German Institute
for Economic Research

No. 10/2010
Volume 6
March 24, 2010

DIW BERLIN

www.diw.de

Weekly Report

German industry succeeds with research-intensive goods

As a country highly specialized in the production of investment goods, Germany has been especially hard hit by the global recession. Because the production profile of German industry is technology-intensive, however, there is reason to believe that Germany will emerge from the present economic crisis with renewed strength. In no other industrialized nation is production as heavily geared to research-intensive goods as it is here. Germany has increased its lead over its most significant rivals not only in motor vehicle manufacturing, but also in machinery, communication equipment, and medical and precision instruments. The success of German companies is based not only on compelling products, but also on the relative efficiency of their production processes compared to other countries.

Heike Belitz
hbelitz@diw.de

Martin Gornig
mgornig@diw.de

Alexander Schiersch
aschiersch@diw.de

A strong focus on production in research- and knowledge-intensive industries is crucial to the competitive position of high-wage countries such as Germany. It is not the least of the reasons why the German federal government regularly consults with the Expert Commission on Research and Innovation (EFI) on the status and prospects of technological productivity. These consultations include analysis of the trends in Germany's production patterns in comparison with the USA, Japan, and other members of the European Union (Box 1).[1] While Asia's emerging countries—India and China in particular—have increased their involvement in technology-intensive sectors, they still account for a very small share of world production.[2] Moreover, detailed structural data are lacking for these countries.

To demonstrate the differences between the established West European countries and the transitional countries of Eastern Europe, the results have been divided into two groups: EU-14 (the original EU countries with the exception of Germany) and EU-10 (the new member states that joined in 2004). The significance of each individual sector is compared internationally according to its share in nominal value added. Data of sufficient breadth and detail for economic efficiency calculations are available for only ten countries within the EU.[3]

1 The Commission's current report was submitted on February 24, 2010. It is based in part on a study by DIW Berlin that is also the basis for the present Weekly Report. Belitz, H., Clemens, M., Gornig, M., Schiersch, A., Schumacher, D., Wirtschaftsstrukturen, Produktivität und Außenhandel im internationalen Vergleich. Studien zum deutschen Innovationssystem No. 5/2010, Expert Commission for Research and Innovation (pub.), Berlin, www.e-fi.de.

2 Cf. OECD, OECD Reviews of Innovation Policy: China. Paris 2008.

3 Efficiency values were calculated for the following European countries, aside from Germany, on the basis of capital

JEL Classification:
O14, O40, O57

Keywords:
Industrial specialisation,
Technological change,
Technical efficiency

Box 1

Classification by sector and region; data basis

R&D-intensive industries and knowledge intensive services

Research-intensive manufacturing industries are the producers of cutting-edge and high-level goods, defined as follows:

- The *cutting-edge technology category* includes goods for which internal R&D expenditures comprise, on an OECD average, more than seven percent of revenues.
- The *high-level technology* category includes goods for which internal R&D expenditures comprise between 2.5 percent and seven percent of revenues.

This distinction is based on the R&D intensity and not meant to imply that cutting-edge technology is more "advanced" or "valuable". Cutting-edge goods are more frequently subject to government intervention in the form of subsidies, government contracts, and non-tariff trade barriers. Policies are created to promote them not only with technological goals in mind, but also in pursuit of national goals in such areas as defense, healthcare, and the aerospace industry.

In the service sector, the percentage of highly qualified employees (graduates) and persons engaged in planning, design, and engineering—in addition to R&D—is used as a classification criterion. In the knowledge-intensive service sectors, the percentage of the workforce with a university or college degree is above average (over eleven percent); the sector also employs an above-average percentage of scientists and engineers (over 4.5 percent).

Division of European countries into survey regions

The EU-14 countries are the original EU member states, with the exception of Germany: Belgium, Denmark, Finland, France, Great Britain, Greece, Ireland, Italy, Luxembourg, the Netherlands, Austria, Spain, Portugal, Sweden.

The EU-10 countries are those that became EU members in May 2004: Estonia, Latvia, Lithuania, Malta, Poland, Slovenia, Slovakia, Czech Republic, Hungary, Cyprus.

Bulgaria and Romania, which joined the EU in 2007, were not considered in the survey.

Data basis

Data compiled by a European research consortium (EU KLEMS) and the OECD (STAN) provide the data basis for an international comparison for the period from 1995 to 2007. The EU KLEMS version of March 2008 provides detailed data, grouped by sector, for every year up to 2005. The values for 2006 and 2007 have been added, and in some cases estimated, from the more current EU KLEMS version of November 2009 and the OECD STAN data from 2009; the EU KLEMS provided data for a more limited classification by sector, while the STAN data allowed a more detailed classification by sector.

1 Legler, H., Frietsch, R., Neuabgrenzung der Wissenswirtschaft—forschungsintensive Industrien und wissensintensive Dienstleistungen. NIW/ISI-Listen 2006. Studien zum deutschen Innovationssystem No. 22-2007, German Federal Ministry of Education and Research (pub.), Berlin 2007.

A strong emphasis on research- and knowledge-intensive production …

In 2007 Germany led all of the other countries in the combined share of gross value added attributable to research-intensive manufacturing industries and knowledge-intensive services (Figure 1). This had not always been the case. The USA still held the lead in 2000. Germany was able to improve its position primarily through further growth in the share of value added output attributable to high-level technologies—already an area of considerable strength. Machinery manufacturing and motor vehicle production in particular made further strides. But Germany's cutting-edge technology sectors, such as communication equipment and medical and precision instruments, also showed strong growth momentum.

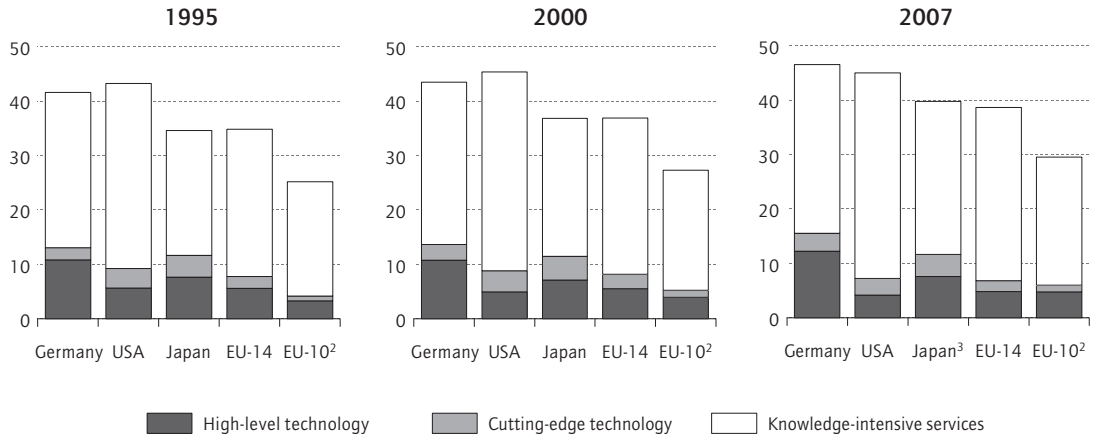
The importance of knowledge-intensive services in Germany increased sharply from 1995 to 2007. These sectors comprised 31 percent of gross value added, putting them on a par with the EU-14, but they remained considerably smaller than in the USA (where they comprised 38 percent). Japan has a rather unique structural profile. It has the highest share of gross value added attributable to cutting-edge technology, but its knowledge-intensive services carry only little weight. Although Japan has begun

stock data: Austria, Czech Republic, Slovenia, Finland, the Netherlands, Denmark, Sweden, Italy, Portugal, and Great Britain. The aggregate data have been weighted with the valued added figure in each case.

Figure 1

Research-intensive manufacturing industries and knowledge-intensive services

Shares[1] in percent



1 In relation to total gross value added.
2 Countries that acceded in May 2004.
3 2006.

Sources: EUKLEMS Database 11/2009; OECD STAN 2009; calculations of DIW Berlin. **DIW** Berlin 2010

In Germany, research- and knowledge-intensive production carries the greatest weight. The USA, which was still in the lead in 2000, has since been outstripped.

to approach the average for the other industrialized countries, which are becoming increasingly service-oriented, it still has a long way to go. While total research- and knowledge-intensive production accounted for the lowest share in value added output in the new EU member states (EU-10), these countries have experienced above-average growth rates in comparison to 1995. The share of gross value added attributable to high-level technology was already higher than in the USA and nearly as high as in the EU-14 countries. By contrast, growth in the share attributable to knowledge-intensive services was stagnant.

On the whole, the economy became increasingly research- and knowledge-oriented in all regions during the survey period. The share in value added generated by research-intensive industries increased only in the new EU countries (EU-10) and Germany. Cutting-edge technologies have also gained considerably in importance there.

… and rising international market shares

The shares in overall production attributable to the various categories of research- and knowledge-intensive goods and services in all of the countries included in the survey serve as an indicator of Germany's competitive position in those sectors.[4] The changes in these market shares show that nearly all sectors of research-intensive industry in Germany were highly successful between 1995 and 2007 (Table 1). Manufacturing of motor vehicles and other transport equipment posted especially strong gains in market share. But sectors in the cutting-edge technology category have also experienced considerable gains in Germany. The greatest gains in market share in this category have been achieved by medical and precision instruments, communication equipment, and aircraft and spacecraft. Machinery and equipment, traditionally a strong industry in Germany, has also held its own, presumably owing to the positive effects of growth in the market for environmental protection goods.[5] There has been little change in the relative position

4 This observation is different from a pure analysis of comparative trade advantages (see the second contribution in this report). On the one hand, the comparison focuses on countries with similar production conditions; on the other hand, total production, and not just imports and exports, is considered.

5 Still, 35 percent of machinery and equipment production is regarded as potential environmental protection goods. Cf. Legler, H., Schasse, U., Produktionsstruktur und internationale Wettbewerbsposition der deutschen Umweltschutzwirtschaft. Hannover 2009. See also Blazejczak, J., Braun, F., Edler, D., Weltweite Nachfrage nach Umweltund Klimaschutzgütern steigt: Gute Wachstumschancen für deutsche Anbieter. Wochenbericht des DIW Berlin No. 18/2009.

Table 1

Changes in market share[1] attributable to research- and knowledge-intensive sectors – 2007 in comparison to 1995

In percentage points

	Nace code	Germany	EU-14	EU-10[2]	Japan	USA
Pharmaceuticals	244	0.47	–3.78	–0.43	–4.09	7.82
Office machinery and computers	30	1.84	–4.27	1.39	0.24	0.80
Communication equipment	32	3.06	–0.11	1.58	5.50	–10.02
Medical and precision instruments	33	3.68	1.95	0.67	–4.75	–1.55
Aircraft and spacecraft	353	2.85	–3.36	0.11	0.67	–0.27
Cutting-edge technology		**2.60**	**–0.08**	**0.77**	**–1.87**	**–1.43**
Chemical products	24[3]	–0.49	–2.84	0.38	–3.90	6.85
Machinery and equipment	29	1.73	1.88	1.09	–2.00	–2.70
Electrical machinery and apparatus	31	–0.11	1.32	4.32	–4.01	–1.51
Motor vehicles	34	6.10	–0.90	2.96	6.17	–14.33
Other transport equipment	35[4]	4.01	6.67	1.03	–4.08	–7.63
High-level technology		**2.14**	**–0.06**	**1.80**	**–0.60**	**–3.29**
Research-intensive manufacturing industries		**2.16**	**–0.10**	**1.45**	**–0.95**	**–2.56**
Publishing and printing	22	–1.52	0.36	1.22	–1.71	1.65
Post and telecommunications	64	–2.64	5.45	0.30	0.29	–3.39
Financial intermediation	65	–3.66	–0.04	1.13	–2.16	4.72
Insurance and pension funding	66	–0.48	2.35	1.18	–3.63	0.58
Other financial activities	67	–	–	–	–	–
Computer and related activities	72	–0.75	4.03	1.26	–7.75	3.21
Research and development	73	0.48	–6.74	–1.98	0.03	8.22
Other business activities	74	–2.23	2.66	0.49	–1.22	0.30
Health and social work	N	–0.92	–2.96	–0.59	1.88	2.59
Recreational, cultural, and sporting activities	92	–2.50	1.86	0.81	–4.29	4.12
Knowledge-intensive commercial services		**–1.80**	**1.03**	**0.42**	**–1.16**	**1.51**
Number of sectors with gains in market share						
Research-intensive industries		8	4	9	4	3
Knowledge-intensive commercial services		1	6	7	3	8

1 Measured in terms of gross value added on the basis of PPP.
2 Countries that joined the EU in May 2004.
3 Without the pharmaceutical industry (244).
4 Without aircraft and spacecraft (353) and without shipbuilding (351).

Sources: EU KLEMS Database; OECD STAN 2009; calculations of DIW Berlin. **DIW** Berlin 2010

Germany's research-intensive industries have increased their market share, while those in the USA have lost some of theirs. For knowledge-intensive services the situation is the reverse.

of the chemicals industry, the pharmaceutical sector, and electrical machinery. On the whole, Germany's research-intensive industry is not concentrated in a few heavily exporting sectors, contrary to common assumptions.[6] Rather, this industry has achieved remarkable success in international markets with a broad portfolio of products.

The new Eastern European member states (EU-10) also achieved gains in market share for their research-intensive industries, though these gains were considerably lower than those seen in Germany. This was true of the cutting-edge technology sectors in particular. No indications of a net shift in production shares from Germany to the new EU countries have been detected. For the most part, both regions have been able to attract growth in production shares.

Technology-intensive industries have suffered large market share losses in the USA and Japan. Virtually every sector has been caught up in these declines. In the USA, only the chemical and pharmaceutical industries were able to reverse the downward trend. In Japan, motor vehicle manufacturing and communication equipment have bucked the trend with impressive gains.

Although knowledge-intensive services gained in importance in Germany, the country fares quite poorly when the change in production shares attributable to them is compared to other countries. The country was able to maintain its position only in the field of research and development. On the

6 Cf., for example, Gerlach, F., Ziegler, A., Das deutsche Modell auf dem Prüfstand—Innovationen in der Krise. In: WSI Mitteilungen 2/2010, 63–69.

whole, growth in knowledge-intensive services lagged behind that registered in the comparison countries. The USA was particularly successful in achieving increases in market share, but the other EU countries also gained in importance. In common with Germany, Japan has also lost market share for its knowledge-intensive services, though to a considerably lesser extent.

Efficient production of research-intensive goods …

The key to achieving a strong competitive position in research- and knowledge-intensive production is to develop compelling products and services. But it is also important to make research- and knowledge-intensive production as efficient as possible.

Efficiency is fairly easy to measure empirically if certain assumptions are made. For the present calculations, the non-parametric estimation method used in data envelopment analysis was used (Box 2). For each sector, the best combination of input factors and output was calculated as a benchmark. A value of 1 indicates that the sector concerned is operating efficiently, thereby defining the benchmark. Efficiency values less than 1 indicate by how much actual production remains below possible output.

In 1995, Germany achieved an efficiency value of just under 0.90 in the category of research-intensive industries (Figure 2). This put it slightly behind the USA but considerably ahead of Japan and the EU countries considered in this report.

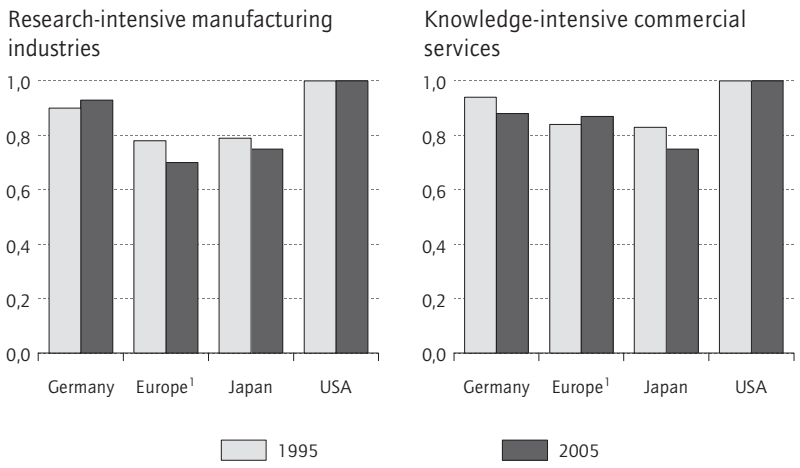
If one looks at each sector separately (Table 2), one is struck by the fact that Germany had achieved good to excellent values in the high-technology field as early as 1995. German automotive manufacturing, for example, is ranked as efficient (and represents the benchmark), and machinery and equipment, with an efficiency value of 0.93, likewise reaches a high level. By contrast, two other important sectors—chemicals and electrical machinery—receive the significantly lower values of 0.89 and 0.79 respectively. Particularly conspicuous among the cutting-edge technology sectors are communication equipment and medical and precision instruments with their relatively low efficiency values of 0.77 and 0.78 respectively. Even when considered in the aggregate, cutting-edge technology has a noticeably lower efficiency value (0.82) than high-level technology (0.92).

On the whole, the efficiency of research-intensive industries in Germany increased substantially between 1995 and 2005.[7] By contrast, the average efficiency values for Japan and the EU countries considered here fell during the same period. The USA was able to maintain its leading position. The improvement in Germany's position resulted from efficiency increases in both high-technology and cutting-edge technology sectors. The automotive manufacturing sector, for example, was able to maintain its high level of efficiency, while machinery and electrical equipment were able to push into the lead. Thus three of the four largest German industrial sectors registered the best possible results in terms of their efficiency in 2005, while the chemical industry was unable to keep up.

In the cutting-edge technology category, the medical and precision instruments sector managed to hike its efficiency rating from 0.78 to 1. In so doing, it defined the benchmark for efficient production as compared to other countries. A considerable increase in efficiency was observed also in the German communication equipment sector. There were slight improvements in the aircraft and spacecraft and other transport equipment sectors. On the other hand, the efficiency position of the German pharmaceutical and chemical industries deteriorated. Closer analysis

Figure 2

Efficiency levels in research- and knowledge-intensive sectors



1 Countries selected: Austria, Czech Republic, Slovenia, Finland, the Netherlands, Denmark, Sweden, Italy, Portugal, and Great Britain.

Sources: EU KLEMS Database; calculations of DIW Berlin. **DIW** Berlin 2010

Rising efficiency level of research-intensive industries in Germany and loss of efficiency in the case of knowledge-intensive services.

7 The efficiency increases must be interpreted on the output side as income gains. How such income gains are allocated to the production factors labor and capital has not been examined here.

Box 2

Method of efficiency analysis

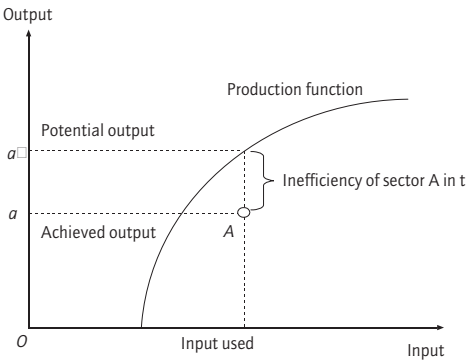
Efficiency analysis is a method used to gauge the performance capability of companies, sectors, or countries. Performance capability is defined here as the ability of the relevant unit to produce a given output with minimum input, or the maximum output with a given input. The Data Envelopment Analysis (DEA) method has been used for this purpose in the present survey. It is based on the idea of a production possibility set and a production function ("frontier") that defines its limits.

The position and shape of the frontier is determined by the observable input-output combinations for individual countries in each sector. The degree of inefficiency is derived from the distance of the sector in a country from the estimated production function. Output actually achieved is expressed as a fraction of potential output. Consequently, efficiency is measured only in values between 0 and 1. A value of 1 indicates that the sector concerned is operating efficiently and thereby defines the production function at the same time. If the value is less than 1, on the other hand, its difference from 1 shows by how many percentage points actual output falls short of potential output.

In the present simplified example, sector A produces at time t less than would be possible using the given input according to the production function. From the quotient of the values a and a', for example, the efficiency value 0.75 is derived. This value indicates that the output achieved is a quarter less than the output that would be possible with more efficient use of resources.

Figure

Output-oriented efficiency measurement



Source: graph by DIW Berlin. **DIW** Berlin 2010

shows that this was attributable primarily to the dynamic pace of development in the USA, which has been making strides as an innovator in the pharmaceutical industry in particular.

… but a decline in efficiency in knowledge-intensive services

Germany also registered a relatively high efficiency value (0.94) for knowledge-intensive services in 1995. Particularly worthy of note are publishing and printing, telecommunications, and business-oriented services. Germany, along with other countries, represented the benchmark for efficient production in all three sectors in 1995.

While Germany's position improved in the research-intensive industries, its position with respect to knowledge-intensive services deteriorated to a value of 0.88. Far from being limited to particular sectors, this negative development was observed along a broad front. The telecommunications sector stood out in a more positive light as it once again achieved an efficiency value of 1 in 2005.

In comparison with other countries, the efficiency of knowledge-intensive services in Germany in 2005, though still higher than in Japan, no longer exceeded the average value of the other EU countries considered here. This was due primarily to the positive direction taken by efficiency levels in Great Britain and the Netherlands. At the same time, Germany continued to lag behind the USA by ever wider margins.

Conclusion

Over the last few years, Germany's production portfolio has further shifted towards research-intensive goods and knowledge-intensive services. The most important mainstays of this economic structure are sectors that fall under the category of high-level technologies such as machinery and automotive manufacturing. But cutting-edge technology sectors such as medical and precision instruments have also

Table 2

Efficiency values for research- and knowledge-intensive sectors

Measure of efficiency less than or equal to 1

	Nace code	Germany		Europe[1]		Japan		USA	
		1995	2005	1995	2005	1995	2005	1995	2005
Pharmaceuticals	244	0.86	0.71	0.76	0.63	0.94	0.92	1.00	1.00
Office machinery and computers	30	1.00	1.00	0.93	0.84	0.90	0.89	1.00	1.00
Communication equipment	32	0.77	0.89	0.78	0.68	0.74	0.97	1.00	1.00
Medical and precision instruments	33	0.78	1.00	0.75	0.79	0.54	0.39	1.00	1.00
Aircraft and spacecraft	353	0.73	0.77	0.70	0.78	–	–	1.00	1.00
Cutting-edge technology		**0.82**	**0.89**	**0.78**	**0.71**	**0.76**	**0.88**	**1.00**	**1.00**
Chemical products	24[2]	0.89	0.70	0.75	0.64	0.93	0.52	1.00	1.00
Machinery and equipment	29	0.93	1.00	0.81	0.71	0.70	0.52	1.00	1.00
Electrical machinery and apparatus	31	0.79	1.00	0.78	0.71	0.67	0.53	1.00	1.00
Motor vehicles	34	1.00	1.00	0.78	0.70	0.90	0.94	1.00	1.00
Other transport equipment	35[3]	0.73	0.76	0.69	0.75	–	–	1.00	1.00
High-level technology		**0.92**	**0.94**	**0.78**	**0.69**	**0.80**	**0.68**	**1.00**	**1.00**
Research-intensive manufacturing industries		**0.90**	**0.93**	**0.78**	**0.70**	**0.79**	**0.75**	**1.00**	**1.00**
Publishing and printing	22	0.99	0.73	0.90	0.74	0.74	0.47	1.00	1.00
Post and telecommunications	64	1.00	1.00	0.77	0.77	0.91	0.78	1.00	1.00
Financial intermediation	65	0.82	0.95	0.87	0.90	1.00	1.00	1.00	1.00
Insurance and pension funding	66	0.96	0.92	0.84	0.86	1.00	1.00	1.00	1.00
Other financial activities	67	1.00	1.00	0.93	0.82	–	–	–	–
Computer and related activities	72	0.95	0.73	0.63	0.81	0.86	0.68	1.00	1.00
Research and development	73	0.75	0.70	0.95	0.93	0.83	0.75	1.00	1.00
Other business activities	74	1.00	0.95	0.73	0.85	0.51	0.52	1.00	1.00
Health and social work	N	0.88	0.77	0.95	0.95	0.73	0.63	1.00	1.00
Recreational, cultural, and sporting activities	92	1.00	0.89	0.80	0.82	0.99	1.00	1.00	1.00
Knowledge-intensive commercial services		0.94	0.88	0.84	0.87	0.83	0.75	1.00	1.00

1 Countries selected: Austria, Czech Republic, Slovenia, Finland, the Netherlands, Denmark, Sweden, Italy, Portugal, and Great Britain.
2 Without the pharmaceutical industry (244).
3 Without aircraft and spacecraft (353) and without shipbuilding (351).

Sources: EU KLEMS Database; calculations of DIW Berlin. **DIW** Berlin 2010

Many research-intensive manufacturing industries in Germany represent the benchmark and are just as efficient as their counterparts in the USA. The knowledge-intensive services are no less efficient than in the rest of Europe or in Japan.

contributed to the crucial importance of technology-intensive industries in Germany. Knowledge-intensive services, by contrast, account for an only average share of total value added in Germany as compared to other countries.

In the past, with its broad product portfolio of research-intensive goods and the business services to accompany them, Germany was highly successful in both domestic and international markets. Until 2008, the competitive strength of companies in this segment and a healthy global economy were the driving forces behind Germany's overall economic growth. The onset of the financial crisis had a dramatically chilling effect on the global economy, however. The demand for investment goods decreased sharply across all sectors. In 2009, unusually severe contractions in production were forced upon what had been the most important growth sectors in the high-level technology category.

Nevertheless, with its research-intensive industries, Germany occupies a position from which its medium- and long-term prospects are favorable in comparison to those of other countries. Both technological progress and the economic modernization process in regions such as Eastern Europe and in many parts of Asia will increase global demand for investment goods. This is an area in which German vendors have a strong presence with the most technologically advanced products.

Germany has the distinction of having a wide-ranging product portfolio that covers virtually the entire spectrum of high-level technologies, a large share of cutting-edge technology, and some associated business-oriented, knowledge-intensive services. Germany's industrial sectors are well represented in important future markets with a cross-sectional character, such as transport, healthcare, energy production, and environmental and climate protection.

Research-intensive goods especially are produced with extreme efficiency. Germany has become the benchmark for efficient production in virtually every key sector of research-intensive industry. This has enabled it to defend, and even increase, its market shares against nations with a considerably more favorable cost level.

(First published as "Deutsche Industrie durch forschungsintensive Güter erfolgreich", in: Wochenbericht des DIW Berlin Nr. 9/2010.)

DIW Berlin
Mohrenstraße 58
10117 Berlin

Tel. +49-30-897 89-0
Fax +49-30-897 89-200

ISSN 1860-3343