weight in patents compared to high-level technology and therefore has a greater effect on the sum of both sectors, that is high technology (see Box 04).

Strong specialisation in automotive technology, weak values in ICT

Patents can be used to obtain a fine differentiation in terms of sub-sectors. A profile of German patent specialisation shows which fields contribute to the strengths and weaknesses in the high-technology sector. As in the analysis of research and development, the automotive sector is in first place, and engines, motors, and drive technology also ranks highly (Figure 5). These are followed by sub-sections of mechanical engineering such as machine tools or special machines. In measuring and control technology, the strength of high-level instruments is apparent, whereas the advanced instruments category has an index which is slightly below the world average. In the cutting-edge technology, the patent analysis shows negative values for computer equipment, telecommunications, radio and television technology, and also for biotechnology and pharmaceuticals, which illustrates the technology background to the relatively low values of the cutting-edge technology for other innovation indicators classified by products or economic sectors.

D 5 NEW ENTERPRISES

The entrepreneurial dynamic is an important aspect of the technological structural transformation. The foundation of new companies as well as the closure of companies which are not successful can stimulate competition for the best solutions.[89]

New enterprises with new ideas can extend and modernise the range of product and services on offer, and they are a challenge to existing companies. New enterprises in research and knowledge-intensive sectors of the economy have a special significance. However, bringing new ideas onto the market also involves risks and uncertainties. The competition among young, innovative companies and with established companies can be intense, and inevitably some of the new enterprises will not be able to survive in the long term. But even 'failed' new enterprises contribute to structural change. The business ideas they introduced and the innovative options they chose have either failed or they have been adopted more successfully by other companies, and possibly marketed in an improved form.

There have been various phases of starting up new enterprises in Germany. The numbers of start-ups remained fairly constant from 1995 to 1998. They then declined by an average of five per cent per annum between 1999 and 2002, and increased markedly in 2003 and 2004 by about ten per cent per annum, before returning in 2005 and 2006 to the level of 1995.

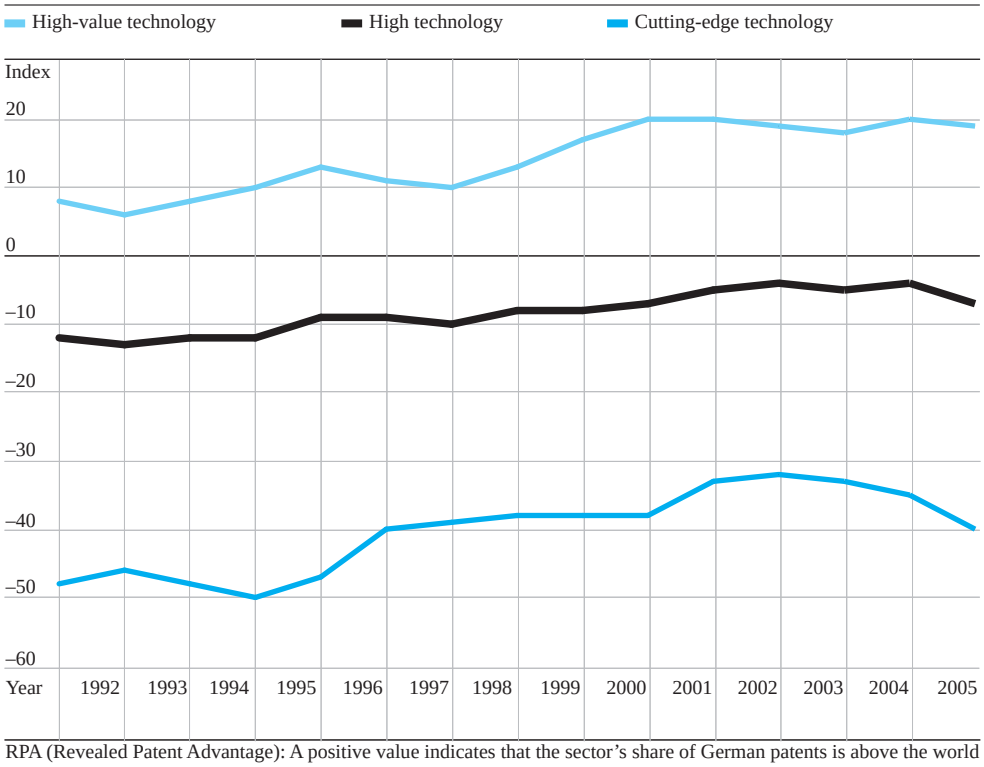
Fewer foundations of knowledge-intensive enterprises after the New-Economy boom

In 2006, 13 per cent of all new enterprises were involved in knowledge-intensive services, whereas the research-intensive manufacturing sector only accounted for about one per cent. From 1995 to 2000 the share of the new enterprises which were in the knowledge-intensive services had increased from 13 per cent to more than 15 per cent. There was a small surge in the foundation of new enterprises in 1999 and 2000, in particular for ICT services. This was clearly attributable to the New-Economy boom. When this collapsed, the trend was reversed and the share of the knowledge-intensive services declined significantly until 2004.

Knowledge-intensive services can involve knowledge-intensive consultancy (management, law and finances, advertising) and the technology-oriented services (telecommunications, computers, office technology, R&D-services). The technology-oriented services were affected by the New-Economy boom and bust, whereas the knowledge-intensive consultancy services proved more stable and are currently slightly ahead of the levels in the mid-1990s (Figure 19).

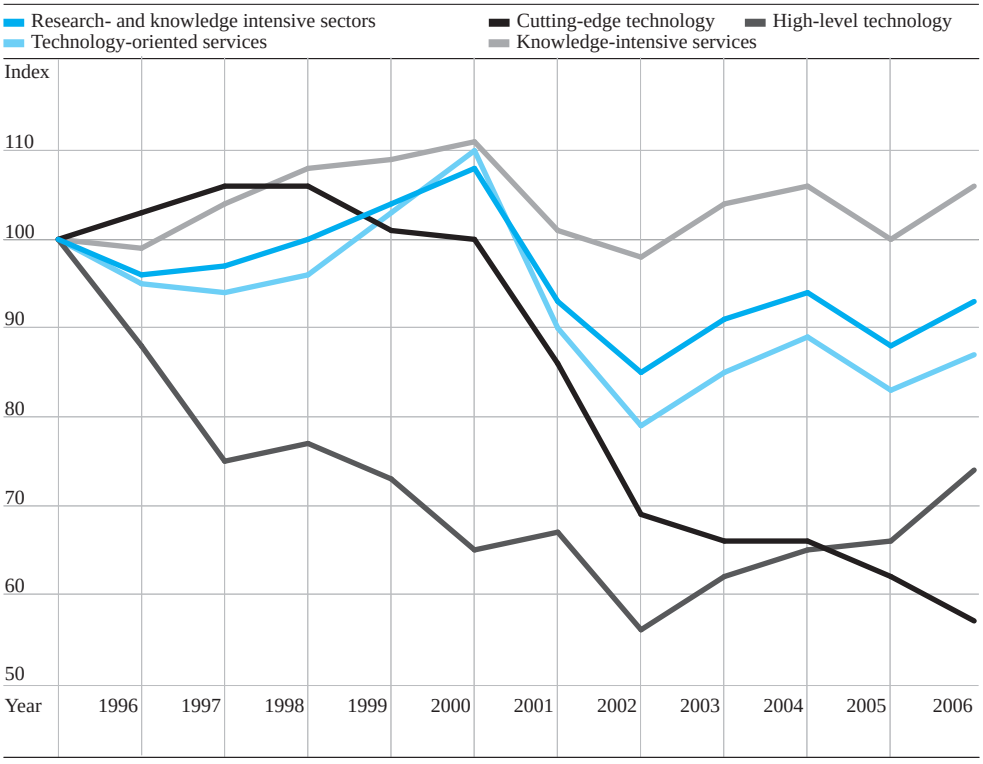
The proportion of the new enterprises which are in the research-intensive manufacturing sector has declined steadily since the mid-1990s, and only began to increase again slightly in 2006. But the absolute numbers of new enterprises have hardly been affected by the research-intensive manufacturing sector, i. e. the classic cutting-edge technologies such as pharmaceuticals and biotechnology, medical engineering, metrology/optics, electronics, or aeronautics and astronautics. It would be premature from the slight increase in 2006 to expect a new wave of technology start-ups, because

Specialisation (RPA) of Germany in high-technology sectors FIG 18



RPA (Revealed Patent Advantage): A positive value indicates that the sector's share of German patents is above the world average.[90]
Source: Databases EPPATENT, WOPATENT (Questel-Orbit). Calculations by Fraunhofer ISI.

New enterprises in Germany in research- and knowledge-intensive sectors FIG 19



2006: provisional values. 1995 = 100.
Source: ZEW-Gründungspanel. Calculations by ZEW.

the current levels are still well below those at the start of the decade.

High barriers to starting up in the research-intensive manufacturing sector

The start-up rate, the number of new enterprises as a proportion of all companies, is an indicator of the regeneration of a sector of the economy. The figures show that the start-up rates for the knowledge-intensive services (technology-oriented services seven per cent, knowledge-intensive consultancy eight per cent) are much higher than those in research-intensive manufacturing (four per cent). The low start-up rate for the research-intensive manufacturing sector is an indication of the comparatively high barriers to entering this sector. In addition to the demands up-front for property, plant and equipment and to cover the development of products, entrepreneurs also encounter difficulties dealing with financing and recruiting a workforce, and in many market sectors will also have to confront the dominance of large companies. In the case of knowledge-intensive services the barriers to starting up are usually lower, both in terms of finance and also human resources, and in most sectors the competitors will be other small companies.

Numbers of company closures now declining again

At the same time as new enterprises are starting up, other companies are closing down. Annual closures increased steadily in Germany from 1995 to 2004, peaking at 290 000. In 2005 and 2006 there was a slight decrease. At first sight it seems surprising that numbers of closures increased even during the economic upswing at the end of the 1990s. A reason for this could be the competition between small companies following the relatively large numbers of new enterprises started in the 1990s. The numbers of closures rose sharply in the period of economic stagnation in 2001 and 2002.

Above-average numbers of knowledge-intensive service companies closed down, and their share of all closures increased from seven per cent in 1995 to nearly twelve per cent in 2001. Since then the proportion fell again to ten per cent (2006). Research-intensive manufacturing companies accounted for 1.5 per cent of closures in (1995) but this declined to 0.7 per cent in 2006. For cutting-edge technology, knowledge-intensive consultancy and technology-oriented services the closure dynamic basically followed the general pattern. In the case of the high-level technologies the numbers of annual closures remained virtually constant from 1995 to 2005, but there were fewer closures in 2006.

From 1995 to 2005 the annual closure rates (the number of closures in a year proportional to the numbers of companies in the sector) in the research und knowledge-intensive branches of the economy were below the general average. The rates were particularly low for cutting-edge technology and high-level technology.

Positive development of company stock in the knowledge-intensive sector

The relationship between start-ups and closures can be used to assess the entrepreneurial dynamics of a sector and these are important indicators of technological potential, showing the direction and the extent of structural change. The rate of change of the company stock, which corresponds to the balance of start-up and closure rates, was positive for the economy as a whole from 1995 to 2001, and for the research- and knowledge-intensive sectors, in other words the annual average of the number of active companies in Germany increased. Since 2002, the total numbers of companies in all sectors have declined year on year, and only increased again slightly in 2006. In the research- and knowledge-intensive sectors of the economy, in contrast, the number of companies decreased in 2002, but then start-ups and closures balanced each other out in 2003, and numbers began to increase again from 2004 onwards. Among the research- and knowledge-intensive sectors, the knowledge-intensive services had the most positive development in the numbers of companies.

Germany in a medium position as to start-up rates

An international comparison of start-up rates is a good way to assess the developments in Germany. The start-up rates, the number of new enterprises as a proportion of all companies, prove to be a good basis of comparison, because the differences in the definition of enterprises between countries are to some extent equalled out. The highest start-up rates among the 15 selected countries were in Great Britain, France, and the USA, where start-up companies in 2003 or 2004 represented 12 to 14 per cent of the total number of

Glass fibres

Deformed aluminium profile

companies. The start-up rate in Germany was eight per cent in 2004, which gives it a medium-to-low ranking; Japan (two per cent) and Switzerland (three per cent) had by far the lowest start-up rates.

For research-intensive manufacturing, Great Britain and the USA came out top, but Germany had a relatively low rate here of about three per cent, and only Japan had a lower value with 1.5 per cent. In all countries except Great Britain the start-up rates for knowledge-intensive services were above those for their overall economy. The highest rates are in Denmark, Norway, Great Britain, the USA, and France. Germany again finished well down the rankings in this category, with a start-up rate of about eight per cent.

Relatively low German closure rates

Not only are start-up rates in Germany comparatively low, but so are closure rates in an international comparison. This is not surprising, because high barriers to market entrance also act as protective barriers for those already inside. With an average value of eight per cent over all sectors, the numbers of closures as a proportion of all companies is much smaller than in Great Britain, France or the USA. General closure rates are only lower in Sweden, Japan, Portugal, and Switzerland. In the research-intensive manufacturing sector, Germany had a closure rate of about four per cent in 2004 – the lowest level behind Switzerland and equal with Sweden. A closure rate of seven per cent in the knowledge-intensive services in Germany was a medium value.

Moderate German company turnover

The comparison between countries shows that high start-up rates tend to go together with high closure rates, just as low start-up rates go together with low closure rates. It is therefore not possible to conclude from high start-up rates that the numbers of companies are increasing rapidly. The countries with a dynamic company structure (i. e. low barriers to market entrance and exit) include the USA and Great Britain, and also France, the Netherlands, Norway and Denmark. This applies both for the general economy and the research-intensive and knowledge-intensive sectors (Figure 20). An indicator for this is the company turnover – the sum of start-ups plus closures in relation to the number of companies. For the research-intensive manufacturing sectors, only Japan and Switzerland were less dynamic than Germany, although for the knowledge-intensive services Sweden, Spain, Portugal, Japan, and Switzerland were all behind Germany.

In addition to the structure and intensity of the start-up activities, the development of the start-up numbers over time is another important measure for international comparisons of start-up dynamics. The analysis of the data for Germany shows a marked decrease in the numbers of start-ups in the research-intensive manufacturing sector over the past ten years, whereas there was increasing start-up activity in the knowledge-intensive services in 1999/2000 and again since 2002. The other major economies with specialisation in knowledge-intensive economic sectors, i. e. USA, France, and Great Britain, show a basically similar development. However, Germany is somewhat less dynamic both in the general economy and in the research- and knowledge-intensive sectors.

In the research-intensive manufacturing sector Germany and the other large economies have decreasing numbers of start-ups. However, nowhere was this decline as pronounced as in Germany.

Even in the USA, there was a decline in the research-intensive manufacturing sector. This is in stark contrast to the public attention paid to the foundation of new companies in biotechnology and the computer industry. A few very dynamic sectors are not enough to start a general start-up boom.

Favourable development of company stock also in international comparison

Despite the lower start-up rates and weak company dynamics, the company stock in Germany grew more through until 2001 than in the comparison countries. In 2001 the level was 18 per cent above that in 1995, compared with a net increase of 8 per cent in Great Britain, and of five per cent in both the USA and in France. The larger number of company closures in 2002 and 2003 in Germany coupled with lower numbers of start-ups led to a drop in the number of companies, while numbers continued to increase in the USA and above all in Great Britain. Overall, however, the company situation in Germany is favourable, because the closure rates are still considerably lower than in the other countries.

The situation is more varied in the research- and knowledge-intensive sectors. In the research-intensive manufacturing sector there have hardly been any changes in the numbers of companies in the USA, Germany, France, and Great Britain. In the knowledge-intensive services, Germany was able to keep up with the international trend of increasing numbers of companies through until 2000. But from 2001 the number of active companies stagnated, whereas they continued to increase in Great Britain and France. In an international comparison, the start-up activities in Germany have four special features:

– The company dynamic is very low. Both the numbers of start-ups and of closures are lower in relation to the overall numbers of companies than in most other countries.
– The structure of the start-up activity is less strongly directed to research- and knowledge-intensive sectors of the economy than in the other highly developed countries.
– The development of company start-ups over time is relatively weak, in particular for knowledge-intensive services.
– Nevertheless the number of companies has developed more favourably than in the other countries, because the low rate of start-ups has been compensated for by a low rate of closures.

It is positive that the number of companies has increased more in Germany than in other countries. However, from the point of view of promoting innovation, the low number of newly founded companies is relevant. The innovation pressure on existing companies is lower, fewer innovation impulses are provided by start-ups, and fewer innovation ideas are tested for their acceptability and market relevance. In Germany the barriers faced by new companies wishing to enter markets are higher by international standards, but the established companies then receive better support.

D 6 EDUCATION AND SCIENCE

The structural change in Germany over the past decade towards a research- and knowledge-intensive economy has consequences for the demands on the qualifications of the workforce. There is a growing need for highly qualified personnel, in particular graduates from higher education, who play a key role in successful innovation. This is the case for research and development, where the demand is mainly for natural scientists and engineers, as well as for the knowledge-intensive services, for which other graduates are also required. This section addresses aspects of education which are particularly relevant in the context of research and innovation.[91]

Increasing numbers of graduates due to knowledge intensification

In 2006, some 1.85 million graduates were working as employees in the commercial sector in Germany, with 682 000 natural scientists and engineers, and about 1.2 million graduates in other disciplines. About three-quarters of each group were employed in knowledge-intensive sectors. The numbers are even higher if the total workforce is considered, because in particular in the services sector many graduates are self-employed. Whereas almost 60 per cent of natural scientists and engineers work in the manufacturing sector, some 70 per cent of other graduates are employed in the services sector. More than a third of graduates in the commercial sector are thus natural scientists or engineers; the demand in this sector is particularly high.

A steadily increasing proportion of the employees in the commercial economy are graduates, and in knowledge-intensive sectors, the percentages are on average four or five times higher