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Patent Applications – Structures, Trends and Recent Developments

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1. Summary

In the first part of this report, transnational patent applications will be analysed, as they enable the assessment of the technological competitiveness of nations in a comparable way. Patents are interpreted as an output indicator of R&D processes, which – at the same time – are input to future market activities, especially in international high-tech markets.

The absolute number of patents filings has been growing since 2002 in almost all countries, after the economic crisis at the beginning of the new century. Very recently – this is the priority year 2007 – the numbers for some countries decreased again, which can be explained by the recent economic crisis of the years 2008 and 2009. Applicants have one year's time to decide if they should file a national patent also internationally. It seems that many companies decided not to follow the international route, under the impression of the recession in 2008 or not to publish their filings at all, which has a retrospective effect on the data of the priority year 2007. This impact of the crisis is especially visible in countries that are very active in the USA – including the USA themselves – where the crisis had its point of departure. Countries like Germany and Japan do not yet show direct effects. This finding is also backed by the trends of the applications to the USPTO, where even the number of filings by US inventors stagnated in the priority year 2007.

While the overall growth of patent filings at the transnational level is visible in almost all technological areas as well as in all countries – though especially visible in China, Korea, but also Canada and Japan – the growth at the USPTO is almost exclusively driven by the new and emerging countries – and this is even more interesting to note – and almost only in the area of electrical engineering (including ICT), while the other technological areas are stagnating.

The patent profiles of Germany, the EU-27 and the USA reveal considerable similarities between Germany and the EU and at the same time considerable differences between the EU (or Germany, respectively) and the USA. Europe is specialised in machinery and transport, while the USA – similar to many other countries in the world – are active in ICT and additionally in life sciences and health technologies / medical instruments. The profiles of Europe and Germany would have a completely different shape if the 3%-goals were reached. The USA specialises in leading-edge technologies, which necessitate – by definition –spending a higher share on R&D, while Europe and Germany are specialised in medium-tech technologies which require a lower share of R&D. The fact that the profiles of Germany and the EU hardly changed within recent years – as any structural change has a longer time horizon – at least partly explains why the 3%-goals were not achieved by 2010.

A shift-share analysis that breaks down the change in the number of patent applications between 1997 and 2007 for the USA, Japan, Germany and the EU-27 countries allows a further differentiation of the structural changes of recent years. While the overall growth of worldwide applications reached 87% in the period under observation and the role of the large innovation-oriented countries is still visible, it is especially the structural and intensification effects that have negative values in these countries, while the trend effect – reflecting the size of the countries – reaches positive values in almost all cases. This means that, on the one hand, the large industrialised countries were not able to restructure their portfolio according to the new world order and, on the other hand, did not keep pace with the developments mainly introduced by the new emerging countries like South Korea or China. This is first and foremost true for information and communication technologies, but even for established technologies that belong to their traditional strengths, for example like some areas of mechanical engineering in the case of Germany. Japan alone seems to have been able to cope with the structural changes after they suffered from the Asian Crisis of the 1990s.

Analysis of the university patent applications to the German Patent and Trademark Office (DPMA) reveals considerable structural changes after the abolition of the so-called professor's privilege in the year 2002. The number of university-owned patents increased since then and the number of patents privately applied for decreased. Besides the fact that professors have to report the inventions to the universities, which then decide to apply for a patent or not, the professors also receive an indication of the economic relevance of the invention from the technology transfer centres of the universities. This might also prevent them from filing their inventions privately, also in cases where the universities refrain from doing so. The most striking and challenging finding is that the number of company-owned, but university-invented patents also considerably decreased since the beginning of this century. Although these findings need more in-depth analyses, they hint that one of the main intentions of recent innovation policy in Germany, namely the strengthening of the science-industry linkage, suffered from the new legal regime.

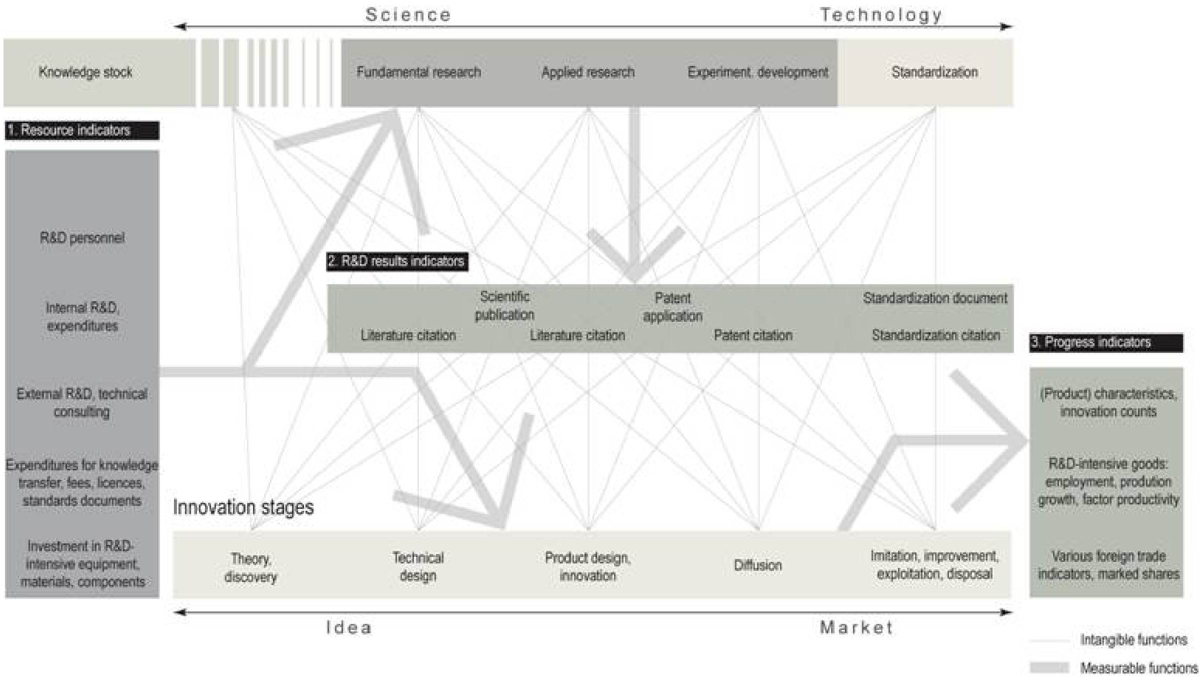
2. Introduction

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, keeping in mind the very recent intention to provide 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 of 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).

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.

Figure 1: Indicator System to Analyse Innovation Systems Performance



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

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 assessment of the technological competitiveness of nations. Especially 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. The data applied here is a concept recently suggested by Frietsch and Schmoch (2009) and has already been used in earlier analyses of this series (Frietsch/Jung 2009), 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-tech 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 has been successfully accomplished already in the middle of the first decade of the new century (Schmoch 2009).

However, the frequent use and the availability of patent data may give the impression that it is a simple indicator and straightforward to use. The opposite is true. As an innovation indicator, patents are rather complex, as they not only require in-depth knowledge of the data sources, their reliability and validity, plus their interpretability. But a mandatory prerequisite is also a deep knowledge of the central legal framework conditions, the application processes, the differences of the patent systems at different patent offices, the incentives and disincentives of the patent system for applicants, strategic aspects of patent filings, and finally, some idea about the decision processes in companies or research institutions which apply for patents or decide not to do so. Furthermore, some knowledge about technologies and their representation in patent documents is a profitable asset for any differentiated patent analysis.

The most frequent and most misleading assumption by unfamiliar users is that there is one (and only one) patent application per invention, implicitly assuming that any invention is only filed once, that any patent is the same as the other, and any patent can be compared or can simply be counted and summed up with any other patent. Patent offices administer patent applications, they examine the claims and they grant a temporary monopoly for the exclusive use of patents. But patent offices can only do this within the territory of its responsibility. If a patent protection is reached in Germany and France, for example, the technology can still be used freely in any other country. Therefore, an applicant approaches more than one patent office if broad market coverage is intended. As a consequence, the first question in any patent analysis should be: which patents are to be analysed? And the answer to this question depends to a great extent on the scope or the range of the intended analysis.

But for the interpretation of the results of the statistical analysis, the analyst should be aware of a caveat that is directly related to the selection of a certain patent office, namely, the possible home advantage or home bias. The probability that a national applicant files a patent at his/her home office is usually higher than for any applicant from any other country. This means, for example, US applicants have a home advantage at the USPTO (United States Patent and Trademark Office), Japanese applicants have a strong home advantage at the JPO (Japanese Patent Office) and German applicants show a strong home bias towards the DPMA (German Patent and Trademark Office). Applicants from smaller countries with no large home market often directly file in a larger neighbour country or at international patent authorities. For example, traditionally, Swiss applicants show a strong focus on the German market – and thereby the German Patent Office – Belgian applicants direct their activities towards France and also Germany, or Canadian applicants file more patents in the USA than in Canada. However, in their individual home countries or home offices, respectively, they still have a strong home advantage. Using German patent filings to generally compare Germany's strengths and weaknesses in technological competitiveness with their counterparts from other countries is not advisable. If the interest is exclusively centred on the German market, this might be a good approach. Measuring German and international applicants on the same scale or the same standard is not possible with this approach.

This report intends to give 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 3 presents 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 decomposes the change between 1997 and 2007 for a selected set of countries using shift-share-analysis. Chapter 5 will discuss patent applications to the USPTO and Chapter 6 analyses patent filings of German universities and universities of applied sciences.

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

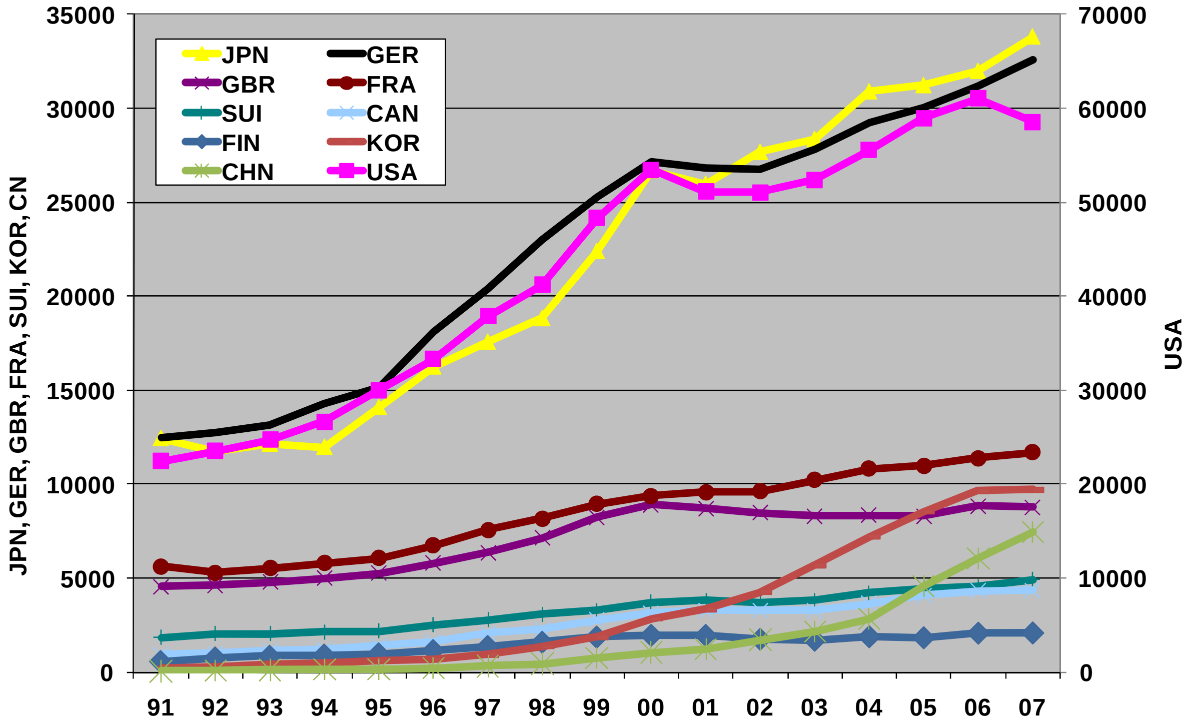
$$RPA_{kj} = 100 * \tanh \ln [(P_{kj}/\sum_j P_{kj})/(\sum_k P_{kj}/\sum_{kj} P_{kj})]$$

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 specializations below the average, respectively.

3. Trends in International Patent Applications

The number of patent applications at the international level has been growing very fast in the second half of the 1990s, for several reasons (Janz et al. 2001; Kortum/Lerner 1999). First of all, there was an increase in R&D expenditure and a growing importance of technological capabilities. Emergence and growing importance of technology-intensive sectors such as biotechnology or nanotechnology contributed to this development (van Zeebroeck/van Pottelsberghe de la Potterie 2007). Also, part of growth can be explained by an increased efficiency in research and development and productivity growth of researchers. However, these facts alone are not able to explain the entire growth of transnational patent filings. Further explanations include a growing tendency towards international filings instead of purely national filings. So what was applied for only at the national level before is increasingly also being applied for internationally. This tendency is partly driven by the more globalised business environment and partly by diffusion of harmonised patenting procedures such as the PCT route (van Zeebroeck/van Pottelsberghe de la Potterie 2007). Finally, an increasing propensity to patent (Hall et al. 2001; Kortum/Lerner 1999), particularly driven by strategic patenting, should account for part of growth in combination with other explanations. This means that contemporary firms more and more used patents as a means for their strategic technology development (Arundel/Patel 2003; Lang 2001; Macdonald 2003), to obtain access to financial sources, e.g. via banks or venture capital funds, which prefer to have a codified idea in hand rather than only in the minds of the entrepreneurs, as an instrument to actively block competitors or just as another means of gratification of their employees (Blind et al. 2006).

Figure 2: Absolute Number of Transnational Patent Applications, 1991-2007



Source: Questel (EPPATENT, WOPATENT); Fraunhofer ISI calculations, update September 2008.

The most striking and interesting finding of this year's report is the fact that the number of transnational patent applications of US inventors considerably decreased in 2007 compared to the priority year 2006 (see Figure 2). Not only is the number almost 6% lower, but also the increasing trend of recent years ended abruptly. And the decrease is visible in almost all technological areas, except for optics, optical devices, electronics and some areas of machinery. The explanation for this turn is – of course – the economic crisis of the year 2008 and that this already affected the patent data of the priority year 2007. The reason is that the decisions on keeping the process alive or not is done 12 months after priority (Paris Convention). Furthermore, the publication of priority filings is 18 months after the priority date. Within these 18 months, patent applications can be withdrawn and will then never be published.

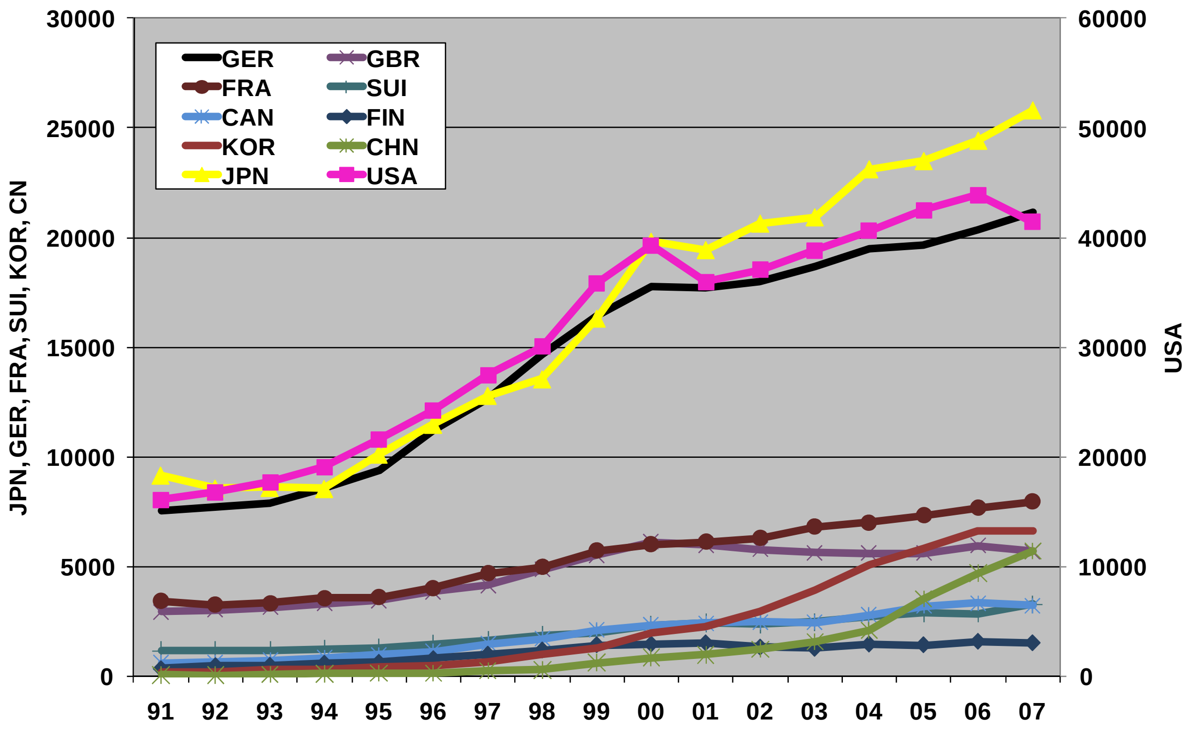
The main explanation for the decrease of transnational patent applications of US inventors – these are mainly filed via the PCT route – is that they decided not to publish or – this is the main case – not to file internationally. And this decision took place in the light of the crisis and already under the impression of the recession in the year 2008, thereby affecting the data of 2007. It seems that a large number of US-based companies have either focused parts of their technological portfolio on the national market, on the one hand, to save international filing costs and, on the other hand, as international investments to bring technologies to markets have not been available to the same extent any more. Or they decided to withdraw the application before publication to keep it secret, thereby also saving the filing costs, and bet on the alternative horse of secrecy, which is less costly at first sight. The fact that the absolute numbers of applications at the USPTO are stagnating (see next section) supports this latter hypothesis. In consequence, it can be expected for the following statistical years 2008 and 2009 that the US American – and following them also other countries – will file considerably smaller numbers of transnational patent applications.

However, the numbers of the other technology-oriented nations displayed in Figure 2 do not seem to be affected by the crisis to the same extent. Although the United Kingdom and Canada – which are highly dependent and focused on the US market – as well as the very ICT-driven countries Korea, Finland and Sweden at least depict stagnating absolute numbers, Germany, Japan, and Switzerland hardly seem to be affected. China's performance based on transnational patents is still a conglomerate of different trends. On the one hand, China is increasing its activities in international markets as well as in patenting in general – two effects that outperform any other trend. On the other hand, China is still undergoing a structural shift that moves the portfolio more and more towards ICT areas (Frietsch/Wang 2009), which are more patent-intensive than many other areas.

If the analysis is restricted to high-tech patent applications only – these are such technological areas that usually require a massive investment in R&D – the effects become even more obvious (see Figure 3). Especially the United Kingdom, Canada and Finland show not only stagnating trends, but even a decrease in the absolute number of high-tech patent applications. Italian and Dutch inventors – not displayed in Figure 2 and Figure 3 – also filed considerably less patents in 2007 than in 2006, or alternatively, they did not maintain them until publication.

The overall trends and the long-term development can also be seen in Figure 2 and Figure 3. While the USA file the most transnational patents, Germany and Japan are both at a similar absolute level, with about half the number of the US patents but still far ahead of the other technology-oriented nations. The United Kingdom has lost the 5th rank after France, which is now held by South Korea. However, China is still forging ahead, but slightly behind the UK. However, when the high-tech patents are analysed, China already took over rank 6 behind France, ousting the UK.

Figure 3: Absolute Number of Transnational Patent Applications in High-tech Fields



Source: Questel (EPPATENT, WOPATENT); Fraunhofer ISI calculations, update September 2008.

Total numbers are only part of the story. In this report the technological competitiveness is of main interest and this is only a relative and not an absolute value. First of all, of course, these absolute numbers depend on the size of a country. And secondly it is also interesting to see if a country's patents are growing faster than the average. This information is displayed in Table 1. In terms of patent intensities – these are patents per 1 million workforce – the three small countries Switzerland, Finland, and Sweden are far ahead, followed by Germany, which filed 556 high-tech patents.

Concerning growth since 1997, Switzerland, Sweden and France especially have been able to reach a higher growth in terms of high-tech patents than their total growth of patent applications. This means that their focus on high-tech has increased in this decade, while the relations of most of the other countries are rather similar between these two indicators. Korea as well as China outperforms all the other countries under observation here, but both of them held only very small patent portfolios at the beginning of the observation period in 1997. This is not to neglect the enormous growth both countries reached in this decade, but they cannot be compared with the performance of the other countries in this period.

In terms of high-tech patents only a few countries – among them Japan that suffered from the Asian crisis in the 1990s and has been catching up again since the late 1990s – were able to grow faster than the total number of transnational patent applications has been growing, namely Switzerland and Canada.

Table 1: Core Indicators for High-tech Patents, 2007

	absolute	High-tech Growth (1997=100)	Intensities (1 m workforce)	Total Growth (1997=100)
Total	141500	191	---	186
SUI	3261	203	739	177
SWE	3000	158	661	147
FIN	1502	152	598	152
GER	21168	167	556	160
JPN	25786	202	402	193
NED	3174	170	373	172
FRA	7957	170	313	154
KOR	6598	1028	282	1057
USA	41401	151	277	155
EU-27	50086	167	229	161
GBR	5680	137	200	138
CAN	3223	220	190	212
ITA	3431	174	148	178
RUS	620	190	9	174
CHN	5679	2502	7	2341

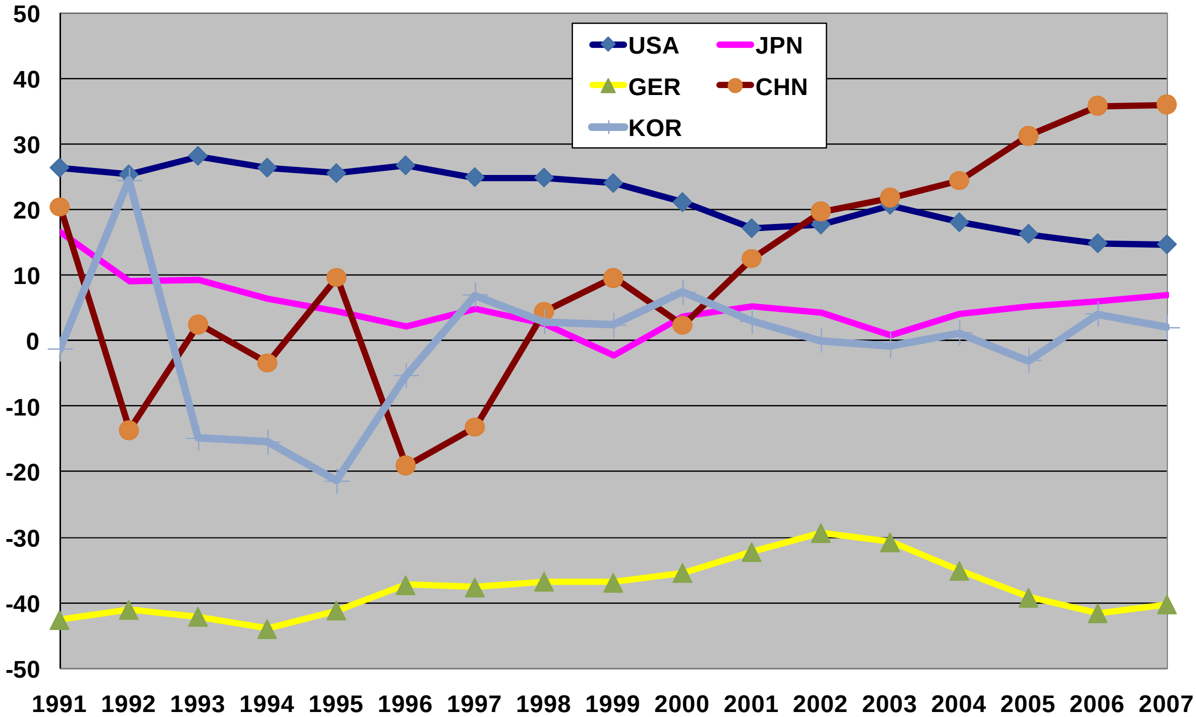
Due to a change in the database because of the new IPC, double counts between high-tech and low-tech might occur. Therefore, the numbers cannot directly be compared with former versions of this table.

Source: Questel (EPPATENT, WOPATENT); Fraunhofer ISI calculations, update October 2009.

Leading-edge technologies are a sub-group of high-tech, defined by the investment in R&D that this technology (or sector) usually demands – at least in Germany and the other OECD countries. Leading-edge technologies are defined as any technology where 7% or more of the turnover is re-invested in research and development (Legler/Frietsch 2007). As can be seen from Figure 3, Germany's relative position in leading-edge technologies improved earlier in this decade, but nowadays takes a downward trend. The reasons for the relative improvement was argued to be a direct implication of the economic downswing after 2001 that especially affected the leading-edge sectors and technologies like biotech/pharmaceuticals and ICT (Frietsch/Jung 2009; Frietsch/Schmoch 2006). These were sectors of relative weakness in Germany and therefore German activities were not hit by the economic crisis to the same extent. The recovery and upturn of these industries in recent years pushed Germany's position downward, as Germany is strong in high-level technologies and associated leading-edge technologies, e.g. in the automobile and machinery sectors, where for example ICT plays an important role as a supplementary or even enabling input.

It seems that once again Germany has not been affected by the recent economic crisis to the same extent, and thereby can improve its relative position. However, this can only be said based on the patent data for 2007. As was argued above, the reaction of companies from traditionally US-American-oriented countries has been very prompt. It has to be kept in mind that the crisis started in the USA, but then made its way around the globe. It can plausibly be assumed that with a certain delay also the filings of the other countries were affected – among them Germany, that is traditionally very export-oriented. In consequence, the specialisation index of Germany's leading-edge technologies might not improve sustainably in the coming years.

Figure 4: Specialisation of Selected Countries in Leading-edge Technologies, 1991-2007



Source: Questel (EPPATENT, WOPATENT); Fraunhofer ISI calculations, update September 2008.

The European Research Area – according to the ambitious plan based on the Barcelona and the Lisbon Strategies – should become the most innovation-friendly and one of the most research-intensive regions in the world by 2010. One of the goals was to raise the R&D intensity (share of R&D expenditure in relation to GDP) to 3%. Germany took on this 3%-goal with its High-tech Strategy in 2006. Unfortunately, the goals were not met either nationally or Europe-wide. Figure 5 gives at least a hint as to why it was not possible to achieve these goals. It compares the patent profiles of Germany and the EU-27 countries for the period 2005-2007. Germany is the largest country within the EU, both in terms of inhabitants, but even more in terms of patent filings. As can be seen in the graph, the specialisation of the EU and of Germany are rather similar. One explanation for this is of course that Germany weighs heavily when calculating the EU figures. But once again, this is only part of the story.

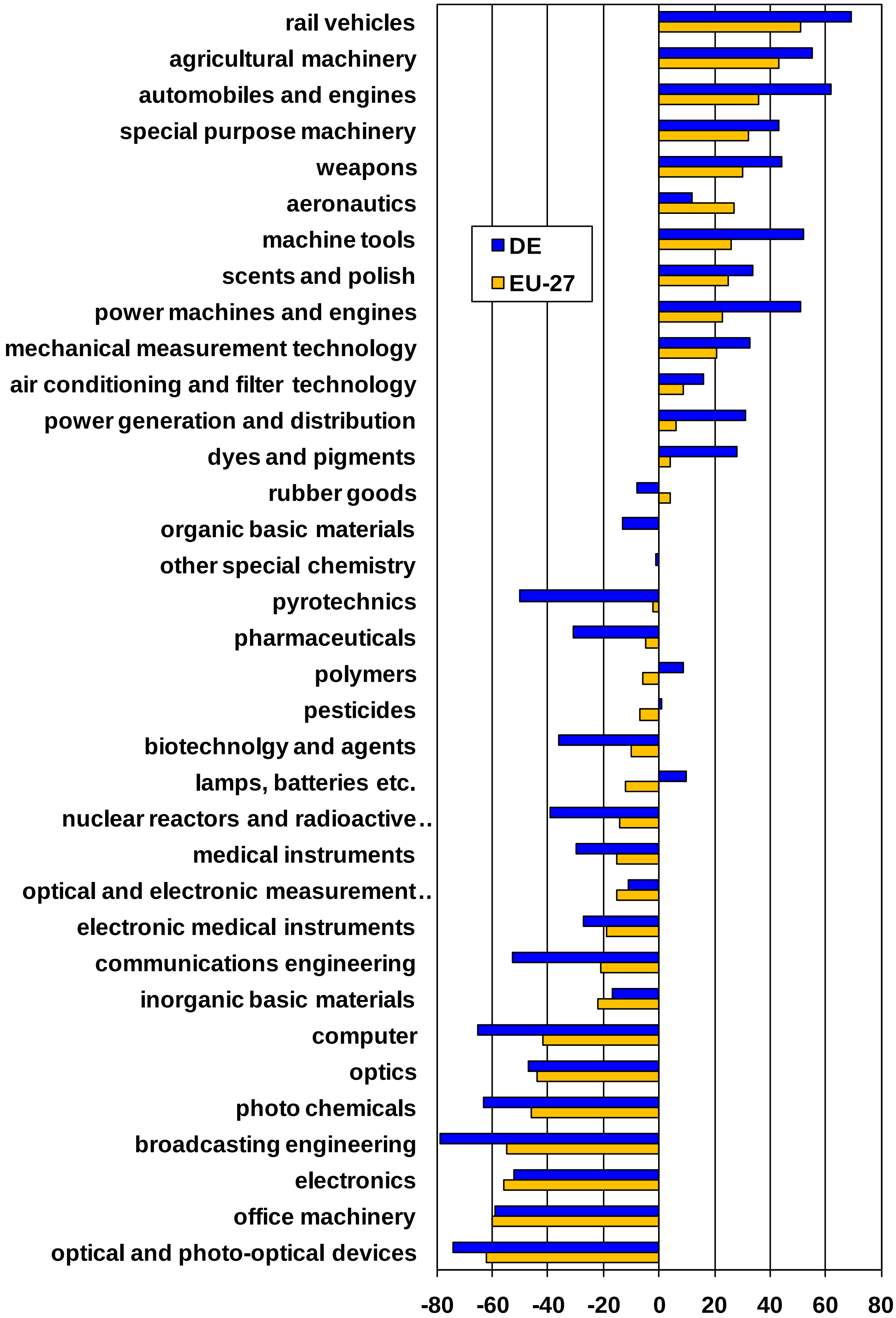
The technological profiles of the EU and of Germany evolved over years and emerged from a long tradition (experience), certain specialisations (synergies), and of course also expertise (science base) in mechanical engineering and automobiles as well as related fields. Neither Europe nor Germany is an area where leading-edge technologies – except for some sub-fields of chemistry, among them pharmaceuticals – traditionally play an outstanding role in the (national) profile. Leading-edge technologies are nowadays mainly driven by information and communication technologies (ICT). However, it is by definition the group of leading-edge technologies that require large investments in R&D while certain areas of engineering and automobiles – though they are also defined as high-tech – demand lower shares of R&D investment in relation to turnover. Therefore, taking the 3%-goal seriously would have meant either spending more R&D money in the engineering and automobiles sectors – which in some sub-fields is done automatically, due to structural changes within the sector – or considerably changing the structure and profile of the whole economy, moving towards ICT. The former strategy might have caused inefficiencies while the latter means entering a crowded market. Given the fact that many other countries – among them the USA, Japan as well as the catching-up countries Korea and China – have high stakes in these areas, could be the explanation for the restricted move of European and German companies towards these fields. This does not mean, by the way, that ICT does not play a role in Europe or in Germany. The opposite is true. But these are used as enabling and supplementary technologies, often embedded in the traditional strengths, namely machines and automobiles.

Figure 6 compares the European and the US American patent profiles, revealing considerable differences. In terms of technological competitiveness, the USA seem to have advantages in some ICT areas as well as in certain fields of chemistry. However, the largest specialisation of the USA can be found in medical instruments as well as electro-medical devices. In the latter area – from a macro-economic perspective – competition with European firms is visible. The other areas belong to the European fields where a relative competitiveness and advantages are obvious.

The specialisation profiles of 14 countries in two time periods are plotted in the annex. Countries like China and Korea, of course, have considerably altered their profiles. The changes of the traditionally industrialised countries are more modest. Germany's profile did not change dramatically in the 11 years under observation here. It even lost ground in some ICT fields, but German inventors have been able to keep or even increase their relative advantage in their traditional strengths, mainly transport and machinery. If the 3%-goal had been reached, this profile would have had a completely different shape.

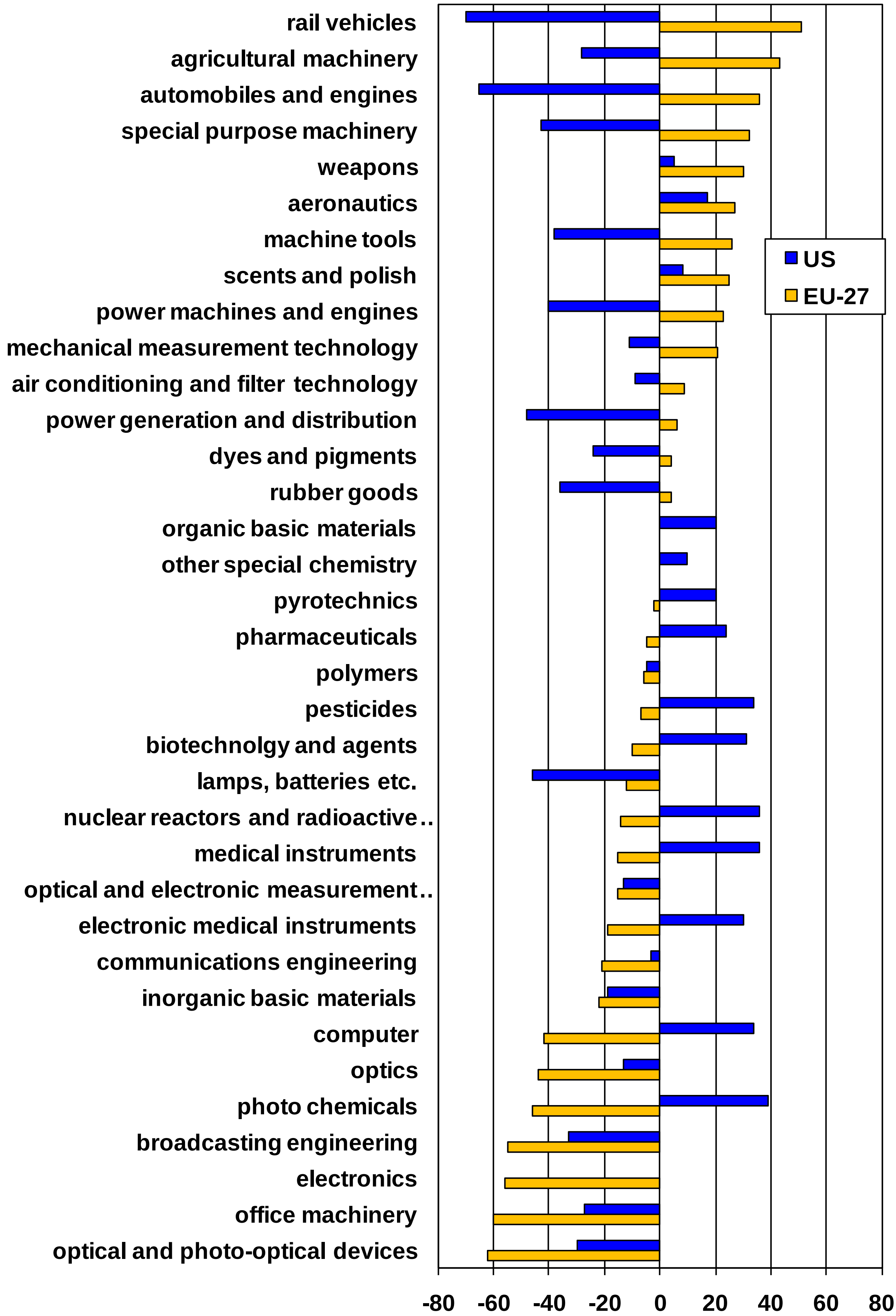
The good news is that the data presented here is the result of individual companies' decisions and the decision-makers in these companies usually know where their markets and their opportunities are. German companies have made good business in their markets and they seem to be prepared for the future, at least in terms of what is here called "technological competitiveness". The future challenge will be not only to keep this high level of technological competence and relative advantage, but also to bring these ideas and technologies to markets. So R&D is one thing and patents are one outcome thereof. But more than just R&D is needed to be innovative and successful.

Figure 5: Patent Specialisation of Germany and EU-27 countries, 2005-2007



Source: Questel (EPPATENT, WOPATENT); Fraunhofer ISI calculations, update October 2009.

Figure 6: Patent Specialisation of the USA and EU-27 countries, 2005-2007



Source: Questel (EPPATENT, WOPATENT); Fraunhofer ISI calculations, update October 2009.

4. Shift-share Analysis

4.1 Methodology

A shift-share analysis allows for the breakdown of changes between two periods. The overall change from one period to another is differentiated by three composites: 1) the overall trend effect, 2) the structural effect and 3) the intensification effect.

The overall trend effect reflects the change in the absolute number of a country's patent applications between the two periods under observation that can be assigned to the total change of the patent applications worldwide. In other words, the trend effect covers the change that one would expect – all the rest being equal – if the respective country just grows in parallel to the world. The structural effect, on the other hand, isolates the part of the change that is induced by the change of the structure of technology fields. Some technological fields are more patent-intensive or have a higher propensity to patent than others. If these fields gain more importance in worldwide patenting, then also the total number of patents of an individual country would change. For example, the enormous patent upsurge in the second part of the 1990s and especially the growth of patent applications in the recent decade can be, to a large extent, attributed to the increased importance of information and communication technologies, which has a high propensity to patent. Finally, the intensification effect reflects the increase or decrease of a country’s relative engagement in a certain technology, mainly focusing on the change in the patent portfolio. For example, if the country engages more in a certain technology field – and more means excluding trend and structural effects – then this indicator will show a positive value.

The formulas for the three indicators and the total can be found here:

$$Trend_{fl}^{t} = P_{fl}^{t-1} * (\frac{P_{ges}^{t}}{P_{ges}^{t-1}} - 1)$$

$$Structure_{fl}^{t} = P_{fl}^{t-1} * (\frac{P_{f}^{t}}{P_{f}^{t-1}} - \frac{P_{ges}^{t}}{P_{ges}^{t-1}})$$

$$Intens_{fl}^{t} = P_{fl}^{t-1} * [\left(\frac{P_{fl}^{t}}{P_{fl}^{t-1}} - \frac{P_{f\,ges}^{t}}{P_{f\,ges}^{t-1}}\right)]$$

$$Total_{fl}^{t} = Trend_{fl}^{t} + Structure_{fl}^{t} + Intens_{fl}^{t}$$

For the further discussion of the results in the next sections it is important to bear in mind that the trend reflects the overall development, the structure reflects the overall changing role of individual fields, whereas the intensification shows the increase or decrease of a country's engagement in a certain technology beyond trend and structural effects. The total change is thereby broken down into these three individual effects, which allow a more fine-tuned assessment of the total change.

4.2 Results

The trend effect reaches a level of 87% growth between 1997 and 2007. This means that, in the period under observation, the total number of patent applications increased to 187% of the number of filings of the base year. Given this overall growth, the structural effects for each of the 36 fields are also displayed in Table 1. These growth rates are the same for all countries, assuming that the fields within the countries would have changed by the same extent as they did worldwide. In the list of fields analysed here only three fields were shrinking in this period – scents and polish, pyrotechnics, and photo chemicals – while all other fields were growing. However, the structural effect reflects the change of the fields given the 87% overall growth. Positive signs imply that the field was growing even faster than the world total of all applications, while a negative sign implies a lower growth of the field than the total number of patent applications between 1997 and 2007. Values smaller than -87% reflect a shrinking of the respective fields. The results prove a relative growth of ICT and also of energy patents in the recent years, while machinery and also chemistry and related fields (except for inorganic chemistry) were growing below average. In sum, more leading-edge technology fields were growing above the average and high-level technology fields did not grow at the same pace. Low-tech in general also decreased.

The most interesting indicator is the intensification effect, which shows if a field in a country has increased or decreased beyond the trend and the structural effect. Values have to be seen in relation to the two other effects. However, positive values indicate a growth of the field in the country that goes beyond the trend and structural effect. Negative values indicate a relative loss of position of this country in the respective field.

Table 2 and Table 3 displays the absolute numbers in 2007, the change (Delta) between 1997 and 2007 as well as the decomposition of this Delta by the three indicators in relative terms (in percent of the base year) for the USA, Japan, Germany, and Europe. For all countries, the statement holds that the absolute number has considerably increased within the decade under observation here. In the case of the USA, the growth accounts for more than 21,000 additional applications per year, which is almost 50% more in 2007 than in 1997. However, the total growth can almost exclusively be explained by the trend effect and the structural effect, which means that the USA just tried to keep pace with the overall development. The intensification effect, on the other hand, shows a negative sign in almost all fields even in the strong area of the USA, namely life sciences. A relative weakening of their position becomes evident when looking at the intensification effects. Biotechnology, pharmaceuticals, medical instruments, and even the associated areas of chemistry show a negative sign. The ICT area has also reached high negative values.

The reason is, of course, that other countries have also increased their technological engagement – and some of them even more than the USA. One example is Japan. Japanese inventors have also more than doubled their patent output and their increase is even larger – in absolute terms – than that of the USA in this period. The main explanatory factors here are also the trend and the structural effect. In addition, the intensification effect also shows some negative signs especially in computer and communication electronics as well as broadcasting engineering. At the same time, the Japanese have been able to reinforce their strengths by increasing the patent output for example in automobiles, measurement, optics, and also in machinery to a very large and outstanding extent. Obviously, in the decade under observation here the Japanese profile underwent a considerable structural change. The Japanese reduced their relative efforts especially in computers and communication engineering, as well as broadcasting engineering. And these are exactly the fields where the new and upcoming countries, among them South Korea and China, have considerably increased their efforts which is effectively the foundation for their international success.

As mentioned in a previous section, Germany has a distinct technology profile compared to especially the USA, Japan and South Korea or China. While these latter countries mainly focus on leading-edge technologies, Germany has its strengths in high-level technologies, especially transport and machinery. In terms of total growth between 1997 and 2007, German inventors were not able to keep up with Japan or the USA, nor with the overall trend. However, the intensification effect shows that German patents decreased especially in electronics, communication engineering and computers, as well as in low-tech areas. However, what is more important to note is that Germany also lost relative grounds in automobiles and engines, while in most parts of mechanical engineering an overall balanced or positive effect is visible. In sum, Germany has been able to maintain its relative strengths in the high-level technologies or even increase them. Relative gains are also visible in biotechnology and pharmaceuticals.

Also, the EU 27 countries were not able to increase their patent output to the same extent as the overall trend. Similar to the USA, most of the intensification effects have a negative sign, especially in ICT, measurement, optics, but also in most of the mechanical engineering areas. Effectively, only aeronautics, biotechnology and pyrotechnics show positive signs, while some others are almost balanced – see some areas of chemicals or pharmaceuticals as well as some machinery fields. This means the profile has changed in the period under observation here. Even though we have treated the EU-27 as having already existed in 1997, one explanation for the structural change and the lagging behind is of course that the new member countries, especially from Eastern Europe did not weigh against the EU-15 countries, but gained some relevance since then. Another explanation is the considerable change in member countries' profiles, thereby changing the overall profile of Europe even more towards high-level technologies, with some – even though decreasing – advantages in telecommunication technologies and the like in the northern countries.

Table 2: Shift-share Analysis of Transnational Patents for USA and Japan

	USA					Japan				
	abs. 2007	Delta 1997 vs. 2007	Trend	Structure	Intensification	abs. 2007	Delta 1997 vs. 2007	Trend	Structure	Intensification
nuclear reactors	101	46	87.0%	-26.6%	23.2%	34	19	87.0%	-26.6%	66.3%
pesticides	1378	557	87.0%	-18.1%	-1.0%	309	91	87.0%	-18.1%	-27.2%
biotechnology and agents	6006	501	87.0%	-34.4%	-43.5%	1629	679	87.0%	-34.4%	18.8%
weapons	137	41	87.0%	-25.5%	-18.8%	13	7	87.0%	-25.5%	55.2%
aeronautics	528	270	87.0%	83.9%	-66.3%	106	38	87.0%	83.9%	-115.0%
computer	5977	3135	87.0%	63.2%	-39.9%	2396	1272	87.0%	63.2%	-37.1%
electronics	2204	1172	87.0%	75.2%	-48.7%	2679	1680	87.0%	75.2%	5.9%
communications eng.	5605	2142	87.0%	39.4%	-64.5%	2902	1301	87.0%	39.4%	-45.1%
electronic medical instr.	1621	952	87.0%	125.6%	-70.3%	614	498	87.0%	125.6%	216.7%
opt./electr. measurement	2263	737	87.0%	33.8%	-72.5%	2363	1542	87.0%	33.8%	67.0%
optics	889	350	87.0%	28.9%	-51.0%	1232	806	87.0%	28.9%	73.3%
dyes and pigments	520	103	87.0%	-16.3%	-46.0%	698	391	87.0%	-16.3%	56.7%
inorganic basic materials	578	179	87.0%	62.2%	-104.3%	906	657	87.0%	62.2%	114.6%
organic basic materials	1996	42	87.0%	-40.3%	-44.5%	809	192	87.0%	-40.3%	-15.5%
polymers	1471	-8	87.0%	-42.9%	-44.6%	1569	738	87.0%	-42.9%	44.8%
pharmaceuticals	3086	738	87.0%	-9.6%	-45.9%	980	407	87.0%	-9.6%	-6.3%
Scents and polish	270	-137	87.0%	-98.9%	-21.7%	125	28	87.0%	-98.9%	40.8%
pyrotechnics	17	-20	87.0%	-127.0%	-14.1%	3	-5	87.0%	-127.0%	-22.5%
photo chemicals	25	-144	87.0%	-167.8%	-4.4%	14	-74	87.0%	-167.8%	-3.3%
other special chemistry	1539	-30	87.0%	-39.6%	-49.3%	931	455	87.0%	-39.6%	48.2%
rubber goods	169	43	87.0%	23.7%	-76.5%	332	218	87.0%	23.7%	80.6%
power machines	1205	484	87.0%	38.7%	-58.6%	1639	1012	87.0%	38.7%	35.8%
air conditioning and filter	991	269	87.0%	-9.0%	-40.7%	730	487	87.0%	-9.0%	122.4%
agricultural machinery	147	41	87.0%	-63.1%	14.8%	28	-1	87.0%	-63.1%	-27.4%
machine tools	766	175	87.0%	-25.8%	-31.6%	886	436	87.0%	-25.8%	35.7%
special purpose machinery	1321	120	87.0%	-33.7%	-43.3%	1112	553	87.0%	-33.7%	45.7%
office machinery	134	-101	87.0%	-82.3%	-47.7%	311	52	87.0%	-82.3%	15.4%
power generation	541	258	87.0%	44.7%	-40.5%	846	561	87.0%	44.7%	65.2%
lamps, batteries etc.	1027	406	87.0%	78.0%	-99.6%	1947	1202	87.0%	78.0%	-3.7%
broadcasting engineering	1455	224	87.0%	-13.7%	-55.1%	2168	545	87.0%	-13.7%	-39.7%
automobiles and engines	1173	247	87.0%	10.7%	-71.1%	2384	1681	87.0%	10.7%	141.5%
rail vehicles	40	16	87.0%	-42.7%	22.3%	28	13	87.0%	-42.7%	42.3%
medical instruments	2953	1369	87.0%	27.5%	-28.0%	693	517	87.0%	27.5%	179.3%
mechanical measurement	705	297	87.0%	-0.9%	-13.3%	372	194	87.0%	-0.9%	22.9%
optical devices	131	-10	87.0%	-13.6%	-80.5%	263	139	87.0%	-13.6%	38.7%
low tech	18144	7133	87.0%	-11.7%	-10.6%	8122	3337	87.0%	-11.7%	-5.6%
Total patent applications	67112	21596				42171	21667			

Source: EPO: PATSTAT; Fraunhofer ISI calculations.

Table 3: Shift-share Analysis of Transnational Patents for Germany and EU-27

	Germany					EU-27				
	abs. 2007	Delta 1997 vs. 2007	Trend	Structure	Intensification	abs. 2007	Delta 1997 vs. 2007	Trend	Structure	Intensification
nuclear reactors	21	-17	87.0%	-26.6%	-105.1%	78	-4	87.0%	-26.6%	-65.3%
pesticides	498	181	87.0%	-18.1%	-11.8%	1017	321	87.0%	-18.1%	-22.8%
biotechnology and agents	1764	846	87.0%	-34.4%	39.4%	5511	2180	87.0%	-34.4%	12.8%
weapons	116	45	87.0%	-25.5%	1.9%	252	98	87.0%	-25.5%	2.1%
aeronautics	341	249	87.0%	83.9%	99.7%	959	685	87.0%	83.9%	79.1%
computer	1064	510	87.0%	63.2%	-58.3%	3484	1879	87.0%	63.2%	-33.2%
electronics	645	240	87.0%	75.2%	-103.0%	1427	633	87.0%	75.2%	-82.5%
communications eng.	1835	574	87.0%	39.4%	-80.9%	6419	2606	87.0%	39.4%	-58.0%
electronic medical instr.	474	336	87.0%	125.6%	30.9%	1294	873	87.0%	125.6%	-5.2%
opt./electr. measurement	1278	576	87.0%	33.8%	-38.7%	3045	1407	87.0%	33.8%	-34.9%
optics	342	119	87.0%	28.9%	-62.5%	823	276	87.0%	28.9%	-65.4%
dyes and pigments	462	140	87.0%	-16.3%	-27.2%	868	269	87.0%	-16.3%	-25.8%
inorganic basic materials	373	223	87.0%	62.2%	-0.5%	829	455	87.0%	62.2%	-27.6%
organic basic materials	881	244	87.0%	-40.3%	-8.4%	2340	828	87.0%	-40.3%	8.1%
polymers	948	186	87.0%	-42.9%	-19.6%	2017	453	87.0%	-42.9%	-15.1%
pharmaceuticals	1048	543	87.0%	-9.6%	30.0%	3262	1459	87.0%	-9.6%	3.5%
Scents and polish	226	29	87.0%	-98.9%	26.6%	455	-126	87.0%	-98.9%	-9.8%
pyrotechnics	3	-7	87.0%	-127.0%	-30.0%	24	-6	87.0%	-127.0%	20.0%
photo chemicals	3	-13	87.0%	-167.8%	-0.4%	15	-90	87.0%	-167.8%	-4.9%
other special chemistry	817	254	87.0%	-39.6%	-2.3%	1999	595	87.0%	-39.6%	-5.0%
rubber goods	144	80	87.0%	23.7%	14.3%	382	187	87.0%	23.7%	-14.8%
power machines	1970	1167	87.0%	38.7%	19.5%	3378	1884	87.0%	38.7%	0.4%
air conditioning and filter	662	220	87.0%	-9.0%	-28.2%	1584	584	87.0%	-9.0%	-19.6%
agricultural machinery	186	34	87.0%	-63.1%	-1.6%	374	48	87.0%	-63.1%	-9.2%
machine tools	1152	422	87.0%	-25.8%	-3.4%	2059	681	87.0%	-25.8%	-11.7%
special purpose machinery	1733	670	87.0%	-33.7%	9.8%	3724	1190	87.0%	-33.7%	-6.3%
office machinery	62	-12	87.0%	-82.3%	-20.9%	145	-29	87.0%	-82.3%	-21.4%
power generation	653	268	87.0%	44.7%	-62.1%	1257	528	87.0%	44.7%	-59.2%
lamps, batteries etc.	1135	630	87.0%	78.0%	-40.2%	2179	1255	87.0%	78.0%	-29.2%
broadcasting engineering	385	82	87.0%	-13.7%	-46.2%	1369	390	87.0%	-13.7%	-33.4%
automobiles and engines	2774	1102	87.0%	10.7%	-31.9%	4772	2004	87.0%	10.7%	-25.3%
rail vehicles	90	5	87.0%	-42.7%	-38.5%	184	31	87.0%	-42.7%	-24.1%
medical instruments	859	402	87.0%	27.5%	-26.5%	2387	1142	87.0%	27.5%	-22.7%
mechanical measurement	632	231	87.0%	-0.9%	-28.5%	1331	546	87.0%	-0.9%	-16.5%
optical devices	37	11	87.0%	-13.6%	-31.1%	117	21	87.0%	-13.6%	-51.5%
low tech	11600	3811	87.0%	-11.7%	-26.4%	28501	9764	87.0%	-11.7%	-23.2%
Total patent applications	37212	14378	37212			89859	35017			

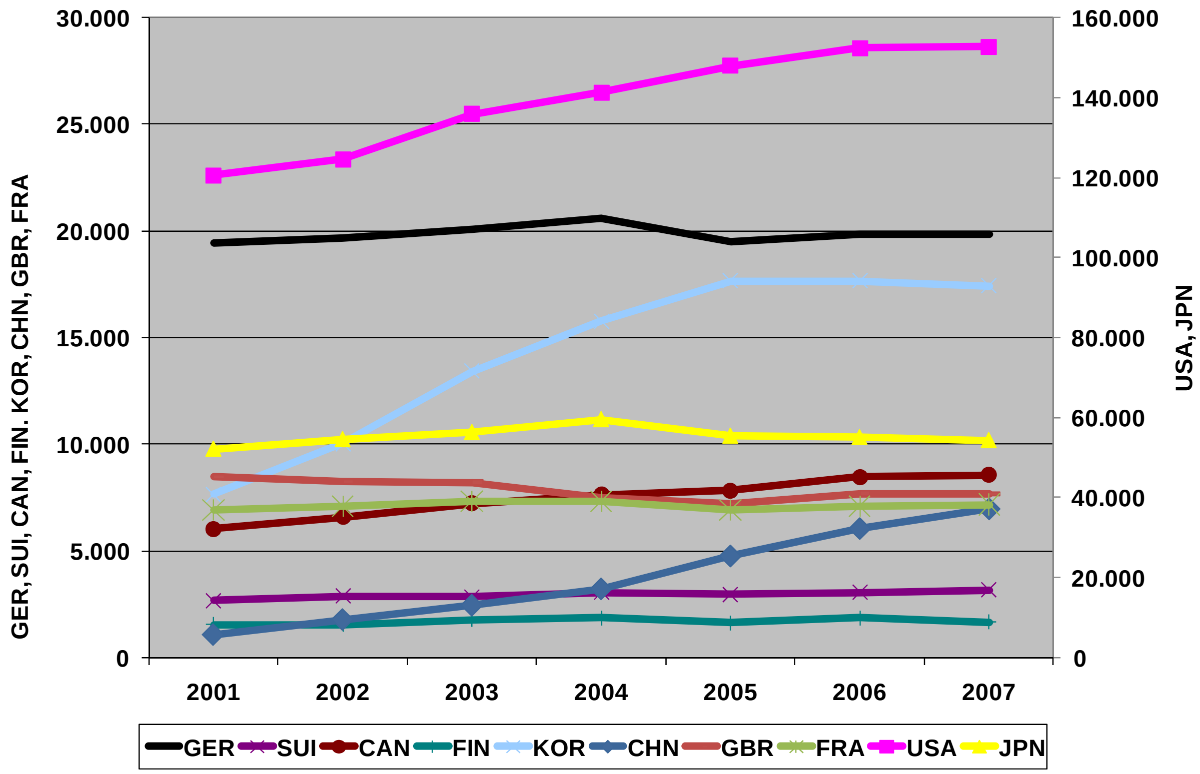
Source: EPO: PATSTAT; Fraunhofer ISI calculations.

5. Patent Applications Filed at the USPTO – Pre-grant Publications

As discussed in the methodological introduction to this report, the USA is the most important national market for technologies in the world. Many companies and therefore many countries have a very strict focus on or at least a strong orientation to this market. This justifies an additional and supplementary analysis of the patent applications to the USPTO.

Figure 7 displays the absolute number of pre-grant patent applications to the USPTO between 2001 and 2007. The USA is far ahead in absolute terms, which is – of course – to be explained by the home advantage and the strong orientation to the national market. Japan ranks second, filing about 55,000 applications per year, followed by Germany that reaches some 20,000. To recall the data based on transnational patents: the ranking was the same, but Germany and Japan filed almost the same absolute numbers. The reason is the stronger focus of the Japanese companies on the US market, while the majority of German companies focus on Europe and the national markets within Europe.

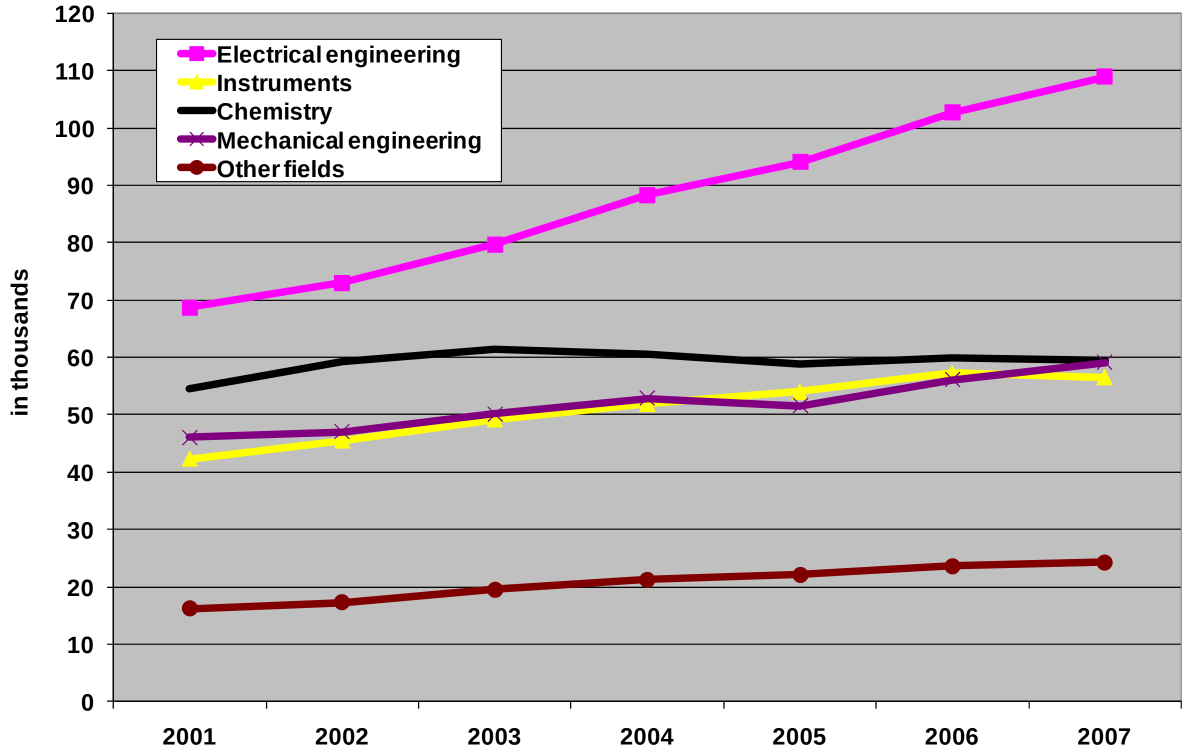
Figure 7: Patent Applications (Pre-grant Publications) at the USPTO, 2001-2007



Source: Questel (USAPPS, WOPATENT); Fraunhofer ISI calculations, update October 2009.

It is interesting to note that the totals of most countries are rather similar over the years under observation here. The USA shows an increasing trend that is stagnating in 2007. As discussed above, this may already be a first effect of the recession in 2008. It is also worth mentioning the Korean curve that has been at a stable level since 2005. This could be a first indication of a kind of "ceiling effect", meaning that the growth due to a shift towards international technology markets has come to an end and the Korean figures now better reflect the "real" technological capabilities. In other words: the data may indicate the end of the transition from an emerging to an industrialised country and South Korea has now finally arrived in the group of technology-oriented nations. This is not yet visible in the case of China, where still enormous growth rates – also at the USPTO – can be found. The transition of Chinese companies towards international and technology-driven markets is still underway.

Figure 8: Patent Applications (Pre-grant Publications) at the USPTO by Technological Areas, 2001-2007



Source: Questel (USAPPS, WOPATENT); Fraunhofer ISI calculations, update October 2009.

The overall increasing trend of USTPO filings is almost exclusively driven by the enormous increase of applications in the area of electrical engineering, which includes information and communication technologies (Figure 8). About 1/3 of all applications at the USPTO are filed in this technological area. This is almost twice the numbers in each of the fields instruments, chemistry, and mechanical engineering. This underlines the statement made above that especially the ICT-driven countries have a strong orientation towards the US market.

Table 4 displays the patent counts for Germany as well as the shares in relation to the total number of filings at the USPTO by technological area. In absolute terms, mechanical engineering as well as chemistry account for the majority of German patents, though electrical engineering and instruments are close behind. The shares of German patents are decreasing steadily and this not only in the field of electrical engineering that was identified as the main driver of the growth at the USPTO. These are also the main areas of the USA, the Scandinavian countries Finland and Sweden, for example, as well as the catching-up countries China and Korea. Both in mechanical engineering and in chemistry a decrease of the German shares by 2 percentage points had to be accepted.

Table 4: Absolute Numbers and Shares of German Applications at the USPTO

	Electrical Engineering	Instruments	Chemistry	Mechanical engineering	Other fields
	absolute				
2001	3,744	3,262	5,777	5,507	755
2002	3,818	3,316	5,768	5,521	851
2003	3,983	3,366	5,576	5,733	959
2004	4,416	3,442	5,413	6,016	1,084
2005	4,279	3,444	5,253	5,412	998
2006	4,287	3,633	5,181	5,843	1,040
2007	4,389	3,594	5,148	5,849	1,064
	In percent of total filings				
2001	5.4%	7.7%	10.6%	11.9%	4.7%
2002	5.2%	7.3%	9.7%	11.8%	4.9%
2003	5.0%	6.8%	9.1%	11.4%	4.9%
2004	5.0%	6.6%	8.9%	11.4%	5.1%
2005	4.5%	6.4%	8.9%	10.5%	4.5%
2006	4.2%	6.3%	8.6%	10.4%	4.4%
2007	4.0%	6.4%	8.7%	9.9%	4.4%

Source: Questel (USAPPS, WOPATENT); Fraunhofer ISI calculations, update October 2009.

6. University Patents

In the late 1990s patent applications as a mode of knowledge transfer from universities were intensively discussed in Germany. The background of this debate is the assumption that the effective application of results of university research can only be achieved if the partnering enterprise gets an exclusive property right. The benchmark for this is the impressive success of US American universities after the introduction of the so-called Bayh-Dole Act in the year 1980 which led to a substantial license income.[2] The specific feature of the American situation is that the universities appear as patent applicants and thus are owners of the patents.

When the law of employee inventions (*Arbeitnehmer-Erfindungsgesetz*) was enacted in 1957 in Germany, the number of patent applications of universities was negligible, so that no need was seen to introduce a specific ruling. In an enterprise, an employee must inform his employer about his or her invention and then the enterprise can use it if interested and must apply for a patent. In contrast, university professors and research staff were allowed to freely dispose of their inventions, even if they were generated in the framework of research at the university. In the 1990s, however, the number of patent applications of universities achieved a considerable level, so that it was necessary to explicitly deal with this phenomenon. Therefore in January 2002, the law of employee inventions was changed and the so-called professors' privilege was abolished. Now professors and the research staff at universities have to inform the employer, in this case the university, about their inventions – comparable to all other employees. Then the university can decide whether it is interested in the invention or it allows the inventor to freely dispose of it. The relevant arguments for and against the abolition of the professors' privilege are documented in Schmoch (2000).

An important precondition for the active rule of universities in exploitating patents was the building of an appropriate infrastructure, competent to undertake the related business. This refers in particular to

- the first advice for university inventors as to the legal approbation of their results,
- support in the patent applicant procedure,
- financial support of patent applications,
- identification of license partners as well as
- the regular contact to the license partner in order to insure the factual commercial exploitation" (Schmoch 2000: 97)

Thus the relevant duty of the patent and license offices is to advise the professors and research staff in the patent application process, the search for license partners as well as drawing up of license contracts, so that the professors can adequately focus on their central duties in teaching and research. In order to support the universities with regard to the application exploitation of patents, 21 patent and license offices (*Patent- und Verwertungsagenturen*, PVA) were established - in general one PVA per federal state, in some cases several PVAs. The PVAs

2 Compare Abramson et. al. (1997: 19f).

were evaluated in the years 2003 and 2006 by the Kienbaum Management Consultants GmbH.[3]

The assessment of Kienbaum focuses first of all on the quality of the work of the single PVAs, whereby the general effect of the change of the law of employees on patent applications at universities was not discussed. For this reason, the effects were analysed in more details in Schmoch (2007) with the major result, that since the year 2000 the number of patent applications of universities is steadily decreasing. However, the most recent application year for that analysis was 2005. Therefore, the present analysis intends to verify whether this general negative trend continued.

6.1 Methodology

The patent applications of universities can be subdivided into three different types of applicants:

- universities or universities of applied sciences (*Fachhochschulen*)
- private persons, in particular university professors
- enterprises.

While it is relatively easy to identify patent applications with universities or universities of applied sciences (UAS) as applicants, the search for the other types is more difficult. In the database PATDPA of the host STN used for the search, the possibility exist, however, to search the title "professor" in the inventor or applicant names. The title "Professor" is usually used in legal documents like patent applications.

The case of private persons applying can happen, if the university is not interested in exploiting an application and allows the professor to freely dispose of the invention. If the university professor applies for a patent himself, he or she appears as applicant and normally in parallel as inventor, so that the application can be identified by database search. The other possibility is that the university professor ignores the existing law and privately applies for a patent without involving the university.

In the case of an enterprise as applicant, the university as origin of an invention can only be identified by the title "professor" of an inventor. This can happen if a university claims the use of the invention, but directly transfers it to an enterprise. According to information from staff of PVAs, many universities use this possibility to avoid the costs of the application process. But also in this case, many university professors directly transfer their rights to an enterprise without informing their university. In some cases, university professors established their own enterprise and used the inventions in the name of this enterprise. Finally, about 10% of the applications of enterprises with professors as inventors refer to cases where the professor does not work at a university full time, but is an employee of the enterprise applying. For instance, various employees of chemical enterprises are so called "honorary professors" at a university

3 Further details can be found on the website www.technologieallianz.de.

(Becher et al. 1996: 28). Although these inventors have a close relation to their university and obtain various ideas through their activity at the university, these inventions belong to the enterprise.

By the search for the title "professor" it is possible to identify applications of private persons and enterprises where university professors appear as inventors or applicants, in addition to applications of universities themselves. The analysis of the patent applications by the universities shows, however, that for about half of these inventions no inventor has a title "professor". Thus the lion's share of inventions of universities comes from university researchers without the title "professor" and cannot be related to the university in a simple way.[4]

It can be assumed that in the case of private persons and enterprises as patent applicants the share of university researches without the title "professor" is substantial. For the present analysis, we conservatively assumed that the share of non-professors in these two groups amounts to 40%.

The necessary searches were conducted in the database PATDPA for the period of 1992 to 2007 whereby the year of the first application, the so-called priority year, was used as reference. Due to the legal delay of 18 months between first application and first publication (*Offenlegung*) only the data for the priority year 2007 were completely available at the time of search in September 2009. First of all, applications at the German Patent and Trademark Office (DPMA) were considered, i.e. only domestic applications. But in some cases German applicants apply for their patents not at the DPMA, but immediately at the European Patent Office (EPO) or as international application, the so called PCT application (PCT = Patent Cooperation).[5]

For the search in patent databases, only those patent applications can be identified which are actually published after the delay of 18 months. In principle, all applicants have the opportunity to withdraw their application within the first 18 months, if a limited patentability or insufficient market opportunities become apparent. By withdrawing the application, the applicant can avoid that competitors are informed about inventive activities of the enterprise. The withdrawal share at the DPMA is considerable and amounts to about 20%. This withdrawal share was not introduced in the analysis, thus only the published applications are considered.

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4 In a more complex approach it is possible to refer to inventor and author names in patent and publications databases to establish linkages to specific universities. Fraunhofer ISI has realized this approach in cooperation with the university Leiden for two limited fields (Noyons et al. 2003). Fraunhofer ISI plans to use this broader approach next year for German and European university-based inventors. A first check by linking patent data with the database VADEMCUM – the listing of German university staff – was done by Schleinkofer (2008).

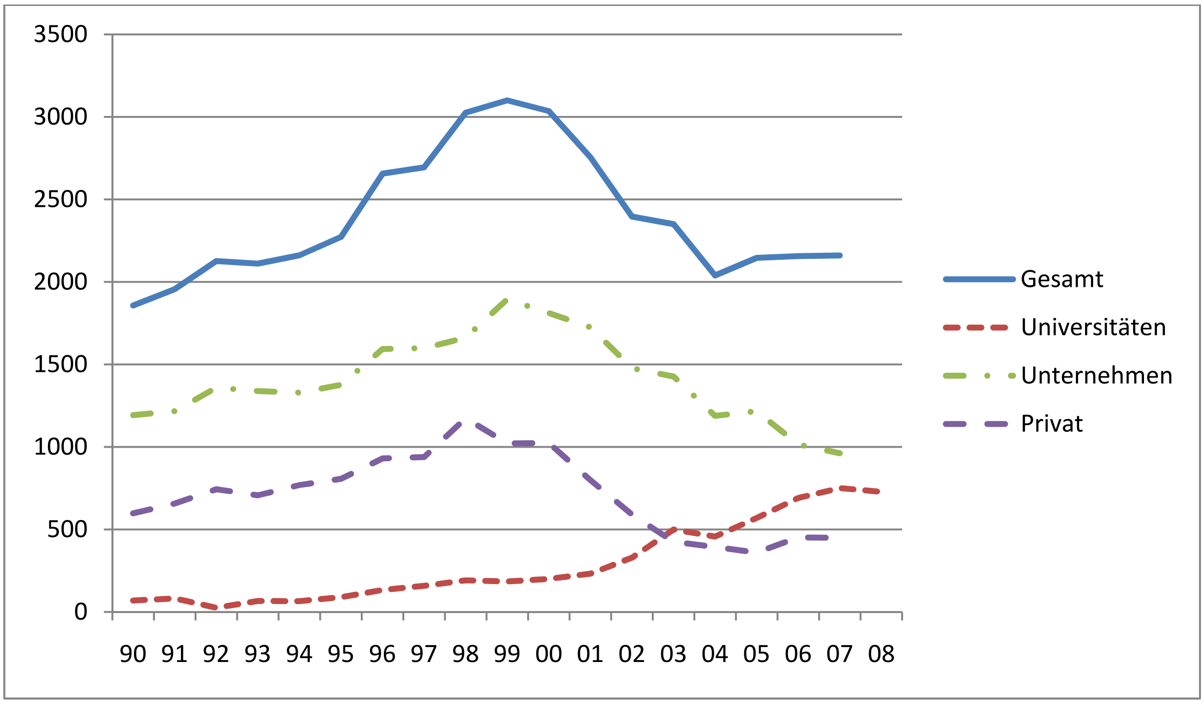
5 As to the advantages of the PCT application, cf. Schmoch (1999)

6.2 Total Numbers of Patent Applications of Universities

The search for patent applications of German universities shows a steadily increasing number of annual applications between 1990 and 1999 with the maximum of about 3,100 applications (Figure 9). As explained above, this estimate is quite conservative and does not include the applications withdrawn before publication. After the year 2000, the number of applications of universities substantially decreases, thus even before the change of the law of employee inventors. Since 2005 the number of applications has stabilized, but at a distinctively lower level than in 1999.

Broken down by type of applicant, the number of applications with universities as applicants considerably increased since 2002. However, the data for 2008 seem to indicate that also here an upper level was reached.[6] After the change of the patent inventor law, such an increase of the patent applications with universities as applicants was to be expected. The number of patent applications should not be taken as direct success criterion for the work of the PVAs. In an economic perspective, it is also important that the incoming declarations of inventions have to be examined critically with regard to their economic exploitability. Thus it can happen that technologically demanding inventions prove to be economically less relevant, for instance, in the case of measuring instruments for very special applications. Therefore a careful examination of the invention declarations, implying a low share of an official claim of inventions by the university, can be a success criterion.

Figure 9: Patent Applications of German Universities at the DPMA by Different Types of Applicants



Sources: PATDPA, searches and calculations by Fraunhofer ISI.

6 The applications with universities as applicants for 2008 were taken from the annual report of the DPMA for 2008.

In parallel to the increase of applications by universities, those by private persons steadily decrease with the trend starting already in the year 1999 as a kind of anticipation of the change of the law. However, the number of inventions of private persons decreases more strongly than the increase of applications by universities. This observation supports the thesis that the abolition of the professors' privilege blocks various professors in their inventive activities. For they receive a high share of the license income according to the new rules, but not the total license fees. According to the assessment of these professors, the support from the PVAs cannot outweigh the loss of income. An important aspect is also that the PVAs assess the declared inventions not only with respect to patentability, but also with regard to their economic potential. This may imply a reduced private engagement of the professors in patent applications, which in view of the financial and time investment involved in a patent application can be assessed positively. In any case, a stabilization of the inventions by private persons can be observed since 2004, although at a much lower level than in 1998.

Furthermore, a substantial decrease of applications by enterprises can be observed, which continued also in recent years. It may be that potential licenses are deterred by too high license claims or that they consider the new legal ruling as too bureaucratic and inflexible. Further clarification is needed on what effects imply such a dramatic decrease of patent applications by enterprises.

As to the shares of the different applicant types within the applications of universities as a whole, applications by universities steadily increased and reached a level of 35% in 2007. This means that still 65% of the applications are filed either by enterprises or by individual applicants, in detail 45% by enterprises and 20% by private persons. It can be assumed that a high share of the applications by enterprises was directly transferred from the PVAs to the enterprises in order to reduce the costs of the application procedure. But even then about 45% of all applications of universities are "illegally" filed by enterprises for private persons without official declaration at the universities. This share seems to be quite high, but an analysis of Lissoni et al. (2008) for France, Italy and Sweden revealed similar structures in these countries.

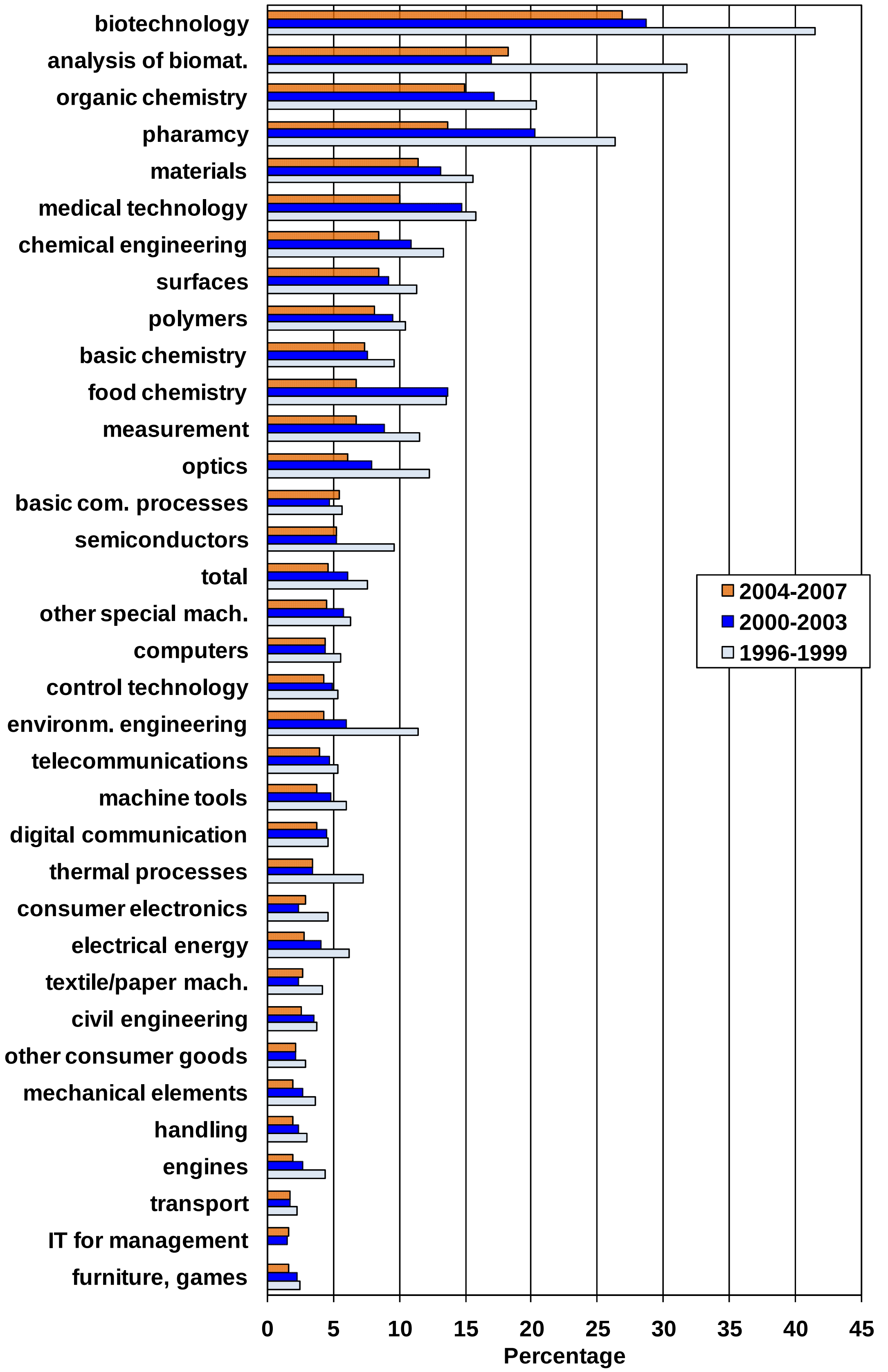
In addition to the change in the law, a further factor explaining the decrease of patent applications of universities, at least partly, is the intense political discourse of the 1990s where the positive effects of university patents were emphasised. The increase of the applications in this period can be largely explained by this discussion. In this context, many universities and their staff made the experience that a patent application is not sufficient to generate license income, and that it is very difficult to find appropriate license partners. In consequence, many professors misspent a lot of time and money. The attitude of the university staff regarding patents became more realistic and unemotional. So the present level of university applications may reflect a realistic level.

6.3 Technical Orientation of Patent Applications of Universities

Compared to all patent applications of German origin at the DPMA, the share of university patents – including all types of applicants – is 4.6% in the period of 2004 to 2007. In the former periods 2000 to 2003 and 1996 to 1999 it was distinctively higher, at 6.1%, respectively 7.5%. This reduction is due to the general decrease of patent applications of universities. It is interesting to analyse which level is achieved in different technology fields. For this purpose, a field classification of the World Intellectual Property Office (WIPO 2009) is used which covers all technology areas of the International Patent Classification and thus all patent applications.

According to this scrutiny, the share of university applications within all German applications is clearly higher in technological fields with a distinct orientation to science. The highest share can be observed in biotechnology where in the period of 2004 to 2007 more than one quarter of all German patent applications come from universities (Figure 10). Other fields with high application activities by universities are "analysis of biomaterials", "organic chemistry", "pharmacy", "materials", "medical technology", "chemical engineering", "surfaces", "polymers" and "basic chemistry". In contrast, the share of university applications in fields with low reference to science such as "furniture, games", "transport" or "handling", the share of universities within all German applications is quite low at about 2%. Thus universities are primarily active in technological fields with close relation to science and in these fields their contribution to technological innovation is substantive.

Figure 10: Share of University Patent Applications within All Applications at the DPMA by Technology Fields



Sources: PATDPA, searches and calculations by Fraunhofer ISI.

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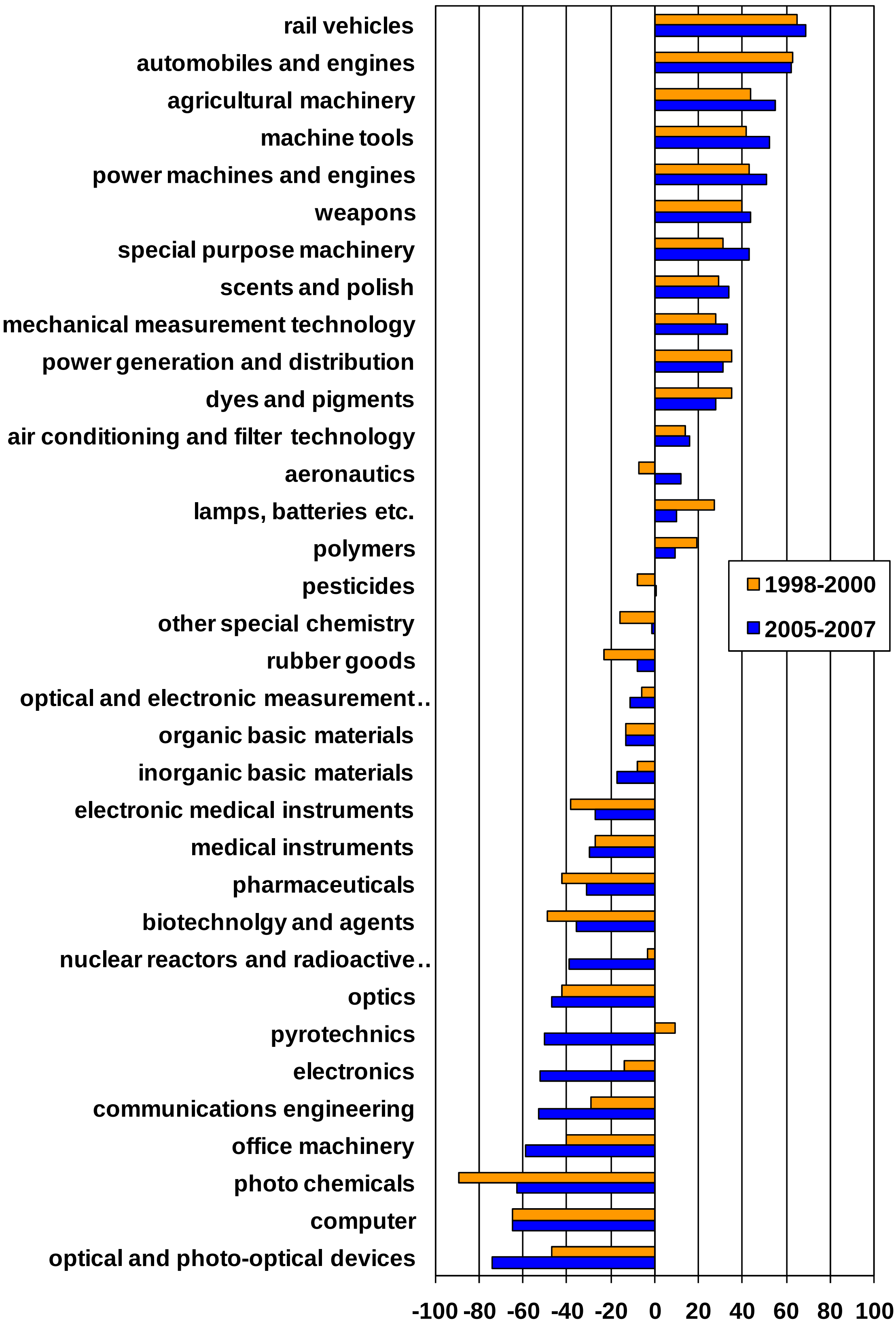
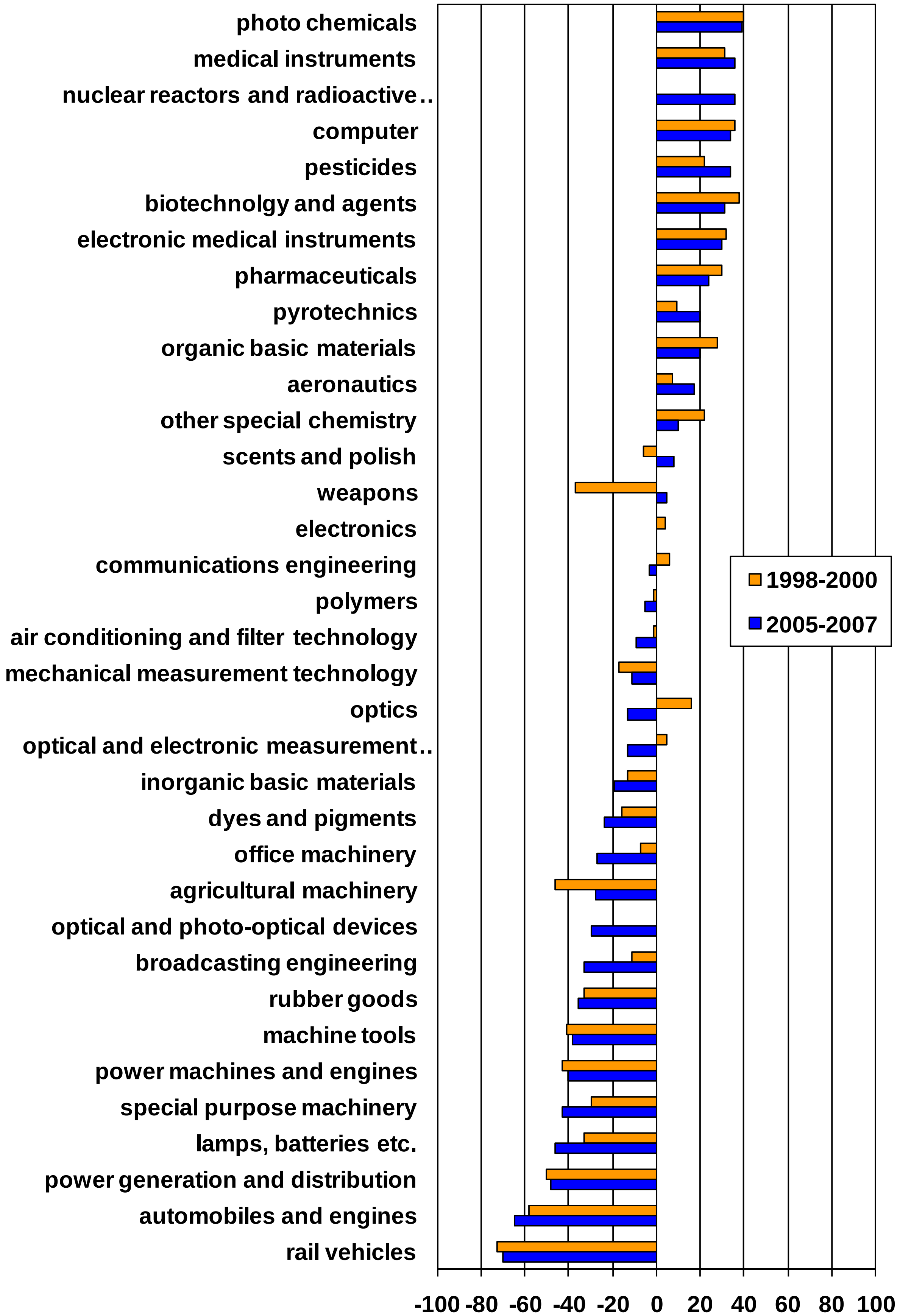
8. Annex

Figure A1: Patent Specialisation of Germany, 1998-2000 and 2005-2007



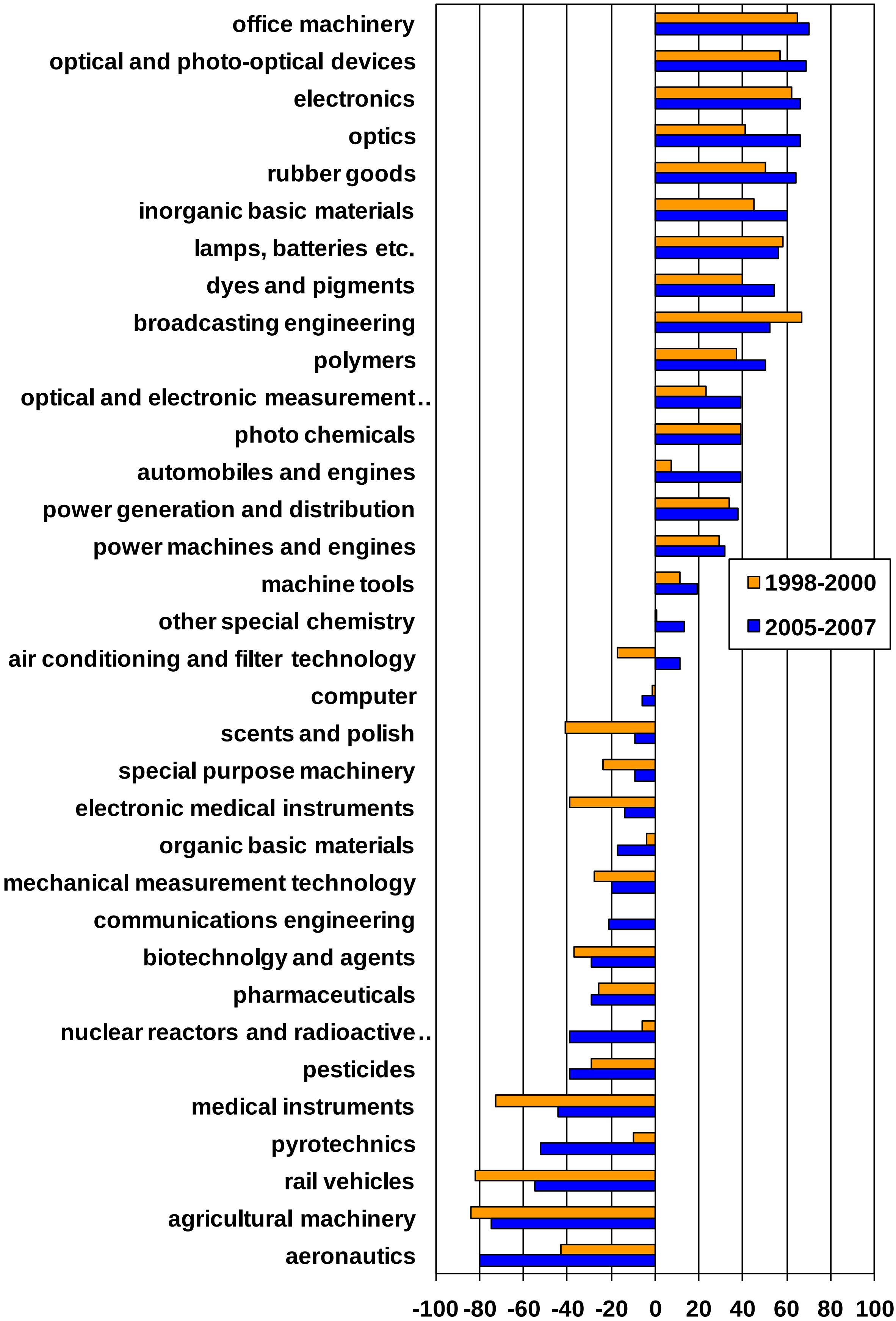
Source: Questel (EPPATENT, WOPATENT); Fraunhofer ISI calculations, update October 2009.

Figure A2: Patent Specialisation of the USA, 1998-2000 and 2005-2007



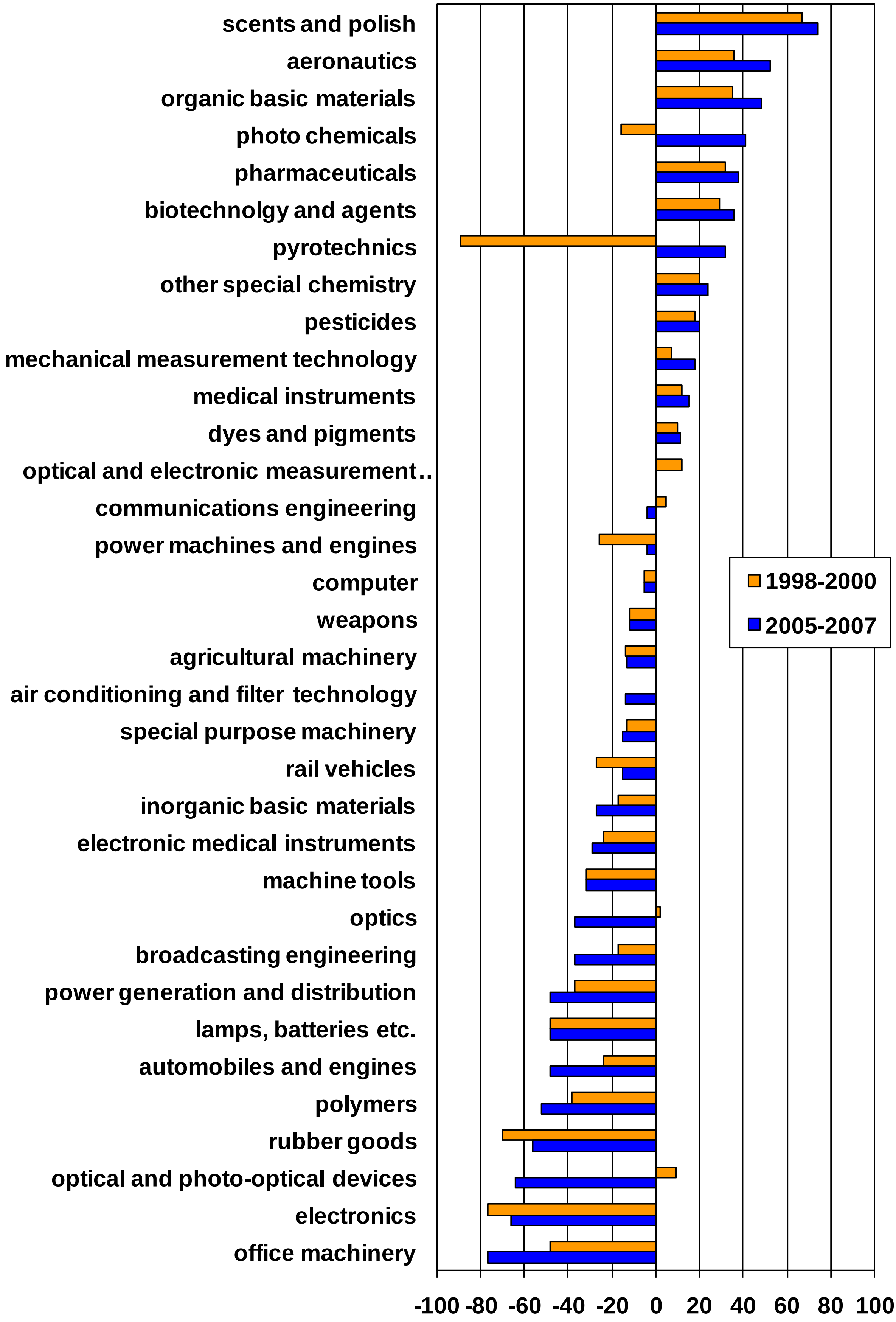
Source: Questel (EPPATENT, WOPATENT); Fraunhofer ISI calculations, update October 2009.

Figure A3: Patent Specialisation of Japan, 1998-2000 and 2005-2007



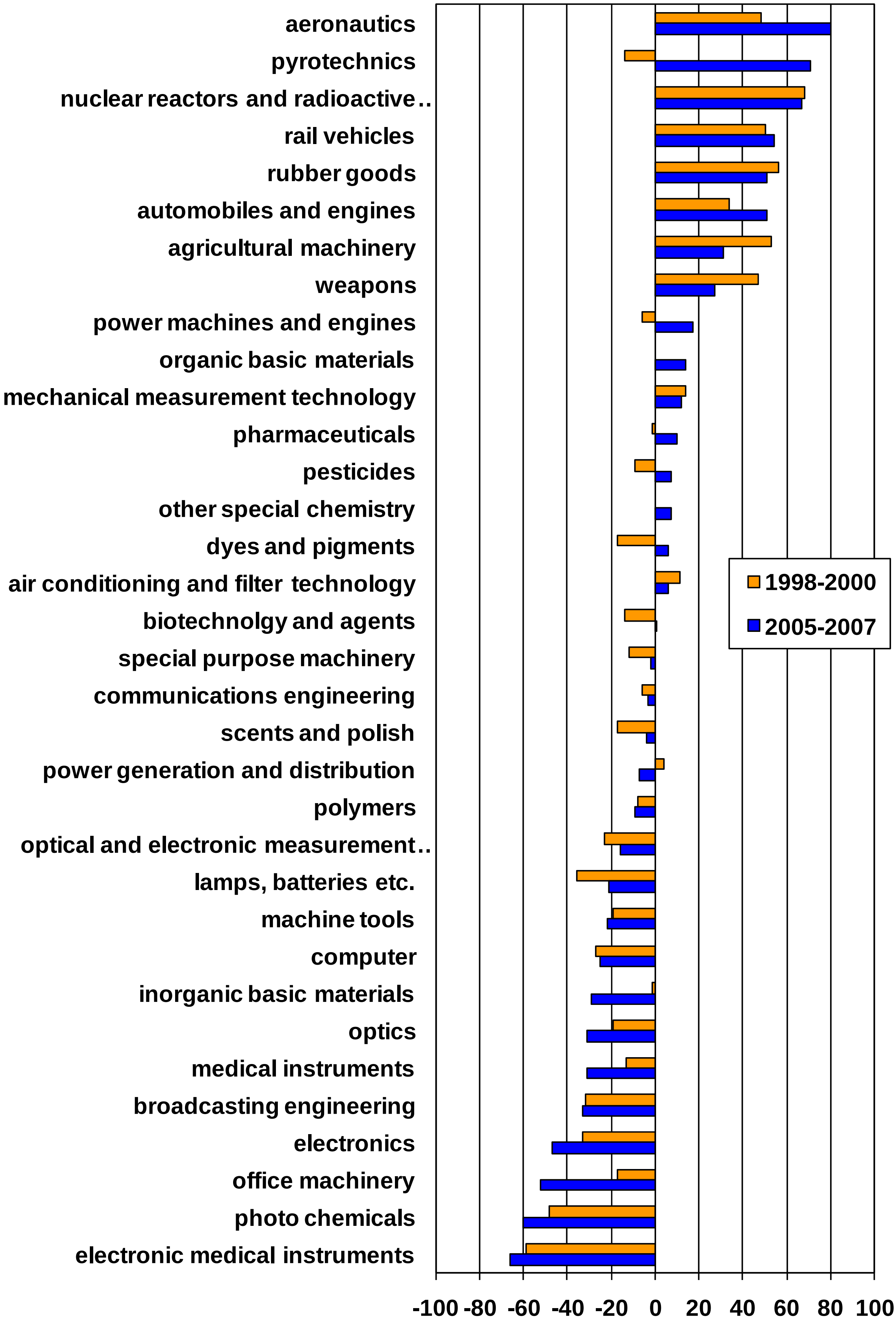
Source: Questel (EPPATENT, WOPATENT); Fraunhofer ISI calculations, update October 2009.

Figure A4: Patent Specialisation of Great Britain, 1998-2000 and 2005-2007



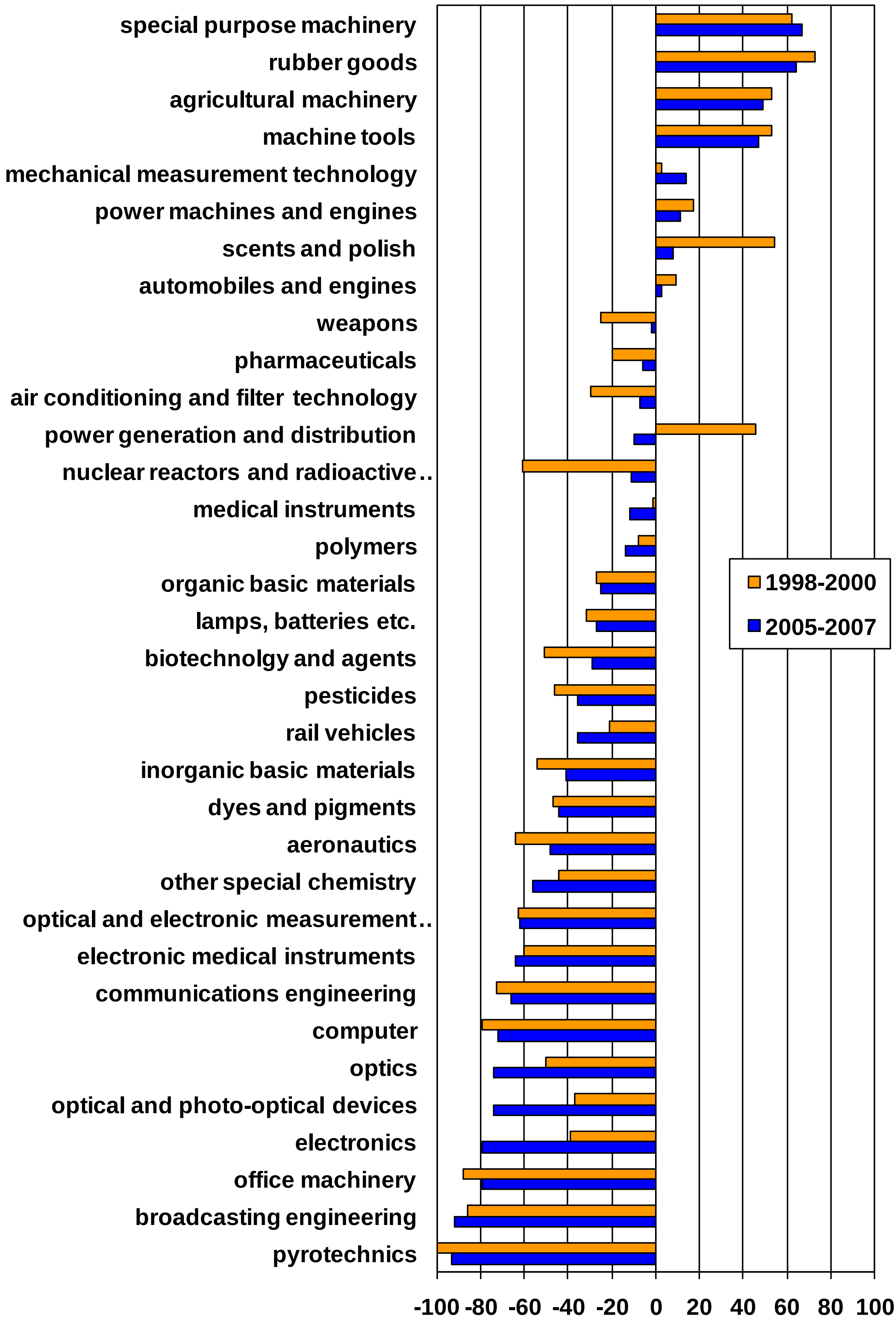
Source: Questel (EPPATENT, WOPATENT); Fraunhofer ISI calculations, update October 2009.

Figure A5: Patent Specialisation of France, 1998-2000 and 2005-2007



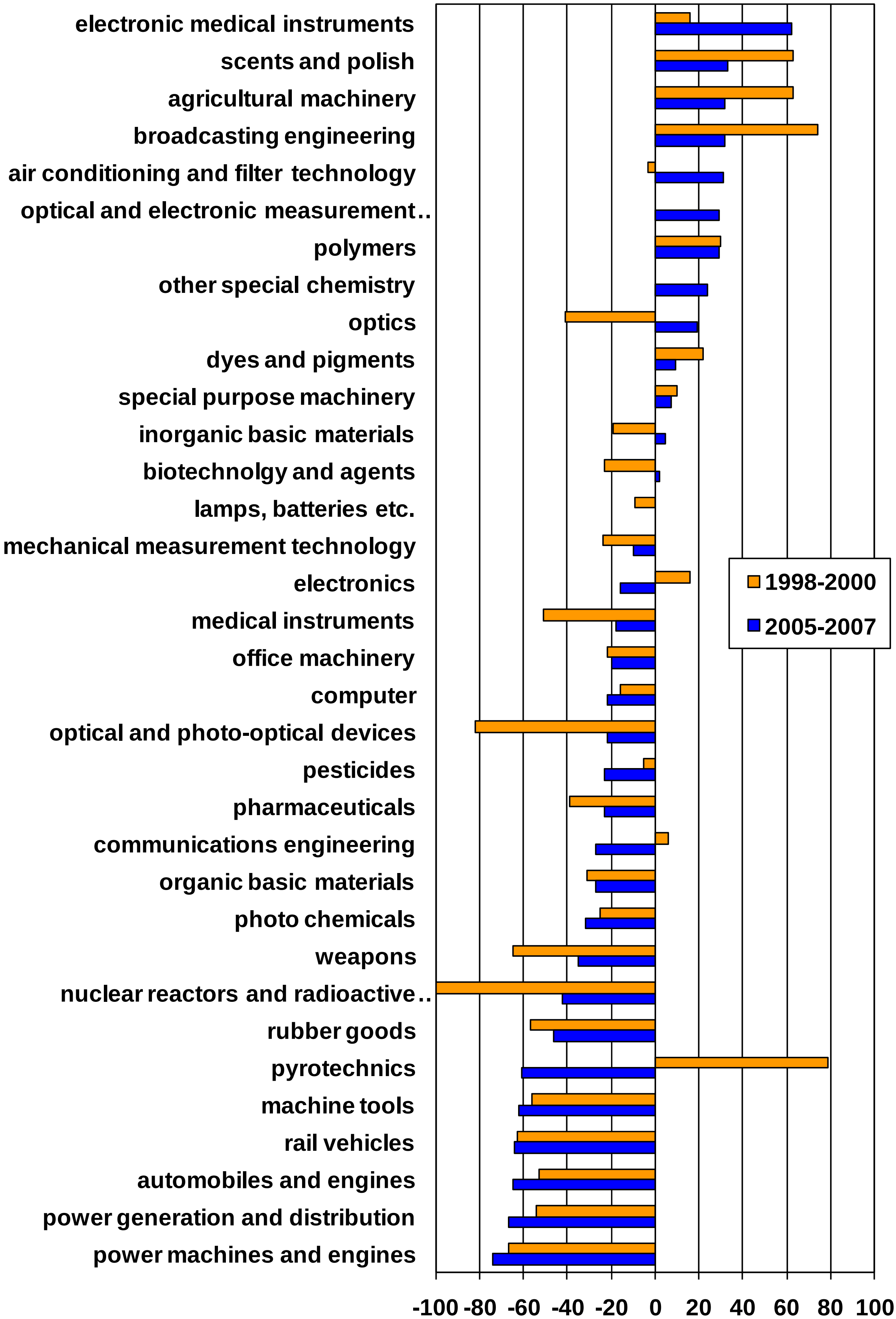
Source: Questel (EPPATENT, WOPATENT); Fraunhofer ISI calculations, update October 2009.

Figure A6: Patent Specialisation of Italy, 1998-2000 and 2005-2007



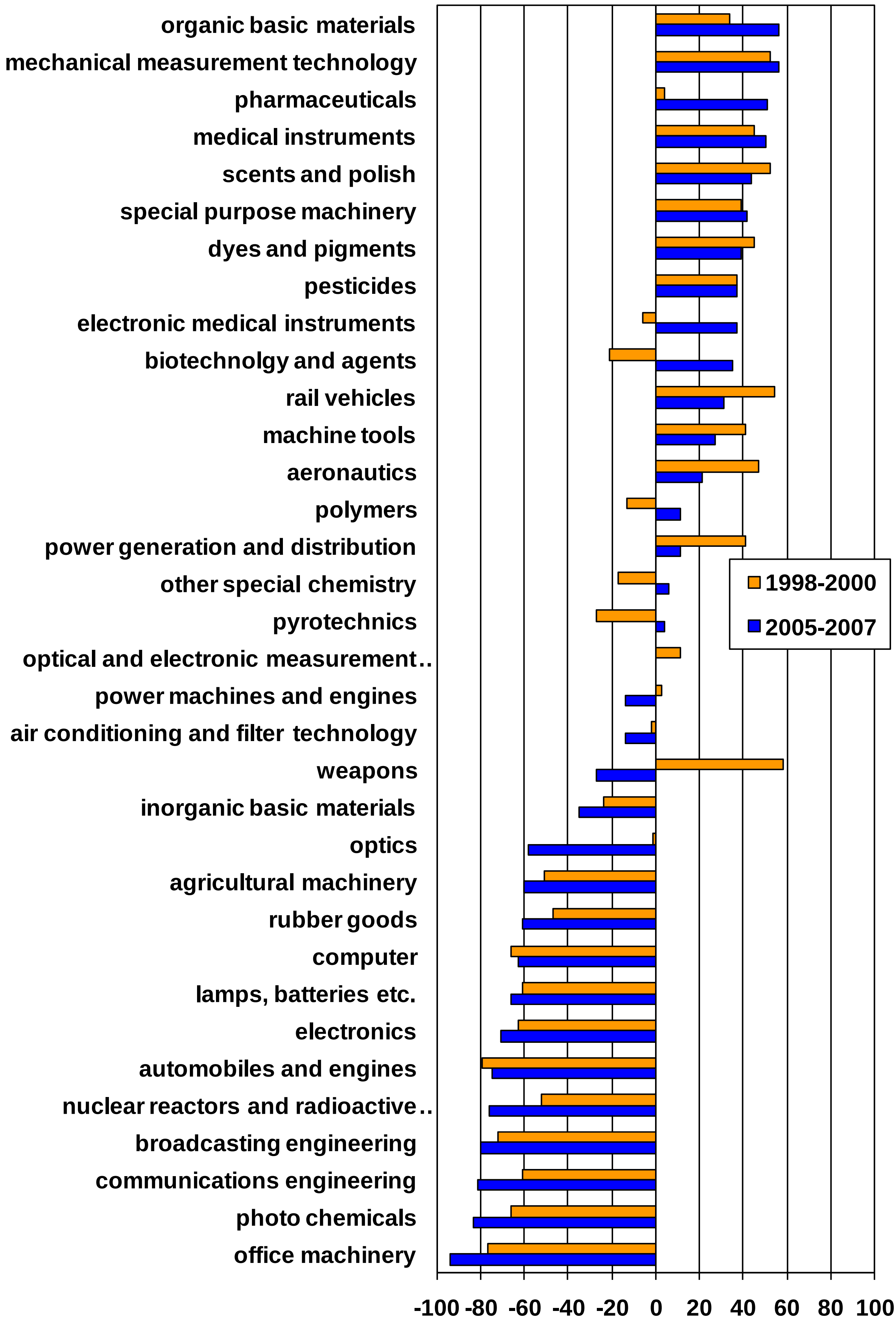
Source: Questel (EPPATENT, WOPATENT); Fraunhofer ISI calculations, update October 2009.

Figure A7: Patent Specialisation of the Netherlands, 1998-2000 and 2005-2007



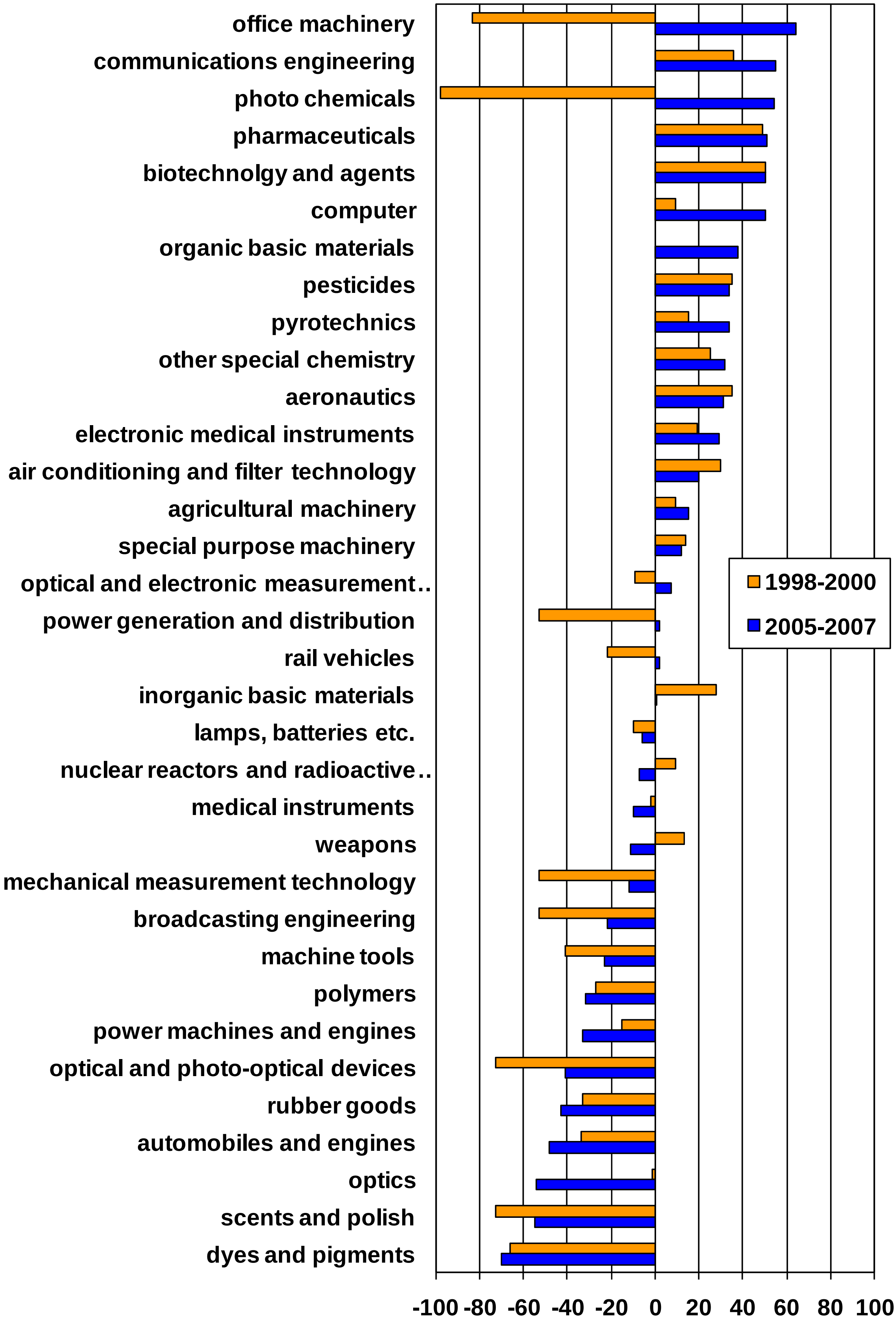
Source: Questel (EPPATENT, WOPATENT); Fraunhofer ISI calculations, update October 2009.

Figure A8: Patent Specialisation of Switzerland, 1998-2000 and 2005-2007



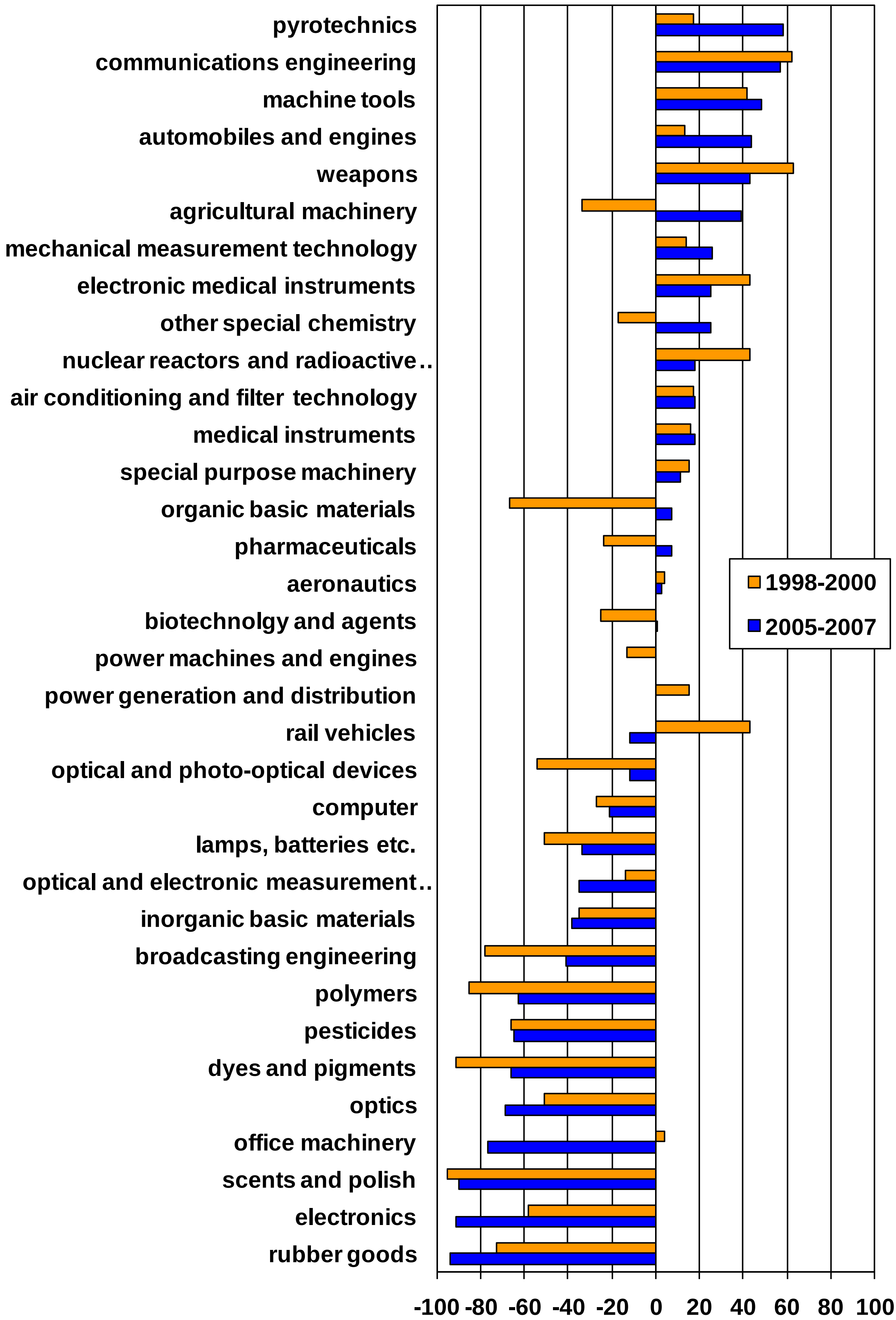
Source: Questel (EPPATENT, WOPATENT); Fraunhofer ISI calculations, update October 2009.

Figure A9: Patent Specialisation of Canada, 1998-2000 and 2005-2007



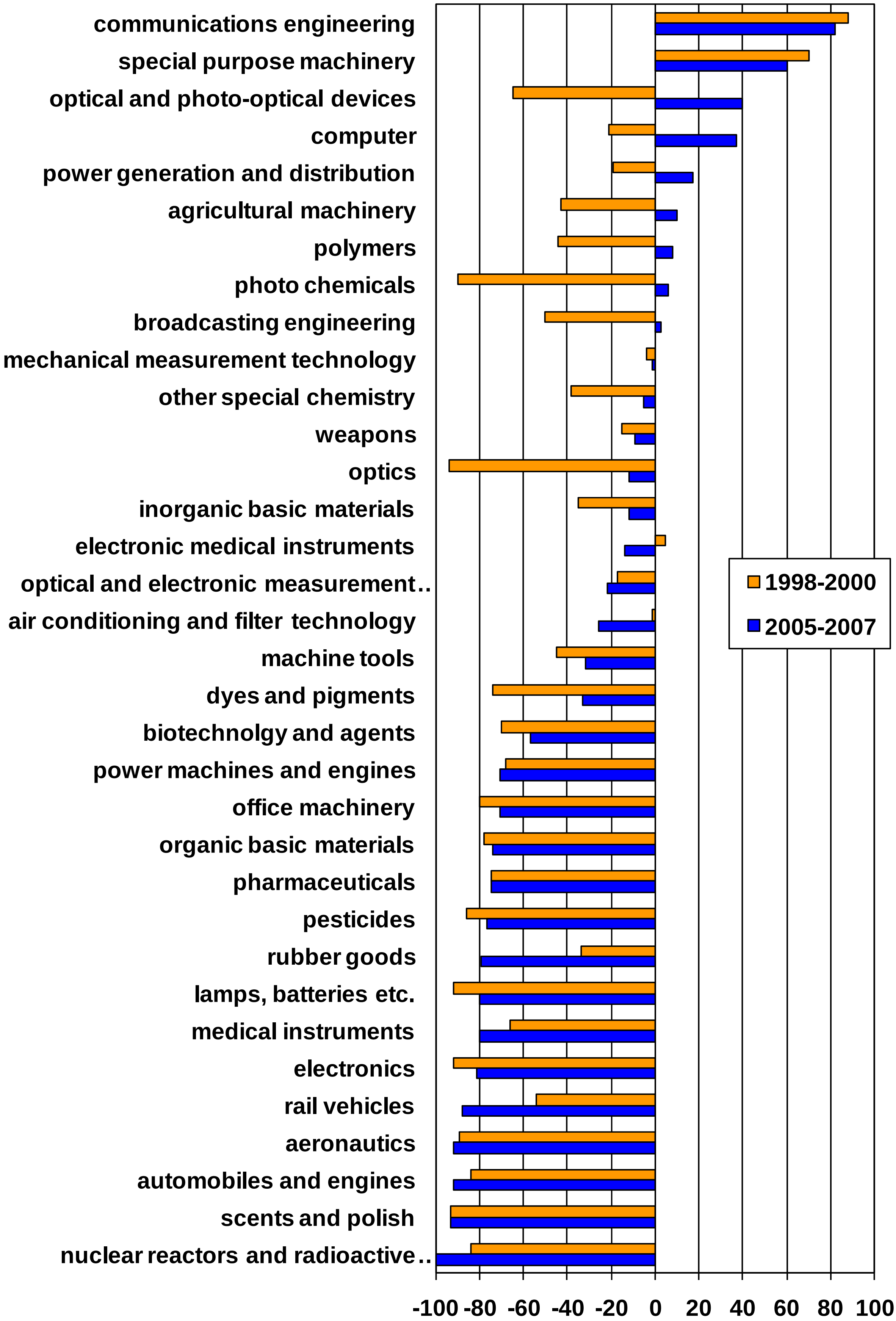
Source: Questel (EPPATENT, WOPATENT); Fraunhofer ISI calculations, update October 2009.

Figure A10: Patent Specialisation of Sweden, 1998-2000 and 2005-2007



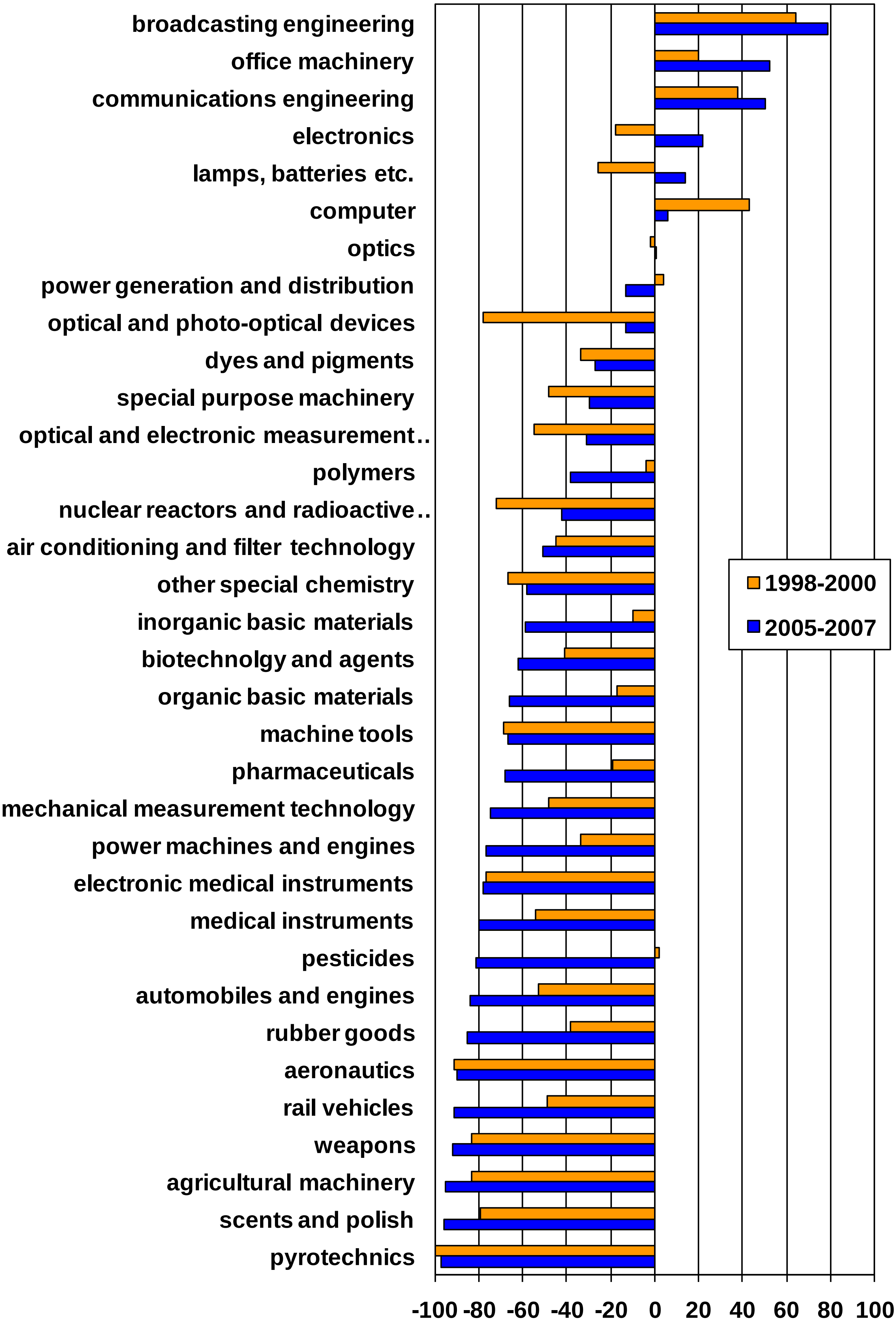
Source: Questel (EPPATENT, WOPATENT); Fraunhofer ISI calculations, update October 2009.

Figure A11: Patent Specialisation of Finland, 1998-2000 and 2005-2007



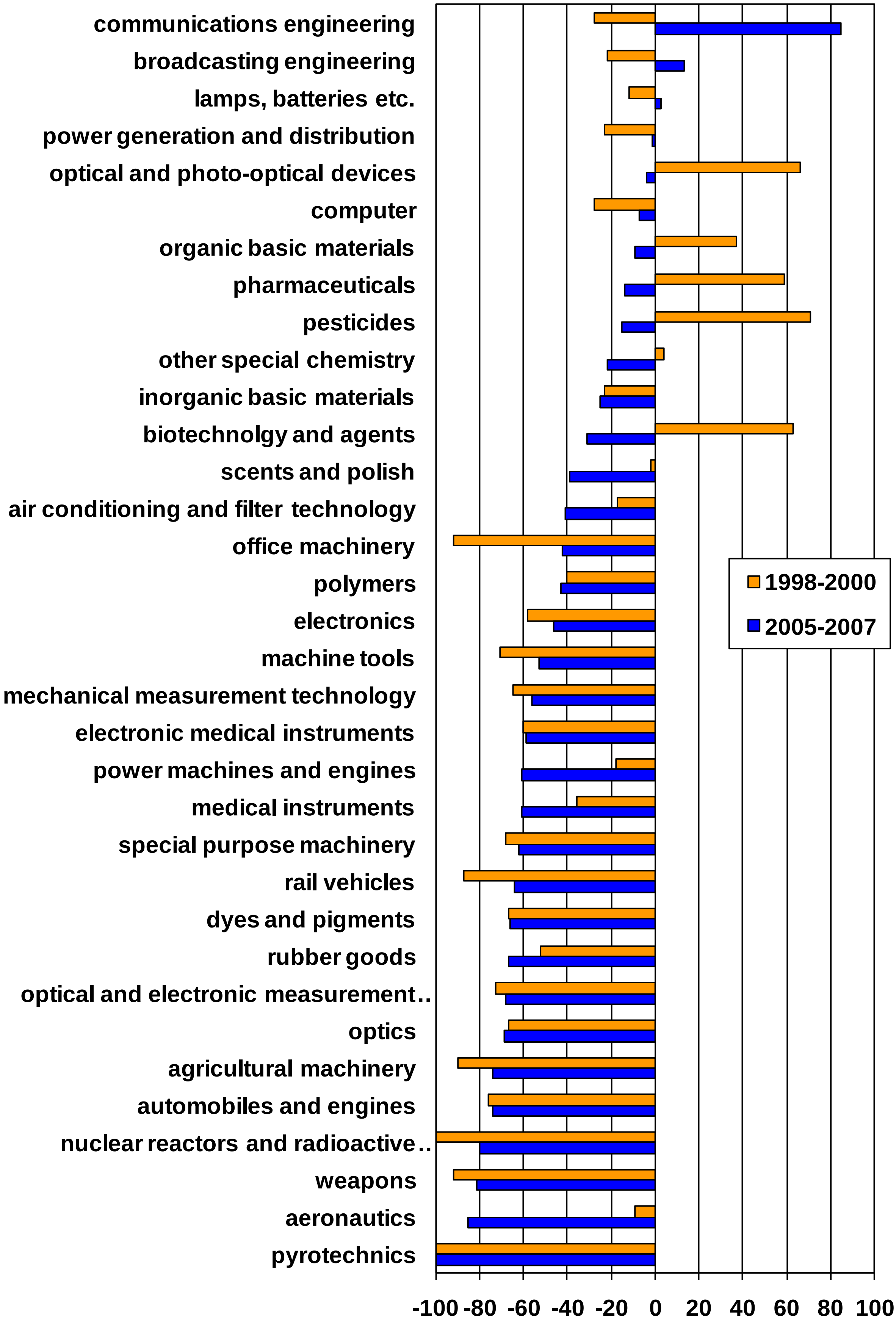
Source: Questel (EPPATENT, WOPATENT); Fraunhofer ISI calculations, update October 2009.

Figure A12: Patent Specialisation of South Korea, 1998-2000 and 2005-2007



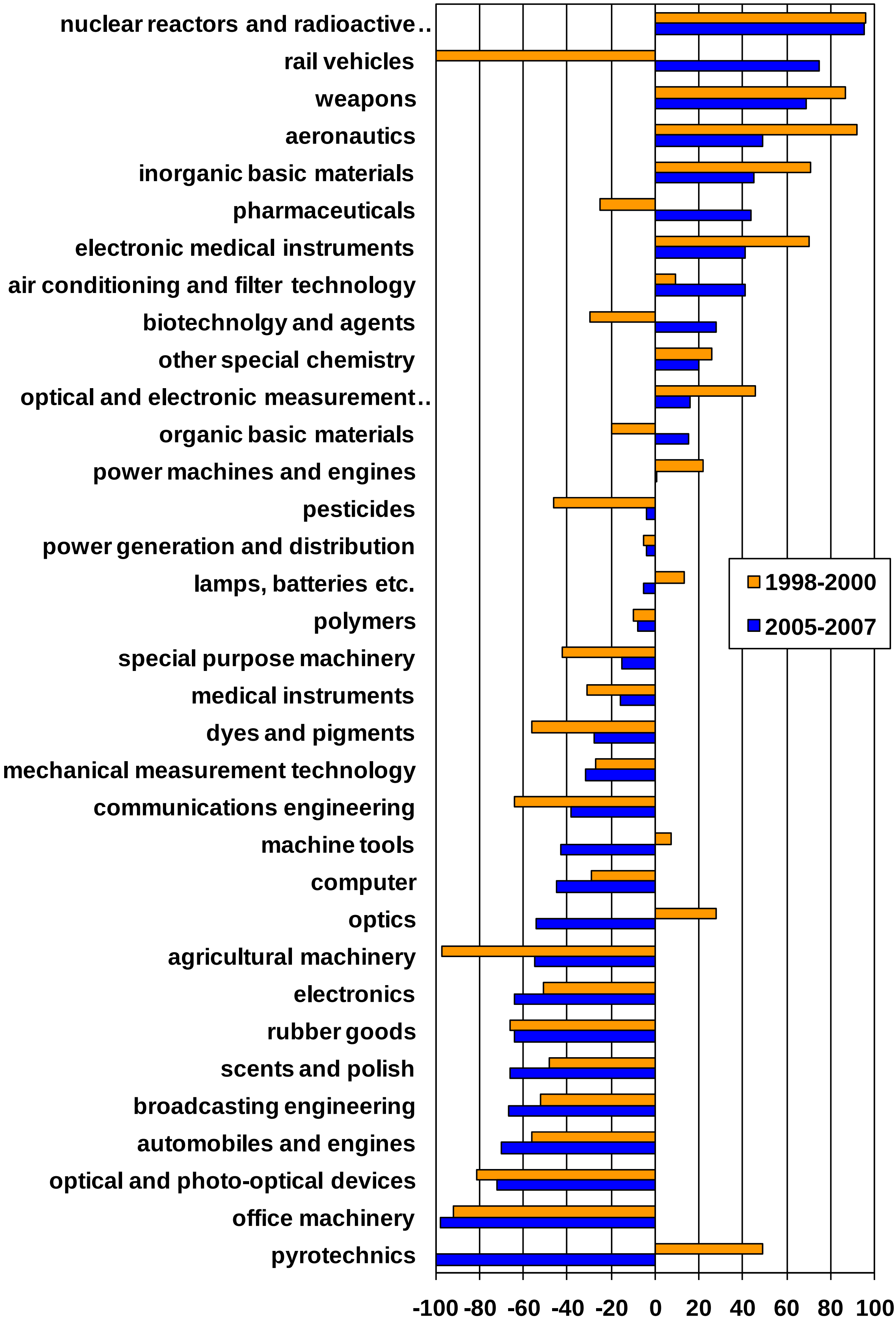
Source: Questel (EPPATENT, WOPATENT); Fraunhofer ISI calculations, update October 2009.

Figure A13: Patent Specialisation of China, 1998-2000 and 2005-2007



Source: Questel (EPPATENT, WOPATENT); Fraunhofer ISI calculations, update October 2009.

Figure A14: Patent Specialisation of the Russian Federation, 1998-2000 and 2005-2007



Source: Questel (EPPATENT, WOPATENT); Fraunhofer ISI calculations, update October 2009.