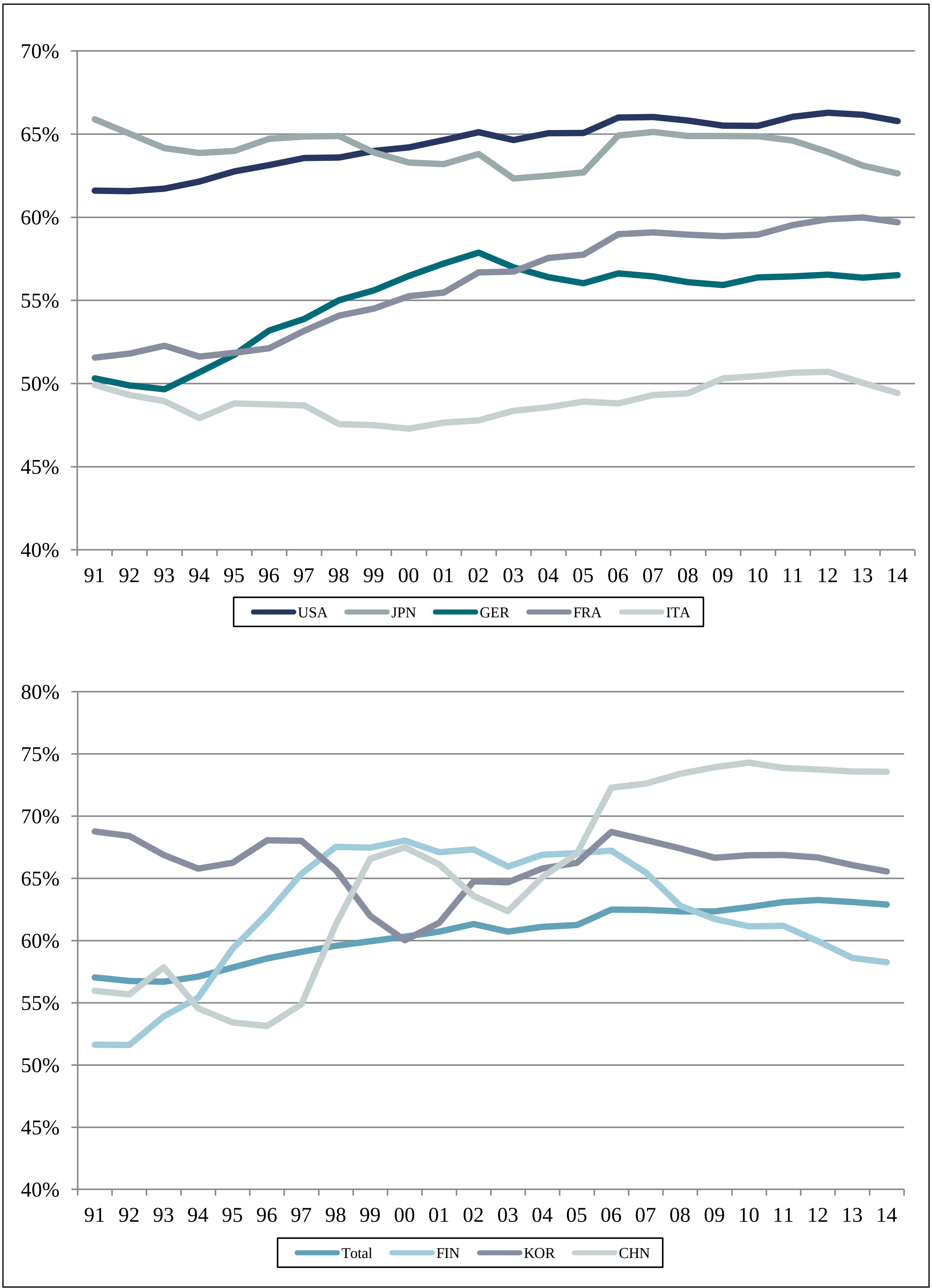
In addition to the patent intensities at a general level, Table 1 provides a differentiation of patent intensities by technological areas and displays the respective shares on total patent filings. It is remarkable that especially Switzerland shows rather high activities in less R&D intensive fields. The same is true for Italy, Poland, Spain and Austria. Also the BRICS countries Brazil and South Africa are very active in fields with a low R&D intensity. China and India deviate from this pattern with a comparably small share of patents in less R&D-intensive fields. China, however, especially shows large shares in leading-edge technologies, whereas the shares in India are higher for high-level technologies.

With regard to high-technology shares, the largest values can be observed for China and Sweden, where the shares exceed 70%. Shares above 65% can be found in the cases of the USA, Korea, India and Israel. In the case of India and Israel, however, this can at least partly be explained by a high orientation towards the US market, which is the most important national market for high-tech products. A similar argument can be made for Canada, which also shows high-tech shares of 64%.

The differentiation by leading-edge and high-level areas further qualifies these findings. Especially China files a large proportion of its patents in leading-edge technologies. However, also Sweden, Finland, Israel, the USA and Canada display comparably high shares. In consequence, these countries reach comparably low shares in high-level technologies compared to the other countries. Germany, Japan, Korea, Italy and Denmark, but also Brazil and India are focused on high-level technologies, but reach comparably low shares in leading-edge areas.

Figure 2 shows the period-specific trends in high-tech shares within the national profiles of selected large countries. While the average share of total transnational high-tech patent applications rose from about 57% at the beginning of the 1990s to about 63% in 2014, some countries underwent a considerable change of their patenting patterns in high-tech areas. China is at the top of the countries under analysis in this graph with a high-tech share of 77% in 2014, followed by Korea and the USA with a value of 66%. In the case of China, the number of filings has slowly started to grow after it joined the WTO and the TRIPS agreement in 2001. This growth is especially visible between 2003 and 2006. Since 2010, however, we see a stagnating trend, yet at a very high level. The high-tech shares of Korea have been decreasing since 2006, although the absolute number of filings from Korea increased considerably. The USA scores third on this indicator and displays constantly increasing shares in high-tech patents over the years. Since 2011, however, a stagnation period can be observed, where the high-tech shares remain at a rather constant level of about 66%. Japan is the fourth most high-technology active country in terms of transnational patenting in the year 2014, at least for this selected country set. Japan, which had clearly lost ground and had lower shares of patenting activities in high-tech areas between 2003 and 2005, had managed to catch up with the USA until 2011. From 2011 onwards, however, a decrease can be observed. France was able to increase its high-tech shares up to 2006, yet the share remained mostly stable from this year onwards until 2010, where another growth period can be observed. Italy encountered an increase in the recent years, so the gap to the other large innovation-oriented countries has become smaller. However, since 2012 the figures have started to decrease again. Germany encountered a decrease in high-tech shares between 2002 and 2005 and showed stagnating trends in the following years. Since 2010, however, a slight increase in high-technology shares can be found.

Figure 2: Shares of high-tech patent applications in total patent applications for selected countries, 1991-2014



Source: EPO – PATSTAT; Fraunhofer ISI calculations

3.2 Technology Profiles and Specialization Patterns

In this section, we provide a discussion of transnational patent applications by German inventors according to the classification of 38 technology fields of the high-tech sector (Gehrke et al. 2013). The absolute number, specialization and the percentage growth of German transnational patent applications by technology fields are displayed in Table 2. The largest growth rates between the periods 2004-2006 and 2012-2014 can be observed in the fields of "aeronautics", "electrical machinery, accessory and facilities", "rail vehicles", "rubber goods" and "power generation and distribution".

Table 2: Transnational Patent applications of Germany by high-technology sectors (absolute, specialization, and growth), 2012-2014

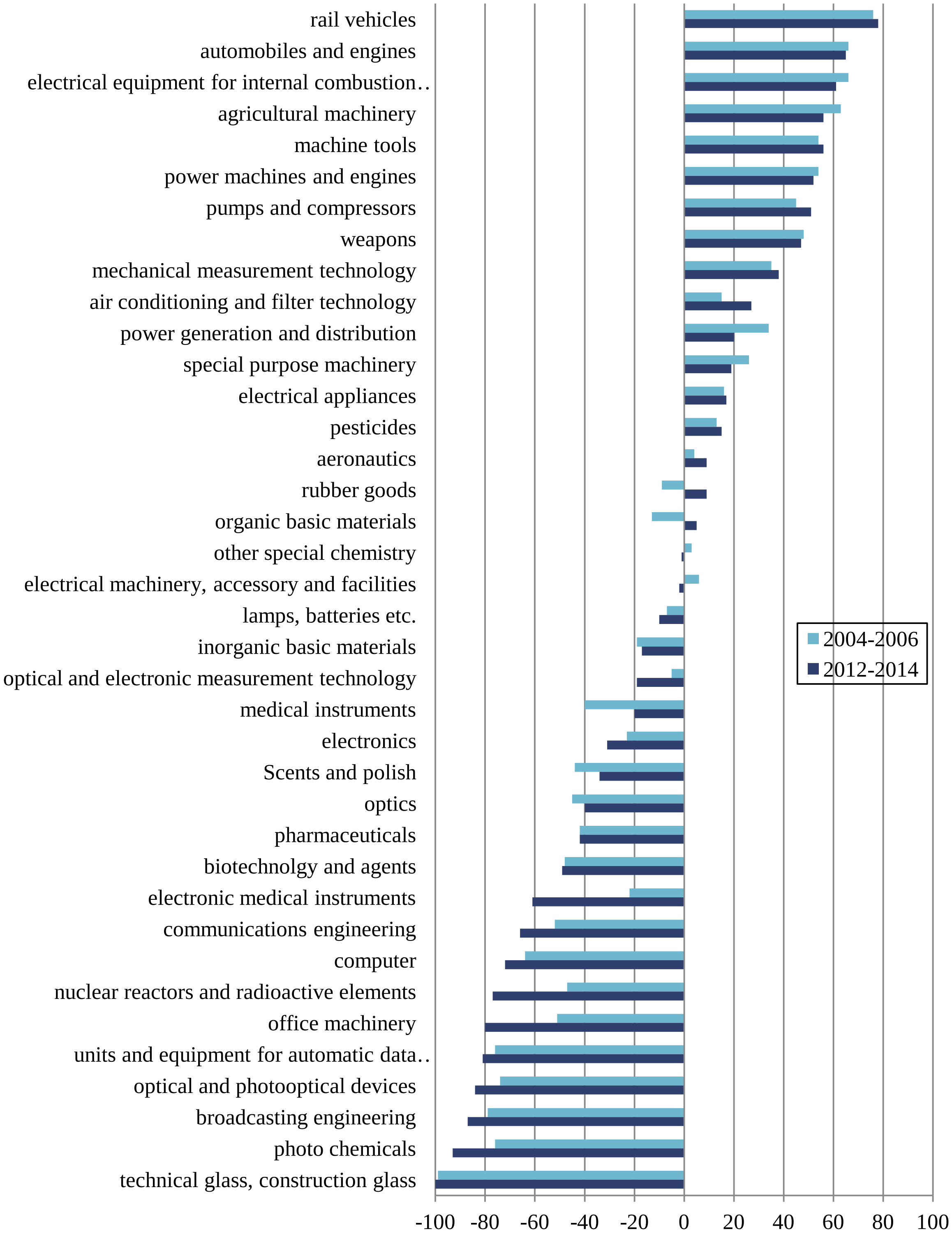
Technology Field	**Abs.**	**RPA**	**% Growth** (02-04=100)
aeronautics	903	9	187.1
electrical machinery, accessory and facilities	549	-2	164.8
rail vehicles	330	78	163.2
rubber goods	335	9	158.7
power generation and distribution	2,120	20	151.3
lamps, batteries etc.	1,668	-10	141.1
units and equipment for automatic data processing machines	767	-81	130.3
pumps and compressors	814	51	127.2
air conditioning and filter technology	1,870	27	125.1
power machines and engines	3,671	52	119.5
agricultural machinery	571	56	119.4
medical instruments	2,537	-20	116.0
electrical appliances	614	17	112.9
optics	614	-40	110.6
Scents and polish	33	-34	110.5
electrical equipment for internal combustion engines and vehicles	1,199	61	109.1
inorganic basic materials	389	-17	107.8
mechanical measurement technology	1,163	38	104.6
electronics	1,248	-31	101.1
machine tools	2,325	56	100.6
optical and electronic measurement technology	2,596	-19	97.6
technical glass, construction glass	101	-100	95.4
optical and photooptical devices	58	-84	89.9
weapons	242	47	88.8
automobiles and engines	5,406	65	86.3
communications engineering	3,721	-66	84.9
special purpose machinery	3,196	19	84.7
other special chemistry	947	-1	76.9
pesticides	510	15	76.4
organic basic materials	1,556	5	74.3
computer	1,763	-72	74.0
broadcasting engineering	550	-87	71.9
pharmaceuticals	1,050	-42	68.4
electronic medical instruments	652	-61	67.9
biotechnology and agents	1,433	-49	66.0
nuclear reactors and radioactive elements	11	-77	55.2
office machinery	46	-80	39.1
photo chemicals	1	-93	7.0

Source: EPO – PATSTAT; Fraunhofer ISI calculations

Among the fields that are growing most slowly in Germany are three smaller fields, namely "photo chemicals", "office machinery" and "nuclear reactors and radioactive elements". Yet, also the chemistry related fields "biotechnology and agents", "pharmaceuticals", "organic basic materials", "other special chemistry" and "pesticides" can be seen as comparably slowly growing fields within the German technology profile followed by the ICT related fields of "broadcasting engineering", "computers" and "communications engineering". This confirms the results from last year's study. Most electronics related fields are growing rather strongly, whereas chemistry and pharmaceuticals as well as ICT related fields do not show very high growth rates. The fields related to the mechanical engineering sector, where Germany has its particular technological strengths, e.g. "machine tools", "agricultural machinery", "automobiles and engines" or "special purpose machinery", show moderate to low growth rates in recent years, which also resembles the trends that have been found in earlier studies of this series.

The specialization (RPA) of the German technology profile of the years 2004-2006 and 2012-2014 is displayed in Figure 3. Germany is specialized, i.e. has comparative advantages, in three main areas: transport (automobiles and engines as well as rail vehicles), machinery and some areas of electrical engineering like power machines and power generation. Germany also has a very strong specialization within the field of "electrical equipment for internal combustion engines and vehicles", which is a more recent trend that has already been found in last year's report. An average activity rate in patenting can be found in the some chemical sectors ("organic basic materials", "inorganic basic materials", "pesticides", "rubber goods", "other special chemistry"). Comparative disadvantages, reflected in negative specialization indices, can be found in ICT related fields, e.g. " broadcasting engineering", "units and equipment for automatic data processing machines", "office machinery" and "computers" as well as in some chemistry related fields like "pharmaceuticals", "photo chemicals" and biotechnology, implying that Germany does not have particular strengths in these sectors in international technology markets. All of these trends can be found in both time periods, i.e. the specialization profile of Germany is rather stable over time.

Figure 3: Germany's technological profile, 2004-2006 vs. 2012-2014



Source: EPO – PATSTAT; Fraunhofer ISI calculations

In order to achieve a better understanding how Germany's technology profile compares to other countries, a hierarchical cluster analysis based on the countries' specialization values across technology fields was conducted. Cluster analyses assign individual objects to a group, i.e. they systematically classify individual objects from a given pile of objects according to their similarity (for further methodological details compare Aldenderfer and Blashfield 1984; Backhaus et al. 2005; Bortz 1999; Kruskal and Wish 1977). Hierarchical clustering methods are characterized by the fact that the number and distribution of groups is reached by stepwise distribution of each single object. The starting point are the smallest possible groups, namely all individual objects, which are distributed bit by bit to larger groups (agglomerative methods). For this classification, distance measures are needed. One of the most common distance measures is the Squared Euclidian Distance, which was also applied for this analysis. For the derivation of the squared Euclidian distance (SED) between two data points, the sum of the squared differences between the corresponding values is calculated:

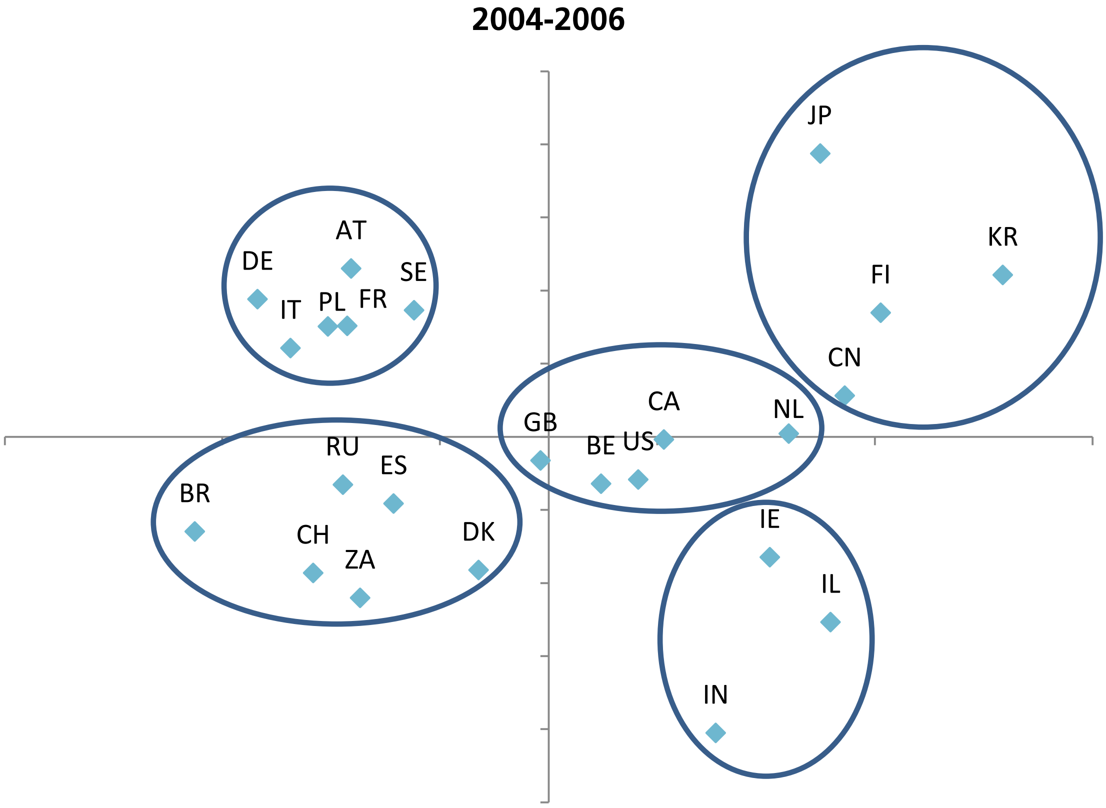
$$D^2 = \sum_{i=1}^{V} (X_i - Y_i)^2$$

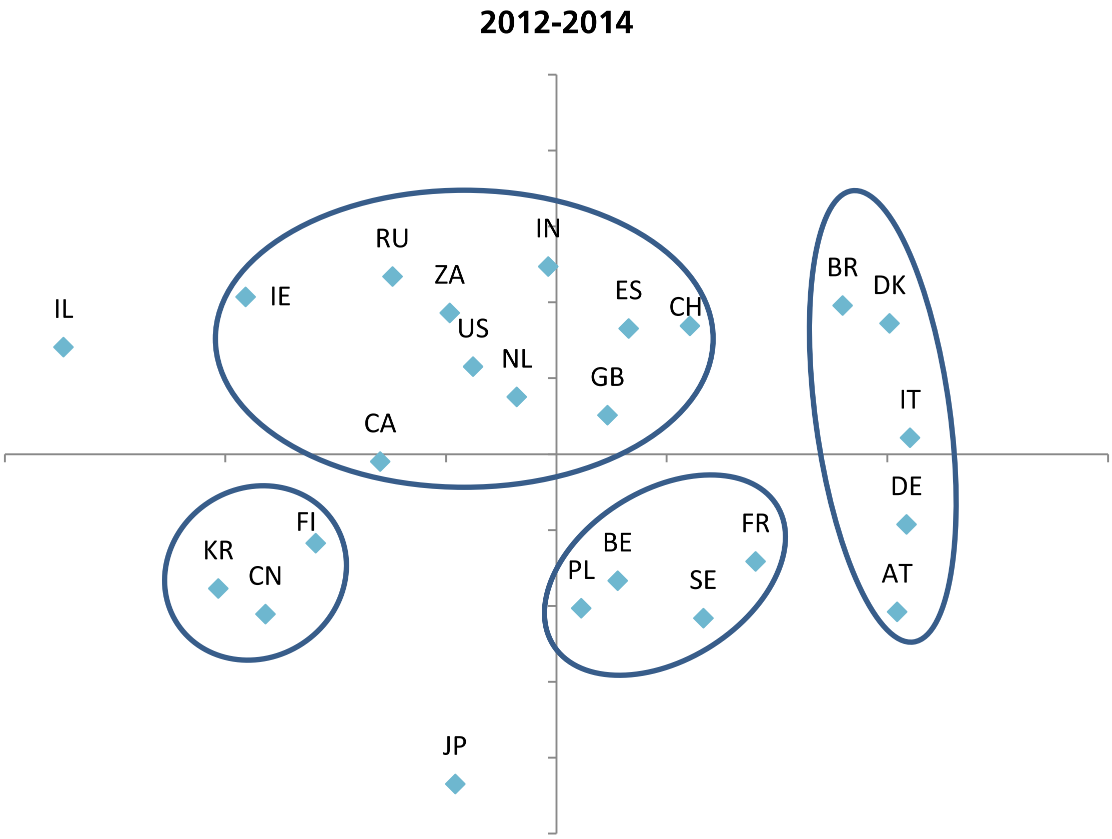
where V is the number of variables used to calculate the distances.

Following the procedure described above, the objects (countries) were combined into clusters based on their RPA values within the classification the NIW/ISI/ZEW list of 38 technology (Gehrke et al. 2013). To better visualize the data, multi-dimensional scaling (MDS) was used. Based on the calculated matrix of item to item similarities, the algorithm assigns a location to each item in an N-dimensional space. Figure 4 shows the MDS graphs for the years 2004-2006 in comparison to 2012-2014. The circles were included manually, to highlight the respective country groupings.

In the period between 2004 and 2006, basically five groups of countries with more or less similar profiles can be identified. The first group of countries consists of Germany and five further European states, i.e. Austria, Italy, Poland, France and Sweden, who have a relatively large similarity in their technological specialization profile. What these countries have in common is a focus on high-level technologies (compared to leading-edge technologies) as well as a comparable share of less R&D-intensive technologies. Only Sweden slightly deviates from this pattern. A second group is formed of Japan, China, Korea and Finland. These countries all show a rather low share of less R&D-intensive technologies and are more focused on electronics and ICT-related fields. A third group consists of the US, Great Britain, Canada, Belgium and the Netherlands. This group shows comparable high-tech shares, but what is more important is that they have a rather balanced portfolio in terms of leading-edge and high-level technologies. The fourth group comprises Brazil, Russia, Spain, South Africa and surprisingly Denmark as well as Switzerland. Among these countries, Germany is the largest country in terms of total transnational patent filings. What these countries have in common is a relatively large share in patent filings in less R&D-intensive areas (all above 50% except for Denmark). Finally, there is a fifth group consisting of Ireland, India and Israel. India and Israel, together with China and Sweden, have the largest high-tech shares within this country comparison. What they also have in common is a strong orientation to the US market, which also explains the proximity to the group including the US, Great Britain and Canada.

Figure 4: Country cluster alongside their technological specialization profiles (MDS), 2004-2006 and 2012-2014





Source: EPO – PATSTAT; Fraunhofer ISI calculations

When looking at the period 2012 to 2014, however, the picture slightly changes. Instead of five, only four groups can be identified, alongside with two outliers, namely Japan and Israel. The group that has remained most stable is the one including China, Korea and Finland, which still has the highest proximity to Japan. The group including Germany has slightly changed. Austria and Italy still have a profile similar to Germany, but also Brazil and Denmark now have entered this group. France, Sweden and Poland, however, now form a distinct group, though there still is a certain proximity to Germany, Austria and Italy. Finally, there is a large group consisting of the remaining countries.

In sum, we can observe a slight convergence of the technology profiles of the countries over the years. This surely has to do with the increasing patent activities and the catching-up of the BRICS countries and their orientation towards international markets.

4 Structures in International Co-Patenting

The internationalization of R&D activities can be analyzed with the help of cooperation structures in international patenting. Co-patents are able to indicate the extent to which countries are cooperating with each other, at least to a certain extent. Since a cooperative patent application is associated with the exchange of knowledge about the patented invention, the analysis of co-patenting further allows us to draw conclusions about international knowledge flows.

Basically, there are several ways to define an international co-patent, e.g. to use patent applicants or inventors or a mixture between the "inventor-" and the "applicant concept" (Fraunhofer ISI et al. 2009). For the current study, we decided to reside to the concept of inventors as this clearly indicates that the innovative endeavors resulting in an international co-patent have been carried out in two different countries. Due to the fact that large firms operate research facilities in other countries, this is not necessarily true for when co-applicants are analyzed.

However, there are downsides to applying patent indicators for the identification of international knowledge flows. Patent filings are only one of many results that can be the outcome of international collaborations and patents can only give us information on the collaborations that have actually led to a patent filing. In addition, tracing the direction and amount of the knowledge flow is challenging, i.e. it is hard to say which country benefits most from the exchanged knowledge and it is important to recognize that the analysis of patent filings only gives us information on the location of the inventor but not on his or her nationality. Finally, an international co-patent may involve inventors from the same company located around the world across its various subsidiaries (see also ADL 2005). The data thus reflects inter- as well as intra-firm international collaboration (Fraunhofer ISI et al. 2009; Guellec and Pluvia Zuniga 2007). Still, it can be assumed that co-patent data is not systematically biased, which is why they can serve as an indicator of international knowledge exchange, especially in relative terms (Fraunhofer ISI et al. 2009).

In sum, we will focus on the transnational co-patent filings of the countries under analysis in the previous chapters. Opposed to earlier reports of this series, we will apply the whole count method to analyze the co-patents by countries. This is not only to gain a different perspective on the co-patenting structures but also due to the fact that the shares of co-patents cannot be easily assigned to an inventor from one or another country as the real contribution of an inventor is unknown. It can therefore make more sense to count each co-patent once for each country in the case a co-inventor from a given country is listed on a patent document.

4.1 A brief literature review

Several characteristics that can foster or hamper international cooperation (for an extended overview see Fraunhofer ISI et al. 2009). First of all, the size of a country influences its propensity to collaborate internationally (Frame and Carpenter 1979), i.e. inventors from smaller countries collaborate more than inventors from large countries since there are fewer domestic partners to collaborate with (Narin et al. 1991; Schubert and Braun 1990). However, conflicting statements on this topic can be found in the literature. Evidence on the degree and direction of this relationship thus remains rather vague (Luukkonen et al. 1992; Luukkonen et al. 1993; Narin et al. 1991).

Besides country size, there still is considerable heterogeneity between countries in their propensity to collaborate, which can be attributed to a multitude of different factors (Hoekman et al. 2010). Mainly geopolitical, historical and language related factors are predominant, but also social, intellectual, cognitive and economic factors seem to be relevant (Frame and Carpenter 1979; Glänzel and Schubert 2004; Luukkonen et al. 1992).

Differences in the propensity to collaborate not only occur between countries but also between fields. In basic disciplines there is a higher propensity to collaborate internationally than in applied disciplines (Liu et al. 2012). Frietsch (2004) as well as Schmoch (2005; 2006) show that strategic aspects should also be taken into account. Getting access to certain data or research facilities might build an incentive to collaborate internationally. In addition, one might willingly choose not to cooperate in a given field in order to protect proprietary knowledge, especially when the need to cooperate is low.

In addition to country- and field-specific differences, Katz (1994) found that collaboration intensity decreases with increasing distance between partners, which has also been found by Hong and Su (2012) regarding university-industry collaborations. Glänzel and Schubert (2004) added the argument that mobility and migration are also relevant. More recent findings by Hoekman et al. (2010) suggest that the geographical distance between collaborating partners became less important in the recent years, due to regular airplane connections and modern communication means. Mattson et al. (2008) provide a summary on the above mentioned motives by introducing four categories: financial reasons (e.g. funding access, facilities sharing), social factors (networking, acknowledgements from the scientific community, preference for teamwork), knowledge improvement, and political factors (including framework programs and others to facilitate collaboration).

In sum, it can be stated that analyzing and interpreting international collaborations should be done with care, having in mind that there are several mutually dependent factors that can influence patterns of collaboration. This also affects the choice and interpretation of the indicators that are able to evaluate the degree of collaboration on an international scale, implying that absolute as well as relative measures should be taken into account (Fraunhofer ISI et al. 2009).

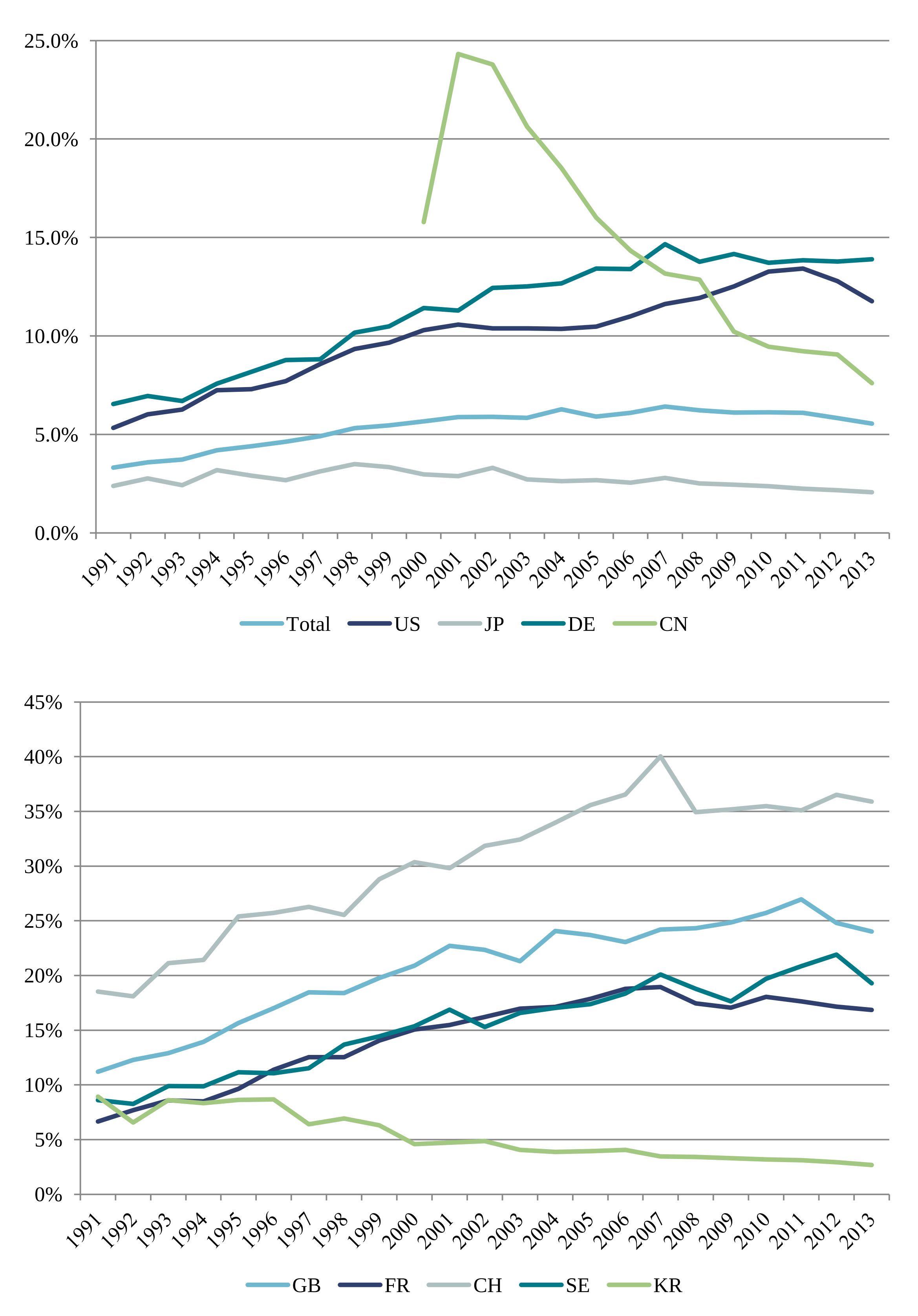
4.2 International Co-Patenting Trends

The co-patenting trends by countries are depicted in Figure 5. Here, the shares of transnational co-patents (with OECD countries) in all transnational patent filings of the respective country are shown, which gives us a first impression on the cooperation intensity of the countries. Large shares imply that many inventors from a given country are cooperating internationally. The top-panel of the figure first of all provides the results for the larger countries in comparison. The lower-panel shows the results for the smaller countries.

The total share of co-patents in all filings has constantly been increasing over the years until 2007. In the year 1991 only about 3.3% of all transnational filings were international co-patents. In 2007, this share has doubled to 6.4%, implying that cooperation has gained importance over the years. From 2007 onwards, however, the share started to slightly decline until a share of 5.5% in 2013 was reached. This trend is influenced by China's as well as Korea's declining shares of the years. The drop in the last two years, however, seems to be a more general trend that is visible in a larger number of countries, e.g. the US, Japan, Great Britain, France and Sweden. Germany has also been affected by a slight decline since 2007, yet the figures have remained rather stable from this year onwards.

Among the countries in our comparison, Switzerland has the largest co-patenting shares with 36% in 2013. It is followed by Great Britain (24%), Sweden (19%) and France (17%), although these three countries encountered the above mentioned decline in co-patenting shares during the last two to three years. With a share of 14% in 2013, Germany still is ahead of the US with 12%. These two countries followed a similar trend across the whole time period, yet Germany is not affected by the decline in the recent years. A closer look at China reveals that, although starting from a very high level, the co-patenting rates have constantly decreased since 2003. Still, about 8% of all Chinese transnational filings are international co-patents. In comparison with the remaining Asian countries, here Japan and Korea, this share still is comparably high. Japan shows a more or less constant co-patenting rate of 2% to 3% over the years, although a slight decline becomes visible. Similar values can be observed for Korea, at least since the year 2000, but at a slightly higher level of co-patenting shares between 3% and 5% over the years.

Figure 5: Shares of transnational co-patents in all transnational patents of the respective country, selected countries, 1991-2013



Source: EPO – PATSTAT; Fraunhofer ISI calculations

For these two Asian countries, this resembles their general underrepresentation in international science and innovation collaborations (Schubert et al. 2013; Weissenberger-Eibl et al. 2011), which also has to do with their industry structure that is dominated by very large firms. Furthermore, the Japanese and also the Korean large enterprises were hardly conducting R&D abroad. More recently, the governments in both countries set up programs to overcome these shortcomings, especially with respect to the public science system. They also realized that international collaboration is a crucial factor in nowadays innovation activities. Apart from Korea, however, it becomes evident that most of the smaller countries have higher co-patenting rates than their large counterparts. This corroborates the theoretical arguments made above.

Table 3 is designed to allow an assessment of the most important cooperation partners for each of the countries under analysis. The values above the diagonal in the table provide the share of co-patents between two countries in all transnational co-patents. In the area below the diagonal line, the absolute numbers of co-patent filings between two countries are depicted. In the last column, the share of a country's total co-patents in all transnational co-patents worldwide is shown. The US has the highest share of co-patents in all transnational co-patents with a value of 24.5%. However, this share is affected by the size of a country, i.e. larger countries in terms of patenting take advantage over smaller countries. The US is followed by Germany with a share of about 14%. Great Britain and France score third and fourth with a share of about 7.2% each. Although a small country in absolute terms, Switzerland reaches rather high shares in total transnational co-patents (over 6%) as it is very cooperation intensive. This means that Switzerland ranks fifth, together with China. The opposite is true for Japan, although it is the second largest country in terms of transnational patent filings. It reaches only a share of about 3.6%. Japan thus has a comparably low level of internationalization of R&D activities, at least as measured in terms of co-patents, implying that its innovation system is relatively isolated compared to the German or the US innovation system for example. This is similar for South Korea, which also shows rather low shares of co-patents in all transnational co-patents.

A look at the absolute numbers reveals the importance of collaboration partners for each of the countries. This, however, becomes even more clearly visible when looking at the share of cooperation partners within the transnational co-patenting portfolio of a given country, which is presented in Table 4. The colors in the table indicate the importance of collaboration partners for each country from green to red. The most important collaboration partner for Germany, for example, is clearly the US. More than 25% of all German co-patents are filed in cooperation with a US inventor. The next largest partners are Switzerland, France and Austria. This can be explained by geographical proximity of these countries to Germany. What is striking when looking at the table is that the US is the most important partner for many countries in our comparison, while the US itself cooperates most strongly with Germany, China, Canada and Great Britain. Germany, however, also is an important partner for many countries, closely followed by China. China itself is highly oriented towards cooperating with US inventors. About 52% of all Chinese co-patents are filed in cooperation with a US inventor, followed by Germany with 11% and Japan with 7%. Yet, this might at least partly have to do with research facilities and production sites of foreign companies in China (Ernst 2006). In sum, the US, and to a certain extent also Germany, still are the most important cooperation partners for the countries in comparison.

Another interesting fact that becomes obvious when looking at the table is the different motivations to collaborate. Many of the countries in our comparison, on the one hand, show a large tendency to cooperate with partners that are geographically close. On the other hand, they seem to seek access to markets, e.g. the US or China, and/or to certain data or research facilities that are not locally available. This leads to the fact that there is a quite multifaceted motivation to collaborate, which can be summarized as "collaborating local", "collaborating with the best" and "collaborating for market access".

Table 3: Absolute number of transnational co-patents and shares in total transnational co-patents, 2011-2013

	AT	BE	BR	CA	CH	CN	DE	DK	ES	FI	FR	GB	IL	IN	IT	JP	KR	NL	PL	RU	SE	US	ZA	Share in total transnational co-patents
AT		0.05%	0.01%	0.04%	0.36%	0.03%	1.05%	0.03%	0.02%	0.09%	0.05%	0.10%	0.00%	0.02%	0.08%	0.02%	0.00%	0.04%	0.01%	0.01%	0.06%	0.20%	0.00%	2.25%
BE	54		0.01%	0.04%	0.09%	0.12%	0.56%	0.01%	0.09%	0.02%	0.59%	0.20%	0.01%	0.03%	0.09%	0.08%	0.02%	0.42%	0.03%	0.01%	0.05%	0.71%	0.00%	3.24%
BR	7	11		0.01%	0.03%	0.00%	0.10%	0.01%	0.02%	0.00%	0.05%	0.04%	0.01%	0.01%	0.02%	0.01%	0.00%	0.01%	0.00%	0.00%	0.03%	0.21%	0.00%	0.57%
CA	36	40	14		0.06%	0.16%	0.22%	0.03%	0.04%	0.02%	0.19%	0.29%	0.03%	0.06%	0.04%	0.06%	0.04%	0.06%	0.01%	0.02%	0.17%	2.86%	0.01%	4.45%
CH	362	88	28	60		0.16%	1.98%	0.04%	0.07%	0.05%	1.14%	0.30%	0.03%	0.08%	0.30%	0.06%	0.02%	0.10%	0.05%	0.03%	0.12%	0.99%	0.01%	6.07%
CN	26	126	1	162	160		0.52%	0.08%	0.04%	0.23%	0.23%	0.35%	0.03%	0.08%	0.06%	0.45%	0.12%	0.08%	0.02%	0.06%	0.27%	3.17%	0.00%	6.25%
DE	1,062	565	97	225	2,006	529		0.22%	0.24%	0.26%	1.60%	0.87%	0.10%	0.20%	0.51%	0.37%	0.11%	0.78%	0.20%	0.13%	0.42%	3.42%	0.03%	13.89%
DK	28	7	7	28	41	85	226		0.01%	0.07%	0.04%	0.17%	0.00%	0.03%	0.02%	0.02%	0.01%	0.03%	0.02%	0.00%	0.19%	0.31%	0.00%	1.36%
ES	17	94	21	37	73	39	245	14		0.01%	0.19%	0.12%	0.06%	0.02%	0.08%	0.02%	0.00%	0.07%	0.01%	0.01%	0.05%	0.35%	0.00%	1.53%
FI	87	22	5	23	54	232	265	75	14		0.03%	0.12%	0.00%	0.05%	0.04%	0.02%	0.00%	0.03%	0.04%	0.03%	0.19%	0.23%	0.00%	1.55%
FR	47	598	48	192	1,152	231	1623	44	195	32		0.48%	0.04%	0.09%	0.28%	0.16%	0.03%	0.19%	0.05%	0.03%	0.12%	1.65%	0.01%	7.24%
GB	101	201	37	290	308	353	886	173	122	126	482		0.06%	0.20%	0.16%	0.23%	0.10%	0.26%	0.05%	0.04%	0.21%	2.88%	0.02%	7.26%
IL	0	12	6	35	26	29	97	2	60	3	39	65		0.03%	0.02%	0.01%	0.01%	0.01%	0.00%	0.02%	0.02%	0.95%	0.00%	1.46%
IN	16	32	14	58	84	84	204	35	19	51	91	203	32		0.04%	0.03%	0.11%	0.08%	0.03%	0.01%	0.05%	1.80%	0.00%	3.07%
IT	76	88	16	44	307	56	512	21	83	39	282	165	25	39		0.04%	0.01%	0.05%	0.03%	0.03%	0.07%	0.59%	0.00%	2.56%
JP	25	81	7	60	63	454	373	19	17	19	158	233	10	35	39		0.17%	0.04%	0.01%	0.01%	0.04%	1.45%	0.00%	3.29%
KR	1	18	1	37	16	119	108	6	0	1	34	102	14	112	11	171		0.02%	0.00%	0.06%	0.01%	0.62%	0.00%	1.45%
NL	41	425	13	65	106	82	787	30	75	32	194	263	9	81	50	36	23		0.02%	0.02%	0.06%	0.92%	0.01%	3.31%
PL	13	31	1	6	53	19	202	21	13	45	48	50	2	28	32	8	2	23		0.01%	0.04%	0.12%	0.00%	0.76%
RU	13	8	1	22	30	61	131	4	6	26	32	37	24	6	35	12	60	19	8		0.01%	0.40%	0.00%	0.94%
SE	58	49	26	171	121	274	428	197	54	192	122	213	16	55	71	38	9	62	44	8		0.62%	0.00%	2.81%
US	206	724	217	2,893	1,006	3,212	3,463	315	351	231	1,675	2,917	965	1,828	599	1,468	625	928	119	409	632		0.06%	24.53%
ZA	0	4	0	7	6	0	31	1	0	0	12	22	3	3	4	2	2	6	1	2	4	63		0.17%
Total	2,276	3,278	578	4,505	6,150	6,334	14,065	1,379	1,549	1,574	7,331	7,349	1,474	3,110	2,594	3,328	1,472	3,350	769	954	2,844	24,846	173	100,00%

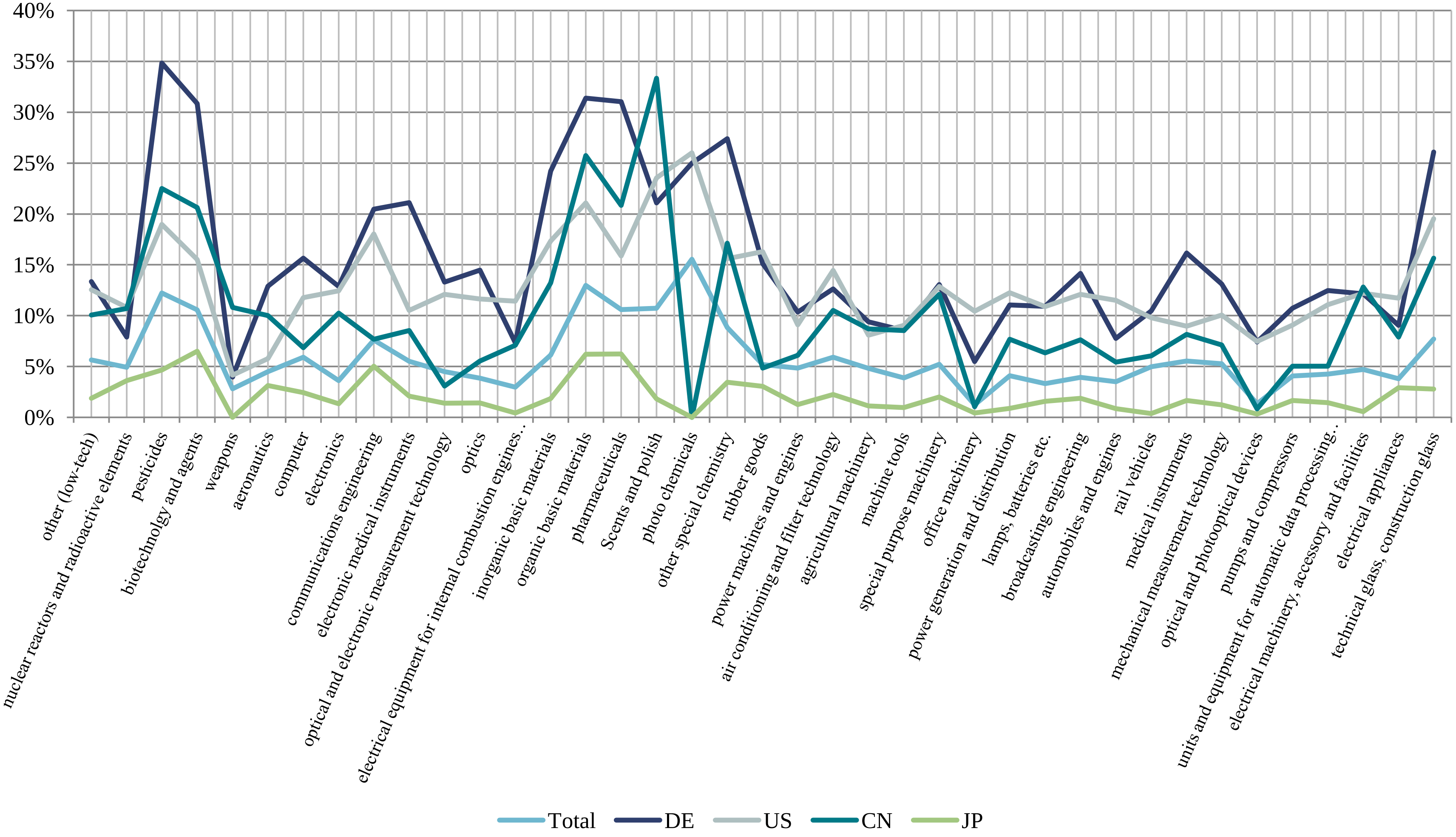
Source: EPO – PATSTAT; Fraunhofer ISI calculations

Table 4: Share of co-patenting partners within the transnational co-patenting portfolio of a given country, 2011-2013

	AT	BE	BR	CA	CH	CN	DE	DK	ES	FI	FR	GB	IL	IN	IT	JP	KR	NL	PL	RU	SE	US	ZA
AT		2%	1%	1%	6%	0%	8%	2%	1%	6%	1%	1%	0%	1%	3%	1%	0%	1%	2%	1%	2%	1%	0%
BE	2%		2%	1%	1%	2%	4%	1%	6%	1%	8%	3%	1%	1%	3%	2%	1%	13%	4%	1%	2%	3%	2%
BR	0%	0%		0%	0%	0%	1%	1%	1%	0%	1%	1%	0%	0%	1%	0%	0%	0%	0%	0%	1%	1%	0%
CA	2%	1%	2%		1%	3%	2%	2%	2%	1%	3%	4%	2%	2%	2%	2%	3%	2%	1%	2%	6%	12%	4%
CH	16%	3%	5%	1%		3%	14%	3%	5%	3%	16%	4%	2%	3%	12%	2%	1%	3%	7%	3%	4%	4%	3%
CN	1%	4%	0%	4%	3%		4%	6%	3%	15%	3%	5%	2%	3%	2%	14%	8%	2%	2%	6%	10%	13%	0%
DE	47%	17%	17%	5%	33%	8%		16%	16%	17%	22%	12%	7%	7%	20%	11%	7%	23%	26%	14%	15%	14%	18%
DK	1%	0%	1%	1%	1%	1%	2%		1%	5%	1%	2%	0%	1%	1%	1%	0%	1%	3%	0%	7%	1%	1%
ES	1%	3%	4%	1%	1%	1%	2%	1%		1%	3%	2%	4%	1%	3%	1%	0%	2%	2%	1%	2%	1%	0%
FI	4%	1%	1%	1%	1%	4%	2%	5%	1%		0%	2%	0%	2%	2%	1%	0%	1%	6%	3%	7%	1%	0%
FR	2%	18%	8%	4%	19%	4%	12%	3%	13%	2%		7%	3%	3%	11%	5%	2%	6%	6%	3%	4%	7%	7%
GB	4%	6%	6%	6%	5%	6%	6%	13%	8%	8%	7%		4%	7%	6%	7%	7%	8%	7%	4%	7%	12%	13%
IL	0%	0%	1%	1%	0%	0%	1%	0%	4%	0%	1%	1%		1%	1%	0%	1%	0%	0%	3%	1%	4%	2%
IN	1%	1%	2%	1%	1%	1%	1%	3%	1%	3%	1%	3%	2%		2%	1%	8%	2%	4%	1%	2%	7%	2%
IT	3%	3%	3%	1%	5%	1%	4%	2%	5%	2%	4%	2%	2%	1%		1%	1%	1%	4%	4%	2%	2%	2%
JP	1%	2%	1%	1%	1%	7%	3%	1%	1%	1%	2%	3%	1%	1%	2%		12%	1%	1%	1%	1%	6%	1%
KR	0%	1%	0%	1%	0%	2%	1%	0%	0%	0%	0%	1%	1%	4%	0%	5%		1%	0%	6%	0%	3%	1%
NL	2%	13%	2%	1%	2%	1%	6%	2%	5%	2%	3%	4%	1%	3%	2%	1%	2%		3%	2%	2%	4%	3%
PL	1%	1%	0%	0%	1%	0%	1%	2%	1%	3%	1%	1%	0%	1%	1%	0%	0%	1%		1%	2%	0%	1%
RU	1%	0%	0%	0%	0%	1%	1%	0%	0%	2%	0%	1%	2%	0%	1%	0%	4%	1%	1%		0%	2%	1%
SE	3%	1%	4%	4%	2%	4%	3%	14%	3%	12%	2%	3%	1%	2%	3%	1%	1%	2%	6%	1%		3%	2%
US	9%	22%	38%	64%	16%	51%	25%	23%	23%	15%	23%	40%	65%	59%	23%	44%	42%	28%	15%	43%	22%		36%
ZA	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Sum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

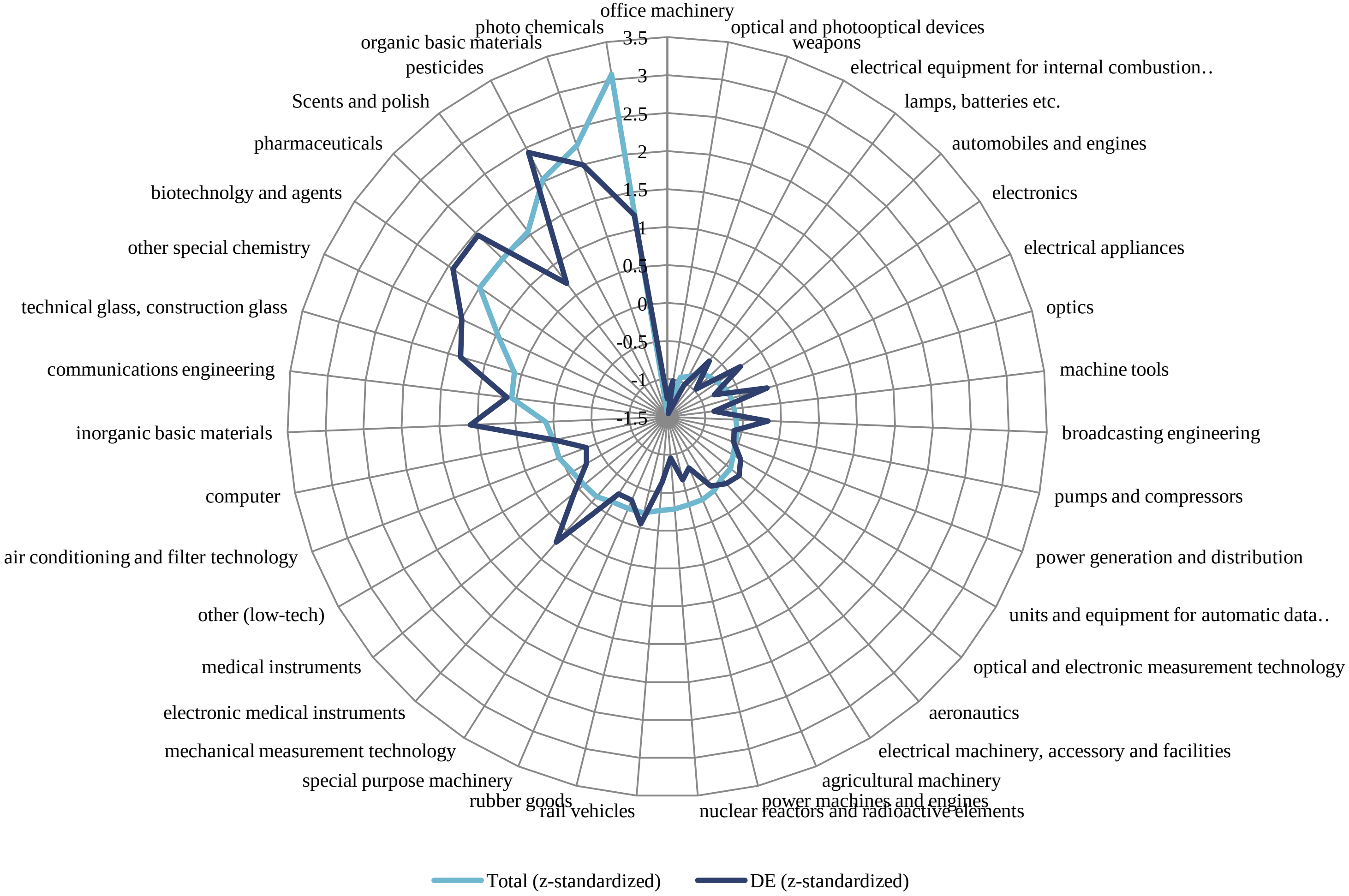
Source: EPO – PATSTAT; Fraunhofer ISI calculations.
Note: The colors in the table indicate the importance of collaboration partners for a given country (vertically). Green resembles the most important partners (largest share of co-patents in a country's total co-patents), red resembles the least important partners.

Figure 6: Share of co-patents by field in all transnational filings within the respective field, by country, 2011-2013



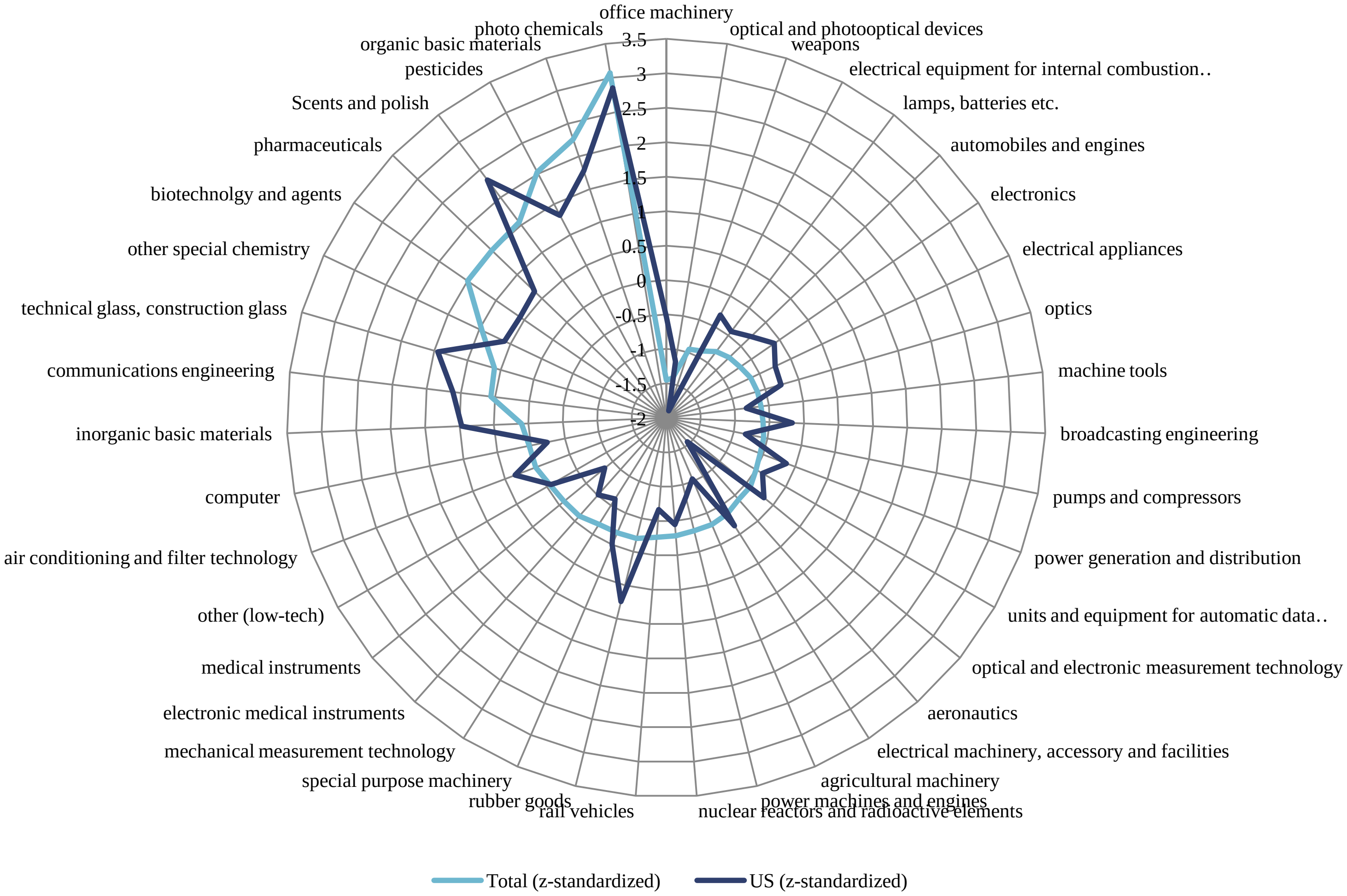
Source: EPO – PATSTAT; Fraunhofer ISI calculations

Figure 7: Differences in field-specific co-patenting trends, z-standardized values, total and DE, 2011-2013



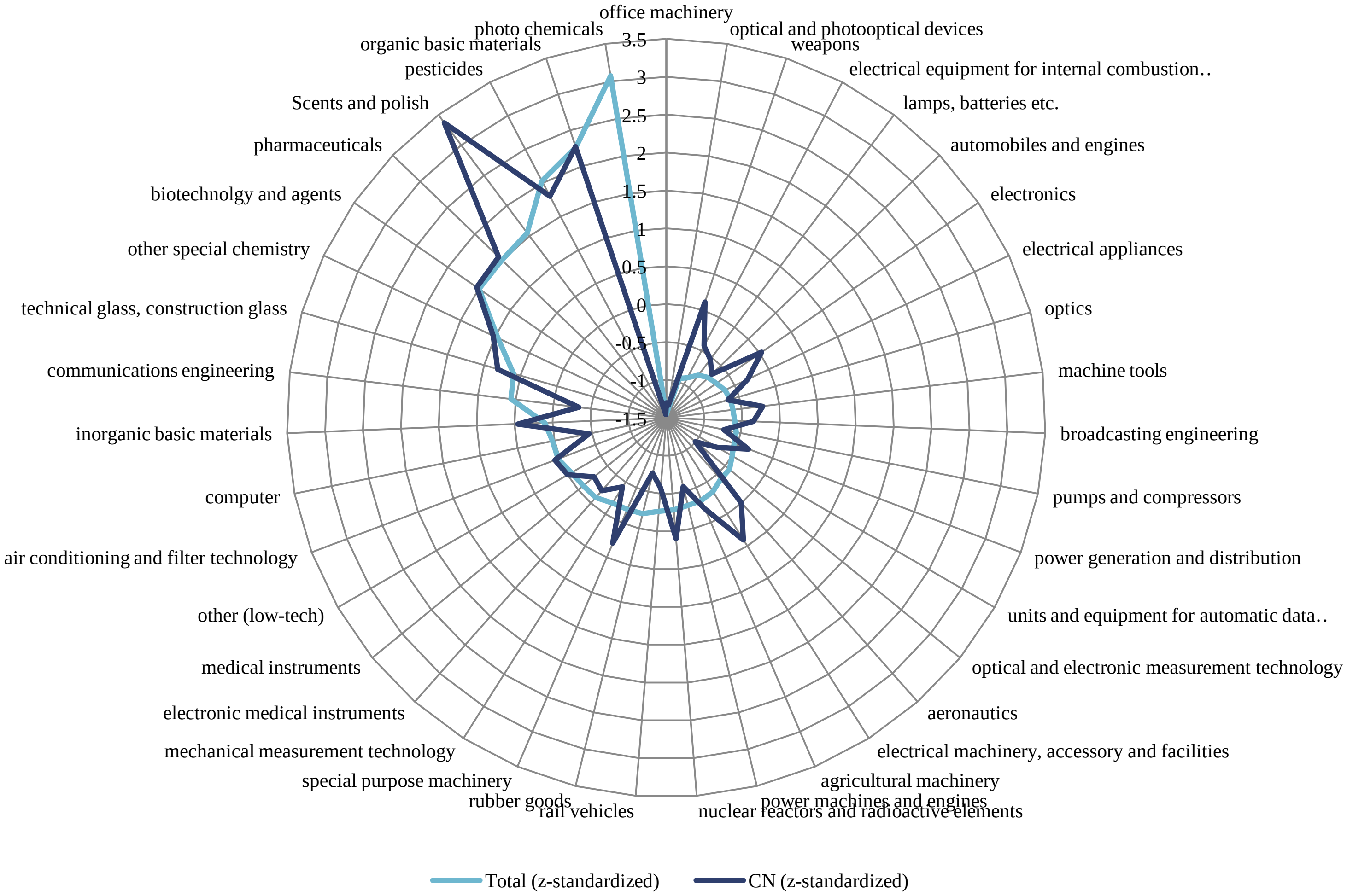
Source: EPO – PATSTAT; Fraunhofer ISI calculations

Figure 8: Differences in field-specific co-patenting trends, z-standardized values, total and US, 2011-2013



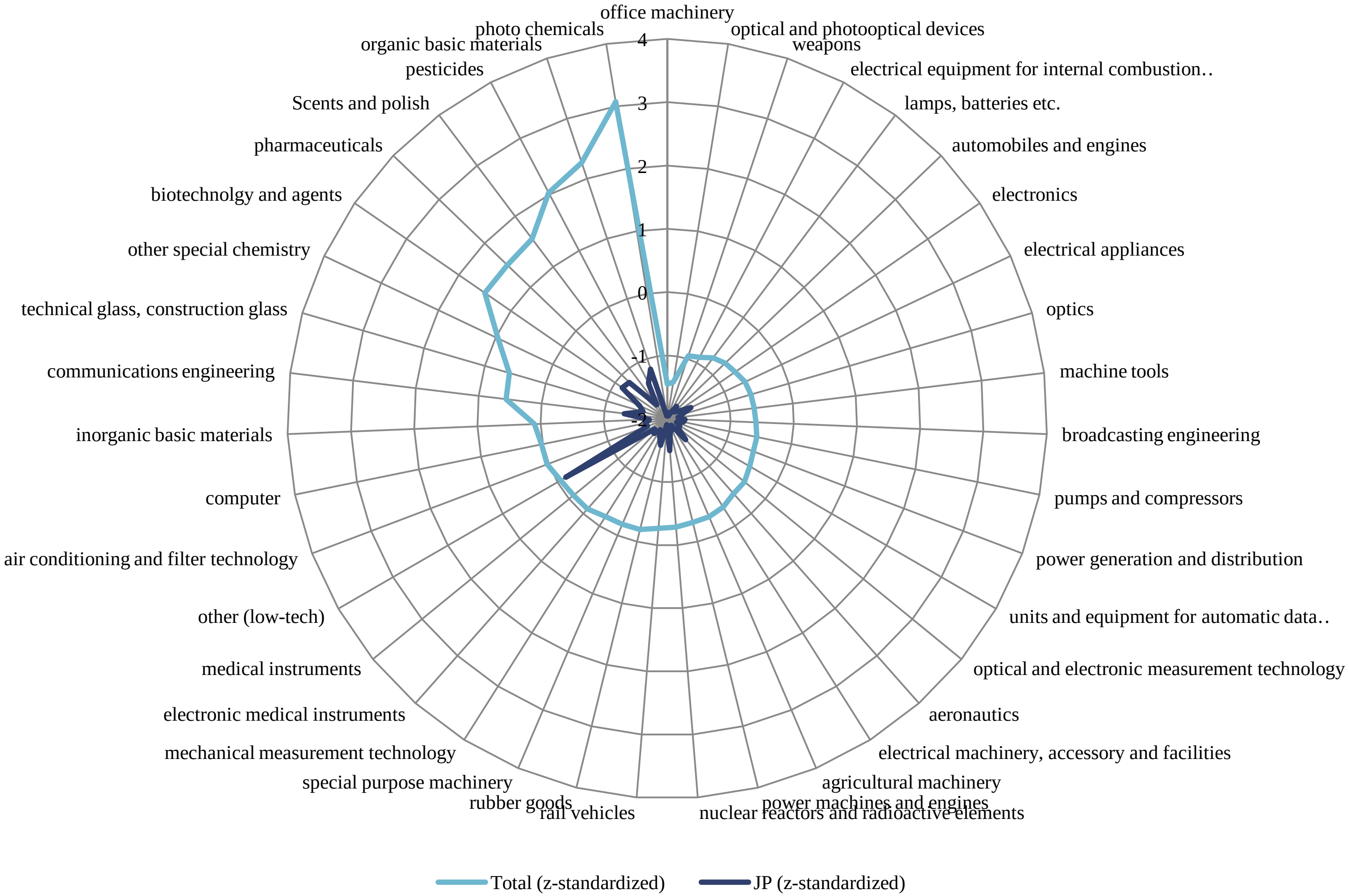
Source: EPO – PATSTAT; Fraunhofer ISI calculations

Figure 9: Differences in field-specific co-patenting trends, z-standardized values, total and CN, 2011-2013



Source: EPO – PATSTAT; Fraunhofer ISI calculations

Figure 10: Differences in field-specific co-patenting trends, z-standardized values, total and JP, 2011-2013



Source: EPO – PATSTAT; Fraunhofer ISI calculations

By now, we have only considered country-specific differences in international co-patenting. As discussed above, however, there are also field specific differences, which we will analyze in more detail below. Figure 6 first of all offers a general overview of the field specific trends in total transnational filings for Germany, the US, China and Japan. In detail, the field specific shares of co-patents of a given country in all transnational filings of the respective country are depicted. It therefore informs about cooperation trends within the given fields in the respective countries.

The first striking thing about the graph is that there are fields that are generally more cooperation intensive than others, i.e. all countries show comparably large shares of co-patents within these fields, whereas in other fields the cooperation intensity is generally lower. This implies that apart from country-specific differences, there are differences in co-patenting intensity with regard to the single fields. The fields that are comparably cooperation intensive across countries are "pesticides", a rather small field in terms of absolute patent numbers, "biotechnology and agents", "organic basic materials", "pharmaceuticals", "scents and polish", "photo chemicals", "other special chemistry", "communications engineering" and "technical glass, construction glass". Consequently, two different trends seem to apply here: the first one is related to chemistry, i.e. most of the chemistry related fields have a high cooperation intensity, while the second one has to do with the size of the fields, i.e. smaller fields in terms of absolute patenting figures are more cooperation-intensive. The argument here is basically the same as for country size. Since there are fewer national partners in smaller fields, international partners have to be found in order to generate innovative results that cannot be carried out without a partner, e.g. due to constraints in expertise, infrastructure etc.

With regard to the country-specifities across the fields, it can be found that Germany shows especially high shares of co-patents within the chemistry related fields, e.g. "pesticides", "organic-" as well as "inorganic basic materials", "pharmaceuticals" and "other special chemistry". The lowest shares can be found in the fields of "weapons", which, however, is true for all countries, "nuclear reactors and radioactive elements", "electrical equipment for internal combustion engines and vehicles" and "automobiles and engines". Germany thus cooperates mostly in chemistry and related fields and less so in the fields of mechanical engineering. Apart from the general trend of a higher cooperation intensity within chemistry, this is in line with the literature stating that companies tend to internationalize and cooperate particularly in the areas of their individual weaknesses to look for complementary technologies and knowledge (Belitz et al. 2006; Belitz 2012; Patel and Vega 1999).

Another fact that has to be kept in mind here, however, is that the values within this graph are not size-independent, i.e. they cannot be compared across, but only within countries. Since, for example, Germany has above average co-patenting shares, it also has higher field-specific shares compared to the total number of filings (at least for the majority of fields), while Japan, on the other hand, has lower shares. In order to correct for this effect, Figure 7 to Figure 10 show z-standardized values for the four countries in comparison to the total number of transnational filings. Here, we can observe which fields within a country are more or less cooperation-intensive compared to the worldwide average. In the case of Germany (Figure 7), the largest positive deviations from the worldwide average can be observed in the fields of "inorganic basic materials", "electronic medical instruments", "technical glass, construction glass", "other special chemistry" and "optics". Negative deviations, i.e. less co-patent filings than average, can be observed in "photo chemicals", "Scents and polish", "nuclear reactors and radioactive elements", and "weapons". In sum, it again becomes visible that Germany reaches high shares of co-patents in chemistry and related fields, while the shares are below average in fields related to mechanical engineering. For the US this picture is different (Figure 8). Here, most of the positive deviations from average can be found in the fields of "rubber goods", "office machinery, "inorganic basic materials" and "technical glass, construction glass", though most of the fields related to chemistry, including "pharmaceuticals" and "biotechnology and agents" are below average, while some of the fields related to electrical engineering and optics show above average values, implying that there are some fields related to electronics where the US is highly internationally cooperation-intensive compared to the worldwide average. In the case of China (Figure 9), high deviations from the average can be observed in "scents and polish", "weapons", "electrical machinery, accessory and facilities" and "electronics", while the largest negative deviations can be found in "photo chemicals", "communications engineering", "optical and electronic measurement technology" and "rubber goods". For Japan, the aforementioned trends can be confirmed. In all technology fields, Japanese co-patenting shares are below average. The fields where the values are closest to the average number of co-patents are "electrical appliances", "optical and photooptical devices", "office machinery" and "other (low-tech)".

4.3 Conclusions

Over the last twenty years, the shares of international co-patents have constantly increased, implying that the need to cooperate internationally has gained increased importance. Deviations from this pattern can only be found for the large Asian economies, i.e. China, Japan and Korea, where the shares have been decreasing in the last decade. Since 2007, however, stagnation in the share of worldwide co-patents can be observed, which has even led to a decrease in co-patenting shares in many countries in the recent years. While co-patenting figures are still stagnating in Germany, decreasing trends between 2011 and 2013 - apart from the Asian countries - can be found for the US, France and Great Britain as well the very cooperation intensive countries Switzerland and Sweden. In sum, however, it can still be stated that the European and North-American countries are more cooperation-intensive than the Asian countries.

The country-by-country trends reveal that the most important collaboration partner for Germany still is the US. Nearly 25% of all German co-patents are filed in cooperation with a US inventor. The next largest partners are Switzerland, France and Austria. US inventors, on the other hand, are most often cooperating with inventors from Germany, China, Canada and Great Britain, while the Chinese are very much oriented towards cooperating with a US partner, followed by Germany and Japan. In general, it can be observed that the US is the most favored cooperation partner worldwide. Germany scores second in this respect, implying a strong international position as a partner in innovation collaborations.

With regard to the country-specifities across the fields, it can be found that Germany shows especially high shares of co-patents within the chemistry related fields and less so in the fields of mechanical engineering. Apart from the general trend of a higher cooperation intensity within chemistry, this is in line with the literature stating that companies tend to internationalize and cooperate particularly in the areas of their individual weaknesses to look for complementary technologies and knowledge (Belitz et al. 2006; Belitz 2012; Patel and Vega 1999).

5 Patent Activities of the German Federal States

In the previous sections, we have discussed several patent related indicators at the international level. Now, we will take a more disaggregated look at the German patent filings, namely at the level of the German federal states (Bundesländer). We thereby aim to answer the question, which of the federal states contribute most strongly to the patent activities of Germany as a whole.

Economic, and thereby also innovative, activities are not equally distributed over geographical space. A regionalized patent statistic therefore allows us to take a closer look at the structural composition of the German innovation landscape. A further differentiation by technologies additionally enables the identification of regional technology clusters and shed more light on the technological strengths and weaknesses of the federal states. This, in turn, allows identifying regional technology trends, which is an important precondition for the composition and framing of regional innovation policies in Germany.

Analogous to the analyses at the international level, we will count transnational patent filings by federal states based on the inventor's address, i.e. a patent application is assigned to the federal state of the inventor.[3] We further apply fractional counting, so each federal state is only assigned a fraction of a patent in case inventors from other federal states are listed. For the identification of the German federal states in patent filings, we use the NUTS-code information available in the OECD REGPAT database, complemented with address information obtained from the German Patent and Trademark Office (DPMA). For filings that could not be assigned a NUTS code with the help of these two data sources, we resorted to the patent family information within the PATSTAT database. In the case that address information could be obtained from any other than the transnational filing, this address information was assigned to the transnational filing.

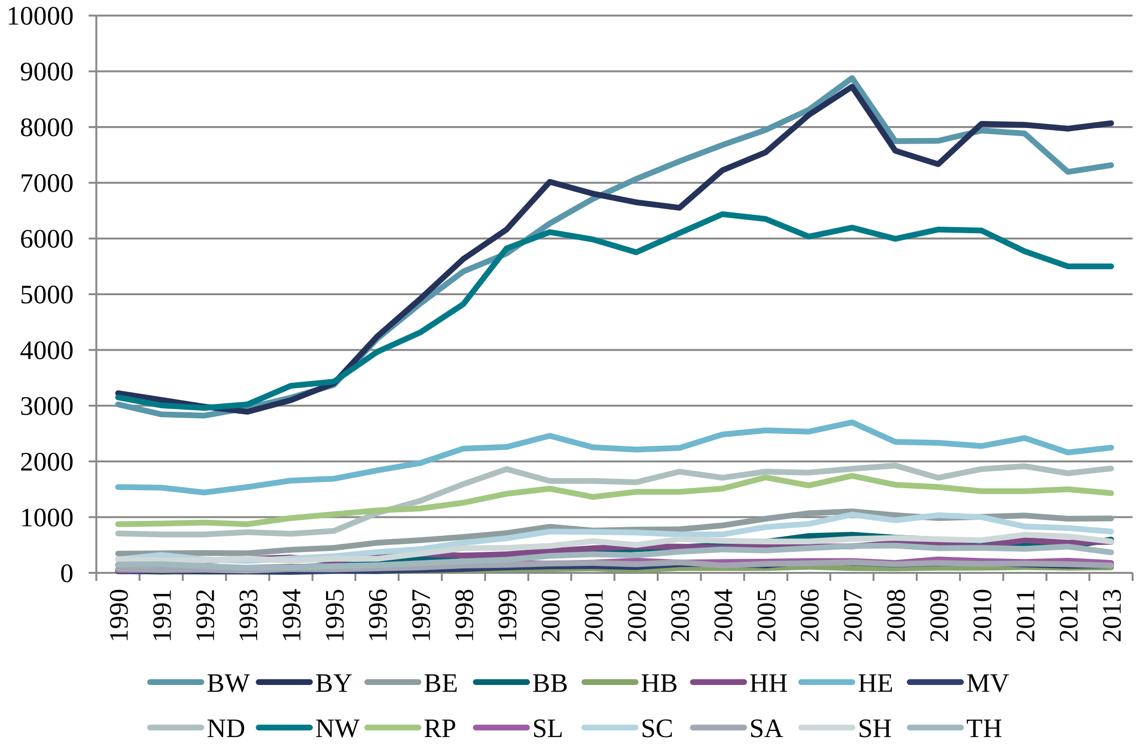
3 Due to the fact that employees cross regional borders when commuting to work, the differentiation by inventor and applicant country makes a difference for the profiles of the German federal states. This has been analyzed more deeply in earlier reports of this series (Neuhäusler et al. 2014).

5.1 Results

5.1.1 Structures and Trends

In Figure 11, the absolute numbers of transnational patent filings by federal state are plotted. Over the years, the number of filings is increasing for all German federal states. It is only recently that the filings have stagnated, or even decreased as for example in the case of North Rhine-Westphalia. In sum, however, it can be stated that the south of Germany has the largest number of transnational filings within the German comparison. Bavaria ranks first, with over 8,000 filings in 2013, followed by Baden-Württemberg (about 7,300 filings in 2013) and North Rhine-Westphalia at a slightly lower level (about 5,500 filings in 2013). These three federal states together are responsible for 75% of all German transnational filings. However, large parts of the German industry are located in these three federal states and about 51% of the German workforce is located there. At the fourth rank, with about 2,200 filings in 2011, is Hesse, followed by Lower-Saxony and Rhineland-Palatinate. The remainder of the federal states is at a similar level with less than 1,000 filings per year.

Figure 11: Number of transnational filings by federal states



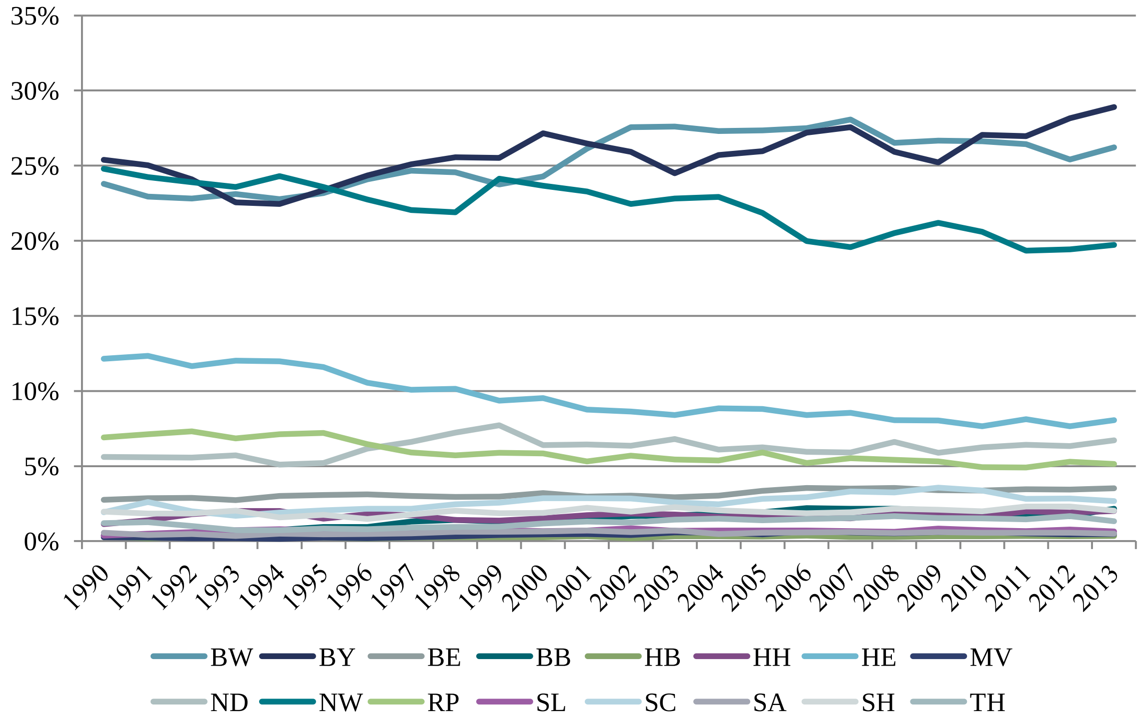
Source: EPO – PATSTAT; calculations by Fraunhofer ISI

Note: BW=Baden-Württemberg, BY=Bavaria, BE=Berlin, BB=Brandenburg, HB=Bremen, HH=Hamburg, HE=Hesse, MV=Mecklenburg-West Pomerania, ND=Lower-Saxony, NW=North Rhine-Westphalia, RP=Rhineland-Palatinate, SL=Saarland, SC=Saxony, SA=Saxony-Anhalt, SH=Schleswig-Holstein, TH=Thuringia.

Figure 12 shows the share of regional filings in total German filings. Here, it becomes even clearer how Baden-Württemberg, Bavaria and North-Rhine Westphalia dominate the number of filings within Germany. We can further observe that most Northern and Eastern German states score at the lower ranks when looking at absolute and proportionate number of filings. When looking at the single federal states it can be found that Baden-Württemberg and Bavaria have increased their filing shares over the years. The opposite, however, is true for North Rhine-Westphalia, Hesse and to a certain extent also Rhineland-Palatinate, where the shares are mostly decreasing over the years.

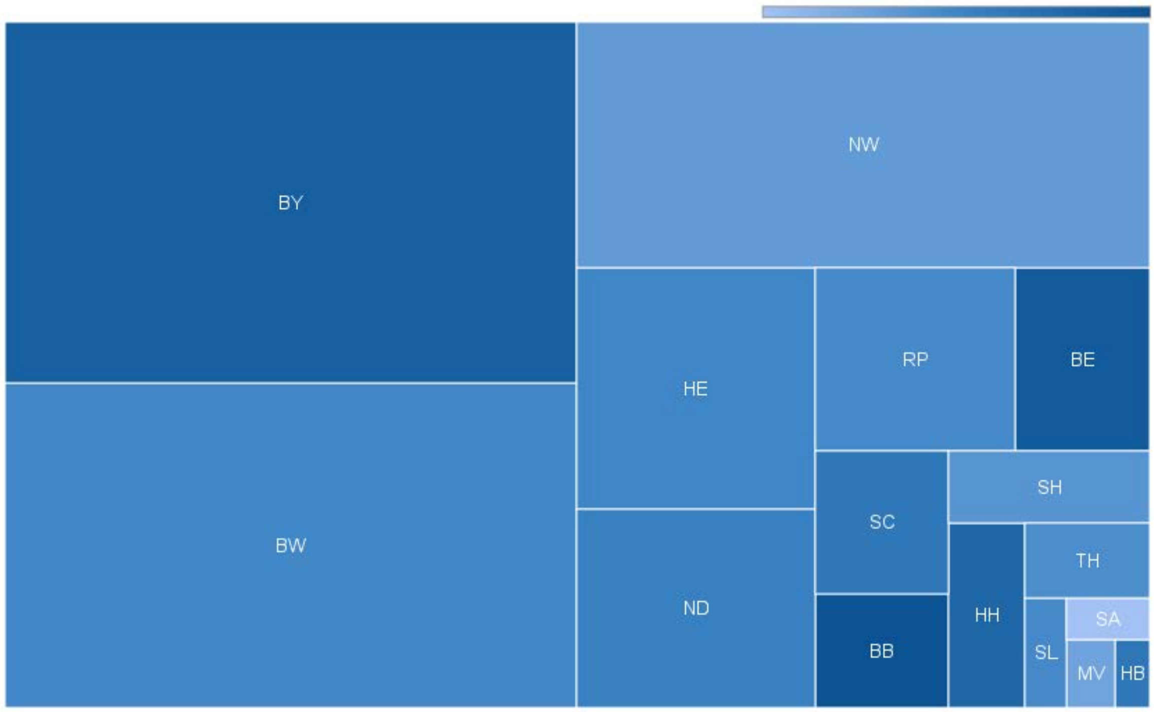
This might become clearer when looking at Figure 13, where the shares and growth rates of the filings of the German federal states are depicted in a tree map. The size of the boxes within the figures indicate the share of the respective federal states, the color indicates the growth rate between 2003 and 2013. Especially the growth rates since 2003 reveal several interesting results. First of all, we can see that there is only moderate growth between 2003 and 2013 for most of the federal states. The largest growth rates can be observed in Brandenburg, Berlin and Bavaria. It is thus two of the Northeastern countries that have managed to increase their amount of filings in the last decade. In Saxony-Anhalt, Mecklenburg-West Pomerania and North Rhine-Westphalia on the other hand, the growth rates are negative.

Figure 12: Share of regional filings in total German transnational filings



Source: EPO – PATSTAT; calculations by Fraunhofer ISI

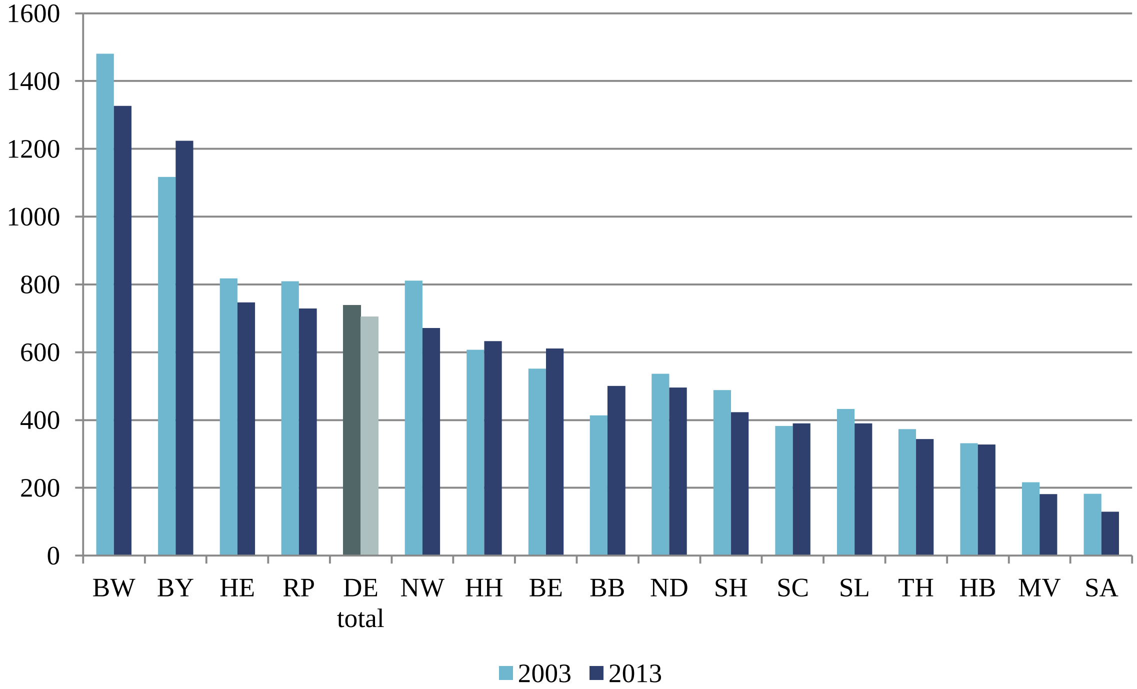
Figure 13: Tree map for the shares (in total German filings) and growth of regional filings, inventor principle, 2013



Source: EPO – PATSTAT; calculations by Fraunhofer ISI

Note: The size of the fields resembles the shares of a region in relation to total German transnational filings. The color (from light to dark) indicates the growth in the number of filings between 2003 and 2013.

Figure 14: Patent intensities per 1 million employees



Source: EPO – PATSTAT; calculations by Fraunhofer ISI

In Figure 14, the patent intensities, calculated as the number of patent filings by a federal state divided by the number of employees in the respective state, are plotted. It can be found that Baden-Württemberg and Bavaria also score first on this indicator, although Baden-Württemberg has lost some ground on this indicator since 2003. North-Rhine Westphalia, on the other hand, which scored third in absolute terms, loses ground and is located in the medium ranks, slightly below the German average, within this comparison. Hesse scores third, followed by Rhineland-Palatinate. These four federal states are the ones that have larger patent intensities than the German average, all other federal states are below average.

Finally, we take a closer look at the internationalization rates of the German federal states. The internationalization rate is calculated by dividing the number transnational filings by the number of filings that are targeted towards the German market, either via PCT, the EPO or via a direct filing at the German Patent and Trademark Office. It basically informs us, which share of patents is filed internationally, compared to the ones only filed in Germany. When looking at the figures (Figure 15), it becomes visible that the highest internationalization rates can be found for Brandenburg, followed by Rhineland-Palatinate, Hesse and Saxony. The less internationalized federal states in terms of patenting are Baden-Württemberg, Lower-Saxony, Bavaria and Thuringia.

Figure 15: Internationalization rate

Source: EPO – PATSTAT; calculations by Fraunhofer ISI

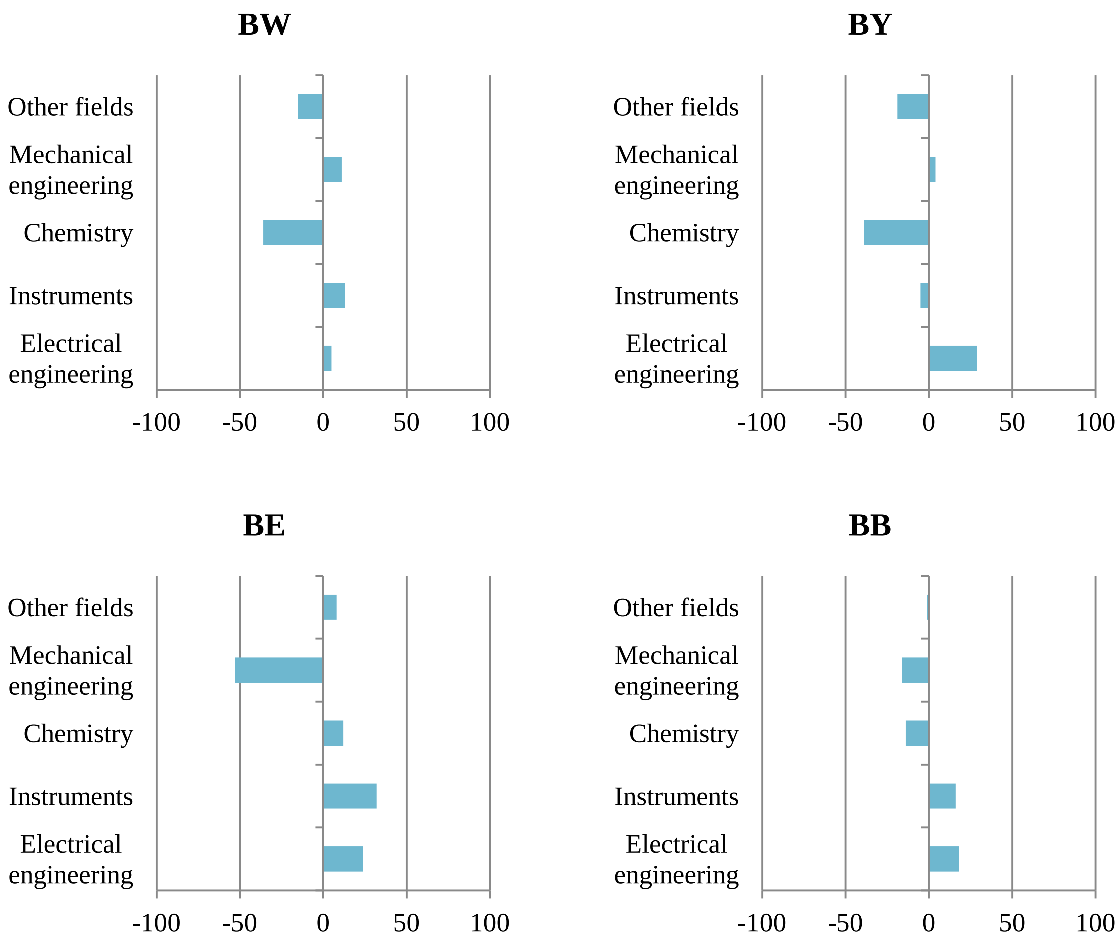
5.1.2 The technological profiles of the German federal states

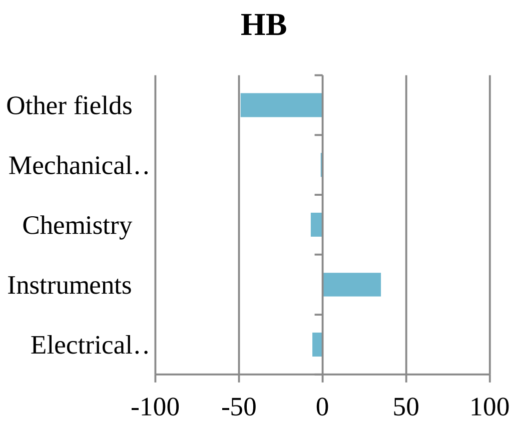
Within this subsection, the technological profiles of the German federal states are presented. They are calculated as specializations (RPA) of the respective federal state alongside an aggregate of the WIPO 35 technology field classification based on Schmoch

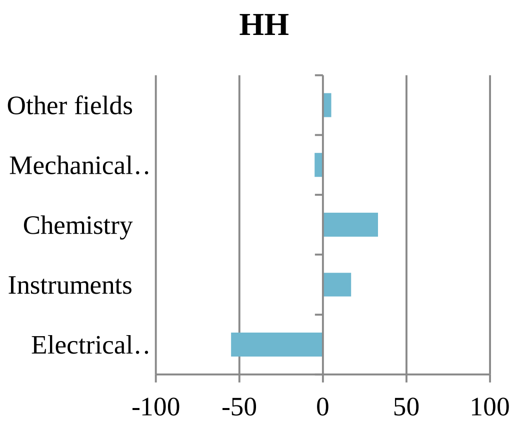
(2008). The baseline for the calculation are Germany's filings as a whole, i.e. positive signs mean that a technology field has a higher weight within the federal state than in Germany, while negative values show a below-average specialization. The technological profiles are provided in Figure 16.

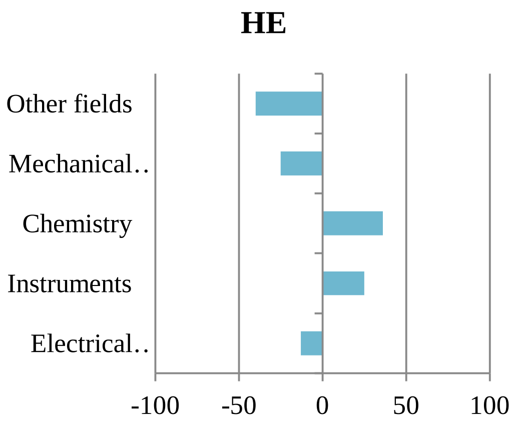
In the technological profile of Baden-Württemberg, the largest RPA values can be found in instruments and mechanical engineering, while also the field of electrical engineering shows a positive value. This implies that Baden-Württemberg has comparative advantages within these three fields, i.e. is specialized above the German average whereas disadvantages can mostly be observed in Chemistry as well as the residual "other fields" class. Bavaria's profile is similar to the one of Baden-Württemberg, yet the field of electrical engineering is more prominent than mechanical engineering and instruments.

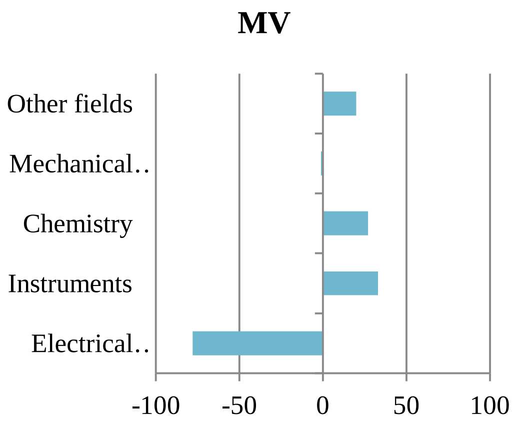
Figure 16: Technological profiles (RPA) of the federal states, 2011-2013

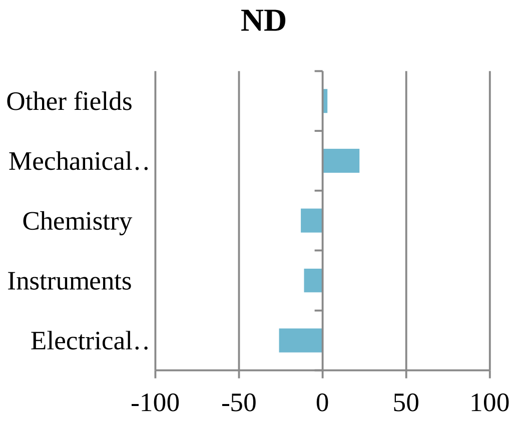


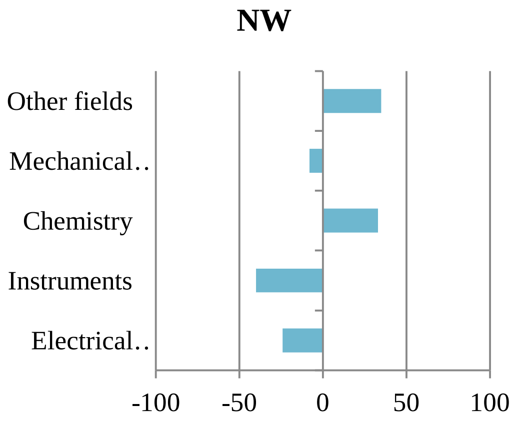

HB
Other fields
Mechanical..
Chemistry
Instruments
Electrical..
-100
-50
0
50
100

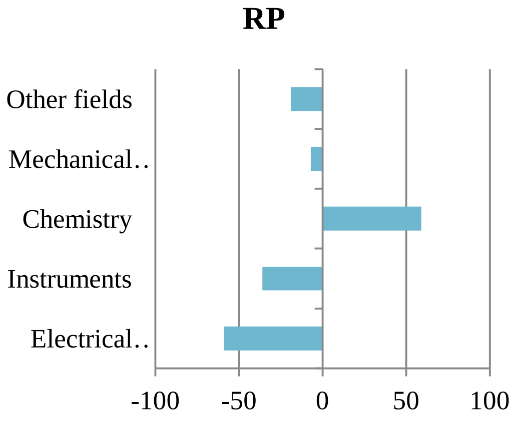

HH
Other fields
Mechanical..
Chemistry
Instruments
Electrical..
-100
-50
0
50
100

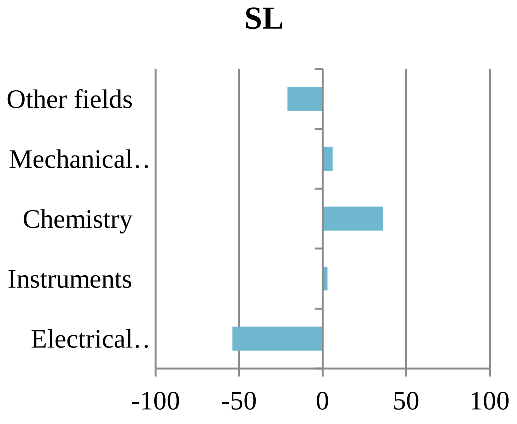

HE
Other fields
Mechanical..
Chemistry
Instruments
Electrical..
-100
-50
0
50
100

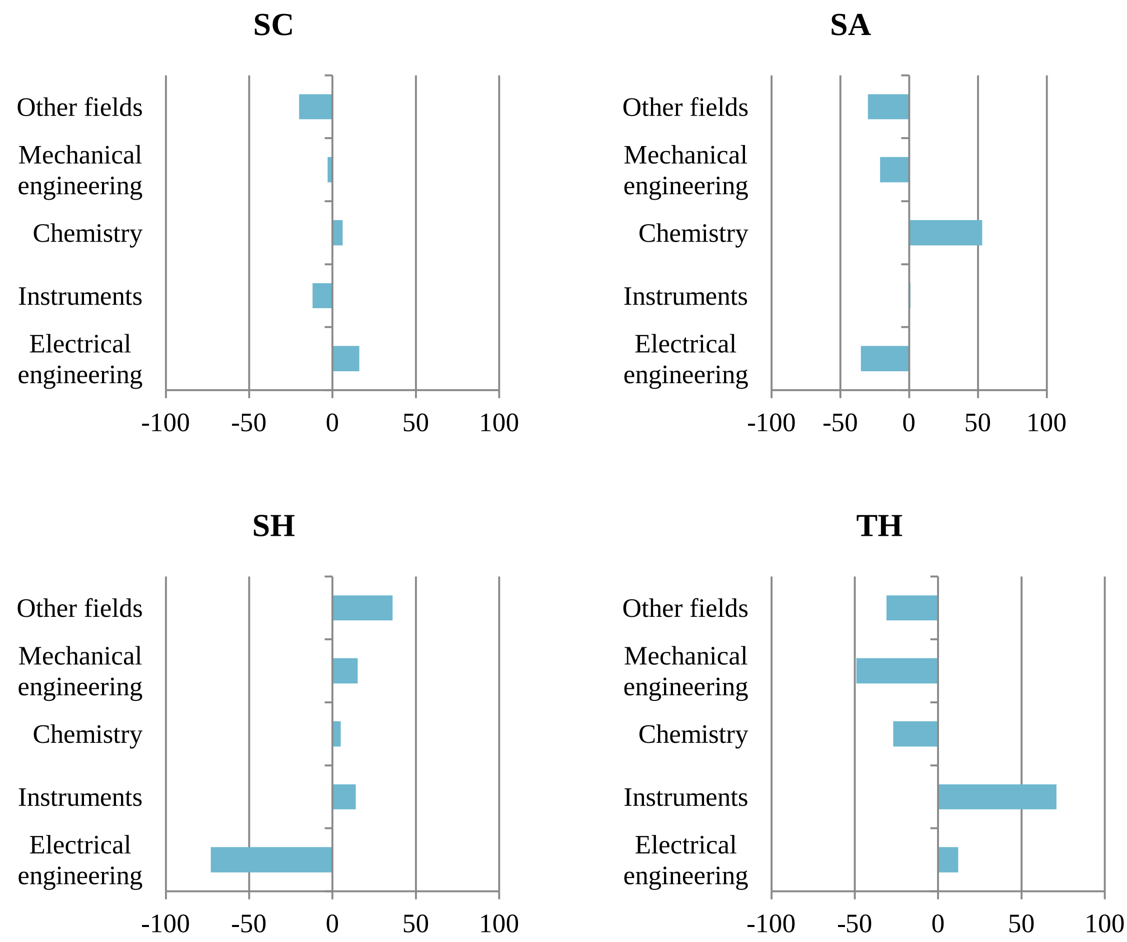

MV
Other fields
Mechanical..
Chemistry
Instruments
Electrical..
-100
-50
0
50
100


ND
Other fields
Mechanical..
Chemistry
Instruments
Electrical..
-100
-50
0
50
100


NW
Other fields
Mechanical..
Chemistry
Instruments
Electrical..
-100
-50
0
50
100


RP
Other fields
Mechanical..
Chemistry
Instruments
Electrical..
-100
-50
0
50
100


SL
Other fields
Mechanical..
Chemistry
Instruments
Electrical..
-100
-50
0
50
100



Source: EPO – PATSTAT; calculations by Fraunhofer ISI

Berlin, on the other hand, is not specialized in mechanical engineering. In fact, it is the only field where Berlin shows negative RPA values. The largest positive values can be found in instruments, followed by electrical engineering and chemistry. Brandenburg shows a rather balanced portfolio. A slight focus on electrical engineering and instruments can be observed, yet there are no larger negative nor positive peaks in Brandenburg's portfolio. In Bremen, a quite distinct specialization on instruments can be observed, while the RPA values in mechanical and electrical engineering as well as instruments revolve around zero. In the class of "other fields", Bremen shows the largest negative values.

In Hamburg, on the other hand, a quite clear focus on chemistry can be observed, which, however, might also be an effect of Hamburg's surrounding. North of Hamburg, chemistry parks are located, where firms like the Drägerwerk AG Co. KGaA, Johnson & Johnson Medical GmbH or AstraZeneca GmbH, are active. Yet, positive specialization values can be observed for the field instruments as well as "other fields". Quite large negative values can be found for electrical engineering. Here, other federal states have comparative advantages to Hamburg. The profile of Hesse is quite similar to Hamburg's profile, i.e. it is specialized in Chemistry and instruments. In electrical engineering, the specialization values are less negative, yet negative values can also be found in mechanical engineering as well as "other fields". Mecklenburg-West Pomerania is also most specialized in chemistry and instruments, which to a certain extent once again resembles Hamburg's profile. Lower-

Saxony, on the other hand, is quite highly specialized in the field of mechanical engineering, which reminds more of the profiles of Baden-Württemberg and Bavaria. The specialization profile of North Rhine-Westphalia is strongly focused on chemistry, followed by "other fields". The focus on Chemistry can also be observed for Rhineland-Palatinate that can mostly be attributed to the BASF AG, one of the largest German patent applicants.

The technological profile of the Saarland is similar to the profile of Rhineland-Palatinate, although less strongly focused on chemistry. In Saxony, on the other hand, the profile is very balanced across all technology fields, i.e. no very positive specialization values can be observed, yet there are also no extremely negative ones. The adjacent Saxony-Anhalt has a completely different structure with a focus set clearly on chemistry. Schleswig-Holstein shows positive specialization values in "other fields", mechanical engineering, instruments and chemistry, which comes at the expense of a comparably low specialization in electrical engineering. Finally, Thuringia is the only federal state with a very clear focus on instruments, especially, which can mostly be attributed to the Carl Zeiss Group, which operates many facilities and subsidiaries in Jena.

5.2 Conclusions

In this section, we have provided regionalized patent statistics for the German federal states. The results show that the south of Germany, especially Bavaria and Baden-Württemberg, file the largest number of patents at the transnational level, and, together with North-Rhine Westphalia, account for about two thirds of the German transnational filings, while accounting for only about the half of the employees in Germany. Baden-Württemberg and Bavaria also show the highest patent intensities within Germany, while the Northern and Eastern German states score at the lower ranks. In terms of growth rates, it can be found that there is only moderate growth between 2003 and 2013 for most of the federal states. The largest growth rates can be observed in Brandenburg, Berlin and Bavaria. It is thus two of the Northeastern countries that have managed to increase their amount of filings in the last decade.

In terms the internationalization rates of the German federal states it becomes visible that the highest internationalization rates can be found for Brandenburg, followed by Rhineland-Palatinate, Hesse and Saxony. The less internationalized federal states in terms of patenting are Baden-Württemberg, Lower-Saxony, Bavaria and Thuringia. Finally, disaggregating the statistics by technology fields offered technology profiles of the German "Bundesländer". The German focus on mechanical engineering is clearly resembled in the profiles of its federal states. The southwestern parts of Germany show a more strict focus on mechanical engineering, while in the Northeastern parts of Germany chemistry seems to play a larger role.

6 Patenting Trends in Public Research

Scientific achievements are usually published in journals, which enables other researchers to access and eventually cite them if they deem them appropriate for their own research (Michels et al. 2013). However, also patent filings can be seen as a major output of R&D activities of universities. They more directly indicate the technological output of research organizations, i.e. universities and public research organizations (PROs), than publications and can thus be used to assess this output. Since patents indicate an interest in the commercial exploitation of a new finding or a new technology (Schmoch 1997), they are more strongly focused on measuring an orientation towards the technological application of a given invention compared to the publication of scientific results in journals. Employing patent statistics to assess the performance of German universities and PROs thus enables us to draw conclusions about their technology-oriented research output.

Especially knowledge and technology transfer from universities has been seen as an important approach towards the modernization of economic structures and the promotion the economic dynamics (Achleitner et al. 2009; Crespi et al. 2011; Egeln et al. 2007). One step aimed to foster this development in Germany and to promote patent filings from universities has been seen in abolishing the traditional professor's privilege (Hochschullehrer-privileg) in 2002, where the individual ownership of academic patents was replaced by a system of institutional ownership by the universities (Blind et al. 2009; Geuna and Rossi 2011; Schmoch 2007).

Despite quite extensive policy actions, still a large share of patent filings from universities is registered by companies and the university staff only appears as an inventor. This might happen in cases where external R&D of companies is carried out by universities or in the case of university-industry collaborations. This implies, however, that simply analyzing patents filed by universities falls short of capturing the "real" share of patents coming out of universities. In the last years, several approaches to solve this problem haven been applied, e.g. by searching for academic titles (PROF, etc.) on patents Schmoch (2007) or using staff lists of universities and match them with the names of inventors listed on patents by Thursby et al. (2009) and by Lissoni et al. (2008). The approach applied here follows the idea of checking the names of scientific authors, thus research-active university staff, and inventors named on patents.

Within this section, we will take a look at the trends in patent filings by public research in Germany. We will take the applicant's perspective and analyze trends in patents filed by universities as well as the four large public research institutes in Germany, i.e. the Max Planck Society, the Fraunhofer Society, the Helmholtz Association and the Leibniz Institutes. The patents owned by universities and Public Research Organizations were identified within the PATSTAT database with the help of a keyword search, including the names of the universities and PROs with different spelling variations and languages as well as a search for the names of the respective cities, also including spelling variations and languages. In the case of the Technical University of Munich, for example, patents are filed under the names "TECHNICAL UNIVERSITY OF MUNICH", "TECHNISCHE UNIVERSITAET MUENCHEN", or "TU MUENCHEN".

In the second part of the analysis, we will focus on academic patents in order to provide a more complete picture of the trends in academic patenting. As already discussed, frequently, the university is not named on the filing as a patent applicant. A simple count of the patents, for which the university is named as the applicant thus provides only a limited picture of the patent output from universities (Dornbusch et al. 2013; Lissoni et al. 2008). We will therefore apply the extended perspective of "academic patents", which – besides the patents where universities are named as patent applicants – also takes university inventors into account, even in the case a patent was filed by a company. Thus, patents filed by universities constitute a sub-sample of academic patents.

6.1 Academic patents: The identification of patents from universities and public research institutions

The approach for the identification of the whole set of academic patents, including university-invented patents, is based on the examination of name matches of authors of scientific publications from the Scopus database and inventors named on a patent filing. Publications list the authors' affiliation and enable us to identify academic inventors and the patents they have contributed to. Within this year's report, we for the first time do not only identify academic patents for universities but also for the public research institutes, to find out whether the effect described for universities can also be found for the PROs.

Based on a keyword search and manual correction, the German universities as well as public research organizations were identified within Scopus. The author-/inventor names from these two tables are matched and, to ensure a high precision, complemented with additional selection criteria, especially to avoid homonyms, i.e. different persons having identical names. A more detailed description of the name matching and its validation can be found in Dornbusch et al. (2013).

For the evaluation of the algorithm a *recall* and *precision* analysis has been applied (Baeza-Yates and Ribeiro-Neto 2011).The recall was estimated using a benchmark (gold standard) set of 200 author/inventor records.[4] The *precision* of the algorithm was validated by an online-survey covering authors for whom academic patents have been identified.[5] Due to the large datasets with imperfect data, 100% for both recall and precision are impossible. However, in order to obtain the best fit between the two, the F-score[6] was calculated, which represents the harmonized mean between recall and precision. However, as a concession to high precision we have to accept a reduced recall, i.e. the retrieved results are

4 Recall: CR/(CR + CM), where CR is Correct Recall and CM is Correct Missing (error type I or false negative); Precision: CR/(CR + IR), where IR is Incorrect Recall (errors type II or false positive).

5 The survey addressed 1681 persons with 2782 patent applications at the German patent office. 435 exploitable answers amounting to 678 patents have been received, equaling a response rate of 26%.

6 F-Score: $F_ß = (1+ß^2)\ (p*r)/(ß^2*p*r)$; p = precision = tp/(tp+fn) and r = recall = tp/(tp+fp) where tp means true positive, fn false negative and fp false positive.

likely to underestimate the amount of academic patents and our results so to say are only able to reflect a lower-bound estimate of academic patents.

To give us at least an indication about how strongly the university patents are underestimated, we have performed an additional analysis with the help of Scopus data for selected German universities. The estimations show that about 75% of the researchers at the Faculty for Chemistry and Pharmacy at the LMU Munich at least have published one article between 1996 and 2010. This share lies at 85% for the Faculty of Electrical and Computer Engineering at the TU Dresden, 73% for the Faculty of Electrical and Computer Engineering at the RWTH Aachen and 80% at the Department of Mechanical Engineering at the TU Darmstadt. In sum, these results show that about 20% to 25% of all researchers at the given universities do not publish and thus also are not covered by our algorithm. In case these researchers file patents, this would lead to an underestimation of academic patents. However, in most cases groups of inventors are named on patent applications. In case a member of the group has published a scientific paper, the patent could still be found by the algorithm. In addition, it can be assumed that researchers that do not publish might belong to the group of technical personnel, so they might also not be actively patenting. All in all, it still has to be kept in mind that the number of academic patents is underestimated. However, it can be assumed that this underestimation is rather limited in terms of absolute filings. Furthermore, the shares of non-publishing researchers are similar across universities, meaning that potential biases are not systematic.

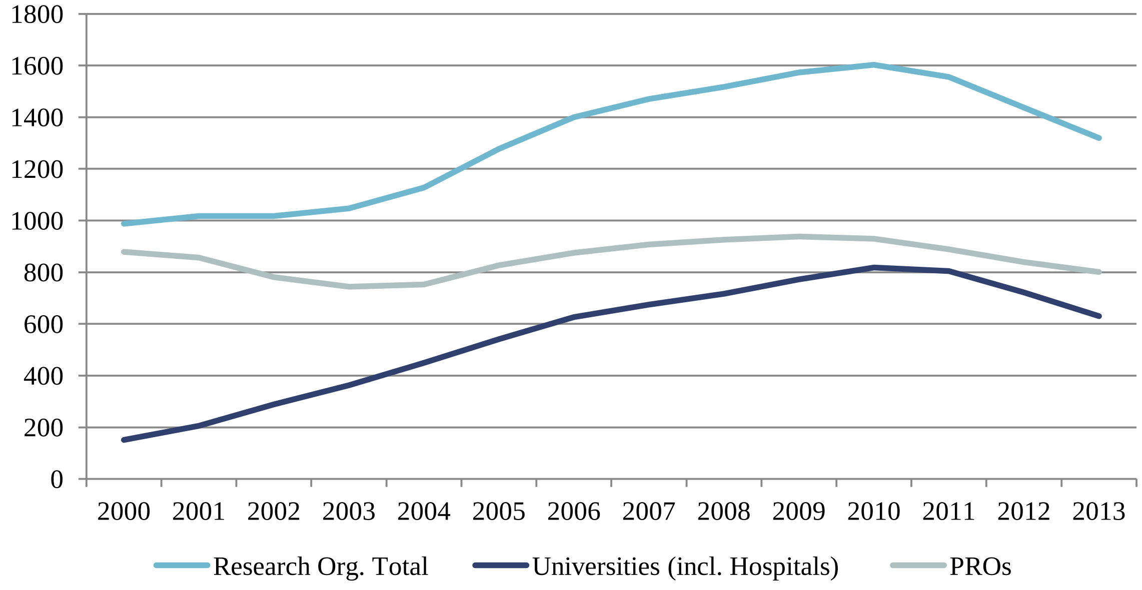
However, the number of academic patents is slightly higher for all analyzed years compared to the report from last year's series. This has to do with the fact that the most recent version of Scopus (version 2015) was used for the matching, which has a better coverage of scientific journals (across all years) and research organizations in general.

6.2 Results

6.2.1 The Applicant Perspective

In Figure 17, the number of patents filed by research organizations in total (universities + PROs), as well as differentiated by universities and public research organizations, is depicted. Up to the year 2010, the filings number of PROs and especially universities are increasing, implying that patenting has become more and more important for universities and PROs over the last 10 years. The larger growth rates for universities can at least partly be attributed to the abolishment of the Hochschullehrerprivileg in 2002. This has led to a convergence in the number of filings from PROs and universities in the last few years.

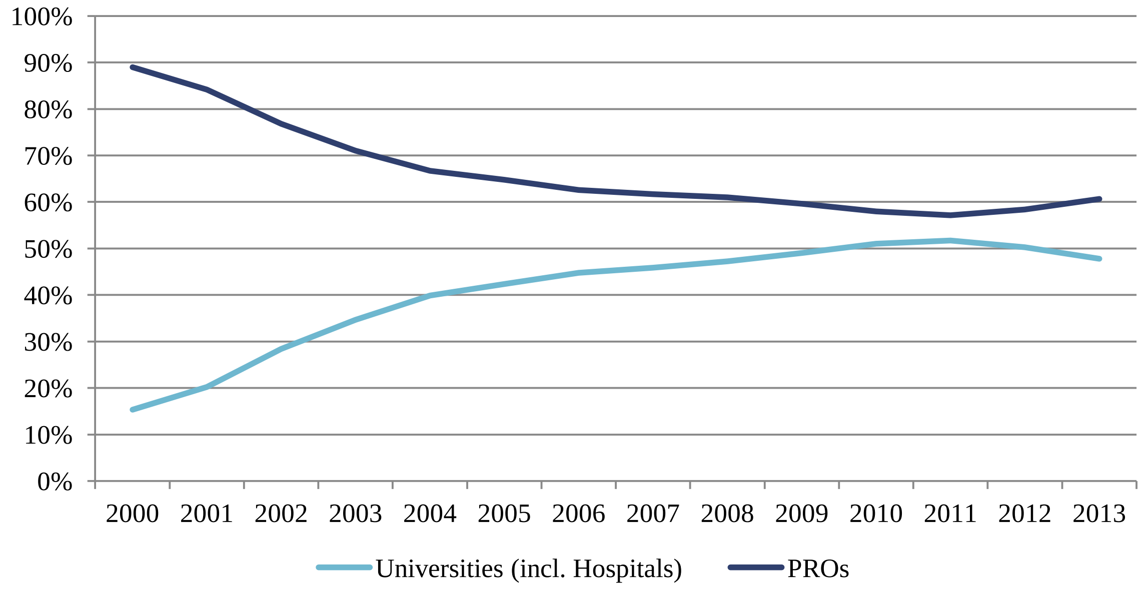
Figure 17: Number of transnational filings by German research organizations (3-years moving average)



Source: EPO – PATSTAT; calculations by Fraunhofer ISI

Since 2010, however, a decline in the number of filings by universities and PROs can be observed. This has several explanations: first, it follows the general trend of stagnating and even slightly decreasing transnational filing figures of Germany. Second, it is especially an effect of a decrease in international filings by universities and PROs. When looking at the German Patent and Trademark Office (DPMA) (not shown), it can be observed that the filings for universities as well as PROs only slightly decreased after 2010.

Figure 18: Shares of filings by universities and public research institutes in all filings by research organizations (3-years moving average)



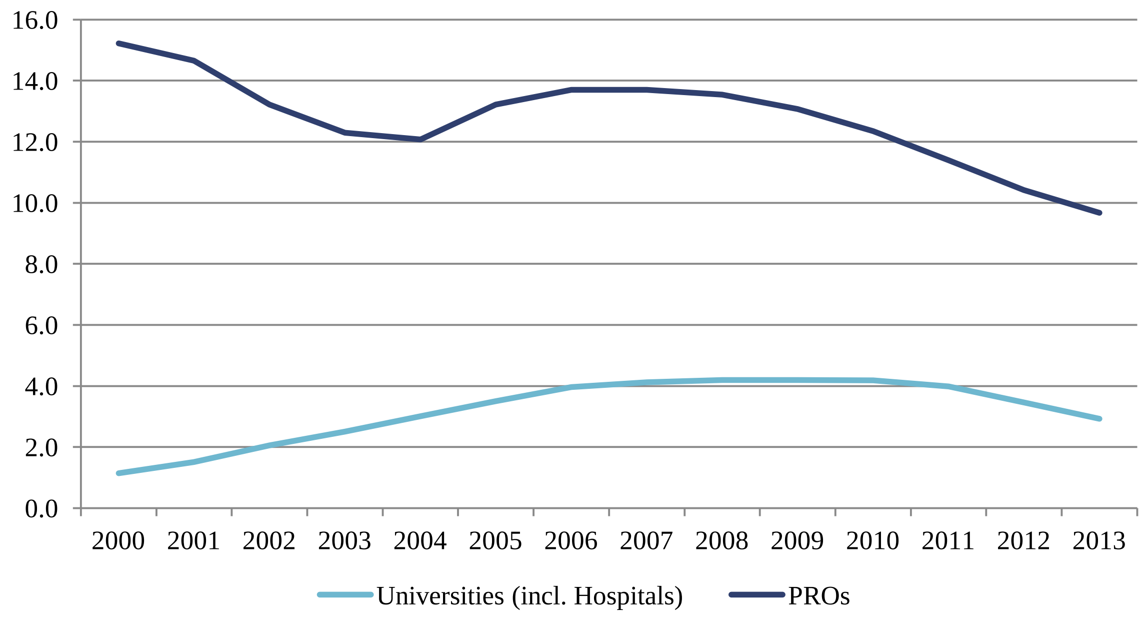
Source: EPO – PATSTAT; calculations by Fraunhofer ISI

Note: The sum of patents filed by universities and public research institutes might exceed 100% in certain years due to cooperative patent filings between universities and PRO.

These trends are also resembled in the shares of filings by universities and public research institutes in total filings by German research organizations (Figure 18). Until the 2000s, the lion's share of filings from public research came from PROs, which has changed in the last ten years. Nearly half of all filings from public research are now filed by universities, with a major growth of these shares from the year 2000 onwards. Due to the fact that university filings declined faster than PRO filings in the last two years, however, we once again can observe an increasing share of PRO filings since 2011.

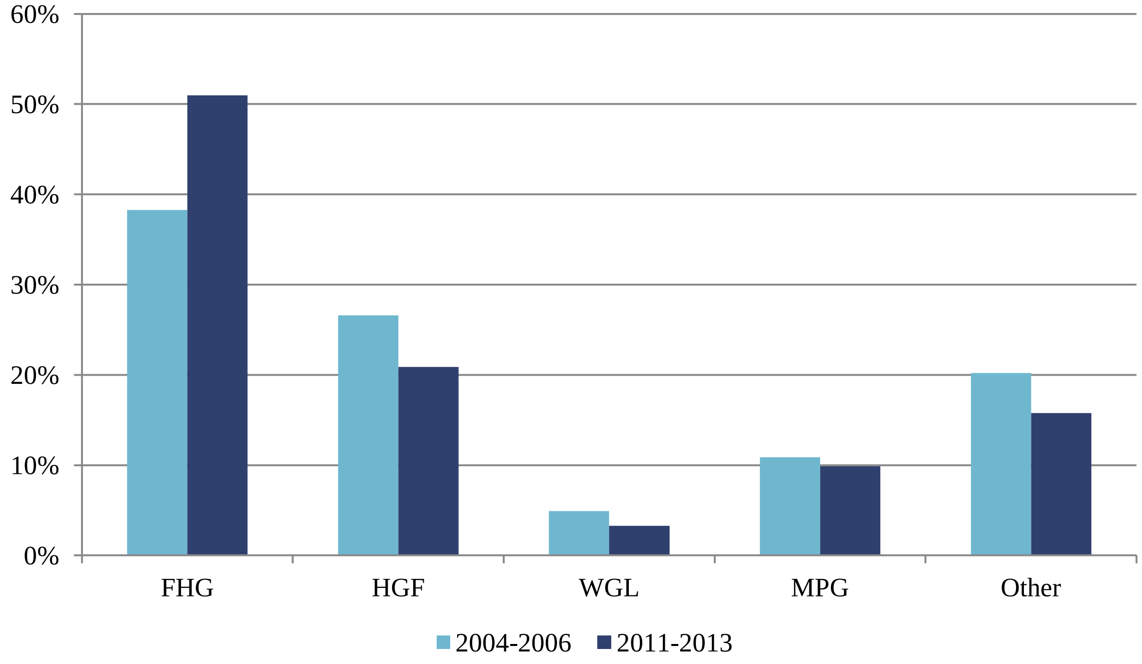
These trends are also reflected in the patent intensities, i.e. the number of transnational patent filings per 1,000 R&D employees (full-time equivalents), of universities and PROs. Especially in the recent years, the patent intensities have been decreasing, which is due to the fact that patent filings have declined while the number of R&D employees has increased. Though the patent intensities of universities have risen in the course of the 2000s, PROs are still far more patent intensive. In PROs on average 9.7 patents are filed per 1,000 employees, while this figure only lies at 2.9 for the universities. Yet, this is mostly driven by the fact that PROs, especially the Fraunhofer Society, but also the Helmholtz Association and some of the Leibniz Institutes, are more focused on applied research, which explains the high patent intensity compared to universities.

Figure 19: Patent intensities (patents per 1,000 employees, full-time equivalents) by German research organizations (3-years moving average)



Source: EPO – PATSTAT; BMBF Datenportal Table 1.7.6 and 1.7.9, calculations by Fraunhofer ISI

Figure 20: Shares of filings by public research organizations in all PRO filings (3-years moving average)



Source: EPO – PATSTAT; calculations by Fraunhofer ISI

Table 5: Patent filings and patent intensities by university applicants

	Transnational Filings		Intensities (per 1.000 R&D employees, FTE)	
	2004-2006	2011-2013	2004-2006	2011-2013
Universitaet Freiburg (i.Br.)	140	171	9,4	7,9
Universitaet Erlangen-Nuernberg	58	161	3,9	7,0
Technische Universitaet Dresden	58	116	3,9	5,7
Karlsruher Institut fuer Technologie	133	113	15,0	9,6
RWTH Aachen	43	105	3,0	5,3
Technische Universitaet Muenchen	50	103	3,3	4,3
Medizinische Hochschule Hannover	48	90	12,6	13,2
Universitaet Heidelberg	33	89	2,0	3,4
Charite - Universitaetsmedizin Berlin	152	88	11,7	6,7
LMU Muenchen	66	77	3,8	2,8
Technische Universitaet Berlin	30	77	2,6	5,7
Universitaet Muenster	30	76	2,1	3,9
Technische Universitaet Darmstadt	20	64	3,0	6,9
Universitaet Tuebingen	62	56	5,2	3,3
Universitaet Bonn	27	54	2,2	3,2
Universitaet Hamburg	36	49	2,3	2,5
Universitaet Mainz	60	49	5,0	3,0
Universitaet Jena	11	45	1,1	3,2
Universitaet Stuttgart	34	45	3,1	3,4
Universitaet Kiel	33	36	2,5	2,5
Universitaet Leipzig	14	36	1,2	2,3
Universitaet Bremen	33	29	5,5	3,9
Universitaet Dortmund	14	29	2,2	3,5
Universitaet Giessen	18	28	1,6	2,1
Universitaet Rostock	28	28	4,6	3,3
Universitaet des Saarlandes	16	26	1,7	2,7
Universitaet Goettingen	45	25	4,3	1,7
Universitaet Marburg	33	25	5,6	3,2
Universitaet Hannover	17	23	2,1	2,3
Technische Universitaet Ilmenau	15	22	6,3	6,4
Universitaet Regensburg	25	22	2,8	1,6
Universitaet Wuerzburg	26	22	2,2	1,3
Universitaet Duesseldorf	13	20	1,5	1,8
Humboldt Universitaet Berlin	29	19	3,4	1,8
Technische Universitaet Hamburg-Harburg	15	19	8,0	6,1
Technische Universitaet Bergakademie Freiberg	6	18	2,7	4,5
Universitaet Duisburg-Essen	28	17	2,9	1,1
Brandenburgische Technische Universitaet Cottbus	14	16	6,4	4,6
Universitaet Frankfurt a.M.	17	16	1,6	1,1
Universitaet Koeln	6	16	0,5	0,9
Technische Universitaet Braunschweig	26	15	3,4	2,1
Universitaet Kassel	24	15	4,4	1,9
Universitaet Konstanz	14	15	3,5	2,9
Universitaet Magdeburg	9	14	1,5	1,8
Universitaet Ulm	9	12	1,4	1,6
Universitaet Bayreuth	4	11	1,0	2,1
Universitaet Potsdam	5	11	1,0	1,2
Universitaet Bielefeld	4	10	0,7	1,3
Technische Universitaet Kaiserslautern	8	9	2,4	1,7
Universitaet Greifswald	12	9	2,6	1,4
Ruhr-Universitaet Bochum	6	8	0,6	0,6
Technische Universitaet Chemnitz	7	8	1,9	1,2
Universitaet der Bundeswehr Hamburg	5	7	7,4	5,4
Universitaet Halle	4	7	0,4	0,7
Technische Universitaet Clausthal	11	6	6,5	2,8
Universitaet Augsburg	3	5	0,9	0,8
Universitaet Luebeck	5	5	3,6	6,8
Universitaet Hohenheim	0	4	0,0	1,1
Universitaet Wuppertal	2	4	0,6	0,7
Universitaet Paderborn	8	3	2,3	0,6
Universitaet Siegen	4	2	1,0	0,4
Universitaet der Bundeswehr Muenchen	0	1	0,0	0,3
Universitaet Osnabrueck	4	1	1,1	0,2
Universitaet Bamberg	0	0	0,0	0,0
Universitaet Hildesheim	0	0	0,0	0,0
Universitaet Koblenz-Landau	2	0	0,7	0,0
Universitaet Lueneburg	0	0	0,0	0,0
Universitaet Mannheim	2	0	0,5	0,0
Universitaet Oldenburg	5	0	1,4	0,0
Universitaet Passau	0	0	0,0	0,0
Universitaet Trier	0	0	0,0	0,0

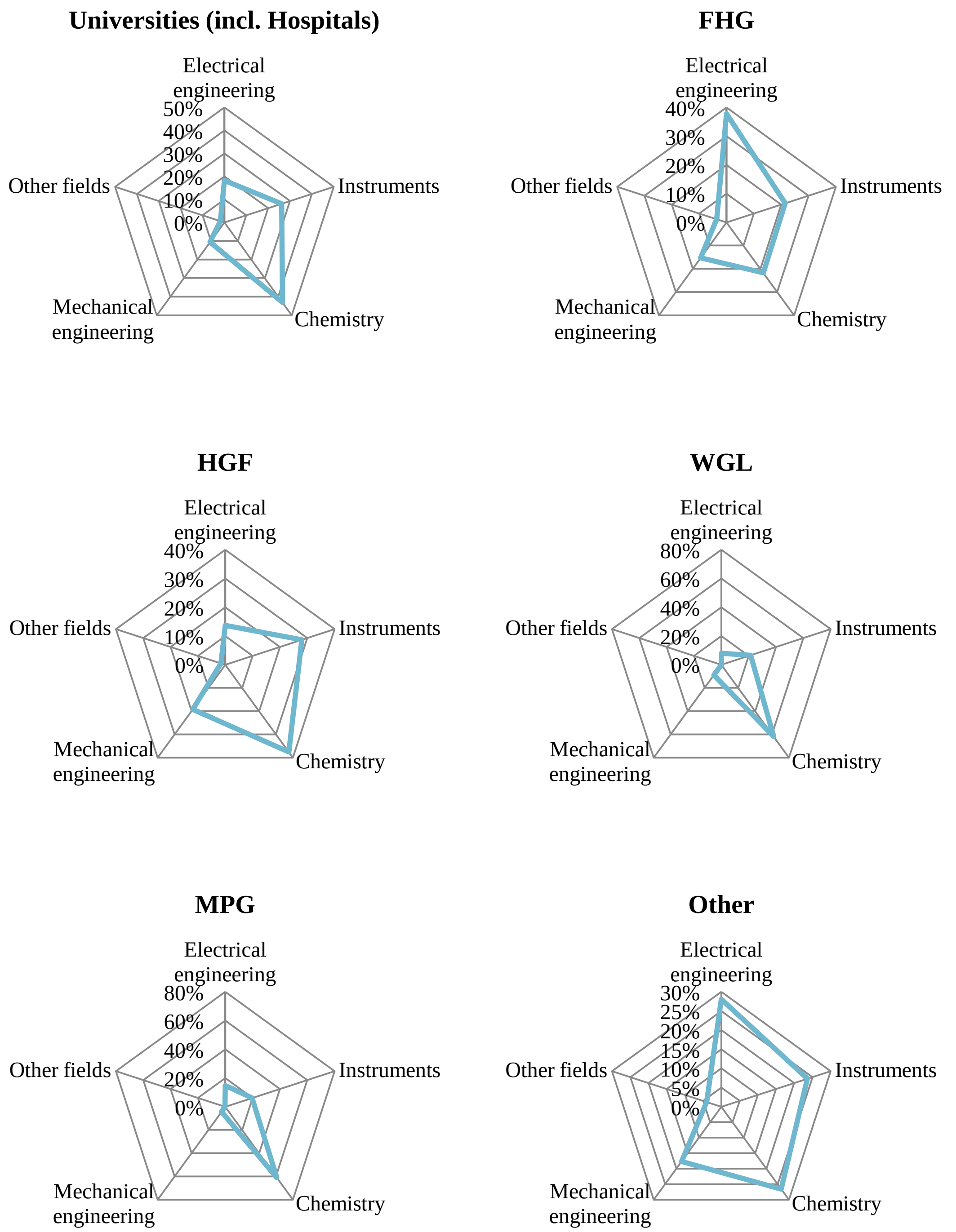
Source: EPO – PATSTAT; Statistisches Bundesamt, Fachserie 11, Reihe 4.4, calculations by Fraunhofer ISI

This is also reflected in the shares of patents by the individual public research organizations in all PROs (Figure 20). Here, it can be found that the Fraunhofer Society is responsible for the largest share of patent filings within the comparison of the public research institutes. This is as expected, as the Fraunhofer Institutes are focused on applied research and their role within the German science system is to serve as a link between basic research and its application in industry. However, we can observe a further concentration of patent filings in the Fraunhofer Society over the years. In the recent years, the Fraunhofer Institutes were responsible for 51% of all PRO filings, while this share only equaled 38% between 2004 and 2006. The second largest PRO in terms of patent filings is the Helmholtz Association, whose role is to pursue more long-term oriented research, with a share of 21% and the "other research institutes" with a share of 16%. The shares of the Max-Planck Society, which is rather strongly focused on basic science within Germany, have only slightly decreased between these two time periods. Finally, the Leibniz Society is smallest in terms of patent filings and is in the recent years only responsible for 3% of the patent filings by PROs.

Besides the PROs, we also take a closer look at the patent intensities of the single universities. Their filing figures are provided in Table 5. The University of Freiburg files the largest number of patents between 2011 and 2013, followed by the University of Nuremberg, the Technical University of Dresden, the Karlsruhe Institute of Technology (KIT) and the RWTH Aachen. These universities also score highest in terms of patent intensities. However, also some smaller universities in terms of patent filings reach high patent intensities, e.g. the Hannover Medical School, the Technical University of Darmstadt and the University of Luebeck.

Finally, we will analyze the technological profiles of universities and the single PROs (Figure 21). With regard to universities, it can be found that by far the largest shares (43%) of filings are made within the field of chemistry. It is followed by instruments with a share of 26%, electrical engineering (18%) and mechanical engineering (11%). Within the "other fields", however, the share of university filings is very low (2%). The Fraunhofer Society, on the other hand, has a large focus on electrical engineering. Other fields like chemistry, instruments and mechanical engineering still reach shares of 15% to 22%. The HGF has a quite balanced profile. Although chemistry reaches the largest shares (38%), the shares within instruments and mechanical engineering are comparably high (28% and 19%, respectively). This, however, comes at the expense of the filing shares in electrical engineering, which are comparably low (14%). The Leibniz Institutes have a major focus on chemistry. About 62% of all filings by WGL Institutes can be allocated to this field. The second largest field is instruments with a share of 21%. All other fields are below 10% within the WGL profile. The profile of the Max-Planck Society is very similar to the WGL. Here, we also find a major focus on chemistry, yet slightly larger shares in electrical engineering can be observed. Finally, the remaining research institutes have a very broad profile, which is quite balanced between all fields (except "other fields").

Figure 21: Field-specific shares of patent filings by universities and PROs



Source: EPO – PATSTAT; calculations by Fraunhofer ISI.

In sum, we can state that universities and most of the more fundamental research oriented PROs have a focus on chemistry, while especially Fraunhofer focuses on electrical engineering. Mechanical engineering is less reflected in the focal points of patenting by public research, be it PROs or universities.

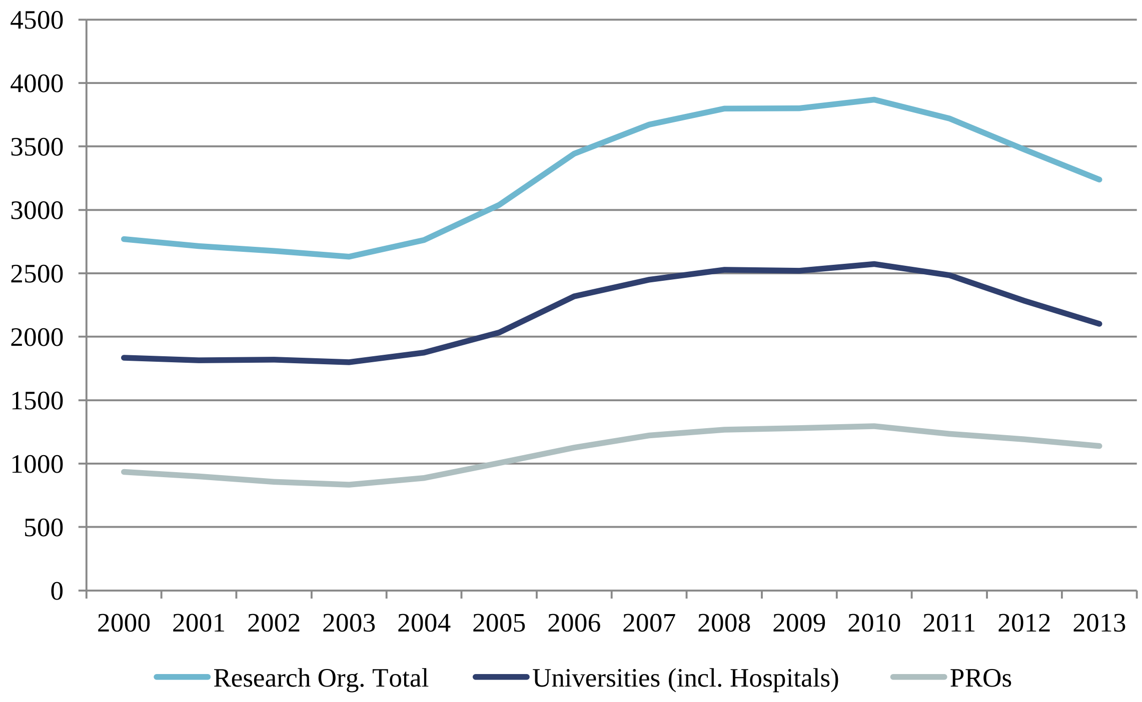
6.2.2 Academic Patents

As already stated in the methodological section, academic patents provide a more complete picture of the trends in patenting by universities and PROs. This is because a large share of patents from universities is registered by companies and the university staff only appears as an inventor. Here, we will thus focus on the extended perspective of "academic patents", which also takes university inventors into account.

The absolute trends in academic patent filings are provided in Figure 22. The trends are quite similar to the trends in patent filings by university and PRO applicants depicted in Figure 17. Between 2003 and 2010, an increase in filings by universities as well as PROs can be observed, while the figures are slightly stagnating since 2011. However, when comparing the absolute figures in 2013, it can be found that the number of academic patents is about 3.5 times higher than the number of patents filed by universities. For the PROs, this trend is similar, yet by far not so strongly pronounced.

What additionally becomes obvious from Figure 22is that the massive growth in filings by university applicants cannot be found when looking at the academic patents by universities. Although a growth in filings between 2003 and 2010 can be observed, it is not as strongly pronounced as in the applicant perspective. An explanation for this is the reaction of universities to the policy change in 2002, namely the abolishment of the "Hochschullehrerprivileg". This policy seems to have worked in the sense that universities now more often show up as the patent applicant. However, it does only to a lesser extent seem to have had an effect on the actual research output of universities.

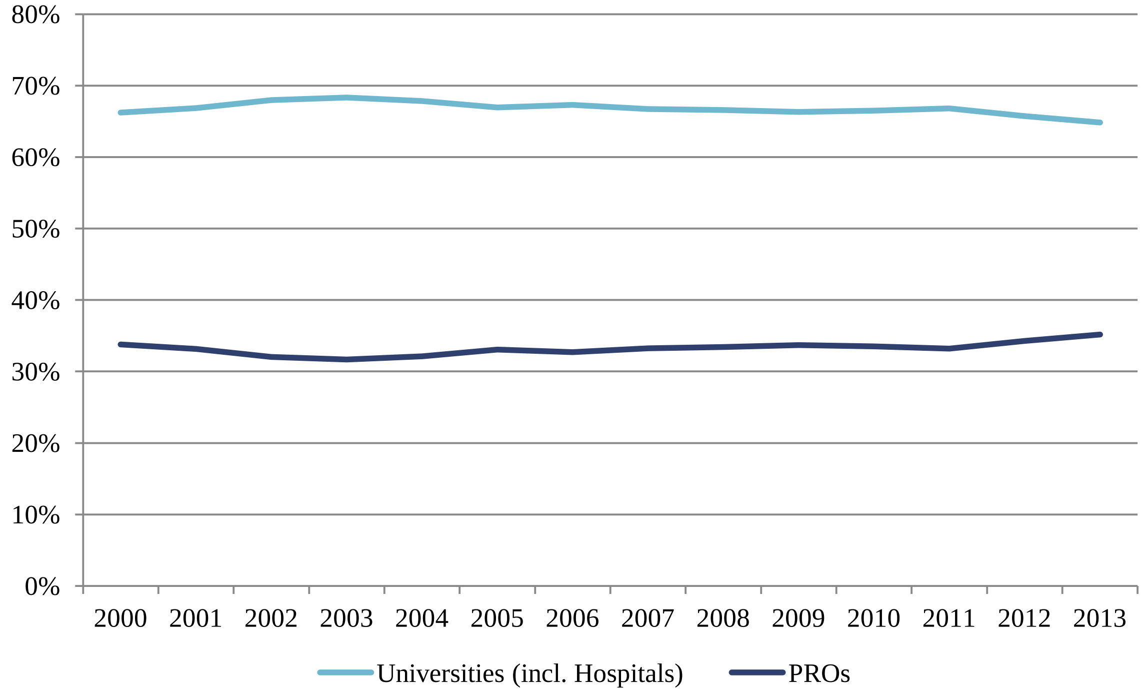
Figure 22: Number of academic patents by German research organizations (3-years moving average), transnational



Source: EPO – PATSTAT; Scopus; calculations by Fraunhofer ISI.

These figures consequently are also resembled in the shares of academic patents by universities and PROs in all filings by German research organizations. The shares have remained stable across the whole time period. About 65% of all academic patents are filed by universities, while the remaining 35% come from public research. The effect of a conversion of patent filings by universities and public research as found in Figure 18 thus also stems from the fact that universities more frequently show up as applicants on patent filings.

Figure 23: Shares of academic patents by universities and public research institutes in all filings by research organizations (3-years moving average)



Source: EPO – PATSTAT; Scopus; calculations by Fraunhofer ISI.

6.3 Conclusions

Within this section, we have analyzed recent trends in patent filings by public research in Germany. By applying the applicant perspective, i.e. analyzing the patents where the universities and public research institutes are listed as applicants, we have found that patenting has become more and more important for universities and PROs over the last 10 years. Especially the growth in university filings has led to a convergence in the number of filings from PROs and universities. Yet, the analyses of academic patents show that this convergence is mostly due to the fact that universities more often show up as patent applicants. Since 2010, however, we find declining patent numbers by universities and PROs. This is also reflected in the patent intensities, i.e. the number of transnational patent filings per 1,000 R&D employees, of universities and PROs. Especially in the recent years the patent intensities have been decreasing. Though the patent intensities of universities have risen in the course of the 2000s, PROs are still far more patent intensive than universities, which is mostly driven by the fact that PROs, especially the Fraunhofer Society but also the Helmholtz Association and some of the Leibniz Institutes, are more focused on applied research leading to a larger amount of patentable inventions. The Fraunhofer Society thus is responsible for the largest share of patent filings within the comparison of the public research institutes, followed by the Helmholtz Association, the Max-Planck Society and the Leibniz Society.

The field specific patent shares of universities and PROs reveal that universities and most of the more fundamental research oriented PROs have a focus on chemistry, while especially Fraunhofer focuses on electrical engineering.

7 Trends in Community Trademark Filings

In this chapter, we will compare trademark filings across major industrialized countries to analyze basic structures of services and product-related services based on trademark indicators. Up to this point in the study, we have only looked at patent indicators to measure innovation activities in Germany. Although also inventions in service sectors are protected by patents, they mostly serve as an output measure for the innovation activities within manufacturing. To take a closer look at innovative services in Germany, however, other indicators are necessary. With regard to services, trademarks have established themselves as a prominent indicator for the measurement of innovation activities (e.g. Gauch 2007; Sandner and Block 2011; Schmoch 2014). Particularly at the micro level, the relationship between trademarks and innovation has been well established (Greenhalgh and Rogers 2006; Sandner and Block 2011). Though trademarks can also be filed for products like technical equipment or technical procedures, services are eligible for protection within the system of trademark rights. Accordingly, trademarks can be used as a complementary indicator for new products and innovation activities in the service sector, which is relatively "close to the market" (Gauch 2007; Mendonca et al. 2004; Schmoch 2014). Especially in the case of knowledge-intensive business services trademarks have shown to be well applicable (Schmoch and Gauch 2009).

Similar to patent protection, trademark protection can be achieved in several ways. In order to have a trademark protected in Germany, for instance, a registration at the German Patent and Trademark Office (GPTO) is possible. An option is the registration of a Community Trademark (CTM) at the OHIM (Office for the Harmonization of the Internal Market), which is valid across the EU, or the registration of an international trademark at the WIPO, which is valid in all countries that have signed the Madrid Protocol. The Madrid system enables the applicant to protect a trademark in a large number of countries by obtaining an international registration that has effect in each of the designated contracting states, i.e. it can be considered a "one-stop-shop" for international trademark protection (WIPO 2016a).

Trademarks are in widespread use as a formal instrument to protect intellectual property. Eligible for protection are all "tokens", e.g. words, pictures etc., which are suitable to distinguish a company's goods or services from those of other companies. These can for example be words, individual letters, numbers, pictures, colors and even acoustic signals. After filing, trademarks are valid for ten years and can be renewed indefinitely (Deutsches Patent- und Markenamt (DPMA) 2008; Graham and Harhoff 2006).

Upon receipt of an application of a trademark at the respective trademark office the trademark will be processed. This includes classification of the trademark according to the NICE classification, a formality check, a check of the trademark "on absolute grounds" - i.e. the trademark is analyzed to see whether it is distinctive but not descriptive – a translation as well as a search for identical or similar marks including a "surveillance letter" that informs third parties about the filing of the given trademark (Office for the Harmonization of the Internal Market (OHIM) 2014). As opposed to patents trademarks thus are not "content certified", i.e. there is no granting process per se. Only formal criteria are checked upon filing. The pursuit of potential violations or infringements of registered trademark rights remains in the hands of the trademark owner. Only if a trademark holder indicates a violation, a procedure of cancellation of the competing trademark can be initiated. After the examination period, a trademark is published. From the date of publication, third parties have three months to object to the registration of the trademark either based on "earlier rights" or on "absolute grounds". If nobody files an opposition, the trademark is registered and the registration is published. After registration, only official appeals can be used to challenge the official decision by the OHIM (Office for the Harmonization of the Internal Market (OHIM) 2014).

7.1 Methods & Classifications

For our analyses, we used data from the trademark register of the GPTO ("DPMAregister"), which covers all filings of CTMs directly filed at the OHIM. Since the DPMAregister is an online database, it provides a significantly smaller analytical potential than offline databases like PATSTAT, for example. This means that the data had to be searched manually and certain indicators or methodological re-calculations, like fractional counting, are not possible.

In addition to country-wise statistics and international comparisons, we have differentiated trademarks by NICE classes. The NICE classification is an international classification of goods and services that is applied for the registration of trademarks. It has been established by the Nice Agreement in 1957 and is comprised of 45 classes. The classes 1 to 34 refer to goods, while classes 35 to 45 refer to services. The classes define the scope and the context of each application and are provided by the applicants themselves. Three classes are covered by the application fee, additional classes are subject to additional fees (Office for the Harmonization of the Internal Market (OHIM) 2014). Since several classes are assigned to one trademark, each trademark is counted once for each NICE class it has been assigned to, i.e. the sum of trademarks across NICE classes is larger than the total amount of trademarks filed. Since the applicant provides the classes and has the option of assigning a multitude of classes, the classification only offers limited insight. A description of the content of the trademark, like an abstract, as in the case of patents, is not available. This is even amplified by the fact that the contents of each class are defined by standard terms the applicant chooses upon filing. This means there is hardly any description of the actual content of the trademark via the keyword list within a class, which complicates interpretations. In particular, trademarks for example in the food industry or drugstore products can hardly be distinguished from marks with a technical background. Within the trademark system it is thus also not possible to identify any level of "inventive step", i.e. high-tech products cannot be differentiated from less R&D-intensive goods. While for patents the formal criterion of inventive step is reviewed by the patent examiners, i.e. a patent must go beyond the state of the art, such an assessment does not take place in the case of trademarks. A distinction between research-intensive and less research-intensive applications via the NICE classification is therefore not possible.

In sum, the differentiation of trademarks across NICE classes has to be made with caution. In our interpretation, we will therefore argue alongside the differentiation of product marks, service marks and mixed marks, i.e. marks that are assigned NICE classes referring to goods as well as NICE classes referring to services. In the more fine-grained disaggregation, we further resort to the definition of "research-intensive services" with regard to service marks by Schmoch (2003), where the classes 35, 36, 38, 41, 42, 43, 44, 45 are regarded as research-intensive services. In the case of products, we will concentrate on eight fields that have been defined as having a high technology relatedness, i.e. they can be seen as potentially research-intensive (Schmoch 2003). The definition of these eight fields can be found in Table 6.

Table 6: Definition of technology related NICE-classes regarding goods

Nr.	Name	NICE classes
1	Chemistry	1, 2, 3, 4, 13
2	Pharmaceuticals	5
3	Metals	6
4	Machines	7, 8
5	Electronics (components, instruments)	9, 14
6	Medical technologies	10
7	Electronic devices	11
8	Vehicles	12

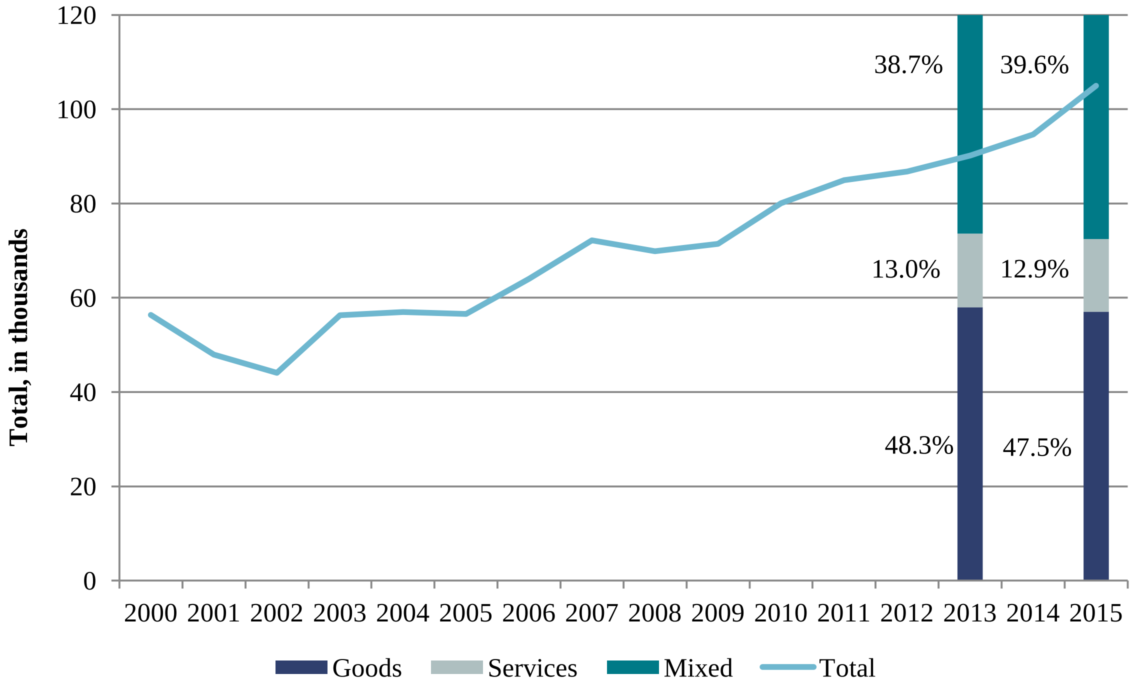
Source: Schmoch (2003)

In parallel to the analyses of patent filings, we will calculate not only absolute numbers of trademark filings but also trademark intensities - defined as the number of trademark applications per 1 million labor force - to account for size effects. On the basis of the NICE Classification, also specialization profiles (RPA) for CTM applications are presented.

7.2 Results

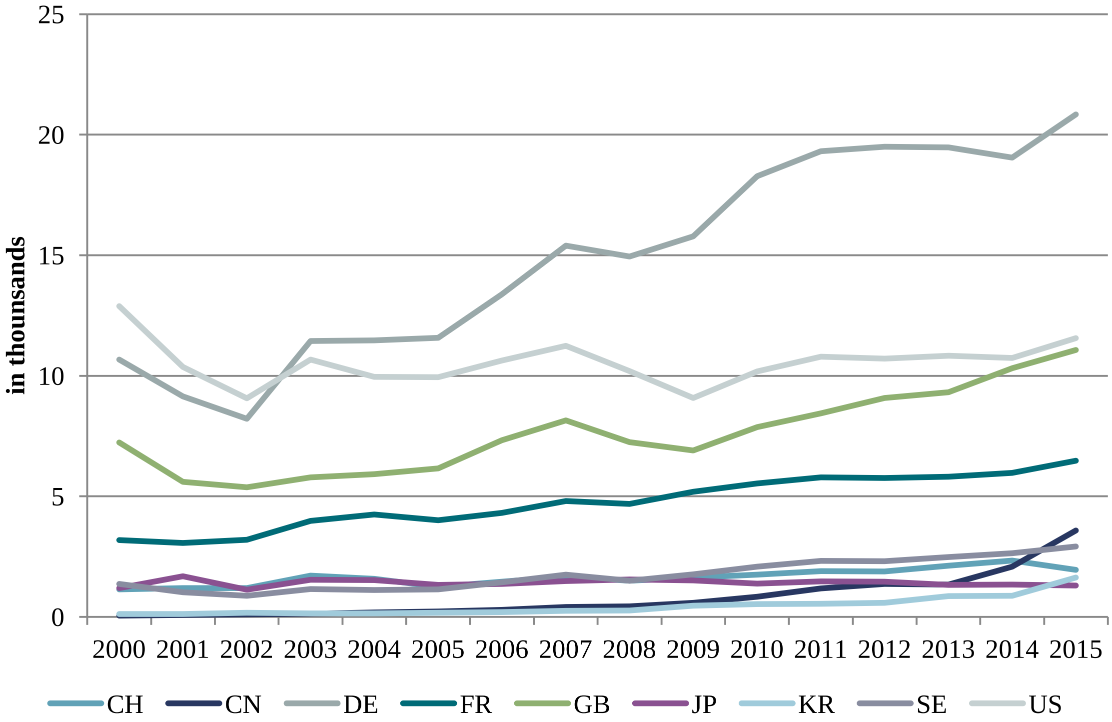
The general trends in trademark filings show a rising trend since the year 2002, where about 44,000 CTMs were filed (Figure 24). In the year 2015, about 105,000 filings have reached the OHIM. The two declines in the time trend between the years 2000 and 2002 as well as 2008 and 2009 show that besides patent filings, also trademark applications were negatively affected by the financial crises in the respective years. Besides the overall trend, the figure also provides information on the shares of trademark filings by types for the years 2013 and 2015. Comparing the two bars in the chart, it becomes obvious that the structure in total trademark filings has barely changed between the two years, i.e. there is only a very slight shift from product marks to mixed marks (about 1%). In total, 47.5% of the trademarks filed in 2015 are product marks, whereas 39.6% are mixed product/service marks and the remaining 12.9% are pure service marks. The mixed marks can mostly be regarded as "product-related", meaning that the product is in the foreground. The additional filing of a service mark thereby often represents product related services, which have gained increased importance within the manufacturing sectors over the last decade (Schmoch 2003).

Figure 24: Absolute number of CTM filings and shares by trademark types, 2000-2015



Source: DPMAregister; calculations by Fraunhofer ISI

Figure 25: Absolute number of CTM filings for selected countries, 2000-2015

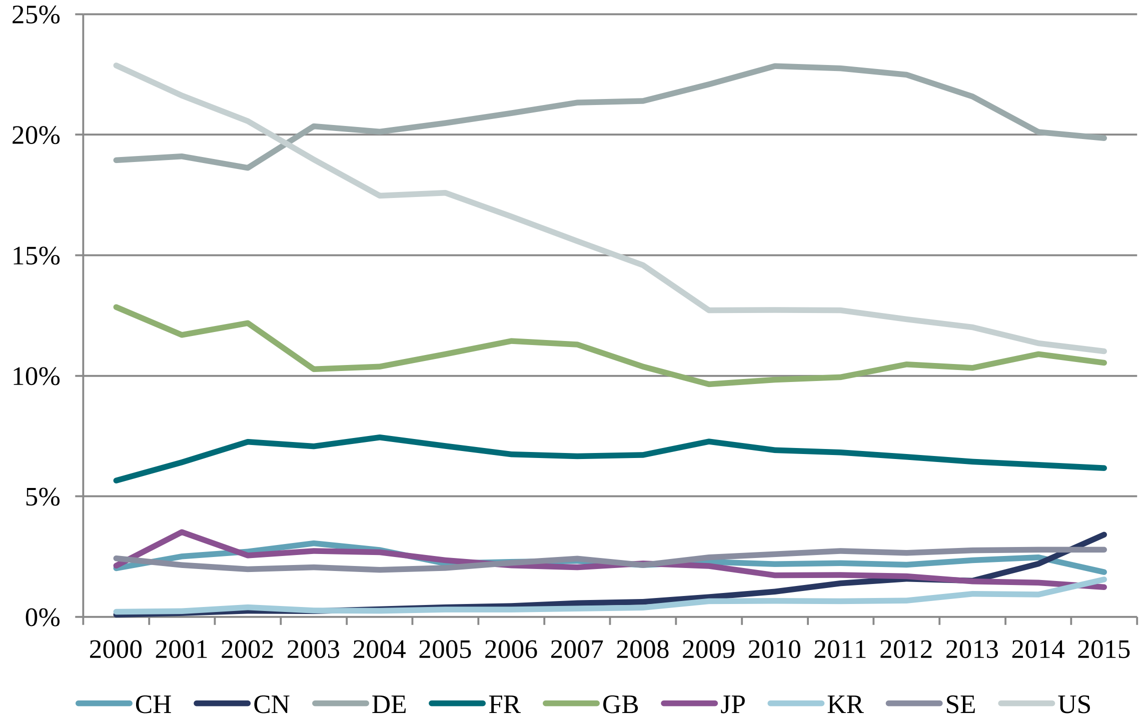


Source: DPMAregister; calculations by Fraunhofer ISI

Differentiating the absolute number of CTM filings by countries provides a clear picture of the largest trademark applicants at the OHIM (Figure 25). Germany is by far the largest trademark applicant at the OHIM with more than 20,000 filings in 2015. Since the year 2000, the trademark filings by German applicants have grown quite constantly. The number of filings thus exceeded the filing figures of the second largest applicant, i.e. the USA, already in the year 2003.[7] This is related to the fact that the number of US trademark applications has remained quite constant at a level slightly above 10,000 across the whole time period. Following the US is Great Britain, where also increasing shares can be observed, implying that Great Britain has managed to catch-up with the US in terms of trademark filings. France scores fourth with about 6,500 filings in 2015. These four countries are followed by a group of smaller countries in terms of trademark filings led by China, where, especially since 2012, trademark filings have grown very rapidly.

7 This lower number of the USA is a direct effect of the fact that we are only able to analyze trademark filings at the OHIM, while the alternative/competing filing procedure via the WIPO is not taken into account due to missing data availability.

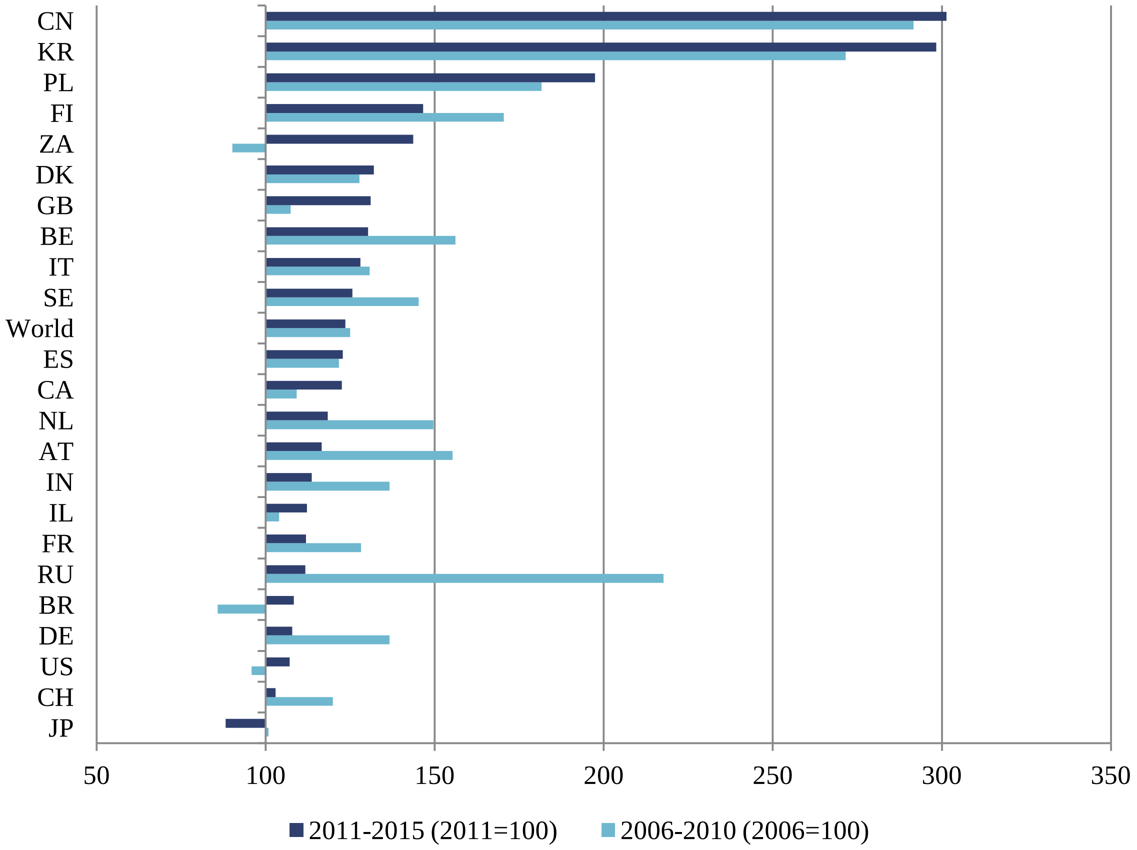
Figure 26: Shares in CTM filings for selected countries, 2000-2015



Source: DPMAregister; calculations by Fraunhofer ISI

Apart from the absolute figures, the country-specific shares in global CTM filings reveal an interesting picture (Figure 26). Germany is responsible for 20% of all trademark filings at the OHIM. Between 2004 and 2010 Germany could constantly increase its shares. Since 2010, however, the growth of Chinese filings has led to a decline in German shares as well as the ones of other countries. This is especially visible for the US, where the shares have decreased over the whole time period. Yet, the US still is the second largest trademark applicant, being responsible for about 11% of all filings at the OHIM. However, the US is closely followed by Great Britain with shares of 10.5%. As we have seen in Figure 25, this is not due to a decline in the absolute numbers of filings from the US, since these have remained constant over the years, but can be explained by the fact that most of the countries under analysis have increased their absolute filing numbers, leading to declining shares for US applicants. France, which is responsible for a share of 6% in 2015, shows a quite constant trend over the years although a slight decrease can be observed in the recent years. With a share of 3.4%, China scores fifth in terms of trademark shares, which is mostly due to the massive growth between 2013 and 2015.

Figure 27: Growth in CTM filings for selected countries between 2006-2010 and 2011-2015



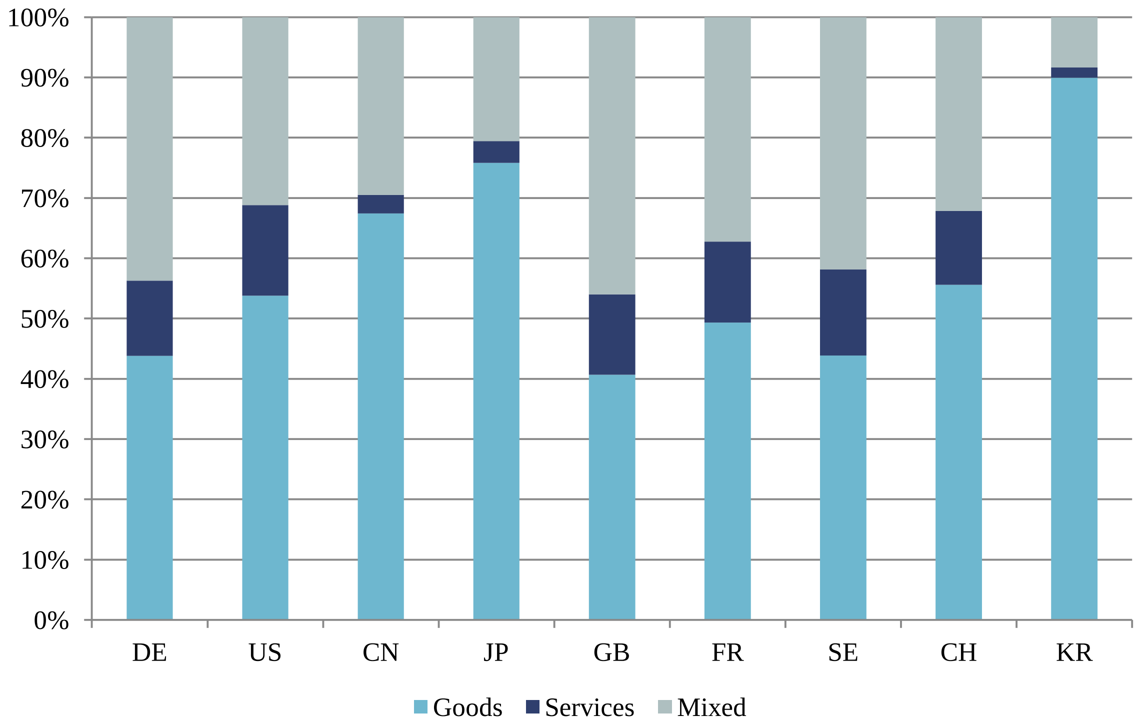
Source: DPMAregister; calculations by Fraunhofer ISI

This becomes even more evident when looking at the growth statistics between 2011 and 2015 (Figure 27).

The largest growth in CTM filings between 2003 and 2013 can be observed for applicants from China, Korea and Poland. All three countries also showed rather large growth rates between 2006 and 2010 but have managed to even increase growth in the last five years. Finland, though still having the fourth largest growth rates between 2011 and 2015, shows smaller growth rates than between 2006 and 2010. Similar effects can be observed for Russia, Sweden, Belgium, Austria, the Netherlands, Switzerland and Germany. German applicants are in the lower ranks in terms of growth of CTM filings in the last five years.

Interestingly, South Africa also has large growth rates in the recent years, though the absolute numbers still are relatively low. Another interesting effect becomes evident when looking at Japan and Korea, since both show rather low numbers of trademark filings compared to transnational patent filings. Yet, for Korea large growth rates can be found whereas Japan's trademark filings have even decreased in the recent year. This might have to do with the fact that non-European applicants might more frequently use the Madrid system for their trademark filings. It might, however, also resemble a tendency to not file many trademarks in Europe.

Figure 28: Shares of trademark types within the countries' portfolios, 2015



Source: DPMAregister; calculations by Fraunhofer ISI

A country-specific view on CTM filings by trademark type is plotted in Figure 28. Here, differences in the trademark portfolios of the analyzed countries can be observed. With regard to Germany, it can be found that the profile largely resembles the worldwide trends (plotted in Figure 24), although the share of mixed type trademarks is slightly larger. The same can be said for the other European countries in this sample. Especially Great Britain and Sweden resemble the German profile very well. Yet, Great Britain is the only country in this comparison with shares of service marks exceeding 45%. This clearly resembles the service oriented sectoral structure of Great Britain. In France and Switzerland, the share of product marks is slightly larger, mostly due to a reduction in the share of mixed marks. The US shows rather large shares of product marks at the OHIM, though still 15% of the filed marks are service marks and 31% are mixed marks. This changes when looking at the Asian countries, where the share of product marks is even larger, while especially the share of service marks is comparably small. Only 2% to 4% of CTMs from these countries are pure service marks.

In sum, it can be found that for the non-European countries, the share of product marks is much larger than the share of services marks as well as mixed types. The only exception is the US, where a comparably large share of mixed and service marks can be observed. The lower shares of service marks from non-European countries at the OHIM, however, can also be attributed to the fact that cross-border "trade" with services is much less common than with products. Since we have a very strong focus to the European market when looking at trademark filings at the OHIM, this at least partly explains the low shares of service marks for the non-European countries.

Further interesting trends can be revealed when looking at the trademark intensities differentiated by trademark types for the year 2015 in Table 7. The trademark figures here are normalized alongside the workforce within the respective countries, i.e. the number of trademark applications per 1 million labor force, to account for size effects. The table is sorted in descending order by overall trademark intensities. It thus becomes obvious that Austria has the highest trademark intensity, followed by Sweden, Denmark, Finland and Germany. The Asian countries and the BRICS countries have the smallest trademark intensities with regard to CTM filings. In terms of product marks, Sweden, Austria, Finland and Denmark show the highest trademark intensities, followed by Switzerland and Germany. With regard to service marks, Austria shows the highest intensities, followed by Sweden, Denmark and Spain. The intensities for mixed service/product marks are highest for Spain, Austria, Sweden and Finland.

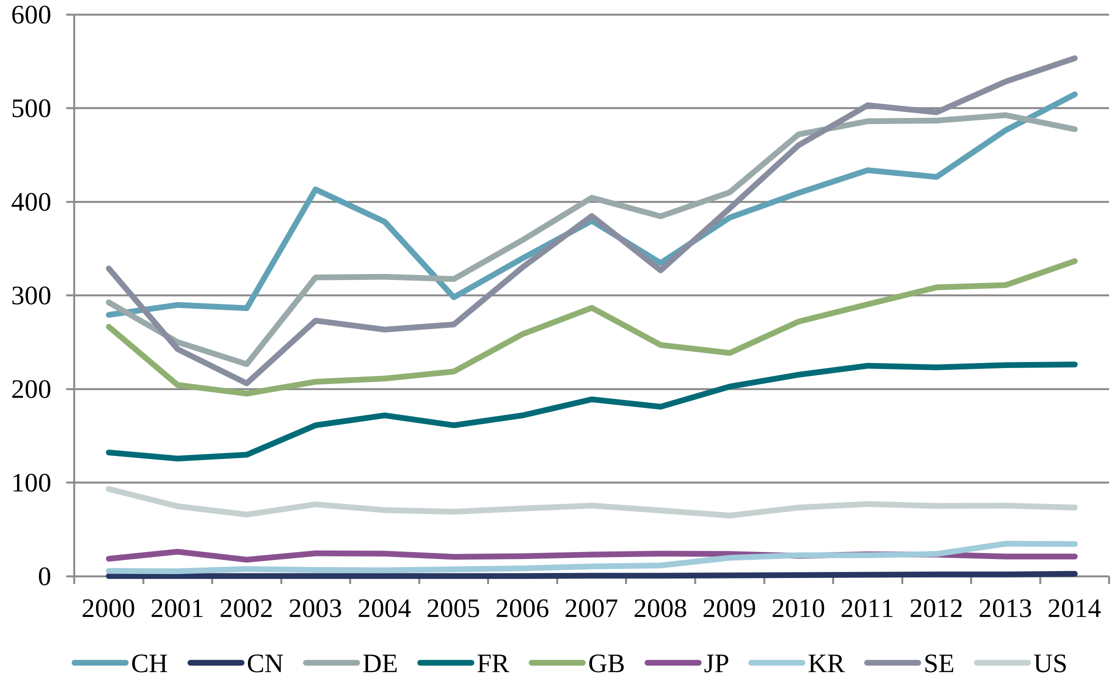
Table 7: Trademark intensities (CTM filings per 1m employment) and shares of trademarks by types, 2015

Country	Total	Goods		Services		Mixed	
AT	630	261	41%	108	17%	261	41%
SE	613	269	44%	87	14%	257	42%
DK	554	242	44%	79	14%	232	42%
FI	549	244	44%	67	12%	238	43%
DE	523	229	44%	65	12%	229	44%
ES	507	167	33%	76	15%	265	52%
NL	452	177	39%	64	14%	211	47%
CH	430	239	56%	53	12%	138	32%
BE	424	175	41%	61	14%	188	44%
IT	396	221	56%	41	10%	135	34%
GB	361	147	41%	48	13%	166	46%
FR	246	121	49%	33	13%	92	37%
PL	207	90	44%	28	13%	89	43%
US	79	43	54%	12	15%	25	31%
IL	75	39	52%	10	13%	26	35%
CA	73	35	48%	10	14%	28	38%
KR	64	57	90%	1	2%	5	8%
JP	20	15	76%	1	4%	4	21%
ZA	16	10	63%	2	14%	4	23%
CN	5	3	67%	0	3%	1	29%
BR	3	1	53%	0	13%	1	34%
IN	1	1	63%	0	8%	0	29%
RU	1	0	38%	0	7%	1	55%

Source: DPMAregister; calculations by Fraunhofer ISI

Further interesting trends can be revealed when looking at the development of trademark intensities for selected countries between 2000 and 2014 (Figure 29). As we can observe in Figure 29, Sweden is the most trademark intensive country (within this comparison), closely followed by Switzerland, and Germany - which had the highest intensities in CTM filings until the year 2010. From 2010 onwards, however, the German trademark intensities stagnated, while the figures for Sweden and Switzerland grew at a rather quick pace. Great Britain and France score fourth and fifth within this comparison. Great Britain, however, also showed relatively large growth in trademark intensities while the filings from France stagnated. The large countries in terms of employees, i.e. the US and China, rank lower on this indicator. Especially China files comparably few CTMs per employee.

Figure 29: Trademark intensities (CTM filings per 1m employment), 2000-2014

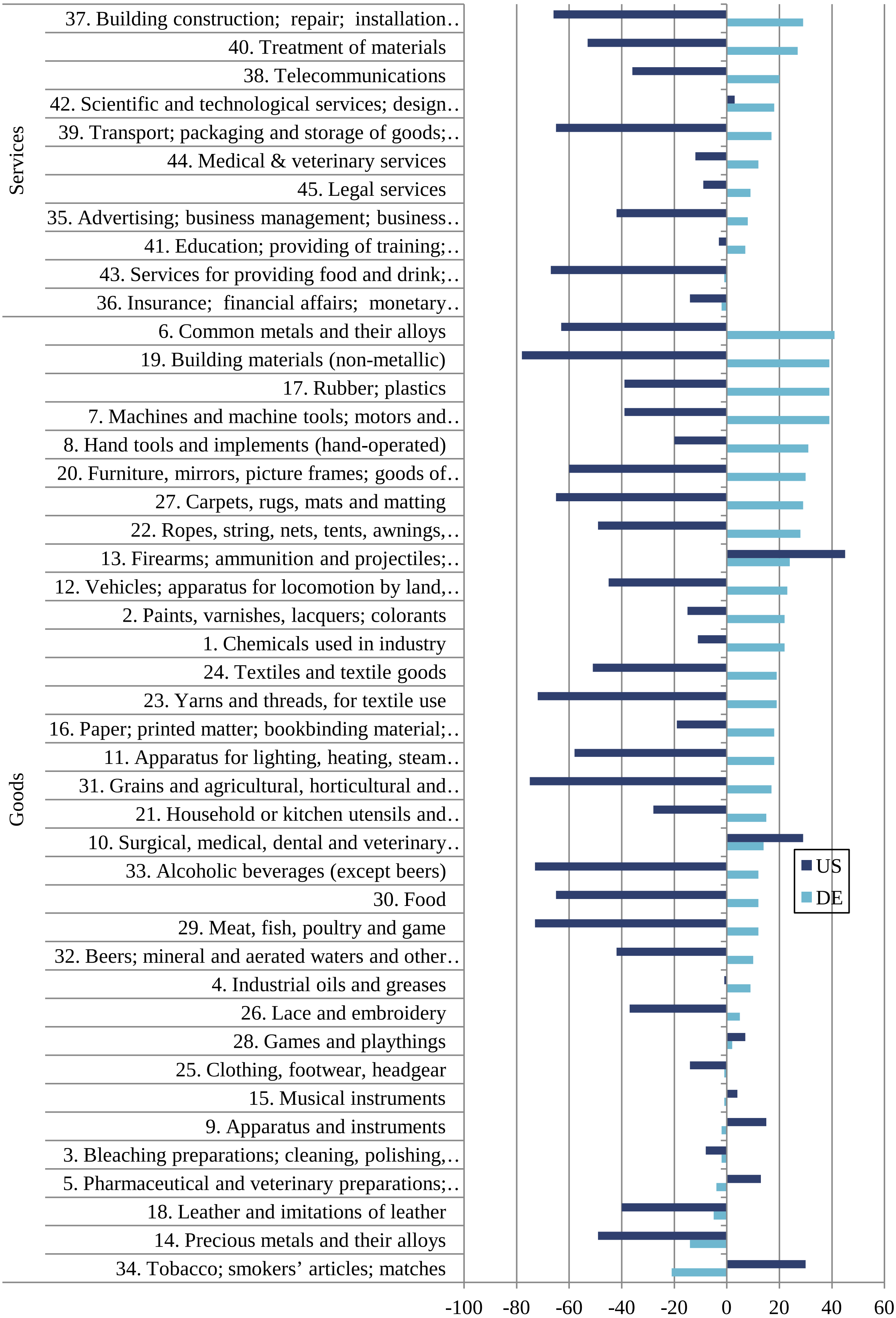


Source: DPMAregister; calculations by Fraunhofer ISI

In a final step, we have calculated the specialization indices for the trademark portfolios of Germany, the USA, Great Britain and France to find out in which fields a country is strongly or weakly represented compared to the total trademark filings at the OHIM. The specialization indices were calculated in the same manner as for the patenting profiles, i.e. positive signs mean that a NICE field has a higher weight within the country than in the world. The specialization indices of the USA, Great Britain and France compared to Germany are provided in Figure 30 to Figure 32.

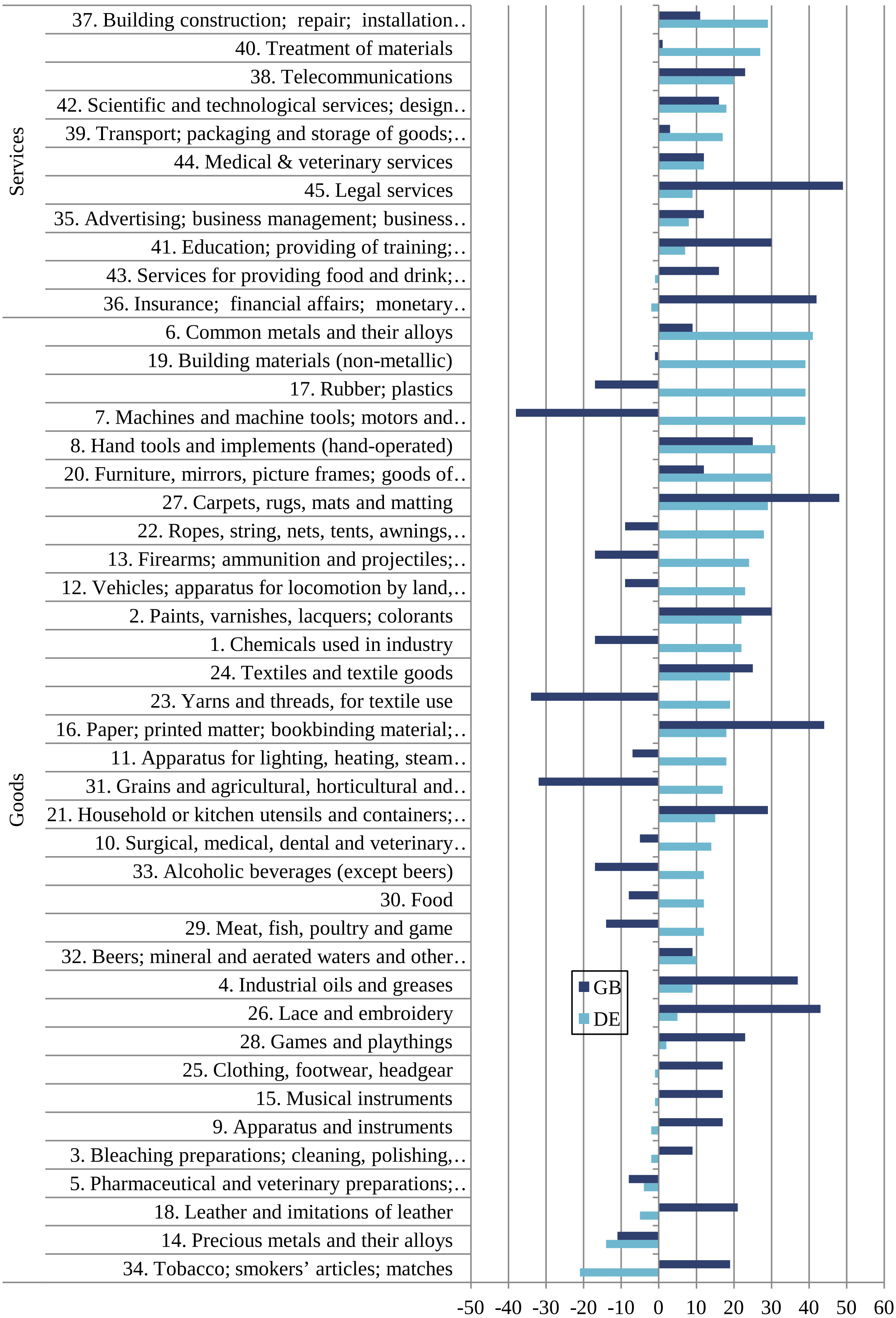
Germany shows positive specialization rates in terms of trademarks across most of the NICE classes in goods as well as services. The US, on the other hand, mostly shows negative specialization values. With regard to fields with high technology relatedness, positive values for the US can be found in pharmaceuticals and medical technologies as well as firearms and instruments. For Germany, specialization values are highest in fields related to machines and metals, while in Great Britain chemistry and related fields, i.e. oils and greases and paints and varnishes, show positive specialization values. In chemicals used in industry, however, Britain has negative values. In France, the largest values can be found in bleaching preparations as well as oils and greases, implying a similarity of the French and British brand profile when it comes to specific strengths.

Figure 30: CTM related profiles Germany and the US, 2015



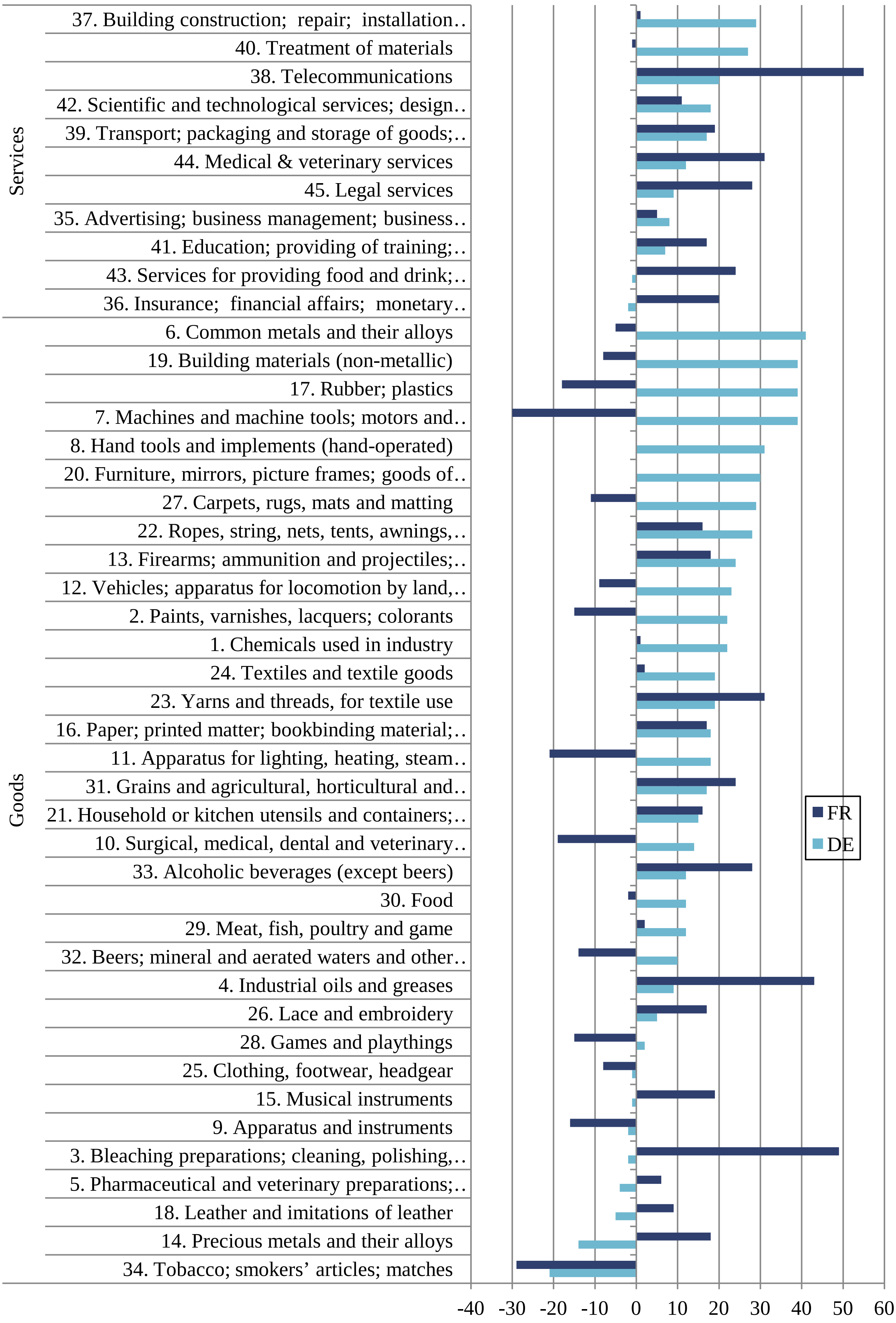
Source: EPO – PATSTAT; calculations by Fraunhofer ISI

Figure 31: CTM related profiles Germany and Great Britain, 2015



Source: EPO – PATSTAT; calculations by Fraunhofer ISI

Figure 32: CTM related profiles Germany and France, 2015



Source: EPO – PATSTAT; calculations by Fraunhofer ISI

7.3 Conclusions

In this section, we have taken a closer look at structures and trends in Community Trademark filings at the OHIM across major industrialized countries and fields. Especially with regard to the service sectors, trademarks can be seen as a complementary innovation indicator to patents that is closer to the commercialization of a certain product (Gauch 2007). Yet, it has to be kept in mind that statistical trademark analyses are associated with pitfalls regarding data availability, the classification system and the content certification of trademark filings as there is no granting process per se.

The general trends in trademark filings show an increase in CTM filings between 2002, where about 44,000 CTMs were filed, and 2015, where nearly 105,000 filings have reached the OHIM. The only slowdowns in CTM filings were visible during the economic crises in 2000/2001 and 2008/2009, which mostly resembles from the patent analysis. Overall, the largest share of trademark filings are related to products (47.5%), closely followed by product related services (39.6%), which have gained ground since 2013. The remaining 13% are pure service marks.

Germany is by far the largest trademark applicant at the OHIM with more than 20,000 filings in 2015, followed by the US, Great Britain and France. Great Britain has managed to catch-up with the US in terms of trademark filings but also China and Korea have shown large growth rates especially in the last few years. This has lead to a decrease in the shares of the trademark filings from the USA.

The patterns in trademark types, however, also differ across countries. Here, it becomes obvious that the non-European countries show a larger share of product marks than their European counterparts. The only exception is the US, where a comparably large share of mixed and service marks can be observed. Since we look at the OHIM, i.e. we have a very strong focus on the European market, however, this can also be attributed to the fact that cross-border "trade" with services is much less common than with products. The largest share of service marks can be found for Great Britain, where the industry is rather oriented towards services.

In terms of trademark intensities, i.e. trademark filings normalized alongside the workforce within the respective countries, the smaller economies like Austria, Sweden, Denmark and Finland show the highest values. Per employee, trademark filings are rather low for the North American, Asian as well as the BRICS countries. This, however, is influenced by the fact that we are analyzing CTMs, which, by nature, are Europe centered.

In sum, it can be stated that Germany has a strong position when it comes to CTM filings. Although we need to stress that we analyze a Europe-centered system Germany can be shown to have by far the largest number of trademark filings, which is spread across all technology fields. However, the Germany strengths in mechanical engineering also become visible in terms of Community Trademarks.

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