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## Research Report

# Research, innovation and technological performance in Germany - EFI Report 2009

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RESEARCH, INNOVATION  
AND TECHNOLOGICAL  
PERFORMANCE IN GERMANY

EXPERTENKOMMISSION  
FORSCHUNG  
UND INNOVATION

EFI

# REPORT

2008 2009 2010

2011 2012 2013

2014 2015 2016

2017 2018 2019

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RESEARCH, INNOVATION  
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EFI



**In memoriam Hariolf Grupp.**

This report is dedicated to the memory of Professor Hariolf Grupp, who was deputy chair of the Commission of Experts for Research and Innovation since it began its work in 2007. He passed away unexpectedly on 20 January 2009.

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## FOREWORD

On behalf of the German Federal Government, the Commission of Experts for Research and Innovation presents its second report. This was originally intended to be a “short” report, in which the key indicators of research and development were up-dated and commented on. However, the Expert Commission has decided to do much more than this, and recommends a series of measures to further strengthen the innovation potential of Germany. In particular in the present economic difficulties, research and innovation policies have a central role to play.

The challenges faced are varied and were already named in the EFI Report 2008. The conditions for the financing of innovations are still not ideal in Germany. The weaknesses of the educational system are already having negative consequences and in the medium-term could represent an existential threat to the innovation potential. The high degree of specialisation in a few manufacturing sectors is an expression of the particular German strengths, but it also creates dependencies and risks.

Because research and innovation policies are only effective over the medium- to long-term, these problems cannot be solved within a short period of time. But politicians must act more rapidly than in the past. The opportunity of introducing fiscal support for research and development has unfortunately not been seized, and the measures introduced by the Federal Government to improve investment financing are not at all convincing.

In this second report we consider other fields of action: the intensification of knowledge and technology transfer, increasing the attractiveness of science as an employment opportunity, and the promotion of innovation processes in small and medium-sized enterprises, in particular in sectors of the knowledge-intensive services.

The shortage of qualified personnel is beginning to represent a threat to the innovative potential of Germany. We urgently need to develop our universities and research institutions and to adopt intelligent, targeted immigration policies.

The Expert Commission also considers the questions relating to the implementation of the Second Recovery Package. This requires particularly rapid and effective action.

Berlin, 4. March 2009



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## SUMMARY

### **Education, research and innovation – a particular priority in a recession**

With its export orientation, Germany is particularly vulnerable to the looming global recession. The German Federal Government has implemented economic recovery packages which include important measures to support and stimulate the economy. However, these stimulus packages only contain a few elements which will significantly promote research and innovation. The Expert Commission suggests that in the course of implementing the second recovery package, more attention should be paid to the concerns of education, research and innovation.

If this is not done, there will be a severe shortfall in the funds available in future to improve the competitive position of Germany. Currently, the German innovation system is still competitive in an international comparison. However, competition is becoming considerably more intense as other industrialised countries and some key emerging economies redouble their efforts. Germany's position with respect to R&I will therefore come under pressure if the level of expenditure for research and innovation is only maintained at present levels. There is an urgent need to expand education, research and innovation.

In the view of the Expert Commission, the major task facing R&I policy in Germany over the coming decade concerns the restructuring of the education system. The tax system must also become more innovation-friendly. Specific incentives are needed in the field of innovation financing. It should also not be forgotten that innovations can make a decisive contribution towards countering the global challenge of climate change and promoting the necessary transition to a sustainable economy. R&I policies therefore overlap in important areas with educational policies, fiscal policies, and environmental and energy strategies, and there must be a close dialogue with these sectors. A policy which was confined solely to research and innovation would not have the desired outcome.

### **Financing innovation is even more difficult in the crisis**

Innovation activities are not possible without adequate financing. In companies, equity is by far the most important source of funding for innovation. The moderate levels of equity held by German small and medium-sized enterprises (SMEs) and a poorly developed market for venture capital in international comparison therefore constitute a key weakness of the German innovation system. In 2008, the German parliament passed

the Law on the Modernisation of the Framework Conditions for Venture Capital and Equity Investments (MoRaKG). The aim of this is to promote the provision of capital for young, unlisted companies. Important provisions are still awaiting formal state aid approval from the European Commission. The Expert Commission expects that even with such approval the measures will not lead to a significant strengthening of the German market for venture capital. The effects of the legislation are limited by the very restricted nature of the provisions. Basically, deficits can be identified in the financing of young enterprises and SMEs. The situation is becoming more acute in view of the current crisis. In view of falling profits, the potential for reinvestment in innovations is declining.

The situation on the market for venture capital has also got markedly worse. The volume of external equity provided will very probably decline. The available capital assets will in turn be distributed less widely, and will in particular flow to existing companies – to the disadvantage of new enterprises. As a consequence, a decline in innovation activities of SMEs is to be expected. An improvement in state credit provisions can help the companies which are able to put up adequate securities. However, it does not solve the central problem.

Already in the past it has been possible to observe that the level of expenditure on innovations – in particular in SMEs – is dependent on the state of the economy. In order to reduce this dependency and to ensure less fluctuation in the innovation activities of SMEs, the Expert Commission recommends the introduction of an innovation-friendly tax system and a definite improvement in the framework conditions for venture capital and Business Angels.

### **More attractive framework conditions needed for the science labour market**

In order to boost innovations, Germany needs not only sufficient funding but also more well-trained people. It is true that the number of university graduates reached a record level in 2006. But in order to meet future demand for academics in Germany, considerably more people than in the past must gain qualifications to attend higher education. The expansion and qualitative improvement of the German education system is therefore essential.

After graduating, many academics turn their back on Germany, which had the number of highly-qualified emigrants in an OECD comparison. And it is the particularly successful scientists who really like going to other countries, because they are offered more attractive working conditions than in Germany, and opportunities to gain further qualifications.

In comparison, the migration of academics from other countries to Germany is less well developed. An active immigration and science policy is therefore needed in order to attract highly-qualified foreigners to Germany and to encourage them to stay. This applies in particular to people from countries outside the European Union. The criteria for them to be admitted onto the German labour market are too restrictive, despite recent changes. This situation could be improved significantly by linking the admission of immigrants to their qualifications and by dispensing with income thresholds.

Germany needs attractive framework conditions for its science labour market. The Expert Commission therefore recommends the following measures:

- Strengthening the autonomy of the universities and independent research institutions,
- Public service legislation (*Beamtenrecht*) should not be applied to scientists,
- Federal state legislation on universities should be reformed to allow more flexible employment, with less rigid teaching requirements for professors,
- Provision of sufficient funding for targeting the promotion of young scientists at federal and state levels, and improvement of the support for young scientists by increased teaching opportunities, and travel grants, with the direct allocation of research funds,
- Application of the tenure principle by German universities and minimisation of phases of restricted employment, as well as support for young scientists to develop non-academic careers,
- Regular surveys on the working conditions for scientists in Germany.

### **Intensifying and improving knowledge and technology transfer**

Universities and publicly-supported research institutions are becoming increasingly important for the dynamics of innovation. Both natural sciences and engineering disciplines as well as the humanities and social sciences can contribute to a considerable degree to the development of commercially successful innovations. The pre-requisite for this is the effective organisation of knowledge and technology transfer between science and business.

Knowledge and technology transfer has various forms. A central element is the training activities of the universities and research institutions. The marketing of protective rights and the promotion of new enterprises are currently among the most important functions of the transfer offices. Germany has a long and successful tradition in contract research. However, there is less experience with strategic partnerships, which provide a sound institutional framework for cooperation between public and private partners.

At present, the organisation of knowledge and technology transfers in Germany is not ideal. Unsuitable structures and processes, together with bureaucratic obstacles, often result in a failure to exploit the existing innovative potential. The universities must find the approaches to knowledge and technology transfer which are most suitable for them. There is no standard solution for all institutions. The research and innovation policies should therefore not specify universally binding transfer structures, but should create appropriate framework conditions and provide incentive systems. The Commission of Experts on Research and Innovation therefore recommends the following measures:

- Support for Public Private Partnerships,
- The introduction of a “Period of grace for innovations” in patent law,
- Creation of performance-related incentives for scientists and transfer office team members,
- Development and regular evaluation of further instruments to promote validation research, that is the proof of the commercial utility of research results,
- Easing of constraints on the participation of universities and research institutions participating in spin-off enterprises,
- Full integration at all universities of courses on how to set up new enterprises.

### **Boosting the innovation potential of small and medium-sized enterprises**

Some 70 percent of employees in Germany work for small and medium-sized enterprises. 43 percent of all SMEs in Germany are innovative, that is they bring new or improved products onto the market. Others are R&D service providers which provide support for the innovation

processes of their customers. The importance of SMEs for the German innovation system is considerable.

In an international comparison, the proportion of innovative SMEs in Germany is still high, but it can be seen to be declining if viewed over time. Research and development must generally be funded from company equity. The traditionally low capital ratios of German SMEs therefore represent a constraint on innovation. In addition, the state share of the financing of R&D expenditure of SMEs has fallen almost continually since the end of the 1980s.

In order to increase the innovative potential of small and medium-sized enterprises, the Expert Commission therefore recommends that the German Federal Government adopts a combination of topic-independent R&D support in the tax system and topic-specific support by means of project funding. The Expert Commission therefore sees the need for the following actions:

- The rapid introduction of broad, technology-unspecific fiscal R&D support,
- Further simplification of existing project promotion programmes for SMEs with increased transparency in combination with optimised consultations between the various administrative departments involved,
- Further development of the project promotion by the introduction of two new measures: the status of Young Innovative Company with freedom from taxes and social security contributions for research-intensive new enterprises, as well as the increased consideration of innovative SMEs when placing public orders, analogous to the Small Business Innovation Research (SBIR) programme in the United States of America,
- Increased integration of SMEs in the processes of knowledge and technology transfer, and upgrading the role of universities of applied science in the transfer process.

### **Utilising the innovation and growth potentials of knowledge-intensive services**

The knowledge-intensive services sector is an important engine of growth and employment in Germany and other industrialised countries. Nearly 40 percent of the value created in Germany comes from this sector. It is also responsible for a large part of the growth in employment in recent years.

However, in an international comparison, knowledge-intensive services are still underdeveloped in Germany. Even though the available statistics have to be interpreted with care, the frequently expressed suspicion that the “Services gap” is only a statistical artefact is not accurate. Germany leaves the growth opportunities in this sector unused.

Germany only has a middle ranking when it comes to foreign trade with knowledge-intensive services. In the course of the continued positive development of this sector, more use should be made of the potential of the knowledge-intensive services to increase exports. Problems that can arise in this context from the unwanted leaking of knowledge have to be balanced against the benefits in each individual case.

In order to benefit from the development potential of the knowledge-intensive services sector and in order to allow more accurate analyses, the Expert Commission proposes the following measures:



- Paying increased consideration to the high-value knowledge-intensive services in innovation policy, economic policy, and in the support of foreign trade,
- Providing targeted support for the expansion of trade in the field of product-accompanying services,
- Increasing public awareness about the importance and variety of innovations in the services sector,
- Improved coverage of service activities within the framework of official statistics.

# REQUIREMENTS FOR IMMEDIATE AND MEDIUM-TERM POLITICAL ACTION

A

## A REQUIREMENTS FOR IMMEDIATE AND MEDIUM-TERM POLITICAL ACTION

### A 1 AVERTING THE CRISIS

#### A 1–1 EDUCATION, RESEARCH AND INNOVATION – EVEN MORE OF A PRIORITY IN THE RECESSION

The looming global recession is unprecedented in this form. It already covers all sectors of the economy. Germany is particularly exposed due to its export orientation, but at the same time, advances in productivity of German companies and their financial successes in recent years mean that they are better equipped for the crisis than their foreign competitors. However, there are now daily reports about collapsing orders, redundancies, and investment cut-backs. It is not yet clear how long the downturn will last or how deep it will be. Threats are also posed by protectionist interventions in other countries. The Federal Government must take decisive steps to counter such tendencies.

The Federal Government has initiated important measures with its Recovery Packages. The steps that have already been agreed on and which are shortly to be adopted are aimed primarily at supporting and stimulating the economy. However, the concerns of education, research and innovation should also be given priority consideration, in order to generate sustainable effects. The Expert Commission suggests that in the course of implementing the Second Recovery Package, the measures decided on by Bundestag and Bundesrat should focus more on these priorities. Otherwise, the consequence will be that, at a later stage, there will be a significant lack of funds to improve the competitive position of Germany. Therefore care must be taken that the measures of the Second Recovery Package also serve to strengthen research and innovation as far as possible.

In addition, the research-relevant measures should be linked together with the Federal Government's High-Tech Strategy and integrated in its further development.

#### A 1–2 STABILISATION OF CORPORATE FINANCING

The first steps of the Federal Government in late autumn 2008 were intended to stabilise the banking system and corporate financing. The priority was to prevent the collapse of system-relevant banks and to maintain the flow of loan-capital. This was the only way to minimise the impact of the financial crisis on the rest of the economy. Otherwise it is possible that the restrictions on credit availability would have robbed companies of the

air to breathe. To this extent, as hard as the measures were for the Federal Government, they were necessary with a view to supplying the German economy with loan capital.

However, the Expert Commission draws attention to the fact that the improved availability of credit will only help the companies to a limited extent when it comes to the financing of innovation.

It is therefore to be expected that the predicted decline in orders and revenues will also be accompanied by a considerable reduction in R&D expenditure. Under these circumstances, it will not be possible for Germany to achieve the goal of investing three percent of its gross domestic product in research and development by 2010. This does not mean that the goal should be completely abandoned, but policy-makers must make greater efforts to change the incentives and framework conditions for R&I.

The equity capitalisation of companies is particularly important. Equity capital formation must be treated more favourably in the taxation system. It is also becoming increasingly important to offer appropriate fiscal stimuli for external equity providers. Only if investment companies and also Business Angels encounter positive fiscal conditions for investments in new enterprises and innovative companies will they be able to develop greater positive macroeconomic effects than in the past. However, the intention of such regulations is not the only important factor – they must also be clearly formulated and practicable.

An example is the provision for losses carried forward in Section 8c of the Law on Corporation Taxation. Although the new regulation was introduced for good reasons, the effect is to make investment financing less attractive in Germany and to exacerbate the problem of inadequate equity funding for domestic companies in times of financial market instability.

## R&I-RELEVANT COMPONENTS OF THE SECOND RECOVERY PACKAGE

A 1–3

### **Investments in education**

Within the framework of the Second Recovery Package, the Federal Government and the federal states (*laender*) have among other things decided to make 8.7 billion euros available in 2009 and 2010, mainly for investments in pre-school centres, schools, universities and research institutions, further training, and research. The Expert Commission regards these necessary investments as a first step in view of the estimated overall need of 100 billion euros for refurbishments.

The funds will be allocated by the *laender* (30 percent) and the municipal and local authorities (70 percent). Priority will be placed on investments in schools and child care facilities. The Expert Commission welcomes these investments, in particular in view of the central role of preventive educational policies for the innovative potential of Germany, which was considered in detail in the EFI Report 2008.

The special funds flowing to the educational institutions will have to be spent in 2009 and 2010. This support could therefore miss out the larger projects of longer duration which are currently still in the planning stage. The rapid flow of funds is impeded for example by the lengthy tender procedures of the building and planning authorities and the ponderous nature of the acquisition procedures. In view of the time constraints, it

would seem sensible to relax the allocation criteria for a period of two years through the Second Recovery Package. It is important at the moment that full use is made of these possibilities. The acquisitions by public authorities must be flexible and stimulate innovations. Orders should not only be placed with large companies with which there is established cooperation. Young and small enterprises must also be taken into consideration.

### **Innovation support for small and medium-sized enterprises**

As a broad measure, in 2009 and 2010 additional funds amounting to 900 million euros are to flow into the economy through the Central Innovation Programme for the *Mittelstand* (ZIM). The Expert Commission regards this measure as positive in principle, because the funds can provide useful support for the financing of innovation projects in small and medium-sized enterprises. However, it only represents the second-best option, and the introduction of fiscal R&D support would be a better contribution to a long-term promotion of research and innovation in SMEs.

The Expert Commission recommends that special priority should be given to the promotion of projects in young, innovative companies in the context of the ZIM programme. In addition, support should also focus on innovative services in order to avoid a one-sided emphasis on technology topics. The Expert Commission still sees the need to complement the general support for SMEs in the medium-term by fiscal R&D-support. The expansion of the ZIM programme must not lead to a further delay in the introduction of fiscal R&D-support.

### **Support for mobility research**

The Expert Commission warmly welcomes the fact that the Federal Government plans in the Second Recovery Package to provide support totalling 500 million euros for application-oriented research in the mobility sector. Specialisation in electro-chemistry, in particular in the industrial manufacture of lithium-ion batteries, and the development of drive concepts with low environmental impact are very important and should be anchored in this support measure. Here too the Expert Commission advises that special consideration should be paid to SMEs and young enterprises. If suitably structured, this programme – as for the ZIM – would also provide targeted support for venture capital financing. It is therefore important that representatives of the venture capital industry and the industrial associations are included in the committees and consultation groups which decide on the allocation of funds, in order to represent the interests of young enterprises.

### **Infrastructure support**

The current measures of the Federal Government envisage infrastructure support in some sectors, including traffic and transport, and information and communications technology (broadband networks). This is warmly welcomed and will also be of benefit to the nation's innovation potential. The expansion of broadband connections in rural areas can significantly contribute to reducing the deficits in the availability of information and communications technologies in Germany. However, there is a lack of decisive infrastructure measures to expand our electric power grid. Robust and "intelligent" supply networks adapted to

meet future needs are essential if the reasonable but ambitious objectives of the Federal Government in the fields of energy efficiency and renewable sources of energy are to be met in a timely fashion.

## NO OFF-SETTING AGAINST EXISTING STRATEGIC MEASURES

A 1–4

The Expert Commission also emphasises that the funding provided for the Second Recovery Package must not be off-set against measures within the framework of the Higher Education Pact or the Excellence Initiative. The German universities and research institutions need these funds urgently in order to be able to create excellent research conditions and to enrol more students. The key provisions for the continuation of the university pact and the excellence initiative should be in place before the 2009 elections in order to provide planning security. The aim is to maintain the course towards a sustainable improvement of the entire education system. The school discussion must not impede the development of education, research and innovation.

## MEDIUM-TERM PROSPECTS – RESEARCH AND INNOVATION 2020

A 2

### ELECTION YEAR 2009

A 2–1

Germany is facing a series of elections in 2009, including a federal election. Work must be started well in advance on the preparations for the next legislature period. For this reason, the Expert Commission describes the medium-term political challenges faced by the new government which will come into office at the end of 2009. The comments here follow on from the discussion in the EFI Report 2008.

### CHALLENGES

A 2–2

Germany faces considerable challenges. The competition from other industrialised countries and the emerging economies is growing. Germany's position in research and innovation would come under pressure even if the expenditures for research and innovation were maintained at present levels. To stand still here means going backwards, because other economies are attaching more importance to education, research and innovation. And these countries often react more directly and faster to important developments than Germany does.

Challenges arise in particular from the knowledge intensification in the economy. The demand for highly-qualified professionals is growing and value-creation processes increasingly rely on the production factor knowledge. In contrast there is less and less demand for simple occupations.

The demographic development in Germany is exacerbating this problem, because the German population is ageing rapidly. The immigration of qualified workers is still viewed with scepticism, and the participation of women is still far behind the possibilities, particularly in central areas of research and innovation.

In Germany, the innovation activities of companies are focused on high-value technology, not on cutting-edge technology. This concentration of economic activities has a positive aspect – it is an expression of successful specialisation. But it can also lead to a high level of dependence and dangerous inflexibility, because specialisation is always only an advantage for a limited period. The current problems in the automotive industry make this plain.

Germany cannot do without the contributions of the established, successful sectors. For the foreseeable future they can make an important contribution to export successes and economic growth.

But new sources of value creation and welfare must be drawn on to a greater extent than in the past. R&I policy is in the end also a provision for the future.

### A 2–3 KEY STRENGTHS

Germany can draw on important strengths in R&I competition. German universities and research institutions lead internationally in many fields. In the course of the Excellence Initiative, there has been growing competition between the universities and research institutions. The increased autonomy of the universities and research institutions is already showing first benefits in some federal states. German companies are innovative, with advantages not only in research but also in other important areas such as construction, design and marketing. The integration of innovative components in convincing products and plants is still very successful in many sectors in Germany.

In addition, the Federal Government has recognised the challenges: the funds for science, research and development have been increased considerably in recent years. Whereas the expenditure in 2005 was still 11.1 billion euros, the figure in 2008 had risen to 13.4 billion. For 2009 the government envisages expenditure of 14.4 billion euros, not yet taking the Recovery Packages measures into account. With the High Tech Strategy, a very promising form of coordination between government departments has been initiated. These steps point in the right direction, but there is a need for further action in the short and medium term.

### A 2–4 NEEDS FOR ACTION – R&I-POLICY 2020

- The German education system, which has historically been a particular strength of the country, has now come under pressure. International comparisons have highlighted weaknesses, in particular in the early phase of education. In addition there are also deficits in innovation-related training in the natural sciences and engineering. For this reason, in its first report the Expert Commission already called for improvements to the education system as a pro-active innovation policy. This demand is still valid.
- Fiscal policy is innovation policy. The German taxation system is hostile to innovation, both with regard to the financing of *mittelstand* companies, and in terms of the financing for new enterprises. Little has been changed in this respect by the company taxation reform in 2008. The creation of an innovation-friendly taxation system and the improvement of the framework conditions for innovation financing are important tasks for the next Federal Government. In this respect, German policy-makers have

long shown a lack of decisiveness. The R&I policy measures are ineffectual if they are undermined by the taxation system. A re-orientation is urgently necessary.

- The global challenge of climate change and the transition to a sustainable economy, in particular to sustainable sources of energy, requires rapid and targeted actions worldwide. Considerable efforts will be necessary, but at the same time there are extensive opportunities for well-positioned high-technology nations. The harmonisation and linking of environmental and R&I policies is becoming increasingly important. Good coordination between political regulation and R&I incentives can help German entrepreneurs to position themselves more effectively in a leading position in the market for environmental goods.
- However, it will not be possible to “protect” domestic suppliers while at the same time offering incentives for the development of sustainable, suitably priced products for the world market.
- The transfer of knowledge to economic applications is hindered because universities and research institutions do not have sufficient freedom to establish appropriate organisational forms or to put incentives in place. An important factor in the use of new knowledge are new enterprises. Here the conditions have been poor for decades. Germany must once again become a land of entrepreneurs in order to be able to use the possibilities of the knowledge society flexibly and in order to secure economic growth and employment opportunities in the long-term.
- Germany is still lagging behind other nations in the process of tertiarisation. Attention is also drawn in this report to the importance of services, in particular knowledge-intensive services. German R&I policy is still excessively focused on technologies and technical products. Important growth opportunities in the services sector can therefore not be fully exploited.
- Innovation processes are profoundly influenced by the provisions of the patenting system and copyright protection measures. There is a growing need for revisions in the responsible institutions, both at the national and at the European level. The shaping of these institutions is not a purely legal problem. Rather it touches on key concerns of R&I policy and therefore requires close coordination, at best within the framework of the High-Tech Strategy. In addition, there is also need for the broadest possible social consensus about how far the protection of intellectual property should go. Terms such as “Trivial patents”, “Patents on life”, “Software patents” and others show how sensitive the matter can become. The Patent Offices of Europe serve above all the welfare of the people of Europe, not only the interests of the patent holders. Germany and Europe require a qualitative improvement of the protection of intellectual property, and not a one-sided intensification.
- The High-Tech Strategy of the Federal Government was started in August 2006. It has ambitious goals, and the intention is to make Germany one of the world’s most innovative nations. The Expert Commission has evaluated the High-Tech Strategy positively – it is an important step to increase the effectiveness of the national policy for research and innovation. In the EFI Report 2008, the Expert Commission also called for a number of improvements, including among other things greater budget transparency, increased focussing on strategic goals, consolidation of the departmental responsibilities, and an increased orientation to services. It is not yet possible to finally evaluate the results of the High-Tech Strategy, and this remains a matter for soundly-based scientific evaluation. Numerous new activities have been started, such as the selection of the first five peak clusters, the innovation alliances, and the Master Plan for Environmental Engineering. Research and innovation policy is always a structural policy and can therefore only be effective over the longer term. Despite the High-Tech Strategy and the considerable extra funding which the Federal Government



has envisaged within the scope of the so-called 6-Billion Programme, there has not yet been an appreciable rise in the macroeconomic R&D-intensity. This was 2.5 per cent in 2006, and stagnated at this value in 2007, although an increase to 2.7 per cent was intended. According to the statistics so far available, the R&D expenditures of the private sector and the federal states have therefore not reacted to the impulses of the German government to the extent hoped for. This development does not mean that the Three Percent Target is in any way a bad goal for German R&I policy or for business – but it is doubtful whether the target will be reached by 2010.

R&I policies will also require considerable efforts in the coming years. There is an urgent need for even better coordination between government departments, but also between the Federal Government and the *laender*. Despite the positive initial situation, in the medium and long-term the competitive position of Germany is threatened unless research and innovation are strengthened, and major obstructions are removed in the educational sector and in the tax system. But this is not only the responsibility of the state – private actors must also make a contribution.

CORE TOPICS 2009

B

## B CORE TOPICS 2009

### B 1 INNOVATION FINANCING

#### **Financing of innovations is still inadequate**

Already in the EFI Report 2008, the Expert Commission for Research and Innovation discussed in detail that innovations are not possible without adequate financing – usually by equity. We emphasised that this is a weak spot for Germany, because of the rather moderate equity funding of its small and medium-sized companies.

This weakness is becoming increasingly obvious in the course of the current crisis. The fiscal framework conditions are hostile to innovation, above all the discrimination of equity in comparison with tax-deductible loan capital. In this respect, fiscal policy is also always innovation policy. Furthermore, the legislative situation in Germany is an unnecessary impediment to the financing of companies with high growth potential.

In 2008, the legislators had attempted to intervene by passing the Law on the Modernisation of the Framework Conditions for Venture Capital and Equity Investments (MoRaKG). The Federal Finance Minister had rightly noted that the inadequate provision of venture capital for young, unlisted companies was a considerable drawback for Germany as a location and this had considerably reduced employment-generating growth potential. One of the elements of MoRaKG is therefore the creation of a new legal form of Venture Capital Participations, with the aim of promoting holdings in young and medium-sized enterprises. It involves two key factors – the classification of the funds covered by the legislation as investment

management and the proper utilisation of losses carried forward. However, the validity of key regulations for Venture Capital Participations still requires approval from the European Commission, which is not certain.<sup>1</sup> Were approval not granted then no improvement at all would have been achieved in this crucial sector, and after all the lengthy debates that had previously been gone through, this would act as quite a negative signal, not least to international investors. Despite this, the fact remains that if the law is adopted in this form it will be very limited anyway. Although the orientation of the law is basically right, its scope is restricted unnecessarily to the seed phase of funding.<sup>2</sup> The law also contains very restrictive provisions regarding the investment behaviour of prospective venture capital investment companies.

In the light of this, the Expert Commission expects that only a few companies will decide to follow this path.

At the same time, the law was intended to improve the conditions for Business Angels. These are experienced entrepreneurs who provide capital and valuable expertise for founders of technology-oriented enterprises in particular. In return, they usually receive a holding in the young company, which they can then sell at a later stage.

In an international comparison, as a study recently confirmed, insufficient use is still made of the possibility of financing new enterprises by Business Angels in Germany.<sup>3</sup> It is estimated that there are 2700 to 3400 active business angels in Germany – in the USA there are 258200. Related to population, Germany has 33 to 41 business angels per million inhabitants, compared with 850 in the USA. However,

there is not only potential regarding the numbers of business angels, but also concerning the financing volumes. Whereas an average of between 100 000 and 200 000 euros is made available in Germany, the average sum in the USA is 332 000 euros.

In order to increase the comparatively low numbers of business angels in Germany and to raise the low investment volume, fiscal advantages were defined in the MoRaKG legislation. The Business Angels Network Germany (BAND) expects above all, that people will be encouraged to act as Business Angels for the first time – so that this form of financing will become more popular and the number of possible investors in Germany will increase. This is a very good and important measure.

Here again, however, the legislation includes excessively restrictive provisions which undermine its effectiveness. At the same time, leaving aside the direction and quality of the provisions, the regulations are so complex that it is doubtful whether the improvement will be widely accepted. Box 01 demonstrates this with an example provided by Business Angels Netzwerk Deutschland e. V.

The Expert Commission is in favour of fiscal and other measures aimed at improving the situation for entrepreneurs being conceived and formulated as clearly as possible. They should not require any unnecessary consultations with fiscal experts or lead to uncertainties. Well meant measures can become ineffective if they are obscure and impracticable.

### **Innovations additionally threatened by financial crisis and economic downturn**

Germany has some catching up to do as far as the financing of innovations in young and medium-large companies are concerned. This financing is important in order to secure the future of the economy in the knowledge and technology society of today. The deep crisis of the financial markets, the end of which is by no means yet in sight, has presented considerable additional challenges for innovation financing worldwide and thus also in Germany. This affects in particular young and medium-large companies.

In a downturn, a key role is played by the behaviour of companies regarding research and innovation.<sup>4</sup>

### **Business Angels tax situation improved**

#### **An example<sup>5</sup>**

A Business Angel has acquired an open holding of 20 percent in a legible limited company (*GmbH*) for 100 000 euros. After six years he sells his shares in the company for 180 000 euros. His maximum tax-free allowance is 20 percent of 200 000 euros, or 40 000 euros. The marginal relief limit begins at 20 percent of 800 000 euros, or 160 000 euros. He is therefore left with a tax-free allowance of 180 000 euros minus 160 000 euros, equals 20 000 euros.

The example shows that this arrangement is more likely to sweeten problematic holdings which in the end lead to a small profit on sale, rather than create a significant incentive for investment. Interpretation problems are raised by the requirement in Section 20 WKBG that within the five years prior to the time of sale the Business Angel must have held directly at least 3 percent but not more than 25 percent of the shares of the target company, but must not had the holding for more than 10 years. This could be understood as a minimum holding period of five years. The intention, however, is that any holding within the previous five years must be within the band of 3 percent to 25 percent, but not that the shares must have been held for five years. If the holding had been within the band, and the shares were already sold after five years, then the tax-free allowance provision would still apply.

BOX 01

When the economic conditions are positive, companies increase their R&D-budget and introduce new products and processes more frequently. According to a recent empirical study<sup>6</sup> the influence of the economy on research and development is lower in Germany than in other countries.

This is remarkable inasmuch as the larger industrialised countries tend to show a greater dependency on the state of the economy than the smaller ones.

The state of the economy has more influence on innovation activities than on research activities.<sup>7</sup> The successful introduction of a product innovation is above all dependent on the situation in the product market in question. Newly launched products are

much more likely to be accepted at a time when demand is expanding.

The results of the above-mentioned study show that a 10 percent decline in turnover only leads to a decline of about 2 percent in R&D-expenditure, increasing to 3.5 percent in the longer term. Small and medium-sized enterprises react more strongly to changes in the economy. In phases when the economy is weak a lack of equity is a decisive constraint on R&D activities.

Research and development in small and medium-sized enterprises is less constant and correlates less closely with the progress of the economy than does research and development in large companies. The same is also true for innovation activities, and applies both for the transfer from the status of non-innovator to that of innovator and vice-versa. In “good times”, SMEs are quicker with innovation activities, but when times get harder they are also the first to make cutbacks. This fact is probably directly related to the financing conditions they face for innovation.

The fine-control of research and development to limit economic influences is not possible and should not be attempted. But pro-cyclical support should also be avoided. Rather, state aid for R&D should be provided continuously and over the long term. Small and medium-sized enterprises deserve special consideration, for the reasons mentioned above. Possibilities for increasing the consistency of R&D and innovation activities in SMEs also during weak phases of the economy, lie above all in the financing sector. Particularly during economic downturns, an equity-friendly fiscal system which supports innovations would therefore be helpful.

### **The situation on the investment capital market has also worsened**

The current financial crisis is obviously having serious consequences for companies and their financing. While the potential for internal financing is limited by the decline in revenues, the situation of the banks threatens to restrict the provision of loan capital, and may even lead to a credit crunch. But also the markets for equity, which is particularly important in connection with research and innovation, are seriously impacted by the global financial crisis.

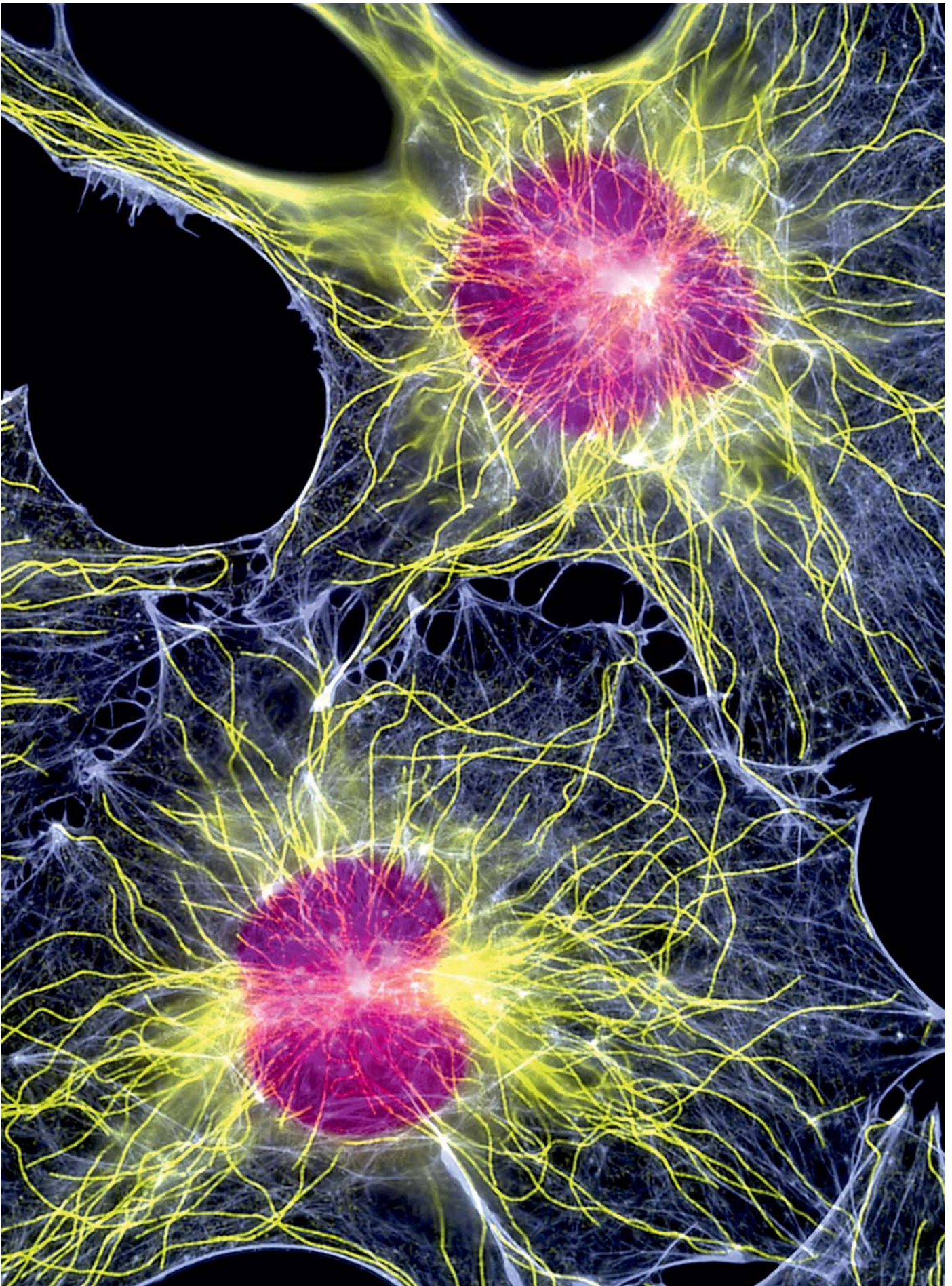
Due to the difficult market environment in 2008, there were only two IPOs in Germany (Prime Standard and General Standard).

In the three previous years there had been a total of 72.<sup>8</sup> This highlights how drastic the drop has been. Access to the public capital markets is currently hardly realistic.

In addition the market for venture capital has also been seriously affected by the financial crisis. This is above all the case for young and medium/large companies – the group of companies whose innovative activities are anyway particularly susceptible to the effects of fluctuations in the economy. Thus the existing investment funds and their portfolio companies face a situation in which it is increasingly difficult to relieve themselves of existing holdings. The period that they are being held is increasing and it is increasingly difficult to find a way out through the stock exchanges, and indeed at times is impossible. In view of the problems with equity and loan financing, many funds are forced to support their existing portfolio companies further with equity. This is obviously to the detriment of new involvement. Provided that the investors maintain their commitments to the fund, the overall investment volume will not sink (because this is already available), but it is distributed among fewer companies, and in particular among existing ones rather than new enterprises. At the same time, more attention will be paid to the survival potential of the businesses, which is a mechanism that could already be observed in the so-called dot-com crisis. The long-lasting structural consequences of this are likely to be felt even more strongly in the current crisis, because it is not only a single segment which is affected but the entire financial system. The situation on the loan capital markets has resulted in established companies entering into fewer transactions which involve equity investors. As a rule, the acquisition of such holdings also involves taking considerable loans in order to make the transaction possible. However, their availability is currently very limited – with the result that the volume of external equity financing also seems to be in threat of declining.

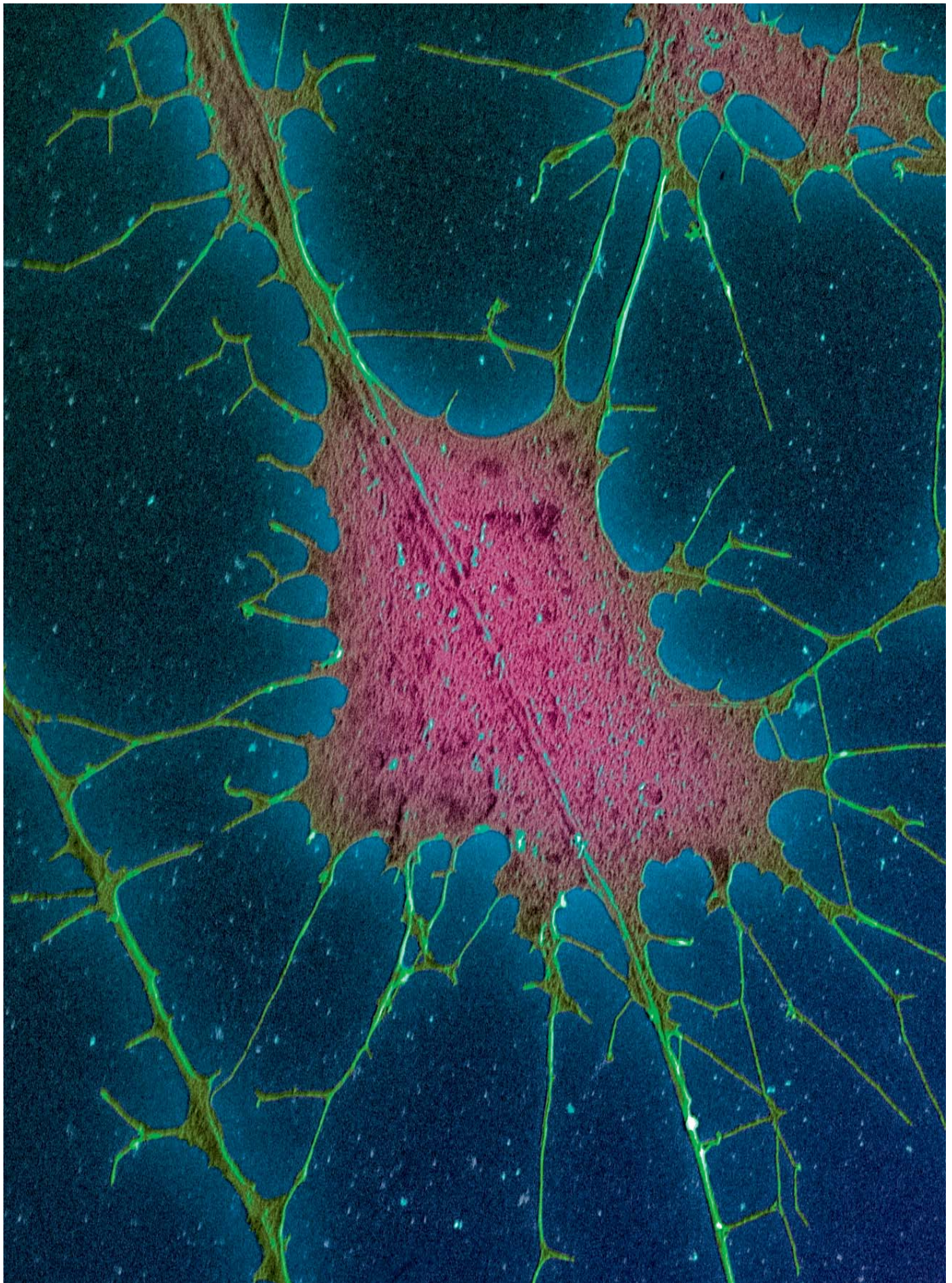
Even more than on the existing funds and their portfolio companies, the current situation will also impact on the flow of new capital into the venture capital funds. This has not been reflected in the fund-raising figures in either Germany or the USA, which





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Nerve cell culture  
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are only available through until the middle of 2008. However, there are indications that this is the case, and the passivity of institutional investors makes this assumption seem very probable.

In an international comparison, the German institutional investors are anyway very reluctant to put up venture capital, in particular when this is focused on newly-founded enterprises. Among other things, there are psychological reasons for this. Also, as an effect of the crisis, sums they have available to invest as private venture capital have shrunk. And it is to be assumed that the insecurity that the crisis brings with it will further increase the reluctance to become involved in this form of investment.

At the same time, one of the arguments in favour of private venture capital – the low correlation with the public markets – is becoming less applicable. The introduction of the fair value principle in the new international accountancy standards is reducing the structural difference between the private and public markets. When companies can no longer include assets at the acquisition cost in their financial statements as they did in the past, but are required to book the value at which they could probably be sold for at arm's length, then the pricing on the private markets will automatically be based on public market prices. The consequence is that the private markets increasingly follow the price movements of the public markets, and becoming less attractive for potential investors.

In the foreseeable future, investors in venture capital funds will be able to choose between making new commitments and taking over shares in existing venture capital funds. The critical situation with the withdrawal from holdings while at the same time having to maintain obligations to the funds means that many investors are experiencing liquidity problems. This boosts the market for secondary purchases of company holdings, and dampens the dealings with new holdings.

It can be assumed that the current financial crisis will in general lead to an appreciable decline in the private equity made available by investors. And these trends from the investment market will in turn have an effect on the business angel market.

These are worrying prospects – both for SMEs and for new enterprises, in particular those involved in

### Key points for an innovation-friendly tax system

BOX 02

The Expert Commission recommends that planning tax reforms should pay more attention to the effects of research and innovation than has been the case in the past. Tax policy is innovation policy – and the current tax system has proved to impede innovation.<sup>9</sup> The Expert Commission makes the following key recommendations for an innovation-friendly tax system:

- Elimination of limitation on losses carried forward when purchasing share certificates,
- Unlimited writing off of losses against future profits,
- Removal of limits on deductibility of interest payments as operating costs
- Avoidance of false incentives for research and innovation by taxing relocations of functions to other countries,
- Improving coordination between interest retention tax and company tax,
- Introduction of R&D support in the tax system, e.g. by tax credits for research and development.

technologies with a promising future, such as sustainable energy technologies. The strategy recommended in the EFI Report 2008 for the identification and the expansion of lead markets is thus meeting with considerable obstacles.

### Urgent reconsideration of the tax policies relating to innovations

With the financial situation having worsened so much in comparison with the previous year and given the importance of financing for innovations financing, then the recommendation for fiscal support for innovation, which is repeated in this Report, seems now to be even more urgent. At the same time the Expert Commission emphasises that the German taxation system must be structured so that it can provide long-term support for innovations. Box 02 gives an overview of some instruments which are available for this. In particular the restrictive treatment of losses carried forward in accordance with Section 8c Corporation Income Tax Act (KStG) for technology-based new enterprises needs to be reconsidered.



BOX 03

**Impact of the Technische Universität Berlin on the city's economy**

A recent study<sup>10</sup> estimates the direct, indirect and induced effects of the entire expenditure of the Technische Universität Berlin (about 370 million euros) on the Berlin economy. The result is that the overall financial impact is considerably greater than the annual expenditure of the TU Berlin and in particular more than the funds that Land Berlin provides as basic funding (some 275 million euros in 2006). In all, there is additional annual value-creation of about 550 million euros, and furthermore demand effects of about 450 million euros are generated in Berlin, more than 11 500 jobs are created or secured in the region, and almost 21.5 million euros tax receipts are generated for Berlin.

At the same time the venture capital sector should be provided with sound framework conditions which would make it internationally competitive – to the benefit of German businesses and their innovative potential.

This is particularly important because other countries are continuing to make progress. In the annual benchmark study of the European Private Equity & Venture Capital Association (EVCA),<sup>11</sup> Germany fell back further in 2008 and is now only ranked 22nd in its list of 27 countries, two places down on the previous year.

The tax system must offer businesses in Germany with better conditions for research and innovation. Without the necessary reorientation, the tax system will counteract the efforts of direct and indirect support and lead to a waste of funds.

**B 2 THE SCIENCE EMPLOYMENT MARKET**

**Lost opportunities due to inadequate investment in research and development**

It is now almost a cliché that investments in research and innovation pay off. But they can also be of benefit for the development of the entire region, as

is shown by the example of the Technical University Berlin (Box 03). Its importance for the Berlin region is based on a number of effects. Firstly, as a teaching institution it contributes to the education of human resources in the region. Human capital is important for businesses in the region – whether for new enterprises, spin-offs or the development of local businesses. Universities and research institutions also boost demand for goods, services and personnel and thus promote growth. More difficult to measure, but no less important, are the “soft” location factors generated by the image effect of universities and research institutions. The debate about the Creative Class (Box 04) has shown how important a creative climate can be when it comes to attracting “Talents”. Universities and research institutions are therefore extremely important for the scientific and economic development of regions and countries.

This only makes it all the more regrettable that Germany invests less in research and development than other countries. The level of three percent of GDP remains an objective, but it will not be reached in the near future.

**No strengthening of innovative potential without an educational offensive**

Germany needs both finances and well trained personnel. The shortage of academics is already apparent and it will grow worse – in relative and absolute numbers. It is estimated that by 2020 the demand for graduates could exceed the numbers available by well over a million (Fig. 01).<sup>12</sup> This is due above all to the fact that a well-trained and numerically strong generation will be gradually reaching retirement age over the coming years. The labour force potential will sink so much that even immigration and increasing numbers of women in employment will not be able to compensate fully for this demographic effect.<sup>13</sup>

Germany is not a special case here. In the USA, Japan, and other European countries the demand for highly-qualified professionals<sup>14</sup> has risen disproportionately. Between 1997 and 2007, the growth in employment of graduates in general and natural scientists and engineers in particular has been above the German level almost throughout the remaining EU-15 countries.<sup>15</sup>

Against this background there is little cause for optimism. The proportion of school-leavers who are qualified for higher education has been rising much slower since the 1990s and the long-term rise in the rate of higher education enrolments has been restricted since 2003. It is only recently that Germany has shown small signs of progress. The rates of enrolment in higher education rose between 2006 and 2007 and reached a peak in 2008. However, it is too early to interpret this as a turnaround, because the shortening of upper secondary education by one year is leading to double cohorts in various places as this is introduced. The international comparison also shows that the proportion of German students accessing tertiary education is below the OECD average and there has been a trend for this gap to increase considerably since 1995.<sup>16</sup> In contrast, the proportion of students failing to graduate is declining and is below the OECD average.<sup>17</sup> But at 21 percent it is still high and the student potential is not being exploited to the full.<sup>18</sup> Problematic are the particularly high 30 percent drop out rates in natural sciences and engineering and the increasing numbers of drop-outs in physics, computer sciences, mechanical engineering, electrical engineering, chemistry, and mathematics.<sup>19</sup>

It is pleasing that the numbers of first degree graduates in Germany reached a new high in 2006 of almost 221 000, which is an increase of nearly 30 percent since 2001. However, an international comparison in this case shows once again that despite the increase in the proportion of graduates, Germany is still lagging behind OECD countries such as Finland, Sweden or Switzerland.<sup>20</sup>

In order to meet the future needs for replacement graduates in Germany, at least 35 percent of a cohort would have to obtain a higher education degree. Taking dropout rates into account, this would mean that 40 percent of a cohort would have to enrol for higher education, and at least 50 percent of each cohort would need to qualify for tertiary education, given that not all school-leavers will go on to higher education.<sup>21</sup> Already today it is an ambitious target to want to replace the highly-qualified professionals who will be retiring from the employment market in the near future. The imminent additional need for graduates calls for corresponding efforts from policy-makers. There are likely to be shortages in particular in economics

### Creative Class

BOX 04

The scientific and political debate about the creative class has its origins in a publication by the urban planner Richard Florida “The Rise of the Creative Class”.<sup>22</sup> According to Florida, the creative people in a society and the innovations they generate are essential for the economic growth of regions. He claims that societies have a particularly promising future if the “creative class” is able to transfer existing knowledge into new, competitive products and services. An environment in which this creative class can thrive is characterised by the three “Ts”: Talent, Technology and Tolerance. Florida’s idea has influenced regional development strategies world-wide, and these now address the promotion of the three T-factors. However, there is still disagreement about whether investments intended to serve the public’s quality of life (such as inter-cultural meeting centres, parks and museums), do actually generate innovations and economic growth.

There are also disputes about whether it is acceptable and legitimate to concentrate public investments on attracting intellectual elites and in turn then to reduce expenditure in social sectors and for “classic” economic support.

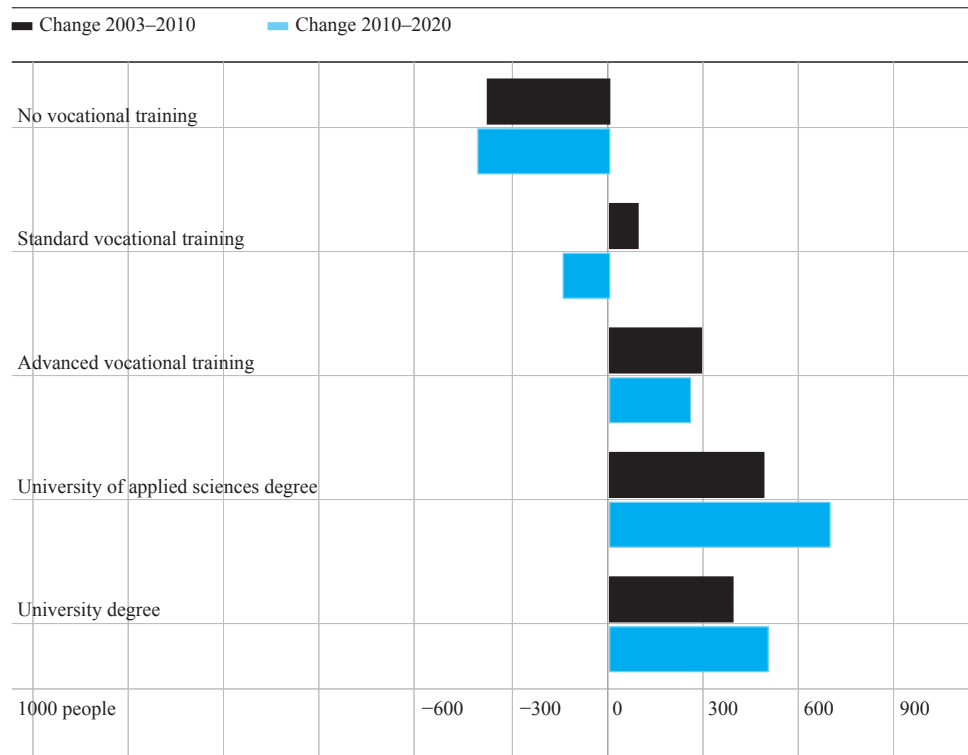
and the social sciences, followed by the educational sciences, teaching, and engineering.<sup>23</sup> The lowest need for expansion is in agriculture, forestry and food sciences, in architecture, and in civil engineering.<sup>24</sup>

If Germany wishes to strengthen its potential for innovation, the education system must necessarily be expanded and improved. This will have to include better tutor-student provisions and better teaching, as well as increased investments in further education.

### **The time is running out: Germany needs an active immigration policy for highly-qualified professionals**

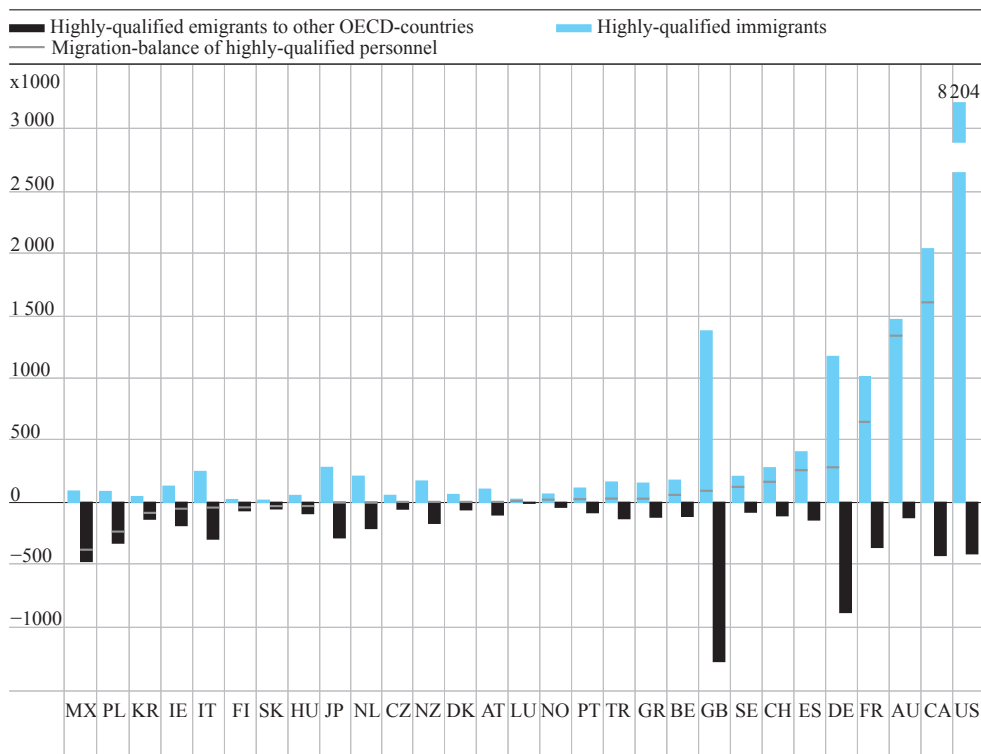
Like most OECD countries, Germany attracts more highly-qualified professionals than it loses (Fig. 02). But Germany has one of the highest numbers of emigrating highly-qualified professionals OECD-

**ABB 01 Demand for personnel in Germany according to level of qualification 2003–2020**



Source: Bonin et al. (2007: 81).

**ABB 02 Highly-qualified immigrants and emigrants for OECD countries**



Data: 2001 (15 and older). OECD Database on Immigrants and Expatriates.  
 Source: OECD (2008b): The Global Competition for Talent: Mobility of the Highly Skilled, Paris.

## BOX 05

### Immigration conditions for highly-qualified professionals in Germany

According to the Immigration Act of 2005, specialists and managers with special professional experience from non-EU states could only receive an unlimited visa to stay in Germany if they earn at least twice the limit for payments to the statutory health insurance system – currently 86 400 euros per annum. This income limit has recently been lowered by the Federal Government in the Labour Migration Control Act to the limit level for general pension contributions (West). Since January 2009, this has been 64 800 euros. The average gross salary of a graduate in Germany is 50 700 euros, so that this reduction has hardly affected the restrictive access to the labour market. If the income is below the limit, then the Federal Employment Agency (BA) can judge whether to grant a work permit, but priority must be given to domestic candidates for the position.

Since January 2009, this situation has been improved for non-EU foreigners who have completed their studies in Germany, who no longer have to submit to the BA priority examination.<sup>25</sup>

wide and one of the lowest numbers of highly-qualified immigrants.<sup>26</sup> The most important OECD destinations for highly-qualified professionals are the USA, which attracts some 45 percent of highly-qualified professional immigrants worldwide, ahead of Canada (11 percent), and Australia (8 percent). In contrast, only approx. 6 percent come to Germany, which is also low in comparison with other European countries such as Great Britain (nearly 8 percent – Fig. 03).<sup>27</sup>

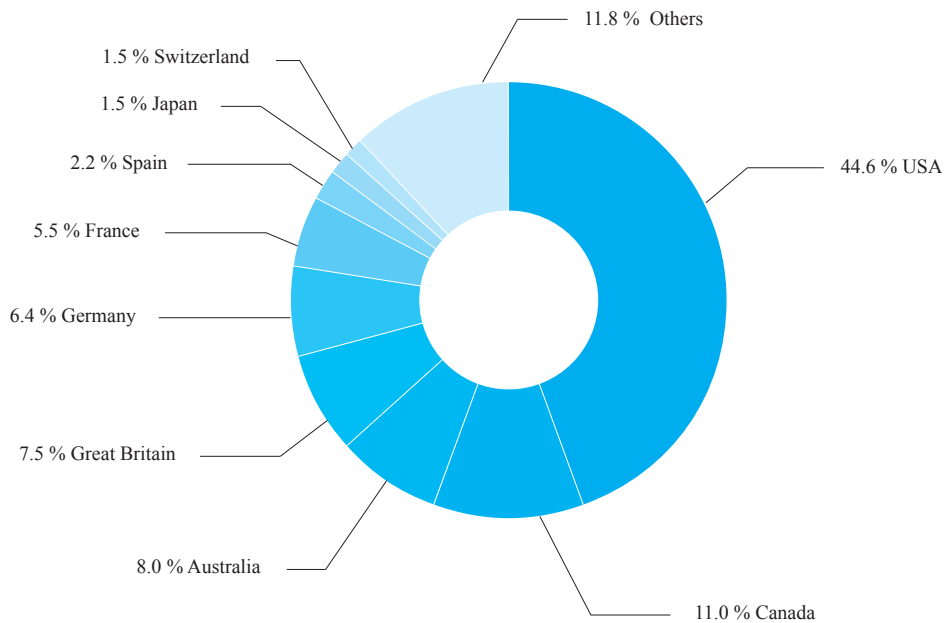
But there are signs of success. The number of graduates from other countries in 2006 rose once again to about 20 000, which is more than double the figure in 2000. A third of these students come from Asia and Eastern Europe and the majority obtain their first degree in Germany, above-average numbers in the natural sciences and engineering.

If it could be ensured that foreign scientists who graduated in Germany would also have career prospects here, this would be an important contribution to meeting the demands for qualified personnel<sup>28</sup> in Germany.<sup>29</sup> This was not the case in the past.

Germany needs an immigration and science policy which is aimed at attracting qualified personnel from abroad. Within the EU, the free labour movement is guaranteed and the exceptions which have restricted the entry of job seekers from Estonia, Latvia, Lithuania, Poland, Slovakia, the Czech Republic, Hungary, Bulgaria, and Romania, have no longer been in force since January 2009.<sup>30</sup> However, the majority of migrants to Germany come from countries outside the European Union – and the proportion will continue to increase in future. Previously, the access to the German labour market was extremely difficult for academics from countries outside the EU due to the high income threshold and the priority examination of the Bundesagentur für Arbeit (Box 05). The underlying logic was the wish to avoid displacement effects on the job market due to foreign employees. However, because highly-qualified foreigners can also increase productivity and create jobs, the German immigration policies sacrifice important potential here.

Other countries have policies aimed at actively attracting skilled and qualified immigrants, and they are successful with this. The assessment of prospective immigrants on the basis of a points system like those used by Australia and Canada is a practical and tested instrument which raises the qualification levels of immigrants, reduces their risk of unemployment, and also reduces possible negative effects on the labour market, or reductions in the income for the local population. By systematic monitoring, the immigration criteria can continuously be adapted to current requirements.<sup>31</sup> The positive effects of such policies are also highlighted by recent findings which indicate that the productivity of regions and their rate of investments increase with the degree of cultural diversity, and particularly so if the immigrants have a high level of qualification.<sup>32</sup> In addition to the recruitment of highly-qualified professionals from other countries, Germany should also try to hold on to its own talent, or to persuade them to come back. Because here too important potential remains unexploited. Germans living in other countries and emigrating Germans have above-average qualifications.<sup>33</sup> The labour mobility of those with higher levels of education will presumably continue to increase, but this does not represent a brain drain. Graduates do not usually emigrate permanently, and most find their way back to Germany.<sup>34</sup>

ABB 03 OECD-target countries for highly-skilled migrants



Data: 2001 (15 years and older). OECD Database on Immigrants and Expatriates.  
Source: OECD (2008b): The Global Competition for Talent: Mobility of the Highly Skilled, Paris.

A study of young scientists in the USA in 2001 found 5000 to 6000 German scientists in the USA, which would represent an immigration of about 14 percent.<sup>35</sup> Compared with the brain drain of some Asian and Latin American countries in the direction of the USA, this is a modest percentage, which is sometimes overlooked in the political debate. And since they return enriched by international contacts and their experience, the mobility of German academics is generally to be welcomed. Nevertheless, as a rule it is the most successful German scientists who receive the grants which enable them to go to the USA. And of these, the most successful obtain an attractive position on their return as an assistant professor with tenure track (Box 06). In addition, the young scientists who go to the USA have research interests in future-oriented sectors and interdisciplinary fields of application (such as molecular genetics, biophysics, bio-process technology, bio-informatics, neuro-sciences, or medical imaging systems). In the structurally conservative German science system they see few opportunities for development.<sup>36</sup>

**The setting must be right:  
No improvements possible without an  
attractive science labour market**

For this reason, Germany needs to provide attractive conditions for the science employment market. A survey of German scientists in other countries and foreign scientists in Germany shows what these might look like.<sup>37</sup> Important factors are the scientific standing, the graduate employment market, and the working conditions for professional scientists.

German science and research have a good standing in an international comparison, and in particular within Europe. This image is mainly determined by non-university research. The universities are rated as good in general, but the leading universities are given rather weak ratings – above all in comparison with the USA and Great Britain.<sup>38</sup>

The respondents see in particular the German university academic job market as rigid and restrictive. They criticise the shortages of personnel, the inadequate employment opportunities, the strict acceptance requirements, the inflexible career structures in the public sector, and the rigid adherence to staffing plans. University administrations and institute committees



## BOX 06

**Tenure Track**

The tenure track relates to a teaching or research position, such as a junior professorship at a college or university, that can lead to a tenured position. However, the universities have so far been slow to adopt this. A study has shown that only 18 percent of junior professors are offered tenure and the criteria for a successful evaluation are frequently felt to lack transparency.<sup>39</sup>

are hardly in a position to make job offers to leading scientists in a non-bureaucratic fashion.

Unattractive for German respondents in other countries are also the provisions for access to academic careers, career planning, and further professional development possibilities. The procedures for working together in German institutions are quite unattractive. The lack of cooperative decision-making structures and of interdisciplinary cooperation are criticised particularly frequently. Foreign scientists in Germany, in contrast, criticise the difficulties in accessing research funding. They point out the need for investments in innovative areas of knowledge and in the research infrastructure for all sub-disciplines which require expensive apparatus. They also feel it is necessary to intensify international cooperation.

In addition, 80 percent of married German scientists working in foreign countries make their decision to return to Germany dependent on their partner also receiving a satisfactory job offer.<sup>40</sup> In an international comparison, German research institutions are very reticent in this respect and rarely create satisfactory working and living conditions for the families of the researcher, for example with Dual-Career programmes.

Some of these points have already been picked up on by political initiatives and projects. Career promotion was strengthened by the Federal Ministry of Education and Research and other institutions by means of independent young researcher groups and junior professorships (Box 07). In addition, post-graduates can work on research programmes in so-called post-graduate schools, with the support of a number of university teachers. The new “Strategy for Modern Departmental Research” also envisages a more active role for Federal Government department

research institutions in the encouragement of young scientists.

Internationally attractive programmes include the “PhD-Net” of DAAD, which intensifies the cooperation of German universities with foreign universities and research institutions. The professorships funded by the Alexander von Humboldt Foundation make it possible for universities and research institutions to recruit up to ten leading foreign scientists from all disciplines every year.

In the framework of a Joint Initiative on Research and Innovation, the Federal Government and the *laender* have undertaken to make strenuous efforts to give financial planning security to the science and research organisations<sup>41</sup> and to increase the annual allocations by at least 3 percent by 2010. The agreement is intended to ensure that it will then be possible to enrol at least 90 000 additional students at the institutions of higher education and to provide funds for more young researchers. The Excellence Initiative also provides universities and research institutions with additional funds for young scientists. So far, 39 post-graduate schools have been supported with a million euros annually. In addition funding was provided for junior professorships and independent young researcher groups.

**Junior professors and heads of young researcher groups**

## BOX 07

In 2002, junior professorships were introduced in Germany. Since the mid-1990s, research funders and non-universities institutions have been appointing heads of groups of young researchers. The aim was to develop alternatives to the conventional route to a Chair. Junior professors and independent heads of young research groups must have completed a doctorate, and these positions offer promising young scientists an opportunity at an early stage in their career with more scope to assume responsibility.

Independent groups of young researchers are now receiving funds from DFG (Emmy-Noether Programme) and from the Volkswagen Foundation (Schumpeter Fellowships). The Max Planck Society has also set up independent groups for young researchers.

BOX 08

**“Initiative Freedom of Science Law”**

In Summer 2008, the Federal Government agreed on the key points on the “Initiative Freedom of Science Law”. Non-university research institutions should be allowed steadily increasing scope for the management of their own finances, including the sections personnel, cooperation, construction, and contracting. Increased flexibility has been provided in the 2009 budget by the allocation of funds for self-management, and which therefore do not have to be spent within the financial year, as well as extending the spread of funds to cover personnel, fixed assets and investments. The more flexible funding framework, the elimination of the requirements for approval in the so-called “W”-payment principles for professors, together with improvements to the appointment conditions are intended to allow institutions to make more attractive offers to scientists. Further measures are aimed at improving the networking between science and business, and the acceleration of construction projects and the acquisition of goods and services. The measures came into force in the 2009 budget year, and will be tested before being finally formulated in legislation. The recent debate about the Second Recovery Package of the Federal Government has once again highlighted the effects of the various degrees of freedom of research institutions with respect to construction and maintenance work. Private educational institutions are much more flexible than public institutions when it comes to awarding such contracts, and they will probably spend the available funds much more quickly.

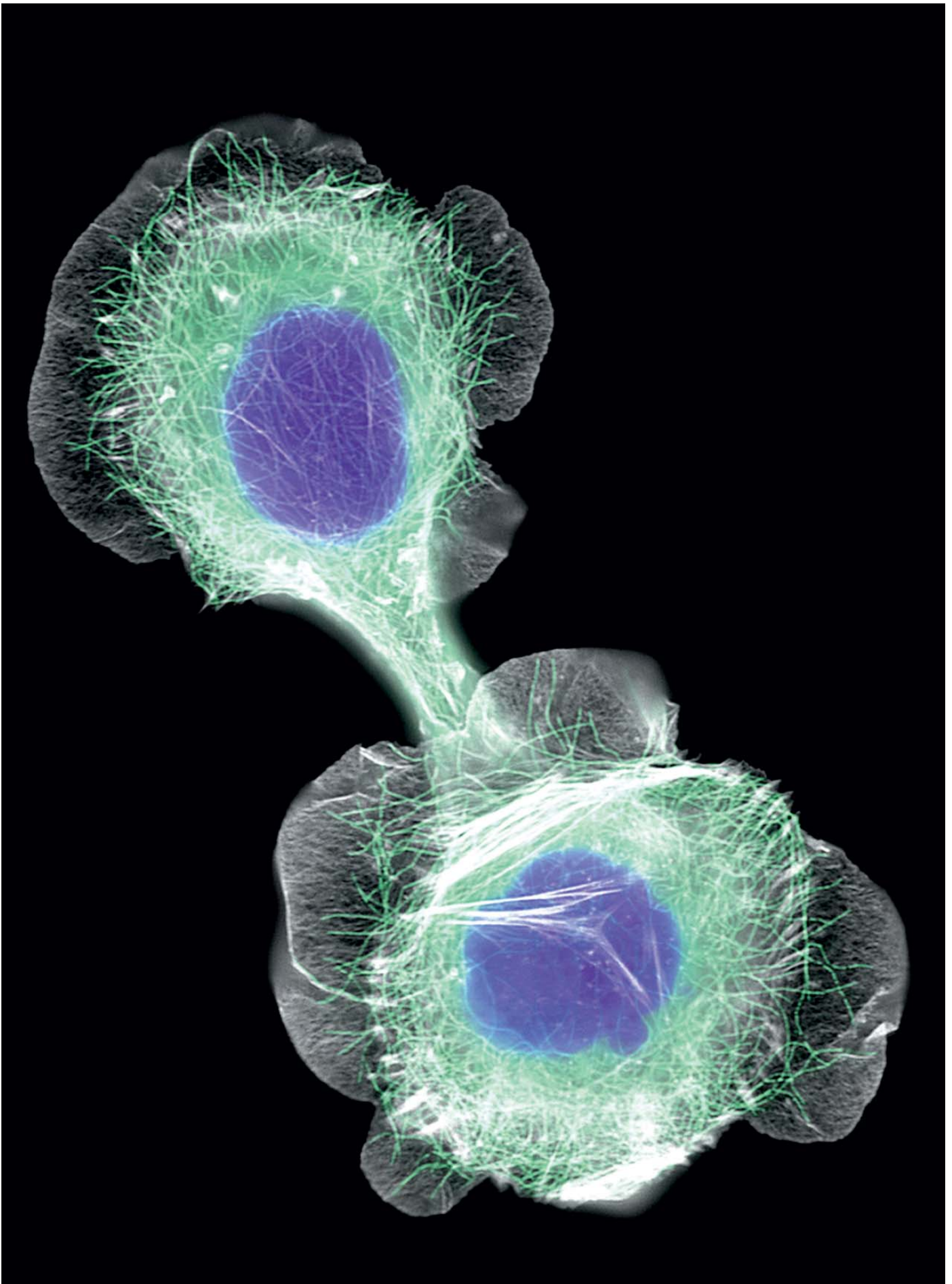
The Federal Government has shown the way with the key points formulated in the draft “Freedom of Science Act” (Box 08). Scientific institutions funded predominantly by the Federal Government shall be enabled to offer improved working conditions to young researchers which are adapted to their specific situation. It is hoped that the federal states will also introduce corresponding legislation for the universities and research institutions for which they are responsible.<sup>42</sup>

All these initiatives are aimed in the same direction. However, the reforms will have to be supported by various actors and institutions in order to improve the competitive situation of Germany as a science location.

Neither the Federal Government nor the *laender* can act alone – the universities and research institutions are also called on to take action.

The Expert Commission gives the following recommendations:

- The autonomy of universities and research institutions is to be strengthened. Scientific institutions must be in the position to develop their own goals, staffing plans and financial strategies. Budget responsibility is a necessary pre-condition.
- The laws on public servants make it hard for researchers to move between university, business, and society. Nor do they aid the international mobility of scientists. It also places restrictions on performance-based salaries. The Expert Commission recommends that public service law should no longer be applicable for scientists.
- Fixed and inflexible teaching obligations can impede research. Teaching requirements should be a topic for contract negotiations and professors should be able to concentrate more or less on teaching or research in various phases of their career. In principle, the Expert Commission supports the unity of teaching and research.
- Whereas the Federal Government should continue to support young researchers (by means of excellence initiatives, post-graduate schools, etc.), the federal states should also provide additional funds for their universities and research institutions, so that these will be able to cope with the expected rise in the numbers of students. The *laender* university legislation should be adapted so that staffing regulation can be reformed, and research cooperation between the universities and with other research institutions, companies, associations and ministries is supported.
- Post-doctorate researchers should be given the greatest possible scope for their scientific work. A first step has been taken with the introduction of junior professorships and independent young researcher groups. Further steps should follow, based on the implementation of the tenure principle. Permanent employment contracts at universities should be awarded on the basis of clear and transparent evaluation procedures. If there is no prospect of continuous employment, contracts should be awarded for a short period. Insecurity in this respect can often lead excellent young scientists to leave the science employment



HaCaT daughter cells  
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New York  
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market or not to consider it in the first place. Research institutions, which are rarely able to offer a tenure track, should try to cooperate with universities here.

- The career goals of young scientists are very varied. Many staff members in research institutions do not intend to stay working in science indefinitely. Their careers outside science must also be supported effectively. Permanent employment options are not always relevant in such cases.
- The best possible support should be provided to prepare young scientists for a career in research. This includes offering opportunities to gain teaching experience, to spend time in other countries, and to apply for research grants and funds to set up research networks. Generally, young scientists should be systematically involved in decision-making processes within the institutes.
- A regular evaluation of working conditions for scientists in Germany is important, and the first Federal Report on the Promotion of Young Scientists (BuWiN) is welcomed. It should appear at regular intervals. A positive aspect is the intention to extend the report to include key areas such as promoting young researchers in the private sector or the analysis of special groups in addition to gender comparisons.

### B3 KNOWLEDGE AND TECHNOLOGY TRANSFER

In recent decades, publicly-funded research institutions in all industrialised countries and in emerging economies have become very important for the dynamics of innovation.<sup>43</sup> The EFI Report 2008 already drew attention to this important development. In particular under difficult financial circumstances, research and innovation policies should aim to intensify knowledge and technology transfer, because science can make a considerable contribution to commercially-successful innovations.<sup>44</sup>

But attention should not be directed solely to engineering and natural science disciplines. With services also becoming increasingly important in Germany, it is necessary to view knowledge in a broader sense. Service innovations are often knowledge-intensive, but frequently they are characterised by a low technology intensity.

#### Key forms of knowledge and technology transfer

- Education and further training
- Research contracts and consultancy
- Strategic cooperation
- Licensing and rights exploitation
- Spin-off companies

BOX 09

Statistical analyses<sup>45</sup> show that the contribution of such innovations to increased productivity and welfare can be just as significant as the contribution of technologically-driven innovations. Engineering and natural sciences are immensely important, but not the only sources of innovations; the humanities, cultural and social sciences can also create innovations and must receive specific consideration in the R&I policies.

#### Supporting the entire breadth of knowledge and technology transfer

Knowledge and technology can be transferred in various ways (Box 09). The most important way is through teaching at universities and research institutions. Elite universities do more than produce Nobel Prize winners – the vast majority of their graduates will be doing practical work. The curricula must take this into account. Research institutions also offer intensive preparation for subsequent innovation-oriented activities in companies. New research findings and methods are transferred very effectively by graduates from universities and research institutions who move into the business sector. Therefore in particular in the course of the Bologna Reforms, close coordination is required between businesses and institutions of higher education. There should not be excessive political intervention concerning course structures and contents. The institutions of higher education would then be able to adapt their curricula to the employment market situation and the requirements of the subject. Personal technology transfer can be even more effective if all students have an opportunity to gain knowledge about business management in the course of their studies.

A further form of knowledge and technology transfer is through external research contracts and consultancy

BOX 10

**Strategic cooperation in  
Public Private Partnerships**

**Catalysis Research Laboratory (CaRLa) of BASF and Heidelberg University**

CaRLa is a joint project of BASF and the University of Heidelberg, supported by Land Baden-Württemberg. Six post-doc researchers from each partner work together on the development of homogeneous catalytic converters. Basic research is carried out at CaRLa, but in addition processes are also developed for specific requirements. Fields of application for homogeneous catalysts include resource-conservation in the production of chemicals and the avoidance of waste products, opening up new, cost-effective methods for the production of existing and new products. The projects are financed equally from private and public funds. This applies both for the infrastructure and also for the on-going costs for personnel and fixed assets. The project will be evaluated for the first time in the autumn of 2009.

**MerckLab at the Technische Universität Darmstadt**

In the joint laboratory of the Technische Universität Darmstadt and Merck KGaA scientists of both institutions have been researching since May 2006 on novel inorganic composite materials which are suitable for printable components for high-performance electronic applications (print electronics). A total of ten co-workers are employed in the Merck Lab. Merck invested about a million euros in setting up and equipping the laboratory. The annual running costs, also amounting to a million euros, are shared equally by the two partners. The TU Darmstadt contributes primarily in the form of personnel and contributions in kind. A period of cooperation of five years has initially been agreed on. Merck registers patents and markets the results.

**Deutsche Telekom Laboratories (T-Labs) at the Technische Universität Berlin**

The Deutsche Telekom Laboratories set up in 2005 are integrated in the Production and Innovation Department of Deutsche Telekom and at the same time is also an associated institute of the Technische Universität Berlin. A year after it had been established, a subsidiary institute was created at the Ben-Gurion University in Beer Sheva (Israel). In

early 2009 a further research institute of Deutsche Telekom was opened in Los Altos (USA).

The T-Labs are structured in the segments Strategic Research and Innovation Development. Focal points are intuitive operation, integratable service components, intelligent access, infrastructure and inherent security. Currently, more than 300 experts and researchers are working in the T-Labs – half of which are Deutsche Telekom employees and the other half staff or students of TU Berlin, with some 180 working at the Campus.

Currently four Chairs funded by Deutsche Telekom are occupied, and others are in planning. The T-Labs have been established without a time limit. The rights for all inventions lie with Deutsche Telekom.

work. Here Germany can look back over a long and successful tradition. In key sectors such as chemistry, mechanical engineering and road vehicle construction there are well functioning links between universities and research institutions and on the one hand and the business sector on the other hand.

Various institutions such as the Fraunhofer Society institutes or the IGF (Industrial Joint Research and Development),<sup>46</sup> provide the German innovation system with a clear advantage in an international comparison. There is also a successful tradition of support for companies by researchers at universities and research institutions, for example through the Steinbeis Foundation.

**Encouraging strategic cooperation agreements**

Strategic cooperation agreements are becoming increasingly frequent, involving institutionally anchored long-term cooperation between private and public partners. An interesting example for the latter form of cooperation are the Deutsche Telekom Laboratories (T-Labs) – a research laboratory set up jointly by the Deutsche Telekom AG and the Technische Universität Berlin. Other examples are Merck Labs at the Technische Universität Darmstadt, and the Katalyselabor CaRLa at the Ruprecht-Karls University Heidelberg (Box 10). Germany has little experience so far with such forms of cooperation. These partnerships still present considerable challenges for both sides in view of the differing cultures,

legal constraints, and problems of resource allocation. The Expert Commission emphasises that these Public Private Partnerships must as far as possible preserve the freedom of the research institutions and universities – in particular concerning the publication of research results. Cooperation could otherwise lead to excessive dependence. Public Private Partnerships offer considerable opportunities, because they are frequently long-term projects and bring together complementary strengths in research and development. Active political support should be provided for further partnerships. Experience with Public Private Partnerships should be made available for a wide group of companies and research institutions.

Licensing of industrial property rights is another main form of knowledge and technology transfer. The complexity of licensing is underestimated in many scientific organisations. The search for licence users requires excellent market knowledge and a well-developed communications network. The negotiation of licence contracts is often difficult, because this involves achieving a balance between the interests of the license holders and the license users. Business and science need to find appropriate models of cooperation. It is not only the obligation of science to ensure successful cooperation. In their own interests, business companies should also respect the special characteristics of scientific organisations and basic research.

New enterprises are a particularly sustainable form of knowledge and technology transfer, because non-codified knowledge of the researcher can be transferred and applied effectively. But this can raise complex questions for the universities and research institutions regarding the transfer or licensing of industrial property rights, the involvement of the scientific institution in the new enterprise, offering the entrepreneur a right of return, and deciding what support the university or research institutions can offer those setting up a new enterprise.

### **Improving the organisation of knowledge and technology transfer at universities and research institutions**

The amendments made in 2002 to the German Law on Employed Inventors (including the elimination of the “University teacher privilege”) have far-reaching consequences for the universities and research in-

stitutions. These are still going through a process of adaptation, but effective organisational and procedural models for knowledge and technology transfer are gradually developing. The patent exploitation agencies which were initially developed have not on the whole been successful, and it will be necessary to search for better solutions. A particular problem has been that aid for the agencies has only been provided in the past by the Federal Government, and then only for short periods, which meant that stable structures and processes could not be established. Furthermore there has not been any independent evaluation of the utilisation of the aid.

The transfer offices have to cope with a wide range of complex demands, but many of them have relatively inexperienced staff because the salary levels have often been set too low. In addition it is necessary to integrate the scientists who are involved. A fundamental reorientation is required on the part of the scientists if the work of the transfer offices is to succeed. An international comparison shows that there is still considerable scope for improvement in Germany.<sup>47</sup>

Political support can be provided for the optimisation of knowledge and technology transfer, first of all by identifying and communicating positive and negative examples. In order for promising models to be implemented, bureaucratic barriers must also be cleared out of the way. The Expert Commission has already drawn attention to the need to offer universities and research institutions more scope for their activities (Box 08). Currently, those involved in knowledge and technology transfer soon find themselves in legal grey area. A “Freedom of Science” law could create room for suitable organisational solutions.

Revenues from the licensing of industrial property rights and expertise cannot play a dominant role in financing public research, in either the short or long term. The macroeconomic benefit of knowledge and technology transfer can not be fully internalised by the universities and research institutions. The revenues from knowledge- and technology transfer as such (licensing and sale of company shares) even for very successful US research universities only amount to some two to four percent of the research budget of the institutions. Nevertheless, knowledge- and technology transfer has a considerable macroeconomic benefit.

This provides a justification for providing state aid for knowledge and technology transfer.

Above all there is a need for professionally-managed transfer offices which have a good network with the business sector and what the companies require, and which also understand the details of research processes and incentives. The logic of basic research must be respected, and scientists cannot be compelled into knowledge and technology transfer by bureaucratic measures. On the contrary, cooperation must offer attractions. In order to be successful, transfer offices must offer incentives to both the scientists and the transfer personnel. These include recognition of transfer achievements when deciding on appointments and promotions, as well as offering economic incentives.<sup>48</sup>

BOX 11

## Patenting

### Patenting with a grace period

Almost all patent organisations now use examination systems, i.e. the provision of a patent is dependent on meeting various criteria. The examination is carried out by personnel of the relevant patent offices, and it is quite possible that these offices reach different conclusions about the patentability. The criteria specified by the European Patent Office or the Deutsche Patent und Markenamt (DPMA) are Novelty,<sup>49</sup> Inventive step<sup>50</sup> and Industrial application.<sup>51</sup> An invention is new if it does not form part of the state of art. It is based on an inventive step if, having regard to the state of the art, it is not obvious to a person skilled in the art. And it is susceptible of industrial application if it can be made or used in any kind of industry, including agriculture. In the European Patent system an invention is no longer new if it has previously been made public in some way, e.g. in the course of a scientific publication or a presentation at a conference or a trade fair. In the USA, the inventor or applicant can apply for a patent within a grace period of one year after a publication (by the inventor or applicant) without the publication giving grounds for a loss of patent.<sup>52</sup>

### First to file vs. First to invent

In the USA they use the first-to-invent system, in which the right to a patent goes to the inventor who can give proof of having been the first to have made the invention on which the patent is based. This

means that an inventor can receive a patent even if they are not the first to file it at the patent office. In cases of conflict, special interference proceedings examine the claim of the applicant inventor. Such cases are rare, but the first-to-invent principle causes high documentation costs, because the time of the invention must be documented internally, and plausible evidence must be collected.

In Europe, the first-to-file system is used. The first applicant receives the patent, even if they are not the original inventor.

### Introduction of a grace period in the patent system

Universities and research institutions have had to weigh up since the reform in 2002 between publication or patenting, between long-term research cooperation or licence receipts in the short term, and between licensing or setting up a spin-off company. A particularly difficult situation arises as a result of the processing times for reports of inventions. In this case, the publication of the research results as quickly as possible can conflict with the intention of filing a patent. In the case of scientific results, it often only becomes apparent in the course of discussions with other specialists that they have a relevant application potential. With the introduction of a period of grace in the patent system it would be possible to resolve this conflict to a large extent. In the USA it is possible to apply for a patent within one year after a publication, without this being held to impinge on the novelty of the invention.

Such a regulation should not lead to legal uncertainty.<sup>53</sup> Rather, the grace period would make the work of the transfer office easier, because the invention can be discussed with potential license users at an early stage without threatening the patent protection. Ideally, the grace period for patent applications would be recognised by all parties to the Patent Cooperation Treaty (PCT). This would have the advantage that scientists would then not have to delay the publication of their research results until a patent has been applied for. A trilateral regulation involving the three major patent systems in Europe, the USA and Japan would also be an option. In exchange for the recognition of the grace period in Europe, the USA could then replace its first to invent rule by the first to file rule which applies



in Europe (Box 11). The German Federal Government should work intensively towards such a solution in negotiations in the European Union and with the USA and Japan.

### **Close the gap in support for the validation of research results**

Results of publicly-financed research frequently require further development before they are suitable for transfer to business companies and acceptable for private financing. This takes place in “validation projects”, which act as a bridge between invention and innovation. Public support of such projects is advisable, but it is currently only provided in individual cases (Box 12).

The Expert Commission approves of an expansion of validation support. This should be open for all technologies. In contrast to private financing, high-risk projects should also be accepted for support – the public measures should not simply duplicate private decision-making processes. Project evaluation must also draw on the market knowledge of experts from science and business. This necessity is also considered in Chapter B 4.

### **Supporting spin-offs from universities and research institutions**

A very effective way to transfer technology is to establish enterprises as spin-offs from universities and research institutions. A new enterprise is often a very good way to transfer new knowledge from science to practical applications. In addition, such new enterprises also create employment opportunities for highly-qualified professionals at the location where the knowledge is generated. The Federal Government has created an extensive range of instruments for this with the EXIST Programmes and other measures. Some of these programmes are now being evaluated. If the measures can be shown to be successful, they should be continued in a suitable form.

Transfer offices have to provide very different support for new enterprises than they do in the case of licensing activities. Spin-off enterprises are less common, but in some cases they can generate much more value for the research institutions which are financially involved.

### **Validation research in GO-Bio and EXIST Transfer**

GO-Bio is a promotion programme of the Federal Ministry for Education and Research (BMBF) which prepares scientists for setting up a company. With GO-Bio they are to develop new processes in life sciences and set up their commercial exploitation. The budget of this programme is up to 150 million euros annually.

EXIST research transfer is a programme of the Federal Ministry for Economics and Technology which supports outstanding research-based new enterprise projects which require complicated and risky development work. In a first phase the technological feasibility is established and prototypes developed. A business plan is also drawn up and the company founded. In a second phase, development work is finalised, business operations begin, and steps are taken to acquire follow-up funding.

If the research institute has a holding in the new enterprise this can solve a financing problem. The new company often has to acquire patent rights which are owned by the university or research institution, but does not have adequate liquidity to pay for them. A solution is to exchange the industrial property rights for shares in the new company which are made over to the university or research institution. However, such models are still rare and are viewed with scepticism in some quarters. Policy-makers can provide support here by highlighting successful examples.

Entrepreneurial training and support for new enterprises should complement one another. Many universities and research institutions now have new enterprise centres, which support the young companies and also offer students an opportunity to gain insights into planning and setting up a company. This is of key importance for promoting an entrepreneurial culture, but universities and research institutions must receive the resources and the freedom to initiate such measures.

BOX 12



## Recommendations

Public research provides important impulses for innovations in business companies. Universities and research institutions in Germany are very active in this respect, and many German companies have been working successfully with them for a long time. However, in the opinion of the Expert Commission, the knowledge created in the public sector could be put to better use. In particular the German *mittelstand* does not utilise these sources of information often enough. Policy-makers have more possibilities to support the transfer of knowledge and technology:

- Knowledge- and technology transfer can be organised in many ways. Universities and research institutions have to find the solutions which are best for them. R&I policies should provide incentives and initiate independent evaluations, but not demand specific processes and structures.
- R&I policies for the organisation of knowledge and technology transfer can identify and communicate good examples.
- Public Private Partnerships should be promoted energetically.
- The Expert Commission urges the introduction of a “Grace period” in patent law.
- The Expert Commission recommends the development and regular evaluation of further instruments to validate the commercial applicability of research results.
- Germany needs to catch up in particular with research-based new enterprises. The involvement of universities and research institutions in spin-off companies should be made easier by the Federal Government and the relevant *laender* ministries.
- Entrepreneurial training should be offered at all universities and research institutions.

## RESEARCH AND INNOVATION IN SMALL BUSINESSES

B 4

Small and medium-sized enterprises (SMEs)<sup>54</sup> play a key role in the German economy. According to an estimate of the Institut für Mittelstandsforschung Bonn (IfM Bonn), some 70 percent of the total workforce of German companies in 2007 were working for these smaller businesses.<sup>55</sup> In the commercial services sector, about 75 percent of the workforce were employed in SMEs, and about 60 percent in the manufacturing sector.<sup>56</sup>

Smaller businesses are particularly prevalent in the services sector. There almost half of the employees registered for social security payments are working in small- and micro-enterprises with up to 49 employees. The proportion of the total work force in Germany working in the services sector rose from 54 percent in 1980 to 72 percent in 2007. Changes in productivity and demand are favouring the growth in services, and the trend to tertiarisation is coupled with the growth in significance of smaller businesses.

Since the begin of the 1990s, employment in the manufacturing sector has been declining, while it has been increasing in the services sector.<sup>57</sup> Under this aspect, among others, the small and medium-sized enterprises are a pillar for the economy. Therefore the conditions provided for them are equally as important as those for the large companies and under no circumstances should they be neglected.

### Types of smaller businesses

85 percent of small and medium-sized businesses are active in the services sector, and 15 percent in the manufacturing sector. Of the smaller businesses in the services sector, 25 percent are in turn active in knowledge-intensive sectors. Five types of SMEs can be distinguished, each with specific functions for the economy.<sup>58</sup>

Type 1: Regularly researching small and medium-sized businesses have a high R&D-intensity,<sup>59</sup> and particularly high in the case of small- and micro-enterprises of this type (Box 13). This group of companies is therefore very significant for the dynamics of innovation.

BOX 13

**Example of a regularly researching company**

CAS Software AG in Karlsruhe was founded in 1986 and it currently has 300 employees. It specialises in software for Customer Relationship Management (CRM) for medium-sized companies, and is one of the leading companies in Europe in this sector. The research concentrates on product-related topics such as speech analysis, methods for data storage and recovery as well as the development of wireless applications. Through strategic partnerships with established companies, CAS Software AG is represented in many European countries.

Type 2: Innovators without regular R&D are constantly launching new products or processes on the market, but only research intermittently, if at all (Box 14). They also make a key contribution to the competitiveness of the German economy. For this group of companies, access to external knowledge, e.g. from research institutions and universities, is vital.

BOX 14

**Example of an innovative company without regular research and development**

Topstar was founded in 1976 and it currently has 450 employees. It produces office furniture, in particular top-segment office chairs, in a highly competitive market. Although the company does not itself carry out any research and development, it keeps track of innovations in the organisation of production and deliveries, so that it can achieve extremely short delivery times. The company is also constantly working to improve the technical basis for office furniture, the materials, and the design, and cooperates with a research institute and leading designers worldwide.

Type 3: Non-innovators do not carry out R&D or innovation activities. These companies also have very specific expertise which enables them to compete internationally, including against companies from emerging economies with much lower wage levels. It is also very important that these companies are reached by knowledge and technology transfer measures, find access to sources of knowledge, and utilise external knowledge.

Type 4: R&D- and knowledge-intensive new enterprises form a numerically small group (Box 15), but above all in cutting-edge technology sectors such as pharmaceuticals, medical technology, instrument technology, or computer engineering they can provide crucial impulses for radical innovations. These companies also play a key role for research and innovation in new sectors and markets, e.g. biotechnology, nanotechnology or sustainable energy technologies, because they can react more flexibly to new demands in growing markets than established companies. Finally, they also represent an important potential for structural change, because they contribute to new forms of value-creation.<sup>60</sup>

These new enterprises often require external funds (venture capital) for their consolidation and growth.

**Example of a research-intensive new enterprise**

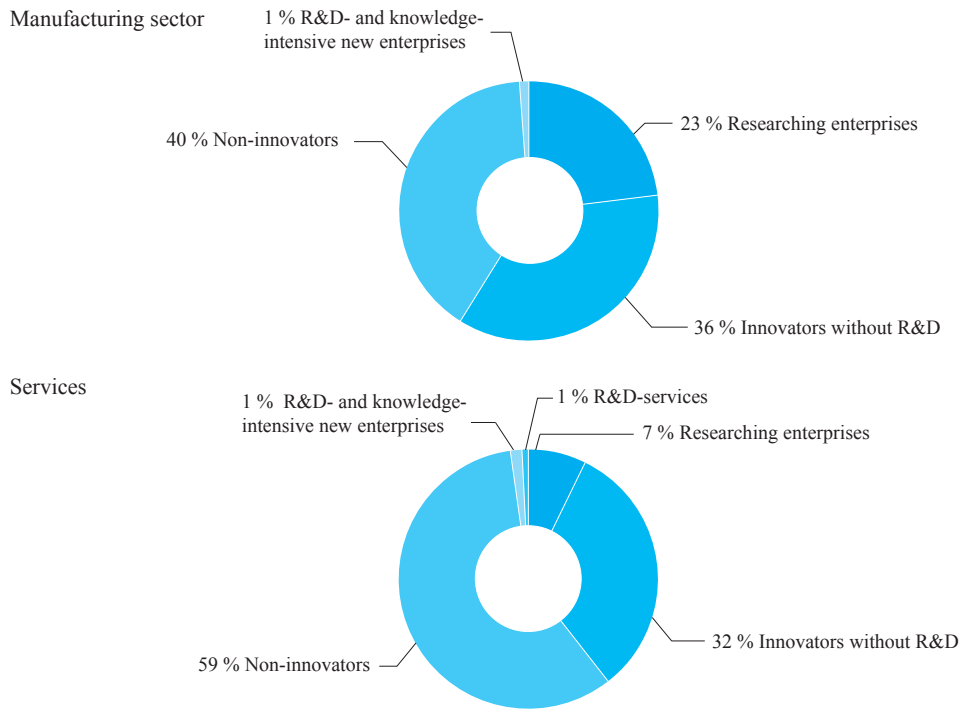
BOX 15

Concentrix Solar GmbH was established in 2005 as a spin-off company from the Fraunhofer Institute for Solar Energy Systems. In 2006, the company received a first round of venture capital from a Swiss investor. It now has 60 employees and is planning to expand further in the near future. The Freiburg-based company has developed an innovative photovoltaic technology from the laboratory setting to series production, and today it runs one of the most modern production lines for so-called Concentrator Photovoltaic Modules. In comparison with conventional silicon technology, which achieve a module efficiency of 13–14 percent, the concentrator technology of Concentrix Solar produces a module efficiency of 27 percent.

Type 5: Service providers in the research and development sector carry out R&D work on behalf of other companies (Box 16). This allows specialisation, with the company concentrating on its core competence, and outsourcing specific questions outside this area. R&D service providers contribute to new developments and support their customer's position relative to international competitors.

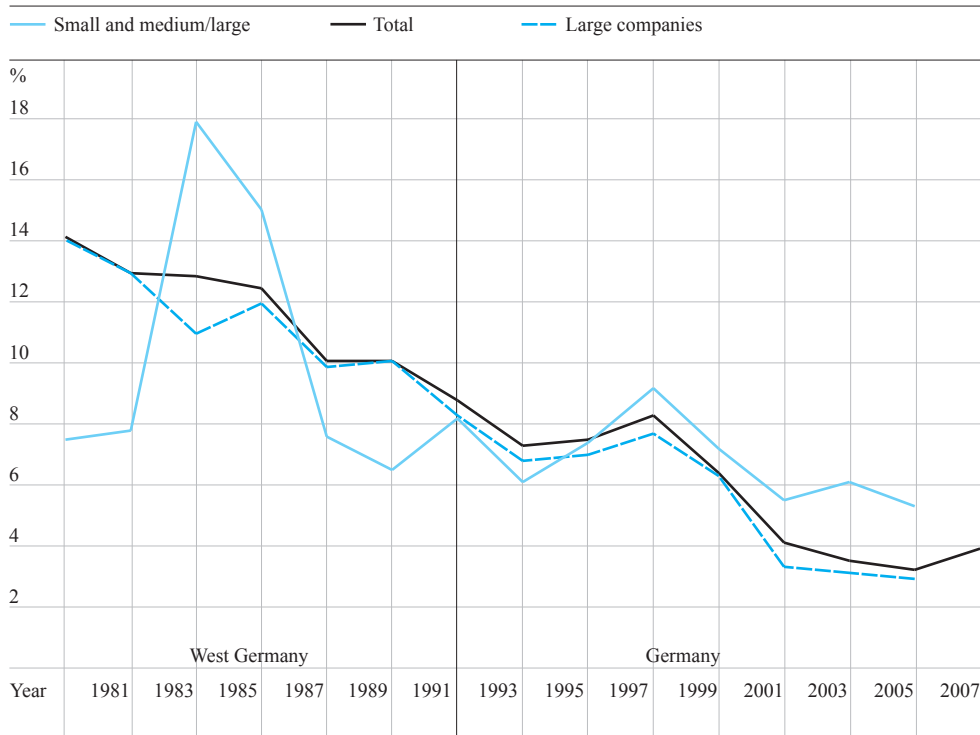
This distribution of smaller businesses between these various types differs between the manufacturing sector and services (Fig. 04). At nearly 25 percent, the proportion of small and medium-sized manufacturing

**ABB 04 Sectoral distribution of small- and medium-sized businesses**



Data 2007. Companies with between 5 and 499 employees.<sup>62</sup>  
 Source: Mannheimer Innovationspanel 2008. Calculations by ZEW and Fraunhofer ISI.

**ABB 05 State R&D-financing as proportion of total R&D-expenditure for small and medium-sized enterprises and large companies**



Source: SV Wissenschaftsstatistik, BMBF (2008). Calculations and estimates by NIW. Calculations by Fraunhofer ISI.

businesses carrying out research is much higher than the proportion of small and medium-sized services businesses (less than 10 percent). The proportions of innovators without R&D is similar in both sectors. The proportion of non-innovators among manufacturing SMEs is just under 40 percent which is considerably lower than the corresponding percentage in the services (58 percent).

### **Research and development in small and medium-sized businesses**

The proportion of small and medium-sized businesses regularly carrying out research had been declining for some time and has recovered slightly since 2003.<sup>62</sup> Even though Germany still has a leading position in a European comparison of the percentages of researching and innovating SMEs,<sup>63</sup> this lead has clearly shrunk and is at risk in the medium term.

Since the 1980s, the state financing<sup>64</sup> of R&D in companies has declined in absolute terms from 6.0 billion euros in 1985 to 1.5 billion euros in 2005. But the sum of 6.0 billion euros in 1985 would have corresponded to 8.5 billion euros at 2005 prices.<sup>65</sup> The proportion of state R&D financing for SMEs has dropped – as with large businesses (Fig. 04).<sup>66</sup> In recent years there has been an increase in public R&D support for companies. In 2007, the corresponding expenditure of the Federal Government is 22.4 percent above that of 2005.<sup>67</sup> This is an important step in the right direction, but in view of the decline in the previous years it is not yet adequate. Therefore the Expert Commission urgently recommends introducing the fiscal R&D support described below.

### **Supporting research and innovation in small businesses**

The Expert Commission welcomes the long-term initiatives of the Federal Government for the improved support for research and innovation of small and medium-sized enterprises. However, in view of the high relevance of SMEs, the Expert Commission sees a need for reflecting on new forms of support for this target group. It has to be taken into consideration that research and innovation are usually financed by equity and the equity ratio of Ger-

### **Example of an R&D service provider**

EMC Microcollections was founded in 1996 as a private company and established as a limited company in 2000. It currently has 30 employees, of which 15 have a Ph.D. The company based in Tübingen develops new products and instruments for the systematic discovery of active pharmaceutical substances. Specialities of EMC Microcollections are combinatorial chemistry, the scaling of synthesis processes, peptide and protein chemistry, synthetic vaccines, and siderophores.

EMC Microcollections works mainly on behalf of large pharmaceutical companies.

BOX 16

man small and medium/large businesses is low by international standards (Chapter B 1). The technological and economic uncertainties of R&D projects are hard to assess, so that it is often not possible to find investors. Research and development also bind a minimum volume of funds and demand a certain continuity in conducting R&D projects.

It is therefore not surprising that financing problems prove to be a major impediment for research and innovation for small and medium-sized businesses.<sup>68</sup> This applies in particular in times of economic stagnation or decline. When business is booming, on the other hand, the shortage of skilled and qualified personnel is perceived as the greatest constraint.

### **Support instruments**

R&D support for SMEs in Germany is usually organised as project funding. This form of support is selective and aimed at supporting particularly capable companies. The effectiveness and efficiency of these programmes is almost always judged as being very positive.<sup>69</sup> The selection process involves screening applications, and the procedure often appears to be very bureaucratic to the companies. In addition, the variety of programmes generates friction between the various supporting agencies and causes costs for the applicants.<sup>70</sup> The heterogeneous funding possibilities at the levels of the Federal Government, the federal states and the European Union have resulted in a confusing array of options.

Important measures to introduce simplification and increase transparency have been taken in hand.<sup>71</sup> The High-Tech Strategy of the Federal Government aims to establish a centre for inter-departmental information and advice on state aid and support for research and innovation. This is intended in particular to assist small and medium-sized enterprises and offer guidance on the relevant aid and support programmes. Despite these steps, the aspect of transparency continues to warrant attention.

### Further development of project support

In recent years, the project support instruments for the target group of SMEs have been developed further. In the BMBF programme “SME-innovative” which forms part of the High-Tech Strategy the application procedure has been made much simpler (Box 17). The support is concentrated in particular fields of technology and advanced research. This focussing may well represent a limitation for some SMEs. They may find the SME support offered by the BMWi through its Central Innovation Programme *Mittelstand* (ZIM) is particularly appropriate, because this is open to all technologies. And recently a long-standing restriction has been lifted under which the research projects had to be carried out in cooperation groups or

BOX 17

#### BMBF Programme: SME Innovation

With SME Innovation, the Federal Ministry for Education and Research aims to promote cutting-edge research in important advanced sectors, in particular in biotechnology, information and communications technology, production technology, resource and energy efficiency, optical technologies, and in nanotechnology.

This programme is intended to offer uncomplicated access to funding support. For example, it is possible to submit a project sketch before completing the actual funding application. The sketch will then be assessed within two months. The full application will also be evaluated within two months. Since the start of the programme in 2007, sketches have been recommended in the previous selection rounds to receive a combined funding of nearly 200 million euros, with a corresponding project volume of more than 320 million euros. More information is available at [www.kmu-innovativ.de](http://www.kmu-innovativ.de).

BOX 18

#### BMBF Programme: Innovations with services

The research programme “Innovations with services” promotes research and development projects in the services sector and focuses on innovation management, innovations in fast-growing fields and people in services companies. The programme is intended for companies, universities and independent research institutions as well as associations. Companies of all sizes are entitled to apply, but mainly smaller and medium/large companies will be supported. Among other things, the programme is intended to broaden the knowledge-base for innovation processes in the services sector. Over the next five years some 70 million euros will be available for this purpose. For more information visit [www.hightech-strategie.de/en/250.php](http://www.hightech-strategie.de/en/250.php)

networks (Box 19). The Expert Commission welcomes this relaxation. The programme “Innovations with services” which is part of the High-Tech Strategy also addresses an important SME sector (Box 18). In the view of the Expert Commission, these activities of the Federal Government contain a series of highly promising approaches. The applications are simplified, restrictive requirements about cooperation agreements and networks are dropped, and increasing attention is paid to innovations in services. This positive assessment does not alter the recommendation of the Expert Commission that fiscal R&D support should be introduced rapidly.

The involvement of two Federal Ministries – BMWi and BMBF – can be explained by the research-related BMBF-programmes and the applied technology orientation of the BMWi programmes. In the opinion of the Expert Commission these arguments are not convincing. Innovation processes do not follow a linear logic according to which research can be carried out far removed from the market, and only then do thoughts need to turn to an application. It therefore seems appropriate to bring together “SME innovative”, “ZIM” and “Innovations with services” in one programme. Whether this is possible in view of the rivalry between departments is a political consideration, but the separation does not seem sensible. Particularly regarding support for SMEs, more efforts must be made to follow the goal of the High-Tech Strategy – the improved harmonisation and cooperation between government departments.



In addition to further development and standardisation of the existing instruments, German R&I policy should also endeavour to extend the range of support instruments for specific contexts. Other countries have interesting approaches to providing support for research and innovation in SMEs, which could give important ideas for innovation policies in Germany. The Expert Commission presents two such strategies. As in the case of fiscal R&D-support, the details of a German strategy could be decided on by working groups of the Research Union Business - Science, in order to integrate the expertise of representatives from politics, business and public administration in the planning.

## BOX 19

### Programme of BMWi for SMEs

#### Central Innovation Programme *Mittelstand* (ZIM)

The ZIM programme is aimed at medium-sized companies and combines the previous BMWi programmes for supporting cooperation and network building between SMEs. It is intended to provide a more transparent programme offering support under standard conditions. ZIM supports both manufacturing projects and projects relating to technological services. Since January 2009, individual projects from east German SMEs can be supported independently from nationwide cooperation projects and networks. (For more information visit [www.zim-bmwi.de](http://www.zim-bmwi.de)). In 2009, 323 million euros has been made available for this.

In addition, the Federal Government has made an additional 900 million euros available through the Second Recovery Package in 2009 and 2010 for the ZIM Programme. At the same time, the programme has been extended to include the provision of support for individual projects of west German SMEs and projects for companies with up to 1 000 employees.

#### „*Jeune Entreprise Innovante*“ in France

An interesting measure is the introduction of the status of *Jeune Entreprise Innovante* (JEI)<sup>72</sup> in France. New SMEs qualify for this status for the first eight years of their existence. They correspond to Type 4 in the classification outlines above, or early-phase R&D and knowledge-intensive enterprises. The JEI-status confers on the companies considerable reduc-

tions in taxes and social payments (Box 20). The effect is therefore an improvement in the financial situation of young, research-active companies, irrespective of their involvement in any specific projects. Given the limited target group, the total of 1 789 French JEI-enterprises in the first year of the scheme is a good start.

Other countries such as Belgium, the Netherlands or Spain have introduced similar regulations. Norway, Sweden, Estonia, and Finland plan to use comparable models in particular to support new biotechnology enterprises. The European Commission officially recognised the status of Young Innovative Company (YIC) in 2007 so that such support for young companies does not contravene EU Law. The Expert Commission recommends the examination of the advantages and disadvantages of introducing the YIC status in Germany, taking the experience in other countries into account.

### *Jeune Entreprise Innovante* (JEI) in France

## BOX 20

The status of JEI was introduced in France in 2004. In order to be granted this status, a company must meet five criteria:

1. It must be an SME in accordance with the EU definition, e.g. it must have less than 250 employees.
2. The company must not be more than eighty years old.
3. Research costs must account for at least 15 percent of the total costs.
4. The company must be independent, i.e. no other company may have a majority holding in it.
5. The company must be a genuine new enterprise.

The JEI-status confers the following advantages in France:

1. JEI are freed from social security payments for research personnel
2. JEI are completely freed from taxes on profits for three years, and then have 50 percent tax relief for a further two years.
3. JEI is completely freed from the annual IFA turnover tax.
4. JEI can be freed by the district authorities from paying French company tax and other company contributions for seven years.



## Small Business Innovation Research (SBIR) in the USA

In the United States, the SBIR Program is the central instrument for the public support of research and innovation in small businesses (Box 21). All ministries awarding R&D contracts are required to reserve at least 2.5 percent of their R&D funds for small businesses. The Expert Commission views the special consideration of small businesses when awarding public contracts as a central advantage in this case. This prevents large companies from enjoying the exclusive benefit of research support from a specific department.

SBIR Projects have three phases: a feasibility study, the research project, and the market launch. For the first two phases, the companies receive financial assistance. The financing of the feasibility analysis is particularly helpful in the opinion of the Expert Commission, in order to increase the probability of technological and commercial success of the project. In the evaluation of applications, the marketing potential plays a role from the start, and the process involves not only technology experts, but also economists.<sup>73</sup> Project evaluation in accordance with the SBIR model also has the advantage that international venture capital investors are familiar with it. Young entrepreneurs therefore have a better chance of acquiring venture capital after receiving a positive evaluation of their application. The Expert Commission recommends examining whether key elements of the SBIR system would be suitable for use in German R&I programmes.

### High time to introduce fiscal support for research and development

Many countries – e.g. Austria, the Netherlands, France, Canada, or USA – have introduced fiscal R&D support. This is an indirect instrument which only relates to research activity as such, but not to the specific contents. The provision of a legal entitlement removes the need for complex application procedures, and claims are registered through the annual tax return. This fiscal support is a considerable incentive, which has been proved in other countries to lead to an appreciable increase in R&D-activities by SMEs.<sup>74</sup> Because it is open in nature, it also reaches SMEs in sectors with less research-intensive technologies

## Small Business Innovation Research (SBIR) in the United States

BOX 21

The SBIR Programme was introduced in 1982 and last extended in 2000. It obliges specialist ministries which finance research to any appreciable extent to reserve 2.5 percent of their R&D funds for companies with fewer than 500 personnel. The SBIR support is divided into three phases:

1. Feasibility studies for a research project; project duration of about 6 months, maximum budget of 100 000 dollars.
2. Carrying out the actual research project; project duration of about 2 years, maximum budget of 750 000 dollars.
3. The marketing of the research results, for which there is no explicit SBIR support. Financing by other private or public investors.

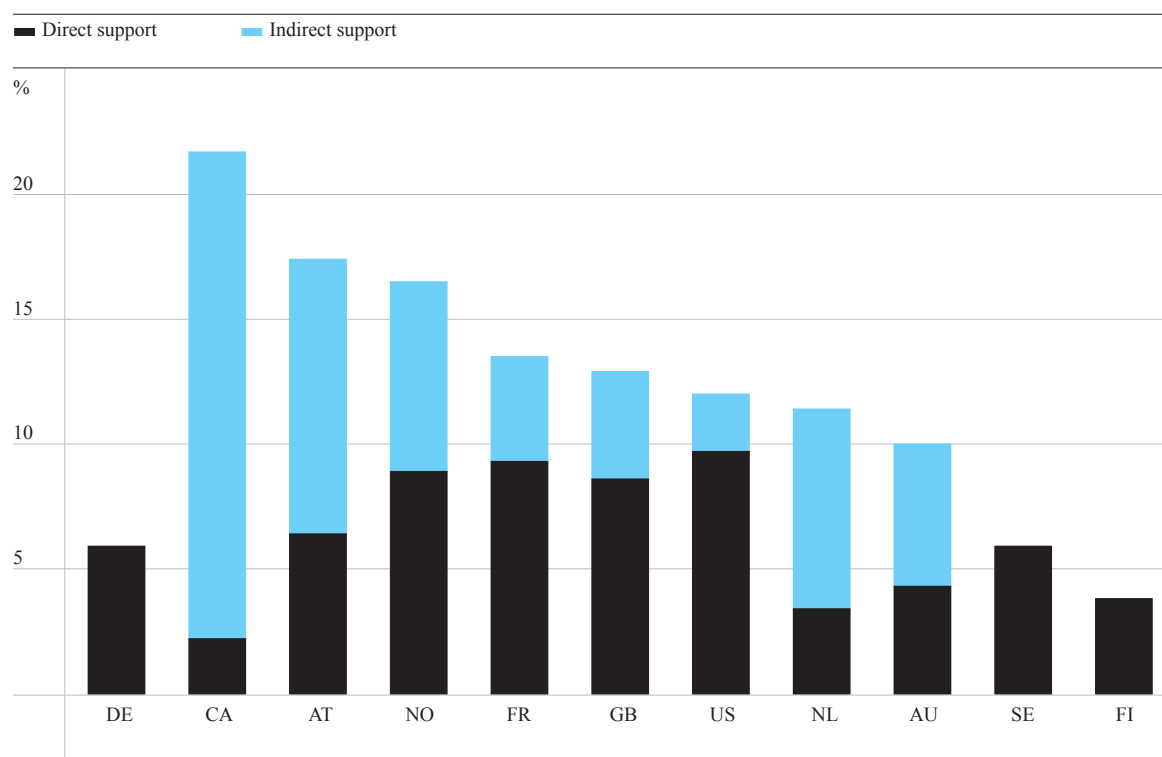
Closely linked to the SBIR programme is the Small Business Technology Transfer Program (STTR), which covers the support of research cooperation between small and medium-sized companies and public scientific institutions and which uses similar support mechanisms.<sup>75</sup>

which rarely benefit from the other programmes. This is focal point for the activities of many Type 3 SMEs (innovating companies). Without research, they can become uncompetitive in the medium-term.

In many OECD-countries, indirect fiscal support for R&D is meanwhile more important than direct support – for example in Canada, the Netherlands or Austria (Fig. 06). Germany has a middle position in an international comparison regarding the provision of direct support. But when the overall state financing is considered it only has a bottom ranking. The Expert Commission therefore pleads for the rapid introduction of fiscal R&D support. This will mean that a much broader range of SMEs will be reached. The EFI Report 2008 already proposed this, and meanwhile a general consensus has formed on the suitability of this measure for Germany. The German Council of Economic Experts,<sup>76</sup> as well as a working group of the Research Union<sup>77</sup> and numerous associations have all recommended the introduction of fiscal R&D-support. A study commissioned by the BMWi<sup>78</sup> also approved of this measure. A Federal Government working group confirms that fiscal R&D support is feasible and will have a positive effect on R&D activities. It is time to

## State financial contributions to business R&D for selected OECD-countries

ABB 06



Data: 2005. Support as a percentage of internal R&D-expenditures.  
Sources: OECD, MSTI 2007/I. OECD, S&T Scoreboard 2007. OECD, S&T Outlook.

introduce fiscal R&D support in Germany. This would have already been appropriate as part of the Second Recovery Package. The Expert Commission sees an important task here for the Federal Government.

There are many possible options for fiscal support. Either it can be tightly restricted to the target group of SMEs, or linked inversely to the size of the company, or it could be completely open, allowing large companies to benefit in the same way as SMEs. One argument in favour of involving large companies is that the provision of fiscal R&D support can be an important factor for multi-national companies when they are choosing their research locations. This is why the working group of the Research Union Business-Science favours this option.<sup>79</sup> The Expert Commission regards an initial focus on SMEs or setting a limit as sensible, because in this way the instrument can develop a particularly broad macroeconomic effect.<sup>80</sup>

### Cooperation partners for SMEs

For small and medium-sized enterprises it is particularly important to be able to draw on external

expertise with respect to innovations. The costs involved in cooperation between a small or medium-sized enterprise and a scientific institution are met in full through the “SME Innovative” by the Federal Government. But the question is which institutions are the best partners for the SMEs. If these are Type 4 technology and knowledge-oriented new enterprises then universities and research institutions are certainly appropriate, especially since many new enterprises are direct research spin-offs. But for the large group of Type 3 companies which do little or no research involving less advanced technology, the cooperation with universities can be problematic, because their “cultures” are very different and communications can be difficult. An alternative can be Fraunhofer Institutes, which are better prepared for the cooperation with business companies and which carry out many research projects for SMEs. Much the same applies for the “associated” institutes at universities, which have relaxed their ties to the university in order to be in a better position to deal with businesses.

The *Fachhochschulen* or universities of applied sciences are often overlooked, although they can provide valuable support for many SMEs. Universities

of applied sciences are oriented towards practical problems and applied research. It is therefore perhaps not so surprising that in the competition “Exchange processes of universities, research institutions and companies” organised by the *Stifterverband* innovation agency and BMBF in 2007, three of the five prizes went to universities of applied sciences. But these institutions only have very limited research capacities, and their professors do not usually have any assistants to support them in their research.

Some federal states have launched initiatives to improve the cooperation between universities of applied sciences and companies.<sup>81</sup> The BMBF is also active here with its “FHprofUnd” programme (previously “FH3”). This involves providing support for cooperation projects, and thus indirectly increasing third-party funding for the universities of applied sciences. But these initiatives cannot change much regarding the poor infrastructure. There is an interesting model in Switzerland, where the *Fachhochschulen* are provided with adequate resources for applied research and can play an important role in supporting the research of SMEs.<sup>82</sup>

In the opinion of the Expert Commission, the R&I policies of the Federal Government and the *laender* should aim to improve the research conditions at the universities of applied science and to provide incentives for their cooperation with SMEs.

### **Smaller businesses in the market for highly-qualified professionals**

The shortage of highly-qualified professionals affects in particular the small and medium-sized enterprises particularly hard. In the medium-term, demographic developments and knowledge intensification of the economy will only make this problem more acute.<sup>83</sup> Graduates prefer to work for large employers because they can earn significantly more there and feel they have a more secure job. This preference is one reason why the proportion of graduates in smaller businesses is only half that of the large companies. There is a significant shortfall in graduates in mathematics, natural sciences, computer sciences, and engineering. In the current financial crisis, the shortage of qualified specialists will be less significant for the smaller businesses than the financing problems. Indeed, smaller businesses have an opportunity at present to

attract highly-qualified professionals with interesting innovations projects. There is no need here for government intervention. The small and medium-sized enterprises and their associations should take the initiative and do more to approach graduates, e.g. by taking part in careers events, job-experience offers, and closer contacts to universities and research institutions.

In order to increase the innovation potential of small and medium-sized enterprises, the Expert Commission sees in summary a need for the following steps:

- The responsible government departments should continue to work to increase the transparency of the support programmes and coordinate these better.
- The financial burden of small and medium-sized enterprises carrying out research and development should be reduced, e.g. by a smaller tax bill and lower social security payments, as with the status of Jeune Entreprise Innovante in France or the EU Young Innovative Companies.
- More public R&D orders should be placed with innovative small and medium-sized enterprises, following the US Small Business Innovation Research Program.
- In order to provide broad support for independent R&D in small and medium-sized enterprises, non-specific fiscal support is needed for R&D.
- Small and medium-sized companies should be integrated more effectively in knowledge and technology transfer processes. This requires strategies and measures to identify suitable science partners. In particular, the universities of applied sciences should be better equipped, so that they can play a more active role as transfer partners of small and medium-sized enterprises.

## B 5 USING THE OPPORTUNITIES OF KNOWLEDGE-INTENSIVE SERVICES

### Growth through knowledge

In addition to the traditional production factors Labour, Capital, and Natural resources, the “fourth factor” of Information and Knowledge is becoming increasingly important in the 21st century. The concept of the “Quaternary Sector” was proposed for this in the 1970s. Some 40 percent of the German workforce are already involved in knowledge-based activities.

Without doubt, knowledge-intensive services have been a key engine for growth and employment for at least a decade in Germany (Fig. 07). The same applies for most other industrial countries. The competition between the federal states in Germany has already begun, as shown by “WissensWirtschaft. NRW – Looking for the best knowledge-intensive services in the value-creation chain.”<sup>84</sup> The question is how German businesses should best make use of the opportunities of structural change in the face of international competition.

The EFI Report 2008 drew attention to the importance of services for the economic performance of Germany, and called for more attention to be paid to the services components in all sectors of the High-Tech Strategy, in particular for product-related services. In addition it called for services-related innovations research to be strengthened: there are still deficits here. In 2008, the Expert Commission commissioned two studies on knowledge-intensive services and the effects of the organisation of services on innovations.<sup>85</sup> The results of these investigations have been drawn on for the following assessment.

### Knowledge-intensive services as element of the economic structure

Overall, services in Germany in 2006 accounted for 62 percent of gross value-creation,<sup>86</sup> with knowledge-intensive services making up 37 percent. Fig. 08 shows how health- and business-oriented services dominate the knowledge-intensive services sector. The insurance and credit sectors and data processing in Germany are relatively less important in an international

### Technology concepts and definitions

BOX 22

Cutting-edge technology goods are R&D-intensive goods for which more than 7 percent of annual revenues is spent on R&D. Examples include active pharmaceutical substances, IT-equipment, aircraft and space vehicles.

High-value technology goods are R&D-intensive goods for which more than 2.5 percent, but not more than 7 percent of annual revenue is spent on R&D. Examples are pharmaceutical products, engines, filters, machine tools, medical technology, motor vehicles, and rail vehicles.

Knowledge-intensive activities can be provided in all sectors. However, it has proved advantageous to separate out the services sectors which mainly involve value-creation on the basis of knowledge-intensive activities. Knowledge-intensive services are those involving a high proportion of university graduates (above 11 percent) and/or an above-average proportion of natural scientists and engineers (more than 4.5 percent).

Examples of sectors of knowledge-intensive services are: telecommunications, software services, insurances, financial services, architectural and engineering services, legal, fiscal and management consultancy, veterinary and health services, communications, libraries, archives, museums.

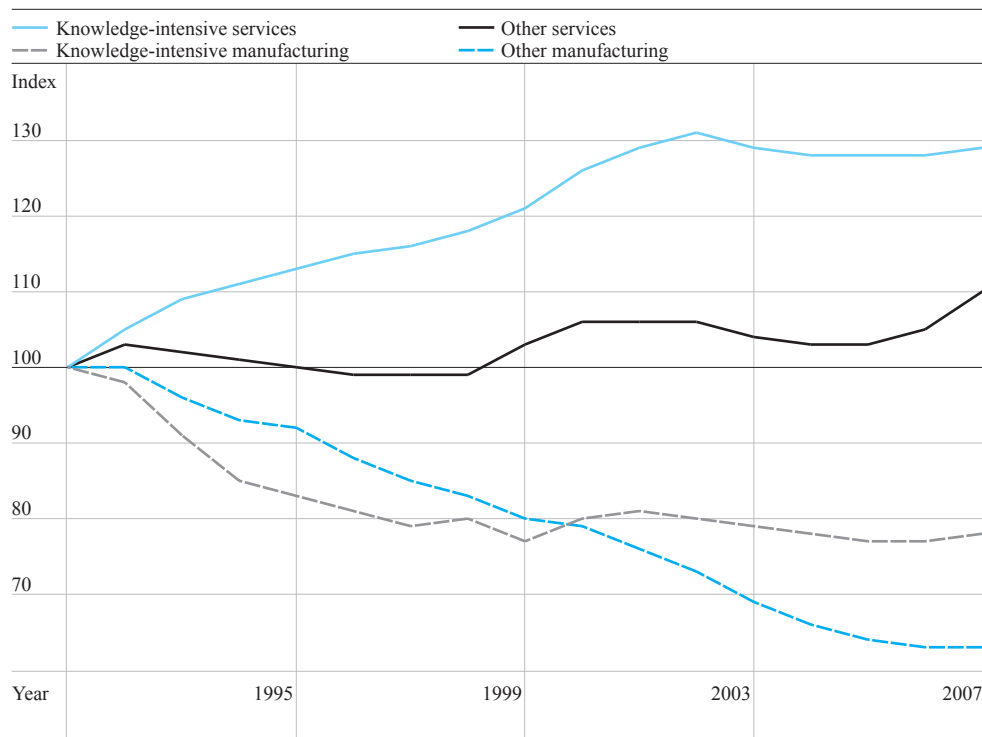
Research- and knowledge-intensive sectors are the research-intensive industrial sectors and the knowledge-intensive services (also simply referred to as the knowledge-intensive sectors).

Section D of this report contains a full list of R&D-intensive industrial sectors and knowledge-intensive services.

comparison. Fig. 08 shows sectors registering a part of the knowledge-intensive services, because in all industrialised countries a considerable part of the knowledge-intensive services are also provided by companies in the manufacturing sector and are allocated to this sector in the statistics.

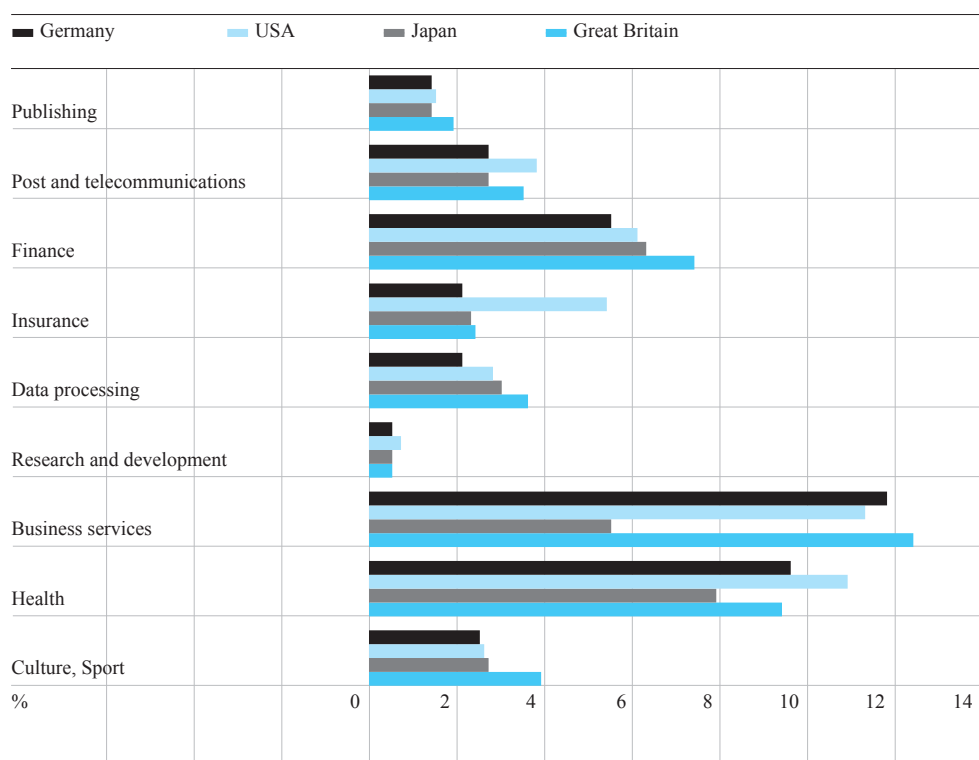
In Germany, a much lower proportion of value is created by the services sector than in most other developed economies and many observers speak of a services gap.<sup>87</sup> The economic structure analysis also shows that knowledge-intensive services in particular are weak in Germany in international comparisons (Fig. 08). These structural differences

**ABB 07** Development of employment in various sectors in Germany



1991 = 100. Proportion of overall employment in 2007: Knowledge-intensive manufacturing 15 percent, Other manufacturing 23 percent, Knowledge-intensive services 24 percent, Other services 38 percent. Source: Bundesagentur für Arbeit, Statistik der sozialversicherungspflichtig Beschäftigten. Calculations and estimates by NIW.

**ABB 08** Share of total value creation of knowledge-intensive services sectors in 2005 in an international comparison



Proportion of knowledge-intensive services in 2005 Total: Great Britain 45.1 percent, Japan 32.4 percent, USA 45.1 percent, Germany 37.1 percent. Source: EUKLEMS Database. Calculations by NIW.



are often explained by the dominance of industrial value-creation in Germany.

The services gap is appreciable. Measured against western industrialised countries<sup>88</sup> the German services sector ought to account for 7 percent more of value-creation. In Germany in 2005, this would have corresponded to a value-creation of 70 billion euros. If the services sector in Germany was to be raised to an average international level, it would require an increase equivalent to the entire value created by the automotive sector. With regard to knowledge-intensive services, the gap relative to the total value-creation was nearly 4 percent or 38 billion euros, which would correspond to the value-creation in the sectors electrical engineering, electronics, telecommunications and media technology.

These statistical results are regarded as problematical by some industry associations. It is, after all, possible that knowledge-intensive services in Germany are provided internally by industrial companies more frequently than in other countries. Statistics based on sectoral distinctions would then give a misleading impression.

The Expert Commission asked for this possibility to be examined more closely in the above-named studies. Analyses were conducted of intermediate performances and the workforce profile in the manufacturing sector and the extent of product-related services, in order to determine whether knowledge-intensive services in Germany were adequately registered in an international comparison. These various investigations all lead to the conclusion that with a very high probability the services gap is not a statistical artefact.

For knowledge-intensive services, R&D activities increase the innovation potential considerably less than for material goods. Important exceptions worldwide are the Internet, data processing and software services, which are among the most R&D-intensive sectors of the economy. Innovations in services are otherwise frequently part of the production processes. It is practically impossible to measure the R&D share of unique performances provided specifically for a customer.

Apart from R&D, the development of innovative services makes more use of additional channels of

knowledge than the creation of material innovations, e.g. the acquisition of equipment and software, as well as further training and qualifications. In the services sector they speak of an “inverted product cycle”: a high openness to innovation is linked above all with the adoption of technology from the manufacturing sector. Following on from this, knowledge-intensive service providers gradually begin their own R&D-activities. For businesses trading with cutting-edge technology products, it is often observed that at a later stage they begin their own production of advanced products which previously had “only” been introduced, marketed and maintained: the service providers become in part manufacturing companies. Despite the weakness in the creation of knowledge-intensive services relative to world levels, Germany has a lead in innovations in this sector in Europe, but this lead is by no means as great as in the manufacturing sector (Fig. 09).

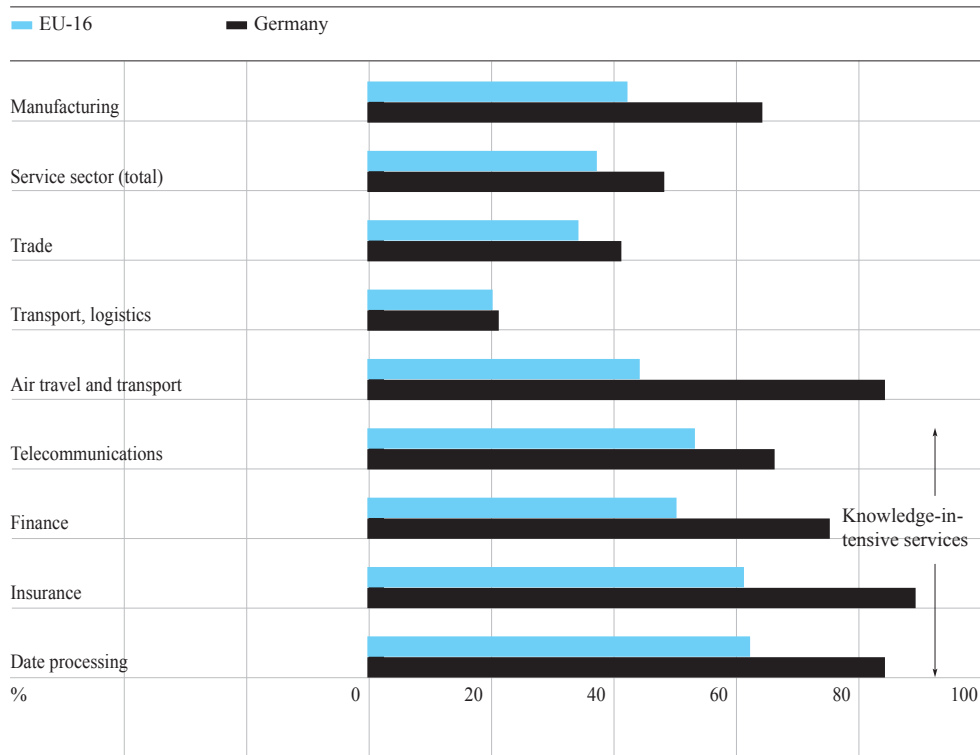
#### **Foreign trade with knowledge-intensive services**

Knowledge-intensive services companies are increasingly export oriented, both with regard to the export rate as well as in the number of exporting companies. Particular company-related services benefit from an extension of cross-border trade. The global trade volume of commercial services for companies has doubled since 2000, and in 2007 represented some 9 percent of world trade in goods and services. In Germany, the export of services in 2006 had a value of 131 billion euros, which was 13 percent of all exports. The export value of knowledge-intensive services was 45 billion euros, which corresponds to a share of 4.4 percent.<sup>89</sup> In comparison, knowledge-intensive services in the USA accounted for 7.2 percent of exports in 2006.

The foreign share of the revenue of German companies in the knowledge-intensive branches is still quite low in comparison with most other European economies. Germany was for a long time a net-importer of knowledge-intensive services. Whereas in the year 2000 only 60 percent of the expenditures were balanced with revenues, this situation has equalised by 2007 (Fig. 10).

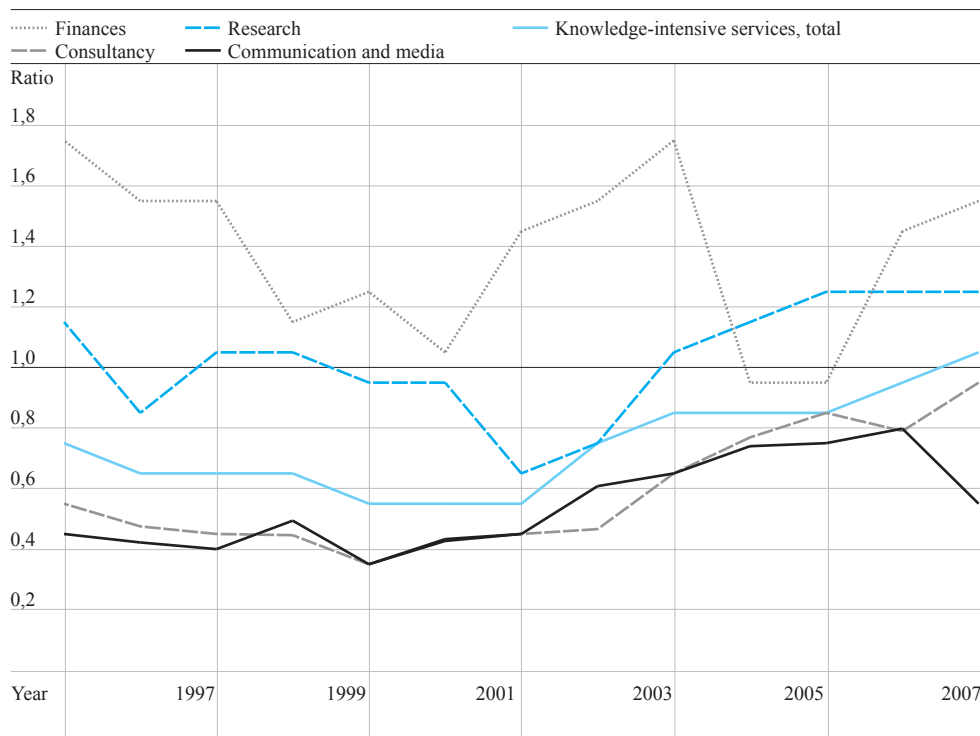
In the EU, Germany is by no means the largest provider of cross-border knowledge-intensive services, which it is in the case of trade with industrial goods. On

**ABB 09** Proportion of innovative companies<sup>90</sup> in selected sectors in a European comparison<sup>91</sup>



Source: Eurostat-CIS4. Compiled by ZEW. Calculations and estimates by NIW.

**ABB 10** Export/import cover ratio in German foreign trade with knowledge-intensive services



Cover ratio = Exports/Imports. Cover ratio/Balance in billion euros 2007: Communications and media 0.6/-2.1. Finances 1.6/12.7; Research 1.3/7.1. Consultancy 1.0/-0.9; Total 1.1/87.5. Sources: OECD-Stat, Dataset Trade in Services by Category; Deutsche Bundesbank, IMF. Calculations and estimates by NIW, RWI and Fraunhofer ISI.

the world market for these services, Germany with 15 percent is only half as important as Great Britain (more than 30 percent). India has the same export volume as Germany. Analogous to domestic value-creation, Germany has a weaker position with foreign trade with services in an international comparison than it does with R&D-intensive goods.

Some observers regard the middle ranking of Germany in an international comparison for the foreign trade with knowledge-intensive services as a negative sign. In particular they view the extensive intake of knowledge from other countries as problematic for the development of Germany as an innovation location. The Expert Commission supports the view that, with the foreseeable expansion of knowledge-intensive services, there is considerable potential for boosting exports of this sort. However, the foreign trade with knowledge-intensive services is not only relevant to innovation in terms of the intake of knowledge, because there is also the outflow of knowledge to consider. It is necessary to weigh up the opportunities and risks in each individual case, and there can be no general guidelines and recommendations. This applies above all for research and consultancy.

#### **Better investigation of the knowledge-intensive services sector**

Although the overall image of the position of Germany for knowledge-intensive services seems quite clear, when viewed more closely some aspects remain blurred. If an attempt is made to investigate individual sectors, it soon becomes impossible to make a systematic international comparison. The data situation is particularly difficult for services provided by manufacturing companies. Considerable work is needed on the problems of R&D and innovation statistics. It is regrettable that any more precise analysis of this part of the economy is so restricted by the inadequacy of the data situation, even though it meanwhile has a considerably higher volume than manufacturing.

#### **Great potential of knowledge-intensive services for economic development**

The Expert Commission recommends that greater importance is attached to the segment of very-high-value services, internally and in international

competition. The competition which has begun between the federal states in Germany about the question of offering the best location for a company can act as a stimulus and ease the way for Public-Private initiatives.

There is also considerable potential for exploiting the fact that many knowledge-intensive services are linked to produced goods. On the basis of the German strength in product-related services, the international market for knowledge-intensive services could be served to a greater extent in this segment in particular. In addition to market-related aspects, the Expert Commission sees a need for action concerning social attitudes, which can also have a considerable influence on the next generation of skilled and qualified personnel. The public perception of innovation as related to material products and “tangible” technology should be widened to include a greater openness to “soft” services. There should be greater general awareness that the economy does not only need as many original technical inventions as possible, but that it is also advanced by innovations in the services sector. The philosophy of the public sector on the provision of support should incorporate these ideas quickly.

The account here does not address in detail the microeconomic aspects of the provision of services, in particular product-related services. Interested readers are referred to Lay et al. (2009).



STRUCTURE AND TRENDS





## C STRUCTURE AND TRENDS

### C 1 EDUCATION AND QUALIFICATIONS

The structural transformation to a knowledge and services economy is not without effects for the qualification requirements of the workforce. Knowledge-intensive sectors are becoming increasingly important for the production of the economy as a whole, and at the same time innovation pressure is rising in these sectors. Both developments lead to a rising demand for qualified personnel, mostly university graduates.<sup>92</sup>

This development presents the education system with considerable challenges, especially because Germany has meanwhile lost the comparatively good position it had. In the following, based on a study commissioned by the Expert Commission on the German innovation system No. 8-2009,<sup>93</sup> current trends of key education indicators are presented and interpreted. First, the demand for highly-qualified professionals on the job market is considered. The analysis then shifts to the supply side, to concentrate on numbers of young people qualifying for and completing higher education, and also on vocational training and further training behaviour.

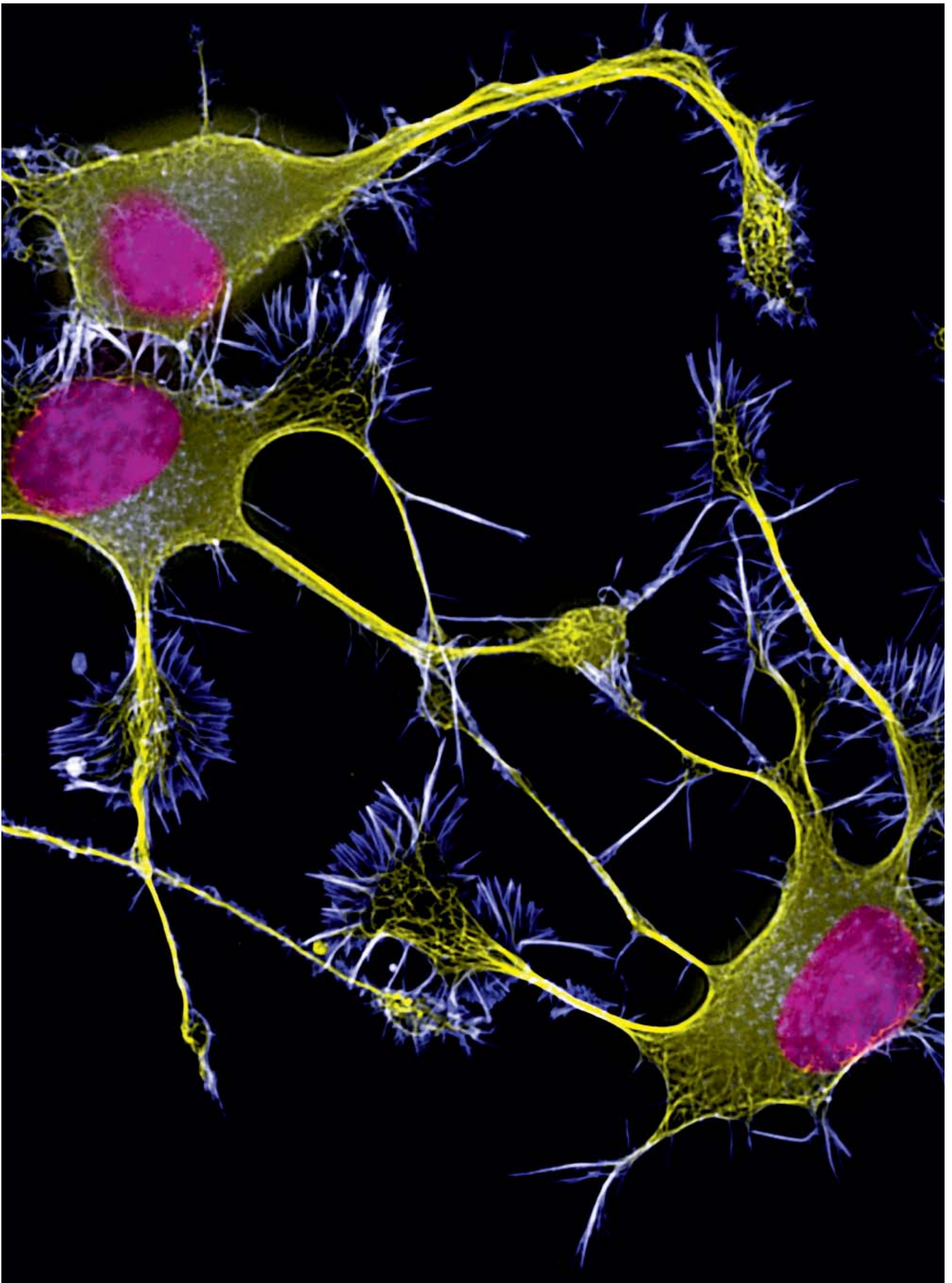
#### **Unbroken trend to more highly-qualified employees in the business economy**

In 2007 a total of more than 1.9 million graduates were in employment and liable to make social security contributions in the business economy in Germany.

These included nearly 700 000 natural scientists/engineers and more than 1.2 million other graduates.

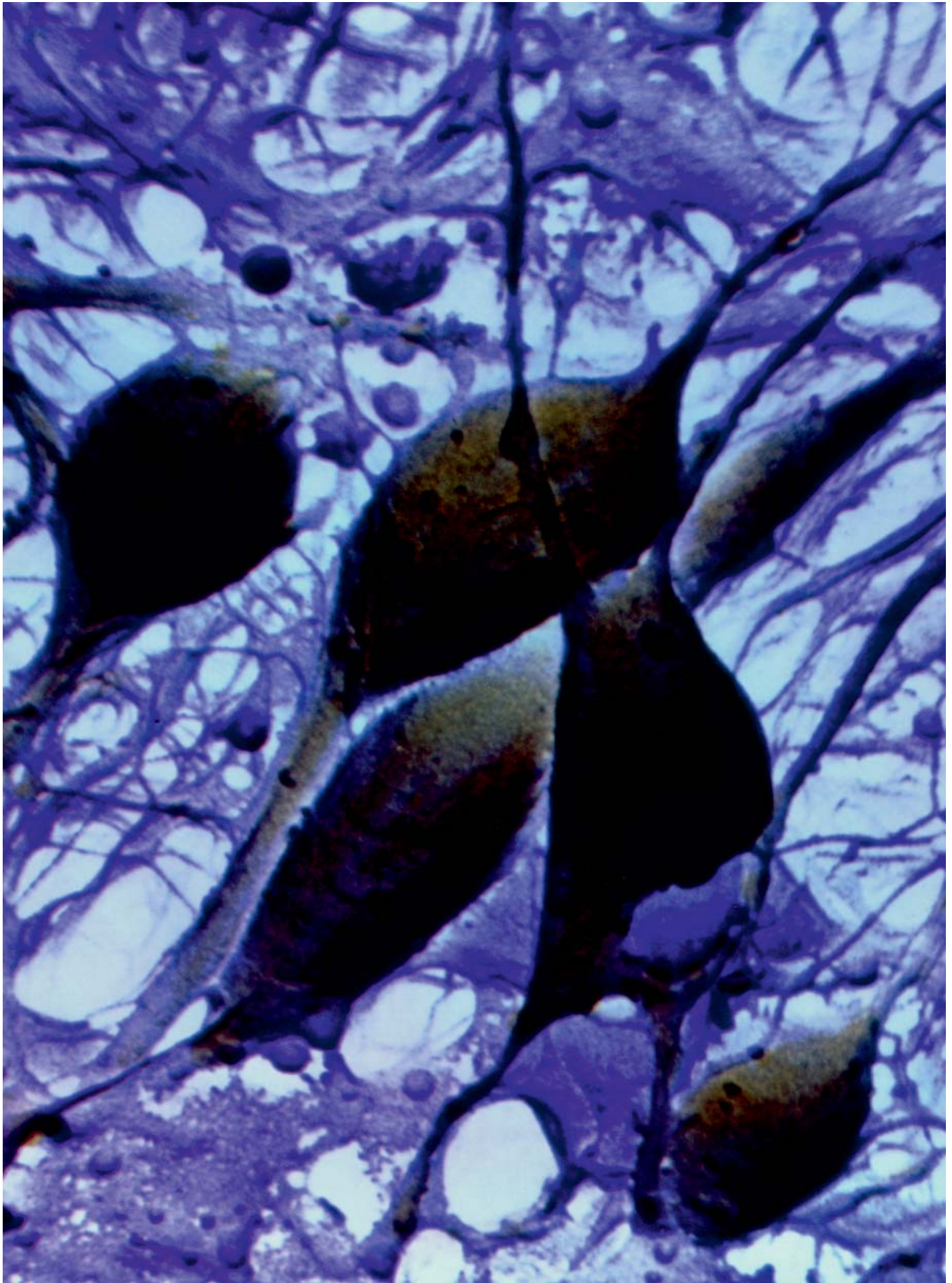
Some three quarters of each sub-group worked in knowledge-intensive sectors of the economy. From 1998 to 2007 the number of regularly employed graduates in the business economy in Germany rose by 355 000; the number of natural scientists and engineers increased by 50 000. At the same time the number of other employees fell by some 770 000, so that the proportion of highly-qualified professionals has clearly increased.

Between 2005 and 2007, a broad upswing in employment could be observed in all European sub-regions. Relative to the EU-15 average, the trend towards academisation has continued. The number of highly-qualified professionals rose in only two years by nearly 1.1 million (4.9 percent), and of these nearly 400 000 were natural scientists and engineers (6.9 percent). Some 80 percent of the additional demand for graduates is attributable to the general employment trend, while the demand for natural scientists and engineers has benefited disproportionately from the fact that services and knowledge-intensive areas have developed better than the rest of the economy (structural effect). In individual sectors, the proportion of these professional groups in the workforce has increased further (knowledge intensification effect). In contrast to the previous period considered, Germany and France are at the peak of a dynamic of growth in overall employment in this period. Nevertheless, in Germany the number of highly-qualified professionals grew by only 3.7 percent between 2005 and 2007 which for the first time is less than for the workforce overall (5.6 percent). This is in part because the labour market reforms introduced in this period favoured the creation of jobs for people with lower qualifications. At the same time it is also a sign of a growing shortage of qualified personnel.



Nerve cell growth  
© Wittmann/SPL/Agentur Focus





Neurons from the cerebral cortex  
© CNRI/SPL/Agentur Focus

Proportion of highly-qualified employees according to sectors - 2007

	Manufacturing sector		Services	
	Knowledge-intensive	Others	Knowledge-intensive	Others
Belgium	17.9	8.6	25.5	7.8
Bulgaria	16.4	8.2	41.3	14.9
Denmark	17.8	7.5	35.6	7.3
<b>Germany</b>	<b>18.5</b>	<b>5.5</b>	<b>21.9</b>	<b>6.6</b>
Estonia	19.9	9.4	39.3	16.9
Finland	29.5	9.8	27.0	8.3
France	17.1	7.8	22.7	9.6
Greece	16.1	5.7	36.1	8.0
Great Britain	22.2	10.9	31.7	10.3
Ireland	30.3	11.9	37.3	10.9
Italy	10.1	4.4	31.1	6.1
Latvia	25.6	10.6	33.3	15.1
Lithuania	20.4	11.0	41.5	18.0
Netherlands	30.2	14.2	37.9	11.9
Norway	27.7	10.8	46.1	14.9
Austria	10.7	3.3	19.7	4.7
Poland	18.4	8.9	41.0	14.6
Portugal	9.0	2.4	28.5	5.9
Romania	13.3	6.7	30.4	10.6
Sweden	16.8	5.8	29.2	9.0
Switzerland	21.5	7.3	27.5	9.5
Slovakia	9.1	5.9	27.6	8.1
Slovenia	6.7	4.2	21.5	5.9
Spain	17.4	9.4	39.8	12.1
Czech Republic	9.0	4.5	24.8	6.6

ISCED 5a and 6. In percent.

Source: EU-Labour force survey. Calculations by Fraunhofer ISI.

### Knowledge intensification in Germany is not keeping up with the international dynamic

In 2007, 8.6 percent of regular employees in the business economy in Germany had a higher education qualification – in 1998 the proportion was 6.9 percent. The proportion of graduates in the knowledge-intensive sectors of the economy, which employs nearly half the workforce in central Europe, is particularly high, with 18.5 percent in the knowledge-intensive manufacturing sector and 21.9 percent in knowledge-intensive services. This is on average some four- to five-times higher than in the other branches of the economy (Tab. 01)<sup>94</sup>

In a European comparison of the proportion of graduates in the workforce, Germany has a lower-middle ranking. Norway and Denmark excel with about

25 percent. The Netherlands and the Baltic States are in the leading group with some 20 percent. There are also a large number of highly-developed countries in which 12 to 18 percent of the workforce have a university qualification.

Germany finds itself in the company of countries such as Spain, Finland, France, and Sweden. Commentators quite rightly draw attention to the importance and high quality of vocational and professional education in Germany. But this alone does not explain the relatively poor position regarding the numbers of academically educated employees, which is particularly striking in the area of knowledge-intensive services – and nor does it explain the worsening position in an international comparison. The limited knowledge dynamic in Germany is based on the relatively low employment effect of knowledge-intensive

services, and also its comparatively weak “innovative orientation”. In other European regions, as well as in the USA and Japan, there is a greater demand above all in IC-services for technical and scientific expertise than in Germany. This suggests that there are also more technological developments in these countries.

### **Increasing numbers of school-leavers qualified to apply for higher education**

With the demographic decline in the size of the active population and at the same time a growing need for highly-qualified professionals, the levels of education of successive population cohorts are very interesting. The number of students leaving the general secondary school system has increased fairly continuously between 1992 and 2006, from 760 000 to 942 000 per annum. Over the same period the number qualified to go on to higher education increased by 35 percent, and the increase has continued through to 2008 – totalling 44 percent overall since 1992. In the future development, figures will decline slightly overall, but with two peaks anticipated in 2011 and 2013 due to overlaps as students begin to take their final school examinations one year earlier. Germany also has vocational secondary schools, which are increasingly conferring qualifications entitling students to go on to higher education. In 2007, 160 000 school-leavers from the vocational secondary schools were thus qualified, or 37 percent of all those with higher education entrance qualification. Most of them obtained an entrance qualification specifically for the universities of applied sciences (*fachhochschule*).

The total number of students leaving school each year with a higher education entrance qualification increased almost continuously between 1992 and 2007 to 434 200. Correspondingly, the proportion qualified to go on to higher education<sup>95</sup> increased to 44.5 percent in 2007 (of which: 31 percent from general upper secondary education; 13.5 percent with a vocational school qualification). This is the central indicator for the quantitative realisation of the demographic potential for academic education. There has been a considerable increase in the number of potential higher education students. This is a precondition if the growing demand for highly-qualified professionals is to be met in the future. By international standards, the proportion of school-leavers qualified for higher education in Germany is still low. Finland, Canada, Italy

and Sweden achieve rates of between 75 percent and 95 percent, and the OECD-average is 63 percent.<sup>96</sup>

Even though the reservoir of potential students is growing, the potential for the science subjects (mathematics, engineering, natural sciences, and computer science) is not growing to the same extent. This is primarily because more and more women are gaining qualifications to attend higher education, but they are then significantly less likely to opt for one of these subjects.

A considerable role is also played by the subject preferences at school, which have a strong influence on what is subsequently studied at university. With mathematics and natural sciences chosen less often as special school subjects, it remains the case that only a minority of school students are predestined to go on to study these science subjects. More than half of all students in the upper secondary schooling are no longer being taught physics or chemistry.

### **Declining interest in higher education in Germany**

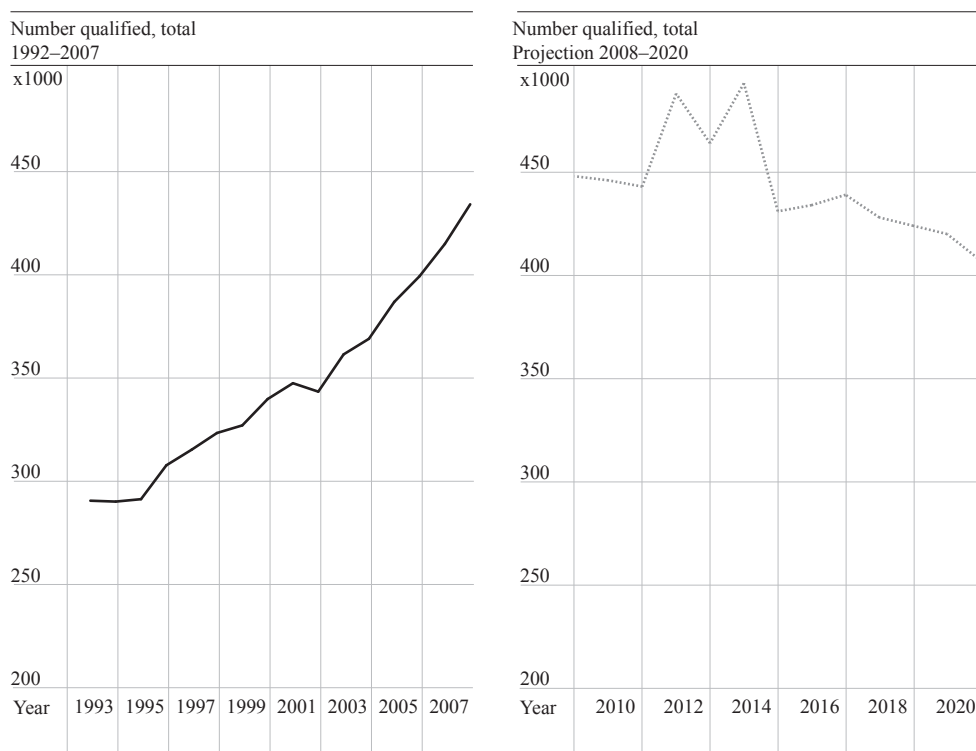
Not all school-leavers who have gained a qualification which entitles them to go on to higher education actually choose this option. There seems in fact to be a declining interest in higher education, and this trend is likely to continue in the future. Of those qualified to go on to higher education the large majority of those who choose not to do so see the highest school qualification as “uncoupled” from going to university. Their interests are more in non-academic training, or having a job and their own income. However, there are signs that financial constraints are an increasingly important reason for not pursuing an initial interest in going on to higher education. Young people are increasingly less prepared to take on the loan part of the university grant (*Bafög*), or they are unwilling or unable to finance university fees.

Traditionally, qualified women are less likely to start a higher education course than qualified men. Of those women who choose not to go on to higher education, nearly a third feel unable to shoulder the financial burdens associated with the university fees. One fifth of those surveyed never had an intention to study. In addition, a tenth cited the unclear and unforeseeable requirements as a reason for deciding not



### School students qualifying for higher education in Germany 1992 to 2020

FIG 11



2007 provisional figures. From 2008 KMK: Projections of secondary and tertiary student numbers 2005 to 2020. Source: Statistisches Bundesamt, Kultusministerkonferenz.

### Overall changes of numbers studying selected subjects at universities

TAB 02

	Drop-outs	Net subject switches	Overall change
<b>Mathematics, Natural sciences</b>	<b>-28</b>	<b>-11</b>	<b>-39</b>
Mathematics	-31	-22	-53
Computer sciences	-32	-7	-39
Physics, earth sciences	-36	-16	-52
Chemistry	-31	-18	-49
Pharmacy	-6	+1	-5
Biology	-15	-9	-24
Geography	-15	-1	-16
<b>Engineering</b>	<b>-25</b>	<b>-12</b>	<b>-37</b>
Mechanical engineering	-34	-12	-46
Electrical engineering	-33	-15	-48
Construction	-16	-19	-35

In percent. For school-leavers in 2006. Note: The net subject switches show the difference between the number of students switching to a subject and those choosing to study something else. The overall change is the sum of the net number of switches and the number of drop-outs.

Source: HIS-Studienabbruchuntersuchung 2008. Calculations by EFI.

to go to university. Significantly fewer men named any of these reasons<sup>97</sup> This has important consequences, because in the past 15 years the proportion of women among those qualified to proceed to tertiary education has risen so that they now constitute a clear majority. Taken together, the two phenomena have the effect that equal numbers of men and women begin higher education courses, while also accounting for the increasing divergence between the numbers qualifying for university and those actually starting courses.

Social background and the family's educational background exercise a very selective effect. Eighty percent of those with academic parents who were qualified to study in higher education went on to do so, but the corresponding figure for those without this family background did not exceed 67 percent. Similar phenomena can be observed through all stages of the educational system. The EFI Report 2008 went into this at some length. In Germany, children of highly-educated parents are four-times more likely to go on to higher education than children from a family without an educational background. The occupational status of the parents, in contrast, has less influence. If the parents have obtained school qualifications, or even a degree, then irrespective of their occupational position there is an above-average probability that their children will begin higher education. Removing this imbalance is necessary simply for reasons of social fairness. Against the background of the long-term rise in the need for highly-qualified professionals, the increased integration in academic education of young people from social strata without an educational background and also of women would have a positive effect on the economic and technological potential.

There has been a marked increase in the numbers of new students enrolling at the 400 universities and research institutions in Germany, in particular between 1998 and 2003. After a dip between 2004 and 2006, the figures rose again in the following two years and in 2008 reached 385 500 first-time enrolments (provisional figures) – the highest number to date. In view of demographic factors and overlapping of cohorts taking final school examinations after 12 and 13 years, this trend is expected to continue until 2013, but then to be reversed. Meanwhile in Germany nearly two fifths of the population of the appropriate age go on to higher education, nearly reaching the 40 percent minimum target set by the Science Council. Nevertheless, with this proportion of higher education

enrolments, Germany is still considerably below the OECD country mean of 56 percent (2006).

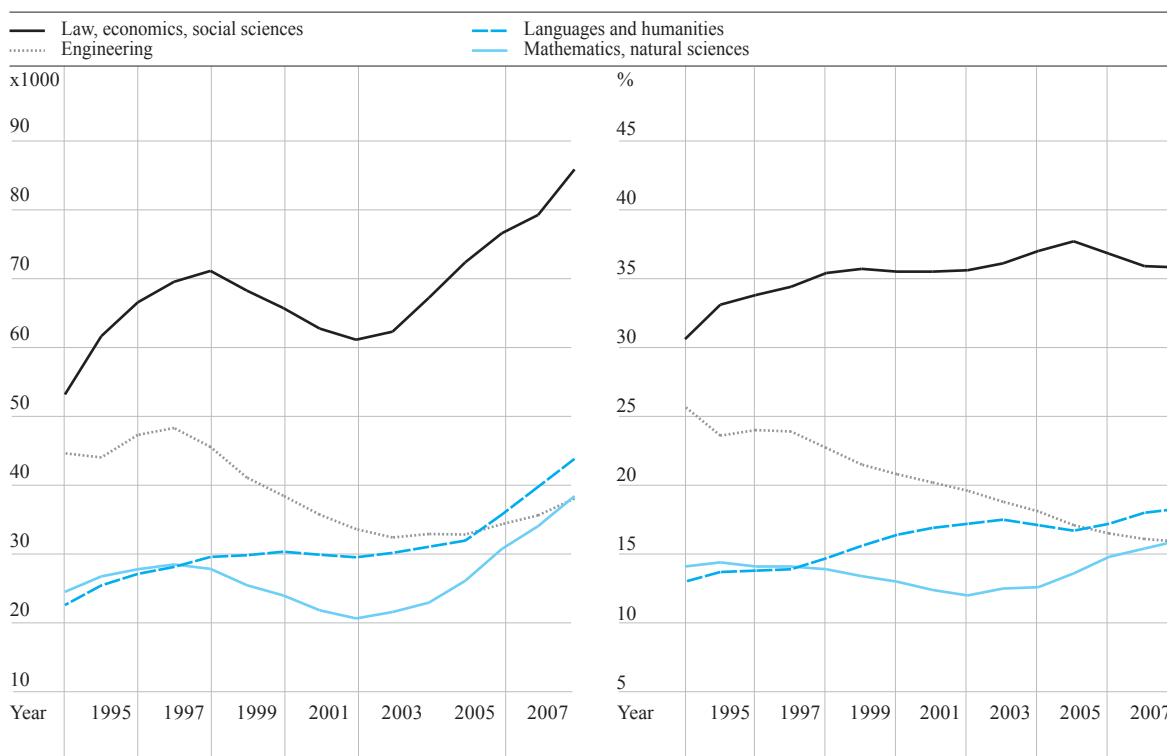
### **Currently more than 50 000 university drop outs every year in Germany**

A further problem is that, of the comparatively few students who start a course, one in five currently fails to complete it. This is a slight improvement over the situation at the end of the 1990s. Nevertheless, this drop-out rate and the absolute numbers involved are a cause for concern, and also an indication of the inefficiency in the higher education system. Of some 260 000 students who enrolled for the first time in 2001, about 55 000 did not finish their studies. In some subjects such as electrical engineering and mechanical engineering, one in three drops out. There is not a fundamental difference in this respect between universities and the universities of applied sciences. One of the goals of the introduction of the bachelor's and master's degree courses was to reduce the high numbers of drop-outs, but they have not yet had this effect. However, so far the statistics for drop-outs only include the very first courses to introduce the bachelor's degree. But it is postulated that with the transition to these courses the demands on students have actually increased and the conditions worsened, and a consequence could be above-average drop-out rates.

In addition, it is also necessary to consider students who switch from one subject to another, because this further reduces the numbers graduating from some degree courses. The net losses are particularly negative in the natural sciences and engineering, because fewer students are attracted to switch to them. In the case of some subjects at German universities, e.g. mathematics, physics, chemistry, mechanical engineering, or electrical engineering, between 46 percent and 53 percent of a cohort of new students do not gain a degree (Tab. 02). At universities of applied sciences (*fachhochschulen*) the situation is less dramatic. Against the background of the perceptible shortage of scientific personnel in the economy, this high level of wastage is not acceptable. However, the problem of drop-outs is more widespread. Indeed, in an international comparison, drop-out rates in Germany are at low to middling levels. But with the relatively low proportion of each cohort starting higher education, the numbers failing to complete their studies in Germany must be judged very critically.

### Graduates in selected groups of subjects

FIG 12



Source: Statistisches Bundesamt, University statistics. Research by HIS/ICE. Own calculations.

### Record numbers of university graduates

The numbers of students graduating from university has risen considerably in Germany in recent years. From 2002 to 2007 there was an increase of 67 000 up to 240 000 students annually obtaining their first university qualification. This is a record number, which is attributable to the rise in student enrolments up until 2003 and the slight fall in the numbers of drop-outs in Germany. However, the structural reform has not had any significant effect on this development. In 2007, just less than ten percent graduated with a bachelor's degree. Only about two percent of students sitting final examinations in 2007 had already gone on to complete the second level and obtain a master's degree.<sup>98</sup>

The extent to which the increase in the numbers of graduates can be equated with increased participation in education is shown by an analysis of the rate of graduation. This expresses the proportion of graduates in a cohort of the population of the same age. Since the end of the 1990s this rate has risen steadily from 17 percent to 24 percent in 2006, indicating the growing importance of higher education. Since 2003 the rate for women has exceeded the rate for men.

However, it must be noted that there is considerably lower education participation among people with a migration background. Also, the rate of graduation in Germany is still low by international standards.

The composition of the subjects studied shows considerable changes. The decline in engineering is continuing, whereas mathematics and the natural sciences have been showing proportional increases for some years. This is influenced above all by the positive development of computer sciences (Fig. 12).

In view of the growing calls for increases in the numbers of students as a response to the shortage of highly-qualified professionals, it must also be noted that the capacity of the universities and research institutions is limited. Over only a few years, the numbers of enrolments have already increased noticeably. Some classes are full to overflowing. This is also linked in certain subjects to a reduction in the lectures and classes on offer. In order to increase the capacity to take on new students and to improve the quality of the teaching, in other words in order to implement the structural reforms successfully, considerable additional resources are needed. According to the Science Council<sup>99</sup> some 1.1 billion euros p.a. will be required

to improve the teaching. On top of this, investments would be required in buildings and infrastructure. Without doubt the Higher Education Pact 2020 is a step in the right direction. However, in some federal states such as Lower Saxony, Bremen, and Hamburg, cuts are being made to budgets in the higher education sector which are diametrically opposed to these intentions, and which will have negative impact on the technological potential of Germany.

### **Boom in vocational training in knowledge-intensive segments**

In addition to the higher education system, the vocational training system also provides a reservoir of skilled personnel for the employment market. Some 60 percent of all those leaving general secondary school go into vocational training either in a vocational college or in a dual training course involving additional practical training. In 2006 a total of 667 813 trainees obtained a vocational qualification and made themselves available on the labour market, which was about 3 percent more than in the year 2000. Of this total, 480 000 obtained a vocational training qualification in combination with a company apprenticeship. This means at least that the potential of trainees in vocations at the medium qualification level was almost totally fulfilled. However, if the demographic developments are also taken into account then despite the slight increase in 2006 it is not to be expected that the dual system will lead to much above 500 000 young people obtaining qualifications in the foreseeable future.

Looking only at those qualifying in the core vocations or in the knowledge- and technology-intensive sectors, then there has been a clear positive trend. In 2006, 221 000 young people gained vocational qualifications, which is 22 percent higher than in the year 2000. While the overall number obtaining qualifications in the dual system in this period declined, the figure for vocations in knowledge-intensive sectors increased by 18 percent. In addition there were some 80 000 young people with qualifications from full-time vocational colleges (+29 percent) who were also available for these vocations. This favourable development is due not least to the fact that in-firm vocational training is growing in significance in the services sector.

In knowledge-intensive sectors of the economy, 26.5 percent of companies are involved in vocational training, which is slightly above the overall average (24 percent). But in addition the employees in these sectors are also more involved in further training activities. This applies above all for the older personnel. In the sectors of the economy with high knowledge intensity, more than 10 percent of staff took part in continuous learning activities in 2006 – compared with nearly 6 percent in the other sectors. There is a noticeable correlation between the qualification level and the participation in further education. One in eight highly-qualified professionals take part in measures for vocational further training – but for those with lower qualifications it is only one in thirty. In contrast, age and gender do not play a very important role.

## **RESEARCH AND DEVELOPMENT<sup>100</sup>**

**C 2**

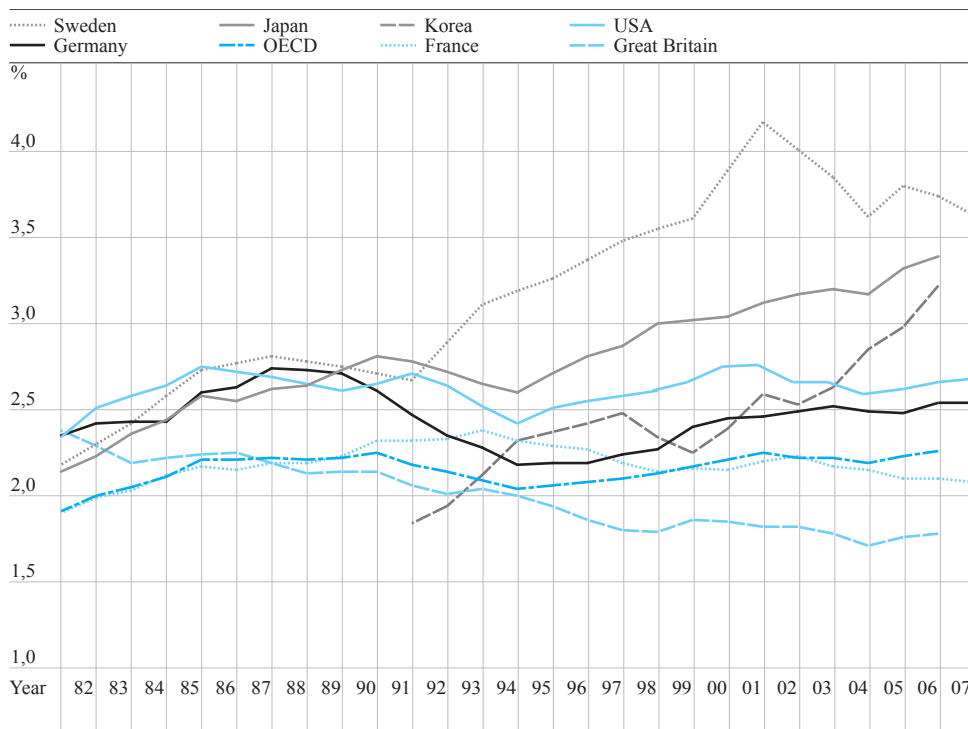
Politicians and the public frequently question how effective investments in research and development actually are – above all when these are financed from taxation. Empirical economic research has meanwhile offered persuasive evidence that R&D-activities not only create direct benefits for private actors in the form of increased productivity, but also bring considerable social returns.<sup>101</sup> Research and development is not the sole cause of economic growth, but in industrialised countries it is one of the most important determinants. Research and development is systematic, creative work to generate new knowledge. The Frascati Manual of the OECD bases statistical comparisons on the financial inputs in the form of expenditure on R&D plant, materials, personnel, and orders, as well as the number of R&D employees (cf. Box 2 in EFI Report 2008). The two parameters provide a basis for the evaluation of the “innovation potential” of an economy or its sectors, because they quantify the materials and resources used for the generation of technological knowledge.

### **Research and development in stop-and-go**

Over the past three decades there has been a clear shift in the worldwide distribution of R&D-capacities. Large economies and whole regions have gone

**R&D expenditures as share of gross domestic product for selected OECD-countries**

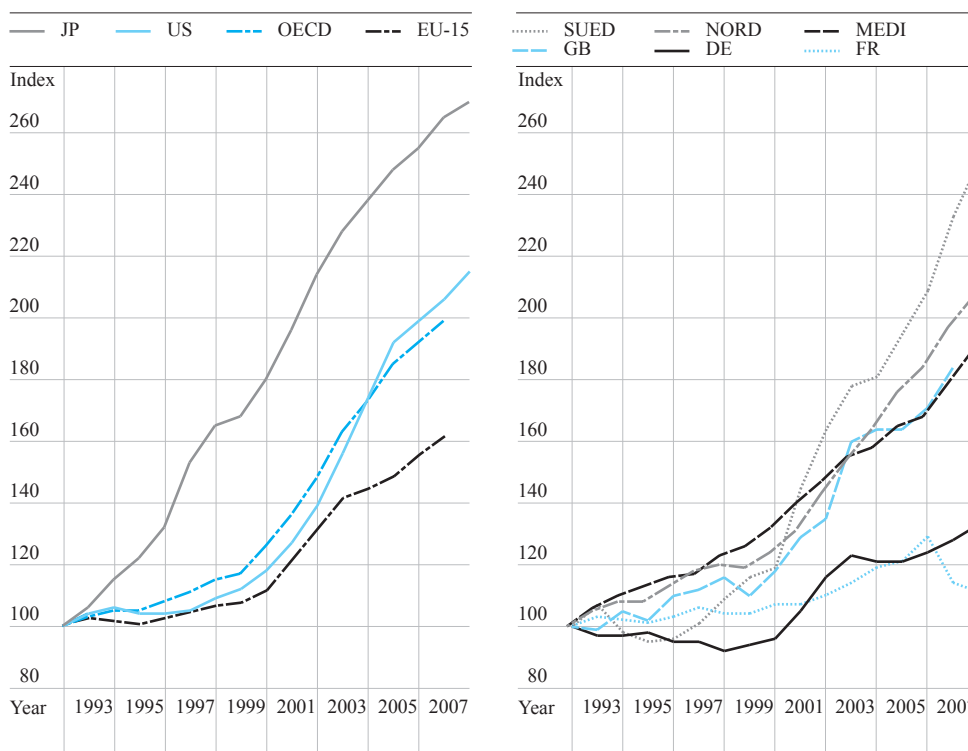
FIG 13



Data estimated in part. Germany until 1990: West Germany. R&D-expenditure in Japan slightly overestimated until 1995. Structural breaks in survey methods 1993 and 1995. Source: OECD, Main Science and Technology Indicators (2008/2). Calculations and estimates of NIW.

**State research and development budgets in selected regions of the world**

FIG 14



Index: 1991 = 100. Semi-log scale. Data estimated in part. NORD: SE, FI, NO, DK, IE, IS. SUED: IT, PT, ES, GR. MEDI: BE, NL, AT, CH. Source: OECD, Main Science and Technology Indicators (2008/2). Calculations and estimates of NIW.



through a range of changes one way and then the other – depending on the prevailing conditions. In addition, the overall progress of research and development has become less constant, including in Germany. After a sharp rise in the share of R&D-expenditure in the German gross domestic product in the 1980s, there was a considerable decline in the 1990s. Other countries, in particular Japan and the USA, showed similar trends, although the variations were not as extreme. In the second half of the 1990s, the USA further expanded R&D-expenditure, in contrast to Germany. Between 1994 and 2000, 52 percent of additional R&D-capacities created in the western industrialised countries were established in the USA.

In the large western industrialised nations, R&D-expenditure is generally pro-cyclical. If growth stagnates, R&D-expenditure mostly stays at the same level. A number of smaller economies, in contrast, continually increased their R&D-efforts in real terms throughout the 1990s: this includes countries such as Sweden, Finland, and Ireland, but also Korea. Above all, the economic structural change to the advantage of cutting-edge technology sectors has boosted the R&D intensity and overlaid short-term reactions to the economic fluctuations.

In the late 1990s, business and government in Germany had halted the decline in R&D-expenditure and switched back to expansion. In a global comparison, this took place with a delay of three years. Today, Germany is one of the countries in which research and development is carried out both on a broad industrial base and also with above-average intensity. The USA, Japan and, with reservations, France and Korea can also be classed in this category. In contrast, smaller economies such as Sweden, Finland, and Switzerland tend to concentrate their R&D-capacities: research and development is carried out in a few sectors with above-average intensity, but the process is not as broadly based as in Germany.

Over the past decade, the dynamic of the R&D capacities of Germany has lagged considerably behind the average of the western industrialised countries, which is largely characterised by the development in the USA. Among the OECD countries, however, the Nordic countries have been most dynamic, even if they have had to reduce the growth of their R&D capacity again somewhat since the year 2000.

### **Germany's R&D-intensity remains slightly above the OECD-average**

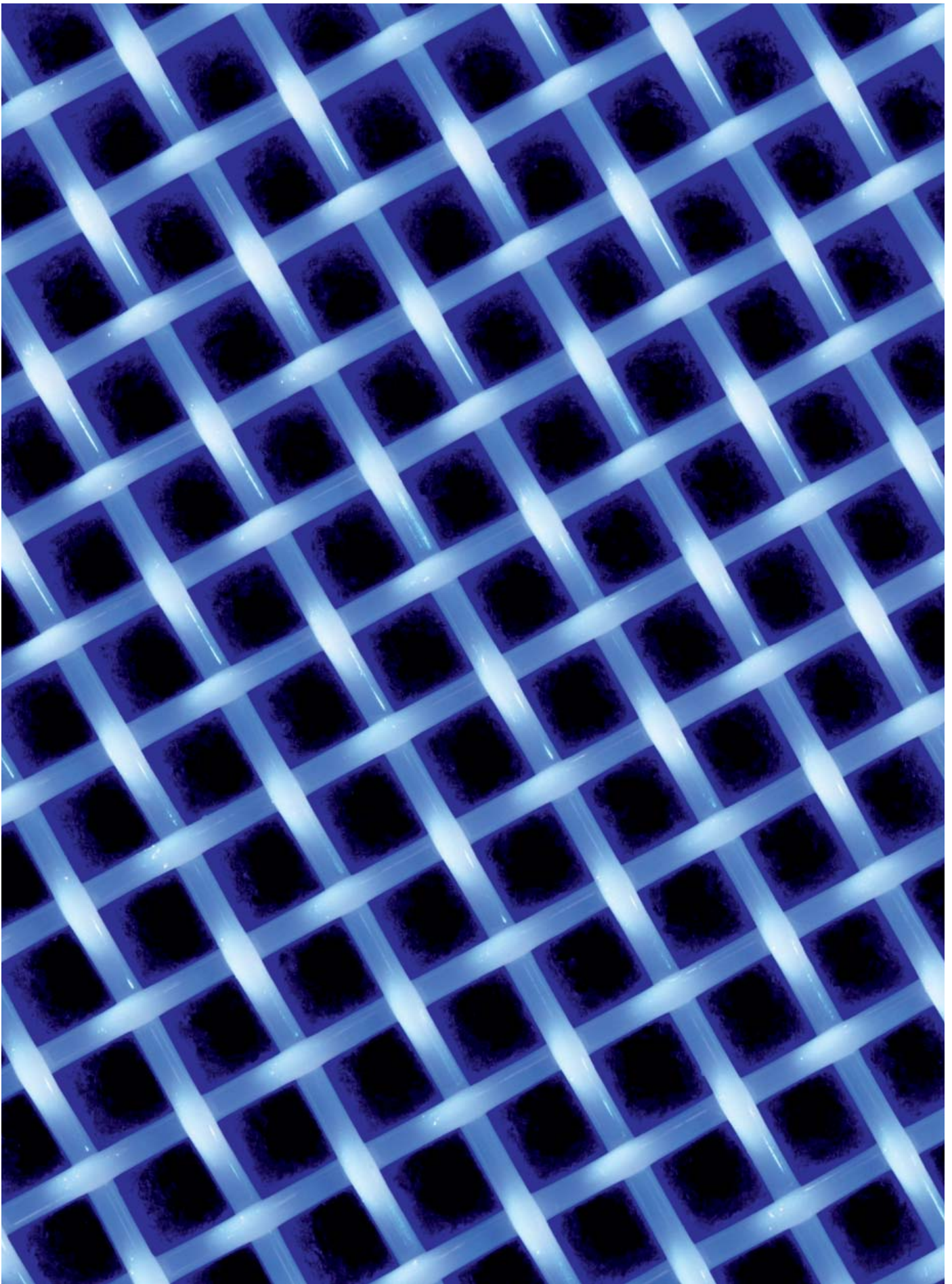
Currently (figures for 2006), Sweden is top in a worldwide comparison of national R&D-intensities with 3.7 percent, followed by Finland (3.5 percent), Japan (3.4 percent), Korea (3.2 percent), Switzerland (2004: 2.9 percent) and the USA (2.7 percent). Austria is next with 2.6 percent (2007: 2.7 percent) in front of Germany and Denmark (2.5 percent). Bringing up the rear of the countries shown in Fig. 13 is Italy. In Germany the R&D-intensity has also remained constant overall in 2007.

In the OECD area, the overall expenditure on research and development is about 825 billion dollars (2006) which corresponds to 2.3 percent of the domestic product of the member countries. Whereas Germany was in first place in the 1980s, and was still in the leading group in the early 1990s (fourth in 1991), by 2006 it was only at the front of the chasing pack among the OECD-countries. In a European context, however, the situation is still comparatively positive, because the EU-15 member states as a whole put up only 1.9 percent of their domestic product for research and development (EU-27: nearly 1.8 percent). In 2007 there was a slight improvement. The European Union has not shown progress in recent years despite intensively pursuing the three percent target for 2010 and it is still clearly behind the USA and Japan.

The growth of real R&D-expenditure in the OECD countries has just about halved since the year 2000, from 5 percent p.a. in the upswing phase for R&D between 1994 and 2000 to 2.7 percent between 2000 and 2006. The decline in R&D growth rates has been sharpest in the North European countries (from 7.4 to 3.4 percent) and the USA (from 6.1 to 1.6 percent). In Germany, France, and Great Britain the R&D growth rates between 2003 and 2006 were lower than in the USA (Tab. 03).

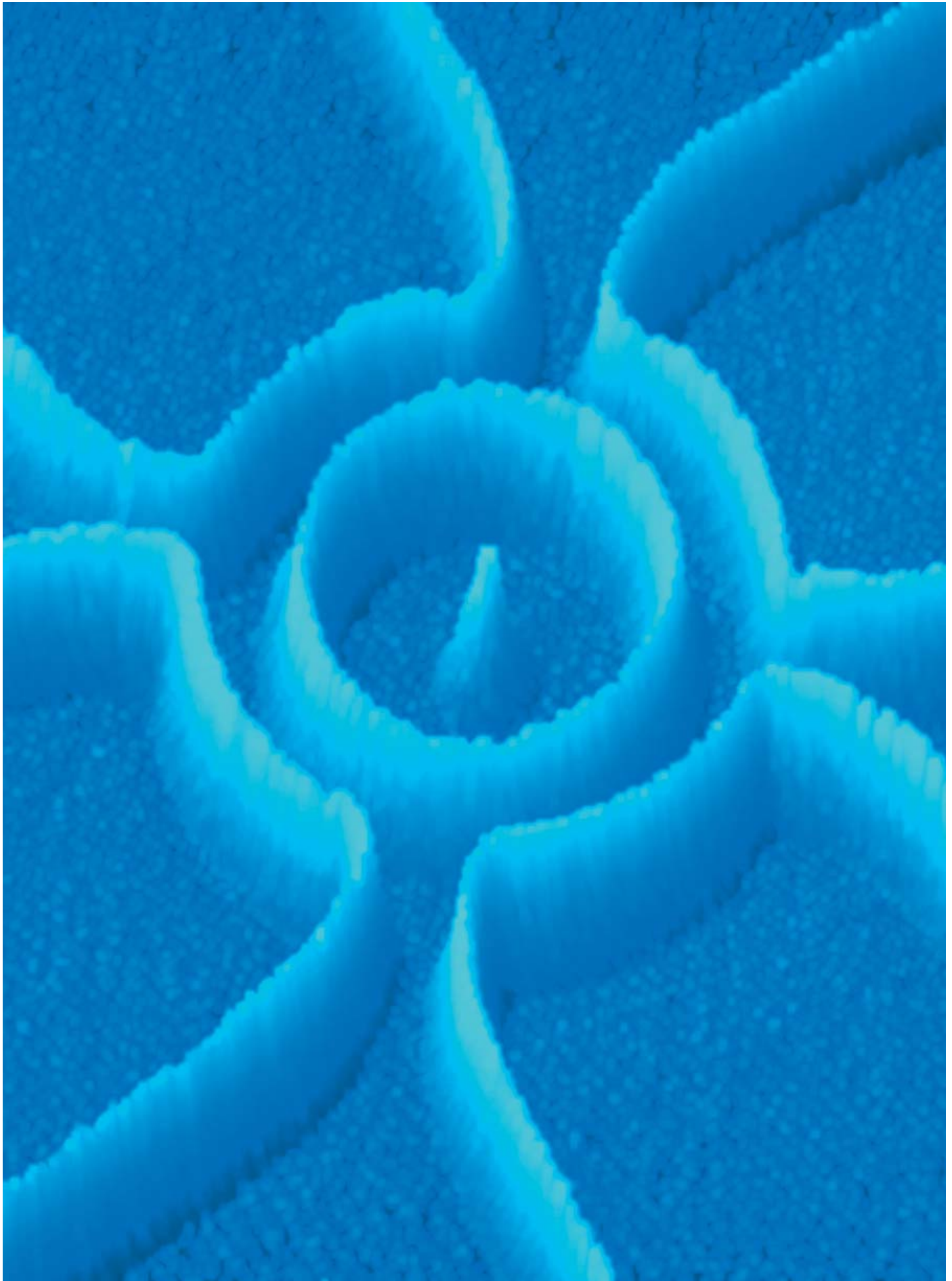
### **State R&D financing in Germany at an historical low?**

With the increased innovation competition, the focus has again been on state research activities and state aid for research and development in business companies. Even if entrepreneurial R&D-activities dominate



Polyester silk fibres  
© Pasięka / SPL / Agentur Focus





Quantum ring  
© Swiss Nanoscience Institute Basel

Change of real R&amp;D expenditures according to regions and sectors 1994–2006

TAB 03

	OECD	US	JP	EU-15	DE	GB	FR	NORTH	SOUTH	MID
<b>Business sector</b>										
1994–2000	5.9	7.4	3.8	4.3	4.9	1.9	1.6	8.9	4.0	5.0
2000–2003	0.8	–1.9	4.2	1.6	0.9	0.5	1.7	2.9	3.9	1.8
2003–2006	4.5	4.0	5.4	2.7	1.9	1.6	1.3	3.2	6.5	4.3
1994–2006	4.2	4.2	4.3	3.2	3.2	1.5	1.5	5.9	4.6	4.0
<b>Public sector</b>										
1994–2000	3.3	2.8	4.0	2.3	2.0	1.6	1.1	4.4	4.2	1.4
2000–2003	4.0	7.1	–2.6	2.7	1.9	2.3	1.5	4.3	4.7	2.4
2003–2006	1.9	1.1	1.3	2.6	1.7	4.6	0.6	4.1	3.6	1.9
1994–2006	3.1	3.4	1.6	2.5	1.9	2.5	1.1	4.3	4.2	1.8
<b>Total</b>										
1994–2000	5.0	6.1	3.9	3.6	4.0	1.8	1.4	7.4	4.1	3.7
2000–2003	1.8	0.5	2.3	2.0	1.2	1.1	1.6	3.3	4.3	2.0
2003–2006	3.7	3.1	4.4	2.6	1.8	2.7	1.1	3.5	5.0	3.5
1994–2006	3.9	3.9	3.6	2.9	2.8	1.9	1.4	5.4	4.4	3.2

In percent. Public sector: universities and R&D institutions. Data in part estimated.

NORTH: SE, FI, NO, DK, IE, IS. SOUTH: IT, PT, ES, GR. MID: BE, NL, AT, CH

Source: OECD, Main Science and Technology Indicators (2008/2). Calculations and estimates of NIW.

in many industrialised countries, public R&D expenditure is important for innovation in the economy in general.

Above all in the 1980s and 1990s there was a steady decline in state funding for research and development. On average, the state contributions of the OECD-countries in the year 2000 were well below 30 percent, compared with about 45 percent in 1980. Currently about a third of R&D costs are met by national governments, including in Germany and in the USA. In contrast, the state share of R&D-financing in emerging markets is frequently 50 percent and more. This process can currently be observed in some countries in Asia and eastern Europe. Relative to the domestic product, the state contributions to R&D-financing in the OECD have sunk since 1985 from 0.91 through 0.83 (1990) to 0.62 percent (2000), and in Germany from 0.98 to 0.77 percent. The new decade brought a rise in the OECD to 0.67 percent (by 2003), fed above all by the R&D involvement of the USA. In contrast, in Germany the level in 2005 was 0.7 percent, the lowest since 1981.

Following the general trend, state R&D involvement also initially declined in the EU member states. The

declared goal was a state funding contribution of 1 percent of GDP, but in 2006 the EU-15 were far away from this with only 0.63 percent. Since then, the EU member states have reacted, and the R&D budget provisions no longer match the picture of (absolute or relative) declining state R&D commitments. Increases in R&D aid for companies or expanding the R&D-capacity at universities and research institutions are indications of the increased government involvement in the R&D sector. The OECD countries report a (nominal) rise in R&D-expenditure of more than 7 percent per annum between 1998 and 2006.

### Marked increase in state R&D budgets

In Germany, after a virtual standstill in the 1990s, the state R&D budget was increased by about 1 percent point annually beginning in 1998. From 2006 to 2007 there was even an expansion by 4.5 percent. However, considerably more importance was attached to research and development by countries such as the USA, Korea, Great Britain or Canada, where the R&D budgets were increased much more. Germany concentrated its state R&D-expenditure to a much greater extent on civilian sectors than most of the

**TAB 04** Types of R&D activities in selected OECD countries

	Land/Region	Basic research	Applied research	Experimental development
Total	OECD-19	18.2	23.6	57.0
Universities and research institutions	OECD-19	74.8	21.7	3.5
Scientific institutions	OECD-19	28.4	34.7	36.3
Business	OECD-19	5.3	21.2	73.5
Business	OECD-23	5.2	25.0	69.8
	Germany	4.5	51.8	43.8
	USA	4.2	18.7	77.1
	Japan	6.0	19.3	74.5
	Great Britain	14.1	25.5	60.3
	France	5.0	41.2	53.7
	Italy	4.6	50.9	44.5

2004 or current year. Percentages, slight inexplicable differences.  
Source: OECD, Basic R&D Statistics. Calculations by NIW.

other countries. But even so the slight increase in state R&D expenditure in Germany was not sufficient for it to maintain its position even there.

The intensity with which industrial research and development was supported by the state varies considerably between countries, and the typical national characteristics often have historical roots. The state funded share of the R&D-expenditure in Italy, France and the USA is about 10 percent, which has a clear quantitative effect. In Great Britain the level was similarly high for a long time. Germany had a level of 6 percent in 2004 according to statistics,<sup>102</sup> and according to BMBF figures only 4.5 percent since 2005 (down from about 10 percent in the mid-1990s and 18 percent in the early 1980s). The OECD-mean since 2002 has been 7 percent, at times even slightly higher. This shows that state support for industrial research in Germany is weak.

The Federal Government has recently reacted by adopting political measures, for example the Excellence Competition for universities and the High-Tech Strategy. Because the relevant statistics are not yet available, it is not yet possible to say whether it has been possible to emerge from the trough described above.

### Public research institutions as important business cooperation partners

The growing importance currently attached to state R&D institutions is not to be regarded as temporary and compensatory. This is also because business companies are now less likely to be adopting medium-term R&D strategies, and are reacting increasingly to short-term market prospects. In order to prevent their own technological possibilities from becoming too restricted, the companies buy in additional knowledge from research institutions or they cooperate with business partners in Germany or elsewhere.<sup>103</sup> Open Innovation is becoming increasingly common.

Research-intensive universities and faculties are often integrated in innovation networks, and they have become more attractive as cooperation partners, in particular for small and medium-sized enterprises. The universities and research institutions, in turn, can acquire external funding for personnel and equipment through such cooperation projects, which benefits the quantity and quality of their research and teaching. At the same time, the practical relevance of research findings can be tried and tested. The focus of state-financed research and development in Germany is on applied research, which has a positive effect on the cooperation between university and business. More than half the funding flows into this area, while only



Proportion of research and development funded by business in public institutions in OECD-countries

TAB 05

	Universities	Scientific institutions	Total	Business R&D-funds for science/research (percent of internal R&D-expenditures)
Germany	14.2 <sup>1</sup>	10.5	12.5 <sup>1</sup>	5.4 <sup>1</sup>
Great Britain	4.8	9.0	5.9	3.5
France	1.7 <sup>2</sup>	8.1 <sup>2</sup>	4.7 <sup>2</sup>	2.6 <sup>2</sup>
Italy	1.2	4.1	23 <sup>2</sup>	2.2 <sup>2</sup>
Netherlands	6.8	16.1 <sup>3</sup>	10.0	7.4
Sweden	5.1 <sup>2</sup>	5.1	4.4	1.5
Finland	6.6	12.7	8.6	3.4
Switzerland	8.7	no figures	no figures	no figures
USA	5.4 <sup>2</sup>	2.6 <sup>2,3</sup>	4.7 <sup>2,3</sup>	1.6 <sup>2,3</sup>
Canada	8.4 <sup>2</sup>	2.8 <sup>2</sup>	7.3 <sup>2</sup>	5.9 <sup>2</sup>
Japan	2.9	0.7	2.0	0.6
Korea	13.7	4.5	8.8	2.4
<i>EU-15 total</i>	<i>6.7<sup>1</sup></i>	<i>8.3<sup>1</sup></i>	<i>7.2<sup>1,2</sup></i>	<i>4.0<sup>1,2</sup></i>
<i>OECD total</i>	<i>6.2<sup>1</sup></i>	<i>3.7<sup>1</sup></i>	<i>5.2<sup>1,2</sup></i>	<i>2.2<sup>1,2</sup></i>

Data 2006. In percent. Netherlands, EU-15 and OECD: 2003 not 2006, Sweden: 2005 not 2006, Switzerland: 2004 not 2006.

1 Estimates. 2 Provisional. 3 Including private non-profit organisations.

Source: OECD, Main Science and Technology Indicators (2008/2). Collation, calculations and estimates by NIW.

4.5 percent goes into basic research. 43.8 percent flows to experimental development (Tab. 04).

### Trend for less state funding in private research and development ...

The worldwide increase in state R&D-expenditure this century is only in part attributable to the fact that the state has provided businesses with more R&D support. It is mainly related to the increase in the R&D capacities in universities and research institutions. In Germany, the proportion of the overall government R&D budget flowing to business has sunk from 32 percent (1982) to between 10 and 11 percent (2006).<sup>104</sup>

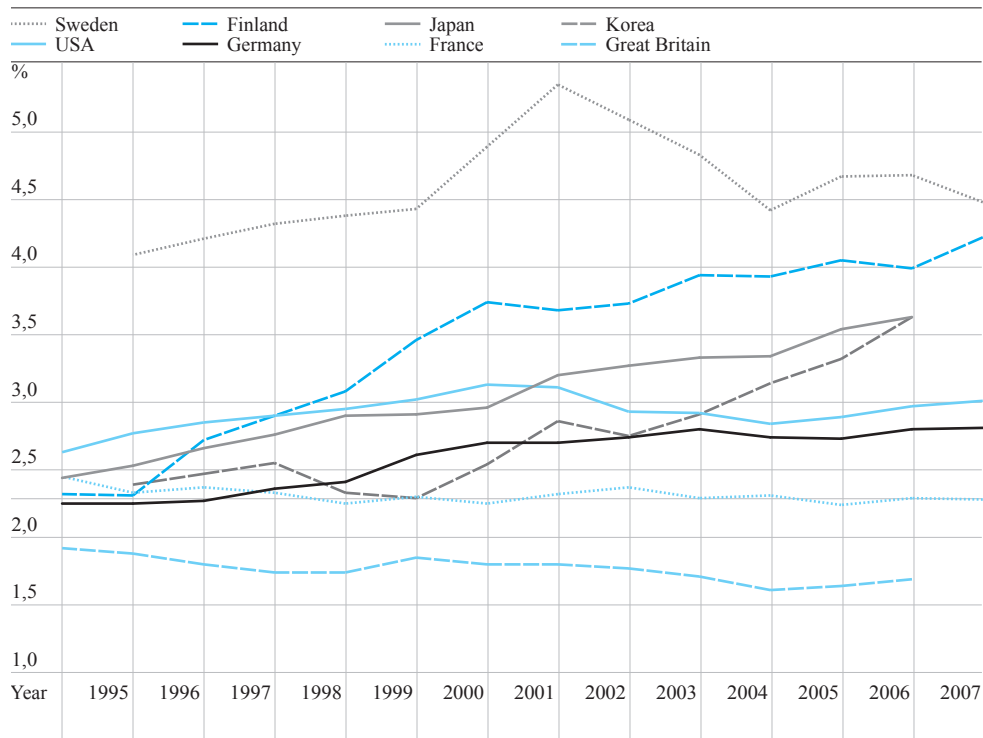
Viewing the long-term development since the early 1990s, R&D expenditure in the public sector in Germany has risen in real terms (28 percent bis 2007), but much more weakly than in the Nordic countries (95 percent), Southern Europe (75 percent), Great Britain (51 percent bis 2006), and USA (56 percent) as well as in comparison with Japan (35 percent bis 2006). It took until 2005 for public R&D-capacities in Germany to exceed the volumes of 2002 again. In general, most countries in the first half of the new decade again showed a slightly increased state share in the R&D expenditure.

Nearly 45 percent of the (weak) real growth in capacity for carrying out research and development in the OECD countries is in the public sector, and 55 percent is in the business sector. From a German perspective, businesses had lost significant shares in research and development expenditure in the first half of the 1990s, but then bounced back, so that its share of R&D capacities is now 70 percent, slightly above the OECD-average (69 percent).

### ... but increasing private share in financing public research and development

When research and development are carried out in the public sector this does not mean that it is funded in full by the government. On average in the OECD (2006), business companies finance 6.2 percent of university research and 3.7 percent of research and development in non-university R&D institutions. Germany is one of the front-runners concerning the business share in financing research and development in public institutions. 14.2 percent of university research and 10.5 percent of the research in non-university institutions is provided by the business sector. R&D-cooperation relationships between business and science are also particularly close in the Netherlands, in Korea, and in Finland – mostly due to the intensive

**FIG 15 R&D intensity of the business sector in selected OECD countries\***

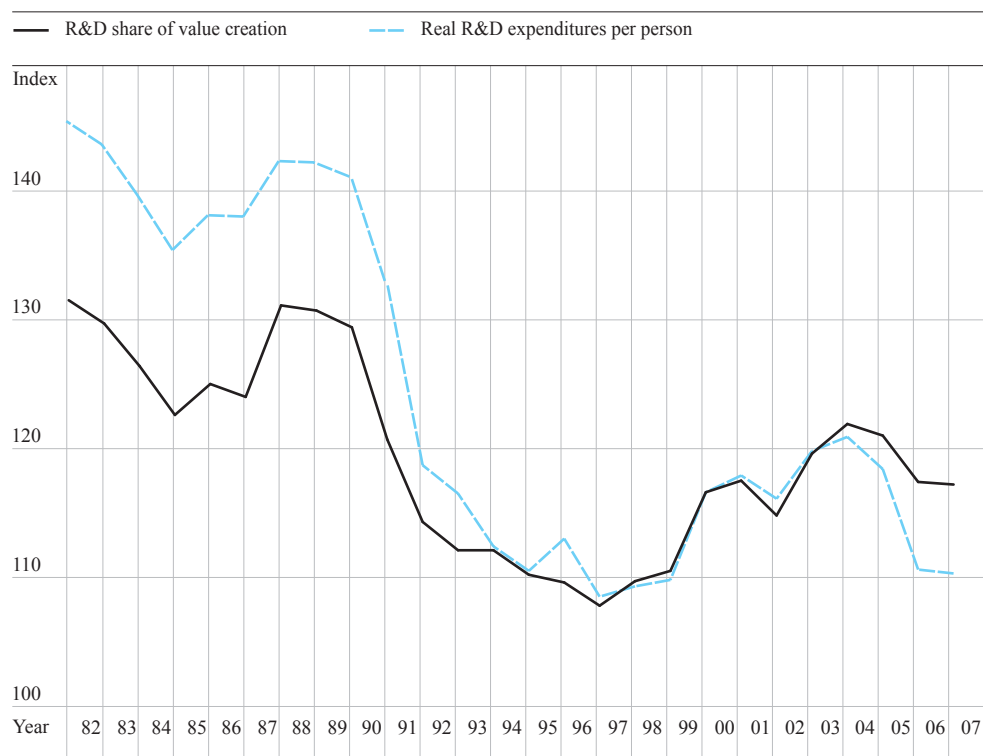


Data estimates in part.

\* Gross domestic expenditure on R&D as percentage of the gross value creation.

Source: OECD, Main Science and Technology Indicators (2008/2). WSV. Calculations and estimates by NIW.

**FIG 16 R&D-intensity of the German economy 1981 to 2006 in comparison to OECD**



Index: OECD = 100. Until 1990 West Germany.

Source: OECD, Main Science and Technology Indicators (2008/2). Calculations by NIW.

orientation of non-university science institutions to the needs of businesses.

In Germany, the business funding contribution for public R&D projects, compared with in-house activities, has increased to more than 3.5 percent, against the trend. After a revision of the statistics for 2005, the last available year, a figure of 5.4 percent is obtained. It seems that the science system has become more relevant for German businesses.

### **More research and development activity in the business sector since 2003**

Businesses OECD-wide spent 570 billion dollars on research and development in 2006, which is 2.4 percent of gross value-creation in the company sector. The R&D intensity of business in Sweden is 4.7 percent (2007: 4.5 percent) which is almost twice the OECD average; Finland follows with 4.0 percent (2007: 4.2 percent), and then Japan and Korea (both 3.6 percent) and Switzerland (3.1 percent in 2004). Business R&D intensity is also above average in the USA (3.0 percent), Denmark (2.9 percent), Germany (2.8 percent), Austria (2.6 percent, 2007: 2.7 percent) and Iceland (2.5 percent). Germany's business sector is therefore not in a bad position in comparison with the other western industrialised countries regarding research and development, but it has lost ground. At the start of the 1980s the companies in Germany had an R&D-share of 2.4 percent of the value created in the business sector, placing it second behind the USA (2.5 percent), but in 2006 it was only in eighth place.

After a weak phase at the start of the new millennium, business R&D activity has increased again since about 2003 in the OECD countries. Until 2006 the annual average growth rate was 4.5 percent, driven above all by Japan and Korea, but also by Southern Europe; the USA and Central Europe were at 4 percent, Northern Europe above 3 percent, and Germany below 2 percent. The EU-15 achieved an annual value of 2.7 percent. In particular China made considerable progress with R&D activity in the business sector. In the past decade, companies in China have increased their R&D expenditure by more than a factor of ten, primarily in the R&D-intensive industry. China has also become one of the largest recipients worldwide of foreign direct investments in the R&D-segment.

Since 1994, German companies have expanded their R&D-capacity at just about the average rate for the EU. They are ahead of the company sectors of France and Great Britain, but have lost the dynamic lead of the past in a European comparison. This is because practically all small European economies have been making efforts to come as close as possible to the European Commission's R&D-target of 3 percent in 2010.

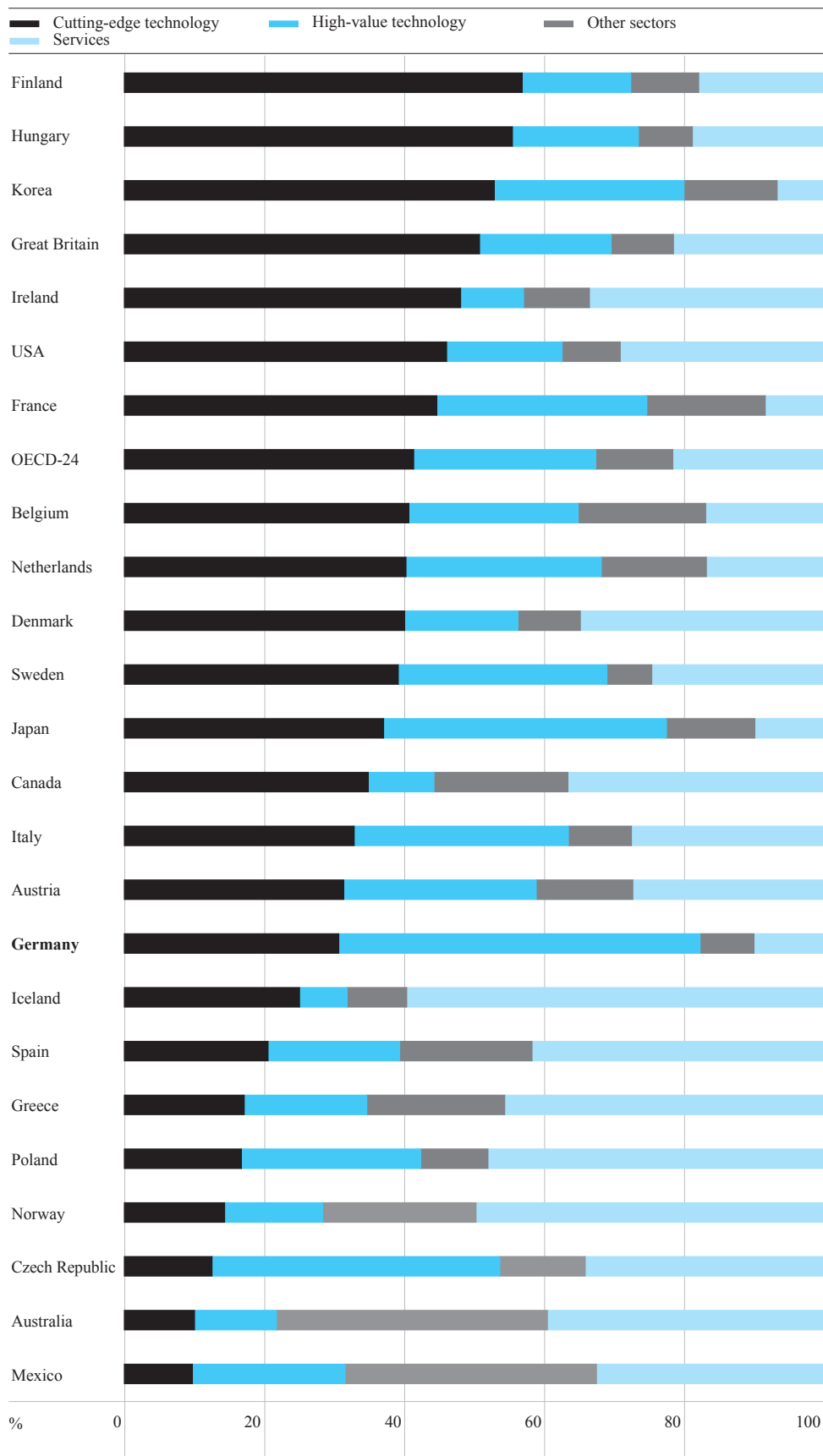
However, the EU as a whole is a long way away from its target. With a 1.9 percent share of value-creation in the company sector, research and development has not grown in importance since 2000, for all the declarations. No ground has been lost to the USA, but the R&D position has clearly worsened in comparison with Japan and the other Asian countries.

### **Below average increase in R&D activity of German businesses**

German businesses produce with a higher R&D intensity than the average in an OECD comparison, but the lead over other countries is melting away. The R&D-activities of companies are being adapted in the new decade to the progress of the economy in general and the revenues anticipated from the individual R&D-projects. Research and development activity has almost lost an independent dynamic and its own long-term perspective. In 2007, German companies invested 54.2 billion euros, which was 4.2 percent more than in the previous year. Over recent years the companies in Germany always invested a little more in research and development than initially planned, which is a sign of trust in a good economic development and an expression of a positive attitude to R&D and an appreciation of it. The tendency towards increased R&D – particularly in large companies in cutting-edge technology sectors – is probably related to a growing medium-term strategic orientation of industrial research. Nevertheless, the increase in R&D expenditure in the recent past has always lagged behind the revenue development.

German companies can no longer keep up with the international dynamic. Leaving aside the USA, the position of German economy has worsened in comparison with most world regions since 2000. Since 2004 the R&D-capacities in the business sectors of OECD countries have expanded on average by 5.8 percent,

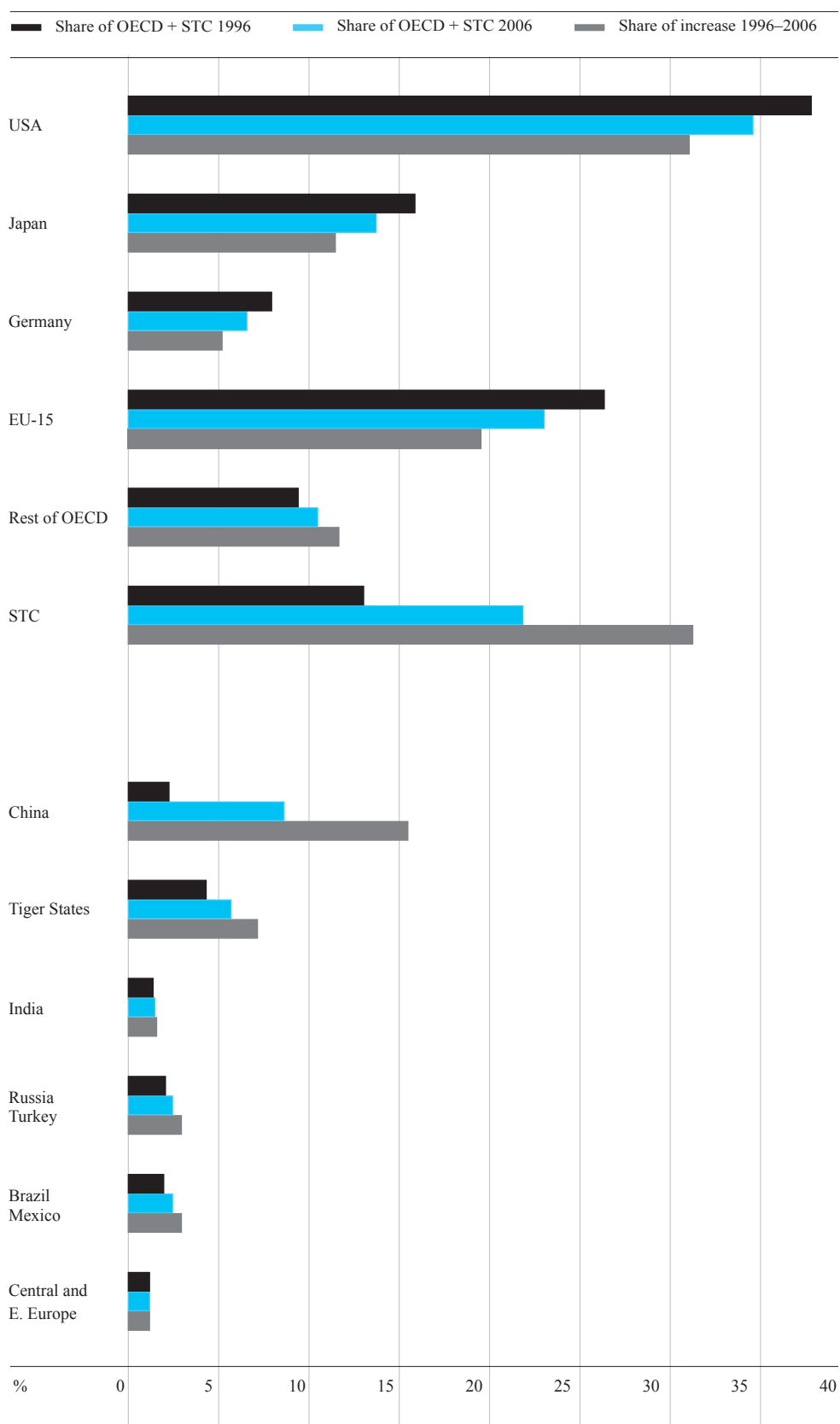
**FIG 17 International comparison of R&D-expenditures in various sectors in 2005**



Source: OECD, ANBERD Database. STI-Database. Calculations and estimates by NIW.

Proportion of GDP expenditure on R&amp;D (GERD) in an international comparison

FIG 18



India: 2005 instead of 2006. Rest of OECD: OECD without US, JP, DE, KR, TR, PL, HU, CZ, SK, MX.

Selected Threshold Countries (STC): All emerging economies. Tiger States: KR, TW, SG.

Central and Eastern Europe: PL, HU, CZ, SK, SI, EE, LV, LT, BG, RO.

Source: OECD, MSTI (2008/2), Eurostat, MOST India (2006), MCT do Brasil (2008). Calculations by NIW.



but the German business sector is a long way from this, at 2.9 percent. Correspondingly, the importance of its research and development in the global economy has also declined significantly, from 12 percent at the start of the 1980s to about 7 percent in 2005.

### **Automotive sector most important for research and development in Germany**

In the OECD countries, 76 percent of all internal R&D expenditures is in the manufacturing sector, more than 67 percent in the R&D-intensive manufacturing sector alone (2005). Nearly 22 percent is in the services sector. Other sectors, including non-R&D-intensive manufacturing, energy supplies and water management, construction, and agriculture, account for 2 percent of R&D-expenditure. Germany differs considerably from the average structure. R&D-intensive manufacturing, at 82 percent, has the highest proportion of R&D-expenditure among the countries included, while the services sector only had a very low share of 10 percent, similar to Korea, Japan, and France, where this sector accounts for some 8 to 10 percent of R&D-expenditure. In Germany the focus for decades has been on the high-value technology sector, which accounts in total for nearly 52 percent of R&D-expenditure. No other OECD countries have such a large proportion in this sector (mean: 26 percent).

In this sector group it is above all automotive construction, and also mechanical engineering and the chemical industry which represent Germany's outstanding strength. In contrast, the electronics-related sector (IT, electronics/media technology, IC) and the services sector (including company and data services) are relatively weak, not only in an international comparison, but also in most cases since the mid-1990s. R&D capacity growth in the German car industry has been very high: more than half the growth in R&D-capacity in Germany since 1995 has been in the automotive sector, and this development has even increased since 2005. 22 percent of the R&D-capacity of the automotive industry in the entire OECD are based in Germany.

Thus the "German innovation system" is increasingly dependent on this industrial sector. It is solely due to the automotive industry that the R&D-intensity in the German economy is above average. In all other sectors of the economy, research and development have lagged behind between 1995 and 2005. Previous strong points

of Germany, for example have weakened in the pharmaceutical industry and in telecommunications. This specialisation pattern is found throughout the German innovation system and is not only apparent for R&D, but also in the economic structure and in foreign trade or patents.

### **More countries are entering into the international innovation competition**

In addition to the western industrialised countries, other countries also have to be included in the R&D analysis and compared with Germany. This is the case in particular for Korea, Taiwan, and Singapore, the larger central and eastern European emerging markets, as well as the five young EU member states. China and India must also be included.<sup>105</sup>

With the development of a knowledge economy in these countries, the international innovation race has considerably more participants on the starting blocks. The emerging markets in 2006 were spending more than one fifth (22 percent) of gross domestic expenditure for research and development of the OECD countries and emerging markets combined. Since the mid-1990s the R&D-growth centres have been shifting increasingly into the Asian area, above all to the Asian emerging markets. China, India and the Tiger States have doubled their share from 8 percent to 16 percent between 1996 and 2006. Nearly one third of additional R&D-expenditure by OECD countries and emerging markets together is spent by the latter, of which half is by China alone. They have increased their share of worldwide R&D-resources from 13 percent (1996) to 22 percent (2006). For company expenditure the increase was even greater (from 11 percent to 20.5 percent).

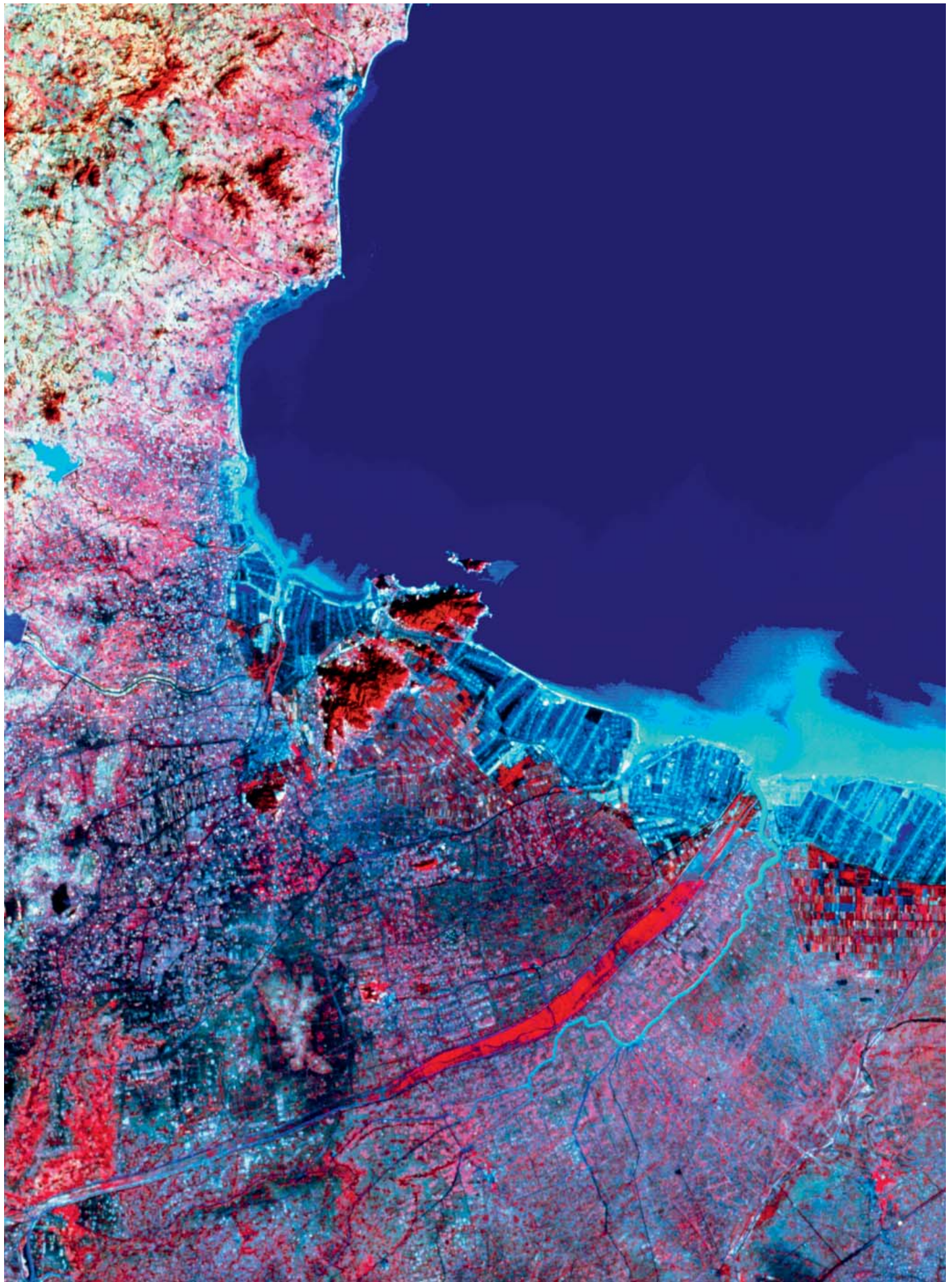
### **China continues its rapid expansion**

Quantitatively, China is on a particularly rapid R&D course of expansion. R&D expenditure since the mid-1990s has increased more than seven-fold to 87 billion dollars and in only a short period it has moved ahead of Germany (67 billion dollar) into third place among the R&D-rich countries (USA 349 billion dollar, Japan 139 billion dollar). Korea lies in sixth place in absolute terms between France and Great Britain, Russia, Brazil and Taiwan follow Canada in places



Europe by night  
© NASA/SPL/Agentur Focus





Satellite view of Linzhong Kao bay, China  
© NRSC / SPL / Agentur Focus

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).

## INNOVATION ACTIVITIES OF GERMAN BUSINESSES

C 3

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.<sup>106</sup> 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.<sup>107</sup>

### 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 continually 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-

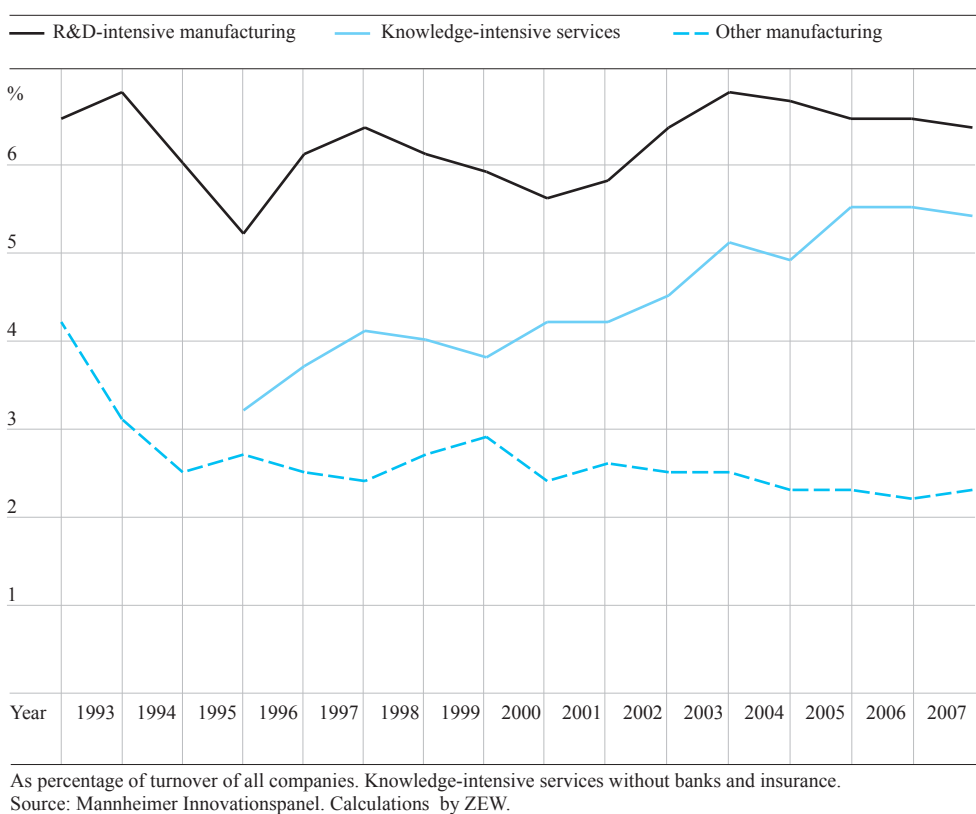


**Innovator rate in manufacturing and in the knowledge-intensive services in Germany**

FIG 19


**Innovation intensity in manufacturing and in the knowledge-intensive services in Germany**

FIG 20



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 than 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.

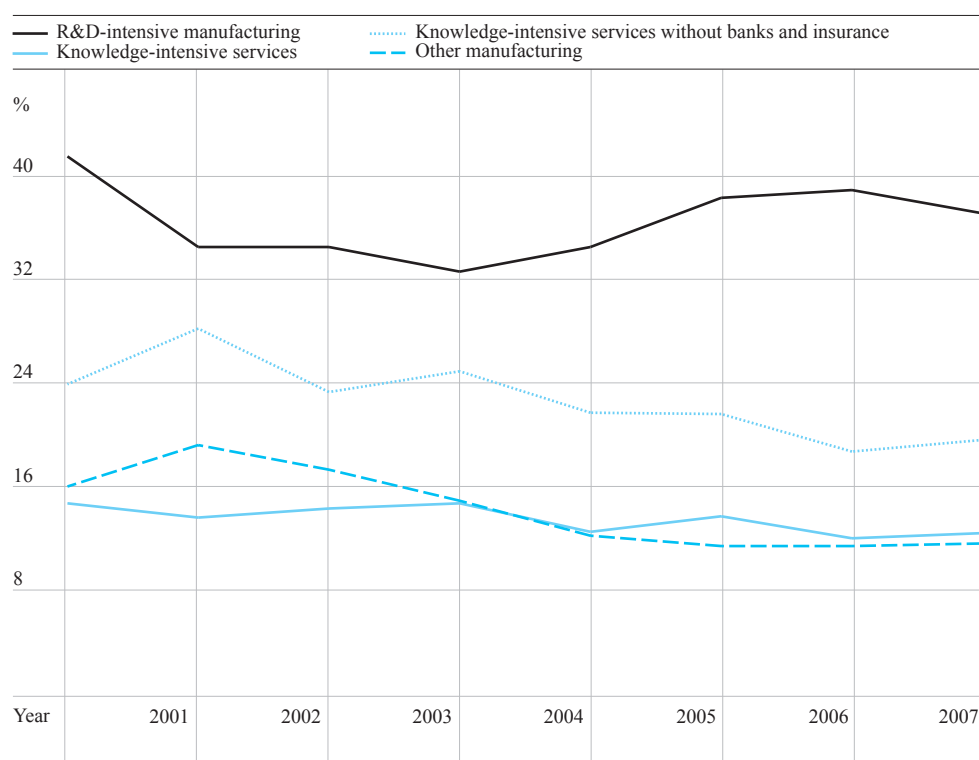
Market novelties are the most demanding and riskiest form of innovation. In the R&D-intensive manufacturing sector the share of turnover companies achieved with market novelties fell from nearly 9 percent in 2006 to 8 percent in 2007, and at the same time the share of companies able to introduce market 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

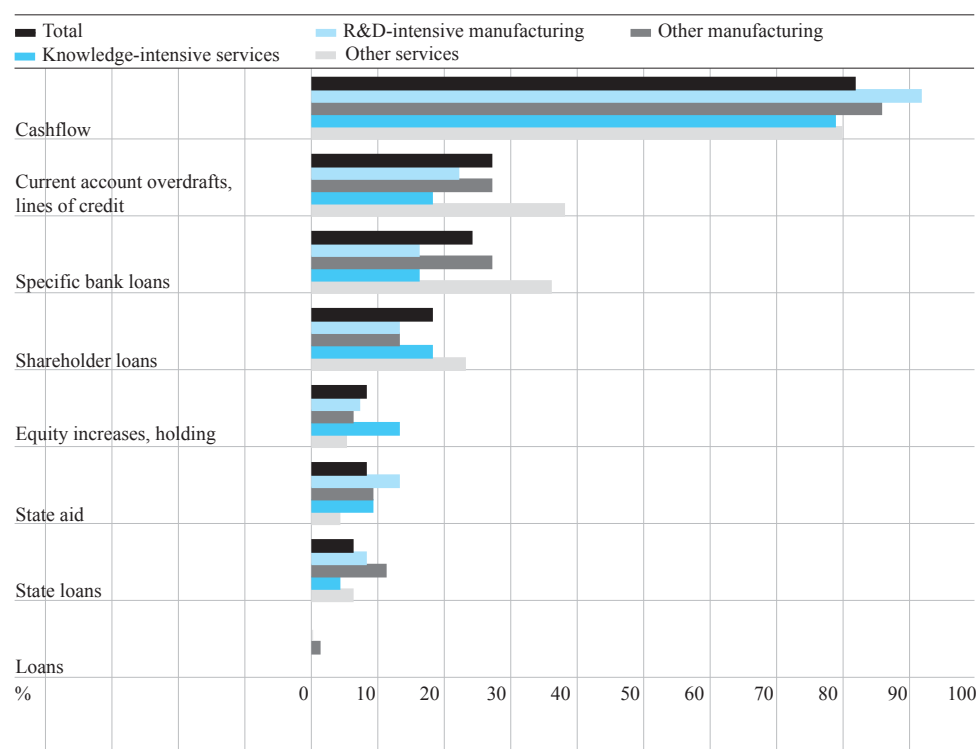
FIG 21



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 than 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.

## C4 SMALL TO MEDIUM-SIZED ENTERPRISES

The following section is based on an evaluation of various studies on aspects of research and innovation.<sup>108</sup> 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.<sup>109</sup> In the sector of commercial services, some 75 percent worked in small and medium companies, and in the manufacturing sector about 60 percent.<sup>110</sup> 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.

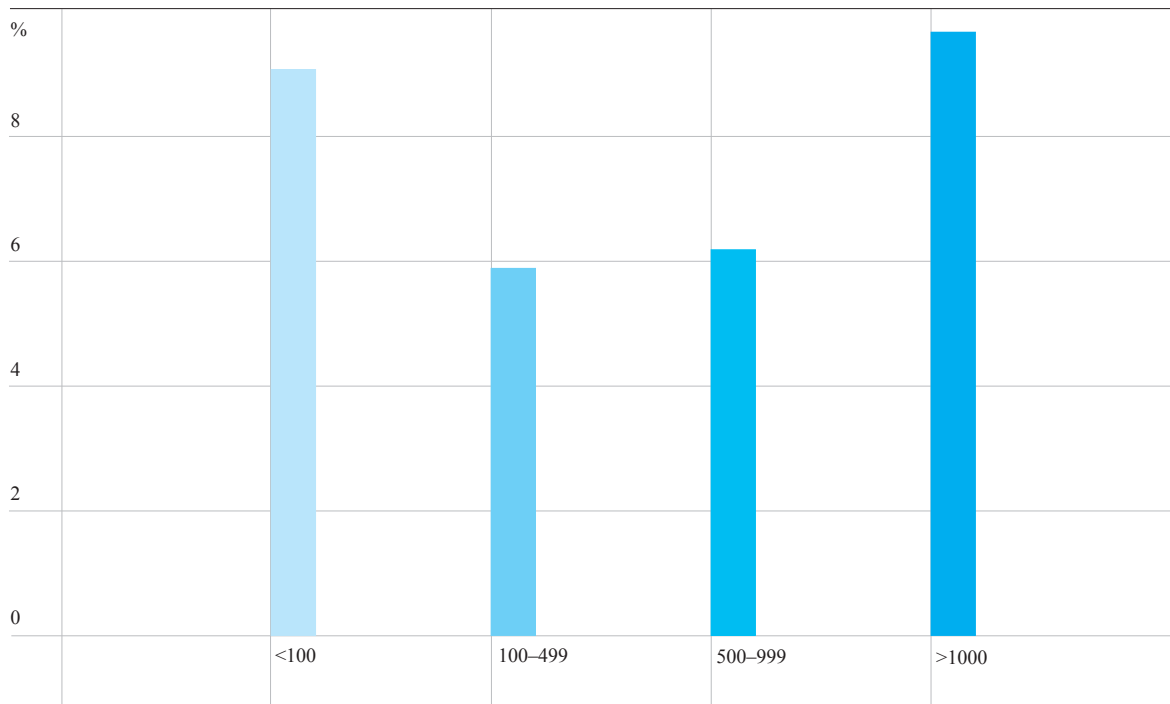
There are very different types of small and medium-sized enterprises with specific functions for the economy. These are discussed in more detail in Chapter B 4. In the case of researching companies, the R&D intensity (the proportion of all personnel who are R&D personnel) is particularly high for small 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.<sup>111</sup> 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



**FIG 23 R&D-intensity of researching companies in Germany 2005**



According to numbers of employees.  
 Source: SV-Wissenschaftsstatistik. Calculations by NIW.

25 percent is much higher than their share of R&D-expenditure (13 percent). Small and medium-sized companies use patents to secure their inventions particularly intensively. In an international comparison, they specialise in Germany on mechanical engineering, in particular machine tool construction.

Above-average numbers of patent applications are made in the fields of control and measurement engineering, and materials, but there is a weakness in information and communications technologies. German small and medium companies are broadly specialised in high-value technology – in contrast to the United States, where they concentrate on the fields of information and communications technology, control and measurement engineering, medical technology, and pharmaceuticals, or in other words in sectors of cutting-edge technology.

Scientific publications by companies are an indicator of the results of basic research with a high potential for radical innovations. Since the start of the 1990s there has been a steady rise in the publications by small and medium/large companies, and their absolute numbers are meanwhile higher than those from large companies. The actively publishing small and medium/large companies are mainly R&D-intensive

start-ups and R&D service providers, which despite their low absolute numbers make a considerable contribution to German innovation activities.

There are considerable differences concerning the employment of highly-qualified professionals depending on the size of the companies. In the manufacturing sector the proportion of natural scientists and engineers in the workforce of companies with up to 50 employees was 5 percent, compared with 12 percent in companies with more than 1000 employees. Overall there is a clear positive relationship between the proportion of natural scientists and engineers employed and the size of the company. This can be found similarly for the group of other graduates in the commercial services. In companies with up to 50 employees the rate was about 9 percent, and in companies with more than 1000 employees it was 19 percent. This situation did not change in the boom-years of 2005 to 2007, in which the annual growth in employment for graduates (1.8 percent), and in particular for natural scientists and engineers (1.5 percent), was much weaker than for employment overall (2.7 percent). This applies in particular for small and medium companies, for which in the knowledge-intensive sector the proportion of natural scientists and engineers is stagnating and in the non-knowledge-in-

tensive sector is even declining. This clearly reflects the shortage of qualified personnel.

A recent study on graduate careers<sup>112</sup> shows that highly-qualified professionals are increasingly deciding to work for large companies, and that particularly in recent years there has been a clear shift to the disadvantage of small and medium companies. One reason for this is that incomes at a small company can be 15 000 euros per annum less than at a large company. And the income disadvantages for women are even greater. A further important reason for preferring to work in a large company is the expectation of greater job security. The reasons given for working in a small or medium company are often defensive, such as the lack of an alternative, the threat of unemployment, and above all limited mobility. But the preference for large companies has little to do with the contents of the work: the work in SMEs and large companies is thought to be similarly interesting.

In summary, small and medium-sized enterprises are already at a disadvantage when it comes to recruiting academics, and in particular natural scientists and engineers in manufacturing. Given the clear preference of university graduates to join large companies this situation will in all probability grow worse.

Further details about the structures and development of small and medium companies are provided in the Studies on the German Innovation System.

## C5 NEW ENTERPRISES

New enterprises promote the technological structural change by using new business ideas to expand or modernise the existing products and services, challenging existing companies. New enterprises in the research- and knowledge-intensive sectors are particularly important in this respect. In new fields of technology, when new consumer trends emerge, and in the early phase of transfer of scientific knowledge through to the development of new products and processes, new enterprises open niche markets and help innovative ideas to achieve a breakthrough if they have not been picked up by large companies. The following results about company dynamics in research- and knowledge-intensive sectors of the economy are

based on an evaluation of the ZEW-Start-up Panel and the Mannheim Company Panel (MUP).<sup>113</sup>

### **Every seventh start-up is in research- and knowledge-intensive sectors**

Start-up activity in Germany bottomed out after the collapse of the New Markets in 2002, but in the following two years there was a marked rise in the numbers of new companies being started up. The development was boosted in part by the labour market reforms in 2003/2004. Since 2005, the numbers of start-ups have begun to decline again. In 2007 there were 226 000 start-ups, which is 16 percent below the level of 2004.

In the research- and knowledge-intensive sectors, start-up activities in 2003 and 2004 were less dynamic than for the economy as a whole. But in turn, the decline in start-up numbers from 2004 to 2007 was 11 percent compared with 16 percent overall.

In 2007, there were 31 400 start-ups in the knowledge-intensive services and the R&D-intensive manufacturing sector. Every seventh newly started company is in research- and knowledge-intensive sectors:

- In 2007 nearly 13 percent of all start-ups were in the knowledge-intensive services. 14 000 companies were started in knowledge-intensive consultancy and 15 000 companies in technology-oriented services.
- More than 1 percent of all start-ups in 2007 were in the R&D-intensive manufacturing sector: 1 700 start-ups in high-value technology and 700 in cutting-edge technology.

### **Low start-up rates in the R&D-intensive manufacturing sector ...**

The number of start-ups related to the overall number of companies gives the start-up rate. It is a measure of the renewal of the stock of companies. The average start-up rate in the research- and knowledge-intensive sectors in 2007 was 6 percent, which is close to the average for all start-ups, which is 6.5 percent. For the knowledge-intensive services the start-up rates were 6.5 percent (technology-oriented services) and

7 percent (knowledge-intensive consultancy). The values for the R&D-intensive manufacturing sector was clearly lower – 3.5 percent for cutting-edge technology and 4 percent for high-value technology.

The discrepancy between start-up rates in the research-intensive and knowledge-intensive sectors is because the market entry barriers in the R&D-intensive manufacturing sector are higher than in the knowledge-intensive services. Factors include a need for a high level of finance, high demands for human resources, the need for specific market knowledge, and a dominance of large companies.

### ... combined with lower closure rates

While new enterprises are starting up, other companies are closing down. The number of company closures has been declining since 2004, after it had previously been on the increase for several years in a row. In 2007, there were 215 000 company closures, either voluntarily or due to insolvency – 10.5 percent of these were in the research- and knowledge-intensive sectors.

The closure rate expresses the number of closures proportional to the number of companies in the sector. In the research- and knowledge-intensive sectors in 2007 this was below 5 percent, and some 1.5 percentage points lower than in the economy as a whole.

In the R&D-intensive manufacturing sector, closure rates were particularly low: 2.5 percent (cutting-edge technology) and 2 percent (high-value technology). Closure rates in the knowledge-intensive services sector were considerably higher, at 4.5 percent (technology-oriented services) and nearly 6 percent (knowledge-intensive consultancy). The closure rates in the research- and knowledge-intensive sectors from the year 2000 show the various effects of the domestic economy on the individual sectors (Fig. 25):

- In the research-intensive industrial sector the closure rates increased quite slowly until 2002 (and not at all in the high-value technology) and declined again after 2002. The weak domestic economy after the collapse of the New Markets did not affect the closure rates due to the strong export-orientation of the R&D-intensive manufacturing sector. In addition there is the high level of fixed assets

in comparison to the services sector, so that the companies tend to react to economic downturns by “submerging”.

- The closure rate in the knowledge-intensive services decreased disproportionately from 2001 and only really began to rebound after 2004. The modest demand after the end of the New Economy Boom impacted on the many small knowledge-intensive service providers with their relatively low export rates, and caused more closures than in the R&D-intensive manufacturing sector. In addition, the market exit barriers are very much lower than for cutting-edge technology and high-value technology, due to the lower levels of sunk costs.

### Growing numbers of companies during the economic upswing

The balance between start-ups and closures shows the change in the company stock and thus the dynamic in a given economic sector. In the general economy, the number of economically active companies decreased between 2002 and 2005, after having increased for many years in sequence. Then in 2006 and 2007 the start-up rate exceeded the closure rate again.

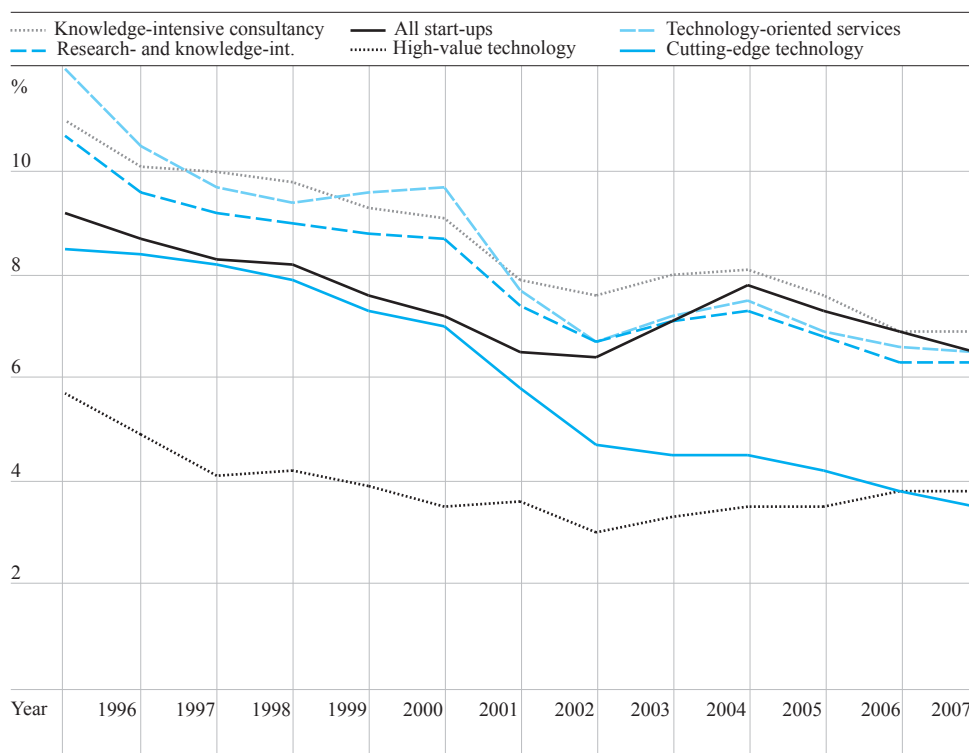
In the research- and knowledge-intensive sectors, a net increase in company stock could already be observed in 2003. Since then, the technology-oriented services have developed most dynamically in the research- and knowledge-intensive sectors. In 2007, the number of companies grew by more than 2 percent. The increase in company stock in knowledge-intensive consultancy was more modest than in previous years. In cutting-edge technology the decline in company numbers in 2002 was followed by a three year stagnation phase. It was only in 2006 and 2007 that the number of companies increased again. In the high-value technology the company stock hardly grew at all in 2003 and 2004. But then the start-up rates were considerably above closure rates, and in 2006 and 2007 the number of companies increased by nearly 2 percent each year.

### Every 50th employee in the business economy works in a new enterprise

In addition to the development of company start-ups and closures, the direct contributions to employment

Start-up rates in the research- and knowledge-intensive business sectors in Germany

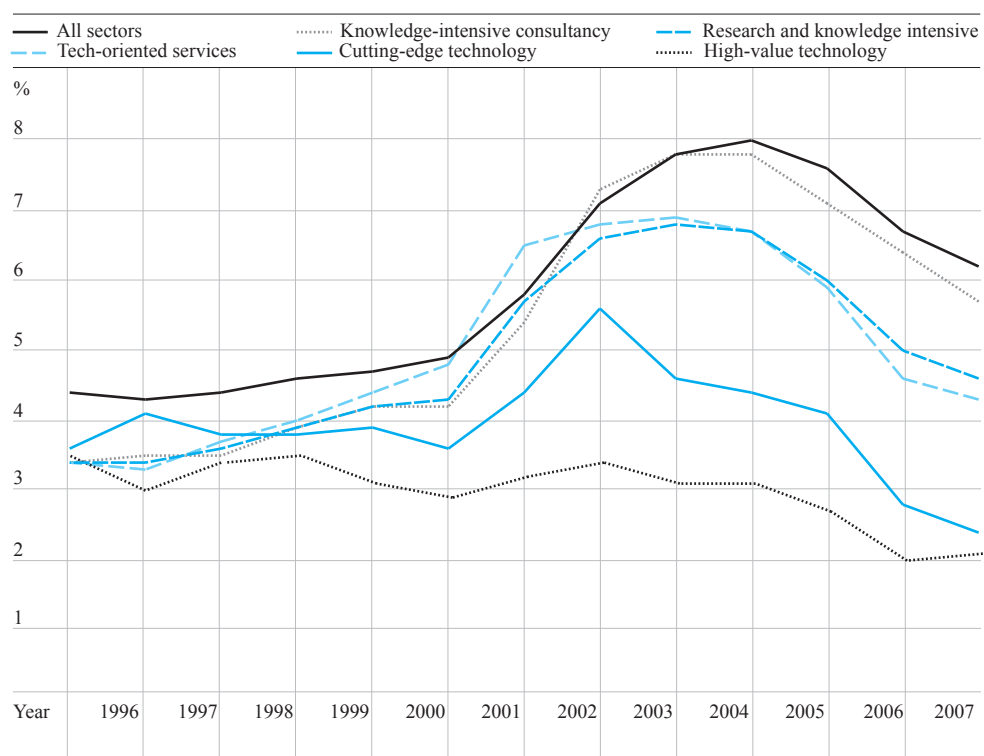
FIG 24



No. of start-ups in a year as percentage of annual average of stock of companies. 2007: provisional values.  
Source: ZEW-Gründungspanel. Calculations by ZEW.

Closure rates in the research- and knowledge-intensive sectors in Germany

FIG 25



No. of closures in a year as a percentage of the annual average stock of companies. 2007: provisional values.  
Source: ZEW, Mannheimer Unternehmenspanel. Calculations by ZEW.

of the start-up cohorts 1997 to 2003 were analysed on the basis of the ZEW-Start-up Panel and the Mannheim Company Panel (MUP). For methodological reasons, the survival probability and employment development could only be determined through until 2005.

Companies starting up between 1997 and 2003 had on average a staff of 2.3 (including the founder) in the first year of business, or 2.5 in the research- and knowledge-intensive sectors. The contribution to employment was highest in the research- and knowledge-intensive start-up companies with 5.7 jobs. Start-up rates were comparatively low because high initial investments in fixed assets represent barriers to market entry, but at the same time the minimum competitive size at the start is higher than in the services sector. In the sectors of knowledge-intensive services, new companies in their first year created on average 2.3 jobs for technology-oriented services and 2.1 jobs for knowledge-intensive consultancy.

Taking all branches of the business sector (without agriculture and forestry, public administration, education and health service, churches, and associations) start-up companies and existing companies created on average some 625 000 jobs annually. This is more than 2 percent of the workforce in the business economy. Of the newly created jobs, 38 000 were in knowledge-intensive consultancy and 43 000 in technology-oriented services. In all, 14 000 jobs were attributable to cutting-edge technology and high-value technology.

#### **Above-average employment development in research- and knowledge-intensive start-ups**

The net contribution to employment for most cohorts of young companies founded between 1997 and 2003 increased in the first and second year after starting up. The contribution fell again in the third year because the jobs lost by companies shrinking or closing down were greater than the extra jobs created in expanding companies. None of the cohorts of companies was able to maintain the initial employment level. By the fourth or in part the fifth year after starting up, the total workforce in the surviving companies fell below the size of the combined workforce of a start-up cohort in the first year of business. And in the following years a continual reduction could be observed. The employment effects of new enterprises are thus neu-

tral when viewed in the long term. The job losses of the older start-up cohorts are balanced out by the jobs created by the newly established enterprises. New start-ups can drive older companies out of the market, or cause them to reduce their business activity as they lose increasing shares of the market. At the same time, new start-ups can also compensate for jobs lost by the closure of older companies whose products are no longer competitive on international markets.

Job creation by start-ups in the research- and knowledge-intensive sectors has special characteristics (Fig. 26). Here, only the 1997 start-up cohort fell under the employment level of the first year of business in the period until 2005. This is due less to differences in the probability of survival of the companies and more to the vigorous growth of the surviving companies. For each of the cohorts, the start-ups in the research- and knowledge-intensive sectors were able to increase employment in the first two to three years of operation by 15 percent, which is quicker than the average for all sectors of about 10 percent. In the favourable economic climate of 1999 to 2000, the new companies grew particularly strongly in the first two to three years; in particular the 1999 cohort benefited from this.

#### **Mainly complementary start-ups in the R&D-intensive manufacturing sector**

In the research- and knowledge-intensive sectors, the R&D-intensive manufacturing sector shows the most favourable employment development. This results from a rapid growth of the companies and their high rate of survival. The 1997 cohort was still showing a higher level of employment in 2005 than in the first year of business. The results indicated that in the cutting-edge - and high-value technology, new enterprises mainly offer products which are complementary to those already on the market and so they tend not to displace existing companies to any great extent.

It is therefore to be expected that the support of start-ups in the R&D-intensive manufacturing sector would contribute very strongly to structural change and have positive net-effects on employment and growth. In the technology-oriented services, employment development for start-ups was also clearly better than for the business sector as a whole. In particular



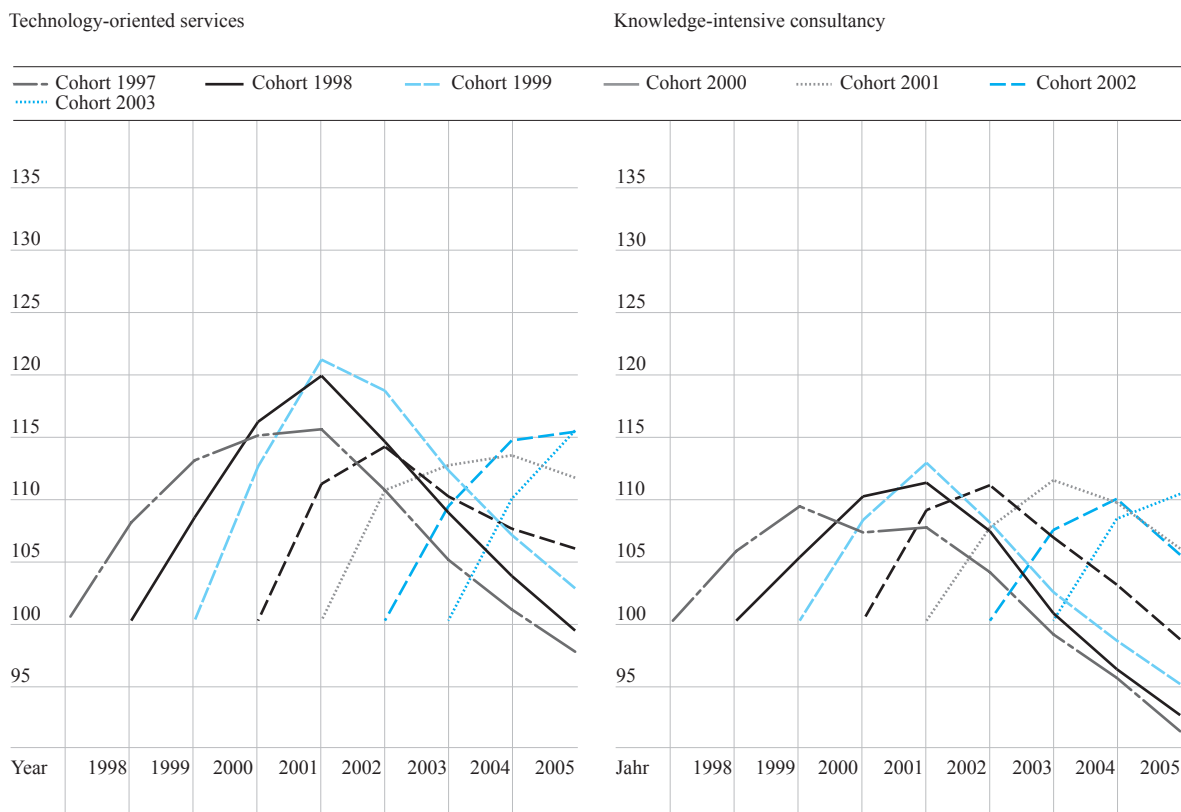
## Development of employment of the cohorts 1997–2003 in the research- and knowledge-intensive business sectors in Germany

FIG 26



1995=100

Source: ZEW-Gründungspanel und Mannheimer Unternehmenspanel. Calculations by ZEW.



1995=100

Source: ZEW-Gründungspanel und Mannheimer Unternehmenspanel. Calculations by ZEW.

**TAB 06 Employment contributions of start-up cohorts in research- and knowledge-intensive sectors of the German economy**

	Total		R&D-intensive manufacturing		Technology-oriented services		Knowledge-intensive consultancy	
	absolute	in %	absolute	in %	absolute	in %	absolute	in %
Employment in 1 <sup>st</sup> year of operations	663	100	16	100	47	100	39	100
Loss of employment after market launch	-185	-28	-3	-18	-12	-25	-10	-25
Net-change in employment in surviving start-ups	182	27	7	41	17	37	12	30
Employment contribution Total	660	99	20	123	52	112	41	105

No. of jobs x 1 000 in 5th business year, Start-up cohorts 1997–2001. (Slight rounding deviations).  
Source: ZEW-Gründungspanel and Mannheimer Unternehmenspanel. Calculations by ZEW.

the 1998 and 1999 cohorts were able to grow rapidly in their first years in the course of the New Economy Boom. The evaluation of the ZEW-Start-up Panel and the Mannheim Company Panel suggests that the employment effects of the start-up cohort are strongly influenced by the state of the economy. However, the observation period is too short to draw conclusions from this for economic policies.

### Clear sectoral difference in the employment balance

The employment level realised in the companies of a cohort at a specific point in time is determined by:

- The employment effect due to the start-ups (i.e. the number of employees in the first year),
- The jobs lost later when companies in the cohort quit the market,
- The net-employment contribution of surviving enterprises.

Table 06 presents the mean employment balance for the 1997 to 2001 cohorts in their fifth year of business. Overall, the employment contribution of the start-up cohorts was on average 1 percent below the level in the first year of business. Job losses by closures (–28 percent) outweighed the net increase in jobs in the surviving companies (+27 percent). However, there were clear gains in employment in comparison with the first year in the research-intensive manufacturing sector (+23 percent). This was the result of relatively high increases in jobs in the surviving companies (+41 percent) and comparatively low

losses of jobs due to companies leaving the market (–18 percent). The increase in the numbers of jobs can be interpreted as showing firstly that companies in cutting-edge technology and high-value technology start with fewer employees than the market potential would allow. This would point to restrictions in the start-up financing or to a level of risk aversion of the entrepreneurs. On the other hand, the marked increase in employment shows the large growth potential of successful start-ups in the research-intensive manufacturing sector.

In the knowledge-intensive services, employment in the fifth year of business was 12 percent higher than the initial level for technology-intensive services and 5 percent higher for knowledge-intensive consultancy. This is the effect of gains in employment of surviving companies of 37 percent (technology-oriented services) and 30 percent (knowledge-intensive consultancy) set against job losses due to market exits of 25 percent in each case.

### Concluding remarks about start-up support

The evaluation of the ZEW-Start-up Panel and the Mannheim Company Panel show that start-up companies in the research- and knowledge-intensive sectors show above-average employment development. Against this background, the Expert Commission recommends focussing the start-up support on research- and knowledge-intensive sectors and overcoming the well-known hurdles facing start-up companies in these sectors. In particular, the financing opportunities for innovative start-up companies should be improved.

But there is also a need to do something about the shortages of qualified personnel, because this represents a further bottleneck for research-intensive and knowledge-intensive company start-ups and restricts their possibilities.

## C6 PATENTS IN INTERNATIONAL COMPETITION

The following section draws on an international comparison of transnational patents.<sup>114</sup>

### Long-term increase in patent applications globally

Patents are an innovation indicator which reflect the output of technological activity, being a result of research and development and innovation activity. Patents serve to secure competitive advantages, and their number is therefore also in direct relationship to the strategic significance of the market for which patent protection is sought. It is also important where a patent is registered. The following analyses draw on the concept of “transnational patents” or “world market patents”. These are patents aimed at various markets and are therefore particularly significant.<sup>115</sup>

In the past ten years there have been three key phases of development, similar to those observed for production. In the second half of the 1990s there was a clear overall increase in transnational patent applications. This was related to an increasing relevance of technology in the competition between highly-developed countries. In parallel, the euphoria of the New Economy Boom also stimulated patent applications, so that in this phase the growth of patent applications in the individual countries was greater than that of research and development expenditures. From 2000 to 2002 there was then a decline in patent applications, especially in cutting-edge technologies such as IC technology, pharmaceuticals and biotechnology. Countries which specialised in these sectors experienced a sharp drop, in particular the United States. The fact that Germany is more specialised in high-value technology protected it to some extent. Great Britain, which is oriented towards the US market, showed a slighter but longer lasting decline; a reversal of this trend only became apparent in 2006. The numbers of British patent applications are currently at about one third of

the German level. Since 2002, the numbers of applications for transnational patents from most countries have risen again appreciably.

Regarding the intensity of world market patents (patents per head of population), Switzerland is in the lead, as in the previous year, but closely followed by Finland and Sweden. Germany is in fourth place (Tab. 07). Since 2002, Germany has experienced a gradual decline in the specialisation in cutting-edge technology relative to other countries, mainly due to the advance of China and Korea, and also of other countries such as Finland, Sweden or Canada (Fig. 27).

### Rapid advance of Korea and China

A remarkable structural change in the international patent system has followed the advances made by Korea and China (Tab. 07). The Koreans already overtook the British levels in 2005 and the numbers are continuing to rise steeply. With the growth of Chinese patent applications it is to be expected that they will also reach the British level in the next year. In terms of the total number of transnational patent applications, China is behind Italy in eighth place. Looking only at applications in R&D-intensive technology, it is well ahead of Italy in seventh place (Tab. 07).

Regarding intensity,<sup>116</sup> China is currently far behind, because its technological activities are concentrated in a few regions and it is without a broad industrial base. This is precisely why considerable growth should be expected in the coming years. The bulk of Chinese patents in the R&D-intensive sector is supported mainly by the high specialisation in cutting-edge technology, which has developed from a negative index of -20 in 1996 to a current positive value of +40, which is considerably better than the USA (Fig. 27). This specialisation is based on patents in IC-technology and increasingly also in biotechnology and pharmaceuticals.

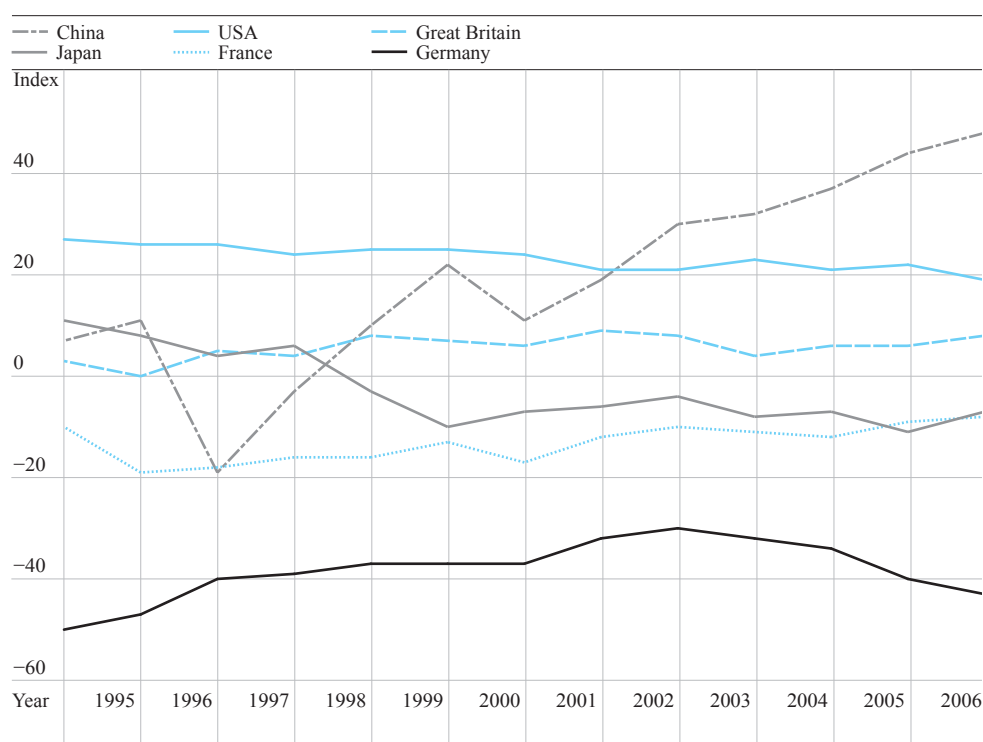
A comparison in the current specialisations of Japan, China and Korea in fields of R&D intensive technology shows clearly that Korea and/or China have penetrated many areas where Japan has been very strong, e.g. office equipment, electronics, optics, and entertainment electronics. Considering Germany, the United States and Japan, there is some overlap between the German and Japanese profiles, for example

**TAB 07 Overview of transnational patent applications in R&D-intensive technology 2006**

	Absolute no. of patents	Growth 2000 bis 2006 (%)	Intensity (Patents/ Employee)
Total	120742	19	–
EU-27	42340	9	192
USA	38327	2	261
Japan	20034	14	312
Germany	17516	7	448
France	6687	20	265
Korea	6277	236	271
Great Britain	5442	–7	173
China	4377	524	6
Italy	2973	26	119
Canada	2847	27	170
Netherlands	2618	–3	312
Switzerland	2472	18	576
Sweden	2408	6	544
Finland	1367	–1	560

Source: Questel (EPPATENT, WOPATENT). Calculations by Fraunhofer ISI.

**FIG 27 Specialisation of selected countries in cutting-edge technology for transnational patent applications**



Neutral value of RPA = 0. Positive indices show above-average specialisation.  
Values above +15 show high-levels of specialisation.  
Source: Questel (EPPATENT, WOPATENT). Calculations by Fraunhofer ISI.

## BOX 24

**Specialisation indices**

Comparisons between countries relating to patents, publications, production or foreign trade on the basis of absolute figures are only of limited value, because these are affected by the size of the countries, their geo-strategic situation, and other specific factors. Therefore, specialisation indices are often used which express the importance of a specific field or sector of a country in relation to a general reference value, usually a global average. Specialisation indices have no dimensions, and the mean or neutral value can conveniently be set to 0. The indices may be formulated mathematically so that a positive value is above-average, and there is a symmetrical distribution. It is also common to set an upper and lower limit for the range, in order to reduce distortions due to outlier values. Comparison relative to the global average mean that increasing national activities in a special field only lead to a higher value if most other countries do not increase their activities to the same extent.

cars and engines, or surface coatings. The German and American profiles, on the other hand, are complementary. In an international comparison, the German profile has a unique structure. It remains to be seen how Japan can withstand the growing competition from China and Korea if the classic rivals in Germany and the USA maintain their positions.

### **International patent cooperation is growing steadily**

The number of international co-patents, that is patents with inventors of different nationalities, has been growing rapidly since the 1990s. This development is mainly due to the fact that multinational companies increasingly draw on the cooperation of inventors from various locations. From the point of view of R&I policies, the development of co-patents is an indication of how a country is linked to the centres of inventive activity in other countries.

The rise in co-patents is closely related to the increase in the number of patent applications, although the 11 percent annual growth in co-patents is considerably higher than the 7.2 percent overall growth in patents. The rates of co-patents in the periods 1998 to

2000 was 10 percent and this rose to 11 percent for the period 2004 to 2006. For 13 of the countries considered, the rate of co-patents grew – the exceptions being Japan, Canada and Korea. Switzerland had the highest rate, and since the end of the 1990s this has further increased from 27 to 34 percent. This reflects the geographic and cultural links to neighbouring countries such as Germany and France, and in particular the large proportion of multinational companies. International co-patents are an indicator in this case for the cooperation between various subsidiaries of these companies. The rate of co-patents is also very high in Canada and in Great Britain. Germany currently has a co-patenting rate of 12 percent which places it in the middle ranks of European countries.

The very low co-patenting rate of Japan (2.5 percent) is perhaps not surprising, because this country has always had a reserved attitude to foreign companies. Korea has opened itself up somewhat more, but since the mid-1990s the rate has sunk from 8 percent to 4 percent and is thus following the Japanese example. The strategy of China is very different, and the rate of international co-patents is currently 14 percent.

### **USA is Germany's most important partner for co-patents**

The rate of international co-patenting of a country depends to a large extent on its technological profile. In 2006, the global average rate for chemistry was 25 percent, which is particularly high, compared with only 11 percent co-patents in mechanical engineering. The strong co-patenting in chemistry reflects the considerable globalisation of this sector. Germany's most important partner countries for co-patents are firstly the USA with 27 percent, followed by Switzerland and France (20 and 12 percent, respectively). In total, 48 percent of German co-patents were generated in cooperation with other EU-15 countries. More than two-thirds of all German co-patents relate to USA and the old EU member states, whereas the combined cooperation with Japan, Korea and China account for no more than 6 percent. However, there is a declining trend of co-patents with the USA, whereas the cooperation with Asian countries has grown. Co-patenting with the USA is primarily in electrical engineering and technical instruments; with Switzerland it is technical instruments and chemistry; and with France it is chemistry. Thus the co-



operation is mainly in the fields in which the partner countries are particularly strong. Overall, co-patents in Germany are mainly in the field of chemistry, but there are relatively few in mechanical engineering, so that German companies are following the general pattern in these sectors.

These comments are based on the study by Frietsch and Jung (2009). The study also investigates:

- General trends and structures for transnational patent applications,
- Patent applications of small and medium-sized enterprises,
- Trends and structures for international co-patents.

## C7 SPECIALIST PUBLICATIONS AND THE EARNINGS OF SCIENCE

This section is based on the results of a study of international specialist publications.<sup>117</sup> The scientific potential of a country is a crucial basis for its technological performance. The contribution to technology development and knowledge-intensive services lies primarily in the education of qualified personnel, and their quality in turn is dependent on the ability of the researchers. Also, the results of scientific research form an important basis for technical development. The links between science and business are frequently indirect and not obvious, because there is often a time lag between the scientific activities and their effects in the economy.

It is difficult to measure scientific performance because the structures in the various disciplines can be very different. One method is the statistical analysis of the numbers of specialist publications and the frequency with which these are cited. In the natural sciences, engineering, medicine, and life sciences the database “Science Citation Index (SCI)” has established itself as the international standard.

### **Increasing integration of German science in the international community**

The German share in international publications has fallen since the year 2000 by 12 percent, a trend

which can also be observed for many other large industrialised countries. This development is attributable to the growth in the activities of emerging markets, which have meanwhile acquired a considerable significance. Their share of SCI-publications in 1990 was at 9 percent, but by the year 2000 this has increased to 15 percent, and by 2007 had risen further to 25 percent. Korea's specialist publications have been increasing appreciably since about 1992, after a long period of low publication activity. Since 1997, Korea has also experienced a massive growth in transnational patent applications. In the case of China, the publications trend changed in about 1996, and for patents in 1999. This demonstrates the indicator function of specialist publications for the availability of highly-qualified professionals who go on to induce a strengthening of the technological capability.

The relative citation frequency<sup>118</sup> is a central indicator for the scientific quality of publications, and here German scientists have maintained a mid-table position, slightly behind their American colleagues. Only Switzerland has an outstanding international position here.

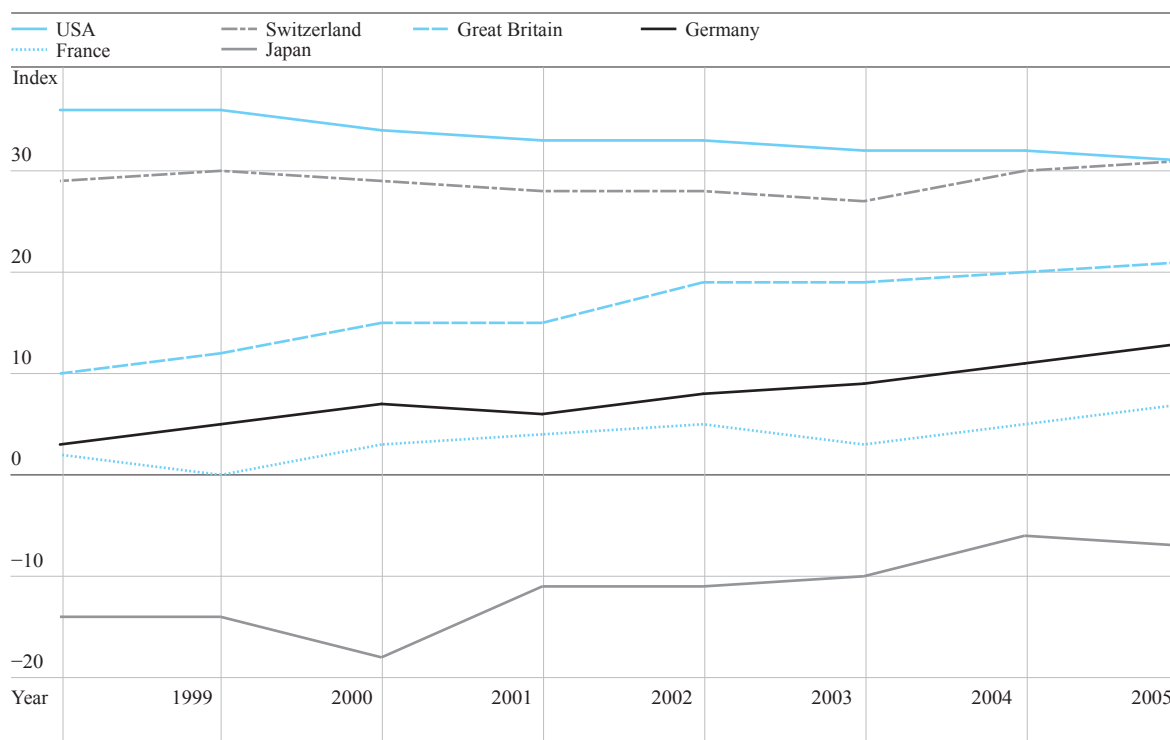
The indicator “international orientation”<sup>119</sup> has for many years shown the orientation of German authors towards high-profile international journals and thus towards closer involvement in the international discourse, although in this case German scientists are following a general trend which is also apparent in other countries (Fig. 28). Switzerland, the USA and the Netherlands occupy the first three places for international orientation. In the cases of Switzerland and the Netherlands (Index-values of 31 and 27) this demonstrates their very intense integration in the international discussion, whereas in the case of the USA (Index 31) it is above all due to their direct access to American journals, which have a broad international readership and thus a considerable influence on the international discussion. However, the index for the USA is declining, and this reflects an upward trend for other countries.

### **German strengths in physics and medical engineering**

For the analysis of publication activities according to subjects, it is usual to calculate specialisation indices, because the publication habits are very different in the various disciplines and therefore a comparison of ab-

International orientation of specialist publications for selected countries

FIG 28



Indices: International orientation with reference to the global average: 0 = average, > 10 very much above average.

Source: SCI. Research by University of Leiden. Calculations by Fraunhofer ISI.

solite numbers could create false impressions. Specialisation indices show whether the share of a discipline in the publications of a country are above or below this share for the publications in the entire database of worldwide publications. The German authors are particularly strong in physics and the closely related nuclear engineering (Fig. 29). A further strength is medical engineering. This structure has remained unchanged in recent years. All three fields show above-average scientific performance, expressed by the relative citation frequency and the international orientation.

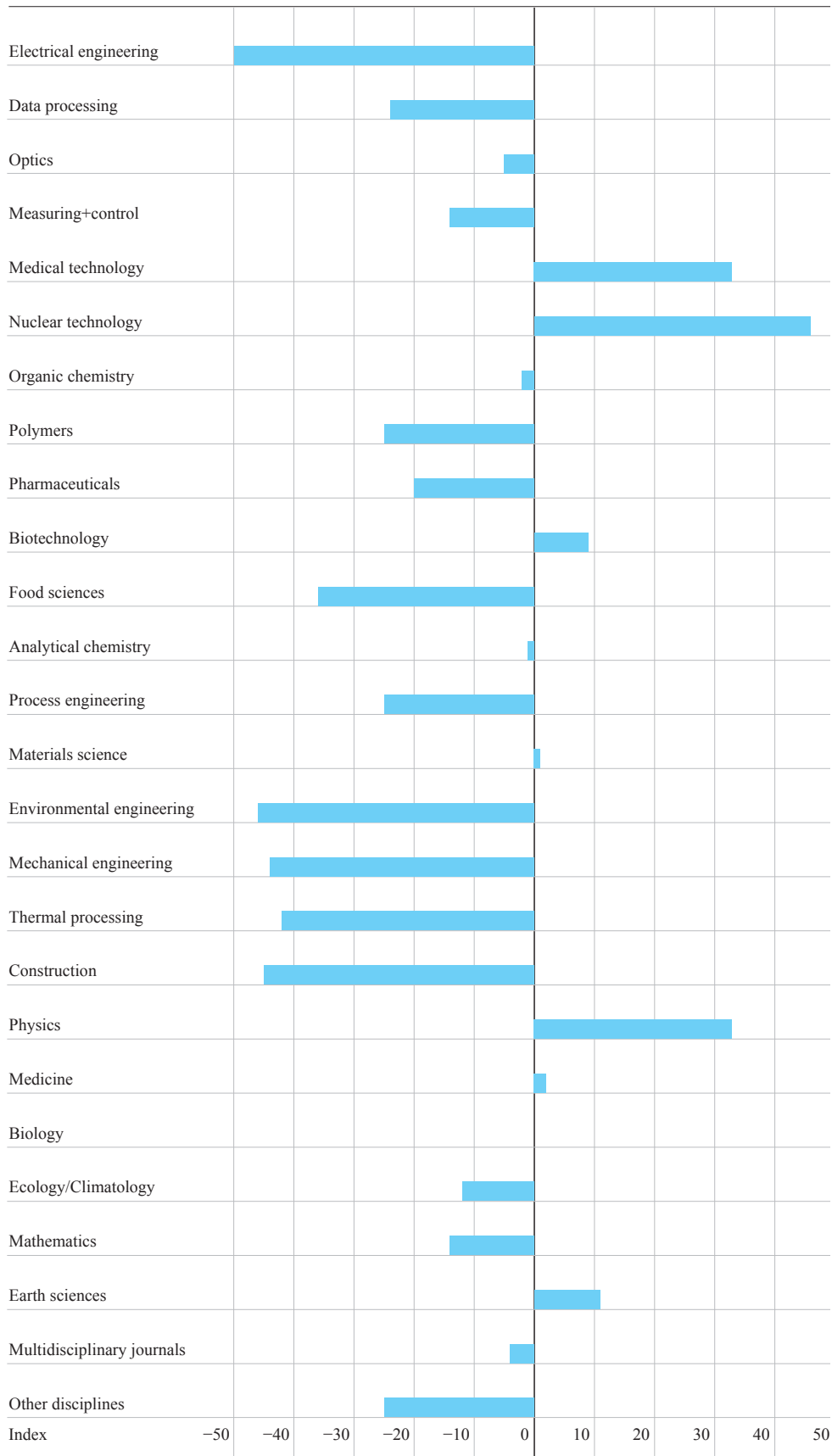
In an international comparison, publication activities are below average for data processing, which also has less weight in the economy. A noticeable contrasting feature is that the German specialisation index for biotechnology is slightly above average, and the scientific performance is also above average. Here the science is better than the economy. The negative indices in the various sub-disciplines of engineering are an artefact and are based on the fact that the relevant publications in other languages apart from English are not covered at all adequately. However, it is possible to conclude that German engineers should become more strongly involved in the international discussions.

### Important contribution of start-up companies to specialist publications

Companies frequently protect the results of their research by patents, but they rarely publish in scientific journals. Only 6 percent of all German SCI-publications are from companies. An important goal of such publications is to signal competence to the scientific institutions and to open up channels for cooperation. The specialist publications of companies reflect the results of strategic basic research which offer a high potential for fundamental innovations. The publication activities of large German companies have been stagnating since the start of the 1990s, but those of small and medium-sized enterprises have been growing constantly; meanwhile they generate more publications than the large companies (Fig. 30).

The majority of the publications of small and medium-sized companies come from small technology-oriented enterprises which are still in an early phase of their development. Medicine and the life sciences are particularly dynamic fields. These results demonstrate a structural change over the past 15 years, during which period large companies have reduced their central research activities and have increased

FIG 29 Specialisation of Germany based on publications in Science Citation Index 2007



Indices: Specialisation with reference to the world average: 0 = average, +20 considerably above average.  
 Source: SCI. Research and calculations by University of Leiden (CWTS). Calculations by Fraunhofer ISI.

applied research in the specialist departments. They then observe the activities of start-up companies and buy these up when they have shown themselves to be successful. A division of labour has established itself in which the start-up companies play an important role. More than 60 percent of publications of small, young companies are written in cooperation with universities, and a good quarter with foreign companies. The small companies are thus clearly linked to international research developments. Co-publications document close cooperation in scientific research, because both sides have to make a relevant contribution. In the case of young companies the founders frequently come directly from scientific institutions and continue to cooperate with their former colleagues.

When considering company publications in terms of disciplines, engineering comes out top in absolute numbers, followed by medicine, natural sciences, and life sciences. This result may seem surprising at first, but it can be explained by the considerable importance of basic research in fields such as materials and surface engineering, sensor technology, or communications technology. The activities of small and medium-sized companies are markedly higher than those of the larger companies in engineering in particular. In contrast, large companies currently equal the absolute levels of small and medium-sized companies in the life sciences. This is attributable in particular to companies such as Quiagen or Miltenyi, which were founded in the 1980s and which meanwhile have considerably more than 500 employees. In addition to the absolute numbers, the growth dynamic of publications of small and medium-sized enterprises is also remarkable, and is much higher than that of large companies in all sub-disciplines (Fig. 31).

These results illustrate the considerable potential of technology-oriented company start-ups for a structural shift of the economy towards cutting-edge technologies. The presentation here touches on the key results of a study by Schmoch and Qu (2009), which also considers:

- Trends and structures of scientific performance in an international comparison,
- Specialist publications of German companies, in particular SMEs,
- Trends and structures of specialist publications from emerging markets.

## PRODUCTION, VALUE CREATION AND EMPLOYMENT

C 8

The structural change of industry and services over the past two decades can conveniently be divided into three periods:

- The 1990s, the second half of which was marked by a global upswing in the economy,
- A weak economic period: 2000–2003,
- An upswing: 2003–2007.

The following statements are based mainly on data through until 2007. The developments in 2008 suggest that 2007 marks an economic highpoint. This is reflected meanwhile in considerably lower growth predictions for 2008 and 2009.

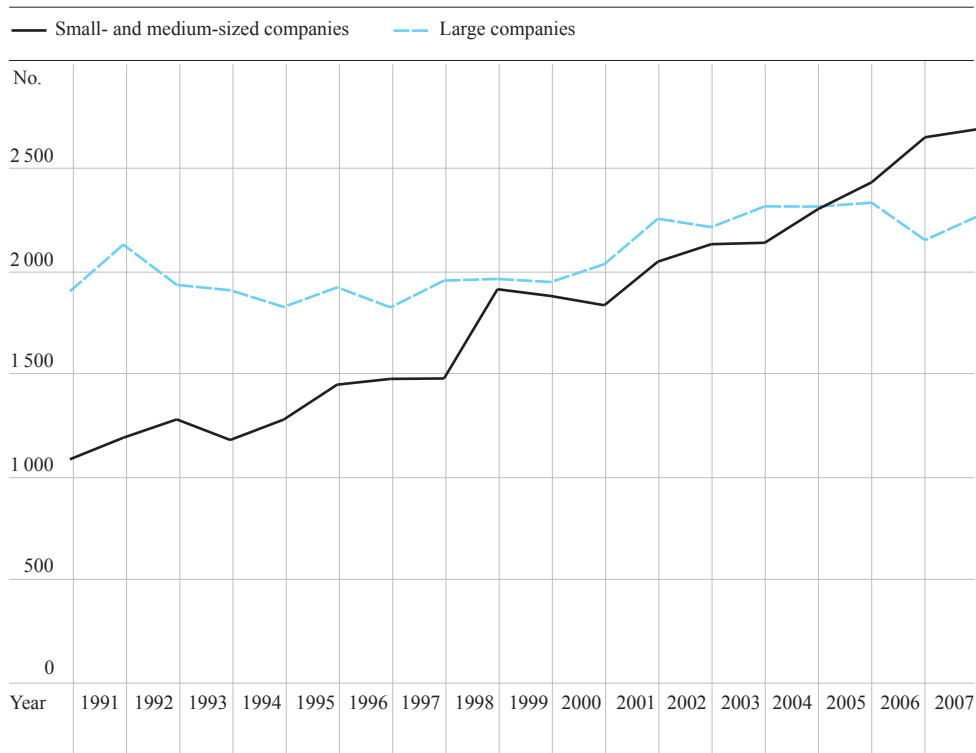
### Research- and knowledge-intensive sectors as a motor for the economic development in Germany

In Germany, above-average value-creation profits and job creation in 'industry' are above all attributable to the research-intensive sectors.<sup>121</sup> This accounts for almost 80 percent of the real growth in production in the manufacturing sector between 1995 and 2007. However the variations in production due to economic fluctuations since the 1990s have also become stronger in the research-intensive sector.

In the cutting-edge technology sector, new, fundamental technologies are frequently developed, and in many cases growth expectations play more of a role than the economic situation. Therefore when the economy was weak there was only a slight dip in production in the cutting-edge technology sector, soon followed again by strong growth.

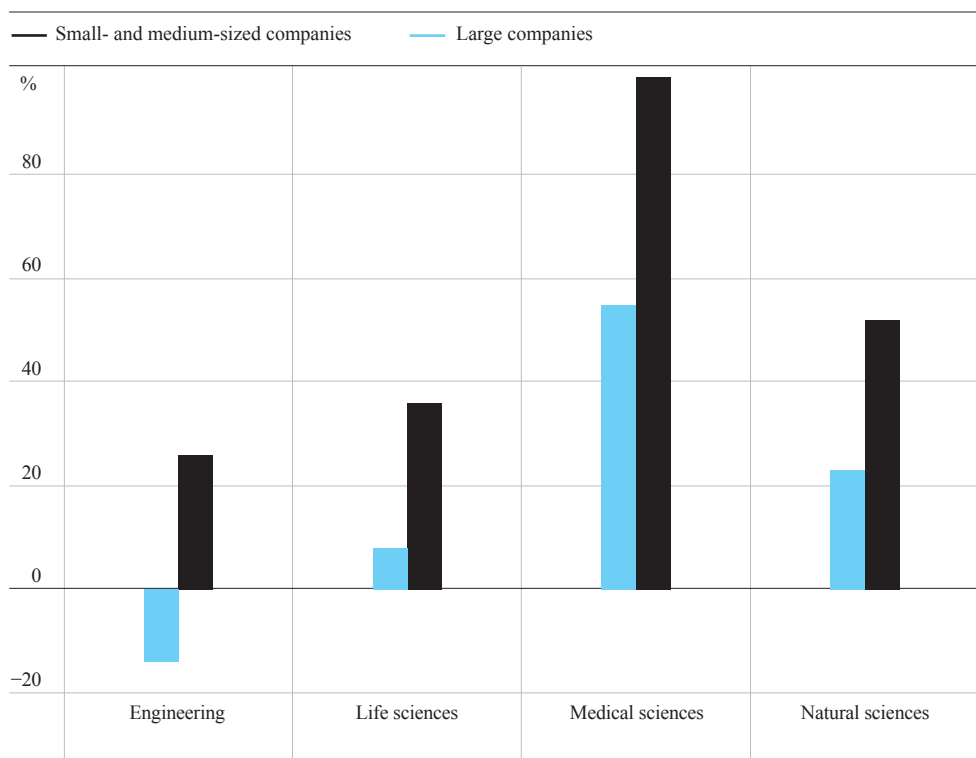
The high-value technology sector picks up newly created technological possibilities, but reacts markedly to cyclical signals. Thus the stagnation in this sector lasted until 2003, and the following growth period was less dynamic than in cutting-edge technology. The development in high-value technology was determined in particular by stable growth of the car makers and their suppliers as well as some branches of mechanical engineering. Other branches of mechanical engineering only experienced strong expansion in the upswing beginning in 2003.

**FIG 30** Numbers of scientific publications by companies of various sizes in Germany



Source: STN (SCISEARCH). Research by Fraunhofer ISI.

**FIG 31** Increase in scientific publications of companies in Germany 2000–2007



Source: STN (SCISEARCH).



In the non-R&D-intensive manufacturing sectors the economic downturn impacted earlier and the subsequent growth in the upswing was weaker.

#### **Clear losses to be expected in the automotive sector and mechanical engineering, with further growth in cutting-edge technology**

For 2008, overall growth is taken to have been 2 percent, with research-intensive manufacturing sectors achieving more than 3 percent, once again performing much better than the other sectors. However, the automotive sector has lost the function as engine of growth in industrial production which it held for many years.

It can be assumed that the annual average industrial production for 2008 is one percentage point down from the previous year. For 2009 a decline in industrial production is expected over a broad front, with the non-research-intensive manufacturing sector being more severely affected than the research-intensive sector. However, the latter is also expected to experience a decline. The associations representing the Computer/Media technology sector are expecting to see a halving of their growth potential, but are still aiming to achieve the clear growth of their market.<sup>121</sup>

#### **Considerable increase in productivity in the R&D-intensive sector. Uncoupling of production volumes and employment**

In 2007, the R&D-intensive sector employed 48 percent of the overall manufacturing workforce.<sup>122</sup> Since the mid-1990s, employment levels in this sector have been declining, interrupted only by a short growth period between 1997 and 2001. However, this is much less severe than in the non-R&D-intensive manufacturing sectors (Fig. 07 in B 5).

In cutting-edge technology, the manufacturers of IC-equipment and components as well as producers of active pharmaceutical substances have been cutting back employment levels to a considerable extent since 2001. There have been positive employment developments in medical technology, weapons/munitions, advanced instruments<sup>123</sup> and in aircraft and spacecraft construction. Despite an above-average expansion of production (Fig. 33), employment in the research-intensive manufacturing sector is also declining in the medium-term.

The differences between developments in growth and employment reflect the considerable advances in productivity. This rapid development is the result of international competitive pressure, which is particularly intense in the R&D-intensive sector.

#### **Strong competition in cutting-edge technology**

In particular in the 1990s, companies in the research-intensive manufacturing sector concentrated on their core competence and increasingly outsourced performances to the non-research-intensive manufacturing sectors, the services sector and to companies in other countries. In the cutting-edge technology sector, the enormous increase in productivity of more than 11 percent p.a. during the upswing from 2003 to 2007 explains why there was strong growth in production coupled with stagnating employment levels.

However, viewing cutting-edge technology overall, while there are considerable increases in production, revenue developments are now weaker. This is above all due to the drop in prices in the IC and electronics sector as a result of increasing international competition and the advances made by the emerging markets, whose industries can operate with much lower labour costs for adequately qualified personnel.

The cutting-edge technology sector is now more than ever a driving force for the economic development of Germany. It provides important impulses for the high-value technology sectors and the services sector. It should also be taken into account that in Germany most employees in cutting-edge technology in 2007 were working in the sub-sectors “Advanced instruments”, “Special pharmaceuticals” and “Medical equipment”.<sup>124</sup> The segments “Electronic components”, “Entertainment electronics” and “IC technology”, which are under particular price pressure, are less important here. Germany has a good status in research and development in both the industrial and academic sectors, so that it is well, but not excellently positioned to be able to cope with international competition in the cutting-edge technologies sector.

#### **Continued employment growth in the services**

Due to the close ties between the manufacturing sector and the services, employment effects are not always

direct in the former, but are felt to a considerable extent indirectly. In particular production and employment in research-intensive manufacturing sectors and the corresponding activities in the services sector can only be viewed in combination. While the longer-term observation of the development of value-creation in the manufacturing sector shows that this is highly cyclical, it went through a period of stable growth at the beginning of the 1990s both in the knowledge-intensive services sector and the non-knowledge-intensive services sector (Fig. 33). And although employment in the manufacturing sector as a whole declined, in the longer term the knowledge-intensive services sectors have opened up more employment opportunities than the other services sectors (Fig. 07 in B 5 and Fig. 32).

When assessing the knowledge-intensive services it must be borne in mind that sub-sectors can have very different significance in different countries. In Germany, "Health" is a particularly important sub-sector in terms of the labour input. It is followed by company-oriented services, a large part of which are non-technological consultancy. The service sectors "Data processing", "Research and development" and "Telecommunications" are less significant. Only about a quarter of knowledge-intensive services are technology-oriented in the narrow sense of the term, which explains the need for large numbers of graduates who do not have a background in the natural sciences or engineering. However, the non-technological service sectors also demand high-value technology, as for example in the cases of "Health", "Finances" or "Non-technological consultancy".

Over the past decade, the trend to tertiarisation<sup>125</sup> has continued; the proportion of employees working in business services has risen from 55 percent in 1998 to 61 percent in 2007. In the medium-term, communications services and non-technological consultancy services have the highest employment dynamics; in financial services the employment has been declining since 2002.

### **Steadily growing proportion of graduates in all sectors of the economy**

The continually rising importance of the research- and knowledge-intensive sectors increases the demand for high level education. The dynamic development of

the economic structure thus exerts a considerable influence on the requirements placed on the education, science and research systems. In these sectors, innovation is usually a key determinant of the ability to compete, and the innovation pressure is much higher than in other parts of the economy. This resulted in a boost in demand for highly-qualified professionals, in particular academics, who play a key role in innovation competition.

The proportion of highly-qualified professionals employed by companies is increasing steadily. In 1998, 6.9 percent of the workforce were graduates, in 2007 8.6 percent. In 2007, more than 1.9 million highly-qualified professionals were employed in businesses in Germany,<sup>126</sup> of which there were some 700 000 natural scientists and engineers and more than 1.2 million graduates in other disciplines. In each case, about three-quarters of the sub-group were working in knowledge-intensive branches of the economy. Most natural scientists and engineers work in the manufacturing sector, and a majority of graduates from other disciplines work in the services sector (Fig. 34).

The orientation of the knowledge-intensive services towards non-scientific academic qualifications can even be observed in the communications services, where the proportion of other graduates is five-times higher than that of natural scientists and engineers. The differences in qualification requirements are also reflected in the middle segment of skilled personnel with vocational training qualifications:<sup>127</sup> The corresponding rate for the knowledge-intensive branches is nearly 78 percent, in the non-knowledge-intensive branches it is only 62 percent.

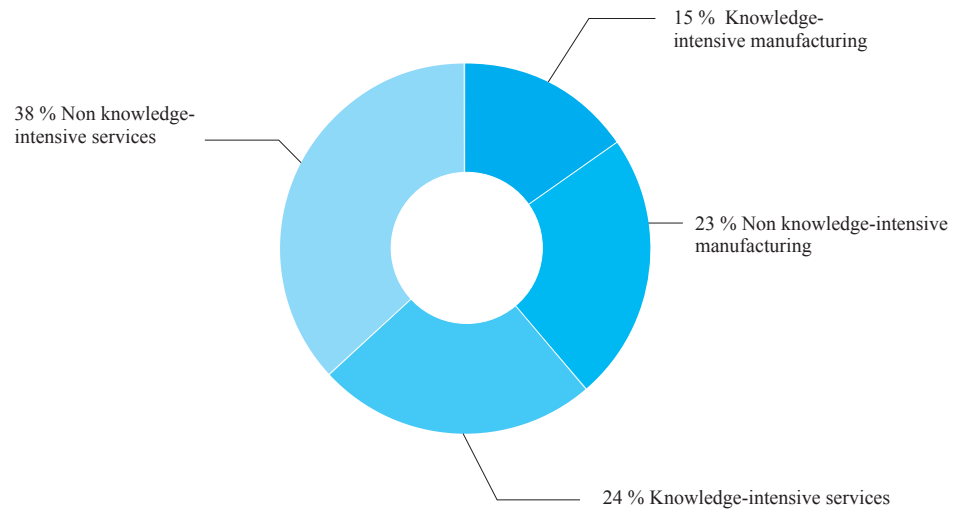
The change in the numbers of graduates can be attributed to three effects:

- The trend effect reflects the part of the change which is due to changes in the economy as a whole, i.e. economic growth or stagnation.
- The structural effect is the result of the shift of the economic structure towards knowledge-intensive sectors.
- The knowledge intensification effect reflects the higher qualification requirements in the sector.

Only in the recent phase from 2005 to 2007 did the overall rise in the employment volume also lead to an increased demand for highly-qualified professionals

Share of employees in various types of businesses in Germany

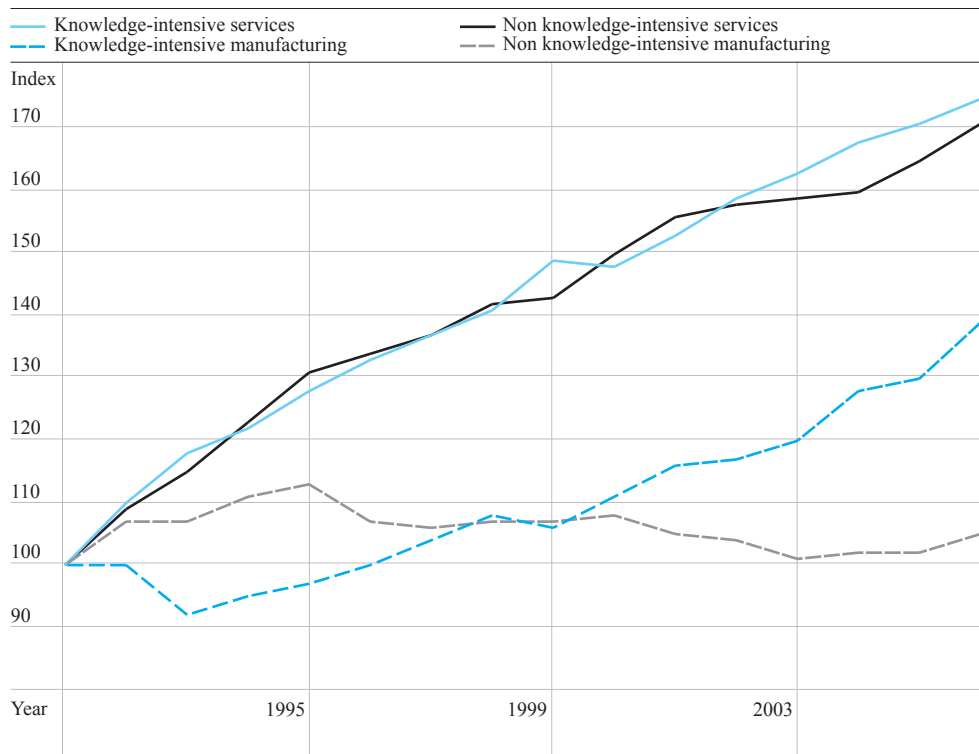
FIG 32



Data 2007. Source: Bundesagentur für Arbeit, Statistik der sozialversicherungspflichtig Beschäftigten. Calculations and estimates of NIW.

Development of gross value creation in various business sectors in Germany<sup>128</sup>

FIG 33



Index: 1998 = 100. Share of knowledge-intensive manufacturing 21 %, Other manufacturing 16 %, Knowledge-intensive services 37 %, Other services 26 %. Source: Statistisches Bundesamt, Series 18, 1.4. Calculations by NIW.

(trend effect). The effect of the structural change to knowledge-intensive sectors was a key factor above all from 1998 to 2002, particularly for knowledge-intensive services. Knowledge intensification was the most important factor from 1998 to 2007, especially in the most recent observation period from 2005 to 2007. Since 2002 the non-knowledge-intensive sector has also been generating significant demand for graduates.

### Shortage of natural scientists and engineers restricts growth

The employment of natural scientists and engineers is influenced by economic fluctuations; it even declined in the period from 2002 to 2005, which affected nearly all economic sectors with the important exception of the automotive sector. In contrast, the overall employment of graduates increased slightly during this economically weak period. The decline in the employment of natural scientists and engineers was probably influenced to some extent by cost considerations on the part of individual businesses. This may have been a rational management attitude, but as a signal for students newly enrolling in these subjects at university

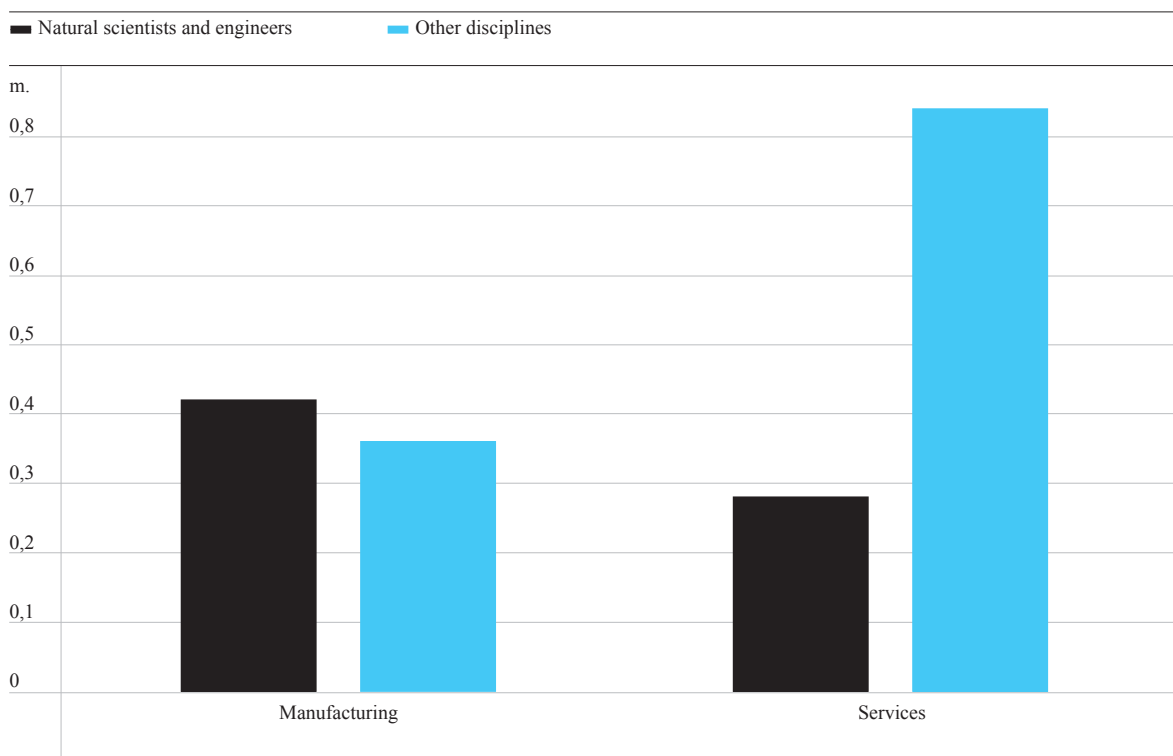
it was rather unfortunate. The problematic showed itself in the upswing period 2005 to 2007, during which 152 000 graduates were newly recruited, but of these only 20 800 were natural scientists and engineers, because the employment market did not have enough people with the relevant qualifications. This situation had not changed significantly by 2007, so that the shortage of natural scientists and engineers is already seriously limiting growth and innovation.

A particular problem in Germany is the rising average age of the natural scientists and engineers. The proportion of 25- to 34-year-olds in this group is not only the lowest in the EU-27 (20 percent), but it has also decreased by 2.6 percent from 2001 to 2006. Overall, as a result of innovations and structural changes, Germany can reckon with an additional demand for 40 000 to 50 000 graduates.

### Clear trend to a knowledge economy throughout Europe

The employment structures in the other established EU Member States (EU-14)<sup>129</sup> are very similar to

FIG 34 No. of graduates employed in the German business sector



Data: 2007.  
 Source: Bundesagentur für Arbeit, Statistik der sozialversicherungspflichtig Beschäftigten. Calculations and estimates of NIW.

Share of employees working in research- and knowledge-intensive companies in Europe

FIG 35

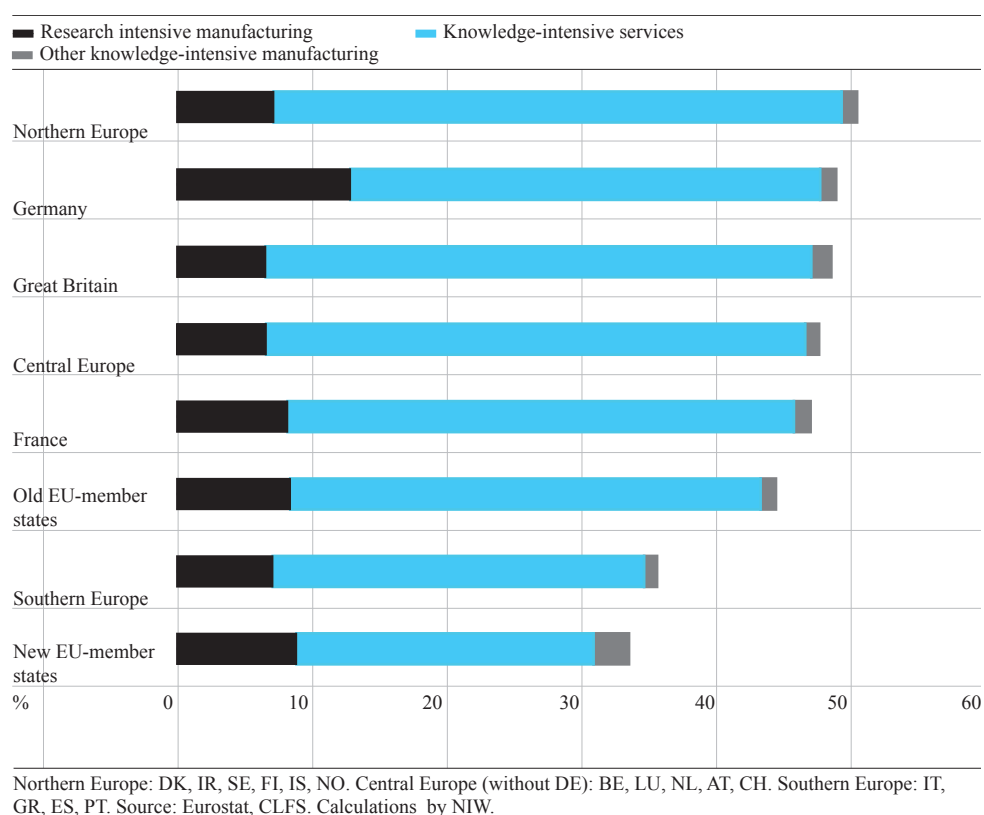
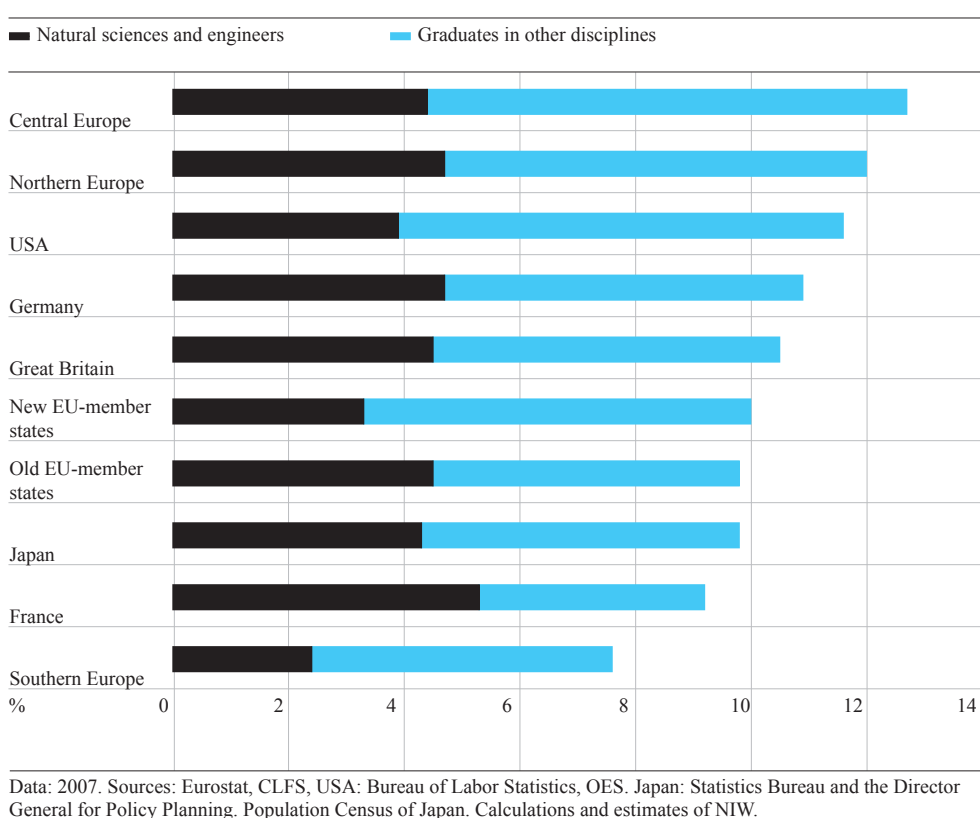
Share of employees with degrees in businesses in selected countries and regions<sup>130</sup>

FIG 36





Germany's: 45 percent of all employees in the business sector are working in research- and knowledge-intensive sectors (Fig. 35).

In the Northern Europe region, more than half of the workforce are active in the business economy. This region is thus the most advanced in Europe in the structural transformation to the knowledge economy, closely followed by Germany and Great Britain. The southern European countries are a long way behind with nearly 36 percent employed in the knowledge-intensive sectors. This is only a little ahead of the younger EU Member States (EU-12) with 33.5 percent, but their "catching-up process" is much more dynamic than is the case with Portugal or Greece. In a European comparison, the higher proportion in research-intensive manufacturing sector in Germany is remarkable, while Northern Europe, Great Britain and Core Europe focus on knowledge-intensive services.

Germany is slightly ahead of Great Britain in the employment of graduates and well above the EU-15 average.<sup>131</sup> But it is clearly behind Central and Northern Europe and also the USA (Fig. 36). This reflects the weight of knowledge-intensive services in these countries, which is based to a particularly high level on mainly non-science graduates. Germany employs a particularly high proportion of natural scientists and engineers. The reason for this is the disproportionately high structural weight of the research-intensive manufacturing sectors. Nevertheless, the corresponding rates in Northern Europe and the Core Region and Great Britain are meanwhile similarly high. This means that Germany has lost its "knowledge lead" over most European regions for natural scientists and engineers. From a German point of view there is now only a knowledge advantage over Southern Europe and the new EU Member States, although the knowledge gap to the quickly growing EU-12-Member States has already become much smaller.

When assessing the knowledge-intensive services it must be borne in mind that sub-sectors can have very different significance in different countries. In Germany, "Health" is a particular important sub-sector in terms of the employment rate. In Sweden and Finland "Health" also has a very high rate, whereas in Great Britain and the Netherlands "Company consultancy" and "Finances" are highly represented.

Over the past ten years, knowledge-intensive sectors have been in front in the services sector in the EU-15 countries with growth rates of 3 percent per annum, and also in the manufacturing sector there is an increasing structural change to knowledge- and research-intensive branches. The IC sector has advanced in this period, which is above all due to an enormous expansion of data processing services with an increase of 8 percent per annum.

### **Considerable demand for graduates throughout Europe**

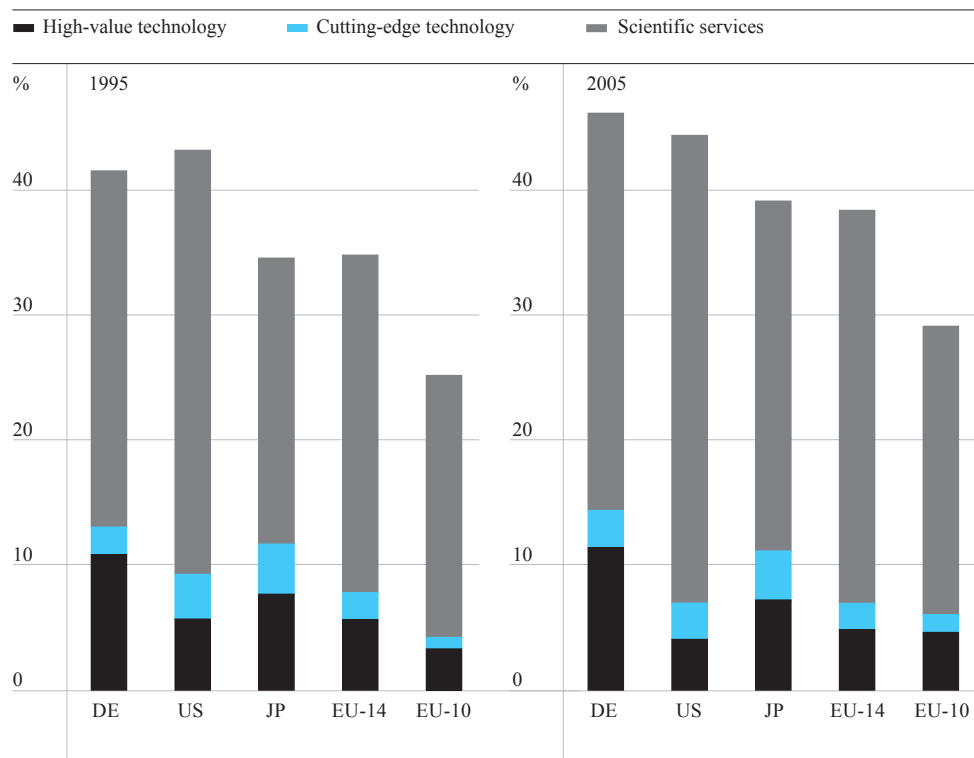
An analysis of the demand for highly-qualified professionals in European regions shows that, as in Germany, the shift to knowledge-intensive sectors and above all the knowledge intensification in the sectors has led to increased demand for graduates. This must be interpreted as a reaction by the companies to the increasing innovation pressure, which is perceived throughout the manufacturing sector to a greater extent than in the services sector and in the rest of the economy.

This development leads in Europe as a whole to a continually increasing demand for highly-qualified professionals. The hope of many countries in Northern and Central Europe that they will be able to meet at least part of their growing need for qualified personnel by attracting people from Eastern Europe, is hardly likely to come to fruition, because in the Eastern European accession countries the levels of graduate employment are rising at about twice the rate of the the old EU member states. In fact, there is therefore more likely to be a return of highly-qualified professionals to Eastern Europe.

### **Germany still successful with high-value technology**

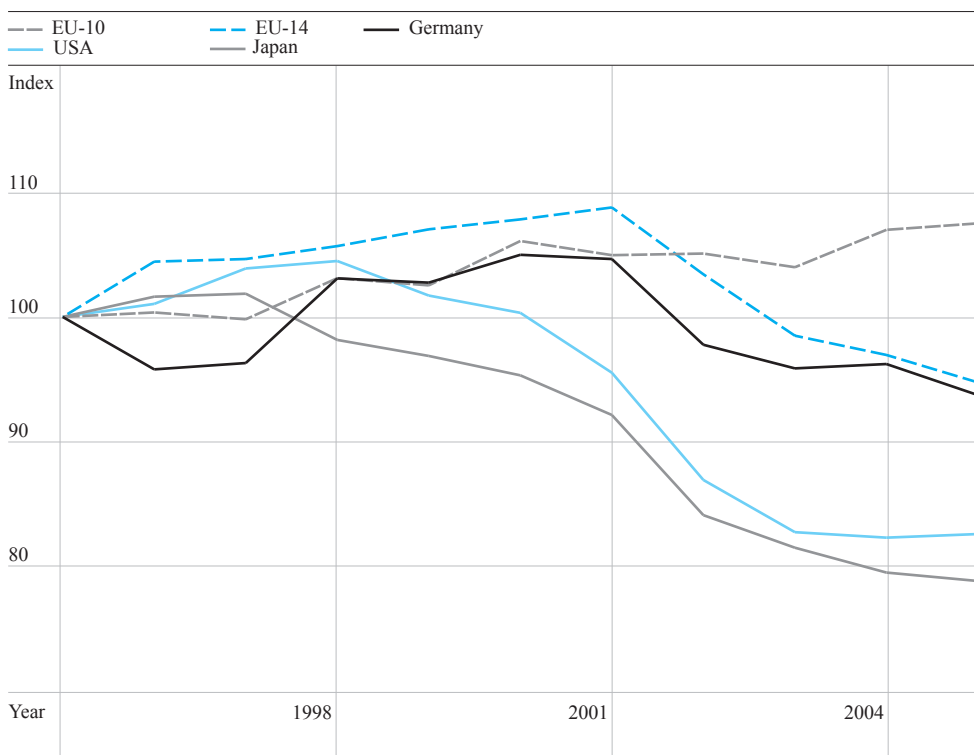
A comparison of Germany with the USA, Japan, and the old and new EU member states for the period from 1995 to 2005, shows that labour employment and value-creation in the manufacturing sector has sunk in nearly all regions (Fig. 37). There was only an increase in the new EU member states in cutting-edge technology. But for commercial knowledge-intensive services they increased everywhere. The greatest growth was in the old EU member states, and

**Proportion of value created by R&D-intensive manufacturing sector and knowledge-intensive services in selected countries and regions** FIG 37



EU-10: new member states without Romania and Bulgaria, EU-14: old EU member states without Germany.  
 Source: EUKLEMS Database 3.2008. Calculations and estimates of DIW.

**Development of employment in cutting-edge technology in selected countries and regions<sup>132</sup>** FIG 38



Index: 1995 = 100. EU-10: new member states without Romania and Bulgaria. EU-14: old EU member states without Germany. Sources: EUKLEMS-Database 3.2008. Calculations and estimates by DIW.

Germany was also involved in this positive trend. In the course of the past decade, Germany has always been more intensely oriented towards the research- and knowledge-intensive sectors of the economy. The share of this sector in Germany is meanwhile well above the average of the old EU member states and ahead of the USA. This is due above all to the traditionally very high share of high-value technology. Overall, the demand for high-value technology goods was more robust than for cutting-edge technology goods. Here, the USA and Japan were particularly heavily hit by the IC crisis, which led to a significant drop in the labour employment in the cutting-edge technology sector (Fig. 38). For knowledge-intensive services, measured in terms of overall employment of labour and the value-creation rate, Germany has a mid-table position between the USA and Japan (Fig. 37). The strong position of the USA is due mainly to the considerable weight of the "Finances" sector. There will certainly be significant alterations here in view of the financial crisis. The weak position of Japan can be explained mainly by the low presence of Finances and Health. Despite the developments outlined above, the intensive deployment of IC technologies is indispensable for maintaining a competitive position in the research-intensive manufacturing sectors and in the knowledge-intensive services sector. A closer analysis of the growth contributions shows that America's good IC infrastructure, above all for the knowledge-intensive services, made an important contribution to productivity. In comparison, the productivity development in the R&D-intensive manufacturing sectors and the knowledge-intensive services in the past ten years in Germany was weaker. Nevertheless, German companies were extremely successful in international markets. Obviously they could obtain relatively high prices in their fields of specialist production, whereas the USA and Japan suffered under the falling prices of IC-products (Fig. 38).

After a more precise statistical analysis, it is not possible to explain the change in the competitive positions in the various sub-sectors of cutting-edge technology and high-value technology in terms of the differences in productivity developments. Clearly, short-term economic aspects do not play a central role in competition. A more important factor seems to be the specialisation profile, i.e. the experience accumulated over a period of time in specific areas of production and services.

### **Strong growth of foreign trade worldwide**

World trade with technology-intensive goods has increased considerably in recent years. Since 2002, the last low-point in the global economy, this trade has increased at an average annual rate of 14 percent, although the exports of non-R&D-intensive products grew at 18 percent p.a. In contrast, cutting-edge technology goods have become relatively less important, with a growth rate of 12 percent. The main reason is the falling prices of goods in the IT and electronics sectors, which resulted in declining shares in trade values. R&D-intensive products accounted for 55 percent of all worldwide exports in 2007.

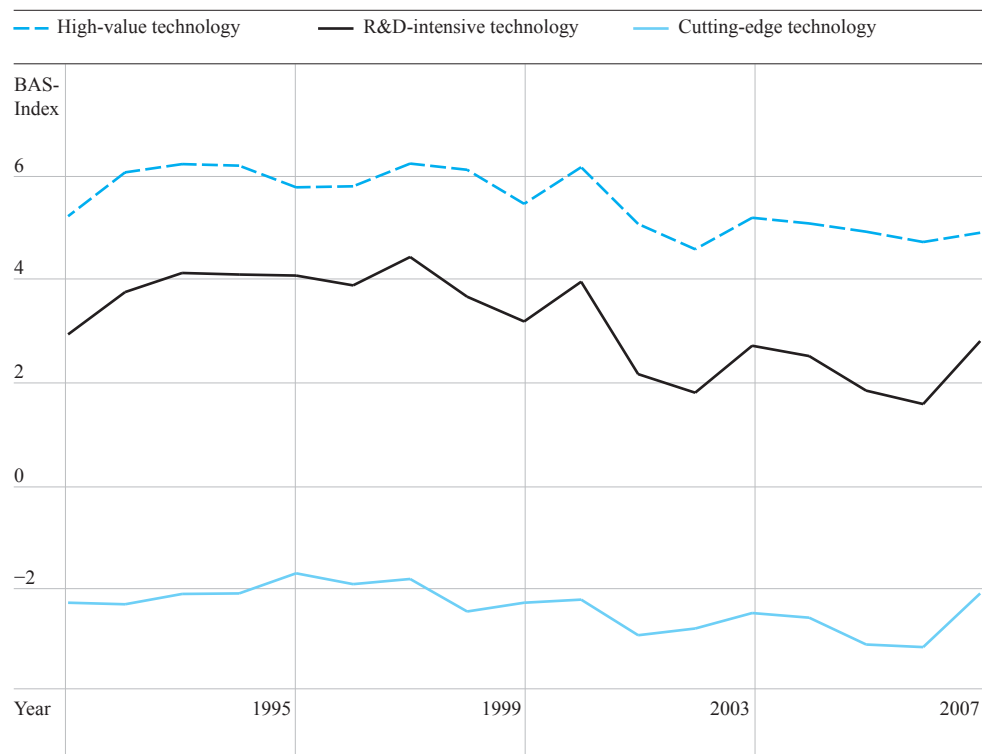
Germany's manufacturing sector has long been focussed on foreign trade and has participated in the general growth in world trade. Between 2000 and 2007 the goods export rate of 29 percent rose to more than 40 percent. The export sector is becoming increasingly dominant and it exerts a fairly decisive influence on the structures of the research-intensive manufacturing sector. Germany has a leading position in terms of its export rate among the large countries. The export rate of France in 2007 was 21 percent, and of Great Britain was 16 percent. Only smaller countries are more strongly export-oriented, such as Austria (44 percent) and above all the Netherlands and Belgium (71 percent and 94 percent, respectively).

### **Foreign trade position of Germany improving further**

The competitiveness of Germany in foreign-trade with technology-intensive goods has improved further in 2007. This is due in part to a somewhat stronger position with high-value technology goods, and in part also to an improved position with cutting-edge technology goods, although the orientation to cutting-edge technology is still much below average by international standards. The most important factor for the situation in the cutting-edge technology is a marked increase in foreign trade with aircraft and spacecraft. This is the largest single item, accounting for 21 percent of cutting-edge technology exports. However, this improvement should not be overrated because in the past there have frequently been considerable fluctuations and also much of the foreign trade is actually related to cross-bookings made internally by Airbus.

The contribution of R&D-intensive goods to the foreign trade balance of Germany

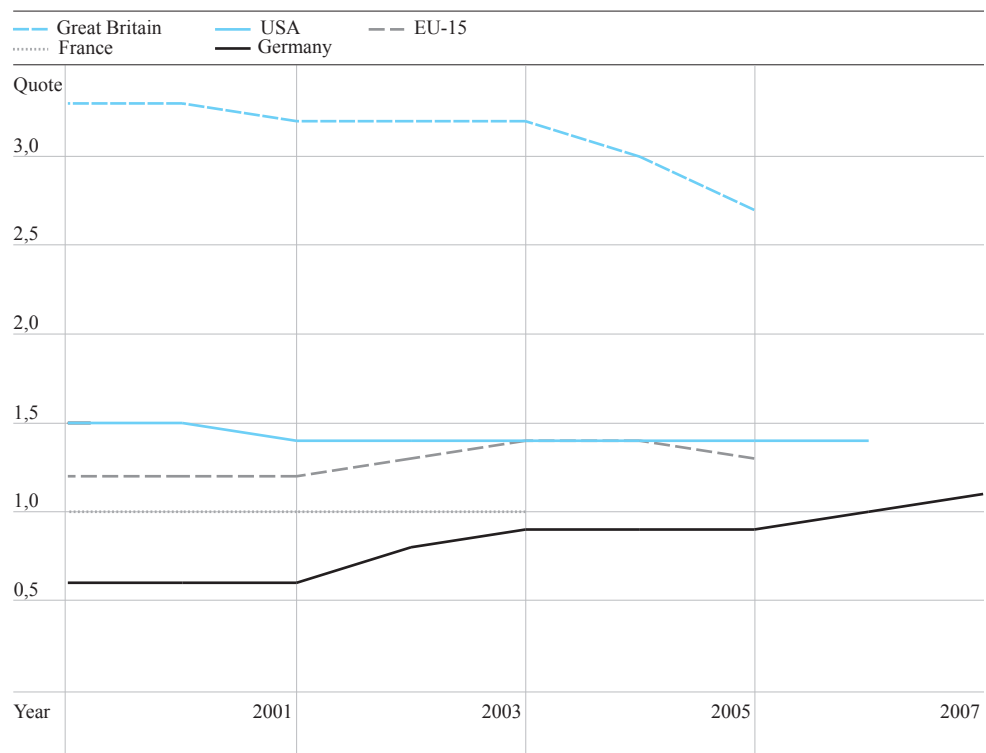
FIG 39



Goods of classes SITC 5 bis 9 without 68.133 0 = average, above +1 = considerably above average.  
Source: UN-Data. Calculations by RWI.

Cover ratio of foreign trade with knowledge-intensive services from selected countries and the old EU member states

FIG 40



Cover ratio = Exports/Imports. Source: OECD Stat. Dataset: Trade in Services by Category. Data of German Bundesbank and IMF. Calculations and estimates by NIW, RWI and Fraunhofer ISI.

The foreign trade position of a country is frequently presented using a specialisation index, the RCA index<sup>134</sup> (see Box 24). Here this includes the relations of exports to imports, so that the developments of both components have to be taken into consideration.

Between 1997 and 2002, the relative export share of Germany generally improved. But between 2002 and 2007 the constellation was exactly the other way round: the relative export share of R&D-intensive goods worsened, which was hardly surprising in view of the arrival of new competitors from the emerging markets. At the same time, the increasing competitiveness of German producers led to a reduction in the import pressure, and this was particularly evident in cutting-edge technology.

The RCA index only reflects the trading situation of a group of goods in comparison with the average for all goods. This led for example in 2007 to an above-average index for all R&D-intensive products (+10), an even higher value for the high-value technology (+25) and a very negative value for the cutting-edge technology (-32).<sup>135</sup> In contrast, the contribution to the balance of trade not only considers the specialisation but also the volume of the trade with the goods in question and thus better reflects the real situation. In 2007, this index was 2.8 overall; this included cutting-edge technology with -2.1 and high-value technology with 4.9. The negative specialisation of the cutting-edge technology is not as pronounced when expressed in this way, because the volume traded is low in comparison with high-value technology (Fig. 39). In the high-value technology, "Motor vehicles" with 3.7 accounts for some 75 percent, which documents the dominance of this sub-sector. The anticipated decline in the automotive industry will therefore have a marked impact on the foreign trade position of Germany with high-value technology.

Services currently account for about a fifth of world trade, so that these have gained a considerable importance. In 2007, Germany had 6.8 percent of world trade in services and was only in third place, some way behind the USA (15.5 percent) and Great Britain (11.7 percent). German companies are less well positioned here than with goods exports.<sup>136</sup> For knowledge-intensive services, they have considerably improved their cover ratio since the mid-1990s and meanwhile have a positive value, so that a good international position has been reached. However the

EU-15, the USA and in particular Great Britain have a higher ratio, so that – as with domestic value-creation – Germany has a weaker position for foreign trade with services in an international comparison.

In Germany, consultancy services are the largest services exports item in the knowledge-intensive sector (42 percent in 2006), followed by about a quarter for communications and media, 20 percent for finances and 14 percent for research (Fig. 40). In the USA, the main positive contributions are from the sectors communications and media; research services had been strong but were declining since 2001; the contribution of finances was only just positive in 2006. The above-average cover ratio – or the high foreign trade balance – of Great Britain is due to good ratios in all sub-sectors, in particular finances.

This review has drawn on important results from more extensive studies:

- Gehrke und Legler (2009) deal with production, foreign revenue, employment and value-creation of research-intensive manufacturing companies in Germany. Value-creation and employment in knowledge-intensive services are investigated. An additional topic is knowledge-intensification and qualification requirements, in particular also in a European comparison.
- Belitz et al. (2009) analyse the link between labour productivity and specialisation in R&D-intensive technology. They also examine the structural changes in labour deployment and value-creation in a comparison of Germany and the EU with the USA and Japan.
- On this basis, they analyse growth contributions in the research- and knowledge-intensive sector and other sectors.
- Döhrn and Stiebale (2009) consider changes in the foreign trade structure of Germany in recent years and investigate the interconnection of technology and knowledge-intensive sectors through direct investments.
- Gehrke et al. (2009) address the quantitative surveying of knowledge-intensive services and also investigate foreign trade in services.



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## LIST OF ABBREVIATIONS

BA	Bundesagentur für Arbeit (Federal Agency for Labour)
BDI	Bundesverband der Deutschen Industrie e.V. (The Federation of German Industries)
BERD	Business Expenditure on R&D
BIBB	Bundesinstitut für Berufsbildung (Federal Institute of Vocational Training)
GDP	Gross domestic product
BMBF	Federal Ministry for Education and Research
BMELV	Federal Ministry of Food, Agriculture and Consumer Protection
BMF	Federal Ministry of Finance
BMU	Federal Ministry for the Environment, Nature Conservation and Reactor Safety
BMVBS	Federal Ministry of Transport, Construction and Urban Affairs
BMWi	Federal Ministry of Economics and Technology
BMZ	Federal Ministry for Economic Cooperation and Development
CO <sub>2</sub>	Carbon dioxide
DIW	Deutsches Institut für Wirtschaftsforschung (German Institute of Economic Research)
DSTI	Directorate for Science, Technology and Industry
EFI	Expert Commission for Research and Innovation
EPO	European Patent Office
ESA	European Space Agency
Eurostat	Office of the European Communities
EU	European Union
GERD	Gross Domestic Expenditure on R&D
GEM	Global Entrepreneurship Monitor
IAB	Institut für Arbeitsmarkt- und Berufsforschung (Institute of Labour Market and Vocational Research)
ICT	Information and communications technology
INSEE	Institut Nationale de la Statistique et des Études Économiques
IT	Information technology
IC	Information and communication
JEI	Japan Economic Institute of America
JPO	Japan Patent Office
KMK	Kultusminister-Konferenz (The Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany)
KStG	Corporation Income Tax Act
MERIT	Maastricht Economic Research Institute for Innovation and Technology
MoRaKG	Law on the Modernisation of the Framework Conditions for Venture Capital and Equity Investments
NIW	Niedersächsisches Institut für Wirtschaftsforschung (Lower Saxony Institute of Economic Research)
OECD	Organisation for Economic Cooperation and Development
PCT	Patent Cooperation Treaty
PISA	Programme for International Student Assessment
RCA	Revealed comparative advantage
R&I	Research and innovation
R&D	Research and development
SBA	Small Business Administration
SCI	Science Citation Index
SITC	Standard International Trade Classification

SME	Small and medium-sized enterprises
StBA	German Federal Office of Statistics
STC	Selected Threshold Countries
USPTO	United States Patent and Trademark Office
WIPO	World Intellectual Property Organization
WO Patent	WIPO application procedure
WTO	World Trade Organization
ZEW	Zentrum für Europäische Wirtschaftsforschung (Centre for European Economic Research)
ZIM	Zentrales Innovationsprogramm Mittelstand (Federal Innovation Programme for Medium-sized Companies)

## LIST OF ABBREVIATIONS OF SINGLE STATES

AT	Austria
AU	Australia
BE	Belgium
BG	Bulgaria
CA	Canada
CH	Switzerland
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
GB	Great Britain
GR	Greece
HU	Hungary
IE	Ireland
IS	Island
IT	Italy
JP	Japan
KR	Korea
LU	Luxembourg
LT	Lithuania
LV	Latvia
MX	Mexico
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
SE	Sweden
SG	Singapore
SI	Slovenia
SK	Slovakia
TR	Turkey
TW	Taiwan
US	United States of America

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## R&D-INTENSIVE INDUSTRIAL SECTORS AND KNOWLEDGE-INTENSIVE SERVICES<sup>137</sup>

### R&D INTENSIVE INDUSTRIAL SECTORS WZ 2003 (4-FIGURE CLASSIFICATION)

<b>WZ 2003</b>	<b>Cutting-edge technology</b>
23.30	Processing of nuclear fuel
24.20	Manufacture of pesticides and other agrochemical products
24.41	Manufacture of basic pharmaceutical products
24.42	Manufacture of pharmaceutical preparations
29.60	Manufacture of weapons and ammunition
30.02	Manufacture of electricity distribution and control apparatus
32.10	Manufacture of electronic components
32.20	Manufacture of telecommunications equipment
32.30	Manufacture of radio and television appliances and sound and video equipment
33.10	Manufacture of medical and surgical equipment and orthopaedic appliances
33.20	Manufacture of instruments and appliances for measuring, controlling navigating and other purposes
33.30	Manufacture of industrial process control equipment
35.30	Construction of aircraft and spacecraft

<b>WZ 2003</b>	<b>High-value technology</b>
24.13	Manufacture of other inorganic basic chemicals
24.14	Manufacture of other organic basic materials
24.16	Manufacture of plastics in primary form
24.17	Manufacture of synthetic rubber in primary forms
24.51	Manufacture of soaps and detergents, cleaning and polishing agents
24.61	Manufacture of explosives
24.63	Manufacture of essential oils
24.64	Manufacture of photographic chemicals
24.66	Manufacture of other chemical products
25.11	Manufacture of rubber tyres and tubes
25.13	Manufacture of other rubber products
26.15	Manufacture and processing of other glass, including technical glassware
29.11	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines
29.12	Manufacture of pumps and compressors
29.13	Manufacture of taps and valves
29.14	Manufacture of bearings, gears, gearing and driving elements
29.24	Manufacture of other general purpose machinery
29.31	Manufacture of agricultural tractors
29.32	Manufacture of other agricultural and forestry machinery
29.41	Manufacture of portable hand held power tools
29.42	Manufacture of other metalworking machine tools
29.43	Manufacture of other machine tools .
29.52	Manufacture of machinery for mining, quarrying and construction
29.53	Manufacture of machinery for food, beverage and tobacco processing
29.54	Manufacture of machinery for textile, apparel and leather production
29.55	Manufacture of machinery for paper and paperboard production
29.56	Manufacture of other special purpose machinery
30.01	Manufacture of office machinery
31.10	Manufacture of electrical motors, generators and transformers
31.20	Manufacture of electricity distribution and control apparatus

31.40	Manufacture of accumulators, primary cells and primary batteries
31.50	Manufacture of lighting equipment and electric lamps
31.61	Manufacture of electrical equipment for engines and vehicles
31.62	Manufacture of other electrical equipment
33.40	Manufacture of optical instruments and photographic equipment
34.10	Manufacture of motor vehicles
34.30	Manufacture of parts and accessories for motor vehicles and their engines
35.20	Manufacture of railway and tramway locomotives and rolling stocks

## KNOWLEDGE-INTENSIVE SERVICES WZ 2003 (3-FIGURE CLASSIFICATION)

<b>WZ 2003</b>	<b>Knowledge-intensive services</b>
	<i>Logistics</i>
603	Transport via pipelines
611	Sea and coastal water transport
622	Non-scheduled air transport
623	Space transport
	<i>Communications</i>
221	Publishing
643	Telecommunications
721	Hardware consultancy
722	Software consultancy and supply
723	Data processing
724	Data base activities
725	Maintenance and repair of office, accounting and computing machinery
726	Other computer related activities
	<i>Finance and assets</i>
651	Monetary intermediation
652	Other financial intermediation
660	Insurance and pension funding, except compulsory social security
671	Activities auxiliary to financial intermediation
701	Real estate activities with own property
	<i>Technical research and consultancy</i>
731	Research and experimental development on natural sciences and engineering
742	Architectural and engineering activities and related consultancy
743	Technical testing and analysis
	<i>Non-technical research and consultancy</i>
732	Research and experimental development on social sciences and humanities
741	Legal, accounting, book-keeping and auditing activities; tax consultancy, market research and public opinion polling; business and management consultancy; holdings
744	Advertising
	<i>Health</i>
523	Retail sale of pharmaceutical and medical goods, cosmetic and toilet articles
851	Human health activities
852	Veterinary activities
921	Motion picture and video activities
922	Radio and television activities
923	Other entertainment activities
924	News agency activities
925	Library, archives, museums and other cultural activities



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The Expert Commission for Research and Innovation regularly commissions studies on topics relating to innovation policies. These are published in the series “Studies on the German Innovation System” which can be accessed at [www.e-fi.de](http://www.e-fi.de). The results of these studies have flown into this report.

Recent studies on the German innovation system:

- |         |  |
|---------|--|
| 1-2009  | Legler, H.; Krawczyk, O. (2009): R&D-Aktivitäten in Wirtschaft und Staat im internationalen Vergleich, Berlin.   |
| 2-2009  | Belitz, H.; Clemens, M.; Gornig, M. (2009): Wirtschaftsstrukturen und Produktivität im internationalen Vergleich, Berlin.  |
| 3-2009  | Gehrke, B.; Legler, H. (2009): Forschungs- und wissensintensive Wirtschaftszweige.<br>Produktion, Wertschöpfung und Beschäftigung in Deutschland sowie Qualifikationserfordernisse im internationalen Vergleich, Berlin.                         |
| 4-2009  | Rammer, C. (2009): Innovationsverhalten der Unternehmen in Germany 2007 – Aktuelle Entwicklungen und die Rolle der Finanzierung, Berlin.   |
| 5-2009  | Metzger, G.; Rammer, C. (2009): Unternehmensdynamik in forschungs- und wissensintensiven Wirtschaftszweigen in Deutschland, Berlin.  |
| 6-2009  | Schmoch, U.; Qu, W. (2009): Performance and structures of the German science system, Berlin.   |
| 7-2009  | Frietsch, R.; Jung, T. (2009): Transnational patents – Structures, trends and recent developments, Berlin.   |
| 8-2009  | Leszczensky, M.; Frietsch, R.; Gehrke, B.; Helmrich, R. (2009): Bildung und Qualifikation als Grundlage der technologischen Leistungsfähigkeit Deutschlands, Berlin.   |
| 9-2009  | Belitz, H.; Schmidt-Ehmcke, J.; Zloczynski, P. (2009): Forschung und Entwicklung deutscher Unternehmen im Ausland, Berlin.   |
| 10-2009 | Döhrn, R.; Stiebale, J. (2009): Außenhandel und ausländische Direktinvestitionen deutscher Unternehmen, Berlin.  |
| 11-2009 | Gehrke, B.; Grenzmann, C.; Kerst, C.; Kladobra, A.; Legler, H.; Troltsch, K. (2009): Kleine und mittelgroße Unternehmen im Fokus: R&D-Aktivitäten, Wirtschaftsstruktur, Ausbildungsanstrengungen und Nachfrage nach Hochqualifizierten, Berlin.  |
| 12-2009 | Buchholz, K.; Gülker, S.; Knie, A.; Simon, D. (2009): Attraktivität von Arbeitsbedingungen in der Wissenschaft im internationalen Vergleich: Wie erfolgreich sind die eingeleiteten wissenschaftspolitischen Initiativen und Programme?, Berlin. |
| 13-2009 | Gehrke, B.; Legler, H.; Schasse, U.; Cordes, A. (2009): Adäquate quantitative Erfassung wissensintensiver Dienstleistungen, Berlin.  |
| 14-2009 | Lay, G.; Brandt, T.; Maloca, S.; Schröter, M.; Stahlecker, T. (2009): Auswirkungen der Außenorientierung und der Dienstleistungen auf Innovationen, Berlin.  |
| 15-2009 | Peters, B.; Licht, G.; Kladobra, A.; Crass, D. (2009): Soziale Erträge der F&E Tätigkeit in Deutschland, Berlin.   |

## END NOTES

- 01 The European Commission opened a formal investigation under state aid rules on 29 January 2009. A decision is not expected until the end of 2009 at the earliest.
- 02 Financing with venture capital can involve either early phase financing for young enterprises (venture capital) or the later-phase financing of established companies (private equity). For more details about the concepts see Kaserer et al. (2007).
- 03 Cf. KfW-Research (2008), Table 2, p. 7 and the references there.
- 04 Cf. Rammer et al. (2004) and Heger (2004).
- 05 Source: Business Angels Netzwerk Germany e.V. (BAND).
- 06 Cf. Rammer et al. (2004).
- 07 This is because the adaptation costs for research are usually much higher than in the field of innovation. An R&D project cannot really be delayed, whereas a market launch is flexible. Cf. Hall (1992 and 2002).
- 08 Cf. Kaserer and Schiereck (2008). In the Q1 2008 there were no company flotations.
- 09 Important proposals for an innovation-friendly tax system have already been made by various bodies. The German Council of Economic Experts in its Report 2008 reported considerable need for corrections to the company taxation 2008. (Cf. Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung 2008: 104 ff.). Spengel (2009) also comments on necessary changes.
- 10 DIW econ (2008).
- 11 EVCA analyses the fiscal and legal conditions for venture capital and entrepreneurship every year in European countries. See European Private Equity & Venture Capital Association (2008).
- 12 Autorengruppe Bildungsberichterstattung (2008: 201) and Bonin et al. (2007).
- 13 Biersack et al. (2008: 6 f.)
- 14 Individuals with an academic qualification.
- 15 Gehrke and Legler (2009: 34 ff.).
- 16 OECD (2008a: 69).
- 17 OECD (2008a).
- 18 Autorengruppe Bildungsberichterstattung (2008: 132); Biersack et al. (2008: 7).
- 19 Autorengruppe Bildungsberichterstattung (2008).
- 20 Ibid.
- 21 Wissenschaftsrat (2006: 63 ff.).
- 22 Florida (2002).
- 23 There is a shortage in particular for mechanical engineers, electrical engineers, and industrial engineers, with considerable regional variations. IAB draws attention to unused potential, in particular the over-Fifties, and women engineers (Biersack et al. 2008: 8).
- 24 Bonin et al. (2007).
- 25 An amendment of Section 27 of the Employment Ordinance (BeschV) for new immigrants came into force on 1 January 2009.
- 26 OECD (2008b).
- 27 For the comparison with Great Britain and France it should also be taken into consideration that Germany has a larger population.
- 28 Skilled and qualified personnel have a vocational qualification and/or a higher education qualification.
- 29 Autorengruppe Bildungsberichterstattung (2008).
- 30 For those without an academic qualification, the Federal Agency for Labour (BA) will continue to give priority to a German resident if appropriate at least until January 2012.
- 31 Brücker and Kolhaas (2004).
- 32 Niebuhr (2007).
- 33 Diehl et al. (2008), and Brücker and Ringer (2008).

- 34 Depending on the survey, the proportion of returning highly-qualified professionals ranges between 50 percent (Backhaus et al. 2002) and 85 percent (Enders and Mugabushaka 2004). Other experts estimate that a quarter to a third of German post-docs remain in the USA for a longer period (Büchtemann 2001).
- 35 There are considerable gaps in the data about the migration of scientists from Germany, because migration statistics do not show the level of qualification or occupation. Surveys and population statistics in host countries (e.g. the USA) and OECD publications allow some conclusions to be drawn. There is an urgent need for improvements here.
- 36 Büchtemann (2001).
- 37 Backhaus et al. (2002).
- 38 Backhaus et al. (2002: 61).
- 39 In the survey, German universities and research institutions and some 370 junior professors were questioned. This is about 41 percent of the estimated 900 junior professors (Federkeil and Buch 2007: 48).
- 40 Backhaus et al. (2002).
- 41 Helmholtz Gemeinschaft, Max-Planck Gesellschaft, Fraunhofer Gesellschaft, Leibniz Gemeinschaft, Deutsche Forschungsgemeinschaft.
- 42 Some institutions already have the sort of scope envisaged in the Freedom of Science initiative. These include the universities and research institutions in North Rhine-Westphalia since the introduction of their Freedom of Universities Law 2007 and university clinics in several federal states, which have been made institutions under public law.
- 43 A good overview is given by Perkmann and Walsh (2007), and Beise and Stahl (1999).
- 44 In the past 20 years, industrial and services companies have become increasingly knowledge-intensive, and innovations are based increasingly on complex knowledge. In many scientific fields, for example biotechnology, results of basic research are directly relevant for applications, as explained by Stokes (1997) in terms of “Pasteur’s Quadrant”.
- 45 Cf. e.g. Schartinger et al. (2002).
- 46 IGF is currently being assessed on behalf of the Federal Ministry for Economics and Technology by the Rheinisch-Westfälische Institut für Wirtschaftsforschung (RWI). Among other things, the fourth interim report highlights the importance of IGF for SMEs. A final evaluation will address additionality and effectiveness of the support.
- 47 Blind et al. (2009).
- 48 Lach and Schankerman (2008), and Debackere and Veugelers (2005).
- 49 European Patent Convention II.1.54 or Section 3 PatG.
- 50 EPC II.1.56 or Section 4 PatG.
- 51 EPC II.1.57 or Section 5 PatG.
- 52 Section 102 (b) US Patent Act.
- 53 BMBF (2002). Cf. Straus (2000).
- 54 Here companies with up to 499 employees.
- 55 The figures include trainees and active company owners (see [www.ifm-bonn.org/index.php?utid=99&id=101](http://www.ifm-bonn.org/index.php?utid=99&id=101), retrieved 12 February 2009).
- 56 Estimates of the Fraunhofer ISI on the basis of data from IfM Bonn and the Federal Agency for Labour.
- 57 There are complex reasons for these developments. The figures for the manufacturing sector have been affected by the weak situation in the construction industry and the “de-industrialisation” in the new laender (eastern Germany).
- 58 The classification used here is based on Rammer et al. (2005).
- 59 R&D-personnel as a percentage of workforce.
- 60 A distinction is made between rapidly growing companies (“gazelles”) and slow growers (“tortoises”), though the latter often show more resilience.

- 61 With between 5 and 499 employees. The upper limit is in contrast to the EU specification for SMEs of 249. The lower threshold also used here is important because there are a large number of companies with fewer than five employees, which would have a relevant influence on the statistical evaluation.
- 62 A more precise quantitative presentation on the structure and trends of small businesses is provided in Section C 4 of this report.
- 63 Rammer and Weissenfeld (2008).
- 64 The financing includes both aid measures and also government R&D orders in the arms industry, telecommunications, etc.
- 65 Based on data from the Stifterverband. The data in the Federal Report on Research and Innovation shows the same trend (BMBF 2008c) .
- 66 The increase in the mid-1980s is explained by various indirect measures, e.g. the PKZ Programme.
- 67 BMFT (1993), BMBF (2008a: 509 f).
- 68 Cf. Rammer (2009).
- 69 Cf. e.g. Kulicke et al. (2005), Lo et al. (2006), Becker et al. (2005) or Blum et al. (2001).
- 70 IW Consult GmbH (2006).
- 71 Boston Consulting Group (2006) and Spengel (2009).
- 72 Young innovative company.
- 73 For further details of the SBIR programme see Shapira and Youtie (2008).
- 74 A list of the relevant studies is provided in Spengel (2009).
- 75 Cf. Wessner (2008).
- 76 German Council of Economic Experts - Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung (2008: 429).
- 77 Cf. Spengel (2009).
- 78 Cf. Astor and Heimer (2008).
- 79 Cf. Spengel (2009).
- 80 This option is also compatible with EU law. As soon as there is counter-financing through company growth and thus higher tax revenues, other options can be considered.
- 81 There were or are initiatives in Baden-Württemberg, Lower Saxony, Saarland, and North Rhine-Westphalia.
- 82 Mayer et al. (2006).
- 83 Cf. in particular Chapter C.4 on the structure and trends of SMEs.
- 84 Published by Land North Rhine-Westphalia in May 2008 in cooperation with the European Fund for Regional Development (NRW-EU-Programme EFRE 2007–2013).
- 85 See Gehrke et al. (2009) and Lay et al. (2009).
- 86 Services without real estate and housing.
- 87 Schumacher (2007), Gehrke et al. (2009) and Belitz et al. (2009).
- 88 Western industrialised countries representing the OECD countries.
- 89 Data from WTO and the OECD, calculations by NIW and Fraunhofer ISI.
- 90 Innovative companies have introduced at least one new product or a new process onto the market in the past three years.
- 91 Survey year 2004, EU-16 refers to EU-15 plus Norway.
- 92 Graduates is used here to cover all forms of higher education qualification.
- 93 Cf. Leszczensky et al. (2009).
- 94 Figures for highly-qualified professionals in the business economy are taken from the statistics on employees liable to make social security contributions, and the proportions of graduates in the knowledge-intensive sectors are calculated using EU surveys of the active population. The results therefore reflect the differences between knowledge-intensive and other branches of the economy, but are not fully compatible.
- 95 The proportion of the cohort of school-leavers aged 18 - 20 years with a qualification to go on to higher education (calculated on the basis of population statistics and school statistics).



- 96 The OECD distinguishes between two types of upper secondary levels of education leading on to tertiary education, the second of which is only provided in Germany: ISCED 3A (designed to provide direct access to the tertiary sector A) and ISCED 4A (post-secondary non-tertiary education to provide direct access to tertiary sector A). For 2006, the OECD figures for Germany show a rate of 40 percent for ISCED 3A, and 11.1 percent for ISCED 4A. Thus OECD gives a higher rate for Germany than the country's own national statistics, and still other countries manage to mobilise considerably more of their demographic potential for higher education.
- 97 Cf. Heine et al. (2008)
- 98 Master's degrees are currently still classed as first degrees in the higher education statistics. This will be changed in the future in order to avoid a double count of first higher education qualifications.
- 99 Cf. Science Council (2008).
- 100 The structure and trend estimates in this chapter are based on the EFI Study on the German Innovation System No. 1-2009 (Legler and Krawczyk). The authors concentrate on global trends of R&D-activities, commercial and state R&D performance and particularly the R&D behaviour in emerging markets.
- 101 The link between R&D and productivity at the company level is discussed by Peters et al. (2009). The study shows for Germany that research activities of companies are linked with significant science externalities in favour of other companies and thus generate additional social revenues of some 130–150 percent of the private revenues. Other studies arrive at similar figures. Cf. Vosskamp and Schmidt-Ehmcke (2006).
- 102 Cf. Rammer and Binz (2006).
- 103 Cf. Legler et al. (2008).
- 104 Figures from OECD (2008d) and BMBF (2007).
- 105 The list of the 19 countries in the analysis are given in Studies of the German Innovation System No. 1-2009 (Legler and Krawczyk).
- 106 For service providers, product innovation includes innovative services.
- 107 Cf. For the following Rammer (2009).
- 108 Frietsch and Jung (2009), Gehrke and Legler (2009), Legler and Krawczyk (2009), Leszczensky et al. (2009), Schmoch and Qu (2009).
- 109 Cf. IfM Bonn, <http://www.ifm-bonn.org/index.php?utid=99&id=101> (retrieved 12 February 2009).
- 110 Estimate of Fraunhofer ISI on the basis of data from IfM Bonn and the Federal Agency for Labour.
- 111 The various statistical results are not consistent. According to the Stifterverband, the Kreditanstalt für Wiederaufbau and the ifo-Institut, the proportion of small industrial enterprises carrying out research has decreased over the past decade, but the Mannheim Innovation Panel (MIP) says it has stagnated. This is probably due to methodological differences.
- 112 Briedis (2007).
- 113 Cf. for the following Metzger and Rammer (2009).
- 114 Frietsch and Jung (2009).
- 115 Transnational patent applications include international applications in accordance with the Patent Cooperation Treaty and applications to the European Patent Office, excluding double counts. In both cases transnational offices are responsible.
- 116 Patent applications per employee.
- 117 Schmoch and Qu (2009).
- 118 The journal-specific indicator “zeitschriftenspezifische Beachtung (ZB)” compares the frequency of citation of an article with the expected frequency for that journal. The expectation value is the average citation frequency for all the articles in the journal. For a country or a region, the indicator shows whether the citation frequency of articles lie above or below the expected values. Positive indices show an above-average citation frequency; a value of zero corresponds to the world average. This indicator makes it possible to compensate for the disadvantages of countries which have less good access to major English-language journals.

- 119 “International orientation” indicates the extent to which the authors of a country publish in international high-standing journals or less renowned journals in relation to the global average. A high rate of publications in international high-profile journals indicates intensive participation in the international scientific discussion.
- 120 In German, the concept “industry” refers to manufacturing in a narrower sense, not including sectors such as energy and water supplies, construction, or mining.
- 121 Estimate based on the Industrietagung of DIW Berlin in October 2008.
- 122 See Bundesagentur für Arbeit, Statistik der sozialversicherungspflichtigen Beschäftigten.
- 123 Instrument manufacture covers a broad range of research intensity, so a distinction is often made between “high-value instruments” and “advanced instruments”.
- 124 With more than 50 percent of employees in cutting-edge technology.
- 125 “Tertiarisation” involves a shift of economic activity from the secondary sector (manufacturing industry) to the tertiary sector (services).
- 126 Figures are based on statistics for employees liable to make social security contributions.
- 127 “Middle segment” refers to employees with vocational qualifications acquired in combination with practical training (“dual system”).
- 128 Total gross value-creation of the business economy (without real estate and housing) in 2006: 1 587.7 billion euros.
- 129 EU-14 = EU-15 without Germany.
- 130 Definition of European regions as in Fig. 35.
- 131 All those in work, and not only those obliged to make social security payments.
- 132 Shares of cutting-edge technology in overall labour employment in the year 2000: Germany 1.97 percent (1995 2.03 percent), USA 2.20 percent (1995 2.89 percent), Japan 2.61 percent (1995 2.92 percent), EU-14 1.21 percent (1995 1.41 percent), EU-10 1.45 percent (1995 1.30 percent).
- 133 SITC = Standard International Trade Classification. SITC 5 to 9 without 68 means that animal fats and oils and non-ferrous metals are excluded which is a usual provision in a technically oriented analysis.
- 134 RCA stands for revealed comparative advantage.
- 135 Here the neutral value for the RCA-Index is 0.
- 136 Statistically, the value of immaterial goods is much harder to register than that of goods. It is particularly difficult to clearly allocate the activities of foreign subsidiaries of companies. The transfer of results from the parent company should be classed as exports.
- 137 Cf. Legler and Frietsch (2007).



