9 to 11; and India and Turkey are also still under the Top 20.

The OECD countries can no longer keep up with the (nominal) R&D-growth rates of the emerging markets. At 13 percent, the average annual growth of the emerging markets between 1996 and 2006 is more than double that in the OECD (6 percent). China has set the pace for R&D expansion since 1996 with 22 percent per annum, followed by the Baltic States with 14 to 18 percent. Singapore, Turkey, Hungary, Mexico and Taiwan also have R&D growth rates of above 10 percent.

As explained, a central indicator for assessing the technological potential of an economy is the intensity with which it conducts research and development: the R&D-expenditure relative to the gross domestic product (GDP). This established measure has to be used with more care in the case of dynamic emerging markets than with established countries, because the quotient is the result of a future-oriented factor (R&D) related to a current variable (GDP). Between 1991 and 2006 there have been some drastic changes to the situations of the countries considered here. Currently, the EU-15 average for R&D intensity (1.9 percent) forms a demarcation line between the research-intensive manufacturing economies and the emerging markets. The European and Latin American emerging markets are on average below 1 percent. Only the Asian emerging markets have been able to catch up from an initial R&D-intensity of below 1 percent (1996) to nearly 1.5 percent in 2006.

This is attributable in particular to the Tiger States but also to the performance of China. Measured in terms of EU or OECD averages, Singapore and Taiwan caught up some time ago; Korea has become an OECD member.

Korea, with an R&D intensity of 3.22 percent of gross domestic expenditure on research and development relative to GDP is ahead of the USA. Only Japan, Sweden, Finland and Israel have a higher R&D intensity. Taiwan follows close behind the USA with an R&D intensity of 2.58 percent, and is ahead of Germany (2.54 percent) and Singapore (2.31 percent) – all above the average for the OECD countries (2.26 percent).

C 3 INNOVATION ACTIVITIES OF GERMAN BUSINESSES

Innovation activities of companies are aimed at achieving at least a temporary competitive advantage over competitors. In the case of a product innovation, a new or improved good is launched with properties which differ markedly from goods already on the market.[106] The introduction of a new or improved production method is a process innovation. The following results, in which the innovation behaviour of industry and services are described, are based on the annual innovation survey of the *Zentrum für Europäische Wirtschaftsforschung (ZEW)*, the Mannheim Innovation Panel.[107]

Lower proportion of companies with product innovations

In 2007, the innovator rate in the German economy could not be increased, despite a favourable general economic situation. The proportion of companies which had introduced at least one new product or a new process within a three-year period remained constant in the R&D intensive manufacturing sector at 75 percent. In the rest of the manufacturing sector the innovator rate fell slightly to 49 percent. Only the knowledge-intensive services managed an increase in the proportion of companies with product or process innovations in 2007, to 54 percent.

The innovation activities of the company in the survey shifted somewhat in 2007 in the direction of process innovation. In the R&D intensive manufacturing sector there was a fall in the proportion of companies launching new products, from 69 to 66 percent. The proportion of companies using new or improved processes to manufacture their products remained constant at 45 percent. In the rest of the manufacturing sector the proportion of companies with product innovations fell from 39 to 37 percent. The proportion of process innovators also sank slightly to 31 percent. The proportion of product innovators in the knowledge-intensive services remained at 40 percent, the proportion with process innovations increased here slightly to 34 percent. The Expert Commission had already expressed concern in EFI Report 2008 about the long term decline in the innovator rate. This trend could not be reversed in 2007.

BOX 23

Indicators for innovation processes in companies

The Expert Commission research and innovation uses a series of indicators for the analysis of innovation processes in German companies.

Innovation input:

- Expenditure for innovation activities are differentiated according to the types of expenditure: Investments in fixed assets and non-tangible assets as well as current expenditure for personnel, material and advanced performances.
- The innovation intensity expresses the innovation expenditure in relation to total turnover.

R&D and innovation activity:

- The R&D activity shows the proportions of companies who continually, occasionally or never carry out R&D.
- Innovation activities can relate to product or process innovations. With product innovations, a distinction is made between innovations which are novel for the company providing them and innovations which are new to the market.
- The innovator rate shows the proportion of companies which have brought at least one new process or new product onto the market within the previous three years.

Innovation success:

- The success of product innovation is measured by the proportion of turnover generated with newly introduced products.

Slight increase in continuous R&D-activities of companies

Internal R&D-activities imply that companies have an innovation strategy aimed at producing original innovations, and do not simply pick up on innovation ideas from other companies. In the R&D-intensive manufacturing sector 64 percent of all companies carried out their own R&D activities in 2007. The proportion of continuously researching companies was 43 percent as in the previous year, and for companies occasionally conducting research and development there was a slight drop from 22 to 20 percent. The tendency is the same for the rest of the manufacturing sector. The proportion of the companies continuously carrying out research and development rose slightly to 14 percent, the proportion occasionally carrying out research fell from 17 to 15 percent. In the knowledge-intensive services, R&D involvement in 2007 was 17 percent, up 2 percentage points over the previous year, while the proportion of companies occasionally carrying out research and development was constant at 10 percent.

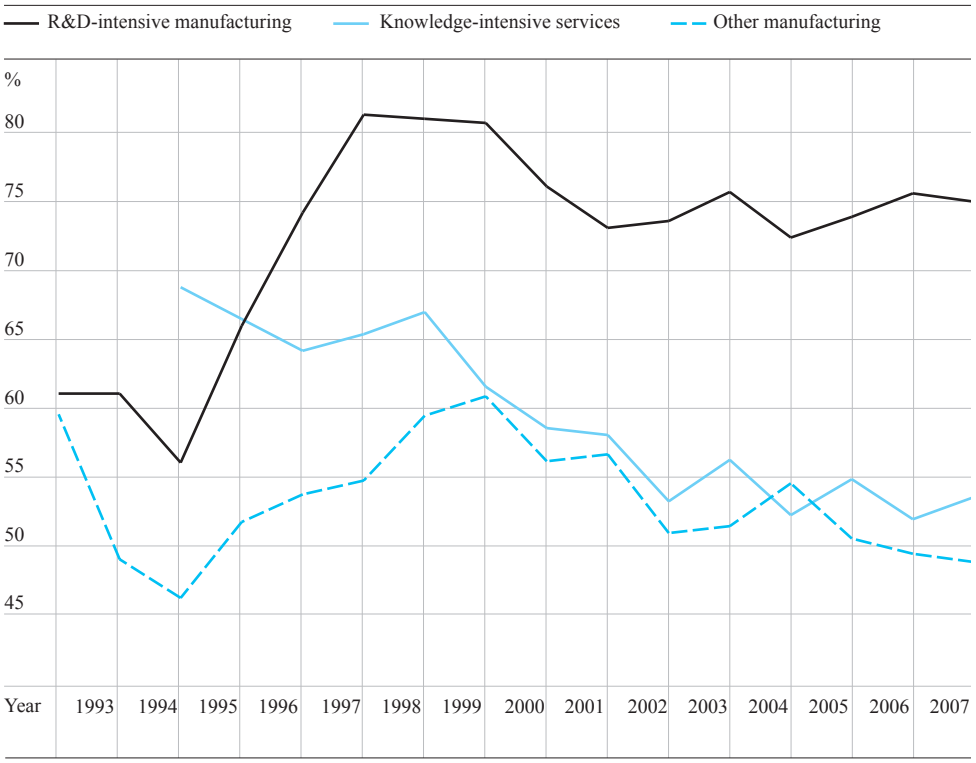
Innovation expenditure in the knowledge-intensive services less than planned

Expenditure on innovation activities in the R&D-intensive manufacturing sector has risen continually since 1999, and reached a volume of 72.5 billion euros in 2007 at current prices. This represented a nominal rate of increase of 6 percent over the previous year. There was the increase of 13 percent in the innovation budget in the rest of the manufacturing sector; however the long-term dynamic in this sectoral group was relatively weak. The total volume of innovation expenditure in the rest of manufacturing sector was 16.1 billion euros, which is considerably lower than in the R&D-intensive manufacturing sector. In the knowledge-intensive services, 21.4 billion euros was spent on innovation activities, which is 6 percent less than in the previous year. This decline could not initially be anticipated. In mid-2007, companies were expecting a growth in innovation expenditure to about 23.5 billion euros. The difference to the actual innovation expenditure is mainly due to the adjustments in the sectors Banks/insurance and IT (in particular telecommunications). If the innovation expenditure is considered in relation to the turnover of the companies, this provides a measure for the innovation intensity of the individual sector groups. For the R&D-intensive manufacturing sector there is a stagnant situation. In 2007, 6.5 percent of turnover was spent on innovations, as in the two previous years. In the rest of the manufacturing sector there was a slight increase in the innovation intensity from 2.2 percent in 2006 to 2.3 percent in 2007. The rate has been relatively stable since the year 2000. The innovation intensity in the knowledge-intensive services increased fairly steadily between 1995 and 2005, but fell slightly again in 2007 to 5.4 percent.

Lower share of innovation investment in the R&D-intensive manufacturing sector

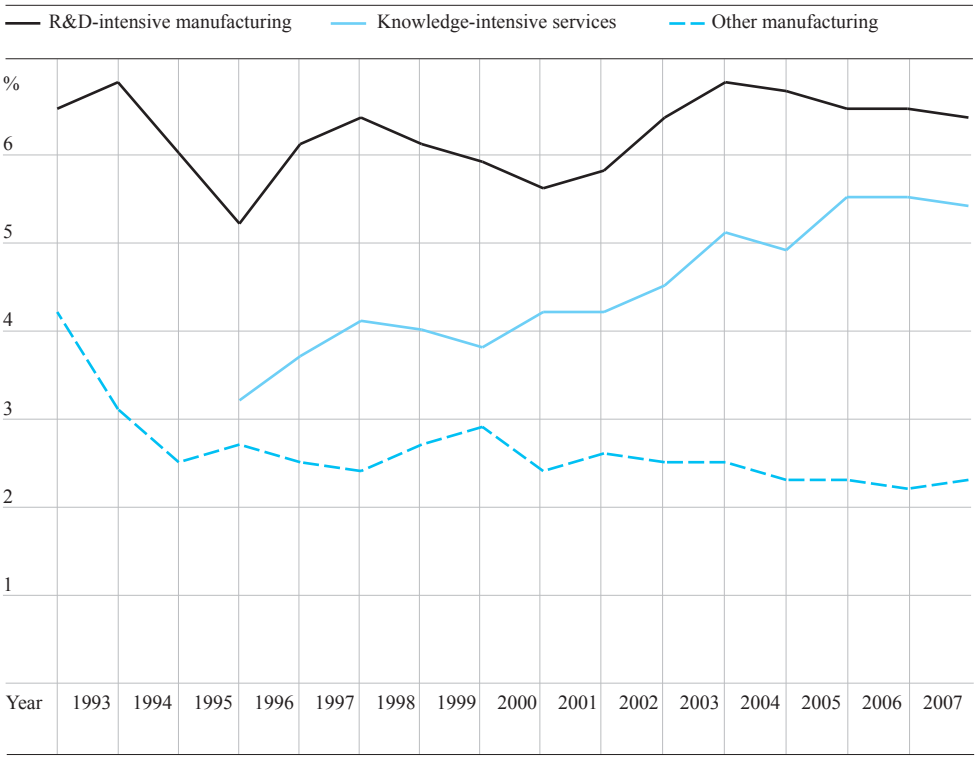
A part of the innovation expenditure of companies is investments which serve the introduction of new products or new processes. These include fixed assets (e.g. machines, buildings) and investments in imma-

Innovator rate in manufacturing and in the knowledge-intensive services in Germany FIG 19



1992, 1993 and 1995 not collected for knowledge-intensive services.
Source: Mannheimer Innovationspanel. Calculations by ZEW.

Innovation intensity in manufacturing and in the knowledge-intensive services in Germany FIG 20



As percentage of turnover of all companies. Knowledge-intensive services without banks and insurance.
Source: Mannheimer Innovationspanel. Calculations by ZEW.

terial assets (e.g. software and license rights). In 2007, the investments represented 27 percent of the total innovation expenditure in the R&D-intensive manufacturing sector. This was much lower that in the rest of the manufacturing sector, where investments accounted for 54 percent of innovation expenditure, and in the knowledge-intensive services where the figure was 38 percent. This result is not surprising, because in the cutting-edge technology and high-value technology a greater proportion of innovation budget is spent on personnel with innovation-related tasks, materials, and intermediate performances (including third party orders) than is the case in the rest of the manufacturing sector and the knowledge-intensive services. R&D-intensive manufacturing companies aim at generating innovation internally rather than purchasing innovation in the form of capital goods and non-tangible assets.

Although investments in the R&D-intensive manufacturing sector were a relatively small proportion of innovation expenditure, these expenses represented 52 percent of the total gross plant and equipment investments in the sector group. This rate has been growing over the past 15 years, in contrast the proportion of replacement investments and capacity expanding investments for products already established on the market, where the rates have declined. The result emphasises the importance of innovations in the R&D-intensive industry and also indicates the relatively short innovation cycles in this sector group. In the rest of the manufacturing industry, the proportion of innovation expenditure invested in plant and equipment since 1993 has been nearly 30 percent with slight annual fluctuations. There was an upward trend in company-related services between 2001 and 2005, and then the proportion of innovation expenditure invested in plant and equipment declined again to 21 percent in 2007.

Less innovation success with market novelties after the New Economy Boom

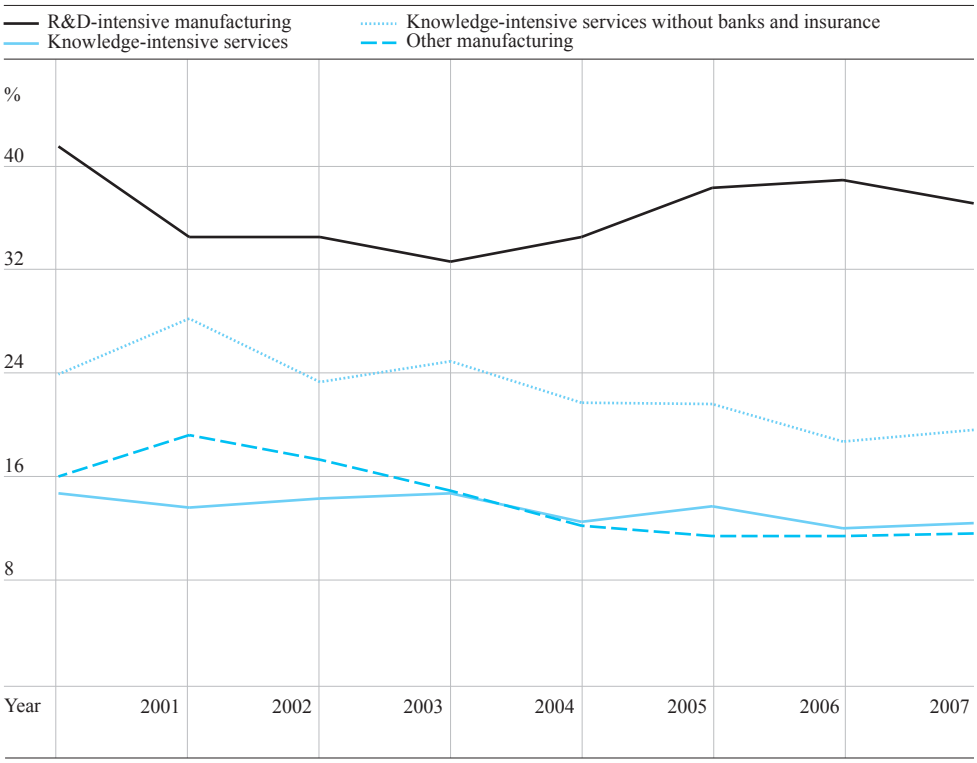
Innovations are risky. Many innovation projects fail because they are not technically successful or the product is not accepted on the market. The Expert Commission distinguishes between innovations which are new on the market, and those which are new for the company offering them, but which are not new for the market overall. Together they form the group of novel products, because innovation is first judged from the point of view of the provider. The success of product innovations can be measured by the share of overall revenue generated with new products. In the R&D-intensive manufacturing sector there was a decline in 2007 to 37 percent of the share of turnover the companies could achieve with products which had been launched not more than three years earlier. Growth had been achieved here for the previous three years. The companies in the rest of the manufacturing sector generated 11.5 percent of their turnover with new products. At 12.5 percent, the proportion in the knowledge-intensive services was a little higher than the sector groups just mentioned, but was way below the value for the R&D-intensive manufacturing sector. The innovation success in the knowledge-intensive services looked somewhat better if the credit and insurance sector was taken out. Then the share of turnover achieved with new products was 20 percent.

Market novelties are the most demanding and riskiest form of innovation. In the R&D-intensive manufacturing sector the share of turnover companies achieved with market novelties fell from nearly 9 percent in 2006 to 8 percent in 2007, and at the same time the share of companies able to introduce market novelties fell to 34 percent, which is 2 percentage points lower than in the previous year. In the rest of the manufacturing sector the share of turnover achieved with market novelties went down slightly and in 2007 was nearly 3 percent. In this sector group, 15 percent of companies were able to launch market novelties successfully, which is down 1 percentage point from the previous year. In 2007, 2 percent of revenues was generated with market novelties in the knowledge-intensive services, up from 1.5 percent in 2006. At the same time the proportion of companies in this sector group with market novelties rose from 13 percent in 2006 to 17.5 percent in 2007. Despite a favourable economic situation, it was not possible in any of the three sector groups to follow on from the exceptional innovation successes achieved with market novelties during the New Economy Boom. That phase was characterised by a broad, rapid diffusion of IC technologies. Currently it is not foreseeable that a new cross-sectional technology would lead in a similar fashion to the development of market novelties.

Company funds are important for innovations

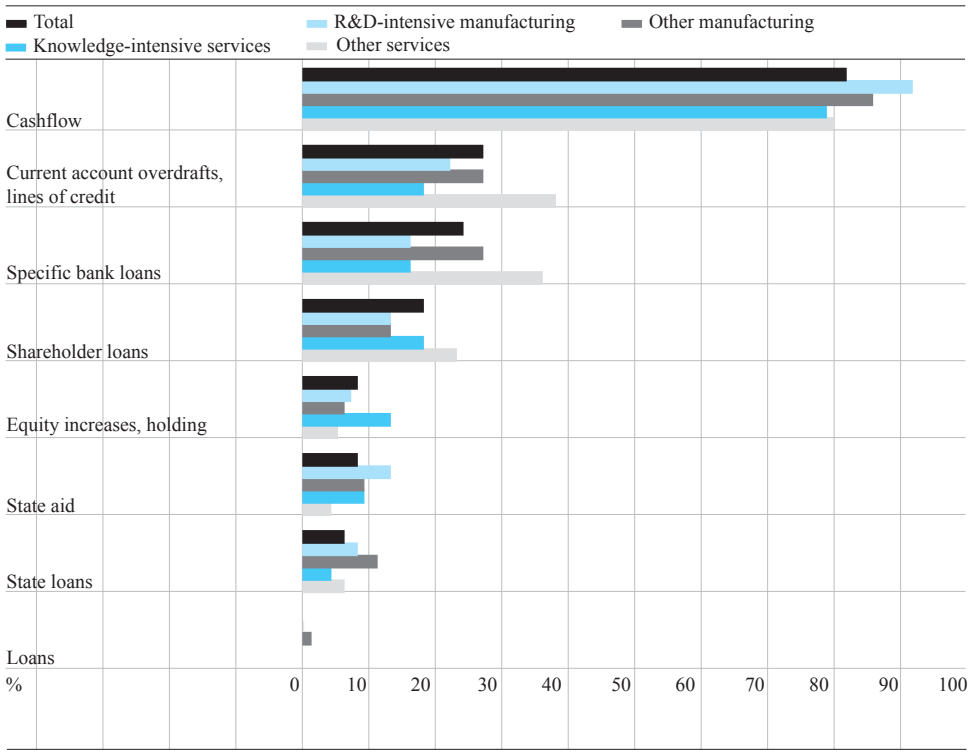
In the Innovation survey 2007, the companies were also asked how they financed their innovations in the period 2004–2006.

Share of turnover with novel products in manufacturing and in the knowledge-intensive services in Germany FIG 21



Revenue with new or considerably improved products less than three years old, as percentage of turnover
All companies. Source: Mannheimer Innovationspanel. Calculations by ZEW.

Use of sources of finance for innovation projects by companies in Germany FIG 22



Data: 2004–2006. Companies with more than 5 employees with innovation activities, Combinations possible.
Source: Mannheimer Innovationspanel. Calculations by ZEW.

By far the most important form of financing for innovations was through company funds (Fig. 22). In the period 2004 – 2006, 82 percent of all companies with five or more personnel in the manufacturing sector and in mainly company-related services drew on company funds in order to finance innovation projects. Half of these companies only used funds from their own operations. Above all in the R&D-intensive manufacturing sector company funds are very frequently used. This sector group has difficulties finding external investors for innovation projects because of the relatively high risks and low possibilities of obtaining securities. Almost all innovative large companies use their own cash flow for innovation financing, whereas every fifth innovative small company with fewer than 50 employees does not draw on its own funds for its innovation projects, or would not be in a position to do so.

Shareholder loans could be regarded as a sort of internal financing, because as a rule these involve the provision of funds from the private assets of the shareholder which is mostly derived from earlier earnings in the company. 18 percent of companies employed this instrument for innovation financing. As would be expected, the use declines with the increasing size of the company. 27 percent of innovative companies in the period 2004 – 2006 drew on current account deposits for innovation financing or made use of overdrafts on company bank accounts. This form of financing plays a more important role than specified bank loans, for which a lower interest is charged but which are also less flexible – only 24 percent of companies use these to finance their projects. Only 1 percent of companies exclusively used bank loans for innovation financing. Small and medium-sized enterprises used loans more frequently than large companies. In the R&D-intensive manufacturing sector, less use was made of loans than in the rest of the manufacturing sector and in most service sectors. The reason for this is that the structures of the innovation expenditure in the latter two fields involve a relatively low R&D-share and are therefore better suited for loan financing that in the R&D-intensive manufacturing sector.

Success with innovations after increase in equity

Increases in equity were used by 8 percent of innovation-active companies in order to carry out their projects. This form of financing involves an inflow of funds from new shareholders, which may also include investment companies and venture capitalists, as well as additional funds provided by existing shareholders. Quite a lot of companies in the fields of business consultancy, advertising and in R&D/technical services, as well as in instrument engineering, increase their equity as a way of financing innovations. Companies which used this instrument were able to achieve considerable innovation successes. The additional equity significantly raises the proportion of revenue from new products and leads to much higher process-side innovation successes. The new equity provides more financial scope which puts the company in a position to achieve rapid innovation progress. In addition, providers of external capital can help to ensure that innovation processes are goal-oriented and show results as quickly as possible. Securing a liquid shareholding market can therefore contribute to strengthening the innovative potential of German companies.

State aid for innovations not yet having a broad effect

In the period 2004 – 2006 only 8 percent of innovative companies made use of state aid / public grants for innovation financing and only 6 percent of companies drew on public loans or support (e.g. the KfW bank group or the federal state banks). State aid was deployed relatively frequently in the fields of R&D- / technical services and IT and in the R&D-intensive manufacturing sector. In some non-research- and knowledge-intensive sectors hardly any companies funded their innovation activities by means of state aid. Since public support is generally provided within the framework of programmes which define access conditions for the nature of the project or the type of project implementation, companies in these sectors effectively have no access to them. The proportion of small and medium-sized enterprises receiving state aid for innovation projects was lower than that of large companies. Only 7 percent of companies with fewer than 50 employees use state aid for innovation financing. These results confirm once more that the public innovation programmes in Germany in the recent past have unfortunately not had a very broad impact. This aspect is considered in more detail in Chapters B 1 and B 4. Public loans are used relatively frequently by less research-intensive manufacturing sectors for innovation projects with a high proportion of fixed investments. Financing such innovation projects is often a focus of loan programmes at federal and federal state levels.

Financing constraints reduce innovation activities

The current financial crisis and the possible reluctance of banks to give loans for innovation projects will probably only have a limited impact on innovation financing, because the figures for the period 2004 – 2006 indicate that there were hardly any companies which obtained funds for innovations solely in this way. The economic downturn can be expected to have a greater effect due to reduction of revenues and profits, because this will reduce the scope for internal financing. It is to be feared that the restrictions on company funds will mean that companies have to significantly reduce their activities in research and innovation. Even at the start of 2007 – under favourable economic conditions – there were financing constraints on the innovation activities of the companies. If their profit situation had improved, 27 percent of the companies said they would have carried out more innovation activities. In particular, companies carrying out research and development could obviously not implement all their ideas because of the lack of sufficient internal financing. A greater potential to increase the R&D-expenditure of the German economy lies above all in those companies which have so far only carried out research and development occasionally. Of this group, more than 15 000 small and medium-sized enterprises were prepared to invest more in research and development if additional funds were available. Broad support measures, such as fiscal R&D-support, which are aimed at improving internal financing opportunities for research and development could therefore have a highly mobilising effect. Instruments which ease the access to (low-interest) credit facilities seem to be less effective ways to improve the internal financing possibilities. Not even half the companies which would have carried out additional innovation activities if the profit situation improved, would have been willing to do so if additional (low-interest) credit facilities were available.

C 4 SMALL TO MEDIUM-SIZED ENTERPRISES

The following section is based on an evaluation of various studies on aspects of research and innovation.[108] Small and medium-sized enterprises (SME) are defined by the European Union as companies with up to 249 employees. In Germany, the proportion of large companies is much higher than in other European Union member states so that the proportion of SMEs in accordance with the EU definition is comparatively low. Therefore many German institutes still use the upper limit of 499 employees in their analyses, and their statistics are not available in accordance with the EU standard.

Using this higher level in the following, in 2007 some 70 percent of the workforce in the business economy were working in these small and medium businesses.[109] In the sector of commercial services, some 75 percent worked in small and medium companies, and in the manufacturing sector about 60 percent.[110] Small and medium enterprises can be found in particular in the services sector, and about half the personnel working in the commercial services are employed in small and very small businesses with no more than 49 employees. The proportion of all gainfully employed people who were working in the services sector in Germany rose between 1980 and 2007 from 54 percent to 72 percent.

There are very different types of small and medium-sized enterprises with specific functions for the economy. These are discussed in more detail in Chapter B 4. In the case of researching companies, the R&D intensity (the proportion of all personnel who are R&D personnel) is particularly high for small companies; it falls for companies with between 100 and 499 employees and then rises again for large companies, giving a U-shaped curve of R&D-intensity as a function of company size (Fig. 23).

Only 13 percent of all business R&D expenditure is attributable to small and medium companies, so that the R&D-share is much smaller than the 70 percent share of the workforce. The low proportion reflects a limited participation in research and development, and in contrast to many other countries it is not increasing markedly.[111] The R&D-involvement of small and medium-sized companies in the sectors of cutting-edge technology is clearly above the average of 12 percent, for example in pharmaceuticals at 59 percent, in telecommunications at 59 percent or in control technology at 79 percent.

For “transnational patents” the share of applications by small and medium companies is 20 percent; large companies account for 60 percent, and the remainder come mainly from science. In the case of patents from companies, the small and medium company share of