

# Weekly Report

## Technological and Regional Patterns in R&D Internationalization by German Companies

*An analysis of patent applications filed with the European Patent Office reveals that German companies primarily expand their research activities abroad in high-tech sectors in which they already conduct long-term intensive research. These sectors are: electrical engineering, control technology, engines, pumps, turbines, thermal processes, mechanical components, and transport. German R&D internationalization is thus founded on fields of research that are highly productive domestically.*

*By contrast, there is cause for concern for Germany as a location for research in the fields of telecommunications, pharmaceuticals, and biotechnology. In these areas German companies have been intensifying their research activities abroad due to relative weakness at home.*

*A particularly controversial topic in the political arena concerns the global competitiveness of Germany as a location for research. Empirical investigation of German research and its main competitors yields surprising results: Germany's competitors are almost exclusively Western European countries, particularly Austria, Switzerland, and France – all German neighbors. While the US continues to play a central role as a location for research funded by German companies, its importance has declined drastically since 1990.*

German companies are increasingly expanding their R&D activities in foreign countries.<sup>1</sup> Yet what effects does this trend have on Germany as a location for research? Negative effects could result if internationalization leads to the migration of R&D abroad and an attendant reduction in domestic R&D activities. This could lead to the closing of German research institutions, the shedding of highly qualified personnel, and a reduction in knowledge transfer between companies and research institutions.

In an analysis of foreign and domestic R&D activities undertaken by German companies between 1990 and 2005, we aimed to determine the areas in which German companies are more and less active in relation to their competitors.<sup>2</sup> In this con-

<sup>1</sup> Belitz, H., Deutschland nach den USA zweitgrößter Forschungsstandort für multinationale Unternehmen. In: DIW Weekly Report No. 18/2008, pp. 226-232.

<sup>2</sup> This investigation was the focal topic of the study Innovationsindikator Deutschland 2008, commissioned by the Deutsche Telekom Foundation and the Federation of German Industries; the German Institute for Economic Research (ed.): Politikberatung kompakt No. 45. Berlin, November 2008.

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## Data Pool

The data pool for this study consisted of transnational patent applications (including applications under the Patent Collaboration Treaty) filed with the European Patent Office by nearly 4,000 international concerns who regularly file a large number of patent applications, and encompassed some 700,000 applications, of the 1.6 million applications submitted over the time frame for which data was collected.<sup>1</sup>

By referencing the Derwent Patent Assignee Code, it was possible to identify common multinational corporate groups that have filed patents through various subsidiaries. The European Patent Office's Worldwide Patent Statistical Database (PATSTAT, first version 2008) served as the source of the registration names and all additional information. This database, maintained by the European Patent Office, contains information on all national and international patent applications.

The geographic base of research for each company (i.e., home country) has been defined here as the country from which the largest percentage of patent applications originate at a given time. In this way, companies are not assigned to countries based on the ultimate beneficial owner of the patent, but rather based on the country with the most important research centers maintained

by the company group. This approach is consistent with the study's goal: to investigate the internationalization of R&D as it emanates from the country in which a company primarily conducts research. Using the Derwent database, a significantly larger number of companies could be allocated to a "home country" than would have been possible through the use of information about subsidiaries and company groups that is difficult to access and limited in availability prior to 2000. Moreover, all previous studies have shown that multinational companies continue to focus their research in their respective home countries. The home country for each company (i.e., the location of the company's research base) was determined using the described method for two periods of time (1990-93 and 2002-05), as the assigned country could change over time due to mergers and acquisitions. Companies that conduct research abroad are predominantly multinational corporations; for this reason, the terms are used here interchangeably.

The patent type, which is assigned by the patent office in accordance with the International Patent Classification (IPC), was used to sort the patents into 30 different technological fields.<sup>2</sup>

<sup>1</sup> See Thomson Scientific: <http://scientific.thomsonreuters.com/support/patents/dwpieref/reftools/companycodes/lookup/> (accessed: Oct. 29, 2008)

<sup>2</sup> The four-digit IPC system consists of a total of over 850 classes, necessitating its paring in line with fields of technology used by FhG-ISI and the OST (Observatoire des Sciences et des Techniques). See [www.obs.ost.fr](http://www.obs.ost.fr). These technology classes were also used by the World Intellectual Property Organization in its 2007 World Patent Report (WIPO2007).

nection we also sought to ascertain to what extent Germany is weakened as a location for research in various fields of technology by the expansion of German companies' foreign research activities.

Publicly available information from patent applications provides insight into the foreign R&D activities of German multinational companies, about where research is conducted and in which fields. For example, patent applications contain information about the company who has filed the application, about the location of the inventor – which usually corresponds to the location where research activities were conducted – as well as information as to which field of technology the patent belongs (see Data Pool box).

## Companies Benefit from Foreign Research

There are two main reasons why companies internationalize their R&D activities:

- To penetrate foreign markets by adapting their products and processes to local conditions; and/or
- To take advantage of foreign expertise.

To penetrate new markets companies must adapt their products to regional needs or even develop special products, as preferences in demand vary from country to country. The need to adapt products to address the special demands of international customers often leads companies to invest in R&D abroad. Some foreign customers even expect their suppliers to conduct development activities in close geographic proximity, to ensure a quick reaction to new product requirements.

A percentage of research and, to a greater extent, development activities are undertaken in order to innovate new production processes in foreign plants and to tool production lines for new products. In the case of such market-driven R&D activities, knowledge is primarily transferred from the company's home country abroad. However, in this internationalization scenario, the R&D conducted in a company's

home country remains the most important source of innovation. Additional foreign research benefits the company at home to the extent that it serves the purpose of expanding reach in foreign markets.

Companies are better able to acquire new technical expertise from research institutions and universities when they are in close proximity geographically to one another. In order to absorb existing knowledge in foreign countries, companies must be imbedded in local research networks with their own research departments. The opportunity to tap the know-how of scientific and technical experts in foreign countries is an important motivation for conducting R&D activities abroad.

An internationalization strategy based primarily on the acquisition of knowledge from foreign countries carries latent risks for domestic research, as such a strategy may result in the reduction of domestic research capacities, which in turn weakens a country's ability to absorb new knowledge from abroad.

Studies show that companies primarily engage in foreign R&D in areas in which intensive research is also conducted at home.<sup>3</sup> This focus on specific fields of research constitutes the basis for penetrating new markets (i.e., a "home-base-exploiting" strategy) or for acquiring new knowledge abroad (i.e., a "home-base-augmenting" strategy). In an analysis of the patent activities of 345 multinational companies between 1994 and 1996, 77% of patent applications could be ascribed to home-based internationalization strategies. Yet there also is a third strategy of so-called "technology-seeking," by which companies conduct foreign research in areas they neglect at home. However, this latter strategy could only be ascribed to 13% of patent activities.<sup>4</sup>

### German Companies Weak in Telecommunications and IT

German companies register more patents than their international competitors in the fields of transport, control technology and engines, pumps, turbines, and mechanical components, all areas with a great deal of international patent activity. German companies also submit a slightly above-average number of patents with the European Patent Office in the fields of electrical engineering, machine tools, thermal processes, and consumer goods. Their foreign

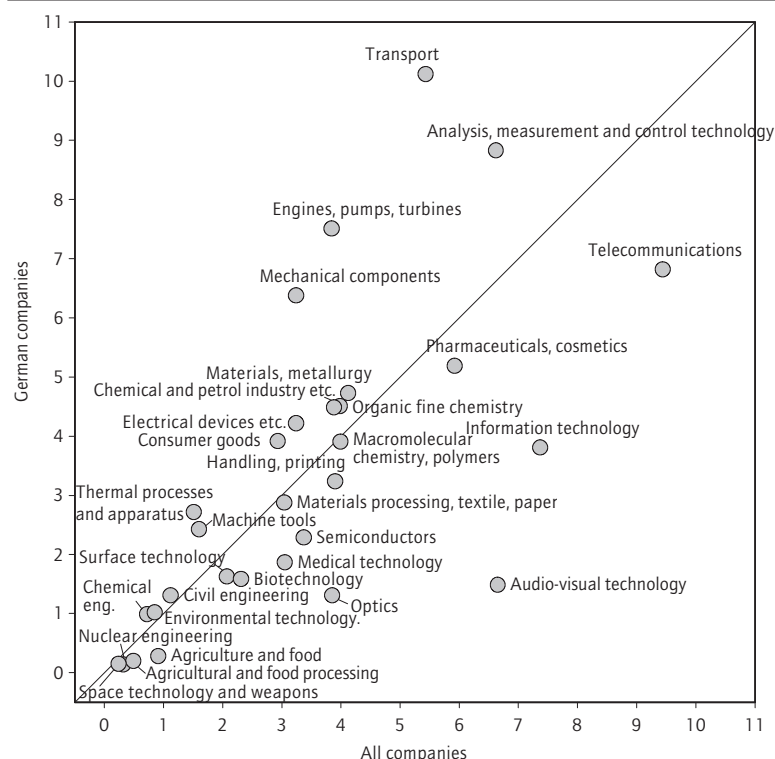
<sup>3</sup> See, among others, OECD (2008), *The Internationalisation of Business R&D: Evidence, Impacts and Implications*. Paris 2008, and the references cited therein.

<sup>4</sup> LeBas, C.; Sierra, C. (2002), *Location versus Country Advantages in R&D Activities: Some Further Results on MNEs Locational Advantages*. Research Policy, Vol. 31, pp. 589-609.

Figure 1

### Percentage of patent applications by technological sector for all companies and German companies, 2002–2005

In percent



Sources: PATSTAT; calculations by DIW Berlin.

DIW Berlin 2008

competitors, by contrast, file a larger proportion of patents in the areas of telecommunications, IT, audiovisual technologies, optics, and pharmaceuticals (see figure 1).

The technological strength of German multinational companies relative to their competitors can be measured by using a specialization co-efficient. This coefficient places the proportion of patents filed by the companies of one country in a given field of technology in relation to the proportion of filings by all companies in the same field. The coefficient tells us if the patent activities of a nation's companies in a field of technology are above or below average internationally.<sup>5</sup>

Measured in terms of patents filed between 1990 and 2004, the intensity of global research activities engaged in by all of the companies surveyed rose particularly in the fields of telecommunications, IT, transport, engines, pumps and turbines, medical technology, pharmaceuticals, and consumer goods (see figure 2). The number of patents submitted by

<sup>5</sup> A value higher than 1 means an above-average share in a field of technology; a value lower than 1 means a below-average share.

German companies in these fields also grew considerably. German companies thus contributed to the worldwide growth dynamic in these areas.

German companies have specific competitive advantages (as indicated by a specialization co-efficient greater than 1) in the fields of electrical engineering, engines, pumps and turbines, transport and thermal processes, mechanical components, consumer goods, and control technology. These are all fields experiencing rapid global growth. However, in some fields undergoing rapid growth German companies did not exhibit any competitive advantage through specialization, including telecommunications, IT, medical technology, and pharmaceuticals (see figure 2). Nevertheless, German patent activities have risen sharply in these areas from the 1990s onward. This testifies to a process of “catch up” in which companies attempt to participate in dynamic areas of research despite a position of relative weakness. US and Japanese companies are the strongest competitors in these areas. US companies file a particularly high concentration of patents in the fields of medical technology and IT. Japanese companies, for their part, are specialized in telecommunications, semiconductors, optics, and audiovisual technologies (see figure 3).

### Foreign Research Mirrors Technological Strengths

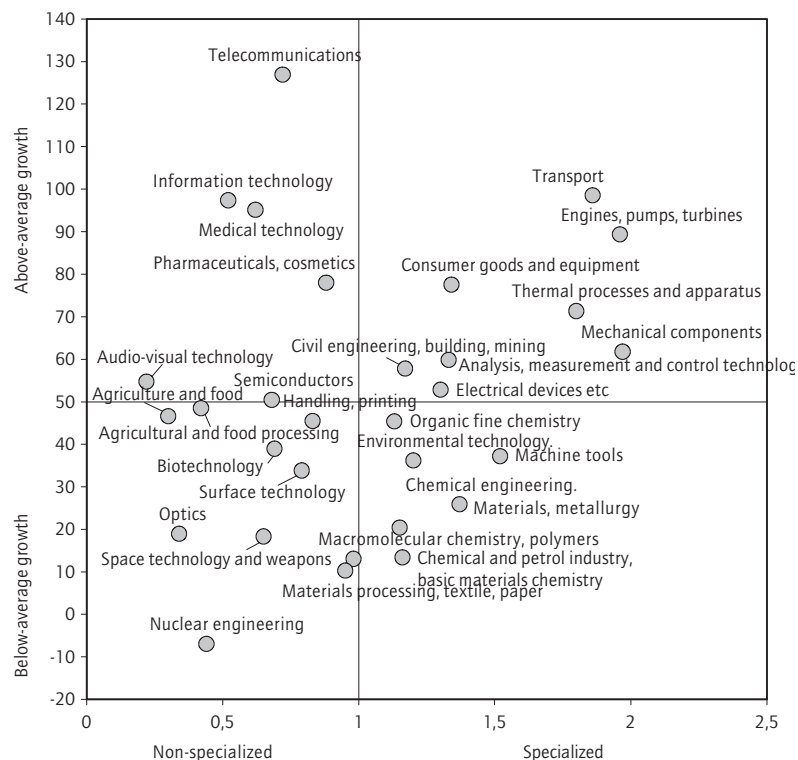
The areas in which German companies specialize in their foreign research shows that, on the one hand, they research in fields in which they already have a strong competitive advantage, in fields with above-average rates of global growth. In this way, the specialization coefficient is over 1 for foreign research in mechanical components, consumer goods, and transport and thermal processes, indicating a strong concentration of foreign R&D activity in these fields (see table 1). In addition, foreign patent activity grew in these areas in near proportion to that within Germany. This can be interpreted as an expansion strategy in which foreign research activities primarily serve the effort to adapt products to local market conditions. This also accounts for the relatively low levels of foreign research in these areas.

By contrast, in the high-growth fields of pharmaceuticals, medical technology, telecommunications, and IT, German companies cannot act from a position of relative technological strength. In these areas various patterns of R&D internationalization are observed. The number of patents filed by German companies abroad in the telecommunications and pharmaceutical branches is proportionally higher than that registered domestically (see figure 4). In

Figure 2

### Worldwide growth in patent applications filed with the EPO, 1990-2004, and the technological specialization of German companies, 2002-2005

In percent



Sources: PATSTAT; calculations by DIW Berlin.

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these areas German companies are only specialized in foreign research. German companies attempt to close gaps in domestic research through knowledge acquisition abroad. Foreign-based researchers, for example, play a role in 33% of the patents filed by German companies in the pharmaceutical branch, and 25% of patents in the telecommunications sector (see figure 5). The increased research undertaken abroad by German companies in areas of relative weakness – such as those above – is indicative of an attempt to compensate for disadvantages in domestic research by acquiring cutting-edge expertise abroad.

The proportion of research undertaken by German companies abroad in the medical technology and IT sectors – which have witnessed particularly dynamic growth since 1990 – is also comparatively high. Yet German companies are not specialized in foreign or domestic research in either of these areas. Foreign patent activity has grown in proportion to domestic activity. This means that a greater proportion of foreign research does not automatically indicate

that Germany has disadvantages as a location for research.

In the fields of biotechnology and organic fine chemistry – two areas which, in contrast to popular perceptions, are not among the fastest growing technology sectors worldwide – German companies have technological disadvantages, yet they concentrate their R&D activities abroad. In the field of biotechnology, nearly 37% of all patents filed by German companies – the highest in any sector – are the product of foreign research activities. In the field of organic fine chemistry this figure is nearly 32%. The proportion of foreign research undertaken in both of these areas hints that Germany suffers from disadvantages as a location for research.

### Competition Centered in US and Europe

Between 2002 and 2005, the most important countries for German R&D in high-tech fields for which German companies had a domestic weakness and a high percentage of patent applications abroad were:

- In telecommunications: Austria, the US, and France.
- In pharmaceuticals, biotechnology, and organic fine chemistry: the US, France, and Switzerland.

From 2002 to 2005, the foreign research activities of German multinational companies were concentrated geographically in Western Europe; the percentage of activities in Western Europe has experienced strong growth since the beginning of the 1990s. The US is the second-most important location for research, yet has lost a great deal of significance since the early 1990s (see figure 6). Japan and other Asian countries continue to make up only a small percentage of foreign research. The most important European countries for German research are Switzerland (14% of all foreign activity), France (13%), and Austria (10%), followed by the UK (6%) and Italy (4%).

At the beginning of the 1990s foreign research conducted by German companies was more concentrated in the US and the industrial countries of Western Europe,<sup>6</sup> which hosted 90% of all R&D activities. Since then, China, the new EU member countries, and the East Asian tiger economies<sup>7</sup> – particularly South Korea – have captured a growing share of German foreign research. Nevertheless, their role remains relatively small – in 2002–2005, nearly

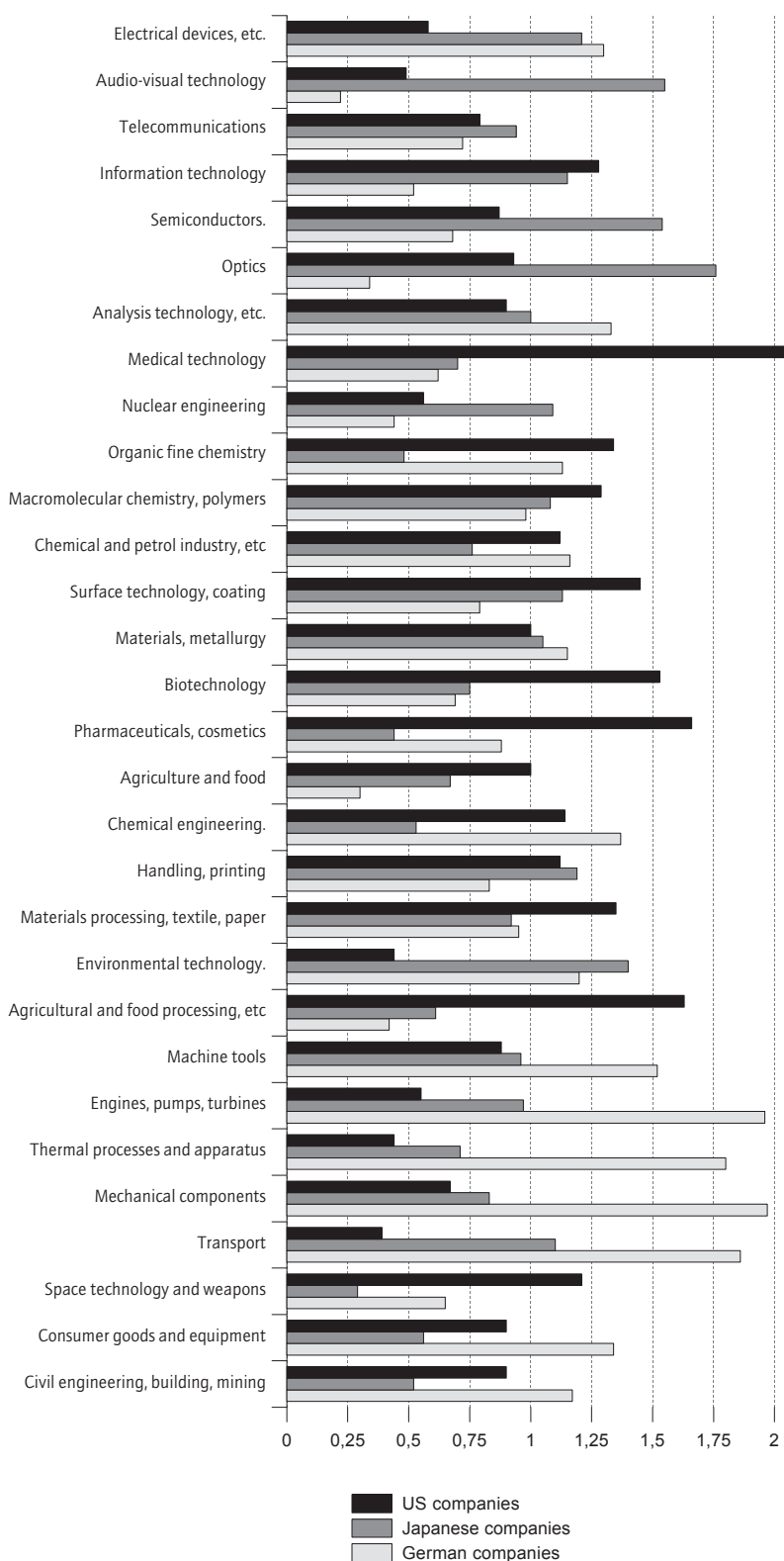
<sup>6</sup> The 15 members of the EU plus Switzerland and Norway are considered to be Western Europe.

<sup>7</sup> South Korea, Taiwan, Singapore, Hong Kong, Indonesia, Malaysia, Thailand, and the Philippines are considered the East Asian tiger economies here.

Figure 3

### Technological specialization of German, US, and Japanese companies, 2002–2005

Specialization co-efficient



Sources: PATSTAT; calculations by DIW Berlin.

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Table

**Internationalization patterns of German companies in selected technological fields**

	German companies			Type of specialization	For informational purposes: All companies
	Specialization co-efficient <sup>1</sup>		Percentage of R&D abroad		Growth in patent applications. 1990-2004 <sup>2</sup>
	Total	Foreign			
Mechanical components	+	+	12.3	Specialized at home and abroad	+
Engines, pumps, turbines	+	0	7.5	Specialized at home	+
Transport	+	+	9.2	Specialized at home and abroad	+
Thermal processes and apparatus	+	+	9.4	Specialized at home and abroad	+
Consumer goods and equipment	+	+	14.4	Specialized at home and abroad	+
Analysis, measurement and control technology	+	+	14.4	Specialized at home and abroad	+
Electrical devices, electrical engineering, electrical energy	+	–	8.9	Specialized at home	+
Civil engineering, building, mining	+	0	11.1	Specialized at home	+
Pharmaceuticals, cosmetics	–	+	32.7	Specialized abroad	+
Telecommunications	–	+	24.8	Specialized abroad	+
Medical technology	–	–	21.8	Not specialized	+
Information technology	–	–	17.9	Not specialized	+
Audio-visual technology	–	–	18.6	Not specialized	+
Biotechnology	–	+	36.7	Specialized abroad	–
Organic fine chemistry	–	+	31.8	Specialized abroad	–

<sup>1</sup> Above 1: +; below 1: –<sup>2</sup> Above-average: +; below-average: –

Source: Calculations by DIW Berlin.

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5% of foreign research by German companies took place in these countries, up from just over 1% in the early 1990s.

## Conclusion

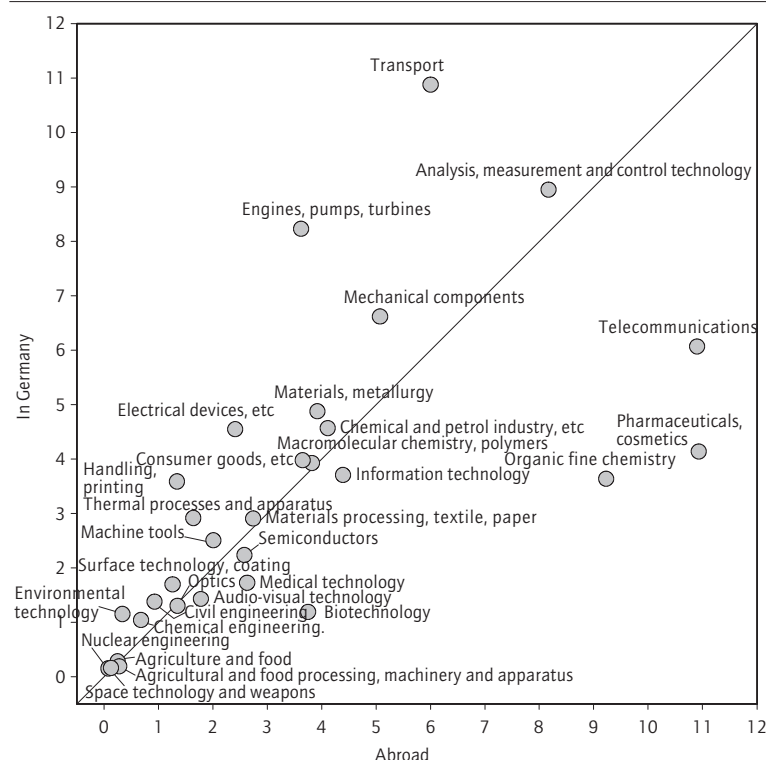
If one views the fields that have witnessed particularly strong growth in patent activity since the early 1990s, R&D undertaken by German companies has been concentrated in the high-tech fields of electrical engineering, control technology, engines, pumps and turbines, mechanical components, transport, consumer goods, and civil engineering. Yet German companies have been less active in several other high-tech fields which have undergone rapid growth: the pharmaceutical, telecommunications, IT, and medical technology sectors.

When researching abroad, German companies focus their activities on areas in which they also conduct intensive domestic R&D. In its core technological competencies, Germany remains an attractive location for corporate research, despite the increasing internationalization of R&D. Yet German companies have increased foreign R&D activities in several high-tech fields in which they have domestic research deficits. This can be indicative of a “catch up” strategy. German companies conduct

Figure 4

## Patent applications of German companies in Germany and abroad by technological sector, 2002–2005

Percentage



Source: PATSTAT; calculations by DIW Berlin.

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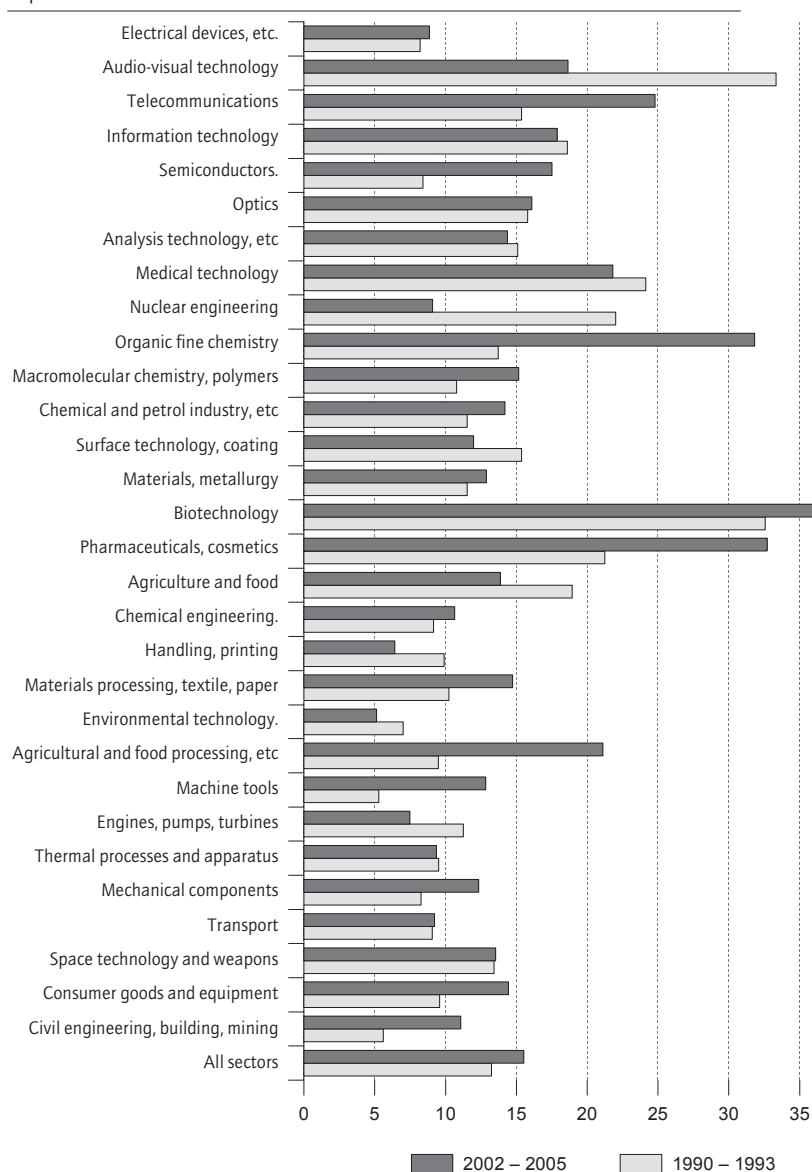
an above-average amount of foreign research in telecommunications and pharmaceuticals – two particularly high-growth fields worldwide – and in biotechnology and organic fine chemistry – which are experiencing somewhat lower growth. In these fields the high rates of foreign activity are likely related in part to deficits in the domestic research environment.

R&D undertaken by German companies abroad is concentrated in Western Europe and the US, where more than 90% of their foreign patent applications originate. Germany thus remains predominant alongside some of its Western European neighbors and the US in the competition to attract companies with its research environment. Germany must weigh itself against these countries with regard to its innovative capacity, as measured by DIW Berlin's innovation indicator.<sup>8</sup>

Figure 5

### Percentage of foreign-based inventors of patents filed by German companies

In percent



Sources: PATSTAT; calculations by DIW Berlin.

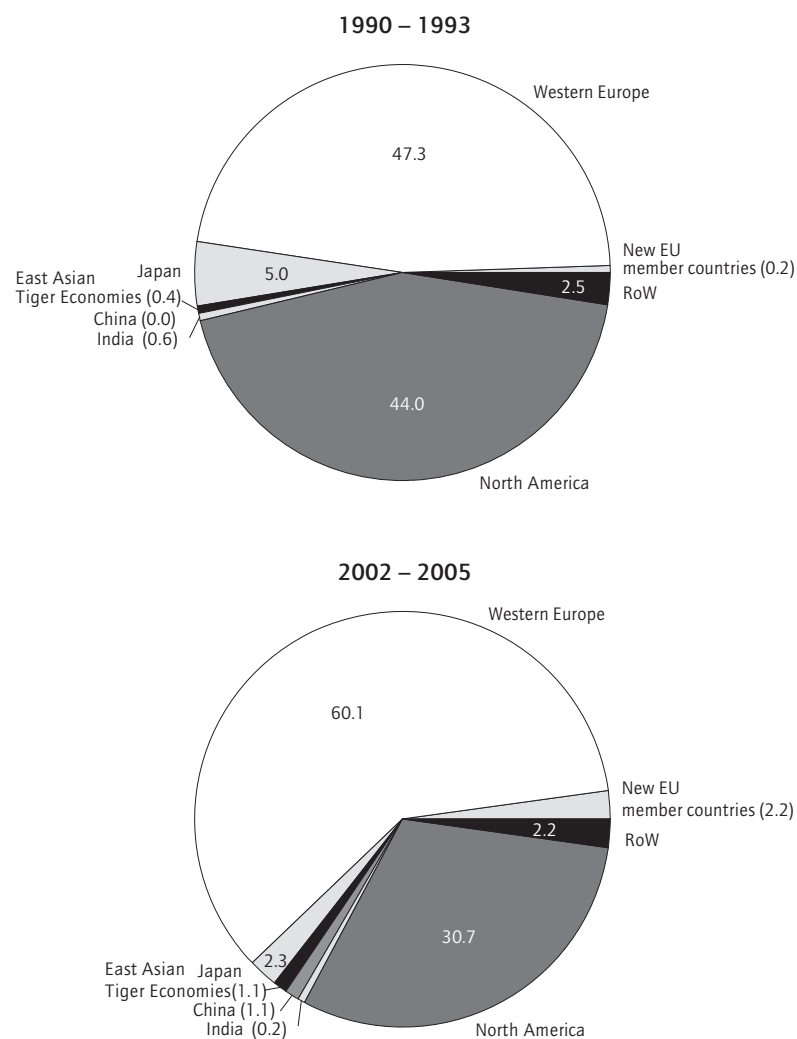
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<sup>8</sup> See Belitz, H., Schmidt-Ehmcke, J., Zloczynski, P.: Deficits in Education Endanger Germany's Innovative Capacity. Weekly Report No. 14/2008

Figure 6

## Foreign R&D Locations of German Companies

Percentae



Sources: PATSTAT; calculations by DIW Berlin.

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