

## D DETAILED REPORT ON RESEARCH AND INNOVATION IN GERMANY

### D 1 CURRENT ECONOMIC STRUCTURES

In this section we examine data from the fields of production, foreign trade, and employment particularly with regard to research-intensive and knowledge-intensive sectors.<sup>73</sup>

#### Strong trend towards a knowledge-intensive economy

Between 1995 and 2007 the gross domestic product of Germany increased by some 20 per cent in real terms, in the EU-15 member countries by 30 per cent, and in the USA by almost 45 per cent. In Japan the growth was lower at about 15 per cent. After a stagnation phase between 2001 and 2003, Germany belatedly resumed a path of growth and from 2005 once again showed stronger growth. But despite this improved dynamic it has not been able to catch up again after falling behind over the past ten years.

These values conceal very different structures for research- and knowledge-intensive sectors and the rest of the economy. The contribution of the research- und knowledge-intensive section of the economy to total value added in Germany increased between 1995 and 2005 from 40 to 46 per cent – indicating a clear structural change in favour of this sector.

#### Value added in the research-intensive industries

In the Manufacturing, the increase in value added and the growth in employment are attributable mainly to research-intensive sectors; more than 80 per cent of the growth in industrial production since the mid-1990s comes from the research-intensive sectors. The expansion in the 1990s resulted primarily from the stable growth of the automotive manufacturers and suppliers, from the chemical industry, and from mechanical engineering. The year 2000 marked a turning point in the economic development. Until 2003 the production in the R&D-intensive industries grew on average by only one per cent per annum, but since 2004 they have profited from a growing demand both internationally and domestically. The production in research-intensive industries increased annually from 2003 to 2006 by 6.3 per cent on average. The other industries only achieved an annual increase of 2.5 per cent. This accelerated the increasing orientation of German industrial production towards research-intensive products. R&D-intensive industries accounted for some 53 per cent of industrial production in 2006 (Figure 07).

In the current upswing there has been an annual average growth of production in the cutting-edge technology section of research-intensive industry of 11.5 per cent from 2003 to 2006. This is primarily attributable to ICT technologies – once again the most dynamic sector with annual growth rates of 20 to 30 per cent. High-level technology also showed considerable increase in production between 2003 and 2006, particularly in mechanical engineering. Thus there is a structural change towards the cutting-edge technologies, however the contribution to value added in 2005 was only three per cent compared with twelve per cent for high-level technology. Thus in the medium-term there will only be a slow change of the current weights between high-level technology and cutting-edge technology.

#### Strong links between research-intensive industry and knowledge-intensive services

The growth in production in Germany has not in fact led to the creation of additional jobs. On the contrary, between 1995 and 2006 employment in research-intensive industry fell by

twelve per cent. However in the rest of industry it fell by 18 per cent, so that the research-intensive sectors have prevented an even greater overall decline in industrial employment (Figure 03).

Research-intensive industries have concentrated more on their core-competence, namely making end-products. They have developed horizontal production structure and have outsourced pre-production to non-research-intensive industries, the services sector, and to other countries. Between 1995 and 2000 the value added in the research-intensive industries sank annually by 3.7 per cent. The result was a reduction in jobs in the research-intensive industries.

The knowledge-intensive services have shown particularly high rates of growth. Between 1995 and 2005 their share of value added increased from 27 to 31 per cent. In 2006, knowledge-intensive services employed almost 41 per cent of the personnel working full-time in the business services economy and of almost 25 per cent of those in the total commercial economy. The expansion of services is above all attributable to outsourcing and pre-performance cooperation between industrial companies and service providers. Their demand for high-value pre-products and equipment means that service providers are increasingly becoming a driving force in innovation processes. As in other industrialised countries, the German economy is going through a double structural change:

- The growth in the industrial sectors is moderate in comparison with the services sector – the employment balance since the start of the 1990s has been clearly negative.
- Knowledge-intensive and research-intensive sectors of the economy are expanding in both in the manufacturing and services sectors.

#### Growing contribution to employment by knowledge-intensive services

In contrast to manufacturing industry, the services have made a positive contribution to employment in Germany since the mid-1990s, more so in the case of the knowledge-intensive services than other services (Figure 03). In the knowledge-intensive services, the number of hours worked between 1995 and 2006 rose by 22 per cent, and in the other services by three per cent. Similar tendencies can be observed internationally. Employment in the industrial sector is declining in most developed economies, although to a lesser degree in the research-intensive industries than in the non-R&D intensive ones. In contrast, in the knowledge-intensive services sector there has been a broad increase in hours worked everywhere, although in Germany there was a period of stagnation in the development of employment at the start of this decade.

#### German weakness in labour productivity

Labour productivity is an important indicator, and in Germany in 2005 it was 18 per cent higher for the business economy than in 1995. However a long-term comparison shows a noticeable weakening in productivity growth. Within the economy as a whole, the R&D-intensive industries show growth of some 45 per cent, considerably above the average. But over the same period R&D-intensive industries in the USA achieved a growth in productivity of 150 per cent, and the EU-15 of 120 per cent. Compared with the USA, Germany lagged behind on average by 5.5 per cent per annum. Productivity in the knowledge-intensive services in Germany grew between 1995 and 2005 by eight per cent, which is much lower than in the manufacturing industry, although this corresponds to the usual structures for the services. Germany again does not do well in an international comparison. Labour produc-

tivity increased in this period in the USA by 28 per cent and in EU-15 by 21 per cent.

Regarding the components of productivity growth, a comparison between Germany and the EU-15, the USA, and Japan shows that the hours worked in manufacturing industry is declining in each case, whereas there is an increase in the hours worked in the knowledge-intensive services. The use of ICT capital goods is particularly important for the increase in labour productivity in the knowledge-intensive services, and here too Germany lags behind its competitors. The high level of growth in the research-intensive industries is based primarily on the improved properties of technical products. Here Germany is much worse than the USA and Japan. In addition, in the United States the increased use of ICT capital also plays a significant role in the manufacturing industry. The combination of both factors explains the lead role of the USA in the development of labour productivity.

In all, Germany has improved the presence of research-intensive goods and knowledge-intensive services in its economic portfolio. Measured in terms of hours worked and valued added, the economic structure of Germany stands up well to international comparisons, with the most important factor being the high-level technology. This has been possible despite the fact that the period from 1995 to 2005 was one of weak growth in the German economy: sectors which were less knowledge-intensive had no growth opportunities in this period. At the same time, productivity development increasingly lagged behind that of important competitors. This was the case for all sectors, but in particular also for research-intensive industries and knowledge-intensive services. Germany does not have a direct structural problem, but does have a serious problem of dynamics.

#### Germany top for the proportion of value added by the knowledge-intensive sector of its economy in international comparison

In a recent comparison of the contribution of the knowledge-intensive sector of the economy to total value added, Germany came out ahead of the USA, the EU-15, the EU-10, and Japan. It has meanwhile even overtaken the USA, which in 1995 still held a considerable lead. This is due above all to the value added by high-level technology. The contribution of

the knowledge-intensive services has also increased considerably over the past decade. The 31 per cent of value added in 2005 is well above that of EU-15, but still less than that of the USA, which was about 36 per cent (Figure 08).

#### German specialisation in high-level technology

An international comparison highlights Germany's strong and growing specialisation in research-intensive industries and in particular in high-level technology. Germany has meanwhile reached an average value for cutting-edge technology products. In the comparison of EU-15, USA, Japan, and Germany, only Japan currently shows marked specialisation here, with its strengths in the computer industry and in media technology. Germany's cutting-edge technology is focused on measurement technology, medical engineering, and pharmaceutical products.<sup>74</sup> Only the USA shows above-average specialisation in the knowledge-intensive services, with Germany at least reaching an average value in this case.

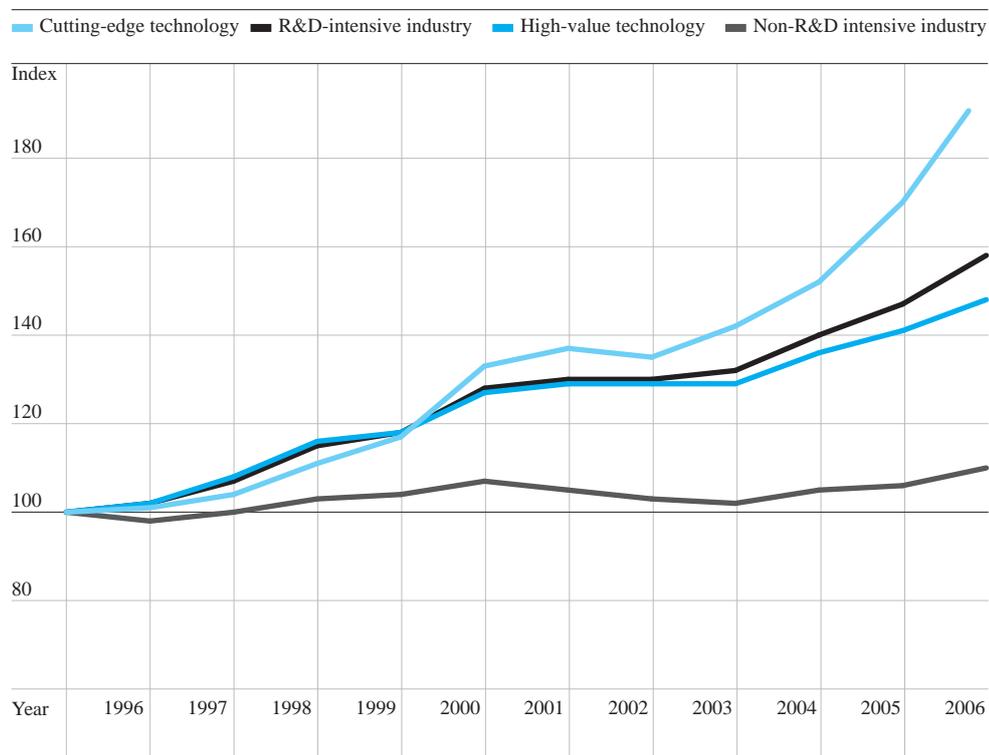
#### Export successes with high-level technology

The production sector in Germany relies heavily on exporting its products. With an export ratio of about 38 per cent in 2006, Germany was well ahead of all other large industrialised countries. Only smaller countries such as the Netherlands, Austria, or Sweden have higher export ratios. At the same time, the German import ratio of about 31 per cent is also comparatively high. In 2005, research-intensive products accounted for some 56 per cent of exports and 51 per cent of imports of OECD countries. These figures have declined since the year 2000, but are still considerably above those in 1993.

In foreign trade there was a decline above all in cutting-edge technology products, whereas high-level technology products increased further in significance. The decline in trade with cutting-edge technology products can be attributed above all to the end of the New-Economy boom in 2001, which was strongly influenced by ICT products. The proportional decline of cutting-edge technology is also due to the changes in prices in relation to non-R&D-intensive products, because processed goods with low technology content have become noticeably more expensive since the year 2000 due to the rising costs of raw materials.

Net production in R&D-intensive industrial sectors in Germany

FIG 07

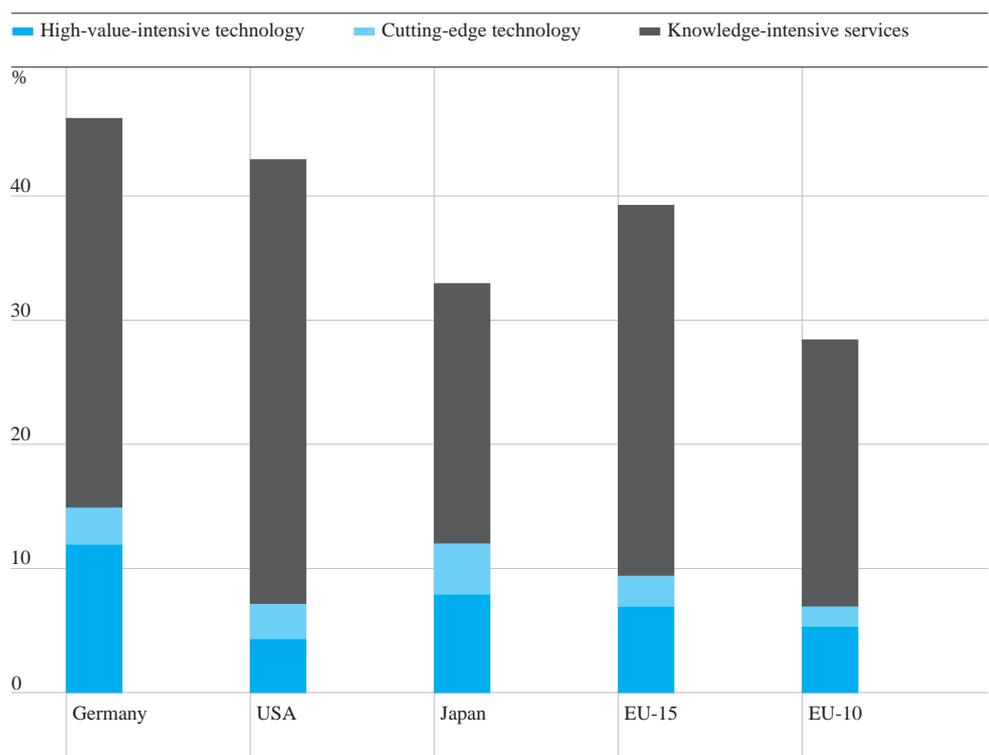


Index 1995 = 100.

Source: Statistisches Bundesamt, Calculations by NIW.

Contribution of R&D-intensive industries and knowledge-intensive services to total value added in 2005

FIG 08



Source: EUKLEMS Database 11/2007. Calculations and estimates by DIW.

German foreign trade with R&D-intensive products has grown considerably faster than trade with other processed industrial goods, and this applies equally for imports and exports. In cutting-edge technology, medical equipment and measuring technology products are the most important exports, whereas computer equipment and medical and measuring technology are in the lead among the imports. Foreign trade with high-level technology is dominated by the automotive industry, which accounts for more than half of the exports and imports. Mechanical engineering products are a considerable way behind in second place, and then again some distance behind follow chemical and electrical engineering products.

#### Shrinking advantage in foreign trade

» D 2 Looking at the foreign trade balance, Germany is showing a deficit regarding cutting-edge technology products, but a surplus with high-level technology products. These structures are usually analysed in terms of the Revealed Comparative Advantage (RCA) index.<sup>75</sup> A positive value of this index is interpreted as a showing of a foreign trade position for a specific group of a country's products which is stronger than its overall economic position. Since the beginning of the 1990s, there has been a gradual decline in the values of this RCA index for Germany, because imports have increased more rapidly than exports. For cutting-edge technology products, the values are clearly negative (Figure 09), whereas for high-level technology the index is positive. Overall, the foreign trade position in high technology is slightly above average, although showing a downward trend.

The influence of various categories of products on Germany's competitive position is demonstrated by their relative contribution to the balance of trade. A comparison over the past decade shows that the figures for R&D intensive goods have declined markedly from 3.8 in 1996 to 1.5 in 2006 (Figure 10). For cutting-edge technology goods the figures are even more negative, and for high-level technology the positive value has fallen. However, the overall profile of specialisation has hardly changed. Significant positive contributions are provided by automotive manufacturing and mechanical engineering. The values are negative for telecommunications, office machinery, and computer equipment. There has been a reversal from positive to negative in the cases of chemicals and pharmaceutical products. In all, the strengths and

weaknesses in foreign trade are a reflection of the production situation.

It is more difficult to judge Germany's position in foreign trade with knowledge-intensive services due to the shortage of good data, and various special factors. The balance of payments has improved between 1999 and 2006 for all knowledge-intensive services. However, direct exports only cover a small part of the trade in these services. They can frequently only be sold through local subsidiaries, because the performances require direct contacts with the customers. Almost all knowledge-intensive services generate a large proportion of their turnover through their foreign subsidiaries, and this business has been growing more rapidly in recent years.

#### RESEARCH AND DEVELOPMENT

Research and development (R&D) in business, universities and scientific institutions plays a central role in the chain of education and qualification, science, research and technology, inventions, investments and innovations, productivity, international competitiveness, growth and employment.<sup>76</sup> All empirical studies show a generally positive influence of R&D on macroeconomic parameters. In addition, however, there are a series of other influential factors, complex interactions and a variety of pre-conditions. In short, R&D in highly developed economies is necessary but not sufficient for innovation processes. Given the importance of research-intensive industries and knowledge-intensive services for production, the generation of employment, and foreign trade, R&D is a key element for the development of the technological potential of Germany.

#### In-house research and development increasingly important for companies

More innovators in Germany are carrying out their own R&D. In 2006, two-thirds of industrial innovators carried out their own R&D, whereas in 1998 it had been a half. Germany has a good position for R&D in an international comparison. In the 1980s it was one of the leading industrialised countries – in a phase in which R&D capacities was expanding very rapidly worldwide. This had been the result of an enormous intensification of R&D in Germany in almost all branches of industry, together with a transformation of the industrial structure and a shift