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Patent Applications – Structures, Trends and Recent Developments 2015

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0 Summary

Core Indicators

The largest technology-providing country at the international level is the USA, where a comparatively large growth in filings between 2012 and 2013 can be observed. The USA is followed by Japan, where the opposite seems to be true. The figures have slightly declined in the last year of the observation period. Germany scores third on this indicator. Here, also a slight decrease in filings can be observed since 2011. In terms of patent intensities, however, rather the smaller countries Switzerland, Finland and Sweden are at the top of the list of the technology-oriented countries analyzed. Japan scores fourth, followed by Germany. 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 2013. Germany scores fourth on this indicator but has slightly lost ground since 2002 and has fallen behind France in terms of high-tech shares, although Germany files about twice as many high-tech patents than France in absolute terms. Yet, Germany, Switzerland, Italy, Denmark are the countries that show the strictest focus on high-level technologies, while many other countries are more active in leading-edge technologies. When looking at Germany's country-specific technology profiles specializations, i.e. comparative advantages, in three main areas can be observed: 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.

In terms of international co-patents, the US shows the highest shares in all transnational co-patents, followed by Germany, Great Britain and France. In relative terms, i.e. when looking at the shares of transnational co-patents in all transnational patents of the respective inventor country, however, smaller countries like Belgium, Switzerland and Ireland reach the highest values. Germany only has a rather low internationalization when regarding this indicator, which is also true for the US.

The regionalization of German patent filings shows that Baden-Württemberg and Bavaria are the largest German "Bundesländer" with regard to the number of patent filings, followed by North-Rhine Westphalia. These three German regions account for about two thirds of the German transnational filings, while only half of the employees are located in these countries, i.e. the patent intensity is also comparably high. The Northern and Eastern German states score at the lower ranks, seen from an absolute as well as a relative perspective.

The analysis of filings by universities and public research institutes shows that the number of transnational patent filings has been increasing during the last 10 years. The growth is even more pronounced for universities than for public research institutes. This has led to a convergence in the number of patent filings between universities and public research institutes in the recent years, which can be attributed to the abolishment of the “Hochschullehrerprivileg" ("professor's privilege") in 2002 and the larger focus of German universities on commercializing their inventions.

Academic Patents and Patent Citations as Performance Indicators for German Universities

The contribution of universities and their employees to patented research is underestimated by only accounting for patents filed by universities. By applying the concept of "academic patents", where we include patents where university employees are named as inventors but not as applicants, we are able to gain a more complete picture of university patenting in Germany. This allows us to apply patents and patent citations as performance indicators for German universities and identify the top performing German universities in terms of patent filings and patent citations. The results show that only a small group of German universities has filed more than 300 academic patents at the EPO between 2008 and 2010. Especially large technical universities and universities with huge medical facilities generate the largest numbers of academic patents; not only in absolute terms but also per employee. In terms of growth rates, the smaller universities (in terms of patent filings) are on top of the list and reach the highest growth rates. A look at the technological profiles shows that biotechnology and pharmaceuticals show the largest shares of academic patents across all German universities but also that academic patents are quite spread across all technology fields.

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 (see for example Schasse et al. 2012). 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. We will further focus on analyses of international cooperation structures in terms of co-patents. Moreover, we will provide a more differentiated look at the German technology landscape at the level of regions, i.e. the German "Bundesländer". Finally, we will analyze patents filed by German universities and public research institutes to gain insights into the technological performance of the German science system. Since, however, universities often are not named as patent applicants - especially when the patent filing is the result of cooperation with partners from industry - we additionally include a special analysis of "academic patents", which draws a more complete picture of the technological activities of German universities.

Since this year's report is in the form of a short study, we will only provide a brief explanation on data and methods as well as the indicators and their interpretation in the following two chapters. More detailed explanations and interpretations can be consulted in the earlier reports within this series.

2 Data and Methods

The patent data for this study were extracted from the "EPO Worldwide Patent Statistical Database" (PATSTAT), which provides information about published patents collected from 83 patent authorities worldwide. The list of research-intensive industries and goods (NIW/ISI/ZEW-Lists 2012) are 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.

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 Indicators and their Interpretation

International Co-patents

The cooperation structures in international patenting resemble the internationalization of R&D activities and are able to indicate the extent to which countries are cooperating with each other. This is based on the assumption that each collaboration that leads to a cooperative patent application is associated with the exchange of knowledge about the patented invention. The analysis of cooperation structures in patenting thus allows us to draw conclusions about international knowledge flows. It is assumed that usually implicit or experiential knowledge is exchanged (Polanyi 1985), which will later "explicitly" be stated in the form of a patent application. By analyzing patent applications, however, our focus remains on the explicable and explicit knowledge (Grupp 1998).

In sum, we will focus on the transnational co-patent filings of the countries under analysis. As with the general patent trends, we will apply fractional counting by inventor countries, i.e. a country is only assigned the fraction of a patent depending on the number of inventors from the given country.

1 Revealed Patent Advantage.

Patent filings by German federal states

With the help of the regionalization of patent filings from Germany, we 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 to take a closer look at the structural composition of the German innovation landscape, which allows us to identify regional technology trends as an important precondition for the composition and framing of regional innovation policies in Germany.

As with the general patent trends, we will apply fractional counting by inventor countries. For the identification of the German federal states in patent filings, we use the NUTS-code information from 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.

Patent filings by German Universities and Public Research Institutes

Patents filed by universities and public research institutes (PRI) help us to assess the technological output of research organizations in Germany. Patents filed by universities and PRI were identified within the PATSTAT database with the help of keyword searches, including the names of the universities 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”. All different spelling variations are taken into account.

The figures for the patent intensities are calculated as the total number of patent filings per 100 employees (full-time equivalents) in the respective universities. The data on university employees were extracted from the German Federal Statistical Office (Statistisches Bundesamt 2013) as well as the Federal Report on Research and Innovation 2012 (Federal Ministry on Education and Research (BMBF) 2012). Gaps within the data for certain years were estimated on the basis of the values of the preceding and following years.

4 Core indicators

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 (Gehrke et al. 2013). Furthermore, we will analyze basic trends in international co-patenting, differentiate the German filings by federal states and take a quick look at patents filed by German universities and public research institutes (PRI).

4.1 International Comparisons

Basic Trends

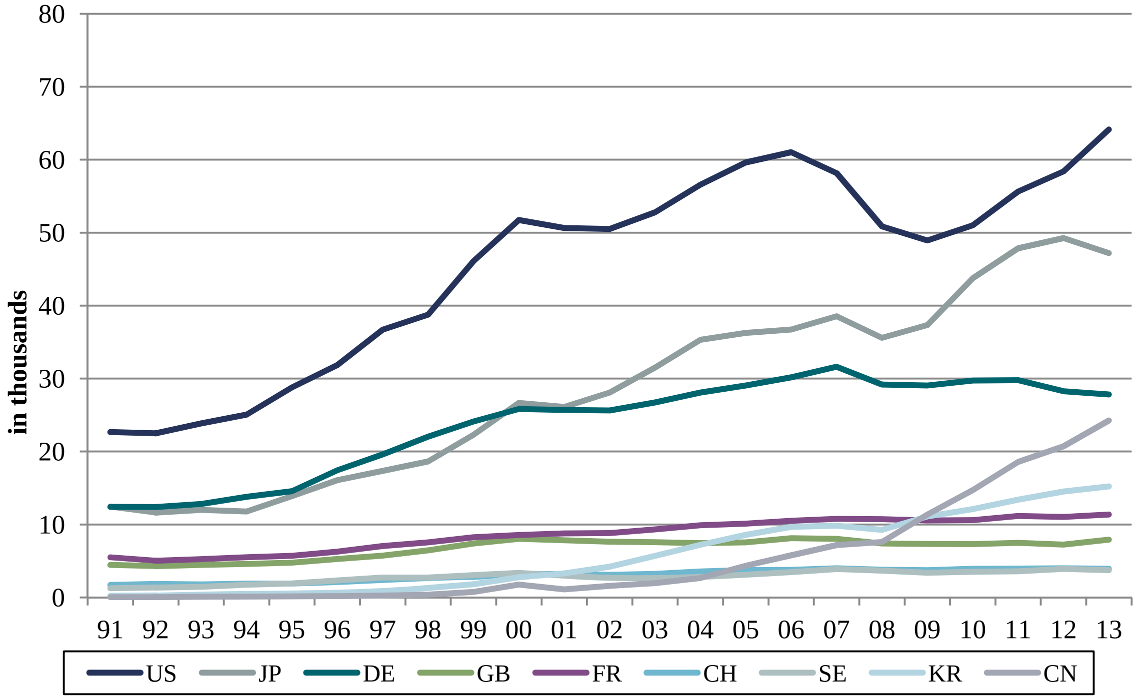
The absolute number of transnational patent filings by inventor countries is displayed in Figure 1**Fehler! Verweisquelle konnte nicht gefunden werden.**. The largest technology-providing country at the international level is the USA, where a comparatively large growth in filings between 2012 and 2013 can be observed. The USA is followed by Japan, where the opposite seems to be true. The figures have slightly declined in the last year. Germany scores third by this indicator. Here, also a slight decrease in filings can be observed since 2011. China scores fourth in terms of the absolute number of filings since 2009 and has shown rather high growth rates since then. Following behind these four countries, there is a large group of countries led by Korea, followed by France and Great Britain. China and Korea have grown strongly in terms of patent filings since 2000 onwards and have thus managed to leave behind France and Great Britain in the total number of transnational applications. Sweden and Switzerland follow Great Britain with nearly 4,000 transnational filings in 2013.

The absolute data presented so far is affected by size effects. An adjustment to these size effects is shown in Table 1, where patent intensities per one million employees are depicted. This size adjustment sheds new light on the country ranks. Although the US is the largest country in absolute terms, it only scores eleventh in terms of patent intensities. Rather smaller countries like Switzerland, Finland and Sweden are at the top of the list of technology-oriented countries analyzed here. Japan, Germany and South Korea are first among the larger countries in terms of patent intensities. Japan even ranks fourth by this indicator this year, directly followed by Germany. This on the one hand resembles a strong technology orientation and the 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. Patents are an important instrument to secure market shares in international technology markets (Frietsch et al. 2014). With the perspective of this indicator,

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.

France, Great Britain and the EU-28 are in the midfield together with the USA, the Netherlands and Belgium. The BRICS countries score on the lower ranks.

Figure 1: Absolute number of transnational patent applications for selected countries, 1991-2013



Source: EPO – PATSTAT; Fraunhofer ISI calculations

In addition to the general patent intensities, Table 1 offers a differentiation of the 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, South Africa and Russia are comparably active in fields with a low R&D intensity. China and India deviate from this pattern with a rather small share of patents in less R&D-intensive fields. China, however, especially shows large shares in leading-edge technologies, whereas in India the shares in leading-edge and high-level technologies are at a more comparable level.

With regard to high-technology shares, the highest values can be observed for China, the USA and Canada, Sweden, Japan, Korea, Israel and India. For these countries, shares lie above 63%. In the case of India, Canada 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. The differentiation by leading-edge and high-level areas further qualifies these findings. The USA, Canada, Korea, Israel but also Finland, Sweden and especially China are filing many of their patents in leading-edge technologies. In consequence, these countries reach comparably low shares in high-level technologies compared to the other countries. Germany and Switzerland, as well as Italy, Denmark and also Japan are focused on high-level technologies, but reach comparably low shares in leading-edge areas.

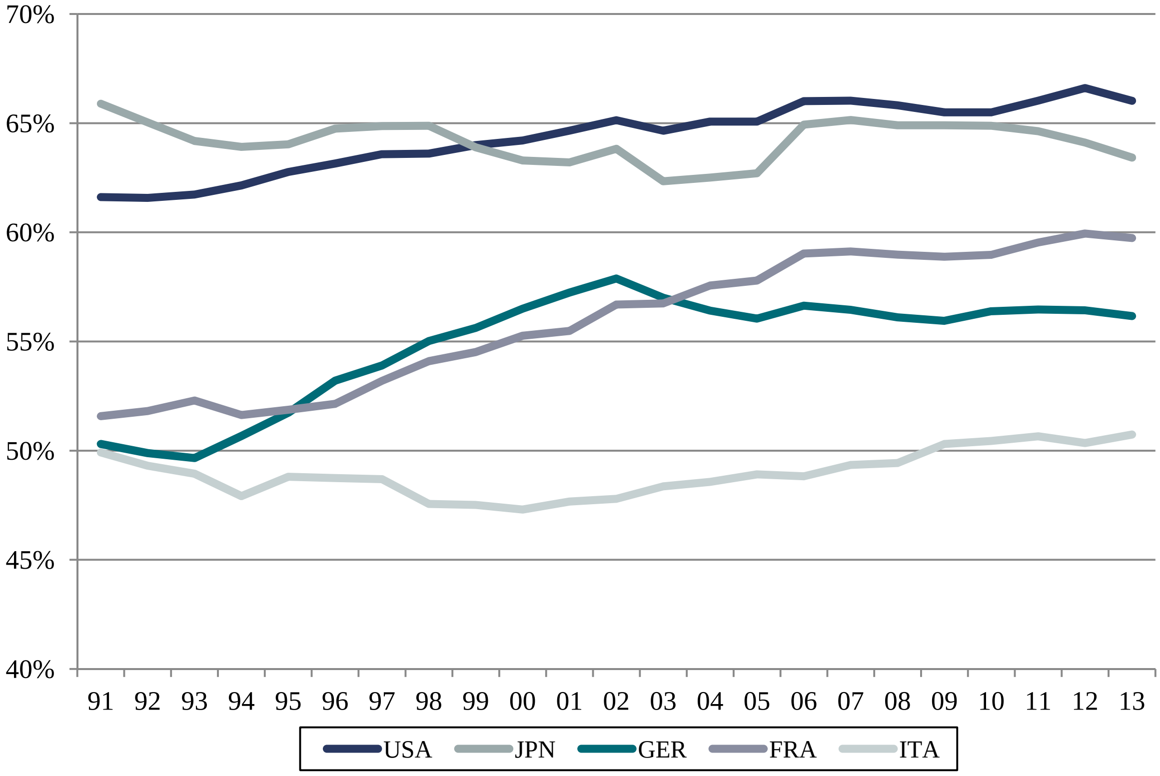
Table 1 Patent intensities (patent applications per 1m employees) and shares of technological areas, 2013

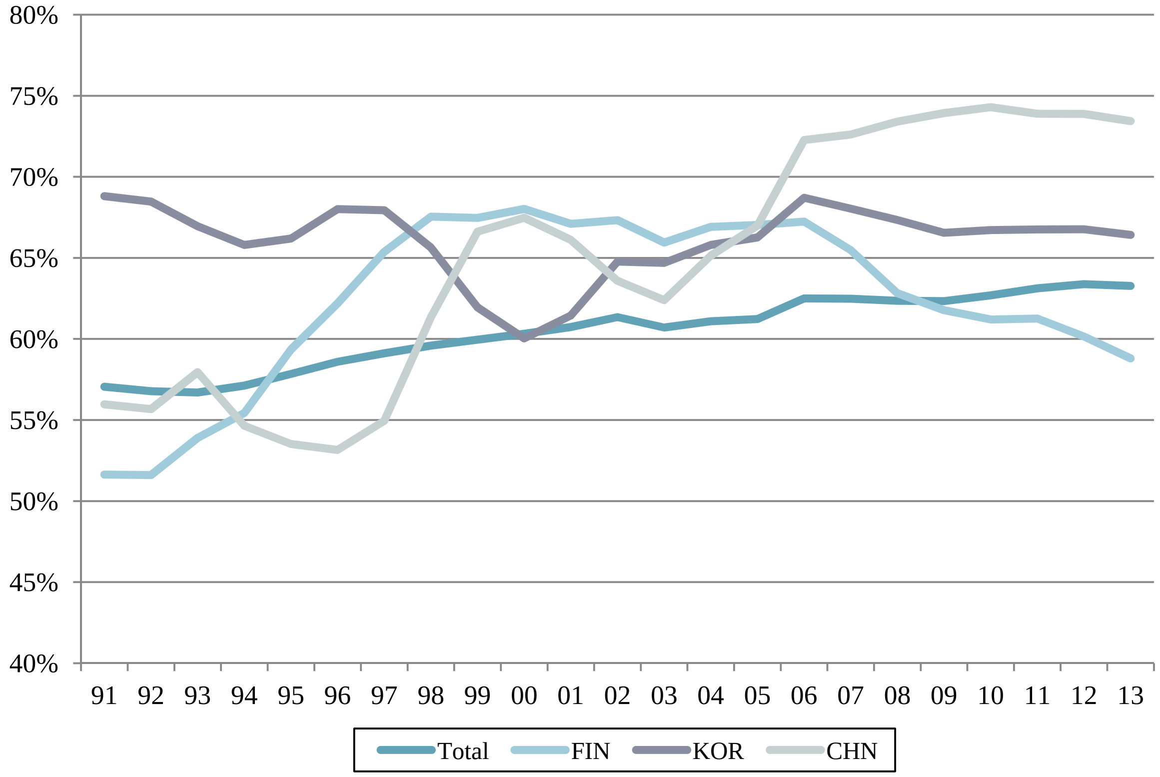
	Total	Less R&D-intensive		High-Tech of which are:		Leading-edge technologies		High-level technologies	
SUI	882	437	50%	462	52%	165	19%	297	34%
FIN	835	350	42%	489	59%	287	34%	202	24%
SWE	795	269	34%	545	68%	287	36%	257	32%
JPN	748	289	39%	473	63%	175	23%	297	40%
GER	704	320	45%	395	56%	124	18%	272	39%
ISR	637	209	33%	436	68%	240	38%	196	31%
DEK	636	263	41%	380	60%	127	20%	253	40%
KOR	608	218	36%	403	66%	184	30%	219	36%
AUT	580	303	52%	282	49%	88	15%	194	33%
NED	517	239	46%	282	55%	138	27%	144	28%
USA	446	159	36%	292	66%	144	32%	148	33%
FRA	441	183	41%	262	59%	118	27%	145	33%
BEL	423	187	44%	240	57%	104	25%	135	32%
EU-27/28	344	153	45%	196	57%	76	22%	120	35%
GBR	264	109	41%	159	60%	74	28%	85	32%
ITA	241	127	53%	123	51%	30	12%	93	39%
CAN	216	82	38%	136	63%	73	34%	62	29%
ESP	146	74	51%	74	51%	31	21%	44	30%
POL	41	21	51%	20	48%	8	19%	12	29%
CHN	32	9	28%	23	73%	15	47%	8	26%
RSA	23	13	57%	9	37%	3	14%	5	23%
RUS	17	8	46%	9	56%	5	30%	4	26%
BRA	7	4	50%	4	51%	1	16%	3	35%
IND	5	2	31%	4	71%	2	32%	2	39%

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%.

Figure 2: Shares of high-tech patent applications in total patent applications for selected countries, 1991-2013





Source: EPO – PATSTAT; Fraunhofer ISI calculations

Figure 2 shows the 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 2013, some countries underwent a considerable change of their patenting patterns in high-tech areas. The USA is at the top of the countries under analysis in this graph and shows rather constantly increasing shares in high-tech patents over the years. Between 2012 and 2013, however, a slight decline can be observed. Japan is the second most high-technology active country in terms of transnational patenting in the year 2013. Japan, which had clearly lost ground and had lower shares of patenting activities in high-tech areas between 2003 and 2005, has managed to catch up with the USA according to this indicator, although a slight decrease is visible from 2011 onwards. France was able to increase its high-tech shares up to 2006, yet the share remains mostly stable from this year onwards, although a slight growth, beginning in 2010, can be observed. Italy encountered a slight decrease in 2012, but seemed to recover in 2013. Germany scores fourth by this indicator, however also with slightly decreasing shares between 2012 and 2013.

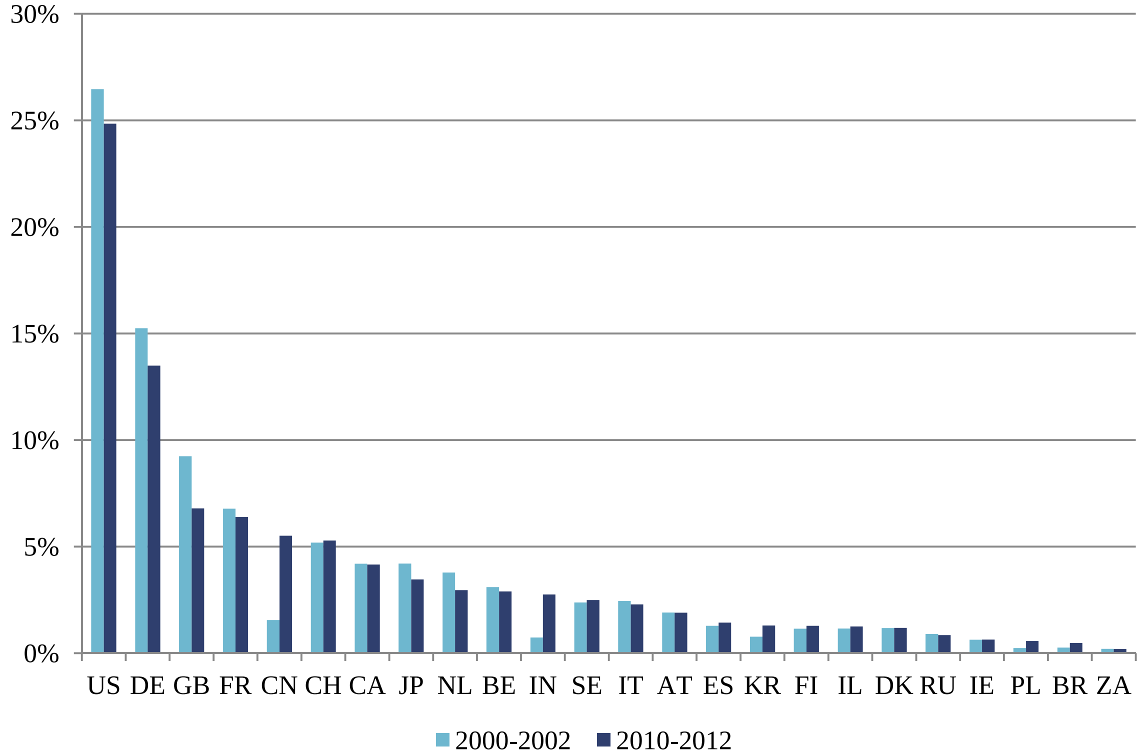
The lower panel of Figure 2: Shares of high-tech patent applications in total patent applications for selected countries, 1991-2013

shows that the high-tech shares of Korea have been decreasing between 2006 and 2009, although the absolute number of filings from Korea increased considerably. Since 2009, a stabilization of Korea's high-tech shares can be observed. 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, a slightly decreasing trend in high-technology shares can be observed.

International Co-Patenting Trends

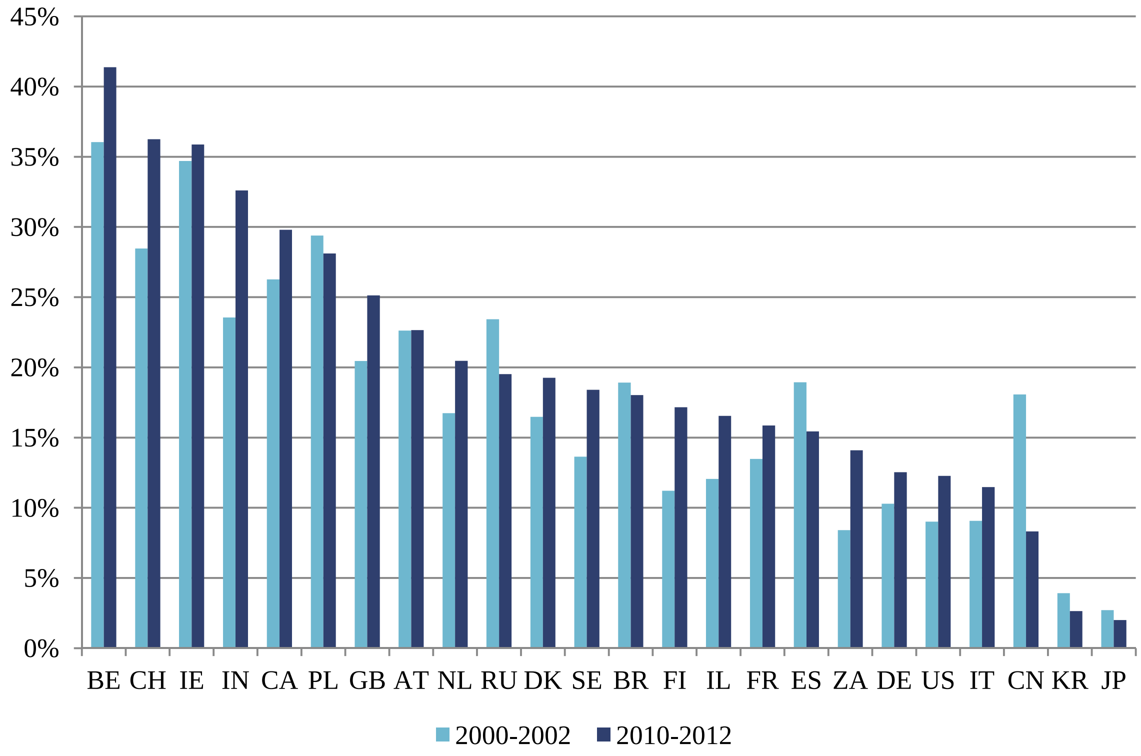
Figure 3 depicts the transnational co-patents by country as a share of all transnational co-patents world-wide. The US has the highest share of co-patents in all transnational co-patents with a value of 25% in the period 2010-212. However, since this figure is affected by size effects, this is not surprising as the US is also the largest filing country in terms of the absolute number of transnational filings. The US is followed by Germany, with a share of about 13% in the same time period. Germany is followed by Great Britain, with a share of about 7% and France with a share of 6%. The decline in the shares for these countries between 2000-2002 and 2010-2012 can mostly be attributed to the large number of filings (and also co-patents) coming from Chinese and Indian inventors. For these two countries, the largest growth of the number of co-patents can be observed between the two time periods.

Figure 3: Shares of transnational co-patents in all transnational filings of the respective country



Source: EPO – PATSTAT; Fraunhofer ISI calculations

Figure 4: Shares of transnational co-patents in all transnational filings of the respective country



Source: EPO – PATSTAT; Fraunhofer ISI calculations

Belgium, Switzerland and Ireland reach the highest shares of co-patents within its transnational patent portfolio, which is even increasing over the years. Similar effects can be found for India and Canada, which score fourth and fifth, respectively. These three countries are the most internationalized countries in terms of co-patenting. With a value of 13% in the period 2010-2012, Germany only has a medium internationalization level when regarding this indicator, which is also true for the US.

Figure 4 shows the shares of transnational co-patents in all transnational patents of the respective inventor country. Japan and Korea rank last by this indicator with only a share of 2% and 3%, respectively. This result has already been found in earlier reports, not only for the total number of patent filings but also within certain technology fields like Key Enabling Technologies (KETs) and Advanced Manufacturing Technologies (AMT) (Neuhäusler et al. 2015), and resembles the general underrepresentation in international science and innovation collaborations of Japan and Korea (Schubert et al. 2013; Weissenberger-Eibl et al. 2011). The reason is that the large firms that are responsible for the majority of patents within these two countries conduct most of their R&D at home and not in foreign countries.

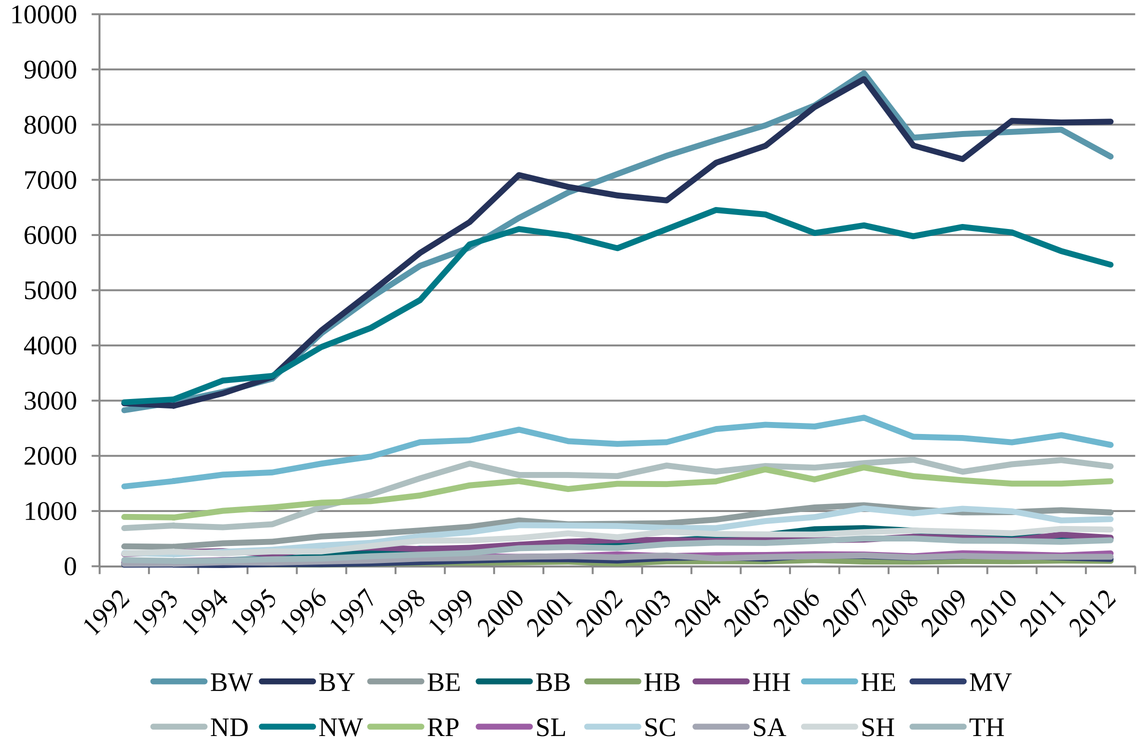
Patent Activities of the German Federal States

In Figure 5, the absolute numbers of transnational patent filings based on the address of the inventor are plotted.[3] Over the years, the number of filings is increasing for all German federal states, with slight decreases during the recent economic crisis. In 2012, also a slight decline in the figures can be observed. This has already been found in the analyses above, i.e. the number of transnational filings of Germany in total has slightly decreased compared to 2011.

The largest number of transnational filings within the German comparison can be found in the south. Bavaria ranks first, with over 8,000 filings in 2012, closely followed by Baden-Württemberg (about 7,400 filings in 2012) and North Rhine-Westphalia, at a slightly lower level (about 5,500 filings in 2012). Large parts of the German industry are located in these three countries. Therefore, it is not surprising that they are responsible for about two thirds of all German transnational filings. At the fourth rank is Hesse, followed by Lower-Saxony and Rhineland-Palatinate, who both reach similar levels in terms of patenting. The remainder of the federal states is at a similar level with 1,000 filings per year or less.

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 last year's report (Neuhäusler et al. 2014).

Figure 5: Number of transnational filings by federal states

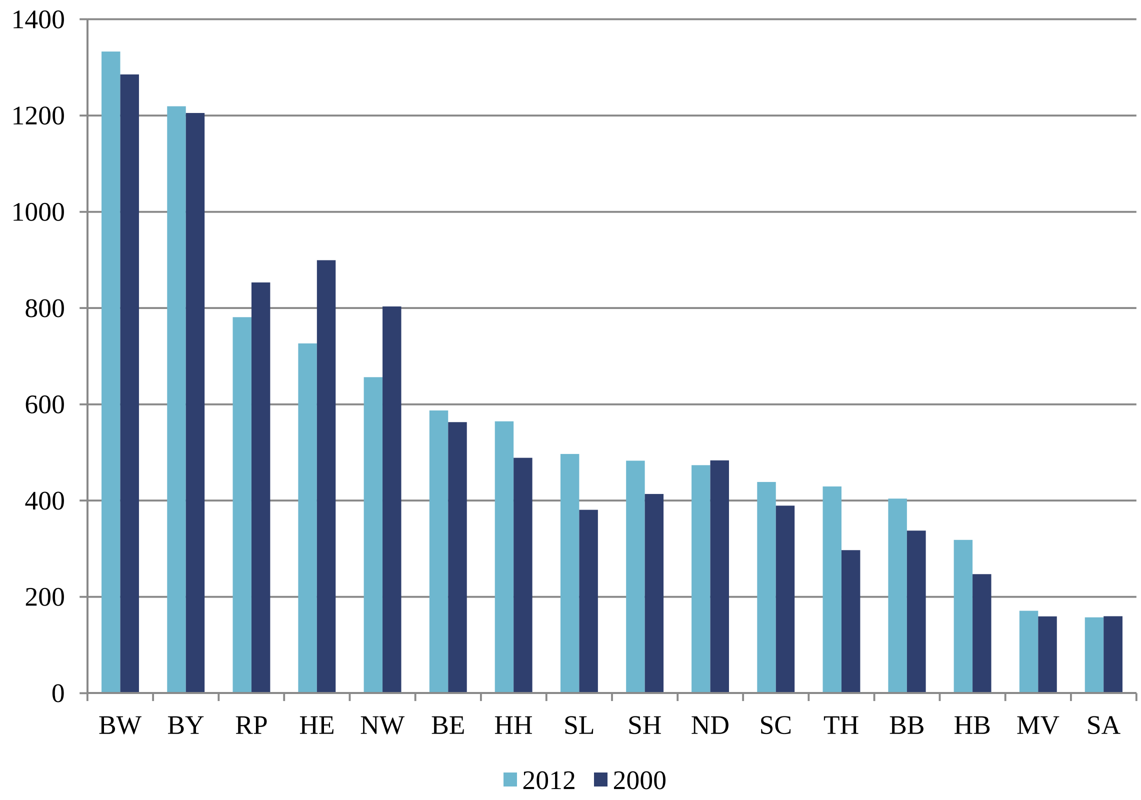


Source: EPO – PATSTAT; calculations by Fraunhofer ISI

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 6 shows the patent intensities, calculated as the number of patent filings by a federal state divided by the number of employees (in millions) in the respective state. Baden-Württemberg and Bavaria also score first by this indicator. North-Rhine Westphalia, on the other hand, which scored third in absolute terms, loses ground and scores only fifth within this comparison, after Rhineland-Palatinate and Hesse. The Eastern German states have the lowest patent intensity in comparison.

Figure 6: Patent intensities of the German federal states (per 1 million employees)



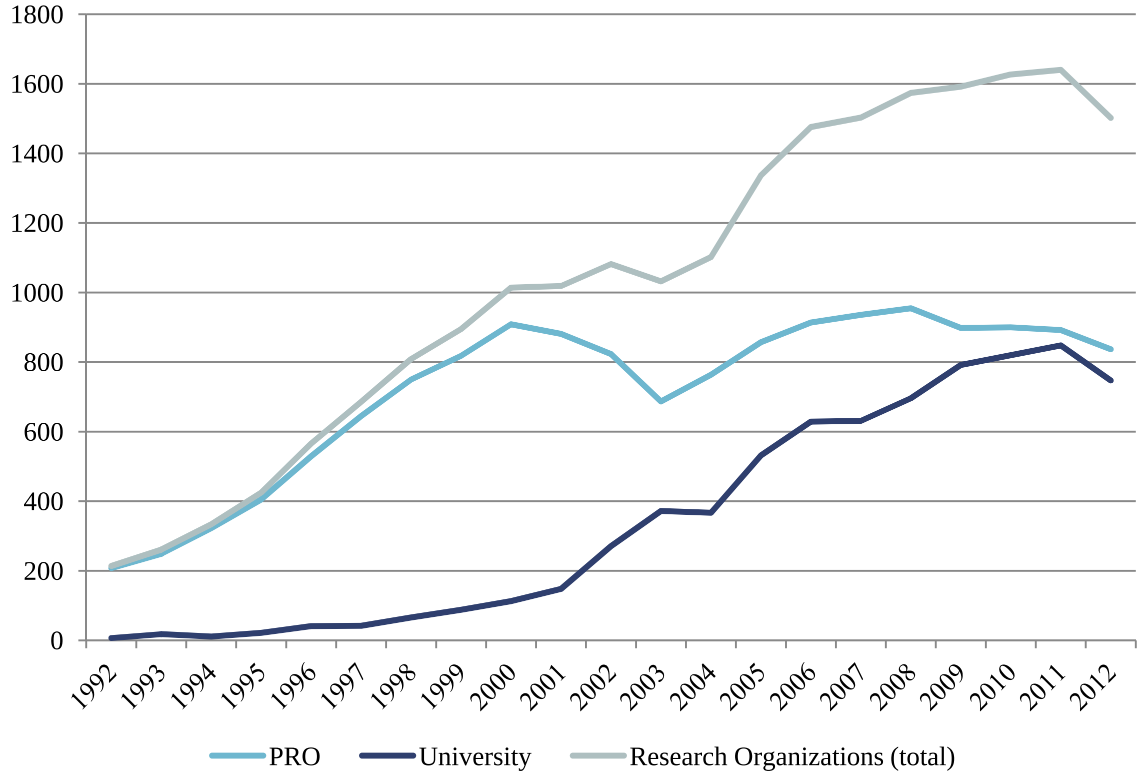
Source: EPO – PATSTAT; Statistisches Bundesamt, calculations by Fraunhofer ISI

Patents filed by Universities and Public Research Institutes

Figure 7 presents the total number of patents filed by research organizations in total, as well as differentiated by universities and public research organizations (PRO). The increase in the number of filings, by PRO but especially by universities, indicates that patenting has become more and more important for universities and PRO over the last 10 years.

In the year 2012, research organizations (in total) were responsible for about 1,500 transnational patent filings. About 750 of those were filed by universities, while about 840 were filed by PRO. For universities, however, higher growth rates can be observed. This increased growth can be explained by a legislation change in 2002 that was targeted towards promoting patent filings from universities and has led to a convergence in the number of filings from PRO and universities in the last few years.

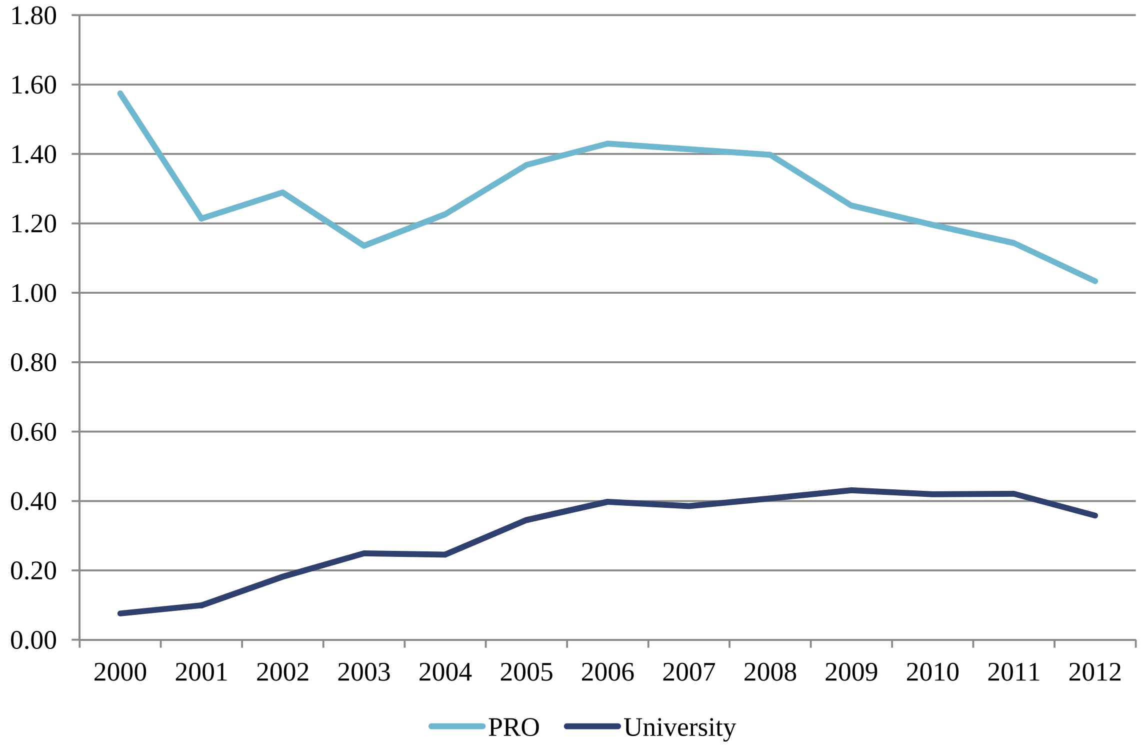
Figure 7: Number of transnational filings by German research organizations



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.

Figure 8: Patent intensities (patents per 1,000 employees, full-time equivalents) by German research organizations



Source: EPO – PATSTAT; BMBF Datenportal, calculations by Fraunhofer ISI

In 2012, a slight decline in the number of filings by universities and PRO can be observed compared to 2011. Besides the fact that the total number of filings by German inventors has slightly decreased over the years, this can be explained by the fact that especially international filings by research organizations were slightly decreasing. When looking at the national filings at the German Patent and Trademark Office (DPMA) (not shown), it can be observed that the filings for universities as well as PRI have remained at similar level as in 2011.

When looking at the patent intensities (Figure 8), i.e. the number of transnational patent filings per 1,000 employees (full-time equivalents), for universities as well as public research institutes, we can see that although universities file nearly as many patents as PRO, their patent intensity, at least in terms of patents where the university is named as an applicant, is rather low. The intensity of PRI is nearly three times higher than the patent intensity of universities. Yet, this is mostly driven by the fact that PRO, especially the Fraunhofer Society but also the Helmholtz Institutes and parts of the Leibniz Institutes, are more focused on applied research, which explains the high patent intensity compared to universities.

4.2 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 highest growth rates between 2003-2005 and 2011-2013 can be found in the fields of "electrical machinery, accessory and facilities", "rail vehicles", "aeronautics" and "lamps and batteries".

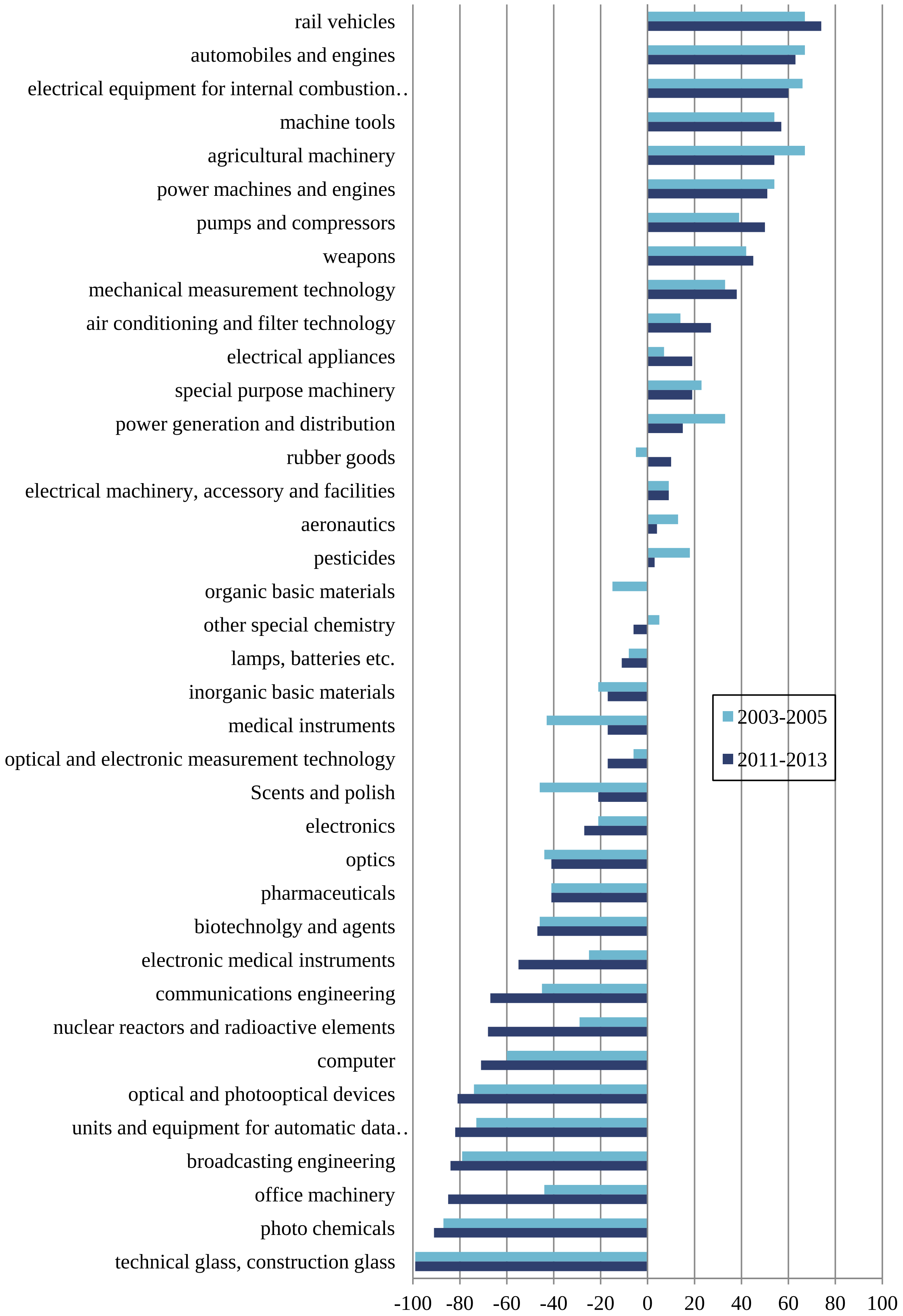
Among the fields that are growing most slowly in Germany are two smaller fields, namely "photo chemicals" and "office machinery". Yet, also the chemistry related fields "biotechnology and agents", "organic basic materials", "other special chemistry", "pesticides" and "pharmaceuticals" can be seen as comparably slowly growing fields within the German technology profile, followed by the ICT related fields of "computers" and "communications engineering" as well as the field "nuclear reactors and radioactive elements". 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.

Table 2 Transnational Patent applications of Germany according by high-technology sectors (absolute, specialization, and growth), 2011-2013

Technology Field	**Abs.**	**RPA**	**% Growth** (03-05=100)
electrical machinery, accessory and facilities	617	10	189.8
rail vehicles	297	73	174.3
aeronautics	800	2	169.3
lamps, batteries etc.	1733	-12	160.4
power generation and distribution	2007	15	158.6
rubber goods	306	10	147.1
electrical appliances	597	22	135.4
air conditioning and filter technology	1853	26	133.2
medical instruments	2597	-20	130.0
power machines and engines	3661	50	129.2
pumps and compressors	756	50	128.4
Scents and polish	40	-28	125.8
units and equipment for automatic data processing machines	738	-81	124.3
inorganic basic materials	417	-13	124.2
electronics	1453	-25	122.0
optics	615	-40	112.1
electrical equipment for internal combustion engines and vehicles	1121	57	110.5
technical glass, construction glass	116	-99	109.7
mechanical measurement technology	1120	38	109.4
optical and electronic measurement technology	2638	-16	106.7
machine tools	2350	57	105.2
weapons	258	47	104.9
agricultural machinery	502	53	99.0
optical and photooptical devices	61	-81	94.9
special purpose machinery	3172	18	87.7
automobiles and engines	5254	63	86.4
broadcasting engineering	616	-84	85.3
electronic medical instruments	701	-54	82.0
communications engineering	3639	-67	81.8
pesticides	496	4	78.8
other special chemistry	986	-3	77.7
computer	1779	-70	73.1
organic basic materials	1513	0	71.3
nuclear reactors and radioactive elements	15	-60	69.7
pharmaceuticals	1077	-42	69.2
biotechnolgy and agents	1479	-49	65.8
office machinery	41	-87	34.4
photo chemicals	2	-81	13.7

Source: EPO – PATSTAT; Fraunhofer ISI calculations

Figure 9: Germany's technological profile, 2003-2005 vs. 2011-2013



Source: EPO – PATSTAT; Fraunhofer ISI calculations

The specialization (RPA) of the German technology profile of the years 2003-2005 and 2011-2013 is displayed in Figure 9. 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 "electrical equipment for internal combustion engines and vehicles".

An average activity rate in patenting can be found in the chemical sectors ("organic basic materials", "other special chemistry"). Comparative disadvantages, reflected in negative specialization indices, can be found in pharmaceuticals, biotechnology, information and communication technologies as well as optics and optical devices, meaning that Germany does not have an outstanding profile 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.

5 Patent Filings and Patent Citations as Performance Indicators for German Universities

Researchers usually publish their scientific achievements 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). Besides publications, however, patent filings are a major output of R&D activities of universities. In contrast to publications, they more directly indicate the technological output of research organizations and can consequently be used to assess this output. Patents are filed to achieve temporary protection of new products or processes on the market place (Schmoch 1997). They indicate an interest in the commercial exploitation of a new finding or a new technology. Thus, 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. By employing patent statistics to assess the performance of German universities, we are able to draw conclusion about the technology-oriented output of these research organizations.

The creation, diffusion and application of scientific and technological knowledge are crucial foundations of technological activities and key elements for the performance of national innovation systems. Within this context, 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). In the recent years, a set of policy actions was undertaken to strengthen and improve the efficiency of technology transfer between university and industry. They mostly aimed towards giving universities a higher autonomy and flexibility to enable them to introduce own regulations that apply to the management of technology transfer, contracts with industry and IPR. An important aspect has been seen in promoting patent filings from universities. One step towards this end has been seen in abolishing the traditional professor's privilege (Hochschullehrerprivileg) in 2002, where the individual ownership of academic patents was replaced by a system of institutional ownership by the universities (Geuna and Rossi 2011). Since then, employee inventions are owned by the employing university and no longer by the inventors themselves. Similar activities have been carried out in several European countries, with the Bayh-Dole Act in the US serving as the prototype. However, research financed fully or partly by external contractors as for example private companies, remains subject to negotiations regarding the allocation of patent rights (Geuna and Rossi 2011).

Consequently, a large share of patent filings from universities is registered by companies and the university staff only appears as inventors. Simply counting the number of patents where the university appears as an applicant thus leads to an incomplete picture of patent filings by universities (the part where firms or individual inventors are named as patent applicants is missed). For a correct detection of trends in patent filings from German universities, an improved approach, which is able to detect patent filings that have not been formally applied for by universities themselves, is needed. The approach followed here is based on the idea of matching the names of scientific authors (research-active university staff) with inventor names from the PATSTAT database.

Once the academic patents have been identified, we are able to capture the performance of German universities in two dimensions, namely quantitatively and qualitatively. These two dimensions are reflected in two indicators, the number of patent filings by universities as well as the average number of citations these patents receive from subsequent patents (forward citations). Although associated with a certain amount of noise (Alcacer and Gittelman 2006; Harhoff et al. 2003), counts of forward citations signal the degree to which a patent contributes to further developing advanced technology and therefore the technological significance or importance of a patent (Carpenter et al. 1981; Hall et al. 2005; Harhoff et al. 2003; Trajtenberg 1990).

This method allows us to detect the top universities in terms of patent filings in Germany. Besides these two indicators, growth rates and patent intensities of the universities will be provided in this chapter. Finally, we will take a closer look at the (aggregate) technological profile of the German universities and the technological profile of the top 3 universities in terms of patent filings and citations. Here, the question whether the filings are widely spread across different technology fields or concentrated to only a few fields stands in the focus of the analysis.

5.1 Data and Methods

5.1.1 The Data

At the core of the analysis, patent filings at the European Patent Office (EPO) based on the PATSTAT database will be analyzed. In addition to the absolute numbers, patent intensities are calculated, which ensures better comparability absent size effects. The figures for the patent intensities are calculated as the total number of patent filings per 100 R&D employees (full-time equivalents) in the respective universities. The data on university employees were extracted from the German Federal Statistical Office (Statistisches Bundesamt 2013) as well as the Federal Report on Research and Innovation 2012 (Federal Ministry on Education and Research (BMBF) 2012). Gaps within the data for certain years were estimated on the basis of the values of the preceding and following years.

5.1.2 The identification of patents from universities and public research institutions

Previous studies have shown that a simple count of the patents, for which the university is named as the applicant, provides only a limited picture of the patent output from universities (c.f. Dornbusch et al. 2013; Lissoni et al. 2009; 2008). To draw a more complete picture of the patent output of universities, also inventions that were made within the university and for which a patent was filed by a company, need to be taken into account to cover the full inventive output of the respective university. The two groups, i.e. patents filed by the university itself ("university filed") and patents filed by other applicants, where university employees where involved in the invention leading to the patent ("university invented"), are referred to as "academic patents" (c.f. Lissoni et al. 2008).

Figure 10: Selection criteria for academic patents

2) Organization | 3) Names | 4) Time | 5) Location | 6) Subject

$$x_{\text{uni-inv}} = 1 \text{ if } (a_{\text{names match}} + b_{\text{time match}} + c_{\text{location match}} + d_{\text{subject match}})$$

	Organization matching	Name matching	Time window matching	Location matching	Classification matching
PATSTAT	?	Full strings of last- and first name	Priority year	NUTS3-Codes and distance matrix	IPC classification = WIPO 34
SCOPUS	Author affiliation = university	Full strings of last- and first name	Publication year: One year time-lag and time-window	NUTS3-Codes and distance matrix	Scopus classification: fine- / coarse-grained

Source: Adapted from Dornbusch et al. (2013)

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. Patents do not indicate the employing institution of an inventor, while the publications list the authors' affiliation and enable us to identify academic inventors and the patents they have contributed to. At the same time this also allows us to connect these patents to the publications of those university employees and academic authors.

Based on a keyword search and manual correction, the German universities were identified and coded as such within Scopus. Their publications, including the adhering bibliographic information, were stored in one and all EPO filings of German inventors were stored within another separate table. Accordingly, 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).

Table 3 Recall, precision and F-Score

Selection criteria: Full name +	**Recall**	**Precision**	**F-Scores** R=P (F_1)	P>R ($F_{0,5}$)
Location*	0.71	0.77	0.74	0.76
Subject match	0.71	0.52	0.60	0.55
Location*, subject match	0.59	0.93	0.72	**0.83**

Source: Dornbusch et al. (2013)

*= Calculations were based on a match of two-digit postal codes, meanwhile NUTS3 Codes including a distance matrix are implemented.

For the evaluation of the alogorithm a *recall* and *precision* analysis has been applied (Baeza-Yates and Ribeiro-Neto 2011).[4] A precondition for this is to generate exact reference datasets. As for the *recall*, namely the estimate of the proportion of correctly identified documents in all documents, we identified the number of patents with universities themselves as applicants by simple keyword searches, as described above, and calculated the share of correctly identified patents. 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 was calculated.[6]

It represents the harmonized mean between recall and precision. A set of different configurations have been tested and the relevant ones, for our purpose of this study, are displayed

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: Fß = (1+ß²) (p*r)/(ß²*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.

in Table 3.[7] The combination of full names with the location criterion as well as the subject match obviously achieves the best results (F-Score: 0.83), particularly when giving precision a higher priority over recall. However, as a concession to high precision we have to accept a reduced recall, i.e. the retrieved results are 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. In detail, we have collected lists of researchers of four faculties with different scientific and technological profiles at selected German universities (LMU Munich - Faculty for Chemistry and Pharmacy, TU Dresden - Faculty of Electrical and Computer Engineering, TU-Darmstadt - Department of Mechanical Engineering, RWTH Aachen - Faculty of Mechanical Engineering). We have then matched these lists with Scopus via a simple name matching algorithm to find out which shares of researchers is actually publishing (and therefore can potentially be matched to the PATSTAT dataset to search for possible patent filings). 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.[8]

However, the number of academic patents is slightly higher for all analyzed years compared to the report from last year's series. This has several reasons that are connected to the fact that the most recent version of Scopus (version 2014) was used for the matching. First, the coverage of scientific journals (across all years) in the recent Scopus version is higher than in the earlier versions. This implies that more publications - and as a consequence more authors that can potentially be matched to inventors from PATSTAT - are included. Second, new names or name variations of universities have been included and added to Scopus' "Organization ID", which also enlarges the potential number of authors that can be matched to PATSTAT. In sum, the coverage of authors at the Scopus side is higher in the most recent version, ultimately leading to a better coverage of academic patents and thus to overall larger filing numbers compared to last year's report.

7 Please compare Dornbusch et al. (2013) for a detailed discussion on the effects and the validation of the chosen selection criteria.

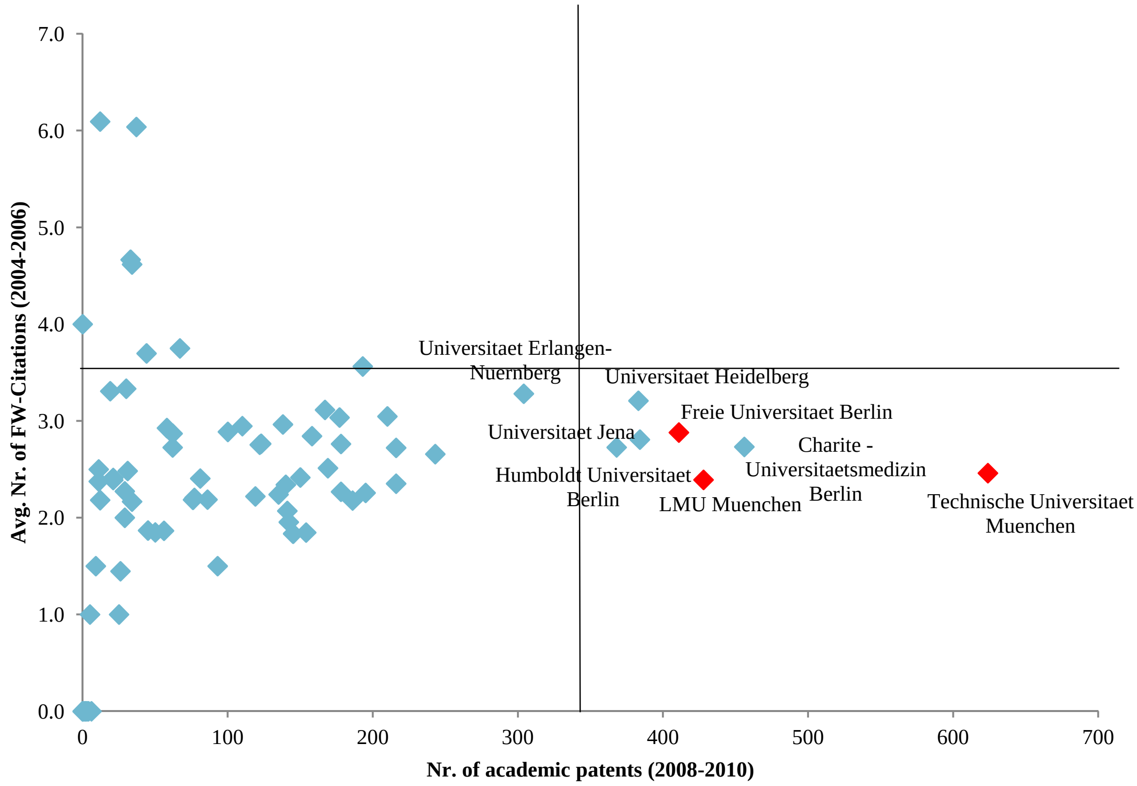
8 Due to the lack of data, only names of university professors were included for TU Darmstadt and the TU Dresden. This is supposed to result in somewhat higher figures compared to also including scientific coworkers etc..

5.2 Results

The identification of the top German universities in terms of the number of patent filings, i.e. the quantitative dimension, and in terms of citations received from subsequent patents, the qualitative dimension, is plotted in Figure 11. This matrix shows which of the German universities has the largest patent output compared to its quality, i.e. the universities oriented towards the upper-right corner are the (technological) top-performers in Germany as measured by these two indicators. The universities with the largest number of academic patents within the time period from 2008 to 2010 in a descending order are the "Technische Universitaet Muenchen", the "Charité - Universitaetsmedizin Berlin" (which is a special case as this is the university hospital of the "Humboldt Universitaet Berlin" and the "Freie Universitaet Berlin"), the "LMU Muenchen", the "Freie Universitaet Berlin", the "Humboldt Universitaet Berlin", the "Universitaet Heidelberg", the "Universitaet Jena" and the "Universitaet Erlangen-Nuernberg". This rather small group constitutes the German universities with more than 300 academic patents each in the 3-year time period. All other universities have significantly fewer patents (below 250) within the same time frame. The two universities with the highest number of citations received on average are the "Universitaet Siegen" and the "Universitaet Bayreuth" (upper left corner), which, however, have filed only a very small number of patents between 2008 and 2010. The largest universities in terms of patents filings listed above, however, also reach rather high citation rates between 2.4 and 3.3, i.e. a high quantity goes along with a comparably high quality.

Since the picture does not provide us with a "final answer" on the top 3 universities, we sticked with the "Technische Universitaet Muenchen", the "LMU Muenchen" and the "Freie Universitaet Berlin" for further analyses of technological profiles (provided below).

Figure 11: Estimated number of academic patents and average number of forward citations by German universities, EPO



Source: EPO – PATSTAT; Elsevier – SCOPUS; calculations by Fraunhofer ISI.

In addition to the absolute number of academic patents as well as the average number of forward citations for all patenting German universities, Table 4 shows the patent intensities, i.e. the number of EPO patent filings per 100 R&D employees (full-time equivalents), for German universities. This "size-corrected" measure shows that smaller universities gain a “small size advantage” and rank higher than in terms of the absolute number of filings. The top universities in terms of intensities are the "Universitaet Luebeck", "Humboldt Universitaet Berlin", "Freie Universitaet Berlin", "Charité - Universitaetsmedizin Berlin", "Universitaet Jena" and the "Technische Universitaet Muenchen". As in last year's report, it is striking that particularly universities in Munich and Berlin show high numbers of academic patents as well as high patent intensities. It should consequently be mentioned that double counts due to co-patents are possible and that in large research clusters like Munich and Berlin close and organizational networks are likely to exist. This is particularly true for universities cooperating with medical facilities such as the Charité University Hospital in Berlin. Besides this fact, however, it can still be stated as a general trend that large technical universities and universities with huge medical facilities (e.g. Charité, Universitaet Heidelberg, LMU Muenchen), located in large agglomerations, generate the largest numbers of academic patents not only in absolute terms but also per employee.

Table 4 Estimated number of academic patents, patent intensities and average number forward citations by German universities, EPO

University Name	Nr. of filings (2008-2010)	Patent Intensities (2008-2010)	Avg. Nr. of FW-Citations (2004-2006)
Technische Universitaet Muenchen	624	3,33	2,5
Charite - Universitaetsmedizin Berlin	456	3,43	2,7
LMU Muenchen	428	1,89	2,4
Freie Universitaet Berlin	411	3,70	2,9
Universitaet Jena	384	3,37	2,8
Universitaet Heidelberg	383	1,91	3,2
Humboldt Universitaet Berlin	368	4,34	2,7
Universitaet Erlangen-Nuernberg	304	1,85	3,3
Technische Universitaet Dresden	243	1,41	2,7
Universitaet Duesseldorf	216	2,45	2,7
Universitaet Freiburg (i.Br.)	216	1,26	2,4
Technische Universitaet Berlin	210	1,89	3,0
Universitaet Mainz	195	1,53	2,3
RWTH Aachen	193	1,15	3,6
Universitaet Stuttgart	186	1,64	2,2
Medizinische Hochschule Hannover	178	2,88	2,8
Karlsruher Institut fuer Technologie	178	1,74	2,3
Universitaet Tuebingen	177	1,37	3,0
Universitaet Duisburg-Essen	169	1,45	2,5
Universitaet Ulm	167	2,30	3,1
Universitaet Hamburg	158	0,95	2,8
Ruhr-Universitaet Bochum	154	1,38	1,8
Universitaet Wuerzburg	150	1,17	2,4
Universitaet Kiel	145	1,15	1,8
Universitaet Muenster	142	0,88	2,0
Universitaet des Saarlandes	141	1,52	2,1
Universitaet Koeln	140	1,12	2,3
Universitaet Marburg	138	2,16	3,0
Technische Universitaet Darmstadt	135	1,71	2,2
Universitaet Regensburg	123	1,22	2,8
Universitaet Hannover	122	1,49	2,8
Universitaet Goettingen	119	1,03	2,2
Universitaet Frankfurt a.M.	110	0,90	2,9
Universitaet Dortmund	100	1,34	2,9
Universitaet Leipzig	93	0,79	1,5
Universitaet Giessen	86	0,76	2,2
Technische Universitaet Braunschweig	81	1,27	2,4
Universitaet Rostock	76	1,10	2,2
Universitaet Halle	67	0,80	3,8
Technische Universitaet Kaiserslautern	62	1,65	2,9
Universitaet Magdeburg	62	0,96	2,7
Universitaet Bonn	58	0,42	2,9
Universitaet Luebeck	56	7,79	1,9
Technische Universitaet Hamburg-Harburg	50	2,14	1,8
Universitaet Greifswald	45	0,79	1,9
Universitaet Konstanz	44	0,97	3,7
Universitaet Bayreuth	37	0,81	6,0
Technische Universitaet Ilmenau	34	1,23	2,2
Universitaet Mannheim	34	0,91	4,6
Universitaet Potsdam	33	0,54	4,7
Universitaet Wuppertal	31	0,73	2,5
Technische Universitaet Chemnitz	30	0,66	3,3
Technische Universitaet Clausthal	29	1,50	2,3
Universitaet Bielefeld	29	0,48	2,0
Universitaet Bremen	26	0,38	1,4
Universitaet Osnabrueck	25	0,70	1,0
Universitaet der Bundeswehr Hamburg	21	2,16	2,4
Universitaet Paderborn	21	0,51	2,4
Universitaet Kassel	19	0,31	3,3
Universitaet Hohenheim	12	0,40	2,2
Universitaet Siegen	12	0,28	6,1
Technische Universitaet Bergakademie Freiberg	11	0,38	2,5
Universitaet Augsburg	11	0,26	2,4
Universitaet der Bundeswehr Muenchen	9	0,40	1,5
Universitaet Trier	6	0,18	0,0
Brandenburgische Technische Universitaet Cottbus	5	0,20	1,0
Universität Vechta	4	0,38	0,0
Universitaet Koblenz-Landau	3	0,12	0,0
Universitaet Weimar	2	0,10	0,0
Universitaet Passau	2	0,09	0,0
Universitaet Lueneburg	1	0,04	0,0
FernUniversitaet Hagen	0	0,00	4,0
Universitaet Bamberg	0	0,00	0,0
Universitaet Frankfurt (Oder)	0	0,00	0,0
Universitaet Oldenburg	0	0,00	0,0
Universität Eichstätt - Ingolstadt	0	0,00	0,0

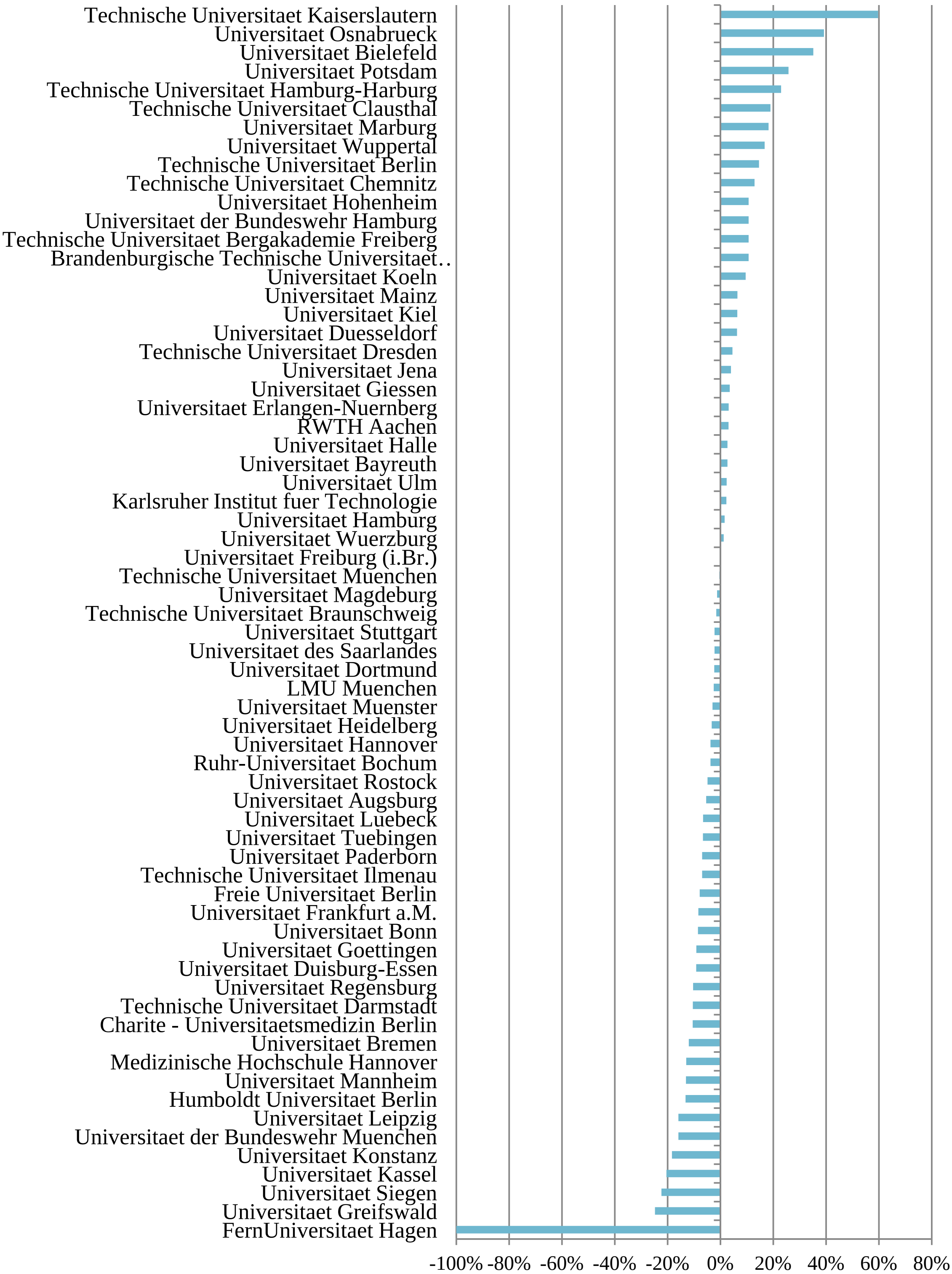
Source: EPO – PATSTAT; Elsevier – SCOPUS; Statistisches Bundesamt; calculations by Fraunhofer ISI.

In Figure 12, the growth rates of academic patents between 2006 and 2010 are shown. As can be seen from the figure, especially smaller universities (in terms of patent filings) have the largest growth rates. On top is the "Technische Universitaet Kaiserslautern", followed by the "Universitaet Osnabrueck", "Universitaet Bielefeld", "Universitaet Potsdam" and the "Technische Universitaet Hamburg-Harburg". However, it has to be mentioned that all these universities still have less than 50 academic patents in the time period from 2006 to 2010 and high growth rates can thus more easily be achieved.

Most of the larger universities in terms of patent filings reach medium growth rates between -3 and +4 percentage points between 2006 and 2010. Only the universities in the Berlin region, i.e. the Charité - Universitaetsmedizin Berlin", the "Humboldt Universitaet Berlin" and the "Freie Universitaet Berlin", show lower growth rates between -8 and -16 percentage points.

One further fact that is important to mention is that many of the technical universities have rather high growth rates. From the TU9, the nine technical universities in Germany, five are in the top10 list in terms of growth rates and all other technical universities also show positive growth in patent filings between 2006 and 2010 (except for "the Technische Universitaet Braunschweig" with a slightly negative value).

Figure 12: Compound Annual Growth Rate (CAGR) of academic patents, EPO, 2006-2010



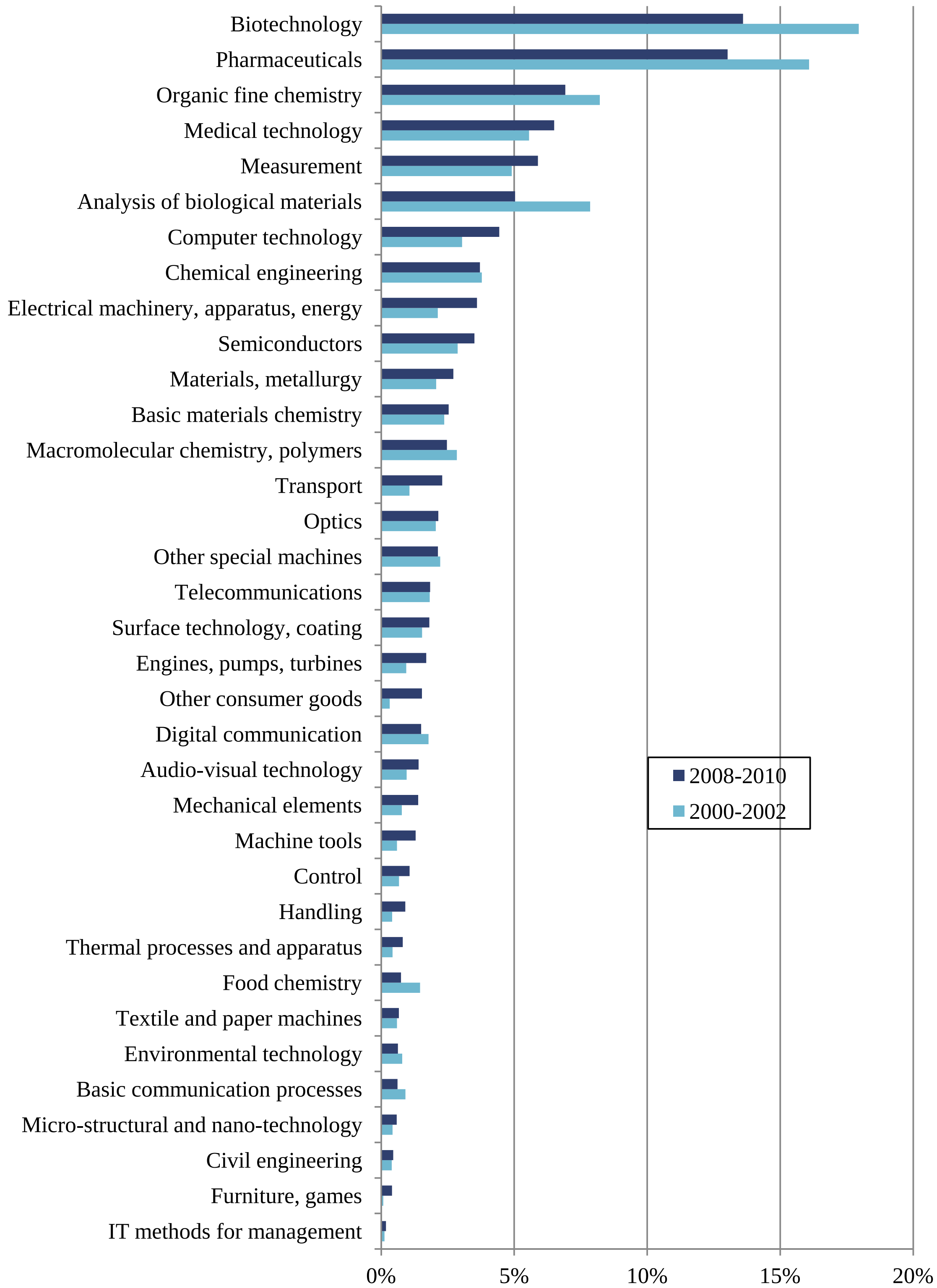
Source: EPO – PATSTAT; Elsevier – SCOPUS; calculations by Fraunhofer ISI.

In the final step, we will take a closer look at the technological profiles of the universities. On aggregate, i.e. across all German universities, this is shown in Figure 13. Here, the above mentioned effect that large technical universities and universities with huge medical facilities generate the largest numbers of academic patents becomes visible once more.

Although the share has slightly decreased between 2000-2002 and 2008-2010 - due to increases in other technology fields - biotechnology and pharmaceuticals show the largest shares of academic patents across all German universities (14% and 13%, respectively), followed by organic fine chemistry, medical technology and measurement. In chemistry and related fields thus the highest shares of academic patents can be found, followed by fields related to instruments and some sub-fields of electrical engineering, e.g. computer technology and semiconductors. The smallest shares of academic patents can be observed in mechanical engineering and related fields. A calculation of the Herfindahl-Hirschman-Index, a concentration measure ranging from 0 (minimum concentration) and 1 (maximum concentration), shows that the filings are rather evenly spread across technology fields (HHI value of 0.08 in 2000-2002 and 0.06 in 2008-2010).

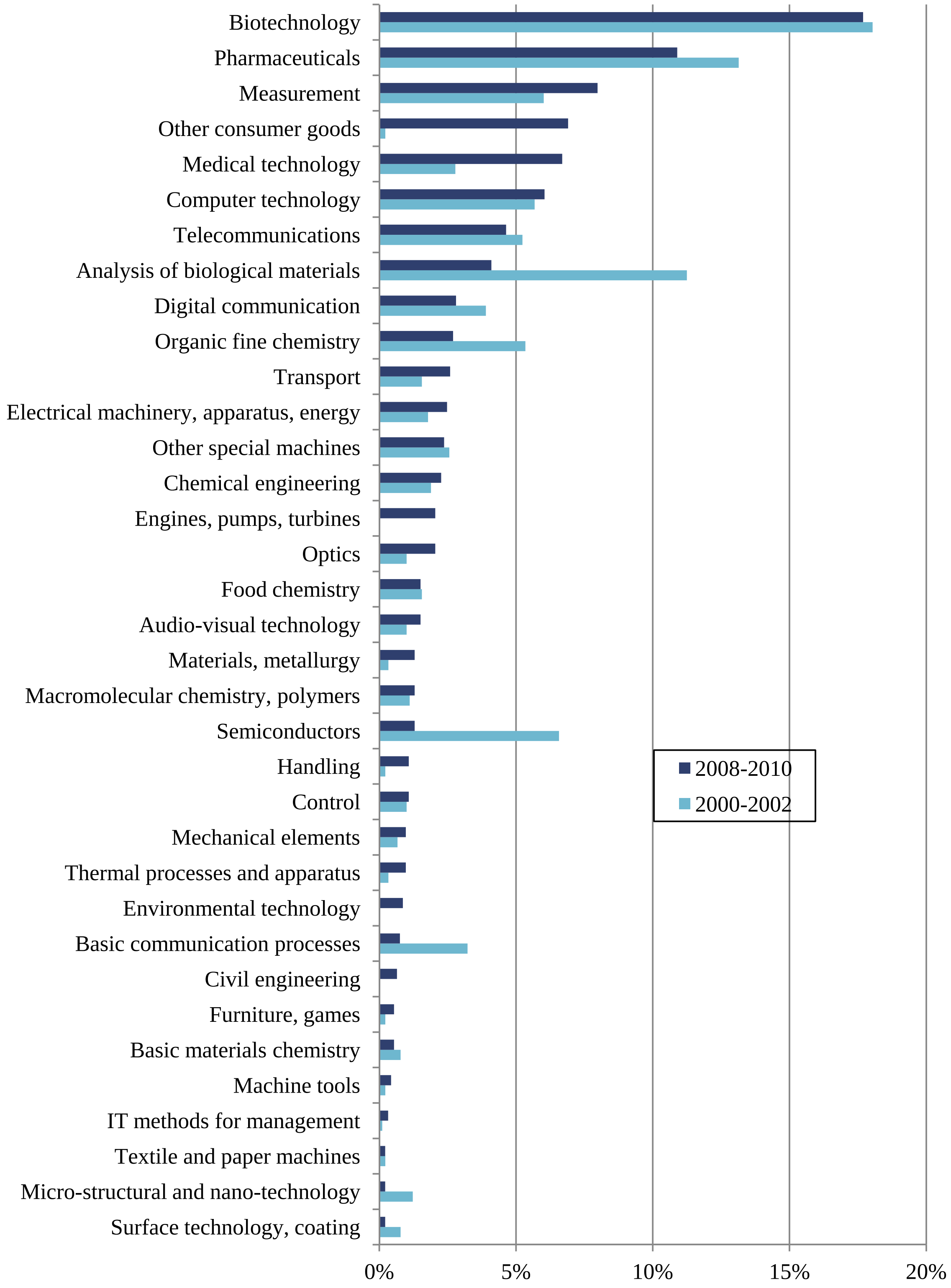
This changes only slightly when looking at the profiles of the top 3 universities listed above. For the "Technische Universitaet Muenchen", for example (Figure 14), also the fields biotechnology and pharmaceuticals reach the largest shares. However, in this university's portfolio, electrical and mechanical engineering seem to play a larger role than on average. The calculation of the HHI though shows a slightly higher concentration than average with a value of 0.09 in 2000-2002 and 0.07 in 2008-2010. At the "LMU Muenchen" (Figure 15), on the other hand, a specialization on chemistry and related fields as well as instruments (optics, medical technology, measurement) can be observed. In addition, the HHI values are higher than at the "Technische Universitaet Muenchen" (0.15 in 2000-2002 and 0.12 in 2008-2010). Finally, at the "Freie Universitaet Berlin" (Figure 16), computer technology and audio-visual technology play a comparably large role. This university has the most uneven spread across technology fields with HHI values of 0.20 in 2000-2002 and 0.19 in 2008-2010, resulting from the largest shares of patents in biotechnology and pharmaceuticals among the universities in comparison.

Figure 13: Technological profile of German universities (total)



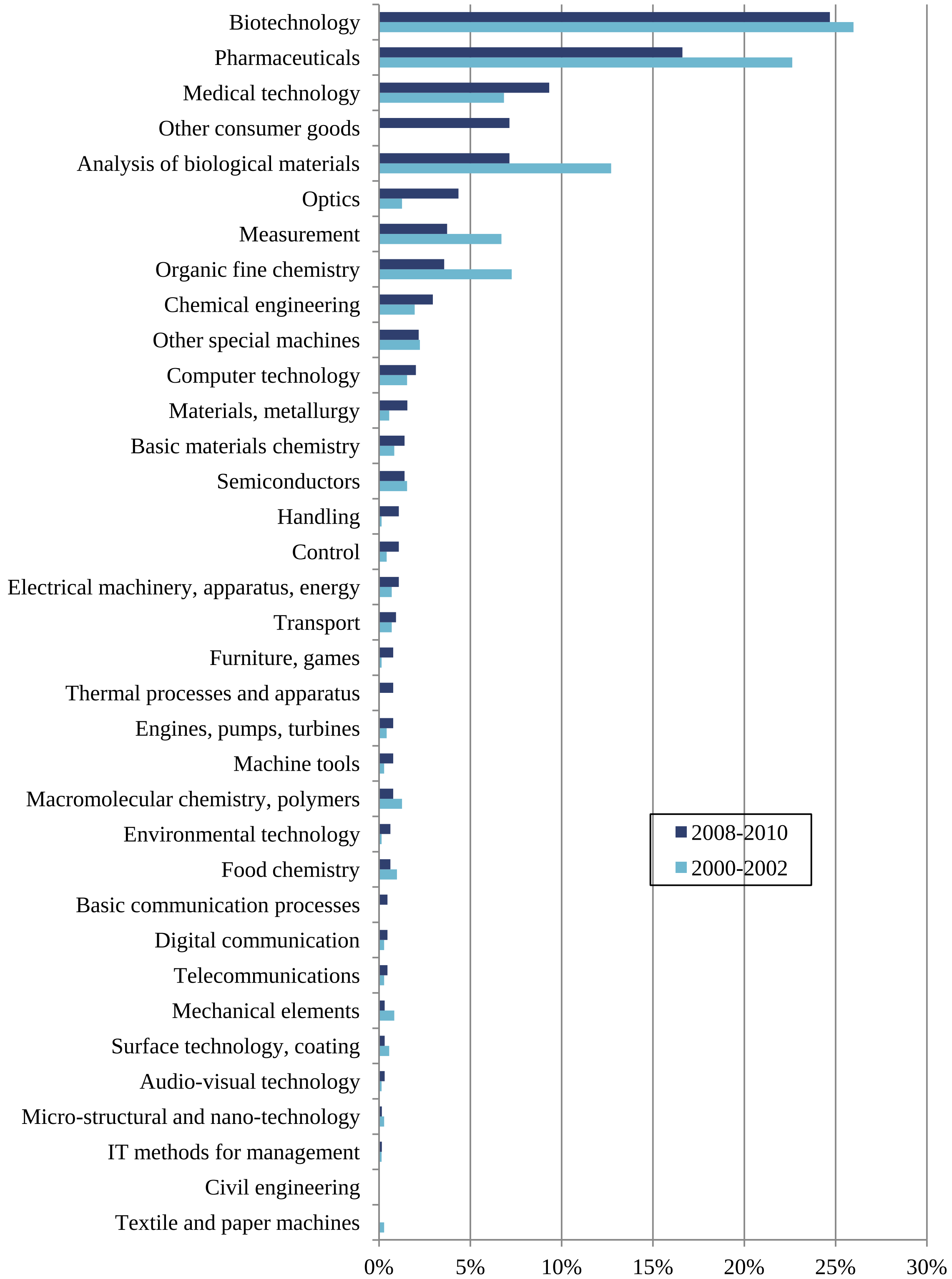
Source: EPO – PATSTAT; Elsevier – SCOPUS; calculations by Fraunhofer ISI.

Figure 14: Technological profile of the "Technische Universitaet Muenchen"



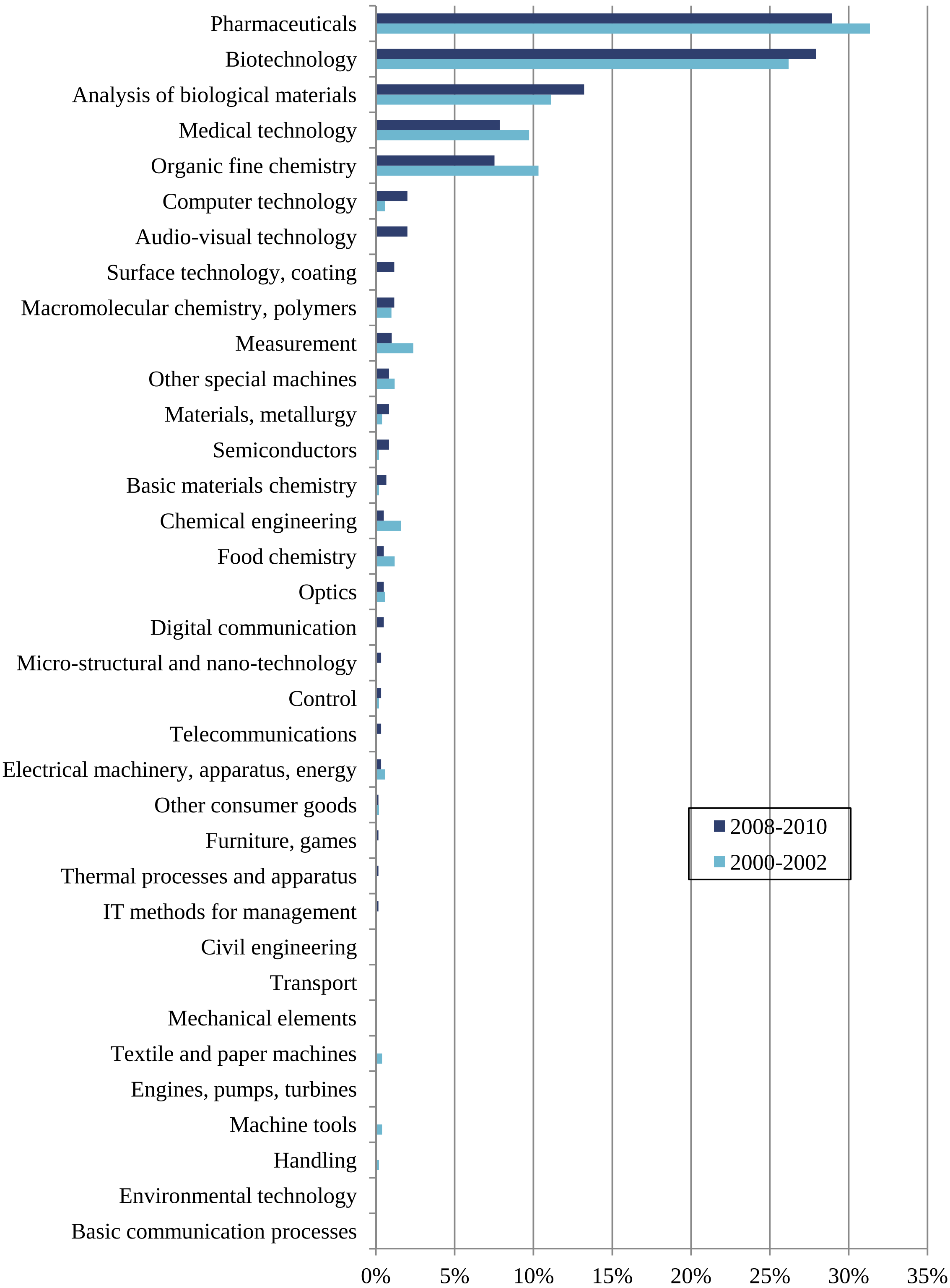
Source: EPO – PATSTAT; Elsevier – SCOPUS; calculations by Fraunhofer ISI.

Figure 15: Technological profile of the "LMU Muenchen"



Source: EPO – PATSTAT; Elsevier – SCOPUS; calculations by Fraunhofer ISI.

Figure 16: Technological profile of the "Freie Universitaet Berlin"



Source: EPO – PATSTAT; Elsevier – SCOPUS; calculations by Fraunhofer ISI.

5.3 Summary and conclusions

In this chapter, we have analyzed the technological performance of German universities in two dimensions, quantitatively and qualitatively. These two dimensions are reflected by two indicators, the number of patent filings by universities as well as the average number of citations these patents receive from subsequent patents. Based on this method, we have identified the top universities in terms of patent filings in Germany. These are the "Technische Universitaet Muenchen", the "Charité - Universitaetsmedizin Berlin, the "LMU Muenchen", the "Freie Universitaet Berlin", the "Humboldt Universitaet Berlin", the "Universitaet Heidelberg", the "Universitaet Jena" and the "Universitaet Erlangen-Nuernberg", each having more than 300 academic patent filings at the EPO between 2008 and 2010. When looking at the patent intensities, smaller universities gain a "small size advantage" and rank higher than in terms of the number of filings. However, the largest universities listed above also reach rather high patent intensities. It can thus be stated that large technical universities and universities with huge medical facilities (e.g. Charité, Universitaet Heidelberg, LMU Muenchen), located in large agglomerations, generate the largest numbers of academic patents not only in absolute terms but also per employee.

Yet, in terms of growth rates, the smaller universities (in terms of patent filings) are on top of the list and reach the highest growth rates. Most of the larger universities in terms of patent filings reach medium growth rates between -3 and +4 percentage points between 2006 and 2010. In addition, it could be found that especially the technical universities have rather high growth rates.

A look at the technological profiles reveals that biotechnology and pharmaceuticals show the largest shares of academic patents across all German universities. In chemistry and related fields thus the highest shares of academic patents can be found, followed by fields related to instruments and some sub-fields of electrical engineering, e.g. computer technology and semiconductors. The smallest shares of academic patents can be observed in mechanical engineering and related fields. The Herfindahl-Hirschman-Index shows a rather high spread of filings across all technology fields. The single universities within our comparison, however, show larger concentrations to certain fields, reflecting the technological specializations of the universities in Germany.

6 References

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