Patent Applications – Structures, Trends and Recent Developments

Rainer Frietsch, Ulrich Schmoch, Peter Neuhäusler, Oliver Rothengatter

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Geschäftsstelle:
Technische Universität Berlin, VWS 2
Müller-Breslau-Strasse (Schleuseninsel)
10623 Berlin

http://www.e-fi.de/

Contact address and further information:

Rainer Frietsch
Fraunhofer Institute for Systems and Innovation Research
Competence Center Policy and Regions
Breslauer Strasse 48
76139 Karlsruhe
Phone: +49-721-6809-197
Fax: +49-721-6809-176
e-mail: rainer.frietsch@isi.fraunhofer.de

Contents

Figures

Tables

1. Summary

The impact of the economic crisis is clearly visible in this year's analyses. The trends of transnational patent applications in the priority year 2007 were mainly affected by a reduced internationalisation of the filings and this was especially visible for countries focusing on the US-American technology market (Frietsch et al. 2010a). Different explanations had to be found for the impact on the priority year 2008, where decreasing filing numbers were visible for all countries, even China. Not only a more selective internationalisation of the filings, but obviously also reduced or postponed R&D processes appear to affect the trends in 2008.

In a long-term perspective, the role of transnational patenting in high-tech and low-tech is very stable. High-tech patents reach an almost constant rate of about 55% in total worldwide patenting, but some of the countries underwent a strict change of their profile in this respect. For example, Italy has constantly lost ground in high-tech patenting since the beginning of the 1990s and only filed 42% of its patents in high-tech sectors in 2008. Also, Japan had a decreasing rate of high-tech patents in their profile, but still reached an above-average level. Korea and China that developed and entered the group of technology-oriented countries also had to face a decreasing share of high-tech patents in their phases ??? when the absolute numbers began to grow very quickly. Korea was able to convert this trend in recent years and is now on an average level of high-tech patenting. Finland, on the other hand, was able to increase its high-tech shares even in times of expansion.

Some countries like Finland or the Netherlands have a greatly polarised profile. They have high shares of low-tech patents and, at the same time, high shares in leading-edge technologies, but very low shares in high-level technologies. Germany and Switzerland are the only countries that show a strict focus on high-level technologies, most of the other countries – especially the new entrants – target leading-edge technologies.

The country profiles of Germany and the USA are opposite to each other. While Germany focuses on transport, machinery and electrical engineering (power machines and power generation), the USA are focused on life sciences and computers. The analysis of the change of the two profiles in the recent decade has shown, however, that the distinction and opposition of the profiles might be becoming blurred and that the competition between these countries – as well as with many other competitors – may further increase in the future.

The patent applications at the USPTO were also affected by the economic crisis and while the absolute numbers for some countries stagnated or even decreased in the priority year 2007, the effects for 2008 are clearly visible for all countries. The USA filed 9.2% less patents in 2008 than in 2007 at the USPTO, many others had to reduce their efforts even more. Only Chinese applications are still growing, but at a much slower pace.

While Germany and some other countries have a transnational market orientation, several countries – among them Korea, India or Taiwan – have a strong focus on the US-American market and are therefore filing many more patents at the USPTO than transnationally. This is not to neglect the fact that also Germany seems to have a more pronounced and focused profile at the USPTO than it has at the transnational level. While the strengths of electrical engineering, transport, and machinery are also visible in the USA, the German relative position in

life sciences is more pronounced and more positive at the USPTO. Especially in the field of electrical medical instruments, a clear market orientation can be found. Germany is among the top applicants at the USPTO as well as in China, for example.

Next to the total numbers of patent applications, analyses were also conducted using patent value adjustment indicators, namely citations and non-withdrawals. None of the adjustment indicators had a strong impact on the relative positions of the countries and the relative distances of the countries. Only the level, but not the structure, is adjusted by the value indicators, when they are applied to national patent profiles. This is not to neglect that their impact might be high and relevant on the level of individual patents or company profiles.

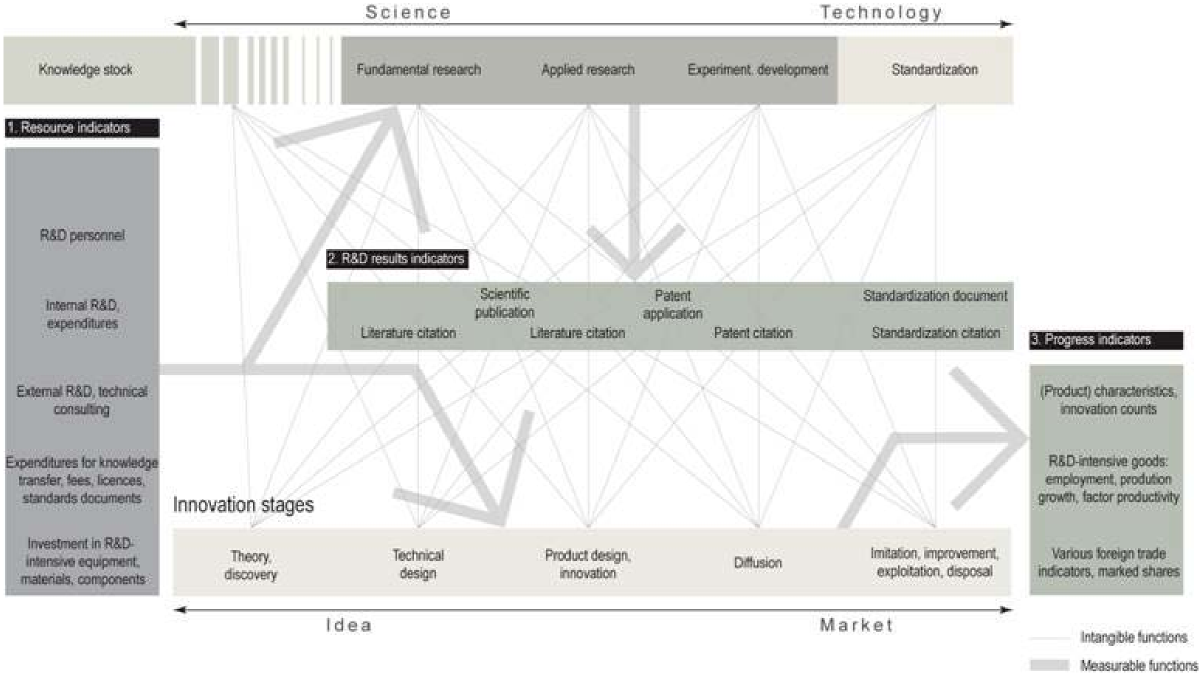
In the last chapter of this report, an analysis of the growth rates of patent subclasses of the International Patent Classification (IPC) was conducted. The results confirm the major trends of technology growth, in particular, the merger of information and telecommunication technology. Software innovation appears to be the most dynamic within the field of large technologies. The annual growth in this subclass is 14%. This result is backed up by a similar strong growth in digital data processing, i.e. hardware. Here the growth is less strong than in software, but the size is much larger. Within the top group of the large subclasses, batteries and fuel cells have to be mentioned. Strong growth in the last decade can be also observed for navigation devices, and medical apparatus. Focusing on Germany's trends, also information and communication technology is quite dynamic with digital data processing, transmission of digital information, and wireless communication networks. Batteries and fuel cells are even of the first rank and a subclass in the context of lighting is in a top ranking as well.

2. Introduction

Patent applications and grants – as output indicators for R&D processes – are the most commonly used indicators to measure the technological performance of countries or innovation systems in general (Freeman 1982; Grupp 1998). Patent data analysis is booming nowadays, increasing the body of literature in the field – and as the literature grows, so too do new insights and new knowledge. Though not all analyses that use patents apply the same methods and definitions (Moed et al. 2004). First and foremost, patents can be seen and analysed from different angles and with different aims: the technological view allows prior art searches or the description of the status of a technology; micro-economic perspectives – for example – allow for the evaluation of individual patents or the role of patent portfolios in technology-based companies; a macro-economic angle offers an assessment of the technological output of national innovation systems, especially in high-tech areas.

In this report we trace the latter path, having in mind the very simple and sober intention of providing information on the technological capabilities and the technological competitiveness of nations. In this respect, patents are used as an output of R&D processes. R&D processes can either be measured by the input – for example, expenditures or human capital – or by the output. In order to achieve a more precise approximation of the "black box" (Schmoch/Hinze 2004) of R&D activities, both perspectives – i.e. input and output – are needed. The input side has been widely analysed and discussed in other reports, also in this series (see, for example, Legler/Krawczyk 2009). Here the strict focus of patents as an indication of output is pursued, following the very early approach of patent statistics pioneers (Griliches 1981; Griliches 1990; Grupp 1998; Pavitt 1982).

Figure 1: Indicator System to analyse Innovation Systems Performance



Source: (Grupp 1998); further developed and designed by Fraunhofer ISI.

Starting from a simple legal perspective, patents give an exclusive right of usage to the applicant for a limited period. In addition, patents can be interpreted as an indicator of the codified knowledge of enterprises, and, in a wider perspective, of countries. As an innovation indicator, patents fit into a system of further indicators to describe scientific and technological competitiveness and to analyse innovation systems. The role of patents here is to be seen as an intermediate measure. Intermediate in so far as it covers the output of R&D systems, for which expenditures or human capital are the input. At the same time, patents form the input for market activities, which are reflected, for example, by foreign trade, turnover or qualified labour. Patents are especially dedicated to measure the output of industrial R&D activities, whereas scientific publications are still the most important output for the public research system, although this latter group of institutions also contributes to patent production. A representation of innovation indicators and their relation are depicted in Figure 1.

Beneath the mechanisms of protection, patents for technical innovations play a special and crucial role, as the formal requirements for patent applications are the strictest ones, and the assertion of patents is backed by a strong legal framework. Any patent has to pass an extensive examination procedure in the patent office(s), done by examiners skilled and trained in the field. This, in turn, makes them so valuable as a source of information also for statistical purposes. Patents and the information contained in patents is systematically structured and of high quality. The formal requirements as well as the technical content are checked by experts.

From the perspective of innovation systems, patents indicate the output of technology generating processes and thereby enable the technological competitiveness of nations to be assessed. In particular, international patent filings are meaningful for comparisons, as they reflect activities in international markets where national and multinational companies meet with their competitors directly and on neutral ground.

This report gives a brief overview of the developments in transnational patent applications since the early 1990s with a special focus on the recent trends and structures. Chapter 4 presents the data and the methods applied. Chapters 4 to 6 discuss total trends, growth rates, intensities (patents per 1 million workforce) and specialisation[1] indices, which are designed to reflect patent structures beyond size effects of countries and technology fields. Chapter 4 offers a discussion of the transnational patent applications up to the most recently available priority year 2008. Chapter 5 discusses patent applications to the USPTO and Chapter 6 tries to value the patent applications by using citation rates and non-withdrawals. Chapter 7 provides an analysis of IPC subclasses to identify the fastest growing technological areas of the recent past.

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1 The specialisation index RPA (Revealed Patent Advantage) is defined as:

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

with P_{kj} indicating the number of patent applications of country k in the technology field j. Positive values point to the fact that the technology has a higher weight in the portfolio of the country than its weight in the world (all applications from all countries at EPO). Negative values indicate specialisations below the average, respectively.

3. Data and methods

The patent data for the study were extracted from the "EPO Worldwide Patent Statistical Database" (PATSTAT), which provides information about published patents collected from 81 patent authorities worldwide. The annual sum of cited patent applications, forward citations and maintained patents at the European Patent Office (EPO) was calculated in total, by selected countries and differentiated by 35 high-technology fields (Legler/Frietsch 2007).

This year, PATSTAT was used for this reporting system for the first time. In earlier years, we used data from professional hosts, especially from Questel-Orbit. The advantage of these online databases was especially their topicality, as they are updated weekly, while PATSTAT is a snapshot of a current status twice a year. However, we have been able to speed up the implementation of PATSTAT in our system and to synchronize the data availability with the reporting process. Based on this switch to PATSTAT as the main source of data, two main changes result, compared to earlier reports of this series, which are based on the advantages that PATSTAT has compared to online databases, namely, the lower costs and the much higher analytical potential. First, we are now able to apply fractional counting of patent filings. We do this in two dimensions; on the one hand, we do fractional counting by inventor countries and, on the other hand, we are also able to apply fractional counting to the IPC classes (International Patent Classification), so 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 second change compared to earlier reports is that we are now able to take citations and legal status information into account, which can be used for the valuation of patents (Frietsch et al. 2010b) and to try to get a more balanced perspective on the national technology profiles.

Patents are counted according to their year of worldwide first filing, the so-called 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 recently suggested by Frietsch and Schmoch (2010), which has already been used in earlier analyses of this series (Frietsch et al. 2010a; Frietsch/Jung 2009) and 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.

The United States Patent and Trademark Office (USPTO) covers the most important national market for high technologies in the world, namely the US market. However, it is still a national market. Some countries, especially the upcoming and emerging countries like South Korea or India, are specially focused on the US market and do not file every patent on a worldwide scale. In consequence, the bias of US applicants/inventors as well as of some other very US-oriented countries is considerable, and the imbalance of European, North American and emerging countries cannot be neglected when the technological performance is compared, based on patent filings at the USPTO. This is why the US data is not the core of this analysis. However, we report them as an additional dimension in the discussion, keeping in mind that there are imbalances in the representation of certain countries. The USPTO data therefore do not appropriately reflect the general technological competitiveness of nations, but are appropriate to reflect the technological activities targeted to the US market – and this is therefore a helpful supplement to the overall analysis presented in this report.

Contrary to the EPO – for example – the USPTO only published granted patents instead of applications until the publication year 2001. Since then, they publish both applications after 18 months and granted patents immediately after the granting procedure is finished (which might take up to 7 years and more after priority). However, purely national filings are still exempted from the pre-grant publication demand so that some applications are still unpublished until the granting of the invention. In this transition phase from grant to pre-grant publication, it may not be meaningful to analyse longer time series at the USPTO, though it seems that the transition to the new system as such was successfully accomplished already in the middle of the first decade of the new century (Schmoch 2009).

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

For the analysis of patents in different technological fields, so called specialisations are calculated. For the analysis of specialisation, the relative patent share (RPA[2]) is estimated. It indicates in which fields a country is strongly or weakly represented compared to total patent applications. The RPA is calculated as follows:

$$RPA_{kj} = 100 * \tanh \ln [(P_{kj}/\Sigma_j P_{kj})/(\Sigma_k P_{kj}/\Sigma_{kj} P_{kj})]$$

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 specialisation. 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.

3.1 Estimators of value – Patent Citations and non-withdrawn patents

Besides the mere number of patent applications, which can be seen as an outcome (or performance) of R&D activities, several quality measures can be applied to assess and differentiate between the value of patents (see Frietsch et al. 2010b). The most frequently discussed range from citation measures, patent grants, opposition or litigation history to the average

2 Revealed Patent Advantage

number of inventors or IPC classes. Several other indicators include licensing history, licensing revenues renewal history, the number of claims, expected sales values of patents measured by survey data; and different composite indicators (or indices) constructed from several of the above listed. Many of the above mentioned were tested and evaluated in a large project on behalf of the "The Commission of Experts for Research and Innovation (Expertenkommission Forschung und Innovation – EFI)" (Frietsch et al. 2010b). Two indicators, namely patent forward citations and non-withdrawn patents, proved to be the most promising for the evaluation of the quality of patents. This present report makes use of these two indications of patent value as a supplementary perspective on the patenting activities of nations.

Patent forward citations are the most common and widely used indicator in literature so far (Narin/Noma 1987; Trajtenberg 1990). The number of forward citations (citations a patent receives) measures the degree to which a patent contributes to the development of further advanced technologies, thus this can be seen as an indicator of technological significance of a patent (Albert et al. 1991; Carpenter et al. 1981). Although several studies show that patent citations are a very noisy signal of patent quality (Alcacer et al. 2009; Alcacer/Gittelman 2006; Hall/Ziedonis 2001).

The other indicator used to compare the quality of patents between countries is the number of non-withdrawn patents within the first three years after application. This indicator builds on the research of Schankerman and Pakes (1986) who introduced the concept of "renewals" as an indicator of patent value, which was later used and further developed by other authors to estimate patent value (Bessen 2008; Grönqvist 2009; Lanjouw et al. 1998). The basic underlying idea is quite simple. Patents only stay alive if regular payments (so called renewal fees) are made, so the private returns accruing for a particular period must be at least as large as the renewal fee paid for that period of time. However, renewal data is retrospective, because only the lapse of a patent (naturally occurring with a lag) contains precise information on the value. So an extreme time lag would have to be taken into account, as patents can be maintained for 20 years after application. As a direct consequence of this considerable time lag, structural changes within the period of observation can hardly be taken into account. Additionally, renewal data are not readily available for all patent offices in a harmonised manner.

Before a patent can be maintained, it has to be granted. Therefore, patent grant has been widely used as one indication of value,or at least of technological and economic "relevance". In the recent report, Frietsch et al. (2010b) were able to show that those patents that are not withdrawn or refused within the first three years reach an almost constant probability of being granted, so that this can be used as an indication of grant. The granting process takes on average about 4 years at most offices, but it takes about 7 years until a statistically relevant share of 90% or more of one cohort is granted. In addition to the constant grant rate, the simplified argument for this indicator is that a patent for which at least some maintenance fees have been paid has to be of greater value than a patent for which no maintenance fees are paid. The indicator of non-withdrawals, as we shall call it, has the advantage that it can capture patent value after a time lag of only three years.

4. Trends of Transnational Patent Applications

This chapter describes the status and the recent trends of transnational patent application – these are families with at least an EPO or a PCT filing – since the beginning of the 1990s. The patents are dated according to their worldwide first filing, the priority date, and we offer data for a selected set of technology-oriented countries[3]. For reasons of presentation, not all countries are displayed in all the figures.

In this chapter, a distinction will be made between low-tech and high-tech areas. High-tech is defined as technologies which usually require an average investment in R&D of more than 2.5% of turnover. High-tech will further be differentiated by high-level and leading-edge technologies. While high-level covers technologies that require R&D expenditures between 2.5% and 7.5%, the leading-edge area covers technologies that are beyond 7.5% investment shares (Legler/Frietsch 2007). In the first section, we discuss the broad areas and broad trends, while the second section will differentiate the national technology profiles, looking at 35 technology fields, according to the high-tech definition.

4.1 Trends and level of patent applications by technology areas

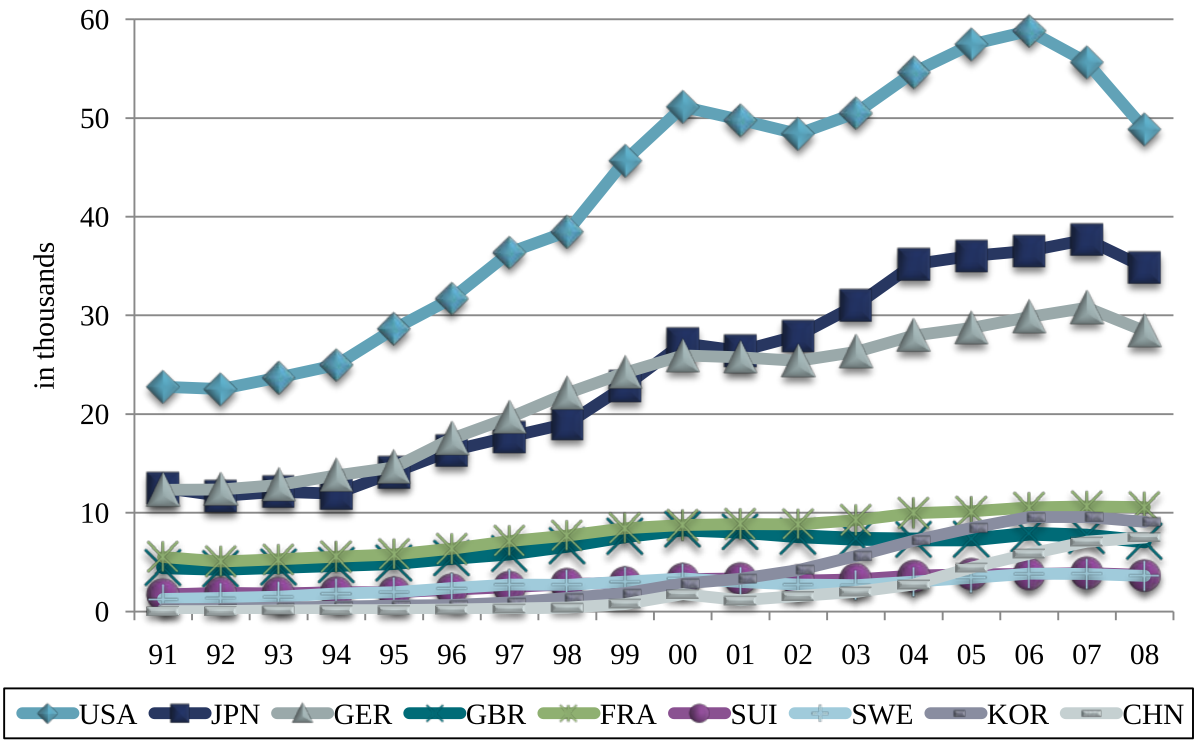
Figure 2 displays the absolute number of transnational patent applications of a selected set of countries. The USA are the largest technology-providing country at an international level, followed by Japan and Germany – and this is almost identical for high-tech and low-tech areas (see Figure A1 and Figure A2 in the annex). Behind this group of the three largest, a large group of countries like France, the United Kingdom and others follow. It is interesting to note that South Korea is nowadays on a similar level to France, having strongly grown since the end of the 1990s. China has not yet reached France and Korea, but operates in absolute terms at a level similar to the United Kingdom. However, China has been able to catch up considerably in the past 5 years since the middle of the first decade of the new century.

The most striking effect can be seen in the last two years of our observation period. The absolute numbers for all countries are decreasing – even for the fastidious China –, a trend that we have already seen in last year's report and which is now consolidated. The explanation was – and this is still true to a large extent, but not the only explanation any more – that the companies applied a much more deliberate strategy for filing internationally. In other words, the companies were still inventing technologies, but the decision to file abroad much more often turned out to be negative. The reason was that the filings of the priority year 2007 were to be transferred to the international offices in 2008 and 2009, when the economic crisis already took effect. This finding and this effect is also vivid for the priority year 2008, but in addition the economic crisis also had an impact on the input side of the R&D processes so that the outputs – namely the patents under analysis here – were also affected. The evidence for this statement stems from the national trends of patent applications, which also decreased in 2008.

3 These are: Germany, USA, Japan, the United Kingdom, France, Switzerland, Sweden, South Korea, China, Canada, Italy, the Netherlands, Finland and Russia.

Companies that are using the patent system do this whenever they have something worth filing, otherwise they would risk losing their intellectual property (IP) to their competitors. They secure their rights first by filing at their national office, at their home base. Thus, as the national filings are decreasing, the conclusion is that they have less IP to protect. Analyses in earlier recessions or crises have shown that companies tend to stretch innovation processes by reducing their investment, without cancelling the projects, or they tend to postpone the start of research projects. The theory suggests investing anti-cyclically in R&D, which means increasing the investment in times of recession and crises, because then the company is ready for the next economic boom with new technologies and might be able to gain increasing market shares. Obviously, reality is not a perfect reflection of the theory.

Figure 2: Absolute number of transnational patent applications for selected countries, 1991-2008



Source: EPO-PATSTAT; Fraunhofer ISI calculations.

The absolute data that has been presented so far is – of course – affected by size effects. One adjustment to these size effects is shown in Table 1, where patent intensities per one million employees are displayed. When using this indicator, the smaller countries Switzerland, Sweden and Finland are at the top of the list of the technology-oriented countries analysed here. Germany and – at some distance – Japan are first among the larger countries on this list. This expresses, on the one hand, the strong technology orientation and the technological competitiveness of these countries. On the other hand, this is 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. With the perspective of this indicator, the USA is in the midfield together with France, Korea or the EU-27.

Table 1: Patent intensities (patent applications per 1 m employment) and shares of technological areas, 2006-2008

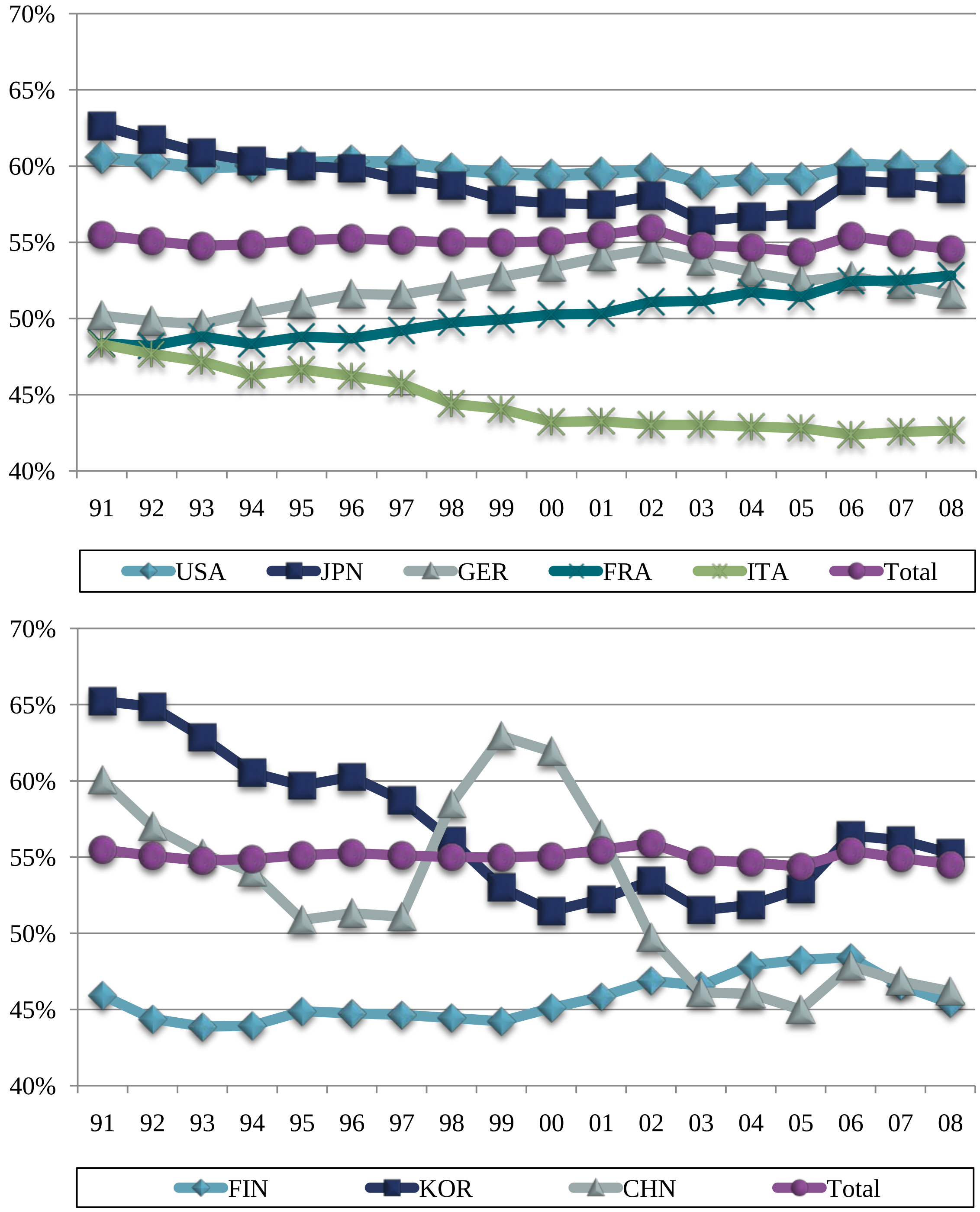
	Total	**Low-tech**		**High-tech** of which are:		Leading-edge technologies		High-level technologies	
SUI	809	402	49.7%	407	50.3%	135	16.7%	272	33.6%
SWE	736	380	51.6%	356	48.4%	168	22.8%	188	25.6%
FIN	697	324	46.5%	373	53.5%	118	16.9%	255	36.6%
GER	673	358	53.2%	315	46.8%	179	26.6%	136	20.2%
JPN	475	202	42.6%	273	57.4%	119	25.1%	153	32.3%
NED	459	222	48.4%	237	51.6%	119	26.0%	118	25.6%
FRA	380	166	43.7%	214	56.3%	94	24.8%	120	31.5%
KOR	346	138	39.8%	208	60.2%	105	30.4%	103	29.8%
USA	330	126	38.4%	202	61.6%	106	32.3%	96	29.3%
EU-27	306	147	47.9%	159	52.1%	61	20.0%	98	32.1%
ITA	242	137	56.6%	105	43.4%	29	12.1%	76	31.3%
GBR	225	104	46.1%	121	53.9%	56	25.0%	65	28.9%
CAN	176	78	44.4%	98	55.6%	55	31.1%	43	24.6%
RUS	11	6	51.0%	5	49.0%	3	23.2%	3	25.8%
CHN	8	3	44.0%	4	56.0%	3	32.5%	2	23.6%

Source: EPO-PATSTAT; Fraunhofer ISI calculations.

In addition, Table 1 offers a differentiation of the patent intensities by technological areas and displays the respective shares of total patent filings. It is remarkable that Switzerland, Finland and especially Italy show rather high activities in low-tech fields and even Sweden or the Netherlands, both especially well-known for their high-tech companies Sony-Ericsson and Philips, have comparably high shares in low-tech patenting. The USA, Japan and Korea, on the other hand, reach rather high shares of high-tech patents, between 57.4% and 60.7%, respectively. The differentiation by leading-edge and high-level areas further qualifies these findings. The USA, Canada, Korea, but also Finland, the Netherlands and Sweden are filing many of their patents in leading-edge technologies. The main technological activities of Sony-Ericsson and Philips are exactly to be found in these very R&D-intensive areas. In consequence, Finland and the Netherlands reach rather low shares in high-level technologies. Germany and also Switzerland are focused on high-level technologies, but reach rather low shares in leading-edge areas.

Figure 3 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 is almost constant at a rate of 55% since the beginning of the 1990s, some countries underwent a considerable change of their patenting in high-tech areas. The USA is at the top of the countries and also reaches a rather stable share of high-tech patents at the transnational level. Japan which was at the top at the beginning of the observation period, clearly lost ground and has lower shares of patenting activities in high-tech areas. France was able to increase its high-tech shares and Italy decreased steadily since the early 1990s, so that the gap to the other large innovation-oriented countries grew constantly.

Figure 3: Shares of high-tech patent applications in total patent applications for selected countries, 1991-2008



Source: EPO-PATSTAT; Fraunhofer ISI calculations.

The lower panel of Figure 3 shows that the shares of Korea and China decreased and fell clearly below the average share, although their absolute numbers were increasing considerably. In the case of China, the filings began growing in the year 2001 when China joined the WTO and the TRIPS agreement. This is also the time when the shares of high-tech patents decreased. It is interesting to note that the Finnish trend is positive over the whole observation period and that this trend was parallel to an increase also of the absolute numbers of patent filings.

4.2 Technology profiles and patterns of specialisation

In this section, we will provide a discussion of the patent applications according to a classification of 35 technology fields of the high-tech sector (Legler/Frietsch 2007). In this year's report we will focus on the comparison of the German and the US-American profile, which are complementary to each other. The German strengths are the US-American weaknesses and vice versa.

The German technology profile of the years 1999-2001 versus 2006-2008 are displayed in Figure 4. Germany has three main areas of activity where it has comparative advantages, i.e. where Germany is specialised in: transport, machinery and some areas of electrical engineering like power machines and power generation. An average activity rate in patenting can be found in chemical materials, polymers, pesticides etc. Comparative disadvantages reflected in negative specialisation indices can be found in pharmaceuticals, biotechnology, information and communication technologies as well as optics and optical devices. So the latter do not belong to the relative German strengths in international technology markets. It is interesting to note that Germany was able to improve its relative position in most of the technology fields where it reaches a positive specialisation, but also at the expense of a relative loss of positions in many areas of relative weakness, namely ICT and electronics. In addition, German inventors were able to gain ground in some of the areas of average activity and considerably improved the values of the specialisation index. This is first of all true for aeronautics and electronic medical instruments (see also growth rates in Table 2).

The US-American profile is displayed in Figure 5 and shows strengths in most of the life science fields (biotechnology, pharmaceuticals and organic chemistry), including medical instruments, as well as positive values in chemistry. The areas of comparative disadvantage at the transnational level are transport, machinery and electrical engineering (power machines and power generation). Also, the USA have been able to reinforce their positions in some of their outstanding fields like medical instruments, computers and some fields of chemistry (see also growth rates in Table 2).

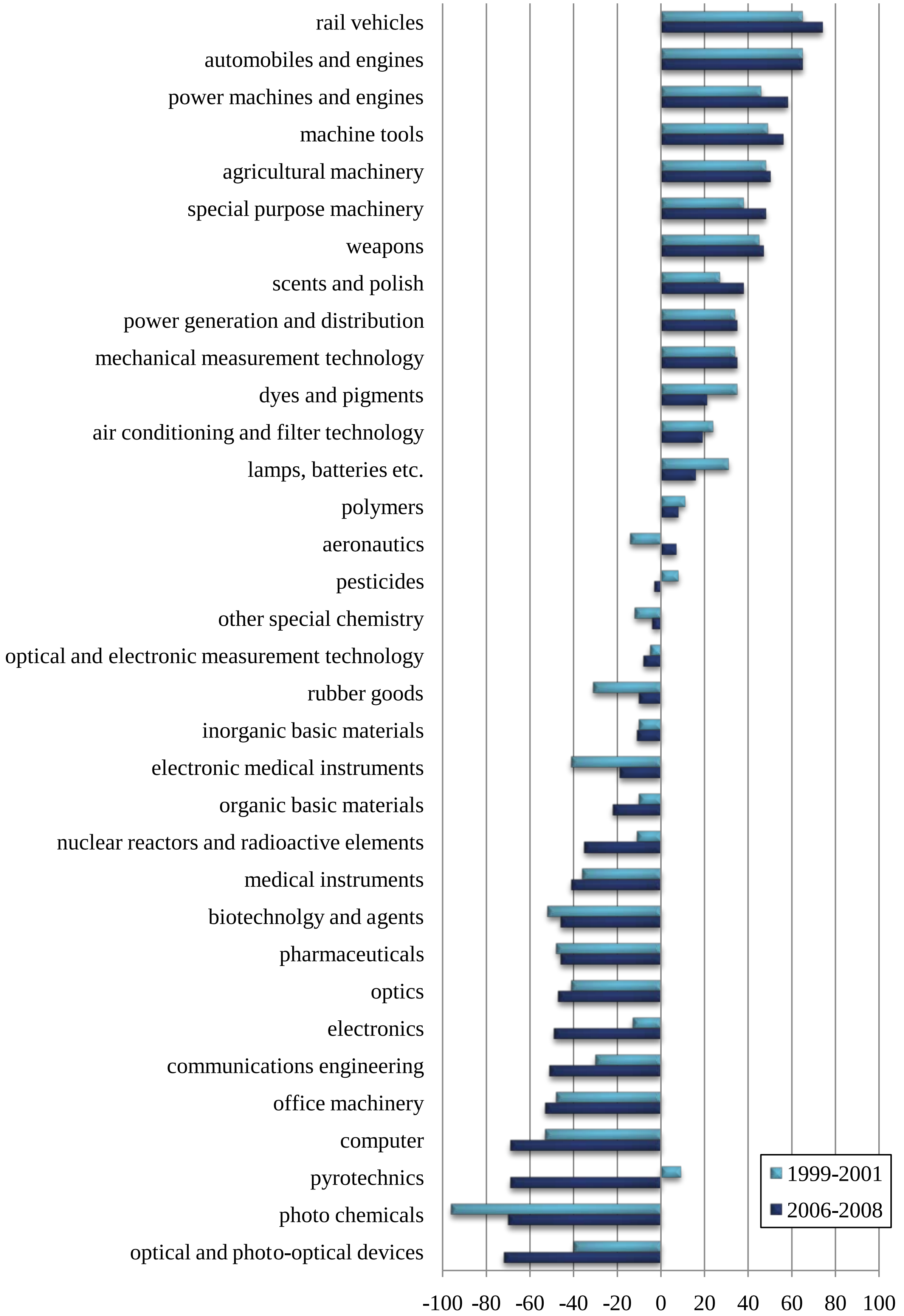
The profiles of the two countries have been rather distinct and differences are still clearly visible, like in transport, biotechnology or computers. In the past decades the successes of the two countries in international markets were also possible because they did not get in each other's ways. However, looking at the changes of the profiles of the two countries and also looking at the innovation policies in Germany (Frietsch/Kroll 2010) and the USA (Shapira/Youtie 2010), it seems that more intersections of the profiles and market activities will occur. Germany enters the circles of the USA in electronic medical instruments as well as biotechnology (or nanotechnology, which is not separately analysed here), while the USA enters the German circles in power generation, mechanical measurement technologies, and machine tools. Of course, there are many other countries that also try to enter these markets and some of them are already very successful. The competition was never only between the USA and Germany, but the increasing intersection of the formerly more distinct profiles is symptomatic for an increasing international competition in the high-tech field in general.

Table 2: Transnational Patent applications of Germany and the USA (absolute, specialisation, and growth), 2006-2008

	DE			USA		
	Abs.	**RPA**	**growth** (99-01=100)	**Abs.**	**RPA**	**growth** (99-01=100)
aeronautics	606	7	220.7	1,320	24	171.6
electronic medical instruments	1,080	-19	213.5	3,367	32	168.7
power machines and engines	3,933	58	154.2	2,504	-38	131.5
rubber goods	244	-10	149.3	294	-48	95.3
inorganic basic materials	427	-11	144.7	800	-9	147.3
power generation and distribution	1,496	35	144.0	1,209	-43	140.6
weapons	293	47	138.0	360	11	183.3
mechanical measurement technology	1,171	35	135.1	1,463	-2	149.9
medical instruments	1,996	-41	133.2	9,879	51	156.7
rail vehicles	234	74	127.4	75	-66	113.9
optical and electronic measurement technology	2,788	-8	127.0	5,254	-5	105.2
pesticides	631	-3	122.7	1,958	46	212.8
lamps, batteries etc.	2,239	16	118.9	2,270	-41	120.5
machine tools	2,478	56	118.6	1,708	-33	126.1
other special chemistry	1,081	-4	117.3	2,456	18	102.0
automobiles and engines	5,998	65	116.6	2,391	-64	97.7
air conditioning and filter technology	1,203	19	115.5	1,996	9	127.3
special purpose machinery	3,548	48	112.1	2,431	-43	85.2
organic basic materials	1,089	-22	106.4	3,020	19	123.0
agricultural machinery	409	50	103.0	405	-7	144.4
computer	2377	-69	100.9	14,906	37	140.7
biotechnology and agents	2,497	-46	99.9	11,593	40	90.2
nuclear reactors and radioactive elements	50	-35	99.0	203	41	211.9
polymers	1,416	8	97.9	2,393	0	101.8
pharmaceuticals	1,238	-46	97.8	5,293	33	90.5
office machinery	129	-53	93.7	296	-35	64.3
electronics	1,441	-49	93.5	5,302	15	135.6
dyes and pigments	609	21	90.4	760	-17	95.3
optics	564	-47	88.9	1,692	-2	72.7
broadcasting engineering	834	-79	88.7	3,499	-24	81.1
communications engineering	2,010	-51	83.9	6,199	-5	86.5
scents and polish	324	38	74.7	397	-1	68.3
optical and photo-optical devices	65	-72	73.4	242	-18	89.8
photo chemicals	7	-70	43.7	56	51	15.3
pyrotechnics	7	-69	20.8	41	30	53.6

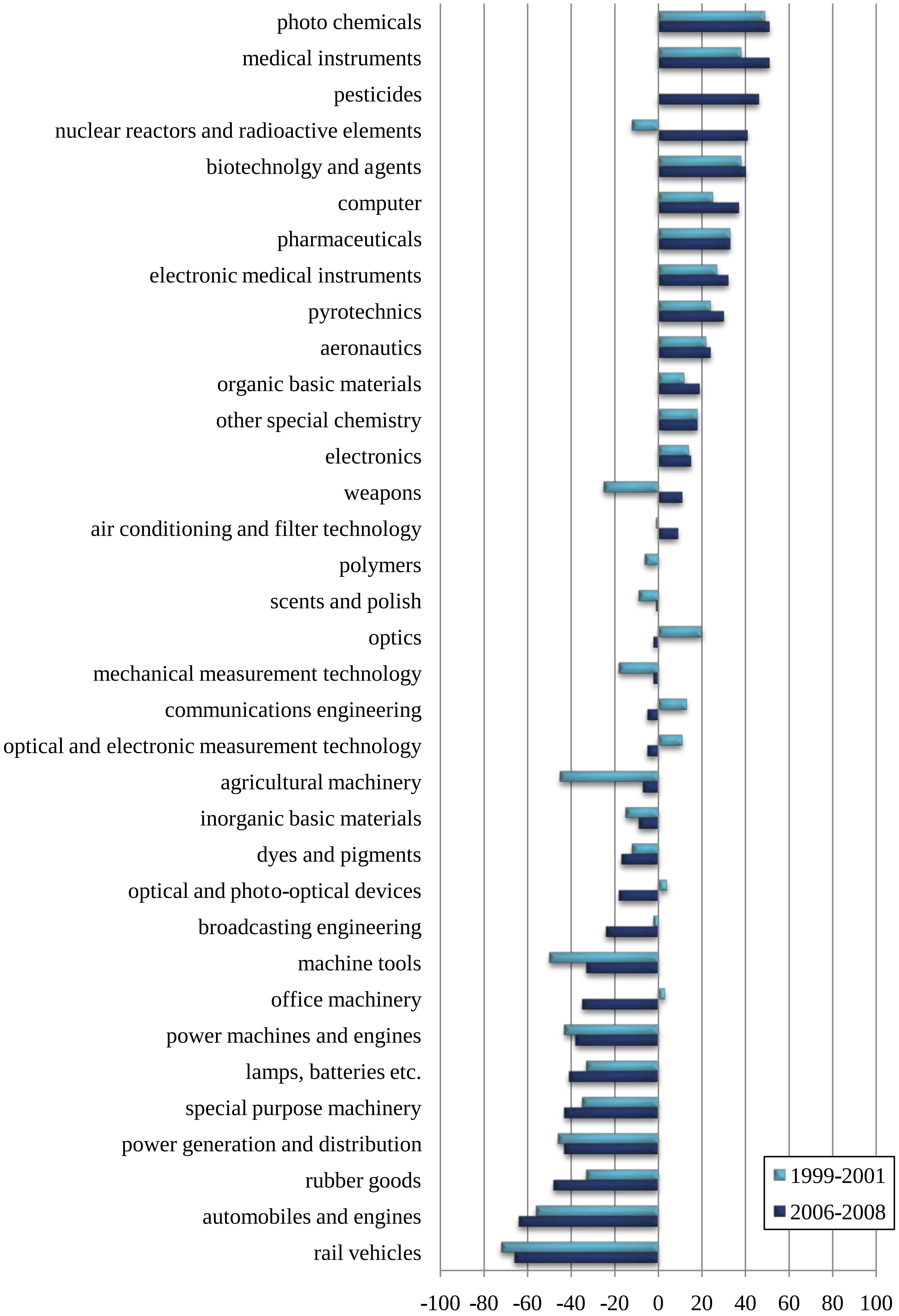
Source: EPO-PATSTAT; Fraunhofer ISI calculations.

Figure 4: Germany's technological profile, 1999-2001 vs. 2006-2008



Source: EPO-PATSTAT; Fraunhofer ISI calculations.

Figure 5: USA's technological profile, 1999-2001 vs. 2006-2008



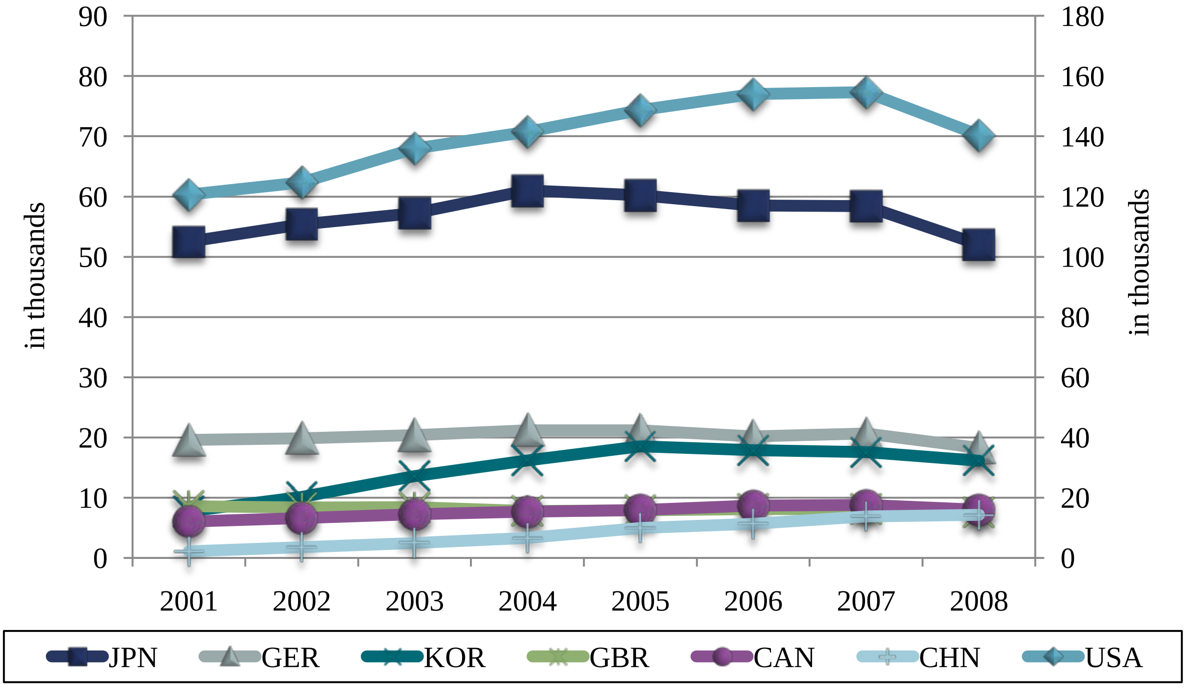
Source: EPO-PATSTAT; Fraunhofer ISI calculations.

5. Patent Applications at the USPTO

Transnational patents are trying to catch international patenting trends and offer an assessment of the technological competitiveness of nations beyond home advantage effects and national idiosyncrasies. In this chapter, we take a completely different perspective when analysing the pre-grant published patent applications to the United States Patent and Trademark Office (USPTO). The USA are the most important national market for high-tech products and many countries have a strong orientation towards this market. For example, countries like South Korea, India or Taiwan almost only file their patents at the USPTO and thereby almost only target the US-American market. This justifies a separate analysis of the trends in the USA, but one has to be aware of the fact that US-American companies and US-American inventors have a home advantage at this office and therefore are hardly comparably in terms of their general technological competitiveness. What is comparable is the technological competitiveness in the US-American market, so any results presented in the following sections have to be interpreted against this background.

5.1 General trends at the USPTO

Figure 6: Total number of pre-grant published patents at the USPTO for selected countries, 2001-2008

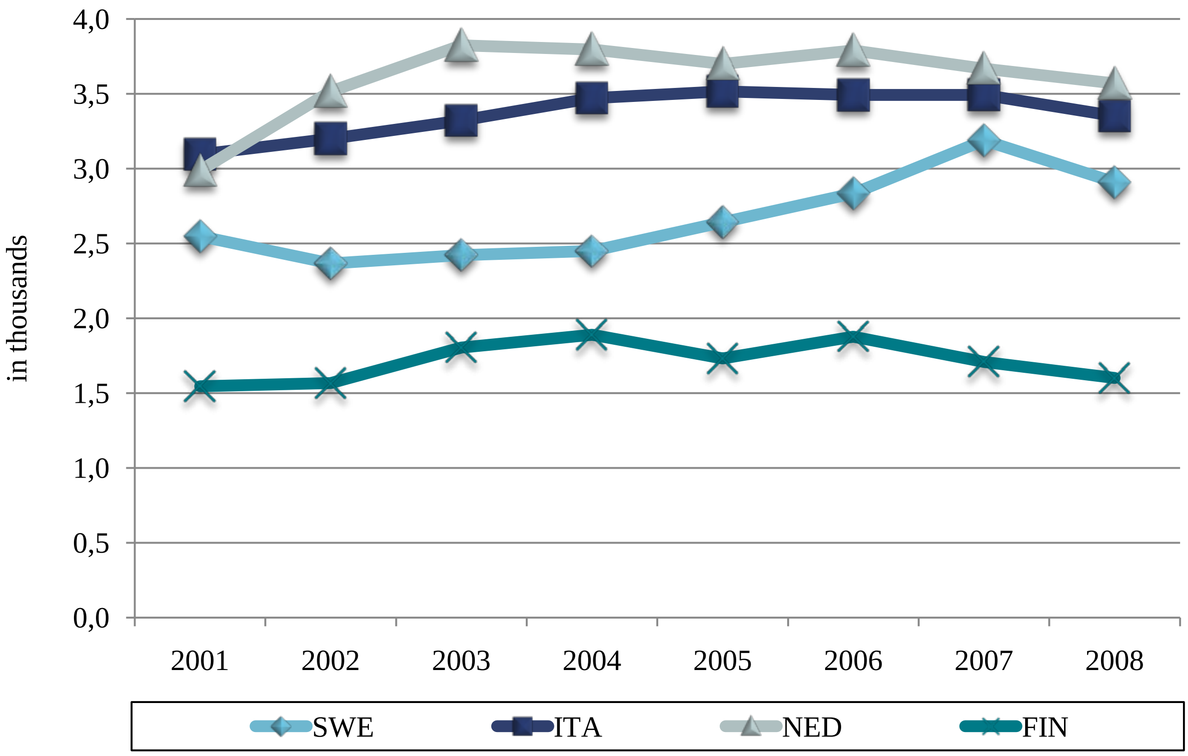


Source: Questel-Orbit – USAPPS, Fraunhofer ISI calculations

Figure 6 illustrates the trends in absolute invention patent applications at the USPTO between 2001 and 2008 for a selected set of countries. The graph for the USA is depicted at the right-hand scale and shows that the absolute numbers are more than twice the number of the next largest country, namely Japan. The distance between the USA and Japan at the transnational level was only about 30% (see Figure 2). Though Japan is also as far ahead of the other nations in absolute terms, Germany is not so much USA-oriented as the other countries and files relatively less patents at the USPTO than it does at the transnational level. Figure 6 shows that South Korea is meanwhile the third largest non-national inventor country at the USPTO, almost outperforming Germany. Taiwan, which is not analysed in this report, is also at a similar absolute level with Germany, filing about 20,000 patents a year (USPTO 2010).

In case of the USA, the numbers slightly increased by about 4.3% on average until 2007 and dropped by about 9% in 2008. The other countries also reduced their efforts at the USPTO in 2008, which is a direct consequence of the economic crisis. Only China is still growing in 2008 compared to 2007 by about 3.6% (compound average growth rate of China between 2001 and 2008 is 37%). Most of the countries already stagnated in 2007, which were the first impacts of the crisis. The argument here is the same as with the transnational patents. The companies from countries outside the USA target the USPTO via the PCT route or as a filing under the Paris Convention, so that the priority filing is done elsewhere and they have one year to decide where to go. As we analyse the data according to the priority date, 2007 priorities at the USPTO were already affected by the crisis, as they were to be transferred within the first year already under the first impressions of the crisis. Among the smaller applicant countries, Sweden was only affected in 2008, but was still growing in 2007 (see Figure 7).

Figure 7: Total number of pre-grant published patents at the USPTO for Sweden, Italy, the Netherlands, and Finland, 2001-2008



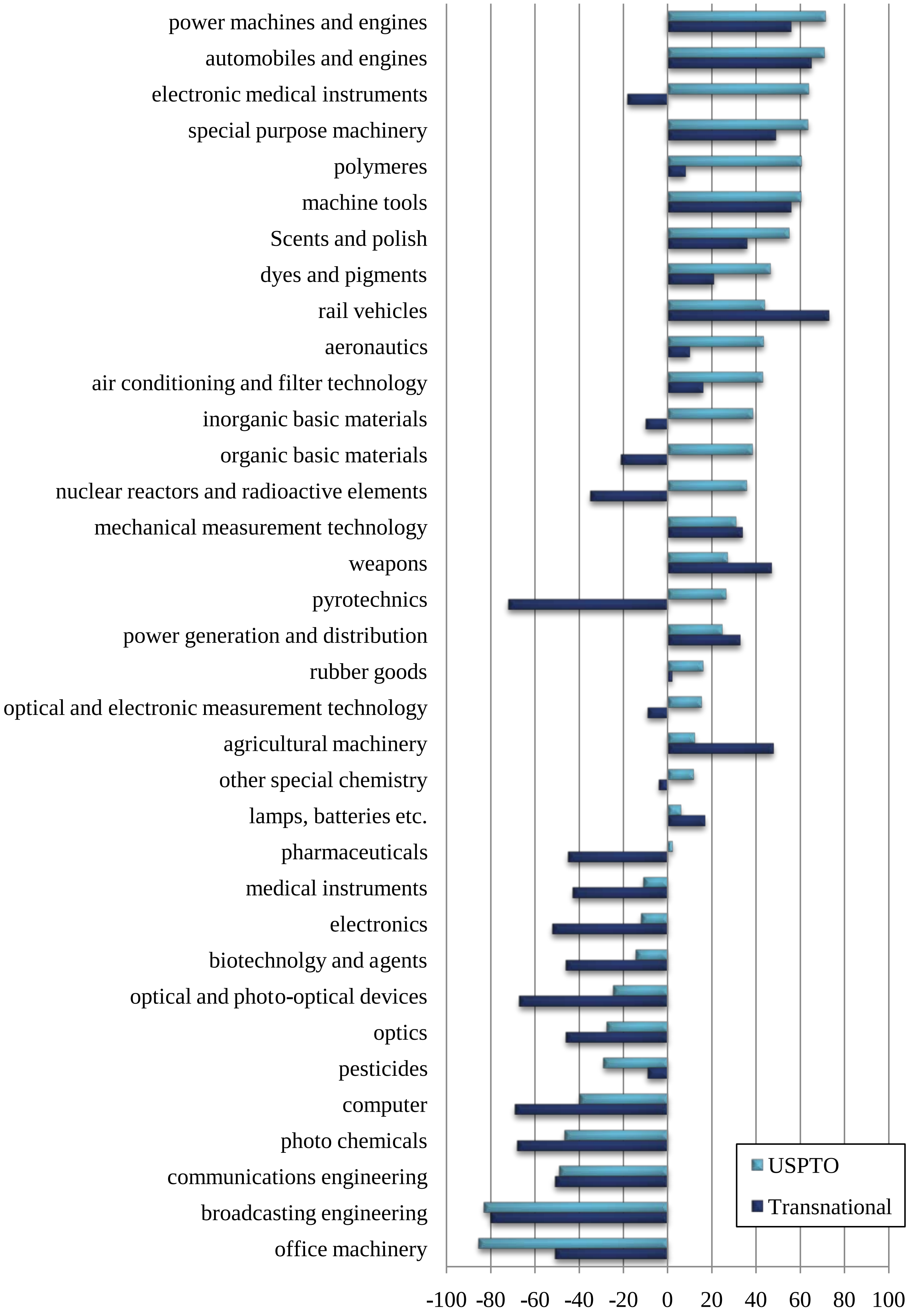
Source: Questel-Orbit – USAPPS, Fraunhofer ISI calculations

It is interesting to note that the annual report of the USPTO does not show any statistical effect of the economic crisis on the published data (USPTO 2010). We compared our results with the official statistics, which had been growing since the beginning of the observation period. The explanations are threefold, but are simply affected by the way patent offices do their statistics. First, the USPTO – like any other office – takes an office perspective and counts any patent by its filing date, which is the date when the process at the particular office starts. As the filing date is affected by the filing process (direct filing, Paris Convention, PCT application), up to 2.5 years difference are possible between these filing procedures; and 2.5 years in times of crisis means that it is over before it statistically impacts the data. Second, the statistics are a mixture of different patent types, while we only focus on invention patents. Third, the office is able to take all patents into account, also those meant to be pre-grant published, even if the process is stopped before the publication, whereas we can only take the published data into account. Therefore, the numbers of official office statistics are usually higher than those accessible to researchers. To sum up, the official USPTO statistics are not comparable to our analyses and they are not appropriate to reflect recent trends.

5.2 Technology profiles and patterns of specialisation at the USPTO

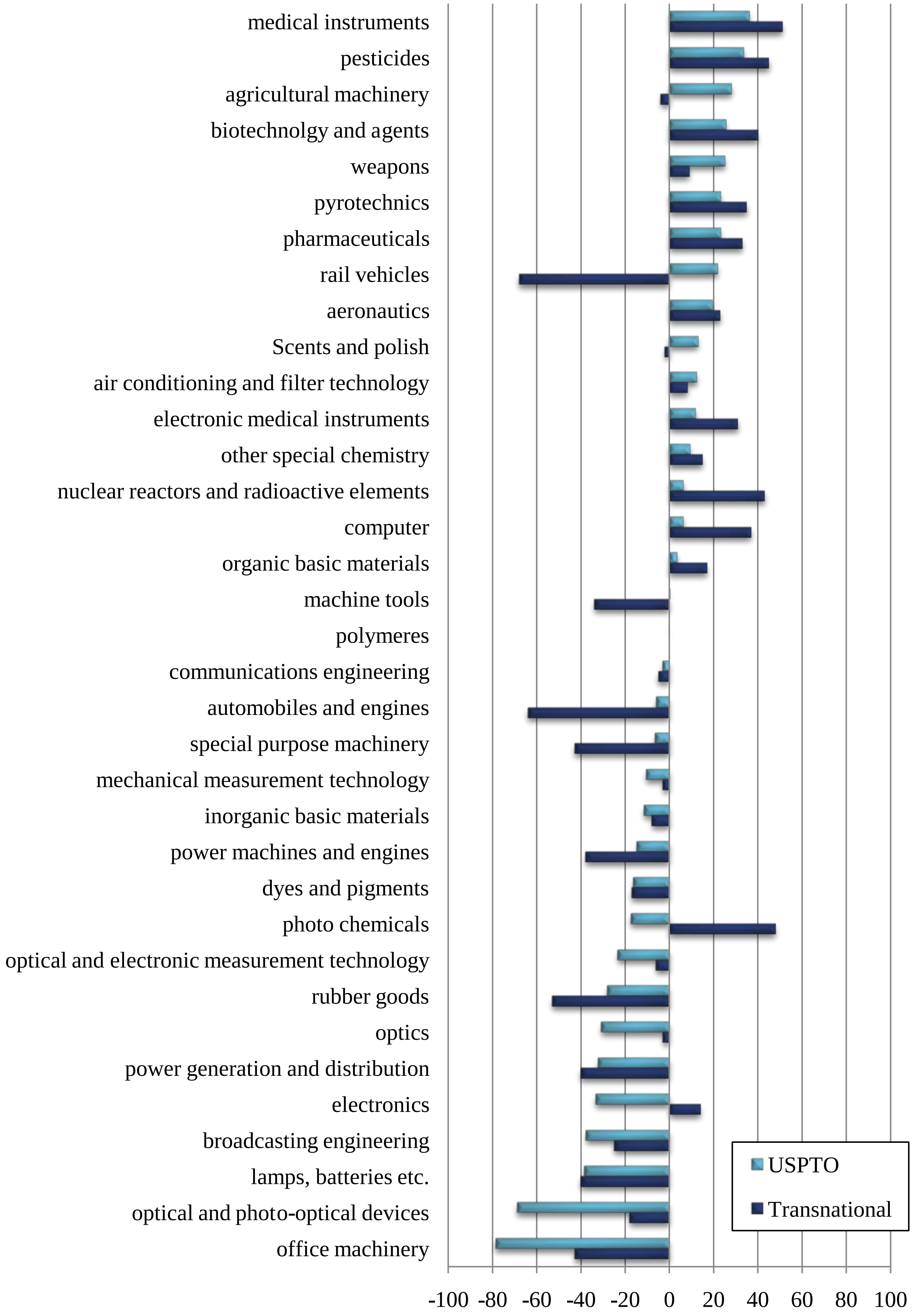
Like in the previous chapter on transnational patents, we will also focus on the comparison of the US-American and the German technology profile at the USPTO. The German profile shows the same but even more pronounced strengths and also some of the weaknesses compared to the transnational profile (Figure 8). It is in electrical engineering (power machines), transport and machinery where German engineers are targeting the US-American technology market. Besides, the German profile is more positive also in life sciences and chemistry. Especially the field of electrical medical instruments is much better performing at the USPTO than at the transnational level. From this comparison, we see two sides of the same coin. On the one hand, the German transnational profile is very much affected by the general competences of Germany. As describes above, the intention of transnational patents is exactly to give a broad overview of the technological competitiveness of nations. On the other hand, the US-American market especially for life science technologies seems much more attractive to Germans than the worldwide markets. Here a selection effect seems to be in action. This latter effect is supported by the fact that, also in the Chinese market, Germany and the USA are the most active patenting countries in the medical instruments fields (Frietsch/Meng 2010). The profile of the USA shows similar patterns, but the other way around (see Figure 9). The national profile is less pronounced compared to what the US-American inventors offer in worldwide technology markets.

Figure 8: Technology profiles of Germany at the USPTO and in transnational patents, 2006-2008



Source: Questel-Orbit – USAPPS, Fraunhofer ISI calculations

Figure 9: Technology profiles of the USA at the USPTO and in transnational patents, 2006-2008



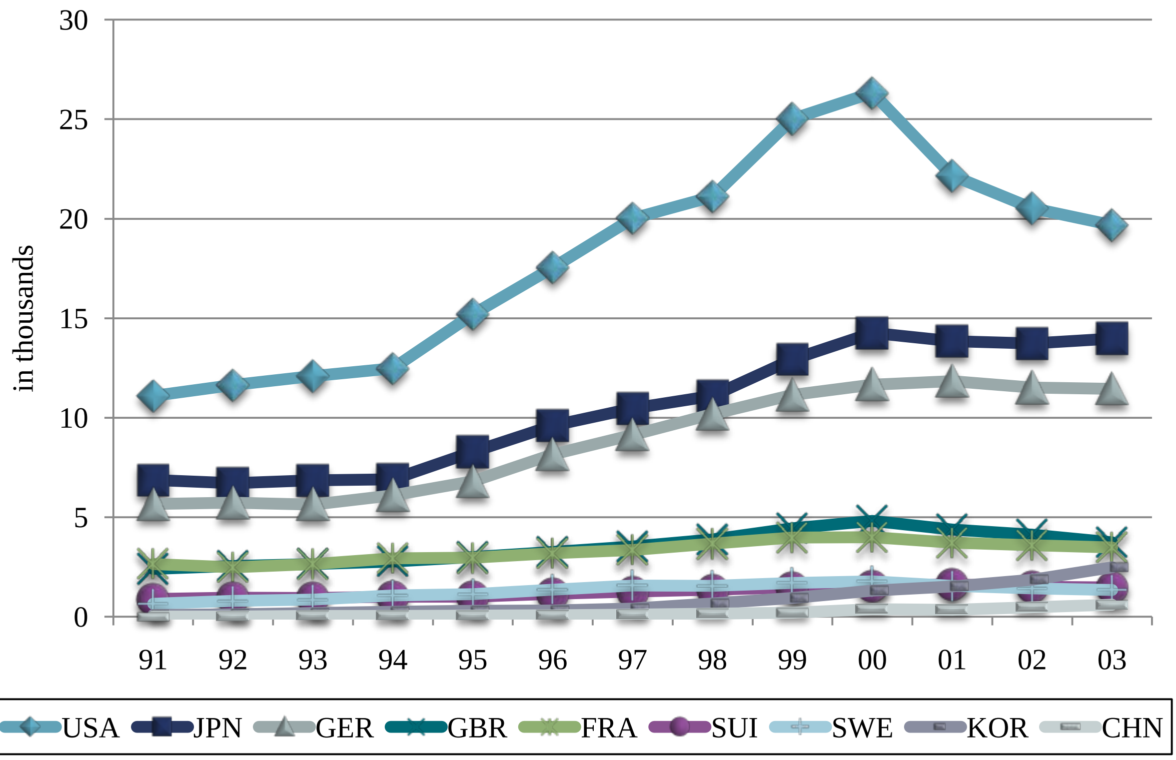
Source: Questel-Orbit – USAPPS, Fraunhofer ISI calculations

6. Valuable Patents – Applying Weights to Account for Differences

The value of patents is extremely skewed (Bessen 2008; Gambardella et al. 2008; Grönqvist 2009; Harhoff/Hoisl 2007)with only a few patents being very valuable, a large number having some medium value and also patents having no direct value. While the value of individual patents is rather straightforward to understand, the value of national patent profiles cannot directly be assessed. In a recent study (Frietsch et al. 2010b), we identified two possible indications of the value of national patent portfolios, which we will apply in this chapter. On the one hand, citations of patents proved to be a meaningful measure as well as the number of patents that survive the first three years of the application process. The first are citation-weighted patents and the latter are called non-withdrawals (including refusals). For a broader discussion, please refer to the chapter on data and methods.

We apply a four-year citation window, which means that we analyse all citations that are made to a priority cohort of patents in the year of filing and the three subsequent years. For technical reasons we analyse the priority cohort of 2003 and we also use this cohort for the analyses of non-withdrawals. In case of citations, we examine transnational patents, but in case of non-withdrawals a restriction to EPO data is necessary, as the legal status information is available only for this group of data in a comparable manner.

Figure 10: Number of cited transnational patent applications (4-year-citation window) of selected countries, 1991-2003

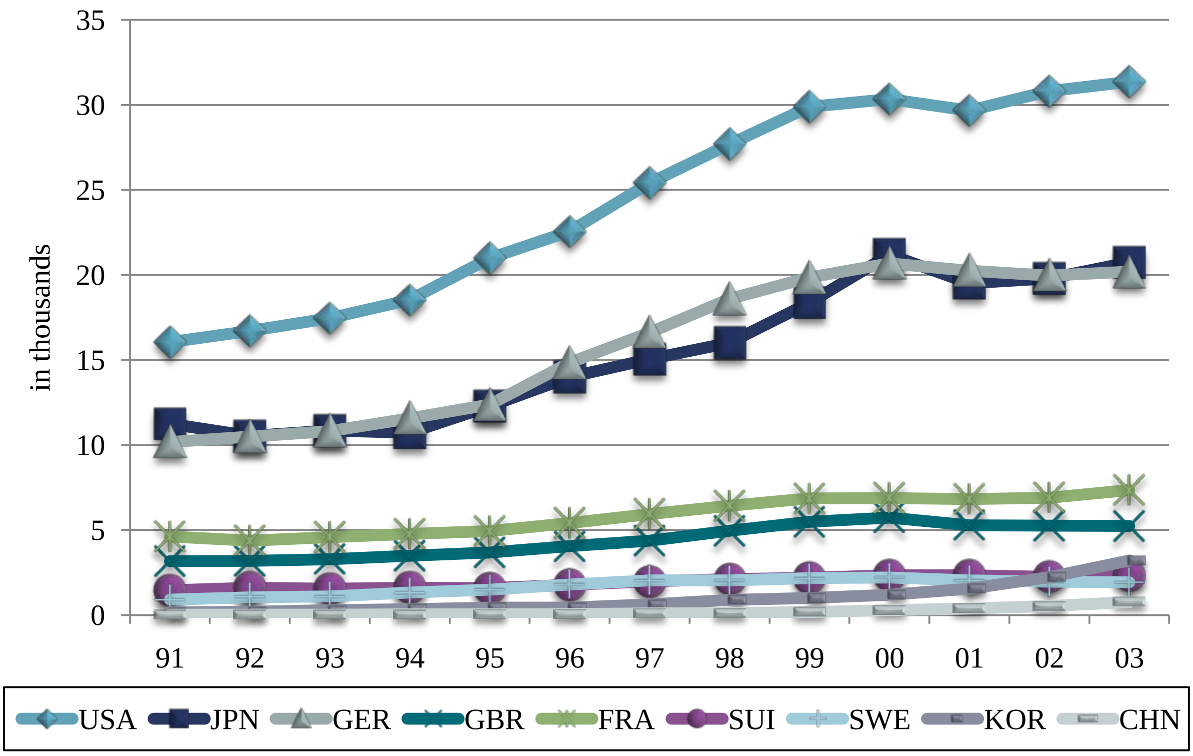


Source: EPO-PATSTAT; Fraunhofer ISI calculations.

The absolute numbers of transnational patent applications that were cited within 4 years after priority date are depicted in Figure 10. The trends in patenting are almost the same as in the case of total transnational patent applications (see Figure 2), but the relations between the countries slightly changed. It is to be stressed again that the time series end in 2003 due to technical reasons of the citation window. Especially the USA are downsized to the same level as Japan and the distance to Germany is also reduced. The Chinese are not yet visible due to their growth in the recent years which could not be displayed in Figure 10. Also Korea has just surpassed Switzerland and is still behind France and the United Kingdom.

Figure 11 displays the absolute number of EPO applications – the legal status data is only available for EPO patents – which were not withdrawn or refused in the early phase of the application process. Patents that are not withdrawn within the first four years are taken into account. A direct comparison to the data in Figure 2 and Figure 10 is therefore not possible, but the trends and the relations between the countries can be interpreted. In the case of non-withdrawals, the relation between the USA and Germany are similar to the relations when the total number of applications is taken into account (see Figure 2). However, Germany and Japan are almost at the same level, but this is not an effect of the selection of non-withdrawals, but an EPO effect. Also, in the case of total applications to the EPO, the level of Germany and Japan is almost the same. Except for Italy and Korea, where the focus on non-withdrawals shows an effect, no impact of the value adjustment by this indicator can be detected.

Figure 11: Absolute number of non-withdrawn EPO applications for selected countries, 1991-2003



Source: EPO-PATSTAT; Fraunhofer ISI calculations.

Table 3: Absolute number, ranking and index of transnational patent applications of selected countries using value adjustment indicators, priority year 2003

Transnational patent applications									
	Absolute no. of filings			Rank			Index (Germany = 100)		
	Transnational	Cited	non-withdrawals (EPO)	Transnational	Cited	non-withdrawals (EPO)	Transnational	Cited	non-withdrawals (EPO)
USA	50,524	19,685	31,367	1	1	1	192	172	155
JPN	31,037	13,981	20,737	2	2	2	118	122	103
GER	26,311	11,452	20,188	3	3	3	100	100	100
FRA	9,252	3,487	7,356	4	5	4	35	30	36
GBR	7,364	3,741	5,234	5	4	5	28	33	26
KOR	5,614	2,484	3,209	6	6	7	21	22	16
ITA	5,241	2,164	3,815	7	7	6	20	19	19
NED	3,944	1,978	3,122	8	8	8	15	17	15
SUI	3,260	1,481	2,353	9	9	9	12	13	12
CAN	2,935	1,279	1,805	10	11	11	11	11	9
SWE	2,663	1,353	1,930	11	10	10	10	12	10
CHN	1,983	604	768	12	13	13	8	5	4
FIN	1,637	774	1,243	13	12	12	6	7	6
RUS	686	182	219	14	14	14	3	2	1

Patent applications at the USPTO						
	Absolute no. of filings		Rank		Index (Germany = 100)	
	USPTO	Cited	USPTO	Cited	USPTO	Cited
USA	132,626	88,214	1	1	735	881
JPN	55,730	34,140	2	2	309	341
GER	18,043	10,014	3	3	100	100
KOR	13,249	8,037	4	4	73	80
GBR	6,902	4,295	5	5	38	43
CAN	6,379	3,931	6	6	35	39
FRA	6,228	3,236	7	7	35	32
NED	3,157	1,884	8	8	17	19
ITA	2,863	1,390	9	9	16	14
SUI	2,217	1,259	10	10	12	13
SWE	2,019	1,218	11	11	11	12
CHN	2,000	1,132	12	12	11	11
FIN	1,520	1,035	13	13	8	10
RUS	348	193	14	14	2	2

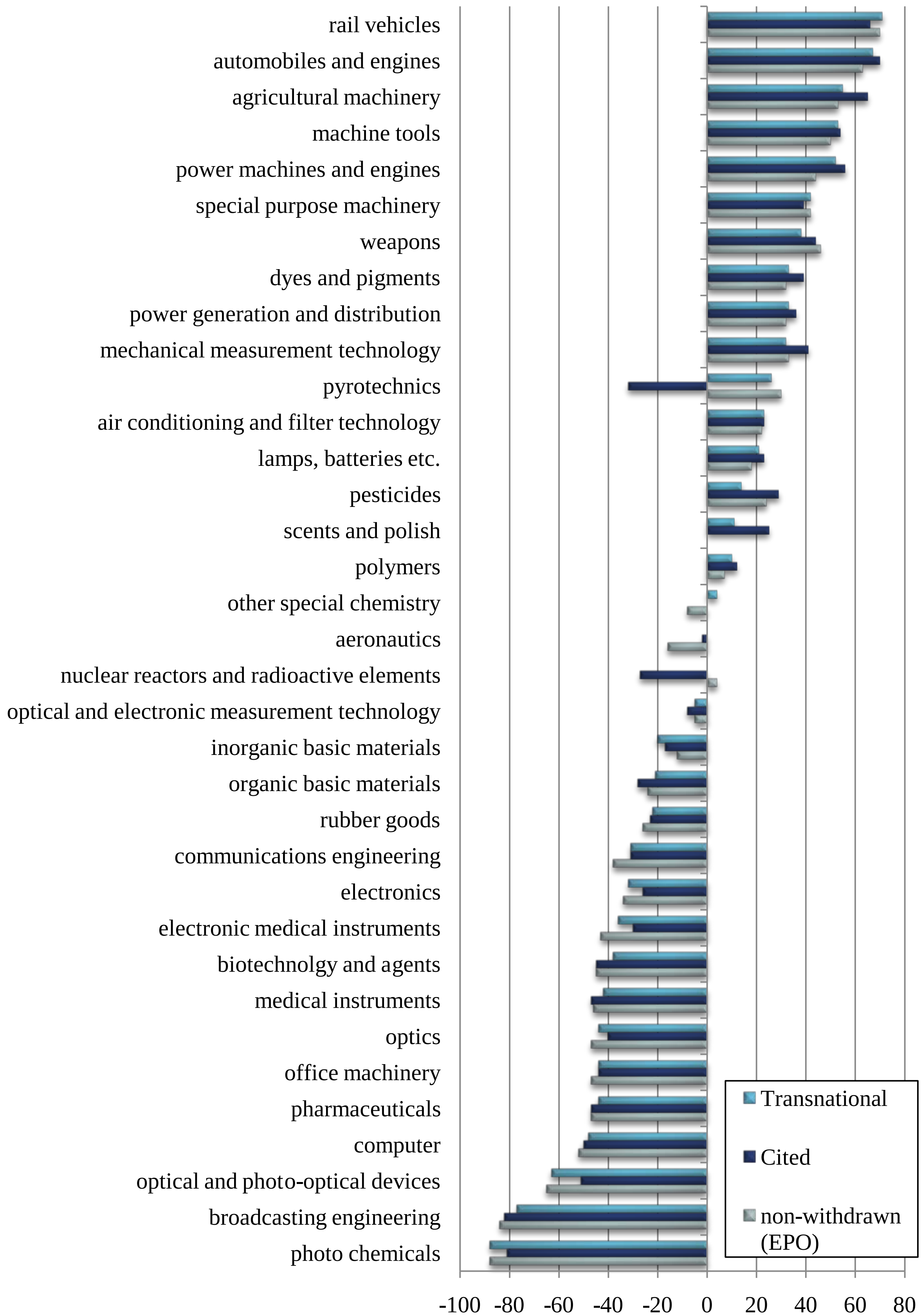
Source: EPO-PATSTAT; Fraunhofer ISI calculations.

Table 3 summarises these latter findings. It contains the absolute numbers, the rankings of the countries and an index to measure the distance between the countries and where Germany is set to a value of 100 as a benchmark. Though the absolute numbers of the three indicators are clearly different, the ranking of the countries is almost the same in all cases. France and the United Kingdom swop their ranks in case of cited patents. In case of non-withdrawals, it is Korea and Italy that swop their ranks. The index shows again that both citations and non-withdrawals discriminate the USA compared to the absolute number of transnational patent applications. In general, non-withdrawals seem to favour Germany in relation to most other countries or there is no impact like in the cases of the Netherlands, Switzerland, Sweden or Finland.

The analysis based on USPTO data (lower panel) reveals a similar picture, although the applicant structures differ. Apart from the expected larger absolute number of filings from the USA, especially Korea and Canada score higher in the ranking. This means that they focus more on the US market than the worldwide market relative to the activities of most other countries. However, no matter if the total number of applications or the number of applications with citations is used, the rankings of the countries remain the same, so the valuation of patents based on citations has also no impact on the structures at the USPTO.

The technological profiles of Germany in the years 2001-2003, taking the three different perspectives, are compared in Figure 12. The patterns are almost identical and the index values vary only little. Exceptions can only be found in the smaller fields in terms of absolute patenting, namely pyrotechnics, nuclear reactors, or aeronautics. In sum, the value adjustment indicators have hardly any impact on the rankings or on the relative positions of the countries analysed in this report. The only difference is the level of absolute numbers.

Figure 12: Germany's specialisation profile using value adjustment indicators, 01-03



Source: EPO-PATSTAT; Fraunhofer ISI calculations.

7. Growth of Technological Fields – An IPC-Subclass Analysis

The forecast of the relevance of technological fields is a major issue of innovation research in order to identify areas that will be a major basis of economic activities. These promising fields may be a focus of special awareness and support activities. In general, forecast is based on expert assessment (see, for instance, Cuhls (2006) or Grupp et al. (1993)), but quantitative analysis of technology-related indicators can be useful as well (see e.g. Reiß et al. 2007).

For the present analysis, the growth of the number of patent applications defined by their indexing in the International Patent Classification (IPC) is analysed. The investigation is based on the 8th edition of the IPC which is regularly revised and the applications are reclassified, if new codes are introduced. This reclassification is also realised in a backward direction, thus antecedent applications are reclassified as well. A specific advantage for this analysis is that all applications are indexed by patent examiners who are experts in their fields. Therefore the indexing of patent applications has a very high quality compared to other classification, for instance, of journal publications.

It is important to be aware of the character of the results that can be achieved by an analysis of patent applications. Patent applications are primarily the outcome of industrial research and development activities with the aim to maintain or achieve competitive advantage in technology-related markets. It is a characteristic feature of enterprises that their patent applications are generally linked to short- and medium-term market expectations. If in a specific market segment these expectations cannot be fulfilled, the enterprises tend to reduce their R&D and patent activities. However, in science-based fields with complex technology, the time lag between the first ideas and market introduction and penetration can be quite long and comprise several decades. In these cases a growth of patent applications can be observed in the last stage of market penetration (Schmoch 2007). In any case, a substantial growth of patent applications in the last decade indicates that a certain field had relevant market returns and that the competition in this market is largely based on technological innovation. Furthermore, the probability is high that the relevance of this field will persist at least in the next decade.

The present analysis examines the growth of transnational applications (direct EPO plus PCT-applications, see (Frietsch/Schmoch 2010) in the period between 1997 and 2007 (priority years). The investigation refers to the level of the so-called subclasses, which is the 4-digit level. All in all, 691 subclasses were scanned. The analysis was conducted for the total of the transnational applications as well as for those with German origin defined by the inventor county.

A general methodological problem of the growth analysis of patent subclasses is that their size in terms of the number of annual applications differs substantially. However, the calculation of growth rates appears to be size-dependant: for mathematical reasons, small fields tend to have higher growth rates than larger ones. This problem can be partially avoided by using so-called Sharp Ratios accounting for annual fluctuations. But the size differences between subclasses of the IPC are so tremendous that this approach proves to be insufficient. Therefore the subclasses were subdivided into the three types of large, medium-sized, and small subclasses. Very small classes were completely excluded, as the involved small numbers imply statistically unreliable outcomes.

Table 4: Large IPC subclasses with the highest growth in the last decade

Rank	Code	Present size	Annual growth factor	Content
1	G06Q	3,480	1.14	Data processing methods
2	H01M	2,480	1.10	Batteries, fuel cells
3	H04L	10,472	1.10	Digital transmission of information
4	F21V	1,078	1.10	Features of lightening devices
5	H04W	4,371	1.11	Wireless communication networks
6	G01C	1,132	1.10	Measuring distances, navigation
7	G06F	12,753	1.10	Digital data processing, computers
8	H02J	992	1.08	Distributing and storing electrical power
9	E21B	1,399	1.08	Earth drilling
10	H05B	1,627	1.08	Electric heating/lighting
11	G02F	1,934	1.08	Optical operation, optical switching
12	A61B	6,474	1.08	Medical diagnosis
13	H01L	8,266	1.07	Semiconductors
14	F16H	1,461	1.06	Gearing
15	G09G	1,265	1.08	Display control
16	A61N	1,458	1.08	Electrotherapy
17	A01N	1,996	1.07	Biocides
18	B62D	1,370	1.07	Motor vehicles
19	G05B	1,090	1.07	Control of non-electric variables
20	C01B	1,271	1.06	Non-metallic elements

Source: EPO-PATSTAT; Fraunhofer ISI calculations.

The results for the large subclasses are shown in Table 4. As a large subclass with the highest growth, the one for data processing methods for administrative, commercial, financial and similar purposes (G06Q) is determined. Thus software innovation appears to be the most dynamic within the field of large technologies. The annual growth in this subclass is 14% with a size of 3,480 applications of worldwide origin in 2006/2007. This result is backed up by a similar strong growth in digital data processing, i.e. hardware (G06F). Here the growth is less strong than in software, but the size is much larger.

A further dynamic area is telecommunication with the subclasses digital transmission (H04L), wireless communication networks (H04W, and optical switching (G02F). A further subclass in the top group is semiconductors with a substantial current size of 8266.

Within the top group of the large subclasses, batteries and fuel cells (H01M) have to be mentioned. This may be linked to the expectation that electric mobility will achieve a broader market penetration in the near future. Another interesting subclass is lighting devices. A major reason for the growth of this technology may be the abolition of classic electric bulbs and the change to energy-efficient devices. Strong growth in the last decade can be also observed for navigation devices (G01C), and medical apparatus (A61B, A61N).

In the top group of large subclasses, chemical technologies appear in terms of biocides (B62D) and non-metallic elements (C01B), whereas the subclasses of organic chemistry (class C07) appear in lower ranks. Anyhow, pharmaceuticals (A61K) are by far the largest subclass (at present 15,633 applications) and its annual growth at 5% is at rank 22. However, the subclass on microorganisms, enzymes and genetic engineering (C12Q) is even decreasing at an annual level of 3%. The size is still quite high (4,128 applications in 2007), but there are obviously no present market incentives for growth. After the boom of the 1990s, the transfer into marketable products and processes appears to be less dynamic. The automotive sector is represented in the top group by gearing (F16H) and motor vehicles (B62D).

It is instructive to compare the list of Table 4 with the most dynamic large subclasses of German origin, as documented in Table 5. Also in the German case, information and communication technology is quite dynamic with digital data processing (G06F), transmission of digital information (H04L), and wireless communication networks (H04W). Batteries and fuel cells (H01M) are even in the first rank and a subclass in the context of lighting (H05B) is in a top rank as well.

Table 5: Large IPC subclasses with German origin with the highest growth in the last decade

Rank	Code	Present size	Annual growth factor	Content
1	H01M	308	2.16	Batteries, fuel cells
2	H05B	306	2.12	Electric heating/lighting
3	A61B	676	2.03	Medical diagnosis
4	G06F	824	2.03	Digital data processing, computers
5	F16D	468	2.01	Couplings, clutches, brakes
6	F16C	328	2.00	Shafts, bearings
7	H04L	956	1.99	Transmission of digital information
8	B23K	310	1.81	Soldering, welding
9	H04W	337	1.79	Wireless communication networks
10	G05B	316	1.79	Control systems
11	A61K	1,953	1.76	Pharmaceuticals
12	F16H	457	1.71	Gearing
13	H02K	360	1.63	Dynamo-electric machines
14	C23C	345	1.54	Coating metallic material
15	G01N	957	1.42	Analysis of biological materials
16	A61Q	390	1.41	Use of cosmetics
17	A01N	353	1.36	Biocides
18	B62D	362	1.34	Motor vehicles
19	C07D	744	1.34	Heterocyclic compounds
20	G02B	429	1.29	Optical elements

Source: EPO-PATSTAT; Fraunhofer ISI calculations.

The major differences to the top ranks of Table 4 are the stronger representation of mechanical engineering and automotives with couplings ((F16D) and couplings (F16 C), soldering (B23K), gearing (F16H), and motor vehicles (B62D) as well as chemistry with pharmaceuticals (A61K), analysis of biological materials (G01N), biocides (A01N), and heterocyclic compounds (C07D). Also in the German case, biotechnology (C12N) is decreasing, but less strongly than is the case worldwide (-2% annually).

At the medium-sized level, dynamic smaller high-tech fields may be expected. The growth rates are higher than for the large fields, as expected, but only few technology-intensive fields can be found, such as wind motors (F03D), control for electrical motors, in the context of electric mobility (H02P), control systems for hybrid vehicles (B60W), or apparatus for enzymology and microbiology (C12M).

At this level, various fields linked to household devices appear. These consumer goods are still a main basis of the markets and are closely linked to innovation as well.

Anyhow, the table illustrates that in many traditional fields, new dynamics are induced by new applications, for instance, turbines (for more efficient energy production), conversion between AC and DC (in the context of increasing use of accumulators), or air conditioning (for more efficient use of energy).

Table 6: Medium IPC subclasses with the highest growth in the last decade

Rank	Code	Present size	Annual growth factor	Content
1	F03D	532	1.27	Wind motors
2	B60W	698	1.13	Control systems for hybrid vehicles
3	F21S	627	1.12	Non-portable light devices
4	F01D	980	1.12	Turbines
5	D06F	779	1.12	Laundering
6	H04R	1,000	1.11	Loudspeakers
7	C10L	490	1.10	Fuel
8	F25D	685	1.10	Refrigerators
9	G08G	737	1.09	Control of displays
10	A63F	858	1.10	Indoor games
11	F01N	939	1.09	Exhaust apparatus, gas flow silencers
12	A47J	856	1.09	Kitchen equipment
13	H02M	659	1.08	Conversion between AC and DC
14	G01V	607	1.09	Geophysics
15	A47L	841	1.09	Household equipment
16	F04D	605	1.07	Compressors
17	H02P	632	1.08	Control of electrical motors
18	F24F	705	1.09	Air-conditioning
19	E04H	522	1.08	Building structures
20	C12M	678	1.07	Apparatus for enzymology and microbiology

Source: EPO-PATSTAT; Fraunhofer ISI calculations.

In the case of patent applications of German origin, the picture at the medium-sized level according to Table 7 is largely similar to that of Table 6. For instance, the subclasses wind motors (F03D), turbines (F01D) or refrigerators (F25D) appear as well. However, the relevance of household equipment is lower than the world average. It is interesting to note that the data processing methods (G06Q) appear as dynamic field at the medium level, whereas it is a top field in the table of large subclasses at the world level. The same observation applies to navigation (G01C). When these fields are used in the German context, they are very dynamic, but only few enterprises are engaged in them.

Table 7: Medium IPC subclasses with German origin with the highest growth in the last decade

Rank	Code	Present size	Annual growth factor	Content
1	F03D	113	1.21	Wind motors
2	B60K	85	1.20	Mounting of units of vehicles
3	F24J	89	1.17	Heat production
4	F25D	169	1.15	Refrigerators
5	G06Q	172	1.14	Data processing methods
6	F01D	285	1.14	Turbines
7	B64D	88	1.12	Equipment for aircrafts
8	D06F	209	1.12	Laundering
9	H04R	155	1.12	Loudspeakers
10	B60W	199	1.11	Control systems for hybrid vehicles
11	A47L	229	1.11	Domestic washing
12	F04D	161	1.09	Compressors
13	G01C	205	1.09	Measuring distance, navigation
14	F24C	136	1.08	Domestic stoves
15	F28D	128	1.08	Heat exchangers
16	G06T	188	1.08	Image data processing
17	F16F	232	1.07	Shock-absorbers
18	G03F	150	1.07	Photomech. production of semiconductors
19	H01J	219	1.07	Electric discharge tubes
20	F28F	119	1.07	Steam condensers

Source: EPO-PATSTAT; Fraunhofer ISI calculations.

At the level of small subclasses, the contents appear to be quite special (Table 8) and often less technology-intensive, such as cycle saddles (B62J). Only at this level, do nanotechnology (B82B) and micro-technology (B81B and B81C) appear. Furthermore, the field of airplanes appears to be very dynamic. The absolute number of patent applications is quite low, as the propensity to patent in this area is modest.

In the German case, the majority of cases is less spectacular, such as hand-held machine tools (B25D, B25F), which can also be found at the international level. The main exceptions are holographic processes (G03H) and measurement of X-radiation (G01T).

Table 8: Small IPC subclasses with the highest growth in the last decade

Rank	Code	Present size	Annual growth factor	Content
1	F21Y	403	7.00	Light sources
2	B82B	245	7.00	Nanostructures
3	F03G	174	5.10	Spring or similar motors
4	F03B	267	5.28	Machines for liquids
5	B60K	358	4.21	Mounting of units of vehicles
6	F24J	378	4.58	Heat production
7	C10J	141	3.35	Production of producer gas
8	B81C	156	2.88	Manufacture of micro-structures
9	B62J	191	2.34	Cycle saddles
10	B25D	138	2.85	Percussive tools
11	B81B	211	2.58	Micro-structural systems
12	B64C	463	2.61	Aeroplanes
13	B67D	384	2.76	Transferring liquids
14	B25F	182	2.30	Multi-purpose tools
15	B60L	489	2.60	Brakes for cycles
16	B66B	437	2.29	Elevators
17	A61H	432	2.21	Physical therapy apparatus
18	F24C	408	2.15	Domestic stoves
19	F41H	186	2.05	Armed vehicles
20	B25J	427	1.98	Robots

Source: EPO-PATSTAT; Fraunhofer ISI calculations.

Table 9: Small IPC subclasses with German origin with the highest growth in the last decade

Rank	Code	Present size	Annual growth factor	Content
1	F21K	38	10.86	Valves
2	G03H	51	7.29	Holographic processes
3	B25D	76	4.22	Percussive tools
4	B25F	71	3.62	Multi-purpose tools
5	F16P	35	3.04	Safety devices for machines
6	B27B	41	2.89	Saws
7	G01T	46	2.84	Measurement of X-radiation
8	B64C	81	2.78	Aeroplanes
9	F16H	35	2.65	Gearing
10	H01K	40	2.63	Electric incandescent lamps
11	C10J	28	2.55	Production of producer gas
12	C10L	67	2.42	Fuels
13	F21Y	33	2.41	Lighting devices
14	B67C	39	2.41	Filling with liquids
15	B25J	87	2.35	Robots

Rank	Code	Present size	Annual growth factor	Content
16	A01M	27	2.30	Catching animals
17	F25B	88	2.27	Steam condensers
18	B42D	88	2.19	Book covers
19	B67D	47	2.19	Transferring liquids
20	F41A	42	2.18	Small arms

Source: EPO-PATSTAT; Fraunhofer ISI calculations.

All in all, the analysis of the growth of IPC subclasses primarily confirms the major trends of technology growth, in particular the merger of information and telecommunication technology, implying a substantial dynamics. The expectation of identifying new dynamic fields at the level of subclasses of lower size does not appear to be realistic. At this level, rather dynamic fields of mundane technology can be found. However, these results show that this mundane technology is a substantial part of the present economy and that it is also closely linked to innovation.

The approach can be used to assess the growth potential of German enterprises in leading-edge technology. For instance, the large fields of digital transmission of information of wireless communication networks can be found in the worldwide top list as well as the German one (Table 4 and Table 5). A further breakdown to the level of IPC main groups can clarify which specific technologies are relevant for these dynamics. A next step would be to identify relevant applicants and their association to sectors. In consequence, promising fields for Germany in leading-edge technology can be found.

8. References

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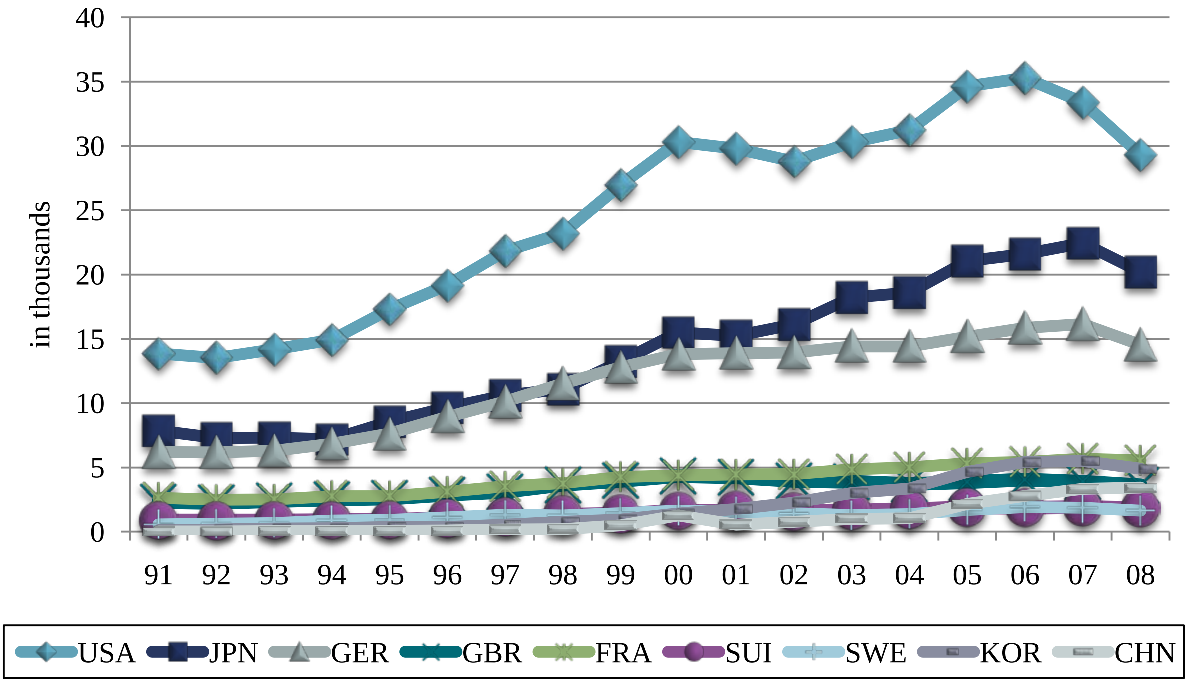
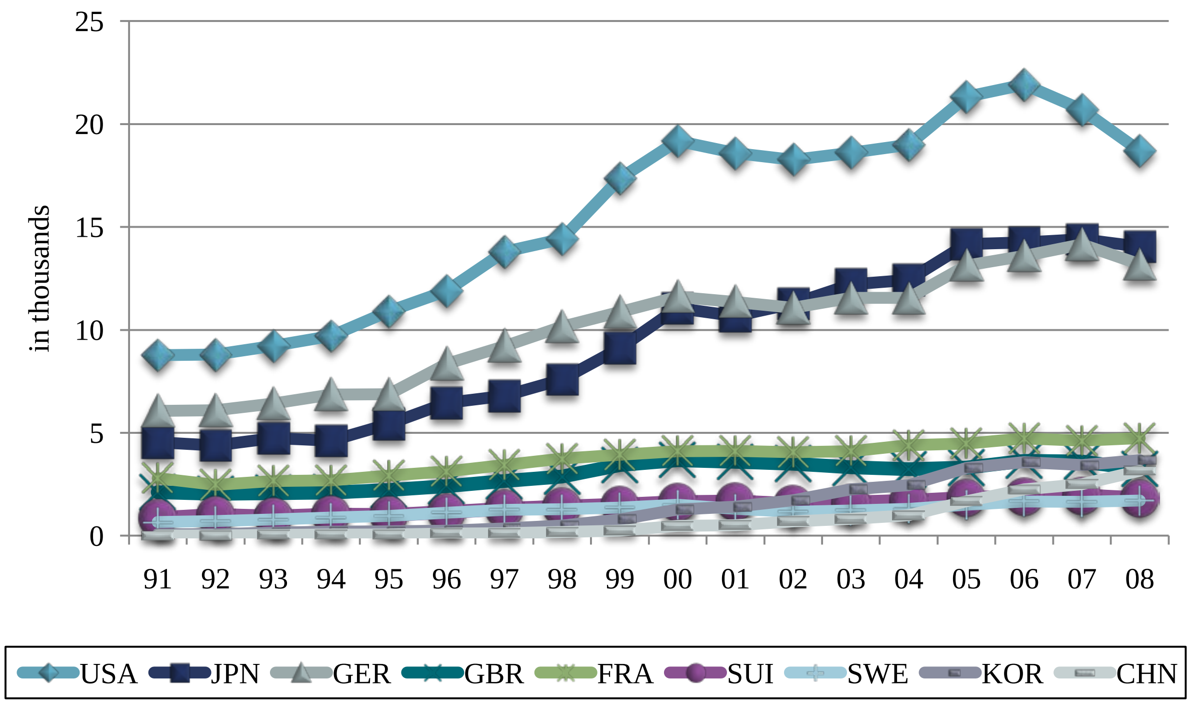
9. Annex

Figure A1: Absolute number of transnational patent applications for selected countries in high-tech areas, 1991-2008



Source: EPO-PATSTAT; Fraunhofer ISI calculations.

Figure A2: Absolute number of transnational patent applications for selected countries in low-tech areas, 1991-2008



Source: EPO-PATSTAT; Fraunhofer ISI calculations.