RESEARCH, INNOVATION
AND TECHNOLOGICAL
PERFORMANCE IN GERMANY

EXPERTENKOMMISSION
FORSCHUNG
UND INNOVATION

EFI

REPORT

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CONTENTS

FOREWORD

On behalf of the Federal Government of Germany, the Commission of Experts for Research and Innovation presents its third report.

The format of the report has been revised this year. Part A discusses current developments and future challenges. Part B of the report then addresses five core topics. The indicators for the status of research and innovation in Part C are presented in a new format, which we hope will be more readily accessible for decision-makers in particular.

The financial and economic crisis is not yet over, but there are signs of moderate growth potential for 2010. The German innovation system has done fairly well in the crisis. In addition, appropriate importance has been attached to research, innovation and education in the plans of the new Federal Government. As welcome as these declarations of intent are, it is important to follow these up by adopting specific measures in various key areas.

In this third report, the following five topics are addressed in detail. First, the Expert Commission analyses the overall structure of the German innovation system and in particular the role of non-university research (Section B 1). It then presents an interim assessment of the Bologna Process, which is currently the subject of lively public debate (Section B 2). Twenty years after German reunification, research and innovation policies in eastern Germany are reviewed (Section B 3). The Expert Commission also considers Germany's technological performance in the field of electromobility (Section B 4), and comments on the efforts of the European Commission to introduce a European Union patent and a unified patent court system (Section B 5).

Highest priorities for the Federal Government should be the introduction of R&D tax support, improvements to the conditions for Business Angels and venture capital, and the systematic improvement of Germany's education and research systems. Broad tax advantages for companies and individual tax-payers are no substitute for these urgently needed measures. Instruments which have been shown to have failed, such as the research premium, should be abandoned. Germany continues to do well in terms of creativity, inventiveness and openness to innovations. Despite financial constraints it is important to target investments in order to maintain and expand these strengths.

Berlin, 24 February 2010

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SUMMARY

SUMMARY

Current developments and challenges

Germany must develop a stronger innovative dynamic if it is to hold its own in the face of growing international competition. The leading position which Germany has traditionally had in high-value technologies can only be maintained by continuing to make high levels of investment in the automotive and chemical industries and in electrical and mechanical engineering. In other fields there is considerable catching up to be done, above all in cutting-edge technologies and in the knowledge-intensive services. The government can give important impulses by providing funding for research institutions, supporting knowledge and technology transfers, and by introducing suitable measures to support company R&D.

The implementation of the High Tech Strategy in 2006 led to an increase in funding for research and development and made national R&I policies more effective. For the continuation of the High Tech Strategy, it would now be appropriate to focus on particularly important fields. These should be identified on the basis of foresight processes. The main aim should be to promote fields of innovation which offer consider-able potential for the future and where the aid provided will develop significant leverage.

In many cases, interesting results from publicly-funded research are not marketed effectively in Germany. The Expert Commission suggests establishing a ‘Commercialisation Fund’ to improve the transfer of research results for commercial applications. Where there are various possible applications, or a need for coordination between actors, then standardisation is another important consideration in the commercialisation of innovative technologies. The state should provide more support for companies involved in standardisation processes than it has in the past.

Shortages of equity capital represent a key constraint on innovation for German companies. The situation has grown worse as a result of the current crisis. There remains a need for a long-term improvement in the framework conditions for the provision of company equity. Important incentives for innovation would also be provided by improvements to the framework conditions for business angels and venture capital investors. In addition, the Expert Commission continues to favour the introduction of tax incentives for R&D. This should be structured in such a way that it also encourages cooperation between business and science. If budget constraints only allow limited tax incentives for R&D, then this should initially be introduced primarily for SMEs.

Additional investments in education are a precondition for strengthening the innovation potential in Germany. The Expert Commission recommends that even more importance should be attached to providing greater equality of social opportunities for access to education. The Expert Commission also approves of lifting the restriction on coopera-tion between the Federal Government and the Laender concerning education, and fa-vours the reexamination of federal responsibilities for education.

When funds are in short supply, they must be deployed efficiently and effectively. This is only possible if state measures are evaluated regularly, and here there is considerable scope for improvement in Germany. All government departments should allocate about one percent of their planned budget to research into evaluation research, which should be anchored in a single institution. The results should be made readily available to the public.

CORE TOPICS OF THE REPORT

A systematic increase in the international competitiveness of the German R&I system

Research and innovation worldwide is subject to a process of transformation which is forcing the highly-developed countries to adopt a new alignment for their R&D activities. The German R&I system must be oriented more towards the challenges of the future and to new topics. This affects both the state and business sectors.

The industrial R&D system in Germany is concentrated mainly in the most important export industries, above all the automotive industry. However, the structural changes towards services and the expansion of the growth fields of cutting-edge technology are less advanced in Germany than in other highly-developed countries. Where German companies expand their R&D activities, particularly in the dynamic high-tech fields, these are often located in other countries. This can lead to the abandonment of strategically important sectors in Germany, and it impairs the effectiveness of cooperation with public sector basic research.

The system of public non-university research is well developed in Germany. However, some institutions do not have a clear remit or research profile – in particular the Helmholtz and Leibniz Associations. The system of government department research should be focussed on tasks of national importance.

Successful innovation depends on the interactions between actors from basic research, the educational system, the business sector, the ministries and the legislative and executive branches. Cohesive and uniform innovation policies should provide effective support for the formation of close ties between these actors at the national level and thus ensure the formation of a better value-creation chain for innovations in specific promising areas.

The effectiveness of German R&I policies is impaired by the way in which responsibilities are divided between various Federal ministries and Laender ministries. The web of departments, project agencies and research institutions is at least in part responsible for the fact that there has not yet been any comprehensive strategic reorientation of innovation policies.

Against this background, the Expert Commission makes the following recommendations:

- German businesses can only compete internationally if they successfully implement innovations. A key condition for this is a systematic increase in expenditure on R&D in public institutions and increased innovation expenditure by businesses. The newly formulated High Tech Strategy must provide additional impulses so that businesses will continue to invest in research and innovation.
- It is essential that active steps are taken to expand cutting-edge technology. This applies above all for segments in which comparative advantages can be secured globally. Investments should be avoided in fields which are subject to international subsidy wars.
- Greater efforts should be made to expand knowledge-intensive services ('services designed in Germany') where these are complementary to existing focal points in the economy. This requires support strategies which are specifically tailored to suit innovation processes in the services sector.
- The High Tech Strategy should be targeted at selected fields of technology. This involves harmonising these fields with those identified in the foresight process and with the investment priorities of the business sector.
- The distribution of funds and the 'division of areas of specialisation' between the various scientific institutions should not be regarded as unchangeable. This applies in particular for departmental research at the levels of the Federal Government and Laender departments. Structural reforms are necessary in order to improve the effectiveness of non-university research organisations. More attention should be paid to strategic coherence.
- Knowledge and Technology transfer from non-university research and from the universities should be expanded as a priority. This goal must not be neglected in the justifiable pursuit of scientific excellence. The management and incentive structures of many research institutions are in need of further improvements. The business sector should also make use of the specific potential of public research within the framework of its innovation strategies.
- As an R&I location, Germany needs new models for the cooperation between the business sector on the one hand and the universities and non-university research institutions on the other hand. The same applies for cooperation within public research.
- Strong research must be financed appropriately and supported through modern accounting and budget instruments. Currently, competition in research is distorted by differences in cost models. In the short term, a flat rate programme payment should be introduced to cover the indirect costs incurred in projects supported by the Federal Government. In the medium-term it is appropriate to reimburse in full the costs of the research institutions carrying out third-party funded projects.

Reforming the Bologna Reform

In the course of the EU's 'Bologna Process', German study programmes are being reorganised to confer bachelor's and master's degrees. The intention is to create an internationally-comparable system, providing education of a high standard which is suited to individual needs. In addition Europe should be strengthened as an educational region which is also very attractive for non-European students. The worldwide exchange of students should be increased, and equal access to higher education should be possible for all social strata. The bachelor's degree should already provide a full, first-level qualification for subsequent careers. The reform in Germany was associated with the hope of modernising and reorganising the curricula, reducing the numbers of drop-outs, and increasing the demand for university courses in general and for mathematics, computer science, natural sciences and engineering in particular. However, so far it has not really been possible to reach these goals.

Hardly any changes have been made to course contents, but students have fewer options to choose from than they had in the diploma or magister courses. Teaching staff face higher teaching commitments overall, and the resultant workload is detrimental to their research and also reduces the individual tutoring of students.

The Expert Commission also sees problems in the elimination of 'orientation' periods as a result of shortening the length of secondary education and of the university courses. Furthermore, the relationship between the system of dual vocational training and the new bachelor's degree courses remains unclear. There are also controversial discussions about how many graduates can or should go on to study for a master's degree.

On a positive note, there has so far been no evidence of a reduction in the level of qualification of young scientists as a consequence of the Bologna Process, and nor do there seem to be any problems in career entries as a result of the changeover.

In the opinion of the Expert Commission the following measures are necessary for the further development of the Bologna Process reforms in Germany:

- In general, universities have not been allowed sufficient autonomy in the implementation of reforms and the shaping of curricula. Where they are given more scope, the universities should use this in order to increase the involvement of employers, alumni and students in the development of courses.
- Obstacles to mobility can be overcome by more generous recognition of previous coursework and credits and the reliable specification of equivalents in course regulations. This should be combined with more comprehensive and more generous financial support for student mobility, an increase in the number of courses taught in English, and support for cooperation agreements between German and foreign universities.
- A bundle of measures is required in order to lower the high numbers of course dropouts: grants and loans for students, options to organise study programmes flexibly or to study part-time; information, advice and preparatory courses prior to committing to a subject or in the initial phases of a degree course; higher quality of teaching, and better course organisation. This also includes checks on performance at an early stage and detailed feed-back.
- Student fees are an important component of university finances in some Laender and they make sense when the receipts are invested in the teaching. But they must not act as a disincentive to young people who want to study. In particular students from low-income households must be offered the best possible financial conditions. This includes expanding and increasing the student grant system (*BAföG*) as well as improving the mobilisation of private sources of funding.
- The supervision of doctoral students in structured programmes such as the DFG postgraduate colleges should be included as part of the teaching duties. Currently, the time spent in this way by professors is to the detriment of research, active institutional involvement, individual career counselling, and the supervision of student organisations. Appropriate adjustments should be made to the personnel structure of the universities.

Favourable conditions for innovation rather than special innovation programmes for eastern Germany

The economic performance in eastern Germany is still considerably below the national average. The R&D expenditure as a share of gross domestic product is also lower than in western Germany. This is due to the relatively low contribution from the business sector. Although there is a shortage of broadly-based innovative companies in eastern Germany, there are some encouraging signs. Both in the new Laender and in Berlin, the representation of cutting-edge technology is above average and is showing considerably more signs of growth than in western Germany. Furthermore, the innovation intensity in the knowledge-intensive services is considerably higher. A further strength of the R&I system in eastern Germany is the well-developed public research and university land-scape, producing a relatively large number of patents and publications.

Certainly, the innovation potential and innovation performance in the new Laender has not yet reached the level of the old Laender, but the evident weaknesses of the eastern German university and research landscape are not fundamentally different from those of the structurally-weak regions of western Germany.

- The primary task of the R&I policies of the Federal Government is to strengthen the overall position of Germany in the competition for innovations. The Expert Commission no longer sees any need to develop new programmes specifically for R&I policies in eastern Germany.
- Accelerating the process of convergence is not a task for innovation policies, but rather for structural policies. Within the framework of the Joint Task 'For the improvement of the regional economic structure' (GRW) the Laender should make greater use of their scope for action in order to focus subsidies on forward-looking branches of the economy in regions with high development potential.
- The Expert Commission is in favour of providing institutional support for external industrial research institutions if they take on important tasks relating to knowledge and technology transfer and can demonstrate that their research is of a sufficient quality.
- Fiscal R&D support and an improvement in the framework conditions both for the provision of companies with equity and for business angels and providers of venture capital would have particularly positive effects in eastern Germany, in view of the weak equity basis of many companies there.

Catching up in the field of electromobility

Electromobility offers the opportunity to achieve a significant reduction in CO2 emissions and significantly improves the security of energy supplies for the transport sector in the medium term. The strategy for the development of electromobility must be integrated in a broader, multimodal strategy for future traffic and transport systems. At present Germany is poorly positioned both in the key technology of vehicle batteries and in power electronics. Both scientists and the business sector misjudged the technological developments. Considerable efforts are now required in order to catch up with the leading nations in this sector.

The Federal Government and the Laender have already undertaken a series of measures in the field of electromobility. At the federal level, EUR 500 million has been made available from the second economic stimulus package for 2009 and 2010. There are currently 17 model regions and ongoing fleet trials for electromobility, and more are being planned. However, in the opinion of the Expert Commission the support projects, R&D activities and marketing measures are not sufficiently harmonised between the federal government, the Laender, the European Union and the manufacturing sector.

In order to establish a lead market for electromobility it will be necessary to concentrate efforts, for example by the rapid and radical conversion of transport in large conurbations to electric vehicles. The development of the new market will require state programmes to support a change in attitudes among vehicle purchasers. This will be necessary in order to reach the high production volumes required for economies of scale. In the opinion of the Expert Commission, national initiatives alone will not be sufficient.

The Expert Commission therefore proposes the following measures:

- The National Electromobility Development Plan is an important first step towards strengthening the position of Germany. Markedly improved coordination and a tighter control of public sector activities are now required in the field of electromobility in order to achieve significant progress. The fragmentation of the national and Laender programmes must be overcome; strategies and initiatives must be developed with a long-term perspective.
- Universities, non-university research institutions, and research promotion organisations should develop stronger and more comprehensive activities in the field of electromobility. In addition to research work, suitable training programmes are necessary to address existing shortages in skilled personnel.
- German companies are not cooperating sufficiently with one another on electromobility. A dialogue should be initiated rapidly with the business companies in order to bring the actors out of their isolation. The Federal Government should only provide further state support when appropriate cooperation is achieved in the field of electromobility.
- On the basis of the existing development expertise in the European automotive sector, the Federal Government should work towards a joint European approach in order to strengthen the European position overall and to achieve economies of scale.
- In contrast to current plans, the Federal Government should only select a few regions – if possible in connection with neighbouring countries – as locations for the market launch of new mobility strategies. This would offer the opportunity of establishing lead markets.
- It must be made attractive for car buyers to turn their backs on the heavy, high-powered vehicles of the fossil-fuel era. Users of electric cars should not only be offered financial stimuli but also additional benefits, e.g. the use of bus lanes in urban areas, or special E-lanes on main highways around the conurbation.

Careful reforms of patent systems and reorganisation in Europe

Patent systems should be structured so that they provide incentives for innovation and thus generate benefits for the economy as a whole. The current systems do not always fulfil this purpose satisfactorily. In the USA, the tightening of patent protection in the mid-1980s caused an escalation of competition for patents. In most sectors this led to an increase in litigation.

In Europe, there has been an increase in patenting activity since the 1990s. In addition, patent applications have become considerably more complex. Applicants are increasingly resorting to tactics which introduce uncertainty to the system. Despite falling quality, however, the grant rate at the European Patent Office has remained almost constant. In view of these developments, the framework conditions should be amended in order to discourage or prevent behaviour which obstructs innovation and progress. Above all, patents should not be granted at all for marginal inventions.

At the European level, efforts are being made to introduce an EU patent. In addition, a European and EU Patent‘s Court, replacing the current fragmented national systems. The Expert Commission welcomes these initiatives. The focus of such an implementation should be on the efficiency of future systems and their quality orientation. German policy-makers should draw on the undisputed advantages of the German patent jurisdiction, and aim to ensure that the central Court of Justice in the new legal system is anchored in Germany.

The Expert Commission notes that stronger patent protection and increased numbers of applications do not in themselves ensure more innovation and growth. Rather it is important to maintain the quality of the patent system:

– Quality advantages which the European patent institutions currently have over other regions, in particular the USA, should be maintained and expanded.
– The quality orientation of the European patent offices must be further improved. A functioning patent system must implement sufficiently exacting provisions concerning novelty and inventive step. Patent officers should be encouraged to reject marginal patents and to sanction unacceptable application behaviour.
– The Federal Government should continue to support the formation of European institutions in the patent system, i.e. a unified patent court system and an EU patent. Efforts should be made to ensure that the new institutions bring further improvements with them in comparison with the existing system. Harmonisation is not an end in itself.
– The behaviour of patent applicants has changed considerably in recent years. Therefore care must always be taken when interpreting patent data, with the inclusion of control groups and other reference measures.

CURRENT DEVELOPMENTS AND CHALLENGES

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A CURRENT DEVELOPMENTS AND CHALLENGES

A 1 CONSEQUENCES OF THE FINANCIAL AND ECONOMIC CRISIS

The crisis of the US real-estate market was felt first in mid-2008 on national financial markets, but then spread to affect the entire economic systems of many countries. The German banking sector experienced acquisitions, liquidity injections, and government guarantees. The crisis was soon impacting on the economy, government budgets, and the job markets in Germany. Due to the dependence of the German economy on exports, by the end of 2008 the crisis was already leading to falling foreign sales by German companies.[1] The impact was particular severe in the Germany economy's key sectors – the automotive industry and mechanical engineering. Massive order losses, short-time working arrangements, and lay-offs were the immediate consequences. The shortage of credit instruments as a result of the crisis combined with changes to regulatory framework conditions have resulted in a more than short-term tightening of the conditions for corporate loans. The numbers in full employment have been falling since mid-2009 and as a result of the economic situation the numbers of workers on short-time increased from about 39 000 in June 2008 to more than 1.4 million in June 2009.[2] This negative macroeconomic development places a considerable burden on government budgets.

Positive effects of the economic recovery packages

By means of two economic recovery packages, the Federal Government adopted various measures immediately after the emergence of the crisis, with the primary aim of cushioning the recessionary effects for Germany. This has been achieved, at least in part. As shown in a study by RWI Essen, the economic recovery packages stimulated short-term economic growth in Germany, or at least prevented a collapse. Overall unemployment did increase in Germany, but to a lesser extent than in other European countries.[3] It was possible to avoid a massive increase in unemployment by means of the German short-time regulations. Public investments in the communal infrastructure and the loan and guarantee programme of the Federal Government were already having a positive effect on the economy – as could be seen by autumn 2009.

The German Council of Economic Experts sees a relatively positive outlook for 2010. Unemployment figures are expected to rise to nearly four million according to the most recent prediction, rather than to five million, as was feared in early 2009. In addition, German output is expected to rise by 1.6 percent in 2010.[4]

Insufficient sustainability

While these measures of the Federal Government were appropriate to cushion the short-term effects of the economic crisis through until the end of 2009, more extensive measures would have been required in order to provide impulses for long-term growth. An analysis of the recovery packages by the German Institute for Economic Research (DIW)[5] with respect to generating long-term growth potential shows that a large proportion of the planned government investments is intended for infrastructure measures. These are generally directed towards basic infrastructure, and include investments in the transport network or investments in public buildings. However, for the innovative potential of Germany it would be more important to increase investments in fields which would promote growth, such as broadband communications or modern electricity networks (smart grids). Such sectors should have received more consideration in the recovery programme.

Particularly in the educational sector, there is an enormous discrepancy between replacement investments and growth-promoting investments. Some 92 percent of expenditure goes on maintaining the existing assets, e.g. building refurbishment. Only eight percent is spent on new laboratories, media facilities, or for up-grading further training structures. But these are precisely the investments which are important for the long-term competitiveness of Germany. A comparison of various economic stimulus packages worldwide reinforces this criticism. A study carried out by the Boston Consulting Group (BCG)[6] shows that the German economic recovery programmes were well suited to mitigate the effects of the short-term drop in demand caused by the crisis. However, in terms of investments in education and technology, the German measures were only given a middle ranking out of the ten national programmes investigated. German laender and local authorities should make full use of any opportunities they have to implement funds from the recovery packages on R&I-relevant projects.

A 2 PROMOTING INNOVATIVE POTENTIAL

Germany can only succeed in the face of growing global competition if it develops a stronger innovative dynamic.

BOX 01

Innovations

An innovation is a novel development which has been or is being implemented. It has to be more than just a “good idea”. In the case of a product innovation, a new or improved good is brought onto the market. This can be a product or a service. In the case of a process innovation, a new or improved production process is introduced. An innovation can also be the implementation of a new marketing measure or an organisational novelty.

BOX 02

Technology – concepts and definitions

The Expert Commission uses the following concepts and definitions:
Schumpeter goods refer to R&D-intensive goods and knowledge-intensive services.
R&D-intensive goods are goods for which on average more than 2.5 percent of annual revenue is spent on research and development.
High-value technology goods are R&D-intensive goods for which between 2.5 and 7 percent of annual revenue is spent on research and development. Typical examples are medical technology, machine tools, engines, filters, motor vehicles, and rail vehicles.
Cutting-edge technology goods are R&D-intensive goods for which more than 7 percent of annual revenue is spent on research and development. Examples include products of information and communications technology, aircraft and space vehicles, measurement and control instruments, or active pharmaceutical substances.
Knowledge-intensive services involve a high proportion of employees with a university degree. Examples of knowledge-intensive services are IT services, software services, insurance, architectural and engineering services, legal services, accounting and management consultancy, veterinary and health services, communications, libraries, archives and museums.
A list of research-intensive industrial sectors and knowledge-intensive services is included in the References section of this report.[7]

The Expert Commission has made detailed proposals concerning this in its previous reports.[8] It is essential to maintain a leading role in key sectors. At the same time, Germany should improve its profile as a location for cutting-edge technologies which are growing in international significance. Both challenges must be addressed by R&I policy-makers.

Maintaining a leading position in high-value technology

Traditionally, high-value technologies are a strength of the German economy. In an international comparison, Germany has established a leading position in the automotive sector, in mechanical engineering, in

BOX 03

Innovation incentives and market failures

The key driving force for innovation and progress is the competition between business companies. Innovative companies are more profitable in the long term than non-innovative ones, so that even without state support there should be a considerable incentive for innovation. However, market forces do not always ensure that innovation is pursued at an economically optimum level. In research, development and innovation there are significant forms of market failure which can have negative consequences for individual businesses. Effective R&I policies can cushion or divert the effects of market failures, but the government cannot take the place of the innovation activities of private actors.

There are important forms of market failure involving public goods, external effects and asymmetrical information. Public goods are non-rival and non-excludable. The consumption of the good by an actor does not reduce the availability of that good for consumption by others, and nobody can effectively be excluded from using it. In such cases, it can be appropriate to provide government financing and production of public goods. For example, this applies in part for basic research.

Externalities in research and innovation take the form of knowledge diffusion, which the knowledge producers cannot stem. For example, by inspecting an innovative product, competitors can obtain knowledge about it without having to bear the full costs for the knowledge production themselves. In this case, the private revenues of innovation diverge from the public revenues, and the innovator will not invest enough in knowledge production when viewed from a social perspective. Suitable instruments to employ here can be the creation or strengthening of ownership rights (e.g. by patents), or the provision of subsidies and tax incentives for knowledge production. However, all instruments also have undesirable side-effects. In the case of patents these are the dead-weight losses, which result from the limitation of competition, and in the case of subsidies there are crowding-in effects.

Asymmetrical availability of information can impede the functioning of markets, and the financing of innovations suffers from such effects. If the provider of finance does not have access to the same information as the recipient, then as a result the provider, fearing opportunistic behaviour or at worst the loss of the investment, will restrict the funds which are made available. In particular new enterprises and SMEs suffer due to such reservations. It is generally accepted that under these circumstances, government intervention by means of R&I policies can be appropriate. However, there can be unintended consequences, because all actors are interested in receiving subsidies. For this reason, the empirical evaluation of government intervention is particularly important in the field of R&I policies. Only such analysis will show whether state intervention is leading to the desired results.

electrical engineering, and in the chemicals sector in recent decades. This position can only be maintained by continuing to make high levels of innovation investment in these fields. The leading role in high-value technologies offers Germany the opportunity to continue to achieve above-average levels of exports. Emerging economies with high growth rates, e.g. China, India or Brazil, are already showing increased demand for capital equipment and production systems involving high-value technologies. This represents a considerable potential for Germany. In these sectors, German companies must continue to ensure that they produce first-class products.

However, market forces do not always create ideal conditions for innovations. There are various forms of market failures in the high-value technology sector (Box 03). If companies are to make sufficient investments in research and development, the government should make active use of suitable instruments of R&I policies. These include the tax incentives R&D which the Expert Commission has frequently called for.[9]

Supporting new potential in cutting-edge technologies

Germany has definite weaknesses with respect to cutting-edge technologies and knowledge-intensive services, and it is therefore essential to promote research and development in these fields. But with a share of seven percent of worldwide R&D expenditure, Germany cannot expect to establish a leading position in all fields of technology. It is necessary to specialise in fields in which German scientific institutions or companies already have comparative strengths and in which a further expansion seems to make sense from a macroeconomic perspective. The market processes involved cannot be replaced by government measures. But in particular in the early phases of development of technologies, the government can provide important impulses through the funding for university and non-university research institutions and the support for knowledge transfer. Start-up companies have a particularly important role to play. The government can also provide support with the acquisition of products of cutting-edge technology – and in this respect Germany only reaches the average level for the EU-15 member states.[10] Support for future technologies must take priority over measures which are primarily aimed at maintaining existing structures.

Over the past decade, Germany has beens able to reduce its structural deficits in comparison with other industrial nations in the field of cutting-edge technologies, although starting from a low base level. In the field of knowledge-intensive services, Germany still has considerable weaknesses[11]. In the new version of the High-Tech Strategy care should be taken that the support in the five fields of requirements (health / nutrition, energy / climate, security, mobility, communications) and in the cross-cutting topics is not only technology-oriented, but also takes into account the associated innovative business models and services.

A 3 NEW APPROACH IN R&I POLICIES – TARGETING THE HIGH-TECH STRATEGY

Cohesive and uniform R&I policies in the new High-Tech Strategy

With the establishment of the High-Tech Strategy in 2006, the previous Federal Government attempted to implement a coordinated strategy for promoting R&I in all government departments. It is not yet possible to assess the medium-term effects of the High-Tech Strategy, but it has been possible to considerably increase the funds deployed for research and development in Germany. The national R&I policies have also been made more effective by improved coordination between government departments. At the same time, the High-Tech Strategy in its original form was characterised by a vaguely defined range of topics and a lack of focus. For the continuation of the High-Tech Strategy, the Federal Government should therefore concentrate more on supporting the most important fields of requirement. The definition of five priorities and cross-cutting topics is a step in the right direction. The increased importance attached to the implementation of research findings is also appropriate and must be extended to cover all priority areas.

Careful selection of support priorities

A systematic approach should be adopted for identifying the most important requirement fields. In the EFI Report 2008, the Expert Commission advised drawing on the results of the Foresight Processes. In addition, a catalogue of criteria must be created for the identification of promising fields of innovation which require government support. The R&I policy should concentrate on areas of knowledge and technology which have a promising future and in which Germany already has a high level of research expertise and a development lead which can be secured internationally, for example by patent applications. As a condition, there should be commercial links in the fields receiving support. Either companies must already exist which are capable of implementation, or it must be possible for new, value-creating industries to grow in Germany. The selected priority technologies should not be dominated by ruinous international competition, and it must be possible to provide a sufficiently large R&D budget in Germany over a longer period.

Advisory bodies

Numerous advisory bodies are active in the overlapping policy fields of the environment, health, energy, and security and they pursue differing policy objectives. In many fields, research and innovation has become increasingly important, but currently there is not an institution which could carry out continuous evaluation of scientific findings and new technologies in order to provide these bodies with adequate information. This point is considered in Section B 1.

The Expert Commission recommends that the Federal Government, together with organisations such as the German Academy of Science and Engineering (Acatech) and the Academies of Sciences should launch a series of analyses of fields of technology which not only address strengths and weaknesses but also illuminate the value-creation potential of new lines of research, develop road maps, and present possible scenarios for the future development. The fields of technology should be evaluated not only by scientists and engineers, but also by business representatives and in particular actors with experience in seed funding, in order to avoid a bias towards established technologies and evaluation strategies. In addition, the analyses should include balanced risk-benefit evaluations, in order to promote the public acceptance of new technologies. Such a remit would be beyond the scope of the Science and Industry Research Union, which does not have an independent capacity to conduct analyses.

A 4 FURTHER DEVELOPMENT OF THE R&I INSTRUMENTS

Continuing the Top Cluster competition

The Top Cluster competition within the framework of the High-Tech Strategy is a good way to promote promising innovation clusters. It supports the cooperation between science and industry and stimulates the commercialisation of marketable products and services. A positive feature is that the support is not spread thinly and indiscriminately, but is targeted on the projects which have particularly good prospects for success. However, it is currently rather short-term. Clusters selected in the competition should receive support for more than five years. The required funds could be released by reducing the number of strategies supported in each round of the competition. A thorough evaluation of the chosen top clusters is particularly important for this instrument.

BOX 04

Shareholding in university spin-off companies

The investment of drive specialists Wittenstein AG in September 2008 in attocube systems AG is an interesting example of cooperation between an existing company and a university spin-off.
attocube systems was founded in 2001 as a spin-off of the Centre for Nano-Science of the Ludwig Maximilian University Munich. It specialises in the development and production of high-precision servo-motors in the nano-range. By acquiring the shareholding in attocube, Wittenstein AG was able to enter the international market for specialist, high-precision nano-drive systems. This created the opportunity to market new nanotechnology products and to establish market leadership in this field. In turn, attocube has benefited from the established global network of its partner.

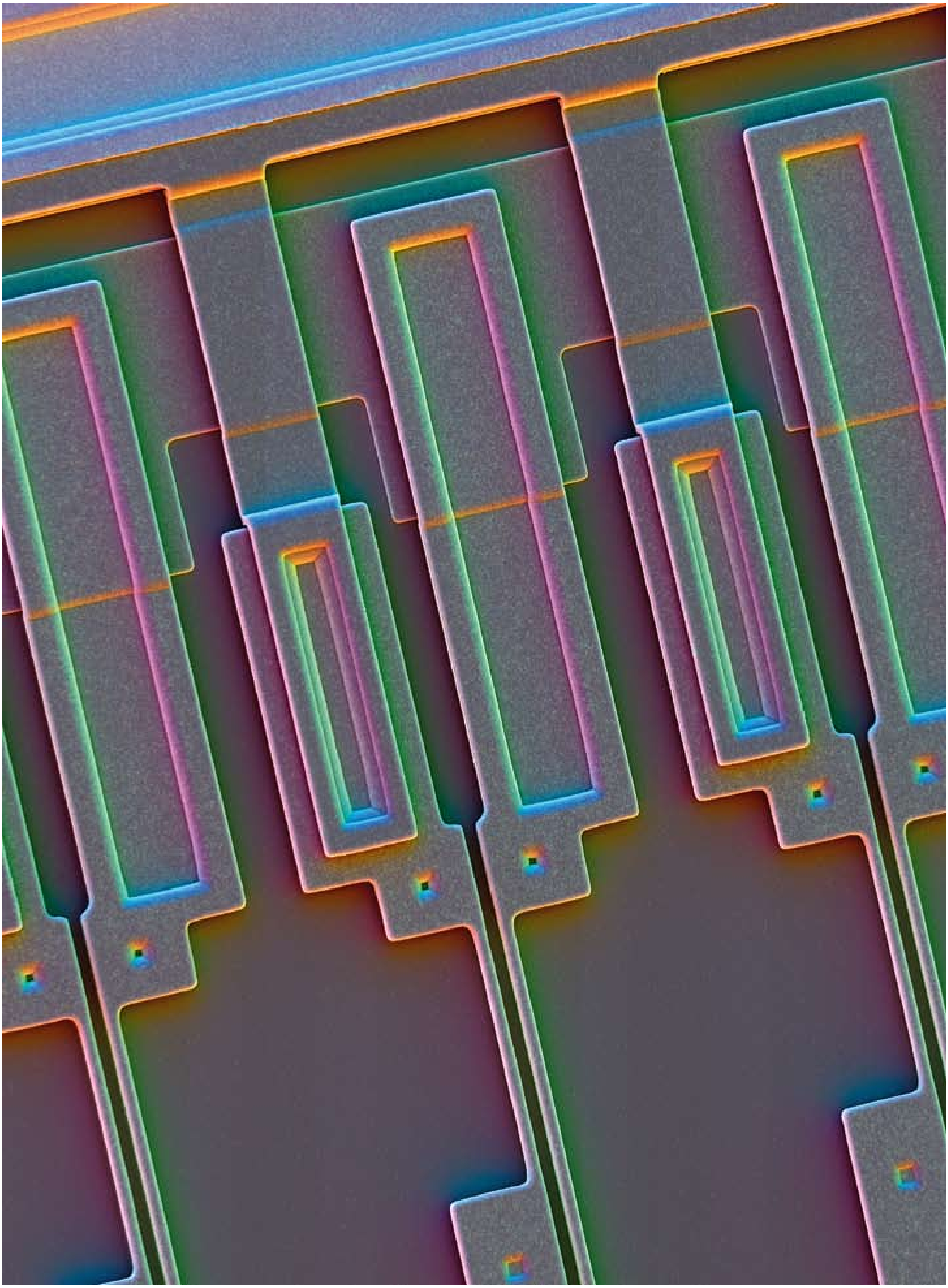
Improved research and knowledge transfer

German universities and scientific institutions generate many promising research findings. However, they frequently lack marketing expertise for newly developed products and services. Germany's economic strength depends to a considerable extent on the commercialisation of developments from the field of cutting-edge technologies. It is very important that there is not a reorientation of basic research to applications, but rather that the results of basic research, which is funded less selectively, should be utilised in a more targeted fashion. This can be done by involving medium-sized companies in university spin-off enterprises (Box 04).
The Expert Commission proposes the formation of a publicly administered "commercialisation fund". This would provide funding for the transfer of research findings. This should go beyond the existing approaches in programmes such as the EXIST Transfer of Research or the High-Tech Start-ups Fund. There is a need for considerably more government financial support for transfer research to fill the funding gap created by the lack of private funding.

Supporting standardisation processes

An important aspect of the commercialisation of innovative technologies is establishing standards where there are various implementation options or where it is necessary to provide coordination between actors. From the point of view of an individual company, successful standardisation can involve a time-consuming and costly process in order to ensure the adoption of its technologies. Above all for small and medium-sized enterprises there can be a lack of incentive to pursue standardisation alone, because competing companies will also profit from the standard-

Germany – Strelasund estuary



Computer semiconductor, microelectro-mechanical system

BOX 05

Laser standards[12]

Favourable conditions for innovations, including standardisation, are crucially important for the successful development of new technologies and markets. The work on early and systematic standardisation for lasers by the Optics and Precision Mechanics Standards Committee (NAFuO) of DIN in the 1980s made it possible a decade later for German industry to assume a lead role in the European standardisation – in augmentation to the European Union's Medicinal Device Directive. Globally, Germany and the United States have together advanced standardisation in this field. Starting from a sound technological base, the framework conditions created by the standardisation create an advantage for German companies over international competition, so that exports have multiplied in the long-term and created more than 50 000 jobs. Effective measures in standardisation meant that uncertainties in the market for laser technology could be reduced at an early stage – to the benefit of German manufacturers.

isation. Many countries therefore provide support for businesses in such processes by promoting the formulation of standardisation proposals in national bodies and standards organisations. In Germany, this is not yet done to a sufficient extent in important future fields.

Germany cannot afford to be left out of the worldwide process of establishing standards for the products of tomorrow. One way to avoid this can be to organise exchange forums on technical novelties at an early stage within the existing standardisation organisations. Such forums or government-initiated working groups should include representatives of all interest groups from science and industry, including from foreign countries, and the setting of appropriate standards should be discussed. Exchange forums can contribute to ensuring that Germany remains in close touch with international developments and can make German companies more competitive.
Cooperation between companies in setting standards raises questions concerning fair competition. However, assessments should pay due attention to the effect which this cooperation has on promoting innovation.

Further improvements to legislation on foundations and endowments

Modern legislation on foundations and endowments can provide impulses for research. In countries such as the USA or Great Britain it is common for large private foundations to fund major research activities. Particularly in the field of medical care, considerable sums are made available for research projects. The British Association of Medical Research Charities (AMRC) is a good example. Apart from cultural differences, current German legislation on foundations is the main reason why relatively little funding is provided for research from private sources. A modernisation of German legislation on foundations and endowments could lead to more foundations in Germany providing funding for research and innovation. An additional extension of the scope for tax deductible donations to charitable organisations and an increase in the maximum deductible amount for donations to foundations which promote research could stimulate the establishment of foundations and increase the support given to them by the general public. According to the Association of German Foundations, the most recent significant amendment to the legislation on foundations in 2007 led to a 26 percent increase in the number of foundations.[13] Currently, the main obstacle to a further modernisation is the requirement that a foundation should spend all revenues within a limited period. It is not permitted to accumulate foundation funds as capital stock to be used subsequently for other purposes, even if these will also be charitable in nature. This constraint should be eliminated.

SUPPORT MEASURES FOR SMALL AND MEDIUM-SIZED ENTERPRISES (SME) A 5

Supporting innovative SMEs – through and beyond the crisis

Small and medium-sized enterprises are important producers of technology, suppliers, and exporters. German SMEs play an outstanding role in the R&D process in an international comparison. According to the Institut für Mittelstandsforschung (IfM) in Bonn, more than 65 percent of the workforce were employed in SMEs.[14] R&D incentives for SMEs have considerable influence on the innovative potential of Germany, because SMEs are particularly important for innovations in cutting-edge technologies.[15]

It is therefore to be welcomed that there are meanwhile a range of programmes targeted specifically towards small and medium-sized enterprises. One example is "SME Innovative" which supports projects in cutting-edge research. With the "Central Innovation Programme for medium-sized enterprises" (ZIM) initiated in 2008, the Federal Government has created an instrument to provide financial support for innovation activities of SMEs. Additional public funding has been made available in order to mitigate the impact of the financial and economic crisis on SMEs. As part of the Recovery Package II, the ZIM programme was increased by EUR 400 million (2009) and EUR 500 million (2010) in order to provide R&D incentives for medium-sized enterprises. The "KfW Special Programme" with a budget of up to EUR 40 billion in 2009 and 2010 was intended to ensure the availability of loans to medium-sized enterprises during the crisis and to cushion the shortage of credit instruments in the wake of the financial crisis. These measures have helped SMEs to cope with credit crunches in the short-term, but R&I policies must continue beyond 2010 to focus on providing support for SMEs.

High time to introduce R&D tax incentives

The Expert Commission has frequently drawn attention to the desirability of R&D tax incentives. In 2008, 21 out of 27 OECD countries had introduced such R&D tax incentives, compared with 12 countries in 1995. In order to ensure that Germany remains an attractive research location, the Expert Commission once again recommends introducing tax incentives for research and development, if possible already in 2010. A reference to this is included in the coalition agreement between CDU / CSU and FDP, but no specific plans have yet been presented for the implementation. Should budget restrictions mean that it is only possible to introduce limited tax support for research for the time being then these should be targeted primarily at SMEs, or should be introduced with a limit on the level of support provided. This should increase the economic effect, because SMEs are more affected by financing constraints in R&I than large companies.

Compared with subsidies for individual research projects, R&D tax incentives have the advantage of being more efficient. The companies choose the research projects they feel offer most promise, without any need to go through extensive and time-consuming application and selection procedures. It is important that the companies do not have to go through bureaucratic procedures so that the incentives can be fully effective. Suitable provisions should also

BOX 06

Tax incentives for R&D in France

In 2008, the French government reformed its support for R&D activities by introducing the "Crédit Impôt Recherche" programme. Companies are given proportional tax credits for their expenditure on research and development, or young innovative companies can receive a direct aid payment. Companies applying for research support for the first time in five years are given a tax credit rate of 50 percent of expenditure instead of the regular 30 percent (before 2008: 10 percent). This provides an important incentive for company research.

The programme covers expenditures for personnel costs, raw materials and patent protection. If companies award research contracts to university or non-university public research institutions the twice the order volume is used as the basis for calculating the tax credit. This component is well suited to stimulate cooperation between scientific institutions and companies.

Since the reform came into force on 1 January 2008, R&D investments have risen in all sectors with the exception of the automotive industry and aeronautics and astronautics. Already in 2008, the number of companies claiming tax credits rose by 24 percent[16]. A further effect of the programme is that it strengthens the position of France as a research location. Companies are setting up their R&D activities preferentially in France or are repatriating activities that had been located abroad. A survey carried out by the French Ministry for Higher Education and Research shows that more than a third of companies have been stimulated to cooperate with scientific institutions. This is particularly the case for large enterprises. But start-up companies also benefit from the programme. In their responses to the survey, 88 percent of young innovative companies said they had received support through the "Crédit Impôt Recherche" programme.[17]

be included so that companies without corresponding tax liabilities can receive an incentive as direct aid. In particular innovative start-up enterprises face considerable research expenditure in the early stages before they can begin to generate any profits. R&D tax incentives should not be restricted to personnel costs, but should cover all R&D expenditure.

Supporting innovation through the tax system

The current fiscal and financial framework conditions for SMEs are not only unsatisfactory but they also act as a constraint on innovation. But as the Expert Commission has already argued in previous reports, it would be possible to create important innovation incentives. These include the removal of limitations on the use of losses carried forward under Section 8c Corporation Income Tax Act (KStG) and support for the provision of risk capital. The difficulties in discounting losses incurred when holdings are sold make investments in young innovative companies in Germany less attractive than in many other countries, where regulations are less restrictive. This constitutes a competitive disadvantage for Germany. The agreed amendments to the Act to Accelerate Economic Growth concerning limitations on losses carried forward also fail to promote innovation for new enterprises. The amendments to the legal provisions are mainly beneficial for distressed companies, for company restructuring, and for losses carried forward to the level of hidden reserves.

The inadequate availability of risk capital is a serious problem for the German innovation system, because such capital is crucial to provide a sound capital basis for young, innovative enterprises. Risk capital providers in Germany require framework conditions which will allow them to compete with those in other European countries. In Germany, only 0.04 percent of GDP is used for venture capital investments, in France 0.06 percent, in Spain, Denmark, and Finland 0.07 percent, in Great Britain 0.09 percent, and in Sweden 0.15 percent.[18] Furthermore, tax incentives should also be provided for Business Angels – experienced entrepreneurs who provide young enterprises with capital and expertise. Support for business angels could create incentives to bring together innovative entrepreneurial ideas and many years of experience in business and marketing.

Replacing research premiums by R&D tax incentives

There is often a considerable gap between supply and demand for exchanges between young innovative enterprises, established medium-sized companies and scientific institutions. Many companies, in particular SMEs, complain about the lack of offers from most scientific institutions relevant to their applications, and also feel themselves inadequately informed in this respect. But cooperation between science and business is essential if innovations are to be developed and marketed. The provision of research premiums in Germany has proved impracticable because of their complexity. As an alternative, support could be provided for cooperation projects between science and industry through R&D tax incentives. This instrument is being used successfully in France (Box 06). The costs for research and development for companies can be considerably reduced in this way.

Demand-oriented support for young innovative enterprises

Young innovative enterprises often have initial difficulties establishing a stable customer basis. In order to support them in this phase, a certain proportion of public acquisitions should be reserved for the products of such companies. This can help them to become established and stimulate follow-up orders from other companies. In the USA this approach has been used successfully for more than 25 years as part of the Small Business Innovation Research programme (SBIR).[19] A similar approach has been proposed in France. In order to broaden the impact of public start-up support, it might be possible to initiate a support programme together with the French government. In the best case, such a project to provide support for young, innovative enterprises could be extended to cover all Europe. This would contribute to overcoming the fragmentation of the European market, in particular for start-up enterprises.

A 6 IMPROVING EDUCATION IN GERMANY

Growth, Education, Solidarity: The educational policy priorities of the new German government

The new coalition attaches importance to education and research. Section 2 of the coalition agreement entitled "Growth, Education, Solidarity" is dedicated to the "Education Republic of Germany". The envisaged increase in Federal expenditure of EUR 12 billion until 2013 is intended in particular to benefit research, namely the High-Tech Strategy, the Pact for Research and Innovation,[20] the Higher Education Pact[21] and the Excellence Initiative. The Expert Commission welcomes these proposals. Other measures in the coalition agreement have the potential to improve the German education system so that more people can receive good education and vocational training. This includes state contributions to so-called Future Accounts[22], language tests and lessons for four-year olds, support for highly talented school-children, a grant system for talented students, and an increase in student enrolments, in particular for applicants from vocational training courses. For this purpose, so-called step-up grants are to be expanded (Box 07), which is necessary in view of the limited numbers currently available (about 1000 grants a year). In addition, the coalition agreement favours increased continuous learning, although it remains vague on this point. In view of the increasing importance of further training throughout life, the Expert Commission urges the Federal Government, Laender, local authorities and companies to work together in order to allow people to acquire further qualifications while they are working or in phases of unemployment.

BOX 07

Step-up grants

Since December 2008, the Federal Ministry of Education and Research has been providing so-called "step-up scholarships" for men and women with vocational experience who wish to go on to higher education. The programme is aimed at "highly-talented" applicants, who are selected in a three-stage process. Anybody can apply who has completed their vocational training very successfully and has at least two years experience in their occupation. So far, some 1500 scholarships have been awarded.
www.aufstieg-durch-bildung.info

Equality of access and full use of all potential

Many of such educational policies benefit primarily those who have already received considerable support in the course of their education. It is well-known that more than 70 percent of grants for the highly talented go to students whose parents have university degrees and more than 40 percent of recipients are only given flat-rate book grants.[23] The Future Accounts for each new-borne child, into which the government pays EUR 150 with a premium to be paid if regular payments are made through until adulthood, will also tend to better higher-income families. Those with less money will have less to save for their children's education. The Expert Commission recommends making greater efforts to achieve more social equality for access to education. Targeted preferential support should go to those who have potential, but who do not receive enough backing from institutions and their family. In this context, the planned introduction of payments to parents who do not send their children to public pre-school care institutions will not contribute to the objectives in hand. In particular, children from educationally disadvantaged strata benefit from early support. The government is wasting the opportunity to counter the educational deficits of these children before they start school. Furthermore, such payments for child care represent a disincentive for women to enter the labour market. For these reasons, the Expert Commission is against the introduction of child-care payments and in favour of an entitlement to a free kindergarten place for all children from the age of three, and also for an obligatory pre-school year for five-year olds.

Removing the ban on cooperation between the Federal Government and Laender

The goal of an "Education Republic of Germany" can only be achieved by a joint approach of the Federal Government, Laender and local authorities. Many of the points included in the coalition agreement are currently the responsibility of the Laender and local authorities. Even though the Growth Acceleration Act has passed through the Bundesrat, it remains to be seen to what extent the Laender and local authorities will implement the specified measures. This is all the more the case because the decline in tax revenues as a result of the financial crisis, in combination with public budget limits and proposed tax cuts, give grounds to fear that it will not be possible to pursue many of the research and educational targets. Where public budget cuts have to be made, then it is areas of discretionary spending which usually suffer, such as education.[24] The ban on cooperation means that with few exceptions it is also not possible for the Federal Government to make special funding allocations. For this reason, the Expert Commission favours lifting the ban on cooperation and reconsidering federal responsibilities for education. Germany cannot afford the tight framework conditions which result from federalism in this sector.

Boosting research at German universities

An important impulse for research is provided by the Excellence Initiative (Box 08). It has had a marked impact on the German science landscape in recent years. Recent investigations of the Berlin-Brandenburg Academy of Sciences (BBAW)[25] show clearly that a "special class" of research funding has resulted which has created a new level of academic reputation. In particular the Excellence clusters are regarded as an outstanding new category of third-party programmes. The BBAW working group draws attention to the importance of the third line of funding to support the universities themselves – apart from the support for individual excellence clusters or graduate schools. This is the only way to develop the best internationally competitive universities.

The effects of the excellence initiatives are varied and extend beyond the individual faculties and universities which receive support. In some cases, universities which made unsuccessful entries for the Excellence Initiative could still benefit. The proposals could be realised with funding from other sources, usually organised at the federal state level. However, in other cases, rejection casts an unfavourable light on the application; unsuccessful applicants and their faculties report significant damage to their reputation. The Expert Commission recommends for the next stage of the Excellence Initiative that applications which are excluded after the second round of assessment should be awarded a sum in the order of EUR 100 000 so that the projects can be further developed and alternative funding acquired.

BOX 08 **Excellence Initiative**

The Excellence Initiative promotes cutting-edge research at German universities. It includes three lines of funding:

1. Graduate schools for young scientists,
2. Excellence clusters which link universities with leading research institutes and businesses
3. "Future concepts" to raise institutional research profiles.

In two rounds of application in 2006 and 2007, a total of EUR 1.9 billion was made available to the universities and their partner institutions for research and the support of young scientists through until 2012. On 4 June 2009, the Federal Government and Laender decided to extend the excellence initiative for the period 2012 to 2017 with a total funding volume of EUR 2.7 billion. The programme will retain its current structure with three lines of funding. The next round of applications is planned for 2010, and the decisions on funding will be taken in 2012.

Promoting excellence in university teaching

Although the Expert Commission welcomes the Excellence Initiative, the University Pact and the Pact for research and innovation, it very much misses proposals aimed explicitly at promoting university teaching, which is not covered by the funding provided by the Excellence Initiative. The call to submit innovative teaching concepts in the next round of the Excellence Initiative is not enough in order to provide support for the Bologna Process and the associated targets. The "Excellence Initiative in Teaching" of the Stifterverband for German Science is an important step,[26] but by itself it will not be sufficient in order to ensure the implementation of the urgent recommendations made by the German Science Council to improve the quality of university teaching and course[27].

A 7 ESTABLISHING EXTENSIVE EVALUATION RESEARCH

It is often difficult to assess how effective policy measures are. An evaluation has to answer complex questions, such as which goals are to be achieved, what constitutes success, and what should the relationship be between the outlay and the returns? Furthermore, which measures best serve the realisation of the specified goals in the short-, medium-, and long-term? In other words: How effective and efficient are the measures over a broad band of quantitative and qualitative indicators of success?

These topics are addressed by evaluation research, which if properly designed makes it possible to estimate in advance the effects of policy instruments (ex ante). The instruments can then be monitored during the implementation and the actual effects assessed subsequently (ex post). Ideally, this process can be established as a rolling evaluation system which provides reliable results.[28]
In order to allow comparisons within and between government departments, a certain standardisation is required for the evaluation of political programmes and a binding catalogue of criteria has to be drawn up. A differentiated system of qualitative and quantitative indicators must be used in order to register the direct and indirect effects of political measures at all levels, including at the public level.

Already in the 1990s, the Fraunhofer Institute for System and Innovation Research (ISI) conducted a study of evaluation research in Germany on behalf of the Federal Ministry of Research and Technology (BMFT).[29] The study highlighted the importance of thorough, inter-departmental evaluation research. It was recommended that this should be made binding for all ministries. The Expert Commission agrees, and recommends that all ministries should allocate about one percent of planned expenditure to evaluation research, in order to make a significant contribution to increasing the efficiency of government support.
In order to establish effective, long-term evaluation research in Germany, it should be concentrated in a single institution. This can then serve as a one-stop address for the various ministries and departments, and it would become a centre of expertise for evaluation research. Data from various evaluation studies would be collected centrally, and this would make it possible to establish a valid data basis so that various programmes could be subjected to long-term comparisons.[30] It is possible to draw on the experience of the Federal Ministry of Economics (BMWi), which in recent years has developed an evaluation profile with clear guidelines for conducting evaluations uniformly, with a contact centre for questions relating to evaluation research.[31]

Various methodological difficulties concerning evaluation research remain unresolved, such as the quantification of indirect effects or the isolation of the consequences of a measure. In order to apply the existing measures in policy-making and to develop evaluation research in Germany further, the Expert Commission suggests that the BMBF carries out a meta-evaluation for the exchange of experience and knowledge, as in 1995. The conclusions should then be implemented. In order for the evaluation research to be carried out over a sufficiently broad scope, it is also important that well-qualified scientists with the necessary expertise should be entrusted with this task. However, they are currently in short supply. Evaluation methods should therefore form a standard part of social science and economics course curricula. Evaluation research should also be introduced as a topic for further training.

The results of extensive evaluation research must be made available to the public. This can contribute significantly towards improving the public awareness about the deployment of public funds. But members of the Bundestag and other actors must also be able to inform themselves better about the effectiveness of political instruments. The Expert Commission has therefore decided to publish future evaluations of innovation-relevant support programmes of the Federal Ministries on its website (www.e-fi.de).

CORE TOPICS 2010

B

B CORE TOPICS 2010

B 1 THE GERMAN R&I-SYSTEM IN AN INTERNATIONAL COMPARISON

The national research and innovation system and the challenges faced

Research and innovation worldwide are going through a profound transformation process. In future, it will be necessary to respond increasingly to significant problems faced by humanity in fields such as energy, climate, environment, and demography, and R&I must contribute to solving these problems. The following developments in the international innovation system have led to key challenges for the economy and the science systems of many countries:

- New demands and conflicts in the fields of energy, mobility, climate, security, and health, which will require coordinated research at various locations.
- Globalisation and the spread of research resources and expertise between increasing numbers of countries pursuing active innovation strategies.
- Intensification of competition and the acceleration of innovation processes.
- The increasing concentration worldwide of R&D activities in fiercely contested cutting-edge technologies, which are expected to generate considerable growth effects.
- Knowledge intensification and the increasing importance of knowledge-intensive services.

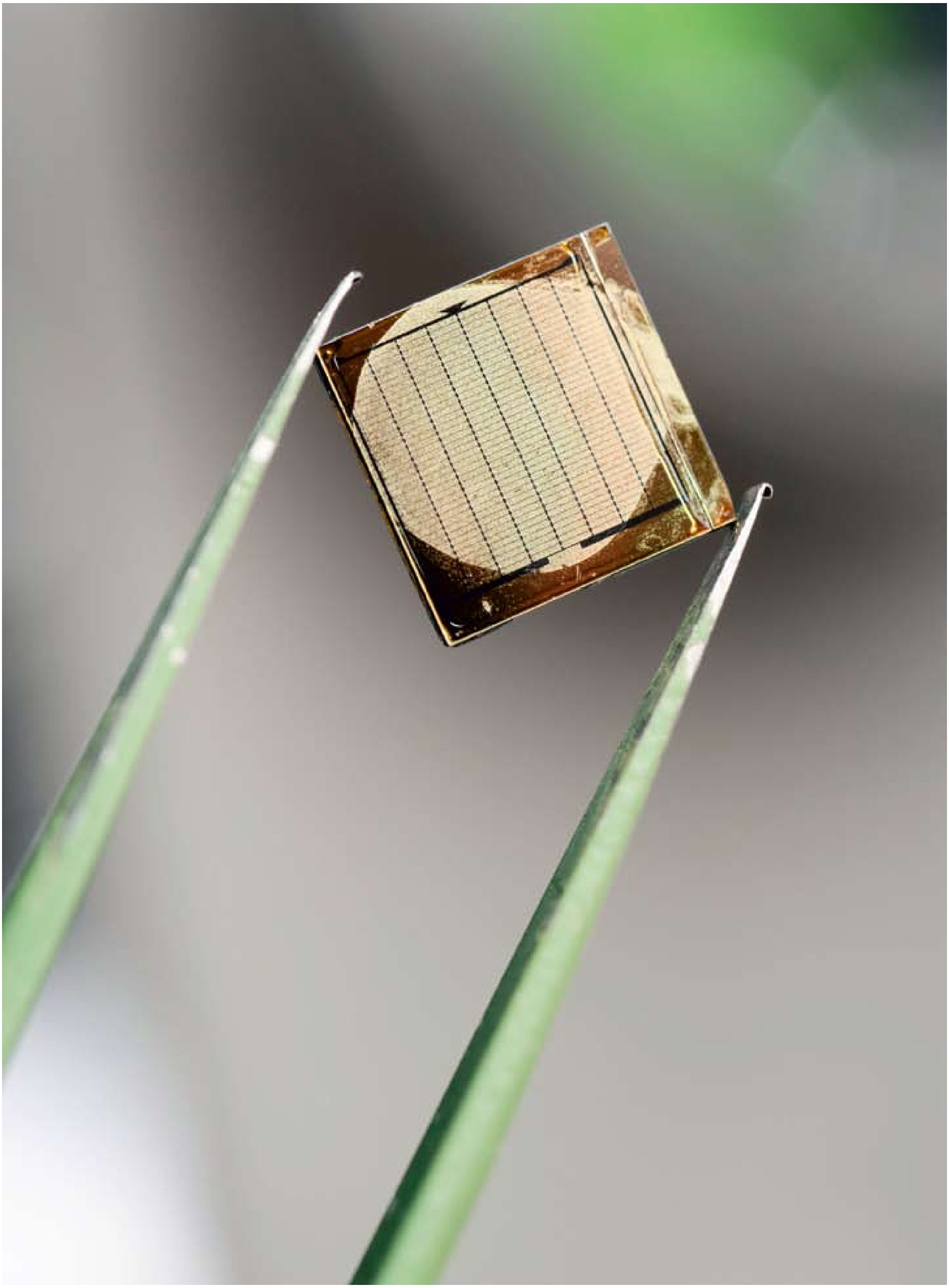
These factors are leading to a reorientation of research in the highly-developed economies. Historically evolved structures and disciplinary divisions are being overcome, the traditional division of labour between basic research and industrial innovation is increasingly being called into question and is being replaced by new organisational structures. Dynamic industries and new fields of demand are increasing becoming the focus of innovation activity, and as a driving force of innovation processes they are influencing the orientation of R&D. Demand- and problem-induced innovation is increasingly providing impulses for public research.[32]

The research and innovation policy-makers in many countries have not yet responded adequately to these structural changes. This is also the case in Germany. The German R&I system has developed considerable potential in important fields, but it must be oriented more to the challenges of the future and new topics. With the High Tech Strategy, in which the emphasis is placed on the most important fields for Germany, the Federal Government has managed to start the necessary reorientation. Further steps should follow, and should also be accompanied by organisational changes to the research system and to innovation policies.

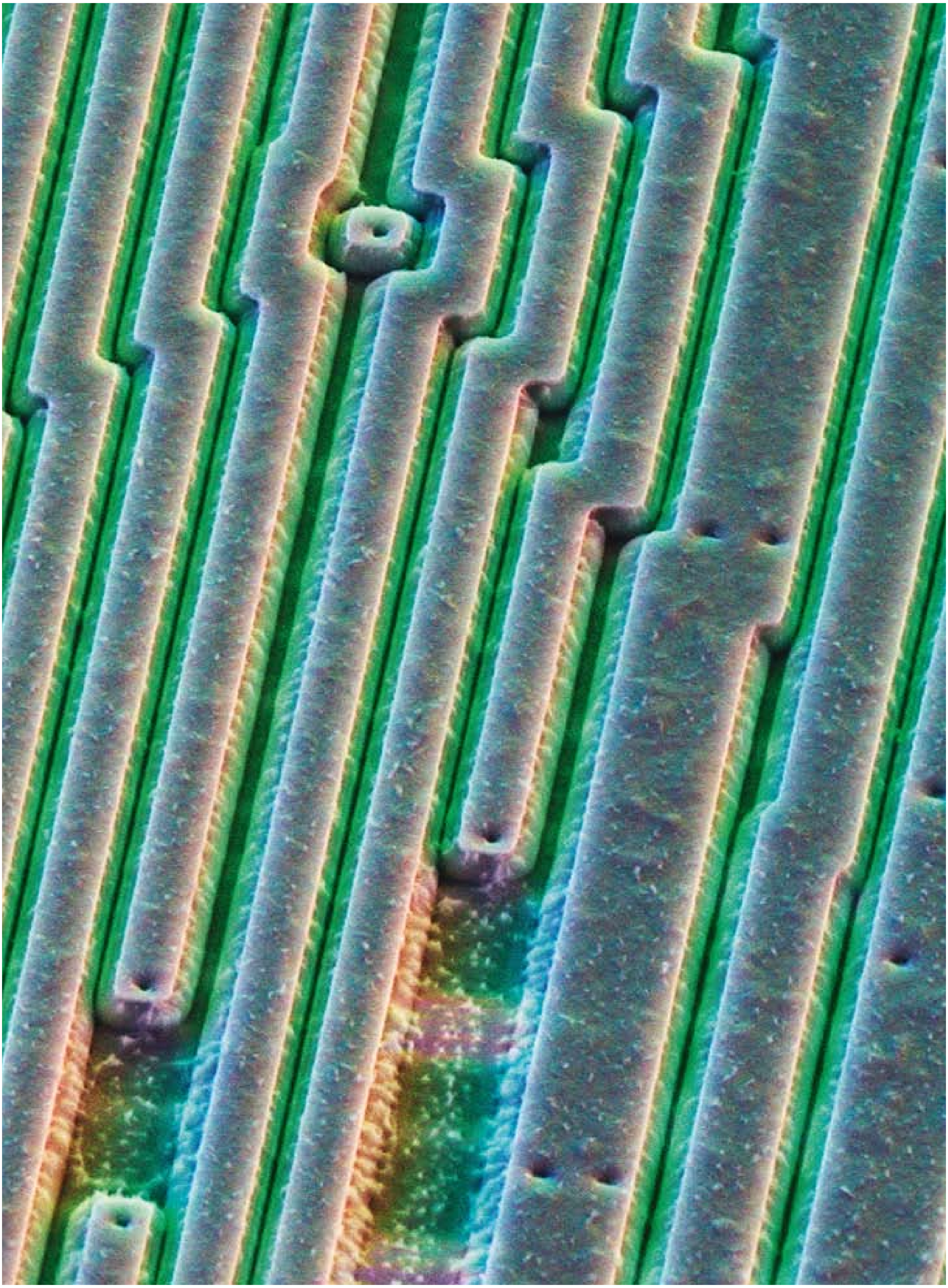
In order to be able to evaluate and control these structural changes to the R&I system, a detailed analysis of the research system and its most important components is required. This section of the report will first consider the industrial R&D system, followed by an assessment of the structure of the public science system.

The research and innovation system of the private sector

Germany has a well-developed and effective industrial R&D system, which concentrates on the most



Component with silicon nanowire



Microprocessor chip

BOX 09

Indicators for the evaluation of the R&I system

Important indicators for the analysis of the national research and innovation systems are the R&D expenditure and the level of R&D employment. For the private sector, innovation expenditure is also registered, which as a rule is much higher than the R&D expenditure.[33] The performance of the private sector is judged on the basis of data relating to growth, structural changes, exports, patent position, etc. The public science systems is assessed by analysing research results such as publications, patents, citations and technology transfer.

Total R&D expenditures in Germany in 2008 amounted to some EUR 66 billion.[34] According to estimates of the Stifterverband there was a slight increase in R&D expenditure as a proportion of the gross domestic product to 2.6 percent (2007: 2.54 percent). At the end of 2007, there were a total of 506 000 R&D employees in Germany, of which 185 000 were scientists.

In recent years, the German private sector has increased the proportion of GDP spent on R&D continually from 1.54 percent in 1998 to 1.78 percent in 2007. In contrast, the proportion spent by the state sector has remained almost constant (0.72 percent 1998 and 0.76 percent 2007). Thus the increase in German R&D intensity from 2.27 percent of GDP in 1998 to 2.54 percent in 2007 is attributable almost exclusively to the private sector. In 2007, 70 percent of national R&D expenditure in Germany comes from the private sector and 30 percent from the public sector, of which 16 percent is attributed to universities and 14 percent to non-university research institutions. In few other countries does the private sector finance a higher proportion.[35] However, in recent years the expansion of R&D expenditure in Germany's private sector has been below average in an international comparison.

important export industries.[36] In 2008 the private sector spent a total of EUR 57.3 billion on R&D – and despite the start of the economic crisis in autumn 2008 this represented an increase of 7.2 percent over the R&D expenditure in 2007.

At the end of 2008, the private sector had 333 000 employees working on research and development.[37] According to company planning data, the expenditure on R&D in 2009 was to be maintained at the previous year's level.[38] However, it is not yet clear whether these plans could be adhered to. By 2010 at the latest it is expected that the companies will reduce their R&D budgets and projects will be stretched or cuts made.[39]

The global financial and economic crisis led in almost all industrialised countries to marked declines in industrial R&D expenditure. Private R&D investments are sensitive to economic changes, but the patterns differ considerably between countries and sectors. Data from previous economic cycles shows that German companies react less to economic downturns than companies in other countries.[40] However, they are also less dynamic when it comes to expanding during economic booms. In the upturn from 2004 to 2007, private sector R&D expenditure in the OECD countries increased by 28 percent; in the German private sector over the same period the increase was only twelve percent.[41]

The typical German growth pattern is characterised by strong performance in the high-value technologies and at the same time deficits in the important cutting-edge technologies. Private sector R&D expenditure remains concentrated on the manufacturing sector and here mainly a few sectors which are traditionally regarded as Germany's main export industries: the automotive sector (34.9 percent), electrical engineering (16.3 percent), chemicals and pharmaceuticals (13.8 percent), and mechanical engineering (10.7 percent). In these R&D-intensive sectors, innovation expenditure in 2008 amounted to EUR 47 billion (Table 1).

In contrast, the structural shift towards services and the expansion of growth fields of cutting-edge technology has progressed less in Germany than in other highly-developed OECD countries. However, 16.9 percent of private sector innovation expenditures meanwhile go on knowledge-intensive services, in particular IT-services and telecommunications (8.7 percent), financial services (3.2 percent), and technological services.

TAB 01 **R&D expenditure and innovation expenditure in the German economy 2008**[42]

Sector	WZ 2008	R&D expenditure EUR billion*	% of total expenditure on R&D	Innovation expenditure EUR billion	% of total expenditure on innovation
Chemistry / Pharmaceuticals	20–21	8.6	13.8	12.6	9.8
Electrical engineering	26–27	10.1	16.3	16.2	12.7
Mechanical engineering	28	6.6	10.7	12.0	9.3
Motor vehicles	29–30	21.7	34.9	36.5	28.5
Research intensive industry	20–21. 26–30	47.0	75.7	77.2	60.3
Other industry	5–19. 22–25. 31–33. 35–39	5.9	9.5	21.1	16.4
Media services	58–60 (ohne 18)	0.3	0.5	1.9	1.5
IT / Telecommunications	61–63	4.7	7.6	11.1	8.7
Financial services	64–66	1.2	2.0	4.0	3.2
Consultancy / Advertising	69–70. 73	0.9	1.4	1.9	1.4
Technical / R&D services	71–72	1.6	2.5	2.7	2.1
Knowledge intensive services	58–66. 69–73	8.6	13.9	21.6	16.9
Other services	46. 49–53. 74. 78–82	0.6	1.0	8.2	6.4
Total		**62.0**	**100.0**	**128.1**	**100.0**

* The Mannheim Innovation panel does not register R&D expenditure in the same way as the science statistics of the Stifterverband. Source: ZEW (2010). Mannheim Innovation Panel 2009.

Lack of dynamics in the cutting-edge technology sector

In the manufacturing sector in Germany, R&D is concentrated on branches with rather moderate growth and medium R&D intensities. Industries which have seen a particularly strong worldwide expansion of R&D in recent years, e.g. the pharmaceutical industry and biotechnology, information and communications technology, and optoelectronics, are less strongly represented in Germany. German manufacturing companies are going through a process of significant structural change internally, in particular through the assimilation of R&D-intensive technologies and the expansion of new fields of business.
In contrast, in many other comparison countries there has been a marked expansion of new manufacturing sectors and especially R&D-intensive cutting-edge technologies. In particular in Sweden, Finland, Denmark and Austria this has led to a significantly higher increase in the average R&D rate than in Germany.[43]

The economic structure in Germany has not been developed in favour of sectors with a particularly high R&D intensity. Instead, the sectors which have grown in Germany are those which have shown a constant or even declining global R&D intensity. It is highly risky to concentrate on motor vehicle construction – which accounted for no less than 35 percent of private sector R&D expenditure. This can be seen clearly in the current economic crisis, in which the pillars of the industrial R&D system – automotive sector, mechanical engineering, and electrical engineering – have been hit particularly hard. The concentration on high-value technologies coupled with the neglect of cutting-edge technology has a negative effect on the innovation dynamics in Germany. Growth fields in cutting-edge technology markets and in knowledge-intensive services are not accessed quickly enough.

In the period from 2002 to 2007, there was a decline in the proportion of companies with an R&D intensity at the level of cutting-edge technologies. The proportion of companies with R&D intensity of more than 7 percent fell from about 6 percent (2002 to 2004) to some 4 percent in the period 2005 to 2007. Between 2003 and 2007, the R&D expenditure of the largest global companies active in pharmaceuticals and biotechnology rose by 33 percent, in IT-hardware by 24 percent, and in software and computer services by 28 percent. In this period, worldwide R&D expenditure in the automotive industry only increased by nine percent and in the chemical industry by 1.5 percent. Only in mechanical engineering (+24 percent) and in medical technology (+32 percent) did German companies participate in expanding the worldwide R&D capacities.

The globalisation of R&D continues

German companies are strongly integrated in the R&D globalisation process and they considerably expanded their involvement in foreign countries between 1998 and 2008. In addition, foreign multinationals are also increasingly present with R&D in Germany, so that these two effects balance each other out. However, here too the R&D location Germany profits more from its traditionally strong sectors, whereas R&D expenditures in cutting-edge technology mostly pass Germany by. For example, American companies concentrate their foreign R&D-investments in the sectors pharmaceuticals, communications technology and semiconductors mainly in Asia and a few European countries such as Great Britain and Ireland or Scandinavia. It is only in the classic fields of German industry (automotive sector, mechanical engineering, chemistry) that they continue to carry out R&D in Germany. The investment profiles of companies from other countries are similar.[44]

Leading German companies are increasingly making R&D investments in other countries, in part in a complementary fashion so that the Germany headquarters are strengthened. However, R&D investments in other countries are increasingly being made as a substitute for R&D involvement in Germany.[45] It is particularly striking that the expansion of R&D activities of German companies in the dynamic sectors is mainly taking place in other countries. This can lead to the abandonment of strategically important sectors in Germany. There have been such negative developments in particular in the pharmaceutical industry and biotechnology as well as in semi-conductor technology and software development. For example, in the German pharmaceutical industry the proportion of R&D expenditure in foreign countries rose between 2003 and 2007 from 50.1 percent to 69.2 percent, in some cases involving particularly promising research, which is now only carried out in foreign R&D laboratories.[46] The trend in pharmaceuticals, biotechnology, medical engineering and software is to choose leading locations in North America, whereas in electronics, telecommunications and electrochemicals there is often a preference for Asia. This development will have longer-term implications for the innovation system in Germany, because it limits the effectiveness of the cooperation with public basic research and also impacts on the educational system. Shifting R&D in particularly dynamic sectors to other countries means losing important impulses for the cooperation between the research institutes at German universities and non-university research institutions. In addition there is the risk of losing important areas of business, which are able to offer valuable job opportunities for the highly qualified.[47]

Public research and science in an international comparison

Over the longer term, there has been a shift towards private R&D. Whereas 47 percent of R&D expenditure in the OECD in 1980 was state funded, this proportion fell successively to 28.1 percent in 2007. Between 1994 and 2000 only one sixth of the increase in R&D expenditure in the OECD countries came from governments, compared with three quarters provided by the private sector.[48] For a long time, Germany did not play a leading role in the development of public research. In particular the USA, the northern and southern European countries have increased state R&D expenditure more than Germany has. It is only since 2004 that the increase in Germany has been above the average for OECD countries.[49]

A strong public research infrastructure is very important and essential for securing the long term future of locations. Germany has now taken the necessary measures by increasing public funding for research. The public research system consists of universities und non-university research institutions (AUF). The two forms are complementary and make a wide range of contributions to research, education and knowledge transfer, and thus directly and indirectly to the innovative potential at the macroeconomic level. In the following, the Expert Commission considers in particular the division of responsibilities between the science institutions in Germany, the forms of cooperation with the private sector and the effectiveness and efficiency of the processes. The analysis focuses first on non-university research and its internal structures.

The structure of public research

The total research budget in the public sector amounts to EUR 19.8 billion (2008). Of this, EUR 10.7 billion go to the universities and EUR 9.1 billion towards non-university research. At the end of 2008, the two sectors together were employing 189 000 R&D personnel (expressed in full-time equivalents), of which 108 000 worked at universities, and 81 000 at non-university institutions.[50]
The German science system has fairly unchanging basic structures, in contrast to other industrialised countries. This can represent an advantage in terms of the continuity of research, but when it comes to flexibility and innovation dynamics there are also disadvantages. It is remarkable that the R&D expenditure of the public science sector as a proportion of gross domestic product has been stable since 1981 at about 0.75 percent. In particular the distribution between universities (0.4 percent) and non-university research (0.35 percent) has remained largely constant over that period.

In the OECD countries, non-university research as a proportion of GDP fell between 1995 and 2007 from 0.3 percent to 0.25 percent.[51] At the same time, the proportion of the research in the university sector increased from 0.33 percent to 0.38 percent of GDP. Other countries also made significant reductions to non-university institutional research relative to GDP in this period, e.g. in the USA from 0.3 percent to 0.25 percent, in Great Britain from 0.28 percent to 0.16 percent, in France from 0.48 percent to 0.34 percent, and in Canada from 0.24 percent to 0.19 percent.

The expansion of the education system and university research has played a key role in many OECD countries since 1995 and even more so after 2000. Average expenditure on university research as a proportion of GDP by OECD countries increased from 0.33 percent 1995 to 0.38 percent 2007, e.g. in the USA from 0.31 percent to 0.36 percent, in Great Britain from 0.37 percent to 0.44 percent. The developments in Canada (increase from 0.46 percent to 0.63 percent) and Korea (from 0.19 percent to 0.37 percent) are particularly remarkable. Germany has not matched this expansion of university research in combination with the consolidation of non-university research structures. Significantly, there was a significant expansion of education over the period in question, so that presumable increased teaching obligations displaced research in the time budgets of university staff. Attention should therefore be paid in coming years to a balanced expansion of education and research, and to improvements in the structure of university research.

Setting priorities in the system of non-university research

Germany has a highly-developed system of research with various independent science organisations with very different remits. In 2007, the four most important organisations employed 56 percent of the scientists of non-university research institutions, namely the Helmholtz Association (HGF) 22 percent, Fraunhofer Society (FhG) 12 percent, the Max Planck Society (MPG) 11 percent, and the Leibniz Association (WGL) 11 percent. Together they account for 74 percent of the research expenditure in the non-university research sector. The following institutions receive about a quarter of the budget for non-university research and employ 44 percent of the personnel: Federal department research institutions 16 percent, Laender institutions 7 percent, academies, scientific libraries and museums 6 percent, and other institutions 15 percent. The other institutions consist of 400 publicly-funded non-profit organisations with widely varying remits in science, research, and technology transfer.

Such organisational and institutional differentiation can easily lead to inefficient duplication and inadequate strategic coherence. Over many years, the institutes of the Fraunhofer Society (FhG) or the Max Planck Society (MPG) have developed a clear research profile and have established an excellent international reputation, but the same cannot be said for all institutions. The institutions organised within Helmholtz Association and the Leibniz Association since the 1990s have meanwhile gone through a transformation process, which has led in many cases to an increase in scientific performance. Many institutes and research sectors in both associations are of excellent quality.

Structure of public research in Germany 2007

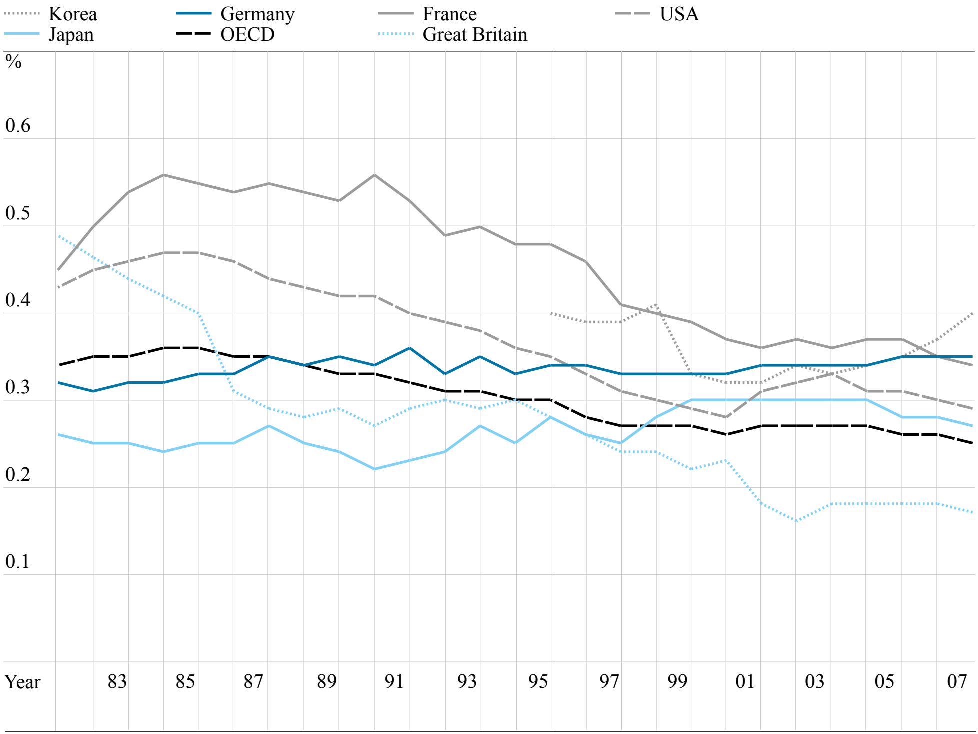
TAB 02

Institution	Research expenditure in Mio. Euro	Research personnel (full-time equivalence)	of which scientists
Non-university research	**8 540**	**80 664**	**43 561**
Max Planck Society (MPG)	1 290	11 785	5 996
Fraunhofer Society (FhG)	1 319	10 519	6 667
Helmholtz Association (HGF)	2 740	23 283	12 190
Leibniz Association (WGL)	966	9 699	5 480
Federal research institutions (BFE)	681	8 319	3 675
Land and communal research institutions	218	2 990	1 354
Other research institutions	1 002	10 930	7 138
Scientific libraries and museums	325	3 119	1 062
Universities	**10 000**	**103 953**	**72 985**
Public research – Total	**18 540**	**184 597**	**116 546**

Source: Statistical Federal Agency. Statistical Federal Yearbook 2009.

Survey responses for the importance of tasks for non-university research institutions in Germany

FIG 01



Source: OECD (2009a). Calculations by ZEW.

However, the research profiles and the remits of these research organisations are much more heterogeneous than the FhG and the MPG.

In the past, reference was made to pillars supporting the German research and science system.[52] Every scientific organisation, it was argued, pursued an independent mission, e.g. basic research at the MPG, or applied research at the FhG. The cooperation was particularly intensive between institutes belonging to the same science organisation, but was comparatively weak between the various science organisations.

The Expert Commission has commissioned a study to examine this claim empirically for the first time. The study shows that in recent years there has been an increase in new and innovative forms of cooperation between the various types of science organisations. Almost all non-university research institutions cooperate with universities, and in the course of the Excellence Initiative various institutions have been integrated in research networks. Common forms of cooperation include joint research projects (72 percent), university chairs for personnel (42 percent), and the joint supervision of postgraduate students (44 percent). Meanwhile, cooperation with institutions from other organisations carrying out non-university research is more common than cooperation with institutions within the same organisation.[53]

Table 3 shows the tasks to which the various non-university research institutions attach the greatest importance. The Max Planck Institutes are clearly focused on basic research, whereas the Fraunhofer Society primarily addresses applied research and knowledge transfer. In contrast, the priorities of the institutions within the Helmholtz Association and the Leibniz Association and also in the Federal departments are much more heterogeneous. The Helmholtz Association is the largest science organisation in Germany with a total of 23 300 personnel and R&D expenditure of EUR 2.7 billion, and many of the HGF institutes achieve commendable research results. The Association also establishes a bridge between basic research and applied research. In addition, the original remit of the HGF is also to organise the investigation of systems using large-scale equipment and extensive scientific infrastructure. The Expert Commission feels that a clearer distinction should be made between those HGF institutions, which are still carrying out large-scale research as originally intended and the others, which now pursue a very different mission. Strategies should be developed for both types of HGF institutions, and they must establish a profile which differentiates them more clearly from other science organisations. In particular the situation of the German Aerospace Centre (DLR) within the HGF should be analysed in detail in terms of research strategies.

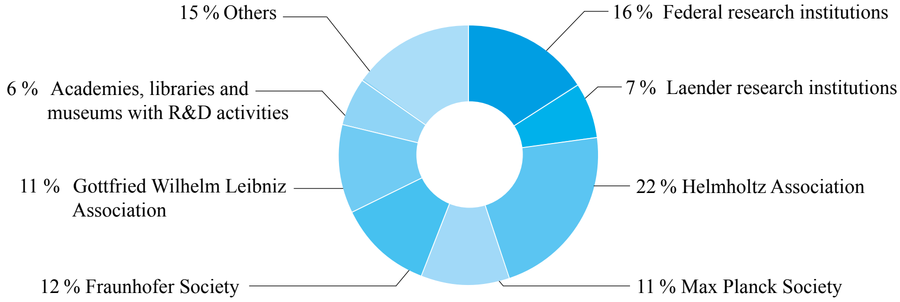
The Leibniz Association (WGL) is an umbrella organisation of 86 legally independent institutions, including not only research institutes but also institutions of the scientific-cultural infrastructure. The WGL employs 9 700 R&D personnel and has an R&D budget of about EUR 1 billion. Its remit includes basic research and applied research, as well as performances relating to information and documentation, knowledge transfer, further and continuous training, and consultancy services for public agencies. The coordination of individual research institutions in the WGL only involves sharing information; the central organisation does not intervene in decisions of the individual institutes. The widely varying remits of the individual institutions within the WGL and the special form of joint funding (50 percent from the Federal Government, 40 percent from the local federal state, and 10 percent from a shared fund of all Laender) suggest that there will be difficult structural adaptations in the coming years.[54]

A considerable proportion of public R&D expenditure goes towards Federal Government departments and research institutions of the Laender and local authorities. The Federal departmental research institutions, allocated to nine ministries, employ a total of 8 300 personnel and have a research budget of EUR 680 million (2007). These research institutions have been evaluated in recent years, although without calling into question the system as a whole. The Commission recommends that the Wissenschaftsrat (German Council of Science and Humanities) should draw relevant conclusions from the evaluation of the government department research institutions. It is necessary to note which tasks are of national importance, and which research activities are very specifically related to only one government department. Institutions, which do not meet these criteria, i.e. which are not carrying out work of national importance and are carrying out general research work, which is rather interdepartmental, should either be integrated into the existing system of science

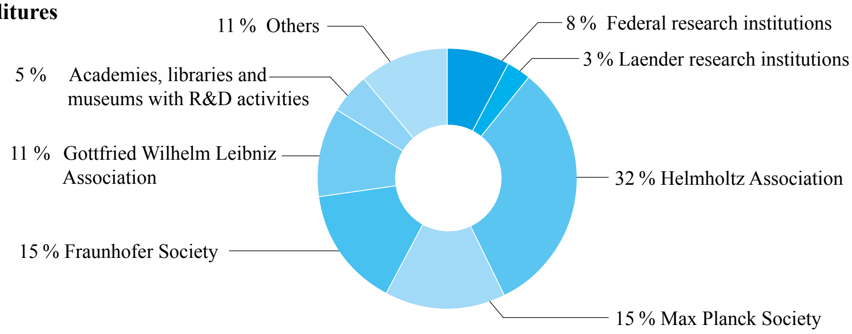
R&D expenditure

FIG 02

Scientists



Expenditures



Source: Statistical Federal Agency, Series 14, Row 3.6 (various years). Calculations by ZEW.

Survey responses for the importance of tasks for non-university research institutions in Germany

TAB 03

	Total	MPG	FhG	HGF	WGL	BFE	Others
Basic research	**44**	100	9	46	62	7	33
Applied research	**57**	3	91	57	48	74	67
Technical development	**18**	3	46	26	6	7	23
Measurements, Tests, Standards /Certification	**11**	0	17	6	6	26	15
Information and documentation	**11**	3	3	3	23	22	8
Training, Further training	**16**	22	3	34	19	7	10
Provision of scientific infrastructure	**15**	6	11	37	13	15	8
Knowledge /technology transfer to companies	**26**	3	57	31	12	7	40
Knowledge transfer to the public	**15**	19	0	14	23	15	15
Advice for public bodies	**20**	3	9	17	19	78	10
Public tasks	**13**	3	3	9	10	56	10

% of non-university organisations in a group (abbreviations as in Table 2) which chose the top response level for the five-level Likert items (multiple responses possible). Source: Polt et al. (2010: Tab. 002 – 004). ZEW, survey 2009. Calculations by ZEW.

organisations, restructured in the medium-term, or closed down. The Federal Government formulated guidelines in 2007 for modern departmental research, which suggested valuable improvements against the background of the previous division of responsibilities and allocation to departments.[55]
On the basis of the new recommendations presented by the Science Council in Spring 2010 a reorganisation of departmental research should be considered both at the Federal Government level and at Laender level. The necessary structural improvements and the recommendations of the Science Council should be fully implemented.[56]

Research and innovation performance of the individual science organisations

The priorities for non-university research outlined above, and often referred to internationally as the "German model", result in various strategies and research performances. Patents applications and publication outputs for the four major science organisations and the universities were analysed for the period 1994 to 2006. At one end of the spectrum, the Fraunhofer Institutes have a large number of patents and a comparatively low publication output. They had more than 70 patent applications per 1 000 scientists annually in the period 2004 to 2006, by far the highest patent productivity.[57] But they only achieved 0.15 SCI publications per scientist each year.

The Max Planck Institutes, which concentrate more on basic research and scientific excellence, report 1.35 SCI publications per scientist and year. Less emphasis is placed on patenting and commercial exploitation, with the result that they have only 12 patent applications per 1 000 scientists annually. Between these two extremes are the Helmholtz institutions, the Leibniz institutions, and the universities. No comparable information about patents and publications is available for government department research and the other institutions.[58]

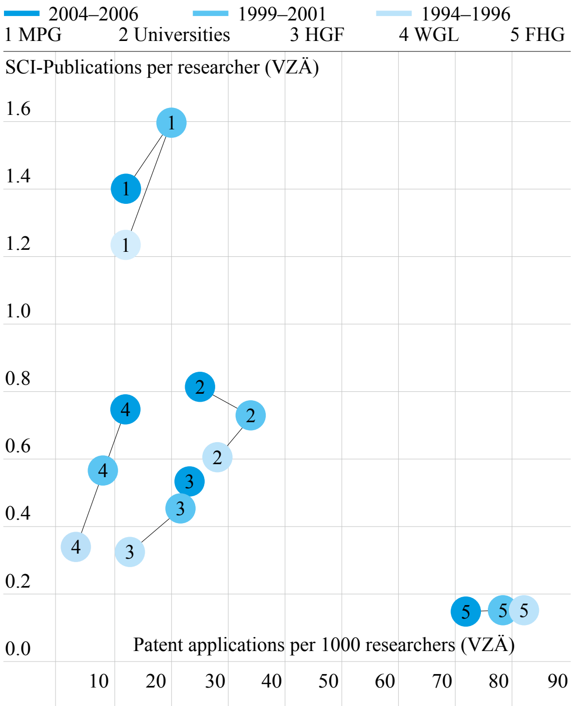
Particularly interesting is the development over time of the research achievements and the light this casts on the changing research strategies. Starting from a low level of publication activity in comparison with MPG, and a low level of patent applications in comparison with FhG, the Helmholtz centres and Leibniz institutes have made marked improvements for both indicators. Between 1994–1995 and 2004–2005, the Leibniz institutes achieved on average an eight percent growth rate in the publication output per scientist; patent applications per scientist increased by 15 percent. For the Helmholtz centres the corresponding growth rates were five and six percent, respectively. These analyses commissioned by the Expert Commission highlight that concentrating only a few indicators such as SCI publications and patent output can lead to the wrong incentives being given.[59] In particular achievements in technology transfers are neglected. Insufficient attention has been paid to this aspect in the past when evaluating institutions.[60]

Project funding and full cost funding

For public research in the non-university research institutions and universities, the structure of the funding plays a crucial role. There is a tendency for a greater weighting to be attached to the project funding relative to the basic funding. The Expert Commission welcomes this, because it encourages competition in R&I. However, project funding requires

FIG 03

Changes in publication and patent intensity of major science organisations and universities[61]



Abbreviations: MPG, HGF, WGL, FhG: see Table 2 or Reference section
Sources: Fraunhofer ISI, evaluation from SCISEARCH (STN) and PATSTAT (EPO). BMBF (2008). StaBA: Series 14 (3.6), 11 (4.4), 22 (4.5) OECD (2009a). Calculations by ZEW.

uniform rules, in particular concerning the accounting of indirect costs. In view of the new European framework conditions and the changed payment procedures of individual project funders, there is a trend towards funding projects on the basis of full costs.

Full cost funding would favour fair competition for funds between the various research institutions and thus increase the efficiency of fund allocation. The rules for accounting for indirect costs are still varied. This can lead to disadvantages for research institutions, which already include relatively high indirect costs, but which face competition from institutions, which only include their direct costs. In contrast, this regulation is disadvantageous for those institutions, in particular the universities, which are only able to include some indirect costs if any, and who frequently have to subsidise the projects from their basic funding.

The coalition agreement between CDU, CSU and FDP envisages considering the introduction of a flat sum in the project support from the Federal Government, like that provided by DFG. It consists of 20 percent of the relevant direct project expenditure and covers the related indirect, additional and variable project expenditures. The Expert Commission expressly approves of the introduction of such a programme flat sum. However, this should only be a first step on the way to full-cost funding.

Interaction between public research and industrial innovation

Effective cooperation between public research and industrial R&D is of key importance in a knowledge-economy. In many areas, Germany has reliable instruments and transfer channels, in particular where it has been possible to establish long-lasting relationships between companies and training and science institutions. There are signs of implementation deficits and transfer breakdowns for younger science disciplines, which have their own dynamics. This is reinforced if there are not enough active companies in the national setting to ensure the implementation. Worldwide innovation in many young disciplines is characterised by the formation of many new enterprises. However, in Germany this dynamic is inadequately developed due to the inadequate framework conditions and the lack of focus on cutting-edge technologies.

Mixed situation for knowledge and technology transfer

The following characteristics favour the successful cooperation between research und industrial innovation in Germany: advanced technology, average R&D intensity, German engineering traditions, production orientation, high quality, low price sensibility and well-established manufacturing structures. On the other hand, there are marked transfer deficits in those areas, which are characterised by: cutting-edge technology, high R&D intensity, new science disciplines, which are not yet established in Germany, entrepreneurship, services orientation, need for cost efficiency, and extremely strong international competition.

Cooperation between public research and the business sector works best where the fields of cooperation and the R&D topics of both sides fit well together and projects are synchronised. However, there are noticeable differences between the R&D portfolios of German companies and the research portfolios in the public sector. Whereas industrial R&D efforts are concentrated on a few manufacturing sectors, and mainly on the development of incremental adaptations, the portfolio of public research covers a relatively broad range of topics from cutting-edge research and high technology.

Promising lines of cutting-edge research are pursued by many research-intensive non-university institutions and the universities in Germany. However, they do not always place the emphasis on transfer possibilities or subsequent commercialisation. The research strategies and incentives structures in many institutions result in scientists being more interested in scientific breakthroughs, publications and increasing their reputation in the scientific community. However, the results obtained in cutting-edge research can only be applied and developed to a limited extent if there is no industrial utilisation domestically. In important fields of information and communications technology, or biotechnology and genetics there are few German companies working to effectively transfer developments into marketable products. R&D-intensive companies in fields such as vehicle manufacturing, chemistry, and mechanical engineering make frequent use of the latest technological advances. However, they mainly use their research results internally. Companies from areas of cutting-edge technology, e.g. pharmaceuticals and biotechnology, network and Internet technology tend to stimulate the innovation process more, but they are less well represented in Germany.

Greater efforts are needed to improve knowledge and technology transfer

Increased efforts are needed both by institutions carrying out basic research and in companies in order to overcome the regrettable deficits in implementation. The private sector must open up promising fields, which are compatible with the specific strengths of German research. These should be promoted by increased third-party funding, the establishment of new foundations and institutes, and new models for cooperation between companies and universities or research institutions. There are growing numbers of examples of this, e.g. at the LMU Munich, RWTH Aachen, and the universities in Darmstadt, Heidelberg und Oldenburg.[62]

Knowledge and technology transfer works very well where manufacturing companies and public research institutions are working in complementary fields and can exchange information on the basis of well-established personal contacts. However, all too many research projects and institutes find no potential industrial partners in their vicinity and prefer to draw on the attractive funding from public sector sources. In addition, these institutes do not have the necessary incentive mechanisms for cooperation with the private sector, or they lack sufficient experience. In particular the institutes of the Fraunhofer Society and the universities cooperate closely with the private sector.

For non-university research institutions, the ability and willingness to engage in transfers depends primarily on the priorities that they set themselves and the personnel management. There are considerable differences between institutions, with some even showing “transfer abstinence”. The key assessment criteria for MPG institutes are excellence and the numbers of publications, as well as training young scientists. In HGF and WGL, the technology transfer mechanisms are not structured clearly enough, which is the result of the greater heterogeneity of these institutions. In the course of the reorientation over the past ten years and in the course of evaluations, both HGF and WGL have attached increasing importance to scientific excellence. The excellence of publications was cited as the most important point for the assessment of performance at HGF in 63 percent of cases (WGL 62 percent), but knowledge and technology transfer to companies was only cited in 14 percent of cases (WGL 13 percent).[63] Scientific excellence should not be abandoned as a goal and evaluation criterion, but in the coming years increased support should be given to cooperation between the private sector and science, and to the willingness to engage in knowledge and technology transfer. This requires measures at the level of control mechanisms, governance, and human resources management, e.g. further training and new career models for scientists.

Governance of the German R&I system

Successful innovation requires the cooperation between various actors from basic research, the education system, and the private and public sectors, as well as legislation and regulations. A “cohesive and uniform innovation policy” should support the close links between the actors and thus ensure the development at the national level of a more effective innovation value chain in specific areas of promise.

In many countries, responsibilities for research and innovation policies develop over time, and as a result are often distributed between several ministries, which restricts the effectiveness of the process chain. As in many other countries, research and innovation policies in Germany are in the main the responsibility of two ministries, the Federal Ministry for Education and Research (BMBF), and the Federal Ministry for Economics and Technology (BMWi). This division of responsibilities can make it more difficult in some cases to implement a “cohesive and uniform innovation policy” and to establish a bridge between basic research and innovation in the private sector.

In addition to the coordination problems between science and economics departments, the governance of the R&I system in Germany has a series of characteristics, which also restrict the efficiency of policy making. For example, numerous departmental research institutions and federal agencies are also allocated to other ministries, in particular the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV), the Federal Ministry of Health (BMG), the Federal Ministry for the Environment, Nature Conservation and Reactor Safety (BMU), the Federal Ministry of Transport, Construction and Urban Affairs (BMVBS), and the Federal Ministry of Defence (BMVg). In important fields of innovation, e.g. electromobility, energy research and materials research, this makes it more difficult to follow an effective national innovation strategy.

An example is materials research, which has been supported since 1984 by consecutive programmes at Federal Government and Laender levels as well as by the EU Commission. Over this period, some excellent research results have been achieved in Germany for important new materials (e.g. structural ceramics, or carbon fibre composites). However, there is often inadequate commercial implementation and a continuous value-creation chain is missing. This is due in part to a failure of coordination, made worse by excessive decentralisation and overlapping in the provision of research support. The transition from research projects to independent entrepreneurial structures is not pursued by the actors involved, among other things because there are numerous follow-up programmes providing support for R&D projects, distributed among several ministries, various project funding institutions and Federal States. For example, projects concerning new materials in aeroplanes fall under the responsibility of the Ministry for Economics and in part the Ministry of Defence. But very similar projects in the automotive sector are classified under mobility and are allocated to the Federal Ministry of Transport. In addition, important complementary developments of processing technologies are covered by the WING programme of the Federal Ministry for Education and Research. Many agencies are involved along this "support chain" and some Laender have also set up their own ambitious materials research programmes. It is quite common for projects to pass along the stages of this support chain, without the research results being transferred to marketable products. Between 2000 and 2008, material researchers were able to obtain follow-up funding in the nanotechnology sector. Currently, funding opportunities for materials projects are being opened up by new initiatives in electromobility and light-weight construction, without rigorous examination of why very similar projects failed in the past (e.g. in the automotive industry).[64]

The High Tech Strategy adopted by the Federal Government was an important step towards overcoming this coordination problem. However, the implementation of the strategy was the responsibility of the individual ministries and the associated project funding institutions and advisory bodies. So far, little use has been made of the opportunities for improved cooperation between the ministries offered by the High Tech Strategy.

In contrast to many other countries, Germany does not yet have a powerful body to coordinate research and innovation policies at the national level and to generate the necessary coherence between government ministries. This is the role played by the *National Science and Technology Council* in the USA, the *Council for Science and Technology Policy* in Japan, or the *Council for Science and Technology Policy* in Korea. The existing institutions in Germany, such as the Science and Industry Research Union or the Council for Innovation and Growth, do not have a comparably broad remit. The Federal Government has important advisory bodies such as the Research Union, the German Academy of Science and Engineering acatech and the Commission of Experts for Research and Innovation, but they do not have clearly separate remits. The Expert Commission feels that Germany should also have a body with high-ranking representatives from business, science and politics to formulate guidelines for research and innovation policies and to supervise their implementation. This should report directly to the Federal Chancellery and have full authority and resources in order to implement the measures needed to increase the effectiveness of the R&I policies.

In other countries, and at the EU level, innovation agencies have been adopted. In Germany, however, the model of project funding institutions predominates, which has its advantages but which also leads to further departmentalisation and individual dynamics. Programmes are often prolonged, and can

continue for decades. The established organisational structure of government departments, project funding institutions and research institutions explains in part why there has so far not been a strategic re-orientation of innovation policies.[65]
A typical dilemma for Germany is due to the twin-track nature of research and innovation policies at the level of the Federal Government and the Laender. The research at universities is mainly the responsibility of the Laender, whereas the non-university research institutions mostly receive funding from federal bodies and fall under their responsibility. Innovation policy and support programmes are implemented in parallel at federal government and Laender levels, in part in overlapping areas, but without the necessary coordination and focussing. Germany can and should urgently reform the excessive federal structure of education, research und innovation policy in order to achieve a higher ranking among the leading innovative countries.

Conclusions and recommendations

The German economy can only compete internationally if it successfully implements innovations. A key condition for this is the systematic increase of public R&D expenditure and private sector expenditure on innovation. The revised High Tech Strategy must provide additional impulses for the private sector to make further targeted investments in research and innovation. The German private sector should increase the proportion of their gross value added spent on R&D. Policy-makers are called on to support this by establishing innovation-friendly framework conditions.

Retain the three percent target – define interim targets

In the course of the current Bundestag through to 2013, efforts should be made to steadily increase R&D both in the private and public sectors. The three percent target of the Federal Government can only be reached in five to ten years time. In view of the financial and economic crisis a more realistic figure in the order of 2.7 to 2.8 percent should be taken as an interim target. The Federal Government and the Laender should set a good example and increase public expenditure on science and R&D to a steady 0.8 percent of gross domestic product.

Expanding cutting-edge technology

Structural economic changes and the further increase of R&D intensities should be a declared aim. This requires a targeted expansion of cutting-edge technology, because in the longer term, Germany cannot rely solely on high-value technologies and leave the cutting-edge technology to other countries. Steps must be taken to expand segments of cutting-edge technology in which a comparative advantage can be secured globally. Investments should be avoided in fields, which are subject to international subsidy wars. Germany cannot afford to invest public funds in areas of applied research, in which there is no realistic chance for private companies to take up the results and contribute to value creation in Germany.

Expanding knowledge-intensive services

Germany still has some catching up to do in many areas of services innovation. The Expert Commission recommends expanding knowledge-intensive services (services designed in Germany) where these are complementary to existing focal points in the economy. This requires support strategies, which are specifically tailored to suit the innovation processes in the services sector.

Increased targeting of the High Tech Strategy

The High Tech Strategy of the Federal Government has sent out an important signal about the importance of science, research und innovation. However, the limited budget was spread across too many fields of technology, which had played an important role in past Federal Government policies. The High Tech Strategy should concentrate on a maximum of ten fields of technology. This involves harmonising these fields with those identified in the foresight process and with the investment priorities in the private sector.

Further optimisation of non-university research

The distribution of funds and the “division of areas of specialisation” between the various scientific institutions should not be regarded as unchangeable. This applies in particular for the departmental research of the Federal Government and Laender. Structural reforms are necessary in order to improve the effectiveness of science organisations. The system of non-university research should be further optimised. In the coming years, particular attention should be paid to science organisations with internal heterogeneity and also in part duplicated research activity, in order to optimise structures and to highlight the specific contributions to Germany's innovation system.

Knowledge and technology transfer as a priority

Knowledge and technology transfer (WTT) from non-university research and the universities should be expanded as a priority. This goal must not be neglected in the justifiable pursuit of scientific excellence, as could be observed in various organisations in recent years.[66]
In particular the governance and the management and incentive structures of many research institutions are in need of further improvements. Suitable lessons should be drawn from the positive experience in many fields in Germany. This should stimulate sustainable improvements in other institutes and science organisations. New models are needed for cooperation between research institutions and the business sector as well as between the various science organisations. This will require the systematic evaluation of the experience gained so far in Germany. At the same time it is necessary to learn from the application of comparable models in other countries and to develop suitable benchmarks.

Improving research and teaching at universities

In future, research at universities must also be strengthened considerably. The Expert Commission recommends developing new models for cooperation between universities and companies in the form of Public Private Partnerships. New models are also needed for cooperation between universities and non-university research institutions along the lines of the existing developments in Karlsruhe and Aachen / Jülich. Universities are the key element for the development of a continuous Education – Research – Innovation chain. The combination of research and graduate training in Master's and PhD courses is the domain of the universities and should be strengthened further. This implies also that awarding PhDs should remain the exclusive priority of full universities. Joint graduate colleges involving universities and non-university research institutions should be developed further, but awarding academic degrees must not be entrusted to institutions outside the universities.

Increasing cost transparency, introducing full-cost funding

Effective research must be financed appropriately and supported with modern accounting and budget instruments. Project support by the Federal Government should in the short term include a lump-sum payment to cover indirect costs. In the medium-term it is appropriate to reimburse in full the costs of the research institutions carrying out third-party funded projects. Special adaptations are required for university research and appropriate infrastructure and cost-accounting systems must be introduced. This will strengthen third-party funded research and create a level playing field for the various science organisations. However, it must not lead to the Laender cutting the basic funding for the universities.

Full financial responsibility for universities

In order to develop infrastructure and establish the accountability of indirect costs it will be necessary in the longer term to overcome the lack of transparency in the division of ownership rights between universities and the responsible Federal State. This applies in particular for the ownership and rights of disposal regarding land, real estate and intellectual property. In the USA, the top universities are particularly strong because they hold property and patent portfolios, and are supported by rich foundations. In Germany, reforms have been introduced in North Rhine-Westphalia and Hesse to transfer real estate to universities. After evaluation of the experience made, new models should be developed for capitalisation and the expansion of foundations along the lines of the American model.

B 2 THE BOLOGNA PROCESS – AN INTERIM ASSESSMENT

Innovations require well-educated personnel. The Expert Commission reports from 2008 and 2009 made clear that Germany's education system is at best average in OECD comparisons and in recent decades has lost the leading position it once held.

The weaknesses are known. Despite a rise, the entry rates to higher education in Germany remain lower than in other countries.[67] This applies in particular for mathematics, computer science, natural sciences and engineering. There is considerable selectivity in terms of social background, which is only in part related to performance and ability. Potential is remaining unused here. The drop-out rates from German universities are high, students take a long time to complete their studies, and there are obstacles in the way of changing to and from foreign universities. Packed timetables, poor supervision provisions and neglect of teaching mean that students do not enjoy optimum conditions and teaching staff has little time for good teaching and good research. Contacts between teaching and research and the business sector, which are so important for the innovation process, also remain underdeveloped.

In the course of the Bologna Process, German university teaching is being reorganised to confer bachelor's and master's degrees. The Expert Commission has been investigating whether the reform has yet been able to overcome any of the weaknesses in the German higher education system.

Bologna Process: Goals, hopes and fears

The Bologna Declaration of 1999 had the goal of introducing an internationally comparable higher education system with a three-level model: an undergraduate cycle (bachelor's degree) and a graduate cycle (master's degree) and a doctorate, which could be adapted to individual needs.[68] The degree awarded after the first cycle was to be relevant to the European labour market as an appropriate level of qualification. Internationally comparable degrees were intended to simplify and increase the worldwide mobility of students. German students should find it easier to study abroad for part of their course, and foreign students would have an extra incentive to study in Germany. This would improve Germany's position in the competition for talented students.

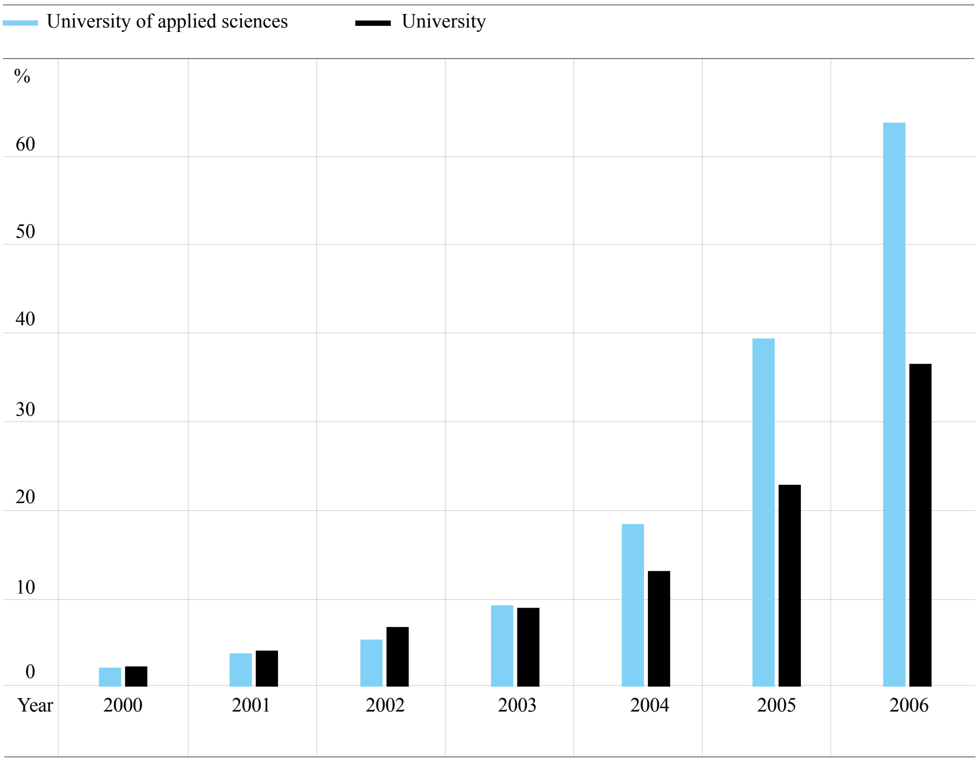
At the follow-up conferences, a social dimension was added to the original Bologna agenda. The reform should also lead to equitable access and completion.[69] Further hopes were raised by the Bologna Process, particularly in Germany. The updating and reorganisation of curricula, the decline in the numbers of drop-outs,[70] and also increased applications, especially for mathematics, computer science, natural science and engineering. To achvieve this last goal, emphasis was placed on recruiting increased numbers of women.[71] The reform proved controversial from the start. In the existing system with 'diploma' and 'magister' courses, students often had more freedom of choice than in the new bachelor's and master's courses. In addition, the new courses were shorter, and given the fact that at the same time the secondary education was reduced from nine to eight years, dispensing with an orientation year (studium generale) also met with criticism. The relationship between the new bachelor's degree courses and the system of dual vocational training remains unclear. Both take about three years and lead to occupational qualifications, but which function does each have? Equally, it is not clear how many graduates will go on to take a master's degree. As a result, warnings were expressed that the Bologna reform would lead to lower levels of education, and to poorer qualifications for graduates. The universities have drawn attention to the changing relationship between teaching and research, and they see the risk that higher teaching commitments could be detrimental to the research performance of university staff. These criticisms make clear that the frequently questioned acceptance of the new qualifications by employers may be only one of many indicators for the success or failure of the reform.

Ten years after Bologna: Initial findings

The transition to the new degree courses is now well under way. After a hesitant start, 45 percent of new students in 2006 were starting a bachelor's degree course (Figure 4).[72] By the summer semester 2009, more than 75 percent of courses were for the new degrees, with considerable difference between the Laender.[73] Five years previously the figure had been below 25 percent. The transition at the uni-

Proportion of all new students in a year starting a bachelor's degree course according to higher education institution

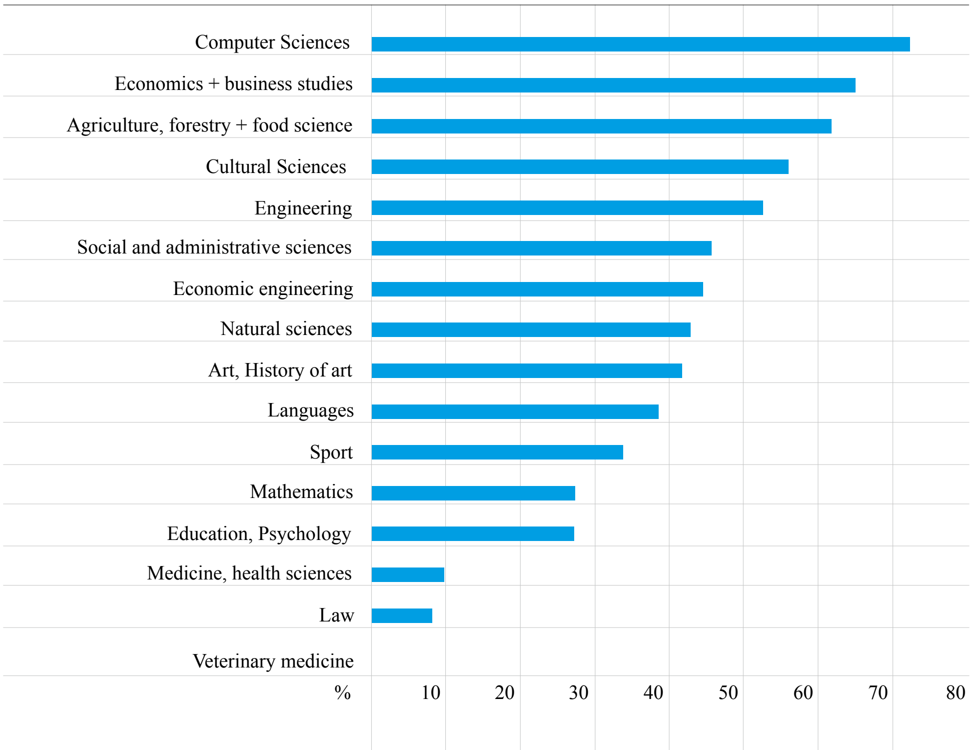
FIG 04



Source: Federal and Land Statistical Offices, Student and examination statistics, 2000 - 2006.Calculations by ZEW. Mühlenweg et al. (2010).

Proportion of all new students in 2006 starting a bachelor's degree course according to subject

FIG 05



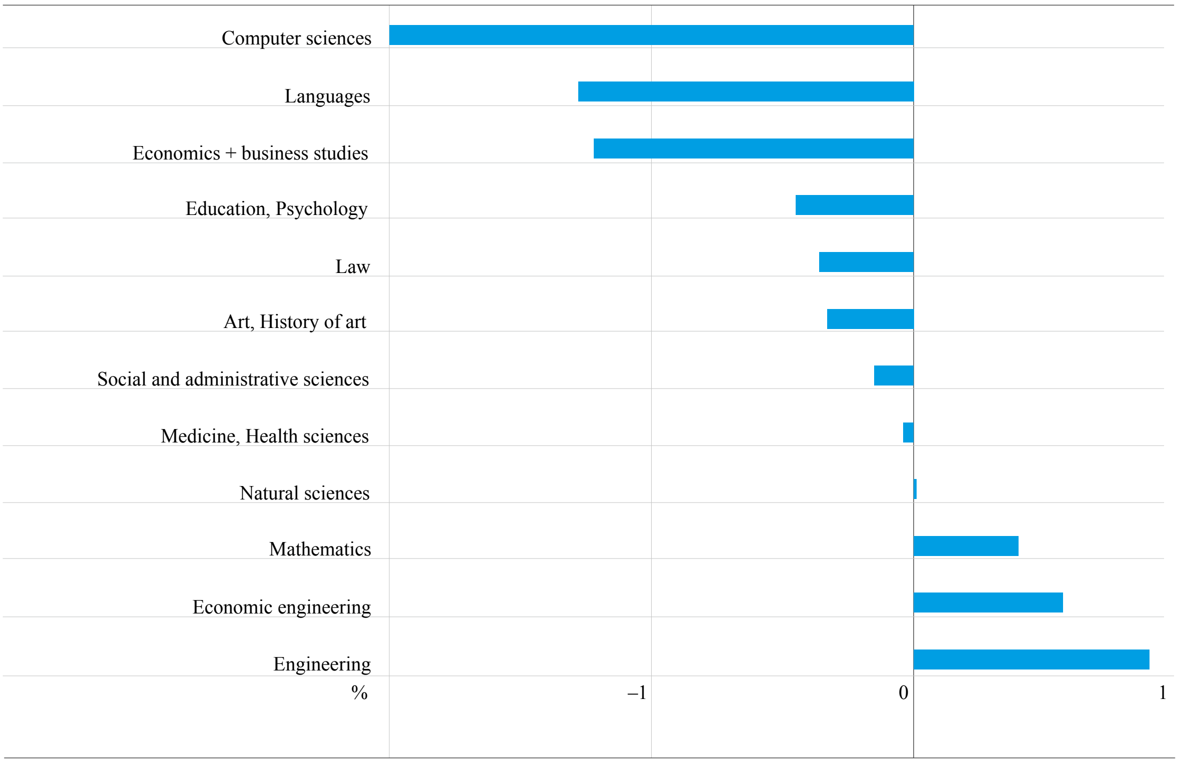
Source: Federal and Land Statistical Offices, Student and examination statistics. Calculations by ZEW. Mühlenweg et al. (2010).

versities of applied sciences (Fachhochschulen) was particularly quick. In 2006, 63 percent of students were studying for a bachelor's degree. At universities, in contrast, the figure was only 36 percent. There are considerable differences between subject groups (Figure 5). In computer sciences and engineering the changes have been implemented faster than the average.

The developments have so far proved disappointing for those who expected that the introduction of the bachelor's degree (generally offering an occupational qualification after six semesters) would significantly increase both tertiary education entry rates and the numbers of graduates. Nor have the changes appreciably reduced the numbers of drop-outs. In fact the drop-out rates from bachelor courses between 2000 and 2004 were at a level, which is comparable with those for diploma courses, and they seem to be stable.[74]

First results also fail to nurture the hope that the shorter, more practically oriented degree courses would attract more students from socially disadvantaged homes than the longer traditional alternatives. There is no evidence that the level of parental education makes students more likely to choose in favour of the new degree courses rather than the traditional ones. The reform has not resulted in more students enrolling for mathematics, computer sciences, natural sciences and engineering. The proportion of potential applicants choosing these subjects did increase from 1995 to 2000, but has since stabilised. The rate of transition[75] to computer science actually fell from 2000 to 2006; in contrast, the rate increased for engineering (Figure 6). It is worrying that the drop-out rates for mathematics, sciences and engineering have risen continuously since 2000. Nor has there been any fundamental change in the ratios of male and female students in these subjects as a consequence of the new courses.[76]

FIG 06 **Development of the rates of enrolment in higher education courses 2000 – 2006**



Source: Federal and Land Statistical Offices, Student and examination statistics, 2000/2001, 2002/2003 and 2007/2008. Calculations by ZEW. Mühlenweg et al. (2010).

Academic qualification and employment situation approx. 1.5 years later TAB 04

	Type of qualification in percent						Total in percent
	BA-FH	MA-FH	DI-FH	BA-U	MA-U	DI/M-U	
Regular employment	58	79	83	20	56	59	59
Job training	1	2	2	2	7	3	3
Degree and employment	12	12	6	22	26	26	21
Only degree	22	1	4	50	7	7	12
Looking for employment	4	2	2	3	2	3	3
Others (family work, etc.)	2	2	2	3	3	2	2
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Number	485	203	4367	2730	1044	13744	22573

BA-FH, MA-FH , DI-FH: Bachelor's degree/Master's degree/Diplom at university of applied sciences (FH):
BA-U, MA-U, DI/M-U: Bachelor's degree/Master's degree/Diplom (or Magister) at a university (U).
Source: INCHER-Kassel. KOAB Graduate survey 2009 (2007 cohort). Alesi et al. (2010).

The reforms have not yet been linked to any significant increase in the proportion of foreign students at German universities.[77] Indeed both the proportion and the absolute numbers of foreign student enrolments have fallen since 2002. Even in the master's degree programmes, which have by far the highest proportion of foreign students, the figures have clearly been falling since 2001. The proportions of foreign students in the bachelor's degree courses are similar to those for diploma degree courses, and have also decreased slightly since 2001.

Even though the tertiary education reforms have not solved the problems of high drop-out rates, social selectivity, a lack of interest in sciences and engineering, and a low proportion of foreign students – it has not produced inadequately qualified graduates, as some feared. One and a half years after obtaining a bachelor's degree, 72 percent of university graduates and 34 percent of graduates from universities of applied sciences (Fachhochschulen) are studying further, mostly for a master's degree at the same type of higher education institution (Table 4: Graduates who are studying + those who are studying and employed). The numbers going on to study for a further degree vary considerably according to subject. The figures at universities are about 55 percent in economics and 86 percent in mathematics and the natural sciences, and at universities of applied sciences they range from 14 percent in the humanities and social sciences to 58 percent in engineering. After obtaining a master's degree at a university, as many go on to study for a further qualification or a doctorate as did in the past after obtaining a traditional qualification.[78] There has been an increase in the numbers going on to further studies after obtaining a master's degree at a university of applied sciences.[79]

Few changes have been made to course contents during the reform. Initial studies suggest that there are no grounds for the fears of some employers that the new degree courses would prove to be very different, but the hopes of others that the course content would be adapted to be more suited to the demands of the working world are also unfulfilled. A study commissioned by the Expert Commission on the changes in nine courses[80] indicates that the opportunity has not been used to introduce any fundamental didactic changes or to revise the contents. Instead, structural reforms and formal changes were made with strict attendance rules, and point deductions. The measures are now often criticised as "over-regulation" or "bureaucratisation"[81] On the whole, more changes have been introduced for the curricula of the master's degree programmes, but in general these are reforms to details, apparently also introduced in the course of quality assurance and accreditation procedures. Whether this is generally the case cannot be established empirically, but there are probably considerable differences from subject to subject and also between universities. Where there is excessive bureaucracy in a faculty or a university, the Expert Commission recommends a "spring clean" so that examination offices and students do not find themselves faced with insurmountable challenges.[82] The Expert Commission also regards it as important that students should be offered scope to organise their own course of studies.

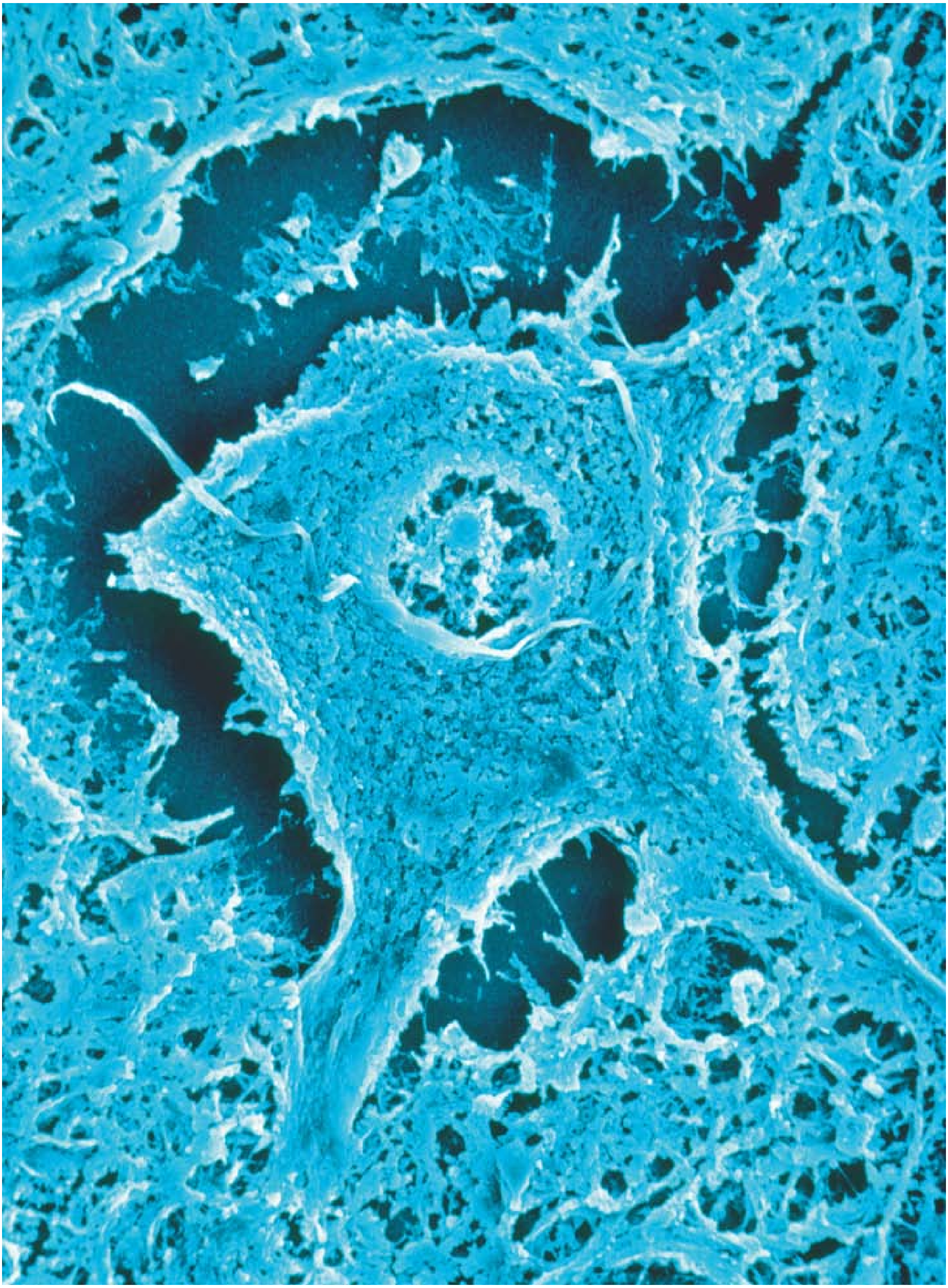
Overall, the course reforms have increased the burden on teaching staff, although here there are also considerable differences between subject groups.[83] The formal teaching requirements are mostly unchanged, but the overall workload has increased as a result of various courses still being offered in parallel (bachelor's, master's, diploma, etc), the need to organise and prepare new curricula, and and because of the increased numbers of students. The burden of setting and marking tests and examinations also increased, primarily due to the packed curricula.[84] The resulting workload of the university staff not only reduces the time available for research, it also reduces the time available for supervising students and is an obstacle to the development of good conditions for students.

In contrast, the transition to the employment system is much less problematic than expected. The direct comparison between those with master's degree and those with a diploma or magister qualification one-and-a-half years later shows that the career prospects with the new qualification are by no means worse. Considering the universities of applied sciences, 91 percent (79 + 12) with a master's degree and 89 percent (83 + 6) with a diploma are fully employed or employed in addition to studying. The comparable figures for universities are 82 percent (56 + 26) for the master's degree and 85 percent (59 + 26) for the traditional qualification (Table 4). For graduates with a bachelor's degree the difference is slightly greater: 20 percent from universities and 58 percent from universities of applied sciences are fully employed. Including those who are in employment while studying for an advanced degree or in occupational further training, the figure for bachelor's degree graduates from universities rises to 42 percent (20 + 22) and from universities of applied sciences to 70 percent (58 + 12). In all cases, the proportion looking for employment is low (2 to 4 percent). If qualitative indicators are included, such as the time spent looking for a job, or job satisfaction, there are still no differences between those completing the new degree courses and those taking the old courses. In terms of income, full-time employment, and qualification for the job (in terms of the level of the qualification and the use of the learning acquired) graduates from universities with a bachelor's degree do only slightly worse than all others. However, in terms of short-term employment and relevance of qualifications for the job, they are at a clear disadvantage compared with all other groups.[85] A look at the various degree subjects individually shows considerable differences in some cases.[86]

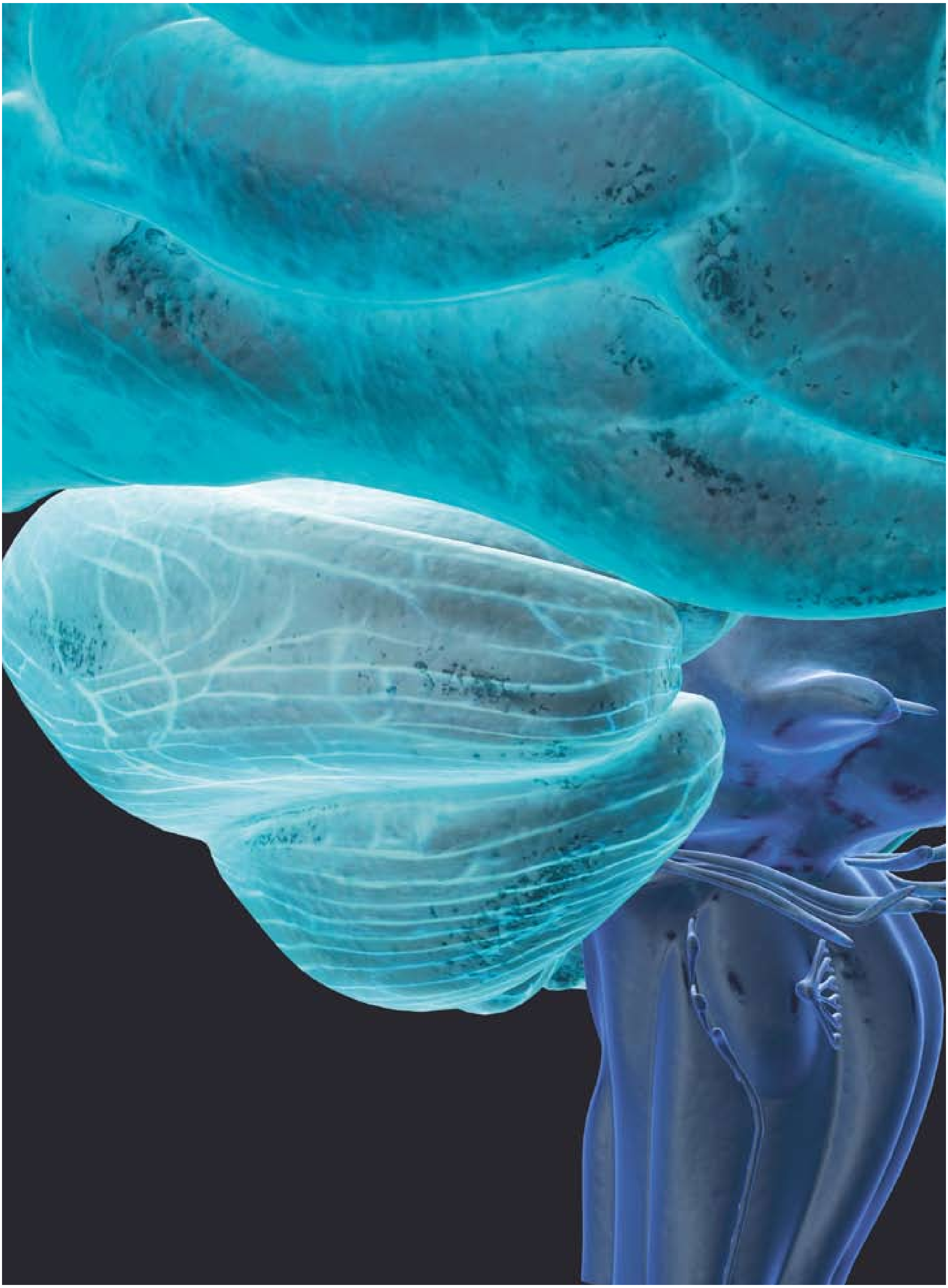
Surveys of employers indicate that they have not yet had much experience with the "new" graduates. As a result there is some uncertainty, but not general rejection. Employers do not complain about a basic lack of qualification. Their evaluation of the risks and opportunities of the new courses relative to the old ones depends more on the specific job requirements, which can vary widely between sectors.[87] A common wish among employers is that the shorter bachelor's degree courses should retain a link to practical requirements, and that students should have the opportunity to gain practical experience as part of their studies.[88]

Reforming the reform

Since the start of the Bologna process, the implementation of the reforms has been accompanied by public debates, stimulated by the student protests in 2009. The Standing Conference of the Ministers of Education and Cultural Affairs of the Laender (Kultusministerkonferenz - KMK) admitted that there was "not inconsiderable scepticism in parts of the academic community concerning the Bologna Process".[89] At the Bologna follow-up conference in Leuven/Louvain-la-Neuve in April 2009, numerous criticisms were raised, which were taken up in October and December 2009 by the Standing Conference. It was decided to revise the joint structural provisions for the Laender for the accreditation of bachelor's and master's courses and to change the requirements for the introduction of credit point systems and modularisation. The objective is to create good conditions at the universities, which contribute to making courses more flexible and which increase the accessibility of the higher education system.[90] The Expert Commission welcomes this approach, but urgently warns against any over-hasty implementation. Given the differences between specific subjects and disci-



Human neuron cell body



Side view of the cerebellum and brain stem plines, appropriate adjustments are required in each case. While integrating the students in the development process, it is important to promote measures, which ensure effective study opportunities. Course contents, structure, and duration must be harmonised, as well as the relationship between compulsory courses and options, and students must be able to make individual choices. Further improvements should be made to the student grant system (BAföG) and the student services set-up responsible for the social concerns of students. There is also a need to improve the acknowledgement of course work and credits between universities (nationally and internationally), to increase international university partnerships and study programmes, as well as to involve employers and alumni more in the development of degree courses.

Conclusion: Bologna alone is not enough

When evaluating the Bologna Process for the innovation location Germany it is necessary to distinguish between specific objectives and more far-reaching hopes. It has to be taken into account that problems encountered in tertiary education may have their origins in earlier phases. Social selection mechanisms begin in early childhood and the choice of degree subjects is influenced by the school system.

From the beginning, expectations were raised by the reforms associated with the Bologna Process which could not be achieved in the short term without the back-up of additional resources and other measures. The review of the first consequences of the reform highlights the need to overcome many weaknesses if the structural reform is to strengthen the innovation location Germany and Europe as a whole.

The Expert Commission recommends the following measures concerning the Bologna Process:

– More autonomy for the universities. A general problem with universities in Germany is that they are not allowed enough freedom to make their own decisions when implementing the reforms. Universities should be able to use all available options when organising new degree courses. Bachelor's degree courses can last six to eight semesters, and master's degree courses two to four semesters. The Expert Commission welcomes the decision of the Standing Conference (KMK, 10 December 2009) to make corresponding amendments to the joint structural requirements for the accreditation of new courses. Instead of fine control, the Laender should offer the universities more scope, while striking a balance between target agreements and the allocation of resources.

– Obstacles to mobility can be overcome by more generous recognition of previous coursework and credits and the reliable specification of equivalents in course regulations. This is highlighted by a KMK resolution.[91] It is also important to actively promote student mobility. This should include more comprehensive and more generous financial support for student mobility, and cooperation between universities in Germany and other countries. The Expert Commission also sees possibilities for an increase in English-language courses, which are particularly attractive for foreign students. Existing programmes should be evaluated to identify examples of good practice.

– Reducing drop-out rates. The Expert Commission already pointed out in the previous report that the drop-out rates in the natural sciences and engineering are particularly high. This is expensive, inefficient and problematic for the innovation location Germany, even if high drop-out rates are not a uniquely German problem.[92] Studies show that there are a range of reasons why students drop out.[93] Inadequate conditions for studying are more significant than other factors, such as attractive educational or occupational alternatives. Complaints concern the poor lectures and seminars, inadequate teaching skills, a lack of optional courses and tutorials, and poorly organised timetables and exam schedules. Some find the demands of university are incompatible with other obligations, such as looking after children, part-time employment, or illness. A bundle of measures is required in order to lower the high numbers of course drop-outs: grants and loans for students, options to organise courses flexibly or to study part-time; information, advice and preparatory courses prior to committing to a subject or in the initial phases of a degree course; higher quality of teaching, and better course organisation. It is also important to include checks on performance at an early stage and give detailed feed-back, and universities which have introduced these have already been able to achieve initial success with reducing drop-out rates in languages, and cultural and social sciences.[94] However, these mechanisms must be coordinated with other measures and as well as making demands of students, they must also be supported. In particular, faculties with high drop-out rates should make greater efforts to develop selection and admission procedures, with tests to establish the suitability of applicants.Developing systems of funding.

– Student fees are an important component of university finances in some Laender and they make sense when the receipts are invested in the teaching. But they must not act as a disincentive to young people who want to study.[95] The Expert Commission believes that in particular students from low-income households must be offered the best possible financial conditions. This includes expanding and increasing the student grant system (BAföG), without age restrictions.[96] The current regulations are too restrictive. Student grants are generally only available for those under thirty years of age. Special conditions apply for those who have qualified for tertiary education through adult education schemes, or who have children. However, the students must begin studying immediately after obtaining the qualifications or when the impediment no longer exists. The Expert Commission welcomes the announcement by the Federal Government that they intend to raise grant levels and parental allowances, and to increase the age limit for master's degree students in 2010 to 35 years. But further changes are needed. In addition to government support, the mobilisation of private sources of funding for university education can also be improved, analogous to the strategy of the Federal Government for expanding the grant system, or along the lines of the grant system in North Rhine-Westphalia.[97]

– Including the supervision of doctoral students as part of the teaching duties of professors. The supervision of doctoral students in structured programmes such as the DFG postgraduate colleges should be included as part of the teaching duties. The Expert Commission points out that the time spent in this way by professors is to the detriment of research, active institutional involvement, individual career counselling, and the supervision of student organisations.

RESEARCH AND INNOVATION IN EASTERN GERMANY

B 3

The 20th anniversary of the fall of the Berlin Wall last year and of German unification this year have once against raised the question about the state of development in the new federal states and appropriate support strategies. The Commission of Experts for Research and Innovation wishes to contribute to answering this question. It seems appropriate to start with a short review of the historical roots of the current situation in the new federal states and in Berlin. What happened in the course of the transformation process and which innovation policies were implemented?

Transformation process and the collapse of industrial R&D in eastern Germany

At the time of the fall of the Berlin Wall, the GDR had a well-developed research and university landscape and a high proportion of highly-qualified personnel in the workforce.[98] However, in the socialist planned economy, research and innovation could not power economic development.

The innovation process organised by the planning authorities was linear. New technologies were generated by scientific research and passed on for implementation to the 'state holding companies' (kombinat) or specific companies. There was thus controlled transfer of knowledge and technology, with hardly any direct feedback from the users of the products. The contents and goals of scientific research were largely derived from plan targets for production. The research and innovation system was not organised to develop new potential for value creation and in this way to continuously renew the structure of the economy. There was no innovation competition, and measures to maintain existing structures were dominant. In addition, the work of scientists was considerably impeded by supply shortages and the lack of opportunities to develop new ideas.

Industrial research and development in the GDR was carried out in special company departments and in legally independent industrial research institutions. The R&D departments were responsible for supervising production processes and for introducing new products and processes, through to series production. The relatively large industrial research institutions were assigned to the state holding companies and in some cases they worked for an entire manufacturing sector. Their remit was to pursue product and process innovations with targeted applied research.

In the course of the transformation of the economic structures of the former GDR, the individual enterprises of the state holding companies were sold off, re-privatised or liquidated. West German and foreign investors were mainly interested in factories and market access, and much less in developing independent R&D capacity in the companies they took over. And where there were management buyouts, funds were not usually readily available for in-house research and development. The result was that the new Laender experienced a massive decline in company research and development.

The former industrial research institutions run by the state holding companies were evaluated in 1991 for the Treuhand holding agency. Many of them were retained as highly subsidised external industrial research institutions – the aim being to maintain research capacities. Other external industrial research institutions were created from the R&D departments of companies, for which no investor could be found. The collapse of production in the new federal states in the early 1990s meant that privatised companies had much less demand for R&D services. This resulted in massive lay offs in the external industrial research institutions. Some of the research companies were wound up. The remaining external industrial research institutions now operate as commercial enterprises or as non-profit organisations without institutional support. The number of R&D employees in the private sector (full-time equivalents) sank from 86 000 in 1989 to 32 000 in 1993.[99]

Basic research in the GDR was carried out by the non-university institutes, which were organised in the Academy of Sciences (AdW). The academic research showed greater variety than industrial research, but was also subject to the decisions of state bodies and the requirements of the plans. The Unification Treaty envisaged winding up the AdW by the end of 1991. With dismissals, departures, the formation of spin-off companies and (early) retirements the personnel numbers of AdW fell from 24 000 in June 1990 to nearly 16 000 in November 1991.[100]

The German Council of Science and Humanities evaluated the institutes and made recommendations about which should be retained. Positively assessed institutes were "re-established" and integrated in west German research institutions; the others were closed. By January 1992 this led to 32 institutes in the so-called "Blue List" (now the Leibniz Association); in addition, eight institutes were integrated in the Fraunhofer Society and two institutes in the Max Planck Society.[101] In some cases, research groups or parts of institutes transferred to existing non-university research institutes or universities in west Germany. The former employees of the "re-established" institutes were not automatically re-employed, but had to submit a new job application. Some research groups therefore preferred to create spin-off companies in private initiatives.

The universities in the GDR carried out some research, but their main remit was to teach. When East Germany joined the Federal Republic of Germany, the new Laender assumed responsibilities for the universities, whose structures were adapted to those of the west German universities. This involved a revision of contents and changes in personnel. Specialist facilities were in part integrated in other universities, and some universities received a new profile as universities of applied sciences. These measures meant that most universities in the new federal states could be retained. Some scientists from individual universities got together and established external industrial research institutions.

The overall result has been that the transformation of the university and research landscape in the new Laender led to a massive decline in industrial research and development. Links which had existed between the manufacturing sector and science in the GDR were for the most part broken. New networks had to be built up from scratch. The external industrial research institutions remain a special feature of the German R&I system, and a reminder of the transformation process. They now have an important service function, in particular for SMEs in the new federal states, which do not have the resources to carry out their own research and development. The public sector in the new federal states and Berlin currently includes 57 universities, 42 institutions of the Leibniz Association, 31 institutes or centres of the Fraunhofer Society, 23 locations of the Max Planck Society, and four research centres of the Helmholtz Association, as well as a series of Federal and Laender institutions with R&D remits.[102] In east Germany (including Berlin), there are nearly 79 000 R&D personnel (full-time equivalents), of which 40 percent are in the private sector and 60 percent in universities und scientific institutions.[103]

Promoting innovation: From stop-gap measures to all-German programmes

Following unification, the key political goal in the new Laender was to establish a viable economic structure, which would be able to survive market exposure and offer sufficient employment and earnings potential.[104] It was recognised at an early stage that research, innovation and technology policies were crucial for reaching this goal. However, in the course of two decades there has been a marked shift in the measures adopted and the philosophy behind these.

Following German unification, the Federal Government adopted innovation policies intended to stabilise R&D in the new federal states and prevent a mass migration of R&D personnel. This involved special programmes for eastern Germany ("Personnel Promotion East" –PFO, and "Economic Stimulation East" - ZFO). And in order to give companies financial scope to place orders for R&D, "Research Commissioning East" was introduced in 1990. Instruments for project-based support were also adopted, in particular for SMEs, and measures were adopted to make it easier to set up new companies. The system of joint industrial research in West Germany, which provides support for research work for SMEs by university and non-university research institutions, was extended to cover the new federal states.[105] Finally, massive investments were made in innovation-relevant infrastructure, both by the Federal Government and the Laender, for example in technology and start-up centres.[106]

This policy of providing broad support was appropriate directly after unification. However, it soon became clear that more focused support instruments were needed, which would operate more efficiently. Until the mid-1990s, the innovation activities of companies in the new Laender were mostly restricted to the imitation of existing products. However, the innovation policies in western and eastern Germany at this time were already having to face new challenges, as described in Section B 1.[107] This made it necessary to develop further the instruments of research and innovation policies in both national and regional contexts. The priorities were the optimisation of the framework conditions and the support for R&I cooperation projects.[108] This reflects the fact that innovations are usually the product of complex systems involving many actors, which do not progress along a one-dimensional, technology-driven line of development, or solely within one organisation.[109]

In order to use R&D support funds more efficiently, they should be concentrated on growth drivers. The Federal Government now increasingly adopts a region-oriented innovation strategy, which requires actors to be more independent and responsible for their own actions.[110] The "Enterprise Region" programme has the goal of strengthening the innovative potential of individual regions in east Germany, which have been selected in a competition. The Expert Commission welcomes the inclusion of competitive elements in the support measures of the Federal Government.

In the recent past, more importance has been attached to the market implementation of research and development results. It is also noticeable that many programmes aimed at supporting east Germany have been merged in national programmes. A good example is the Central Innovation Programme for Small- and Medium-sized Enterprises (ZIM), which has absorbed various east German programmes.

Since the mid-1990s, the proportion of the Federal Government's R&D expenditure going to east Germany has remained stable at about a quarter. The largest sums in east Germany go to the Laender Berlin und Saxony (with Bavaria und Baden-Württemberg receiving most in the old Laender). However, at least twice as many R&D companies in the east receive public support as in the west. And support intensity, (i.e. the proportion of the R&D expenditure of companies carrying out research, which derives from government support) is appreciably higher in east Germany than in west Germany.[111] This shows that the existing support instruments are reaching many companies in the new federal states.

Economic performance in the east still lower than in western Germany

Given the considerable political efforts to create viable, self-supporting structures in the new federal states and Berlin, how successful have these measures been? What is the current economic potential and innovation performance in the new federal states?

In 1991, the real gross domestic product (GDP) in the new federal states bottomed out and then began to rise sharply. Since the mid-1990s the growth rates of GDP in east and west moved closer, with the new federal states mostly growing slightly more than the old Laender. However, the difference in growth rates is so slight that it is not possible to speak of catching up.[112] GDP per resident in the new federal states (without Berlin) is some EUR 22 000; this is 73 percent of the national average. The regions and cities with the lowest GDP per capita are still almost all in the new federal states (Figure 7).

High R&D expenditure in the science sector in the new federal states

High value creation is frequently associated with knowledge- and technology-intensive production and corresponding investments in research and development. Taking overall expenditure on R&D as a proportion of gross domestic product, the west German Laender, at 2.6 percent, are above the OECD average (2.3 percent). However, this is still some way behind leading countries Sweden, Korea, Finland und Japan, who spend about 3.5 percent of GDP on R&D. Eastern Germany, with 2.2 percent, has nearly reached the OECD average. This puts the region ahead of Great Britain (1.8 percent) or the Netherlands (1.7 percent). Of the German Laender, Saxony is well placed (Figure 11) and Berlin is one of the front-runners, with an R&D intensity of almost 3.4 percent. However, in view of its function as the capital city and its status as a Federal State, and given the economic history of the region, Berlin can only be compared with the other Laender to a limited extent.

Whereas the large part of R&D expenditure in the old Laender is provided by the private sector, R&D in the new federal states is mostly government funded. This remains the Achilles heel of the innovation system in east Germany. There is a shortage of innovative companies, which generate growth. Nevertheless, the R&D expenditure has risen continuously since unification. In 2006, it was at least 40 percent higher than in 1995 in east Germany and increased in particular in the private sector.[113] In contrast, the number of R&D employees began to decline slightly after the stabilising in the second half of the 1990s.

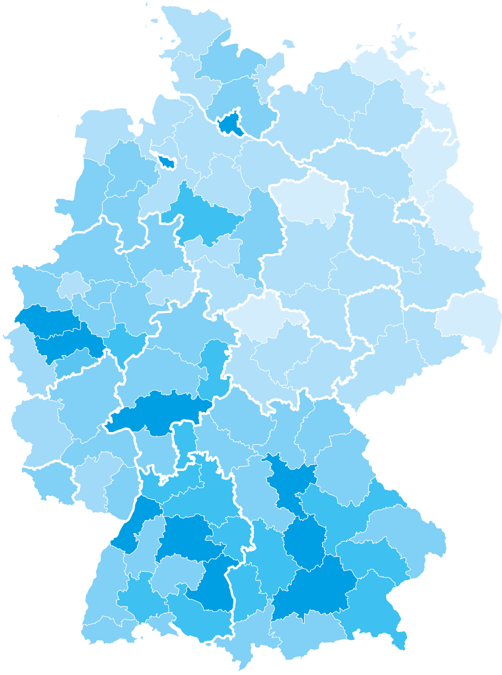
Despite the increase in R&D, the new Laender have not been able to reach the level of the old Laender. In west Germany, R&D employment and R&D expenditure have increased more since 1995 than in east Germany. This is above all due to the development of the private sector, because R&D expenditure and employment in universities and scientific institutions have developed more or less in parallel in east and west.[114] As well as east-west differences in R&D intensity in Germany, there are also differences between north and south. The group of northern Laender are some way behind the southern Laender. There is a considerable deficit in developments in some regions. In general, more R&D work is carried out in urban agglomerations than in rural areas. None of the regions in eastern Germany reaches an R&D intensity above the national average (Figure 9), but individual cities with technology-intensive manufacturing companies do, such as Dresden, Leipzig, and Jena.

In 2007, 84 percent of all R&D personnel in Germany were working in west German Laender, with a slightly upward trend. This is more than would be expected from the distribution of the national population (Table 5). The new Laender account for more than 10 percent of R&D personnel, and Berlin for 5.5 percent. The new Laender are able to maintain their share over time. R&D employment in the private sector is lower than in western Germany, but this is balanced by an increase in the public sector. Berlin has experienced a considerable reduction in R&D personnel, so that its proportion of the national R&D employment has fallen over time.

The gains in the old Laender are mostly due to increased R&D efforts in Bavaria, Baden-Württemberg, and Hesse, which together employ 55 percent of all R&D workers. Correspondingly, an above-average proportion of private sectors employees in these Laender are R&D personnel, whereas the figures in all other Laender are below average. Corresponding trends for R&D expenditure are observed

FIG 07 **Per capita gross domestic product in 2007 (k€)**

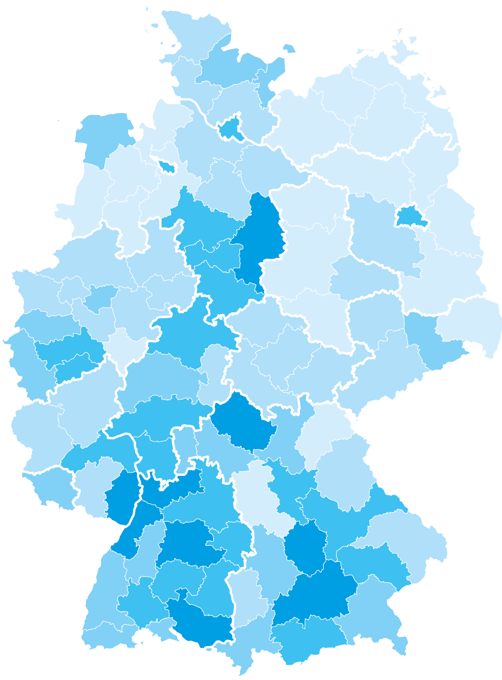
< 20	20 to 25	25 to 30	30 to 35	> 35



Shown for the 2008 boundaries. Data using older boundaries has been converted where appropriate..
Source: Federal and Laender Statistics Offices. Bundesinstitut für Bau-, Stadt- und Raumforschung.
Calculations by EFI.

FIG 08 **Employees in knowledge- and technology-intensive sectors as a proportion of all employees in the commercial sector (31 December 2008) in percent**

< 30	30 to 35	35 to 40	40 to 45	> 45

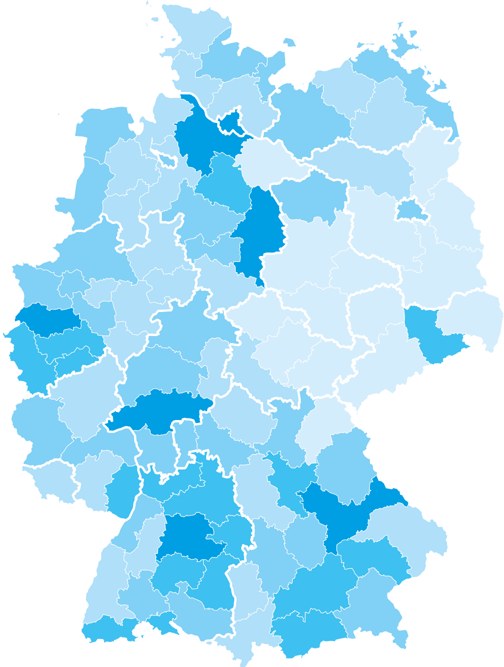


Shown for the 2008 boundaries. Data using older boundaries has been converted where appropriate. Source:
Statistics of Federal Employment Agency. Calculations by EFI.

R&D intensity of the commercial sector in 2007 (x EUR 1 000 per full-time employee)

FIG 09

< 90	90 to 110	110 to 130	130 to 150	> 150

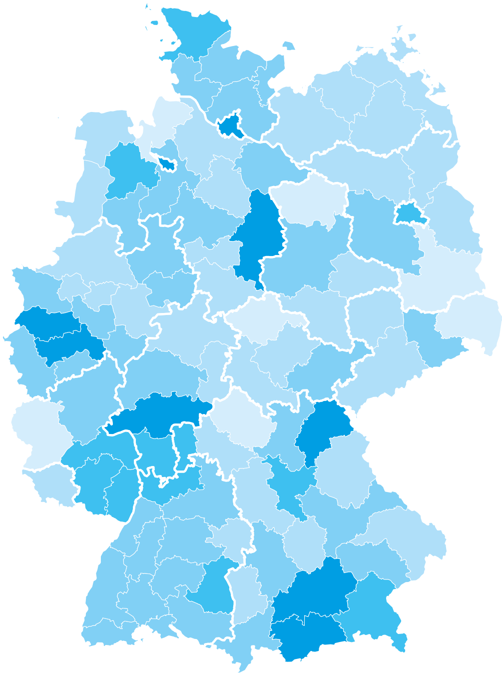


Shown for the 2008 boundaries. Data using older boundaries has been converted where appropriate.
Source: Mannheim Company Panel (ZEW). Calculations by EFI.

Start-up intensity (start-ups per 10 000 employees) in technology- and knowledge- intensive sectors (annual mean 2005 to 2008

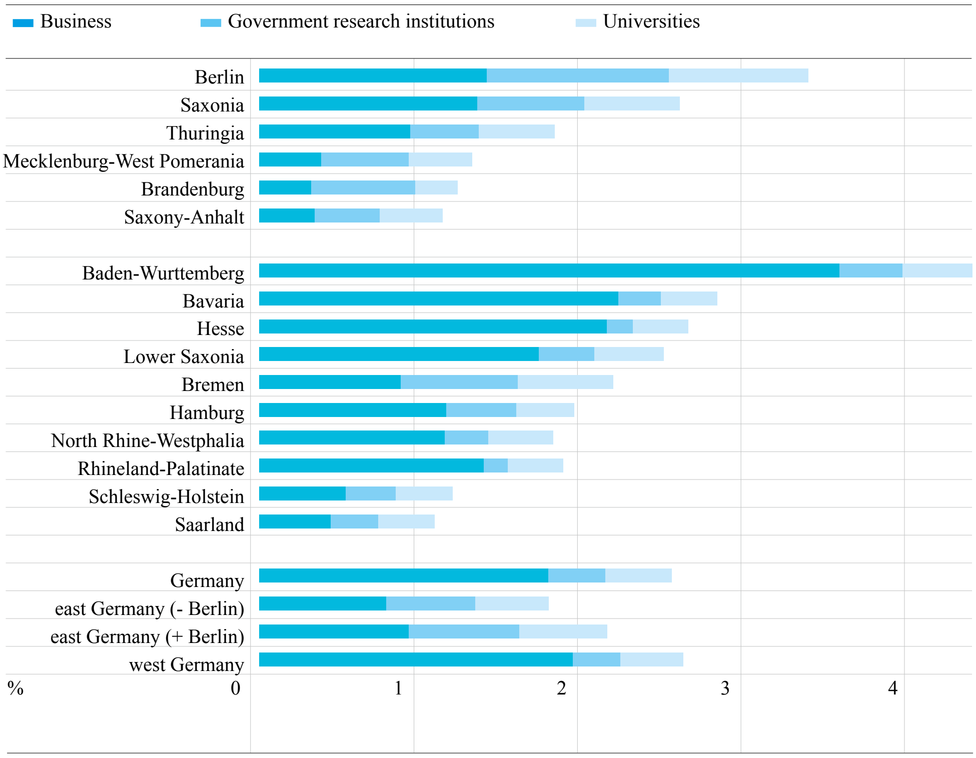
FIG 10

< 4	4 to 6	6 to 8	8 to 10	> 10



Shown for the 2008 boundaries. Data using older boundaries has been converted where appropriate.
Source: Stifterverband. Calculations by EFI.

FIG 11 **Federal state expenditures on R&D as a proportion of GDP (2007)**



Source: Statistical Federal Agency. Stifterverband, Günther et al. (2010b).

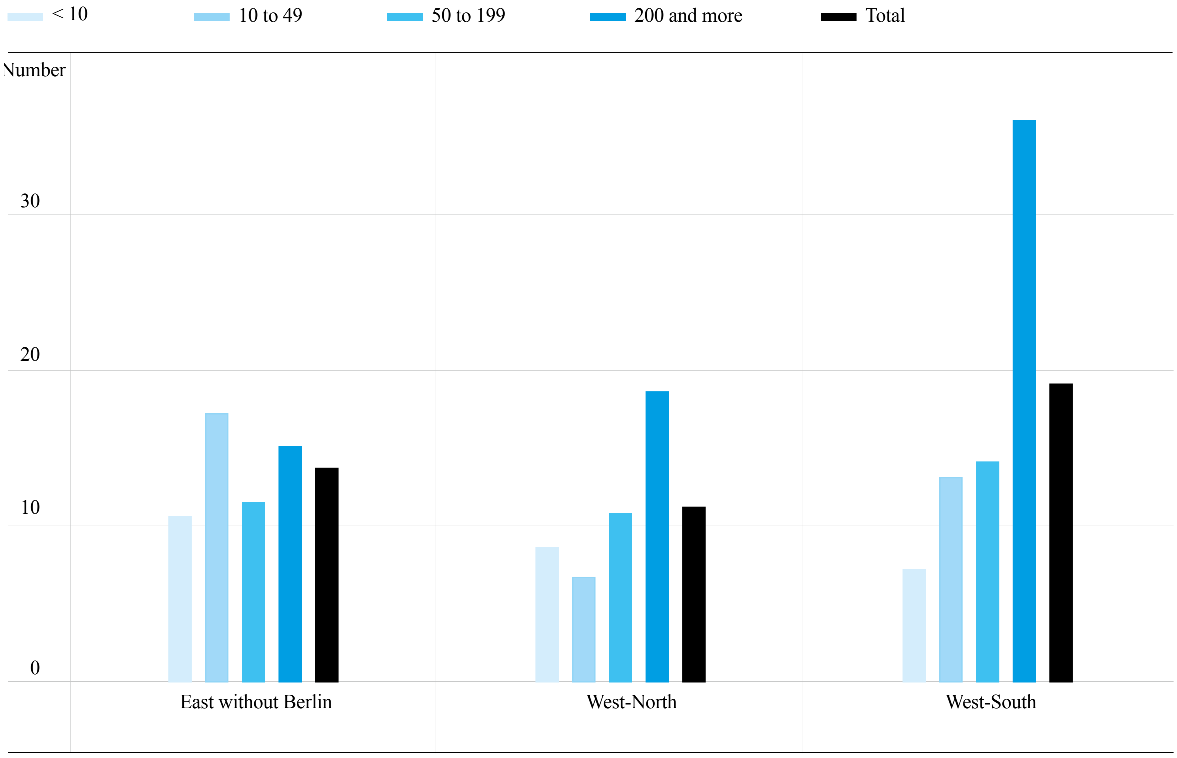
TAB 05 **Structural indicators in comparison**

	east Germany (+ Berlin)	west Germany
No. of residents on 31 December 2008	16.5 million	65.5 million
R&D expenditure as % of GDP 2007	2.2	2.6
R&D expenditure by business as % of GDP 2007	0.9	1.9
Employees in the knowledge economy as % of all business employees. 31 December 2008	32.4	39.9
New enterprises per 10 000 employable persons (start-up intensity) in technology- and knowledge-intensive sectors*	6.1	8.3

*Annual average 2005 to 2008. Sources: Federal and Laender statistical offices. Stifterverband. Federal Employment Agency. Mannheim Company Panel (ZEW). Gehrke et al. (2010). Own calculations.

R&D personnel intensity of companies in 2007 classed according to size[120]

FIG 12



Sources: IAB panel 2007. Calculations by IWH. Günther et al. (2010b).

above all from 2002, since when the three Laender have further established their dominant position. In 2007, 58 percent of internal R&D expenditure was concentrated in these Laender.[115]

Different economic structures in east and west Germany

Differences in the R&D intensity between the new and old Laender are attributable mainly to the weak R&D involvement in east Germany. On closer inspection, it is noticeable that there are considerable differences between the economic structures in east and west Germany.
R&D in Germany is mainly carried out by companies in the manufacturing sector. In the old Laender, 89 percent of all private sector R&D personnel work in this sector, although it only accounts for nearly 20 percent of the west German workforce overall. In east Germany only 71 percent of R&D employees work in the manufacturing sector.[116] More important in east Germany is the R&D capacity in the services sector. A quarter of R&D personnel in the east German private sector work in services companies, compared with only eleven percent in western Germany. Correspondingly, the innovation intensity in the knowledge-intensive services sector in east Germany is also much higher than in west Germany. Currently in east Germany, 48 percent of the companies in the knowledge-intensive services sector pursue innovation processes or introduce new services product, which is still lower than the proportion for west Germany (52 percent).[117] But it seems that an innovative core of knowledge-intensive services companies has developed. This is due among other things to the fact that small and medium-sized enterprises in particular outsource research and development assignments to external service providers, e.g. external industrial research institutions.

If individual companies are considered, rather than economic sectors, then there are clear signs that east Germany is beginning to catch up. This approach is possible using the IAB Panel [118]. The proportion of all personnel in east German small enterprises working in R&D is markedly higher than the corresponding value in Bavaria, Baden-Wurttemberg, and Hesse (Fig. 12). In the services sector, the average independent of company size is as high as in the corresponding companies of the leading west German Laender.[119]

More cutting-edge technology in the new federal states

In the new federal states and in Berlin, sectors of cutting-edge technology are better represented than in west Germany, and in addition they show more growth, e.g. in the period 2000 to 2007 employment in these sectors in east Germany increased by 20 percent, whereas in the west it virtually stagnated. Correspondingly, the proportion of employees in manufacturing companies in east Germany working in research-intensive industries increased from 30 percent (2000) to 35.5 percent (2007). The figure in western Germany (45 percent) is still considerably higher, but east Germany has clearly caught up. This also applies for R&D employment. Whereas in east Germany in 2007 some 40 percent of private sector R&D personnel were working in a cutting-edge technology company, only 26 percent in the west were. Information and communications technology, and control and measurement technology are particularly well represented in the east, and are clustered in accordance with the economic history of the various regions. Economic incentives, e.g. in the form of investment subsidies, have had an additional positive influence on the development. The photovoltaics industry is also clustered in east Germany (Box 10), providing a good basis for the future. However, the research-intensive industries in east Germany spend less on R&D than the same sectors in western Germany. This indicates that R&D projects are on average less demanding. However, it also shows that east German structures are not simply copies of those in west Germany, but that new paths are being pursued, though at present there is

BOX 10 **The photovoltaic industry**

The photovoltaic industry (PV) is a good example of the development of new networks of technological expertise in the new Laender. Meanwhile a number of these industrial centres have established themselves in eastern Germany, with a total of some 10 000 employees (Bitterfeld-Wolfen / Thalheim, Freiberg, Dresden, and Erfurt / Arnstadt).

Photovoltaic cells were already being used in the late 1950s in astronautics. However, broad terrestrial use for power generation seems uneconomic and unnecessary until the early 1990s. Things changed with the emergence of the debate on climate change and sustainable energy supplies. Previous German governments introduced incentive measures such as the “1 000 Roofs Programme”, the “100 000 Roofs Programme” and also legislation on energy from renewable sources (EEG). These steps led to the development of a lead market in photovoltaics and a strong photovoltaics industry in Germany.

Along with Japan, Germany became worldwide technology-leader. Offered further financial support, a number of investors chose to locate in former GDR-operations with relevant product spectra, e.g. Freiberg for metallurgy, Dresden and Erfurt for microelectronics. The subsequent clustering phase saw specialised suppliers also locating in the region and the networking of the PV industry with the regional public sector research landscape. Special university chairs and degree courses were set up to meet the demand for skilled personnel in the PV industry.[121] At present, some 60 percent of all jobs in the German PV industry are in eastern Germany and subsidiaries and branches of foreign companies are also locating there.

The PV development shows that eastern Germany can offer a very attractive location for innovative, research-intensive technologies, which are at first less dependent on existing networks that on suitable regional location factors. These companies bring more research activity into the region than conventional manufacturing companies. Establishing PV in the new Laender not only led to reactions in the universities, which offered appropriate new courses, but also stimulated the further development of the non-university research landscape.

In Halle, for example, the Fraunhofer Centre for Silicon Photovoltaics (CSP) was established as a joint initiative of the Fraunhofer Institutes for Material Mechanics (IWM) and for Solar Energy Systems (ISE). The CSP has good links with the private sector. In 2008 the “Solar Valley in Central Germany” was chosen as one of five clusters in the first round of the Federal Ministry of Education’s best cluster competition. Over five years it will receive some EUR 40 million funding. Saxony, Saxony-Anhalt and Thuringia and the private sector each also invested comparable sums. A partnership has been formed by 35 companies, science and education institutions in order to rapidly reduce the costs of photovoltaic power. Intensive R&D work is being conducted in the field of crystalline silicon technology.

often not the critical mass needed to develop an independent dynamic.

SMEs in the new federal states play a much more important role in conducting research and development than they do in the old Laender. 39 percent of R&D personnel in the new federal states work in companies with fewer than 100 employees, compared with only 5.6 percent in the old Laender. Large-scale companies carrying out R&D are correspondingly under-represented. Over time, the importance of SMEs for R&D in east Germany has increased. Whereas in the west large scale high-value technology companies (motor industry, chemistry, etc.) represent crystallisation points for the development of R&D clusters, this was hardly possible in the east.
After German unification, foreign and west German companies invested considerable sums directly in east Germany. It is sometimes still claimed that much of this involved the introduction of basic, standardised production methods for low-technology products. In fact, though, the R&D intensity of these companies is now above average, and they have a more modern range of products than the original east German companies.[122] In the past, direct investments were important in order to spread new technologies and expertise in the new federal states. But while they were highly relevant when the east German innovation system was establishing itself, they are mostly inadequately positioned to stimulate its further development. The modern range of products is in part explained by the transfer of company R&D results to their branches in eastern Germany. The local research and development of these technology recipients is often of a lower quality than that of companies in the old Laender.

Fewer private sector, but more academic patent applications in east Germany

Whether investments in R&D subsequently "pay off" is of great importance for the success of the east German economy. There are indications of both a successful process of catching up and also of potential for further improvements. Patent applications per 100 000 inhabitants in west Germany (62 applications in 2008) are 1.6-times higher than in the new federal states. This difference is due to the patent weakness of the east German private sector, although the gap to west Germany is slowly closing. In contrast, the numbers of scientific application in the new Laender relative to the number of scientists is higher than in the old Laender, and the publication activity is also above average. In 2008, there were about 1 200 publications per million inhabitants in the new federal states (not including Berlin), compared with about 1 000 in west Germany.[123] The Berlin science system registered 2 800 publications per million inhabitants. These results are evidence of a viable, application-oriented science system.

According to the Mannheim Innovation Panel[124], the innovator rate, that is the proportion of manufacturing companies who have introduced new products in the past three years, was lower in east Germany in 2008 than in west Germany (44 percent vs. 48 percent), but for companies in the services sector it was considerably higher. There are no signs that the gap here is being closed, although the productivity of innovative manufacturing companies in east Germany is now much the same as that in comparable west German companies.[125]

Companies in east Germany invest a greater proportion of their revenues in innovation processes than companies in west Germany. This is the case in particular for services companies and less so for manufacturing companies. Whether innovations are economically successful is shown by the share of revenues achieved with new products. In 2008, the figure for the east German research-intensive industry was 35 percent compared with a west German value of 39 percent. The proportion of revenue generated with new products in east German services companies is also lower in comparison with the west German Laender. The proportion of revenue generated with market innovations in the knowledge-intensive services sectors in east Germany in 2007 was still higher than in west Germany, but it has now fallen to well below the west German level.[126]

In east Germany, about 44 000 companies were started up annually in the period 2005 to 2008. Of these, some 10 000 were in the technology- and knowledge-intensive sectors, giving an average annual start-up intensity of 6.1 start-ups per 10 000 employable persons (Table 5). In west Germany over the same period a start-up intensity of 8.3 was registered. The start-up intensity in east Germany is only above average in Berlin (9.6). More than a quarter of all new enterprises in east Germany start up there. All other regions of eastern Germany have below-average start-up activity. However, some urban centres in the new federal states have a start-up intensity, which can stand comparison with west German levels, e.g. Jena, Dresden and Leipzig, and also Potsdam and Magdeburg.

Challenges to innovation policies

The main challenges faced by policy-makers concerning innovation in eastern Germany are the persistent weakness of R&D in the manufacturing sector and the underdeveloped knowledge-intensive services.

In contrast, special strengths include:

- The well-developed public sector research infrastructure and higher education landscape
- The performance of public sector research, as expressed by above-average numbers of patent applications and publications[127]
- The R&D activities in subsidiaries of foreign companies and in the few large-scale companies (which are frequently higher than those of original east German companies)
- The increasing presence of cutting-edge technology companies, which are contributing to the process of catching up with technology in the old Laender.

In view of the fact that development of viable new, innovative structures in the new federal states began almost from scratch 20 years ago, the achievements are impressive.

Favourable conditions for innovation rather than special innovation programmes for eastern Germany

Twenty years after unification, Germany now has a largely uniform R&I system. Certainly, the innovation potential and innovation performance in the new Laender has not yet reached the level of the old Laender, but the evident weaknesses of the eastern German university and research landscape are not fundamentally different from those of the structurally weak regions of western Germany.

- The objective of making the German research and innovation system more competitive internationally and the goal of establishing comparable living conditions in all regions can be seen to be competing, in the short-term, for limited resources. Strengthening the innovation location involves providing support for agglomerations where innovation is already well-developed. Convergence processes, in contrast, require compensation measures between strongly-growing conurbations and structurally weak regions.

- The primary task of the R&I policies of the Federal Government is to strengthen the overall position of Germany in the competition for innovations. In the medium- and long-term this is also in the interests of structurally weak regions. The Expert Commission no longer sees any need

BOX 11

The threat of shortages of skilled personnel – also in the east

The further economic development of the new Laender is threatened in particular by the considerable decline in population being observed in all regions except the area around the capital Berlin. From 1989 to mid-2008 a total of 1.1 million mainly young people left the region. They continue to do so – between 30 000 and 60 000 annually. The new federal states have experienced a considerable reduction in the proportion and absolute numbers of females aged between 15 and 49 years old since the fall of the Berlin Wall, so that there has also been a drop in birth rates.[128] Many of these women were well educated. Migration and low birth rates not only lead to a significant reduction in population, but have also increased the average age from 37.5 years in 1989 to 45 years at the end of 2007.[129] The demographic projections of the Federal Statistical Office show that a further decline in population levels must be expected in the new Laender.[130]
This development can have serious consequences for the innovation system in east Germany. Despite high unemployment, some sectors and regions also face shortages of skilled labour, and this can hinder innovation and make it more difficult to catch up.[131] The demographic problems thus represent a key constraint on the innovative potential of the new federal states.

to develop new programmes specifically for R&I policies in eastern Germany. Neither is there any need to plan new investment programmes, which would only benefit the old Laender. Accelerating or maintaining the convergence process is a concern for structural policy-makers rather than innovation policies. A powerful structural policy instrument are the investment subsidies under the Joint Project "Improving the Regional Economic Structure" (GRW).[132] The Laender should make more use of the scope available to them in order to focus subsidies more on promising sectors of the economy in regions with high development potential.[133] The Expert Commission feels that the instrument of investment subsidies shows deficits both in terms of its efficiency and its effectiveness. Entitlement to investment subsidies only require general conditions to have been met (such as an initial investment by manufacturing companies, production-related services, or the hotel industry). In view of budgetary constraints, it would make more sense to concentrate the support funds.

– The coalition agreement between the parties CDU, CSU, and FDP proposes to evaluate the external industrial research institutions in the new federal states. In consultation with the Laender, the Federal Government will then decide which institutes will be integrated in the research organisations supported by the Federal Government and Laender.[134] The Expert Commission approves of offering institutional support to institutions carrying out important tasks in knowledge- and technology transfer, which can demonstrate adequate quality of research. However, the Commission does not believe that enforced integration in the Fraunhofer Society, the Helmholtz Association, the Max Planck Society or the Leibniz Association would have the desired effects. The Federal Government and Laender could encourage such integration processes where appropriate, but should otherwise leave this up to the institutions concerned.

– The Expert Commission has repeatedly called for the introduction of tax incentives for R&D, improved conditions for the provision of company with equity, and improved framework conditions for business angels and providers of venture capital. This would also have positive effects in structurally weak regions, (e.g. in eastern Germany), where the equity base for companies is particularly weak, little venture capital is available, and large companies are lacking. Innovative new enterprises and financing innovative projects in SMEs would be eased considerably by such measures.

ELECTROMOBILITY B 4

A revolution in the mobility sector

The transformation of the energy systems towards more sustainability is gaining speed. Today, Germany generates 16 percent of its electricity from renewable sources, largely free of CO_2 emissions.[135] By 2020 it is planned to at least double this proportion.[136] As a consequence, a largely CO_2-free transport system will emerge in the medium- to long-term. This development will be accelerated by the insecurity of supplies of fossil fuels, rising fuel prices, and state regulations driven by climate goals.

Electromobility (Box 12) offers the opportunity to contribute effectively to this transformation process. In addition, it will be possible to achieve a new quality of living in towns and cities. Electric vehicles have the advantage that they release no harmful local emissions[137] and can be designed to

BOX 12

Electromobility

Electromobility refers to the use of electrically-powered vehicles, in particular cars and light goods vehicles, but also electric scooters and bicycles and light-weight vehicles, together with the associated technological and economic infrastructure. The various vehicle types under discussion are listed in Table 6.

Both electric power and hydrogen fuel require the construction of appropriate infrastructure. Setting up the hydrogen infrastructure is much more complicated than providing power supplies. Hybrid vehicles are already commercially available, and Asian companies were pioneers in their introduction. Battery electric vehicles currently only find niche applications, e.g. as light-weight vehicles produced in small series. Many car makers have announced that models will go into series production in the coming years.

TAB 06 **Electromobility – types of vehicle**

Type of vehicle	Use of power grid	Key characteristics
HEV – hybrid electric vehicle	Independent of power grid	IC engine plus electric motor, Braking energy recovered to charge a battery
PHEV – plug-in hybrid electric vehicle	Reliance on power grid	IC engine plus electric motor, Battery rechargeable from grid
BEV – battery electric vehicle	100% dependence on grid	Electric motor, battery recharged from grid, (Braking energy recovered)
FCEV – fuel cell hybrid electric vehicle	No power from grid	Fuel cell, electric motor

Source: EFI.

cause less noise in urban traffic. This opens up possibilities for completely new architecture and urban planning. This applies in particular for megacities, which are currently growing very rapidly.[138] The introduction of electromobility thus acquires a cultural dimension.
Determined, long-term initiatives by the Federal Government are necessary to promote research and innovation in the field of electromobility and to support the marketing of electric vehicles if Germany is to reach essential targets such as a significant reduction of CO2 emissions[139] and the medium-term security of fuel supplies. German policy-makers and the private sector must make intensive efforts to achieve a leading international role in the field of post-fossil mobility.

Integrating electromobility in a comprehensive mobility strategy

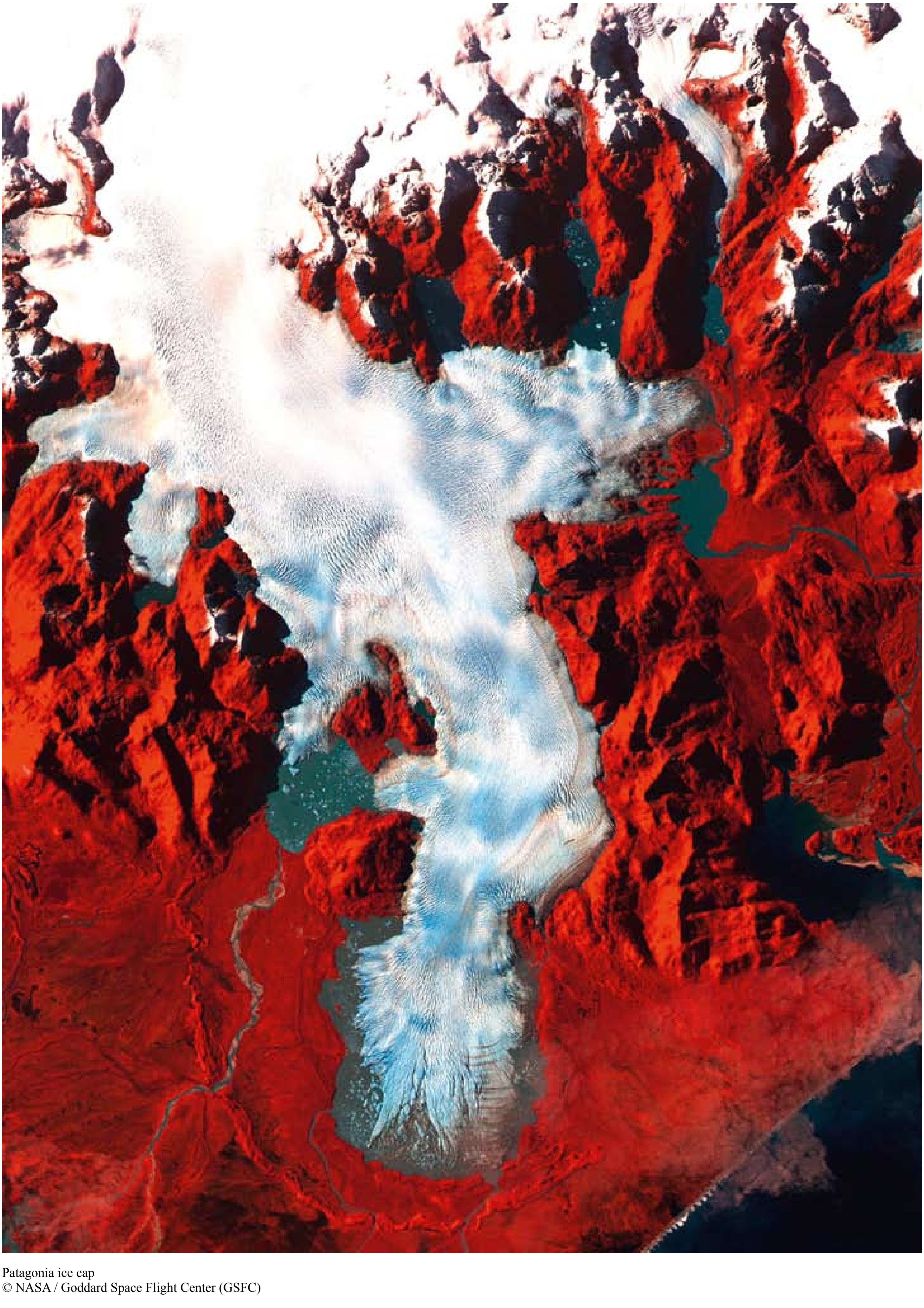
The development of electromobility must be integrated in a multimodal strategy for future traffic and transport systems. These systems cannot yet be predicted with sufficient accuracy. When developing electric cars, attention should therefore be paid to technological adaptability and the flexibility of the concepts.

Against the background of climate change, the transition from fossil to post-fossil mobility must be tackled urgently. In view of the technical constraints, the first objective will be private transport for short trips (100 to 150 km).[140] But it can be assumed that technological developments will make it possible to increase the range in the medium term.

It seems that very long distance individual mobility will continue to require fossil energy for some time to come. Hybrid electric vehicles may cater for some medium distance journeys for a certain period.[141] There will probably be a shift away from the dominant universal profile of cars, which requires that a single vehicle be suitable for short and long journeys, for urban trips and for travelling. Electric rail travel will also play an important role in the strategies of the future. This will apply in particular for inter-city travel. In short there will be a paradigm shift in the entire system of traffic and transport, in which electromobility will play a key role.

Electromobility – a key element of sustainable energy supplies

In the context of "more intelligent" electricity networks, so-called Smart Grids (Box 13), electromobility is likely to become a key factor for stability and economic viability. Vehicles which are not being used can the be recharged by means of optimised remote control whenever there is an over-supply of power available in the grid. With a sufficient number of such vehicles, consumption and generation over the power grid can be harmonised without signif-



Patagonia ice cap

Larsen Ice Shelf, Antarctic

BOX 13

Smart Grids

Information and communications technologies are becoming increasingly important in the power supply sector. This will lead to the development of power supply networks with constantly improving "technical intelligence". These so-called Smart Grids will allow the optimised introduction of decentrally generated power into the distribution network. This includes the regulation of the decentral power generators, in particular those based on wind and solar energy, as well as combined heat and power generators. Power consumers will also be integrated and regulated much more than in the past. This can be supported by variable tariffs and an intelligent response by consumers to the prices. These measures will make it possible to link power consumption and generation dynamically in sustainable power supply structures. Future grids will also be able to utilise stored power, for example in electric vehicles, in order to stabilise the power supply.

icant losses. This will be a particular advantage if there is a large proportion of power from fluctuating sources (e.g. from sun and wind).

Conversely, part of the power stored in the batteries of stationary vehicles can be fed into the grid remotely if there is a short-term undersupply of power. A pre-requisite here will be that the vehicle batteries must be capable of more recharging cycles than are required to operate the vehicle. Future vehicle batteries will very probably have this capability. Electromobility and a sustainable strategy for energy supplies and use are directly linked with one another. This makes it urgently necessary for the automotive sector and the power industry to cooperate closely.

Scientific and technological progress in Germany

The Expert Commission is persuaded that the large-scale introduction of battery-operated electric transport systems is technically feasible. This applies in particular for operating life, number of recharging cycles, weight and cost of batteries, including their potential further use; the availability of raw materials and the feasibility of an extended life-cycle of materials; the possibilities for power electronics and the electric motor; the energetic links between the vehicles and the power grid and the increased use of lightweight construction techniques in the automotive sector. There could be bottlenecks in material supplies, e.g. for lithium, as in other fields of high technology, in particular if there are shortages in important raw materials due to the limited number of suppliers.

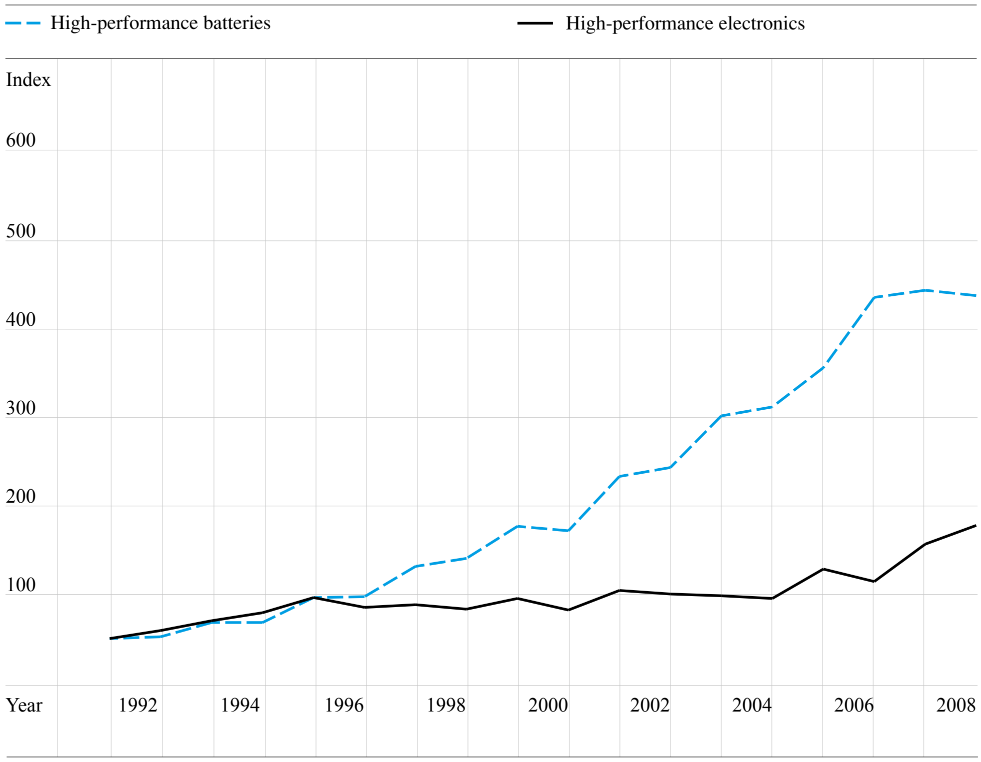
Although a leader in the conventional automotive industry, Germany has some catching up to do in the field of electromobility if it is to reach the worldwide level of technological development and benefit from the described paradigm shift in the transport sector. It is a considerable way behind.

Deficits in science, technology development and training

Key technologies for the electromobility are vehicle batteries, electric motors, mechanical drive strings, power electronics, lightweight construction, and the infrastructure for linking the vehicle systems with the power grid (charging and discharging batteries to support the power supply). Germany is in a poor position in the important sector of vehicle batteries. In power electronics, Germany has at best years a middling position. In both cases, the leadership in research and technology lies with the Asian countries, in particular Japan, Korea and China.

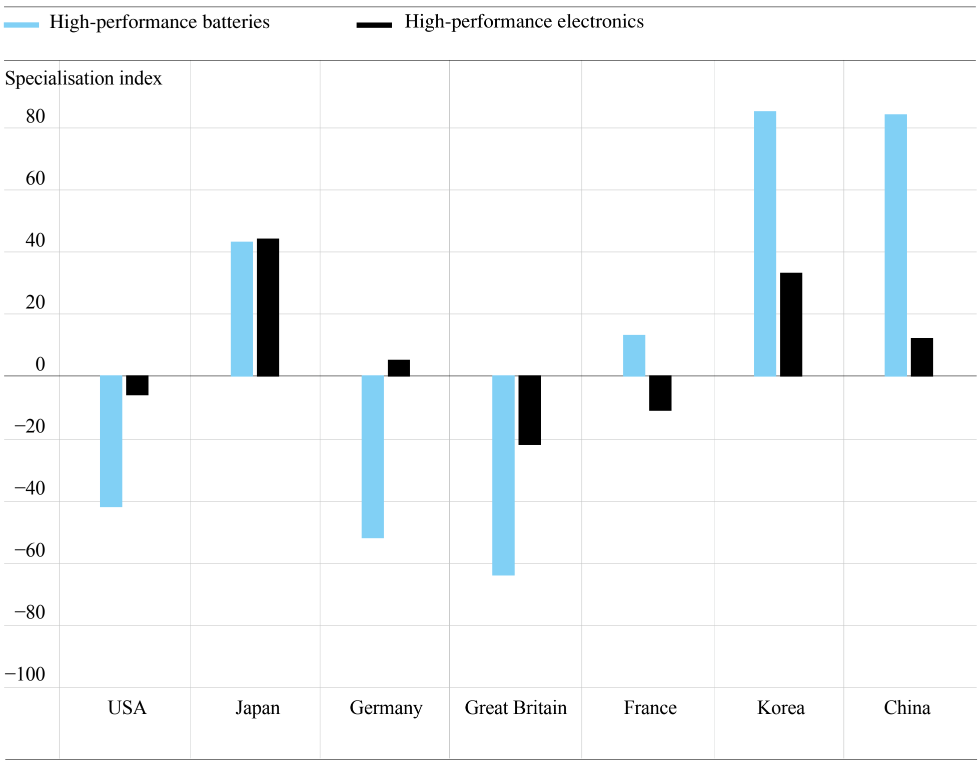
In the past decade in Germany, many Chairs in electrochemistry (the key discipline for battery technology) have fallen vacant or have been given a changed scientific orientation.[142] The focus in research and teaching shifted to other fields which were thought to offer more promise. This trend at the universities was not compensated for by increased activities of the non-university research institutions. It is therefore not surprising that the publication statistics of German scientists in electrochemistry, and in particular in battery technology, have been below average (Box 14). The self-organisation of the German science system has failed in this case from a macroeconomic point of view. The patent balance does not show a more promising position for German companies or research institutes (Box 15).

FIG 13 **International peer-reviewed[143] publications on high-performance batteries and electronics**



Index: 1995 = 100.
Source: Science Citation Index (STN).

FIG 14 **Specialisation[144] in international peer-reviewed publications in selected countries in the fields of high-performance batteries and electronics 2008**



Index value 0 = average publication activity, > 20 much above average. Source: Science Citation Index (STN).

BOX 14

Electromobility – Publications in an international comparison

An analysis of publications relating to high-performance batteries from 1991 to 2008 shows a worldwide increase in peer-reviewed publications, with growth rates of some 13 percent per annum (Fig. 13). The evaluation of country specialisation shows above-average activity in Japan, Korea, and China (Fig. 14). This situation for high-performance batteries is reflected in the wider field of "electrochemistry". Here too the publication figures are steadily increasing. There is considerable specialisation activity in Japan, Korea and above all China. In comparison, Germany has a less well developed specialisation.

There is also a worldwide upwards trend in publications on power electronics, which has increased further in recent years. Here too the east Asian countries are very active, in particular Japan. The German index is slightly above average, and the specialisation is above that for USA, Great Britain and France, although it is much lower than for the three Asian countries.

Meanwhile extensive measures have been introduced at some universities in order to establish research capacity in the neglected areas. In non-university research institutions research associations and electromobility sections are being set up.[145] The Deutsche Forschungsgemeinschaft (DFG) has started a research initiative on lithium high-performance batteries.[146] However, it should not be forgotten that these activities will take time in order to develop their full potential. The shortage of specialists could not be overcome immediately. This makes it all the more important to integrate the universities in the new research initiatives, so that personnel can be suitably qualified as quickly as possible by the integration of research work and teaching.

Assessing the current situation in Germany

The development towards electromobility is not only important and desirable for the above-mentioned reasons. It also offers extremely good economic opportunities, in particular for a high-technology country with considerable innovation potential, such as Germany. The leading position of Germany in the automotive sector is based in the drive area on the technology of internal combustion engines. There are no signs yet that it will be possible to achieve a similar position in electromobility. Other countries started earlier and have invested more massively in electromobility than Germany has. The large part of the value creation for smaller electric cars is from the batteries (about 50 percent), and electric drive systems, including the power electronics (about 20 percent). In both fields other countries are better positioned than Germany. This is shown among other things by the patent analyses (Figure 16).

Science and industry must direct all their efforts towards post-fossil mobility. In view of the current deficits in battery development the German industry will have no choice but to enter into partnerships with international manufacturing companies (in particular from Asia). But Germany should endeavour to develop its own strengths in battery technology.

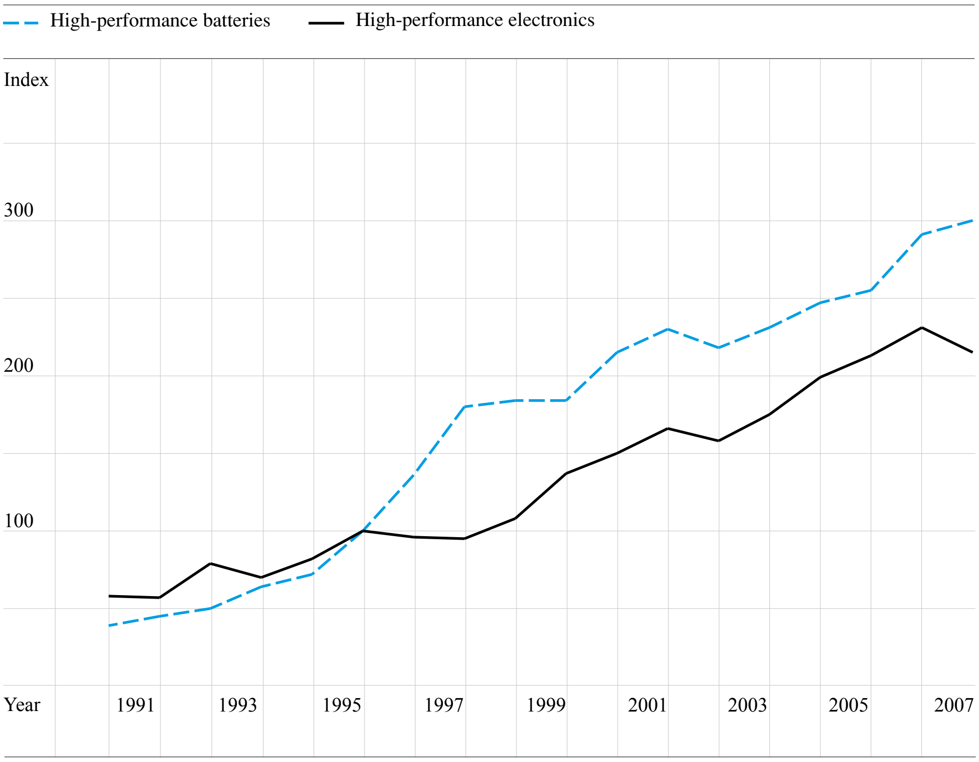
BOX 15

Electromobility – Patents in an international comparison

The analysis of transnational patent applications (PCT applications or applications to the European Patent Office) for two key components of electric cars – high-performance batteries and power electronics – shows a sharp increase in applications (Fig. 15). In 1995 there were 850 patent applications concerning high-performance batteries; in 2007 there were 2 550, or three times as many. There has also been a marked increase in the field of power electronics: Since 1995, annual applications have more than doubled. Concerning inventions relating to high-performance batteries, Germany has a very negative specialisation index (Fig. 16). In contrast, specialisation indices are highly positive for Japan, Korea and China. For power electronics, the German specialisation is average. High levels of specialisation are found again for Japan, Korea, and China.

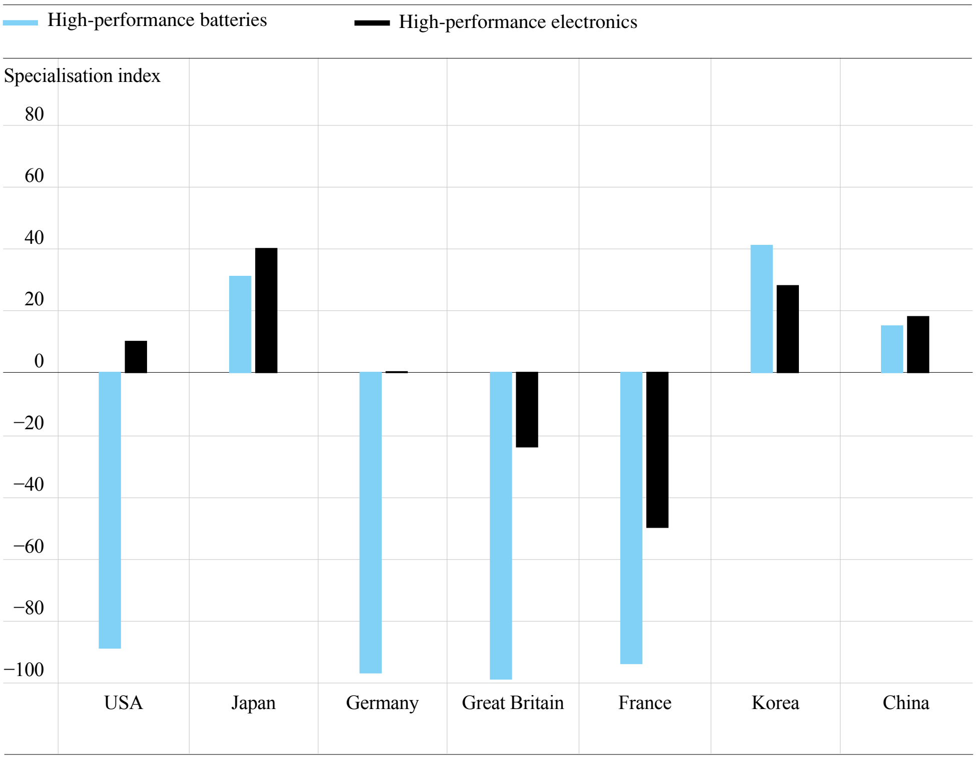
For high-performance batteries, the dominance of Japan is also considerable when expressed in absolute numbers. Although it has nearly 70 percent fewer overall transnational applications than the USA and only 14 percent more than Germany, more than one third of all applications for high-performance batteries in 2007 were from Japan. Germany is considerably under-represented in this sector.

FIG 15 **Transnational patent applications for high-performance batteries and electronics**



Index: 1995 = 100.
Source: World Patent Index (STN).

FIG 16 **Specialisation of transnational patent applications of selected countries in the fields of high-performance and electronics, 2005 to 2007**



Index value 0 = average patent activity, > 20 much above average. Source: World Patent Index (STN).

In this promising field of high technology, a considerable amount of value creation should be kept in Germany. It would probably make sense for the German research and development sector to concentrate on next generation batteries.[147] This will definitely require increases of public support programmes.

Inadequate cooperation and coordination

The transformation to electromobility cannot be made by a series of small changes. Electric vehicles have little in common with current fossil-fuelled cars, in particular concerning energy storage, the drive string, and the supply infrastructure. Such changes are referred to in the research as radical or architectural innovations, because they lead to completely new product concepts and technological solutions. Current strengths in dominant technologies, e.g. internal combustion engines, can not necessarily be converted directly into leading positions in electromobility. It has been shown that in such situations established producers often recognise the threat too late, and they rely for too long on their tried and trusted technology.[148]

In addition, the German automotive industry and its suppliers are competing with one another in the field of electromobility, for reasons which are hard to understand. This leads to a fragmentation of R&D efforts and is harmful for the international position of Germany regarding electromobility. There is a need for pre-competition cooperation projects, in which all the important actors are fully involved – even if they are in competition with one another in the field of fossil mobility. For macroeconomic reasons, the government should coordinate these developments with structured research programmes.

In addition, the lack of an independent national test centre for electromobility currently represents a strategic constraint. Here too, state involvement would seem advisable, at least in the initiation and planning phase.

If German research and development does not gain ground on the international leading group quickly and effectively, the transition to electromobility will considerably weaken Germany as an industrial location. Such a development would be disastrous. About 15 percent of industrial value creation in Germany is based on the conventional automotive industry and its suppliers.[149] According to RWI calculations, about 1.8 million jobs in Germany are directly or indirectly dependent on automotive production.[150] Even if the transition to the widespread implementation of electromobility were to take a decade or longer, massive changes in the economic structures in the automotive sector must be anticipated.

State support for electromobility in Germany

The Federal Government and the Laender have already adopted various measures in the field of electromobility (Box 16). The National Development Plan Electromobility of the Federal Government from August 2009 was initially implemented by the ministries BMBF, BMU, BMWi and BMVBS. With so many ministries involved it was not possible to reach an optimum solution, so that attempts are being made to bundle responsibilities. The current market launching programmes of BMVBS offer scope for further improvements: the Ministry's regulations for support are unclear and changing; there have been delays issuing approval notices.

At the federal level, EUR 500 million has been made available in 2009 and 2010 from the second economic stimulus package. Without these funds, Germany would no longer be able to compete in research and development with countries such as the USA, Japan or China.[151] The National Development Plan is due to run for ten years. However, the continuation of the funding is not ensured, although it is of vital importance if Germany is to play a significant independent role in the development of electromobility. In the opinion of the Expert Commission, the Federal Government's support projects are not sufficiently harmonised with those at Laender level or those of the European Union. There is considerable potential here for optimisation.

The Expert Commission broadly supports the focused activities of the Federal Government and individual Laender in the field of electromobility. However, a precondition for Germany's success in this field is the excellent coordination of R&D efforts in basic research and development. This requirement explicitly extends to the private sector – all those actively involved must rapidly come together in meaningful cooperation. This is currently not being done.

BOX 16

Federal government and Laender support for electromobility

The Federal Government's National Development Plan for Electromobility launched in August 2009 aims at developing and implementing a comprehensive strategy from basic research through to marketing of electric vehicles. A strategy is also to be developed to meet the additional demand for electricity created by electromobility, with the aim of meeting the demand with power from renewable sources and ensuring that electromobility can contribute to the load management of the power grid. In this way, Germany is to become a lead market for electromobility. By 2020, the plan is to have a million electric vehicles on German roads.[152]
The Federal Government made a total of EUR 500 million available for this from the second economic stimulus package. Companies receive up to 50 percent support for approved projects, and public research institutions receive 100 percent. The National Development Plan Electromobility is promoting a range of measures. These include the Federal Ministry of Transport's priority programme "Electromobility in model regions", in which eight model projects receive a total of EUR 115 million in support. As part of its High Tech Strategy, the Federal Government has already initiated the Innovation Alliance Lithium-Ion Battery (LIB 2015). These research activities started at the end of 2008. At total of EUR 60 million Euro will be made available through to 2015; the private sector will be participating with EUR 360 million.[153]
Individual Federal Laender have also set up programmes to support R&D and market launching measures in the field of electromobility. For example, Bavarian companies can receive support amounting to up to 50 percent of their relevant costs, if they carry out R&D in the field of electromobility. In Schleswig-Holstein a centre of competence has been set up for electromobility at the University of Applied Sciences Kiel. North Rhine-Westphalia has a Master Plan Electromobility, which also includes establishing the battery research centre MEET (Münster Electrochemical Energy Technology) at the University of Münster. In April 2009, Lower Saxony also launched its Land Initiative Fuel Cell and Battery Technology and through until 2012 it is providing some EUR 10 million to bring together relevant actors. Baden-Wurttemberg is investing some EUR 15 million in structural measures and projects as part of its Land Initiative Electromobility. A Land Agency Electromobility is to promote interdisciplinary innovations for this field of technology. For this reason, a Land Agency for Electromobility was founded in order to guarantee the support for interdisciplinary innovations in this field of technology.

Uncertainties about a lead market for electromobility in Germany

Progress towards electromobility requires the coordination of many actors, including government authorities. This not only involves research, but also the introduction on the market. It would be unrealistic to leave this to the private sector – central government is a key player and has direct influence with its decisions on the acceptability of new mobility systems. In view of the obligations arising from the climate discussion and growing international competition, possible concepts should rapidly be tested and implemented.

Politicians frequently speak of a "lead market" for electromobility. In innovation research this indicates particularly favourable structures, which make it possible for providers to develop and market new products rapidly and then to introduce these onto other markets first, and with cost advantages. It is argued that the development of telefax machines was faster in Asia because people there were willing to pay a premium for the transmission of graphic symbols and language characters. The use of a lead market can result in market dominance for a certain period.
It is not currently possible to identify a lead market for electromobility in Germany. If anywhere, such a situation is more apparent in Chinese urban agglomerations, where a process of basic motorisation is underway for local transport, where the demand is in the main not for large, heavy and fast cars with a long range. An example in this context is the technology for the electric cycles and electric scooters, which are currently experiencing an enormous boom in China.[154] The next step will be inexpensive, light-weight electric cars. China has adopted timely measures to ensure the development of this market with comprehensive and strategic technological development, in particular in the field of battery technology.

Coordinating trial projects and extending these to the European level

It would only be possible to establish a lead market in Germany if the major urban centres undergo a rapid and radical conversion to electric transport. A precondition would be that the customers switch over from “powerful, fast and long-range” to “light, small and flexible”. Such a change in purchasing behaviour will have to be supported by government programmes during the market launch in order to achieve the large production figures, which can offer significant cost reductions. However, in contrast to other countries, little importance has so far been attached in Germany to planning market incentives. Research into the future acceptability of electromobility is only included in current research proposals in a rudimentary fashion.

Currently in Germany there are 17 model regions and fleet trials for electromobility, with more being planned. This large number of trials could turn out to be counterproductive. It is not possible to identify a real concentration, which could lead to the generation of lead markets. Furthermore, there are no signs of planned coordination of these trials. There is a risk that isolated results will be obtained without producing a meaningful overall picture.

National initiatives alone will not prove sufficient in the view of the Expert Commission, and they should be augmented by transboundary European measures. With European cooperation projects it would probably also be much easier to achieve the necessary comprehensive framework conditions for the widespread introduction of electromobility than with an isolated national strategy. This affects aspects such as standardisation, infrastructure, or preferences in the traffic routing for electric vehicles (the public could be shown the advantages of electromobility under a range of conditions). Such coordination is essential if the economies of scale are to be achieved, which would rapidly lower the costs of new, environmentally-friendly technologies.

Recommendations

Electromobility is an important building block for achieving objectives in the fields of climate protection and the security of energy supplies. However, given the extent to which research and development are lagging behind in Germany it represents a particular challenge.

– The National Electromobility Development Plan is an important first step towards strengthening the position of Germany. Markedly improved coordination and a tighter control of public sector activities are now required in the field of electromobility in order to achieve significant progress. The fragmentation of the national and Laender programmes must be overcome; strategies and initiatives must be developed with a long-term perspective.

– Universities, non-university research institutions, and research promotion organisations should develop stronger and more comprehensive activities in the field of electromobility. In addition to research work, suitable training programmes are necessary to address existing shortages in skilled personnel.

– German companies are not cooperating sufficiently with one another on electromobility. A dialogue should be initiated rapidly with the business companies in order to bring the actors out of their isolation. The Federal Government should only provide further state support when appropriate cooperation is achieved in the field of electromobility.

– On the basis of the existing development expertise in the European automotive sector (for instance in countries such as France and Italy), the Federal Government should work towards a joint European approach in order to strengthen the European position overall and to achieve economies of scale.

– The Federal Government should choose a few regions as locations for the market launch of new mobility strategies and rapidly plan and implement the necessary trials. Possible candidates are metropolitan regions, which ideally would include areas in various countries, e.g. the Ruhr area of Germany and parts of the Benelux countries. European conurbations such as Paris, Rome, Madrid, Athens, or London could also be suitable test regions in a Europe-wide development strategy.

– It must be made attractive for car buyers to turn their backs on the heavy, high-powered vehicles of the fossil-fuel era. Users of electric cars should not only be offered financial stimuli but also additional benefits, e.g. the use of bus lanes in urban areas, or special E-lanes on main highways around the city.

B 5 CURRENT DESIGN OF THE PATENT SYSTEM

The Expert Commission draws in its analyses on patent information and statistics as summarised in Section C 5 of this report. But the patent system is also an important institution of R&I policy-making, and it has been the subject of controversial discussions in recent years. In Section B 5-1, the Expert Commission therefore comments on recent developments in the national and international patent systems, focusing in particular on the behaviour of the patent applicants. In Section B 5-2, the use of patent data in R&I studies is discussed against the background of these changes.

B 5 – 1 ON THE INSTITUTIONAL ORGANISATION OF PATENT SYSTEMS

Innovation and patent protection

Patent systems should provide incentives for R&D activities. The patent holder is entitled to exclude other parties from the use of patented inventions. In extreme cases, this means that patent protection can establish a monopoly. The theory is that the right of exclusion improves the patent holder's prospects of making a profit and thus strengthens their willingness to invest in R&D. At the same time, the publication of the patented invention should then make it easier to develop related innovations. Whether the current systems satisfactorily fulfil this purpose has increasingly been called into question in recent years. Numerous studies in the USA analysed the developments there and were reticent in their assessment of the extent to which the US patent system promoted innovation.[155] It is now generally accepted that patent systems only create a strong positive incentive for innovation in a limited number of technologies or industries.[156] In particular, patent protection has a positive effect on R&D activities in the chemical and pharmaceutical industries. However, patents can also impede innovations and competition in various ways.[157]

The extent to which incentives or dysfunctional effects are generated depends to a considerable extent on the patent system itself, so that it is not meaningful to make generalisations. In particular a comparison of the American and European patent systems shows many important institutional differences. In its evaluation, the Expert Commission assumes that a suitably organised patent system can provide incentives for research and innovation and thus create economic benefits. But what are suitable adjustments to this system?

The development in the USA

In the USA there has been a considerable increase in patent activities since the mid-1980s. Following the creation of the Court of Appeals for the Federal Circuit (CAFC),[158] the rights of patent holders were strengthened considerably. In particular it became much easier to enforce patents in court. Over time, the CAFC also extended patent protection to cover software and business methods. Patent applicants responded to these changes with an increased demand for patent protection. The number of applications increased significantly, and the US Patent Office also had a very high approval rate in an international comparison. Competition escalated between companies for more and more patents.[159] In most sectors there was also an increase in litigation. Patents were also used to exert pressure to pay licence fees by so-called patent trolls, who do not carry out any research or production, but acquire patent rights in order to conduct aggressive patent infringement lawsuits.[160]

The developments in the USA have been criticised in a series of studies, including a comprehensive investigation by the Federal Trade Commission (FTC 2003). The call for reforms has meanwhile resulted in various bills being put before the Senate and the House of Representatives. However, the attempts at reforms have failed to date as a result of disagreements between key actors in the political parties and in various industrial associations. The United States Patent and Trademark Office has begun to apply its rules more restrictedly in an attempt to limit supposed abuse of the system by the applicant. In addition, a number of developments have been reversed by decisions of the Supreme Court, e.g. concerning the use of injunctions (eBay Inc. versus Merc Exchange, L.L.C.).[161] An important on-going case could change the applicability of patent protection to business methods.[162]

Quantity and quality of patents in Europe

In a globalised world, in which the TRIPS Agreement[163] and other international agreements have led to considerable harmonisation of the patent systems, no system can completely disengage from the developments in the patent systems of other countries. Against this background, the question arises whether the European patent system has been affected by developments similar to those in the United States, and whether the patent system in Europe is also in need of reorientation.[164]

In Europe, the increase in patenting only began in the 1990s. Patent applications and approvals at the European Patent Office (EPO) increased much more quickly than the national R&D expenditures or R&D in the OECD countries. Between 1990 and 2000 the annual number of applications filed with the EPO rose at twice the rate of R&D expenditure. The patent applications have also become much more complex. Submissions are increasingly linked with other applications[165] and applicants are tending to build up extensive patent portfolios and patent ‘thickets’.[166] According to EPO research reports, there has also been a continual increase in the proportion of applications for which there was a novelty-destroying prior art, and which are therefore examined particularly closely for the patentability.[167] The average quality of the applications filed with the EPO has been steadily declining over a long period.[168] Despite the rising numbers of applications and despite the falling quality of applications the patent grant rate at the European Patent Office remained constant at about 65 percent over the period 1978 to 2000 (year of application).[169]

A detailed study[170] of the workload and motivation structures of EPO patent examiners cites a series of factors which lead to distortions in the decision-making process in favour of patents being granted.[171] The growing obscurity of the patent system has increased the uncertainty of all users and to a general rise in transaction costs. Patent applicants, for their part, have increased the numbers of applications. This creates the overall impression of a system whose checks and balances are out of control. The self-interest of the patent offices in growth or increasing their income from fees may have supported this development. Like the other major patent offices of the world, the EPO now finds itself facing a large number of unexamined applications. Applicants have to wait several years before the start of the patent examination.

Quality assurance measures

Patent offices have meanwhile adopted a series of measures in order to limit quality problems and the unrestrained granting of patents. A bundle of measures have meanwhile been introduced to raise the bar for patenting at EPO. The grant rate has plunged according to the EPO. Increased requirements for the inventive step are a key precondition for an improvement of the system.[172] As William D. Nordhaus put it in 1972: “[…] The best way to prevent abuse is to ensure that trivial inventions do not receive patents. […]” [173] The Expert Commission warmly welcomes these measures.

The steps taken so far will in all probability still not be sufficient. The fee structure of the patent offices should be structured so that opportunistic behaviour is sanctioned (e.g. an excessive number of claims or multiple applications). In addition, patent examiners should be given the possibility to terminate the examination of marginal patent applications rapidly with a rejection.

Problematic governance structures

The national offices represented in the Administrative Council of the EPO and the EPO itself each receive half the extension fees for the patents granted by EPO. These receipts are a very important source of income for most national patent offices and for the EPO, because as a rule the charges for research and examination do not fully cover the costs actually incurred. Many representatives of national patent offices in the Administrative Council would therefore find it difficult to agree to measures which reduce the numbers of patents granted. The governance structure of the EPO has also proved to be problematic when it comes to deciding on the division of labour between national offices and the European office. Since the national offices in the Administrative Council of the EPO have the final say on all important matters concerning the European office, national interests often dominate. In the on-going discussion about the European Patent Network (EPN), some contributors are more interested in ensuring that the national offices are retained than in seeing the formation of an efficient European structure. In the course of a rational development of the European Union's internal market, very small national patent offices will no longer have any significant economic role to play.

Carefully developing patent institutions in the European single market

There are currently a number of fields in which progress seems possible towards the further development of the EU institutions. For example, plans have been presented to introduce a European Union patent which would be valid in all member states. The European Commission under various Council presidencies has presented proposals for a unified patent jurisdiction. On 4 December 2009, the EU Competitiveness Council meeting unanimously approved the measures for an enhanced patent system in Europe.[174]

However, there are still important aspects to be clarified, e.g. the question of language and translations. The details of the agreement will also be debated in the European Parliament. An agreement on a European Union patent and unified jurisdiction will therefore involve further negotiations between the EU member states. It is vital that the efficiency and quality orientation of the future systems should not be watered down by questionable compromises. The Federal Government should draw attention to the undisputed advantages of the German patent jurisdiction, and aim to ensure that the central Court of Justice in the new legal system is anchored in Germany. Already almost three-quarters of all patent disputes are conducted in Germany, because legal clarification can be obtained quickly here, cost-effectively and with a high level of expertise. A new, unified system must also offer these advantages, because otherwise it would not be possible to achieve any significant improvement. Above all, the new jurisdiction must become a guarantor for the high quality of patents.[175] National German interests and those of the European Patent system are therefore very similar – they should be pursued skilfully and forcefully in negotiations.

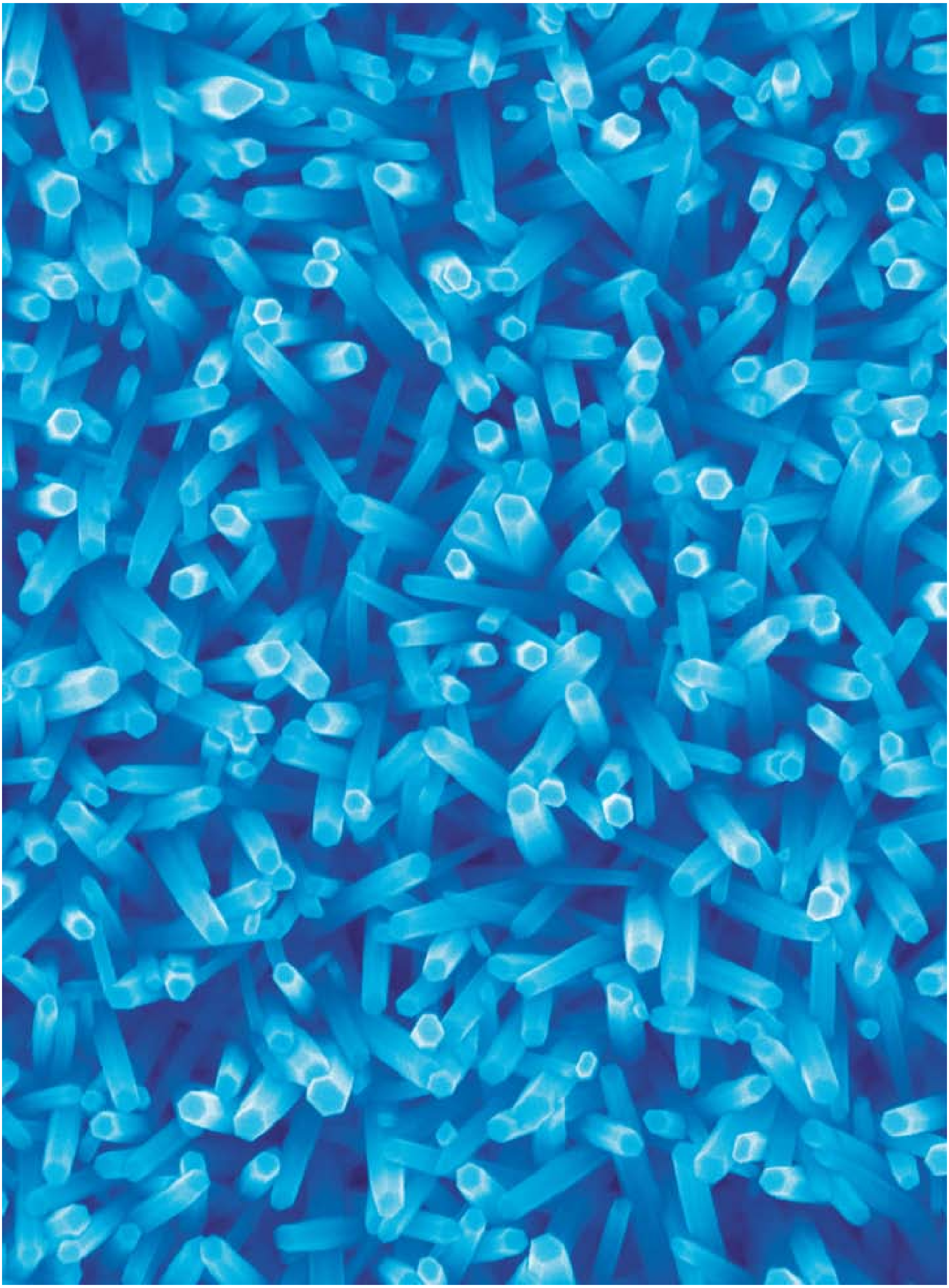
Recommendations

- The quality orientation in the European Patent offices should be upgraded. Policy-makers must ensure that patents are only granted for inventions which show a sufficient inventive step. A patent system which opens its gates for marginal contributions can become an obstacle to innovation.
- Patent examiners must be enabled and encouraged to reject marginal patent applications. They should also be allowed to penalise malicious application behaviour.
- The Federal Government should support the formation of European institutions in the patent system, with a uniform court system and an EU patent. It will not be possible to develop the European Single Market fully if these institutions are nationally fragmented. Efforts should be made to ensure that the new European institutions bring further improvements with them in comparison with the existing system. Harmonisation is not an end in itself.

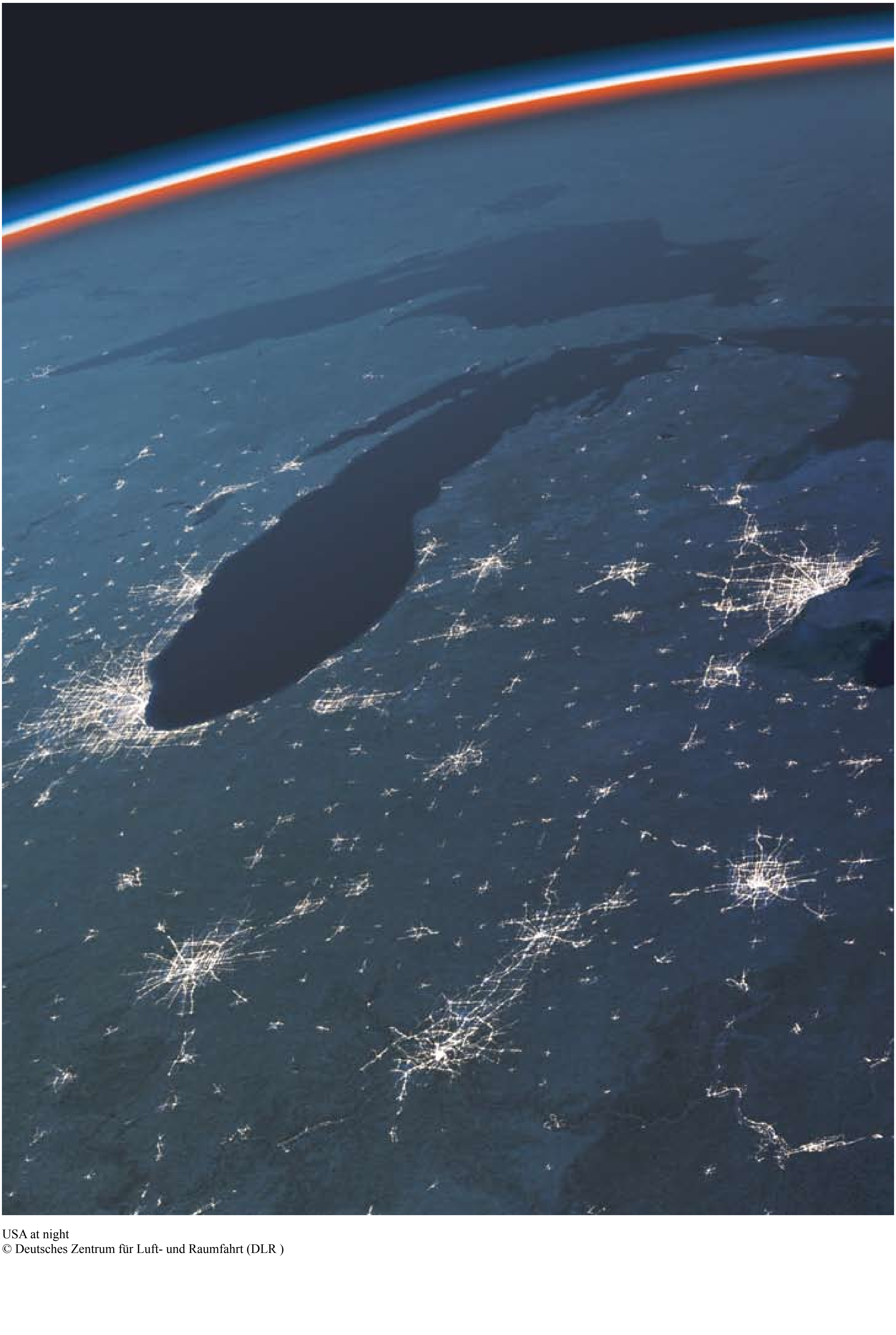
PATENTS AS A PARAMETER OF TECHNOLOGICAL POTENTIAL B 5 – 2

The empirical registration of the innovation processes still presents problems for scientists and policy-makers. In recent years it has been possible to develop and test a series of indicators, but these are subject to changes, which are being carefully monitored by the Commission of Experts for Research and Innovation. They include the changes in the motives of patent applicants mentioned above.

For R&I analyses, patent offer both advantages and disadvantages. The advantages include that datasets are readily available and, because of their legal significance, they are very reliable. In addition, the actors (inventors and applicants) are readily identifiable. The patents can be assigned to a place of origin and a field of technology. It is also possible to iden-



Nanowires of zinc oxide



USA at night

tify the various groups of applicants, e.g. research institutions, universities and private companies. This makes it possible to carry out further analysis. Cross-sectional data[176] for patents correlate highly with input measures such as R&D and innovation expenditure. The innovation process is also correlated with profits, exports and company growth. They thus represent an interesting and attractive parameter for innovation research. On the other hand, there are also disadvantages. Patents only register about half of all inventions – the rest are kept secret. And the role of patents in the innovation process is not always clear. In innovation research, patents are often interpreted as a final quantity, but it would be better to treat them as an interim product in the innovation process.[177] They do not mark the start of an innovation, but they are not the outcome either. And in some sectors of the economy patents are particularly important, whereas in others they tend to be less significant. These aspects have to be taken into consideration when interpreting patent data.

Using patent data in R&I analyses

When analysing innovation processes, patents are generally used in three ways. In some cases, changes in the numbers of applications (e.g. at the German Patent Office) are considered as a reflection of the dynamics of inventive or innovative activity. This approach can be used for various countries, sectors, or institutions. For example, the data on patent applications from German universities can be used in order to assess the removal of the inventor's privilege for university staff in 2002. It is important in these analyses that any distortions in the numbers of patent applications do not change over time. Secondly, countries are often compared in terms of their patent applications in order to draw conclusions about their technological capacity. The comparisons are reliable, provided the patent data from the countries under comparison are subject to the same distortions. Thirdly, patent data can be used to analyse national und regional specialisation patterns. In this case it is not the absolute numbers or growth rates which are considered, but the extent to which various fields of technology are represented in each patent portfolio. Here too it is important to ensure that the units being compared with one another are not subject to different distortions.

Possible distortions in patent analyses

Due to the change in the motivation of patent applicants it is no longer possible to equate the increase in the numbers of patents with an increase in innovations. This means that the fact that the number of application has increased by a certain percentage does not necessarily mean that there has been an increase in inventive activity. Changes in the costs of patenting, in the patent office regulations, or in the motivation of the applicants can have relatively strong effects, which are not necessarily related to a change in inventive activity. Therefore it is also necessary to define suitable control groups.

Comparisons of patent portfolios of countries or regions also require a detailed evaluation, and here too there may in principle be distortions. For example, it is known that the distribution of the value of patents is highly skewed, with the most valuable ten percent of patents in a portfolio accounting for some 90 percent of the overall value. If the patent value distributions of two countries are different, then a straight comparison of the patent numbers can easily lead to a misinterpretation of the technological or economic values of the national patent portfolios.

Results of an investigation

In 2009, the Expert Commission commissioned a study of possible distortions.[178] The results allow a number of conclusions to be drawn. It turns out that patents are still closely linked with export volumes, so that they can reflect the technological standing of a country relative to competitors. The study also shows that weighting patent applications with various indicators hardly leads to any changes in the relative positions of countries. However, when considering individual fields of technology, then weighting can lead to slight shifts of the countries compared with one another. The investigation confirms that the strategic use of patents and the associated increase in numbers of applications is about the same across various countries and fields of technology. Therefore it still makes sense to continue the comparison of "transnational patents" (Section C 5). Nevertheless, the Expert Commission advises paying careful consideration to the possible influence of distortions when interpreting patent data.

Conclusion on the use of patents as indicators

Despite various distortions and weaknesses, patents are useful in analyses intended to contribute to the formulation of R&I policies. In certain cases it will be appropriate to use quality-weighted patent data, above all when considering measurements of technological potential. With specialisation measures, the use of weighted patent data will only result in slight changes.[179] The results previously presented retain their relevance – Germany has a clear specialisation profile with a focus on classic automotive technology, mechanical engineering, electrical engineering and chemistry. The sectors of cutting-edge technology are less well represented in the patent portfolio of German applicants – even when the patent indicators are weighted with the importance of the patents.

STRUCTURE AND TRENDS

C

C STRUCTURE AND TRENDS

In this section, the Commission of Experts for Research and Innovation presents a detailed and focused insight into the development of key R&I indicators, this year with a revised format. Individual indicators are presented in the form of datasheets with commentaries, grouped under topic headings.

C 1 EDUCATION AND QUALIFICATIONS

Overview

In all advanced economies there is a trend towards a knowledge-based economy. This is without an economic alternative and creates an increasing demand for human resources. Well educated and highly-qualified personnel are a prerequisite for research and development, for innovations and their implementation, and for the transfer of scientific findings to the private sector. In particular, there will be growing demand worldwide for people with academic qualifications, with increasing numbers of natural scientists and engineers needed in particular for technological innovation processes.

This development presents enormous challenges for the education system, which has to provide the qualified personnel. The greater the demands on the qualifications of the workforce, the greater is the obligation of the higher education system and the vocational training system to turn out sufficient numbers of highly-qualified and well-trained young people. In order to prevent the foreseeable shortages that can develop here, not least for demographic reasons, measures must be adopted such as increased mobilisation of potential, permeability between vocational training and higher education systems, and continuous education for those already in employment. Germany has unfortunately lost its former leading position in education due to shortcoming in its education policies.

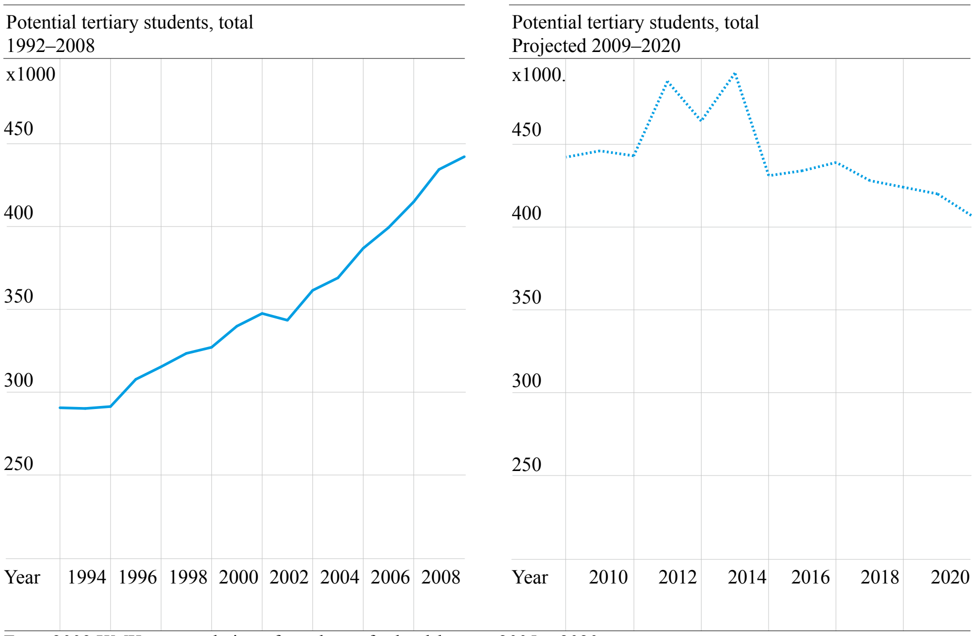
This section draws on a study produced for the Commission of Experts for Research and Innovation.[180] Data is used from the Federal Statistical Office (e.g. microcensus, higher education statistics) as well from the OECD publication "Education at a glance", and surveys of the responsible institutes.

Investigated indicators:

– School-leavers qualified for higher education in Germany
– Number of new tertiary students in an international comparison
– Foreign students at German universities
– Graduation rate and subject structure in an international comparison
– Further training according to employment status and level of qualification
– Proportion of workforce in Europe who are highly qualified

SCHOOL-LEAVERS QUALIFIED FOR HIGHER EDUCATION IN GERMANY

C 1 – 1



From 2009 KMK: extrapolation of numbers of school-leavers 2005 - 2020.
Sources: Federal Statistical Office (collated). Standing Conference of the Ministers for Education of the Laender (2009).

Numbers and proportion of school-leavers qualified for higher education: school-leavers are qualified for tertiary education if they obtain a general or subject-specific higher-education entrance qualification. The proportion of school-leavers qualified for higher education is expressed relative to the age cohort.

Lower proportion of school-leavers qualified for higher education but new record number of school-leavers qualified for higher education

The number and proportion of school-leavers qualified for higher education show how many young people could be trained in the universities to provide the specialist workforce of the future. In 2008, 271 000 school-leavers obtained an entrance qualification for universities or for universities of applied sciences (fachhochschule). Since the mid-1990s this number has been rising almost continually. In 2011 and 2013, the effects of the staggered shortening of school education to twelve years will lead to spikes in the numbers of school-leavers qualified for higher education, but this will then be followed by a downward trend. In 2008, 161 500 young people also left vocational-training schools with a qualification for higher education. This meant that a total of 442 100 school-leavers were qualified to go on to tertiary education in 2008. This is 45 percent of the age cohort and 52 percent more than in 1992. 53 percent of school-leavers qualified for higher education are female.

The potential for tertiary education had increased appreciably. This is due mainly to an increase in the proportion of school-leavers qualified for higher education from 31 percent in 1992 to 45 percent in 2008. This trend will continue, but in an international comparison Germany is still in a poor position. In most OECD countries the proportion of school-leavers qualified for higher education is much higher.

C 1 – 2 NEW TERTIARY STUDENTS IN SELECTED OECD COUNTRIES

Countries	1998	2001	2002	2003	2004	2005	2006	2007
Australia	53	65	77	68	70	82	84	86
Finnland	58	72	71	73	73	73	76	71
France	–	37	37	39	–	–	–	–
Germany	28	32	35	36	37	36	35	34
Italy	42	44	50	54	55	56	55	53
Japan	36	37	39	40	40	41	45	46
Netherlands	52	54	54	52	56	59	58	60
Spain	41	47	49	46	44	43	43	41
Sweden	59	69	75	80	79	76	76	73
United Kingdom	48	46	48	48	52	51	57	55
USA	44	42	64	63	63	64	64	65
Average	40	48	52	53	53	54	56	56

Net rates of tertiary education entry for the typical age cohort.
Sources: OECD (2009c). OECD indicators.

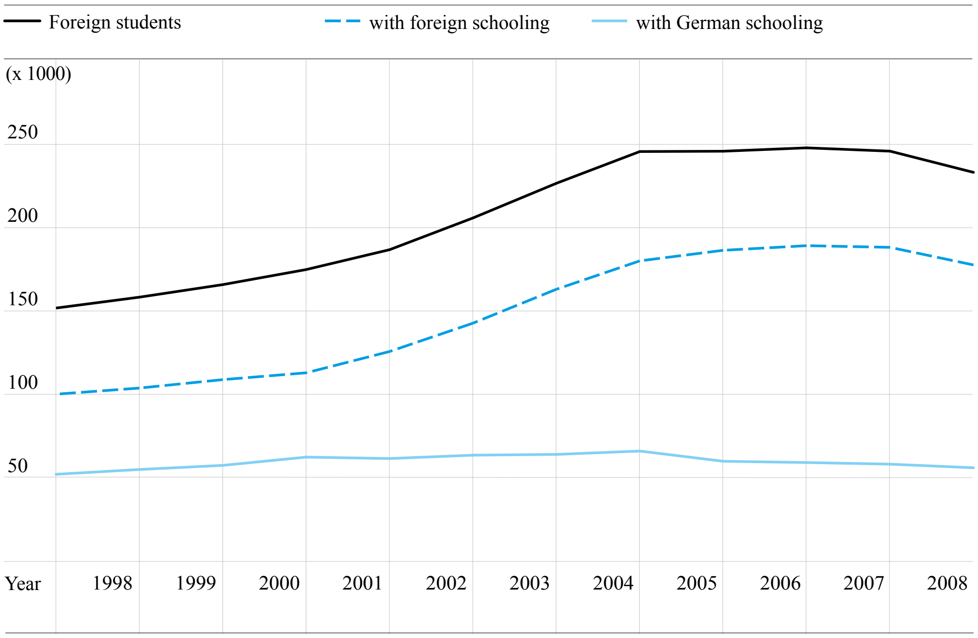
Tertiary education entry rate: Proportion of the appropriate age cohort starting tertiary education. It is a measure for the utilisation of the demographic potential for the formation of academically-trained human resources.

Current high entry rates for tertiary education cannot be maintained

Only three-quarters of the school-leavers qualified to go on to tertiary education actually do so: females less often than males, those with parents with low levels of education less often than those with an academic family background. In 2008, there were 396 600 newly enrolled students at Germany's universities. According to preliminary figures, the number was even higher in 2009 at 423 000. However, in contrast to the numbers of school-leavers qualified for higher education, the numbers of entrants have fluctuated. At the start of the 1990s and between 2004 and 2006 there was actually a marked decrease. Just less than half of tertiary education entrants are female, although they represent more than half the school-leavers qualified for higher education. 15 percent of new tertiary students now come from other countries.

In the next few years, the combined effects of switch to 12-years of schooling and a brief rise in birth rates at the end of 1990s will lead to a further increase in the number of entrants to tertiary education. However, due to the long-term demographic trends this will be followed by a decrease beginning in about 2014. The Standing Conference of the Ministers for Education of the Laender (KMK) expects about 374 000 entrants to tertiary education in 2020. The tertiary education entry rate in 2007 was 34 percent, which is the lowest value among the OECD comparison countries. In the USA, Sweden and Finland the entry rates were 65 percent and higher.

FOREIGN STUDENTS AT GERMAN UNIVERSITIES AND COLLEGES



Sources: DAAD (2009). Federal Statistical Office.

Foreign students are non-German nationals, who may either have attended school in Germany and obtained a higher-education entrance qualification there or may have attended school in another country.

Foreigners and "upwardly mobile" students more likely to choose science subjects

One way of increasing the numbers of students, in particular those studying mathematics, computer sciences, natural sciences and engineering, is to make use of the development potential among foreign students and those with a non-academic family background. In 2008, 234 000 foreign students were enrolled at German universities, of which 178 000 had not attended a German school. The overall proportion of foreigners is thus about 12 percent, compared with 8.3 percent a decade previously. However, both this increase and the recent decline are solely due to changes in the numbers of students with non-German schooling. The unchanging numbers of foreign entrants with German schooling over the past decade is an indication that Germany has problems guiding schoolchildren with a migrant background through to higher education. Every second foreign student with non-German schooling comes from a European country, and a large majority are from eastern Europe. Every third student is from Asia, and China is particularly well represented, (higher degrees and doctorates are particularly attractive for this group). 79 percent of foreign students with German schooling come from a European country, and of these a quarter have Turkish nationality. In the Winter Semester 2007 / 2008, 55 percent of all students in Germany had parents with academic qualifications, and only 9 percent had parents with basic secondary education or lower. Students with a non-academic background are more likely to enrol for mathematics, computer sciences, natural sciences and engineering. Engineering is a typical choice for the educationally "upwardly mobile", and the proportion of foreign students in this case is also particularly high.

C 1 – 4 GRADUATES AND SUBJECTS STUDIED

	1995	2000	2002	2005	2006	2007	2008
Total no. of graduates	197 015	176 654	172 606	207 936	220 782	239 877	260 498
Of which women, %	41.2	45.6	48.1	50.8	51.6	51.8	52.2
University graduates, (%)	63.6	64.3	63.2	60.8	61.9	62.4	62.4
Languages and humanities	27 125	29 911	30 175	35 732	39 769	43 827	50 680
in percent	13.8	16.9	17.5	17.2	18	18.3	19.4
Law, economics, social sciences	66 538	62 732	62 284	76 566	79 235	85 838	87 196
in percent	33.8	35.5	36.1	36.8	35.9	35.8	33.5
Mathematics, natural sciences	27 800	21 844	21 594	30 737	34 062	38 417	43 333
in percent	14.1	12.4	12.5	14.8	15.4	16.0	16.6
Medicine / Health sciences	12 075	10 620	10 223	11 817	12 230	13 358	14 345
in percent	6.1	6.0	5.9	5.7	5.5	5.6	5.5
Engineering	47 295	35 725	32 414	34 339	35 627	38 065	42 558
in percent	24.0	20.2	18.8	16.5	16.1	15.9	16.3
Art, Art history	7 280	7 630	7 857	9 678	10 503	10 399	11 185
in percent	3.7	4.3	4.6	4.7	4.8	4.3	4.3

Source: Federal Statistical Office, Series 11 - 4.2. HIS / ICE.

Subject structure and rate of graduation: The subject structure shows the proportion of first degree graduates in each subject or subject group. The rate of graduation measures the proportion of tertiary graduates in the relevant age cohort of the population.

Germany's graduation rate is poor in an international comparison; the proportion of women has increased significantly

The number of first degree graduates from German universities reached a record level of 260 500 in 2008. Compared with 2002, this represents an increase of 50 percent. This trend will continue in the medium-term. However, in the long-term the demographic development will lead to a decline in the numbers of graduates. Over the past 15 years the proportion of women graduates has increased from 40 to 52 percent. However, in mathematics, computer sciences, natural sciences and engineering it is still below a quarter. A third of all graduates qualified in law, economics and social sciences, a fifth in languages and cultural sciences, 17 percent in mathematics and natural sciences, and 16 percent in engineering (which seems to mark an end to its downward spiral).

The graduation rate in Germany has risen in particular since 2002, and is currently at 26.2 percent. However, this is still some way below the target of 35 percent formulated by the Science Council. In an international comparison of graduation rates, Germany is at the end of the field, and in terms of the change of the rate of graduation, Germany comes last in the OECD comparison.

FURTHER TRAINING ACCORDING TO EMPLOYMENT STATUS AND LEVEL OF QUALIFICATION

C 1 – 5

	1996	1997–1999	2000–2002	2003–2005	2006	2007
Employed	**4.1**	**3.8**	**3.4**	**5.2**	**5.3**	**5.5**
Low (ISCED 0–2)	1.1	1.0	0.9	1.3	1.3	1.1
Medium (ISCED 3–4)	3.8	3.4	3.1	3.8	3.9	4.0
High (ISCED 5–6)	6.7	6.2	5.4	10.0	10.6	10.8
Unemployed	**5.5**	**4.5**	**4.4**	**2.7**	**2.4**	**2.8**
Low (ISCED 0–2)	2.0	2.0	2.1	1.5	1.4	1.7
Medium (ISCED 3–4)	5.9	4.8	4.7	2.7	2.4	2.9
High (ISCED 5–6)	10.7	8.5	7.9	5.2	5.0	5.5
Non-employed	**4.1**	**3.5**	**3.3**	**1.1**	**0.9**	**0.8**
Low (ISCED 0–2)	0.5	0.5	0.6	0.4	0.4	0.4
Medium (ISCED 3–4)	5.8	4.7	4.2	1.3	0.9	0.8
High (ISCED 5–6)	8.9	7.4	6.3	2.1	2.0	1.7

Figures as percentages of all those aged 15 to 64 years.
Source: Microcensuses 1996 to 2007. Calculations by EFI.

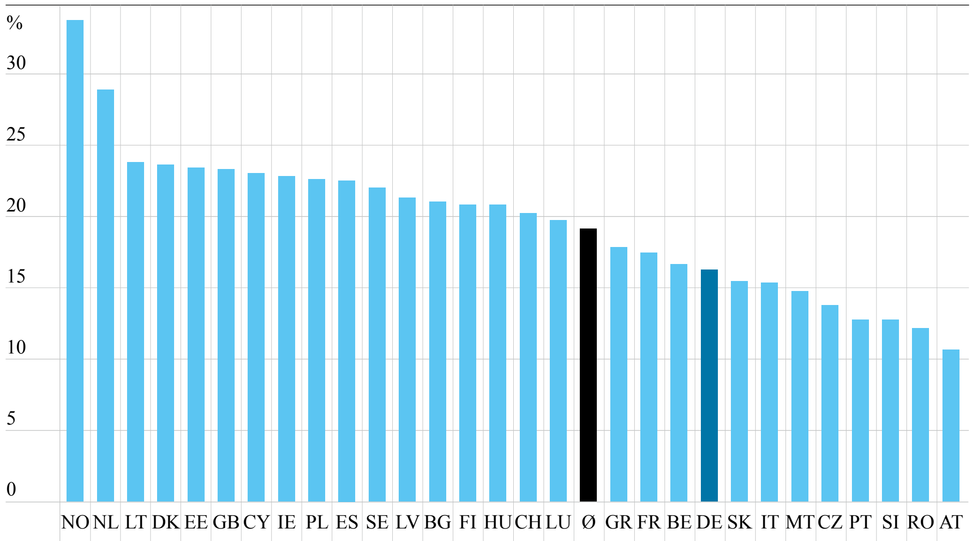
Further education rates: Proportion who have participated in a further training measure in the four weeks prior to being questioned.

Level of qualification and employment status influence further training behaviour

Participation in further training courses is influenced by two main factors: the level of qualification and the employment status of the individual. The higher the level of education, then the higher is the likelihood of receiving further training. The employed are much more likely to attend further training courses than the unemployed or non-employed. This is shown by the responses to the microcensus, in which people are asked if they had taken part in a further training measure in the previous four weeks. In 2007, eleven percent of highly-qualified employed responded positively, compared with only 1.1 percent of the employed with low qualifications. Unemployed people have taken part in further training much less frequently in recent years than the employed. The only exception is the unemployed with low levels of education.

There are only slight differences between men and women (5.2 percent against 5.9 percent in 2007). However, women in the knowledge-intensive occupations are considerably more active in further training than men. Age has only a slight influence on the tendency to take part in further training. The rate of further training is currently similar for all age groups of the highly qualified between 15 and 54 years, ranging from 11 to 12 percent. Across all qualification levels, however, there is a steady rise in participation in further training above an age of about 35 years.

C 1 – 6 PROPORTION OF EUROPE'S WORKFORCE WHO ARE HIGHLY QUALIFIED* IN 2008



*ISCED 5a + 6.
Source: European Labour Force survey. Calculations and presentation by Fraunhofer ISI.

Highly qualified: People with a tertiary education qualification in accordance with the International Standard Classification of Education (ISCED). Level 5A includes qualifications such as a "diplom", a bachelor's degree or a master's degree. Level 6 is reserved for programmes, which lead to advanced research qualifications, such as a doctorate or an habilitation at institutions of higher education.

Increasing demand for highly-qualified personnel

In Germany, 16.3 percent of employed people held a university degree in 2008. This proportion has risen steadily in recent decades. However, Germany has at first sight a very weak position in an international comparison. This is due in part to the higher importance attached in Germany to vocational training courses and dual vocational training, where in other countries higher education courses are provided.

Considering only those working in knowledge-intensive jobs, Germany does better, reaching the EU average with about 43 percent. There is thus a considerable difference in qualifications between knowledge-intensive and non-knowledge-intensive sectors in Germany. This applies above all for the services sector. Here the proportion of the employees with a tertiary qualification is five times higher in the knowledge-intensive sectors than in the remaining services sectors. In an international comparison, the proportion of people with lower level tertiary qualifications in Germany is usually lower than in other countries.

Overview

Research and development is essential for the generation of new products and services. Although a number of companies produce innovations without formal R&D, the examination of R&D activities gives key criteria for assessing the technological capacity of a country. In particular the financial expenditure and the numbers of R&D personnel are of interest, as well as the involvement of the private sector and the state in R&D activities.

A high R&D rate has positive effects for competitiveness, growth and employment. For example, over the past decade the economy grew most where the R&D capacities expanded fastest. To this extent, Germany has no alternative in the long term to a strategy based on research, development and innovation.

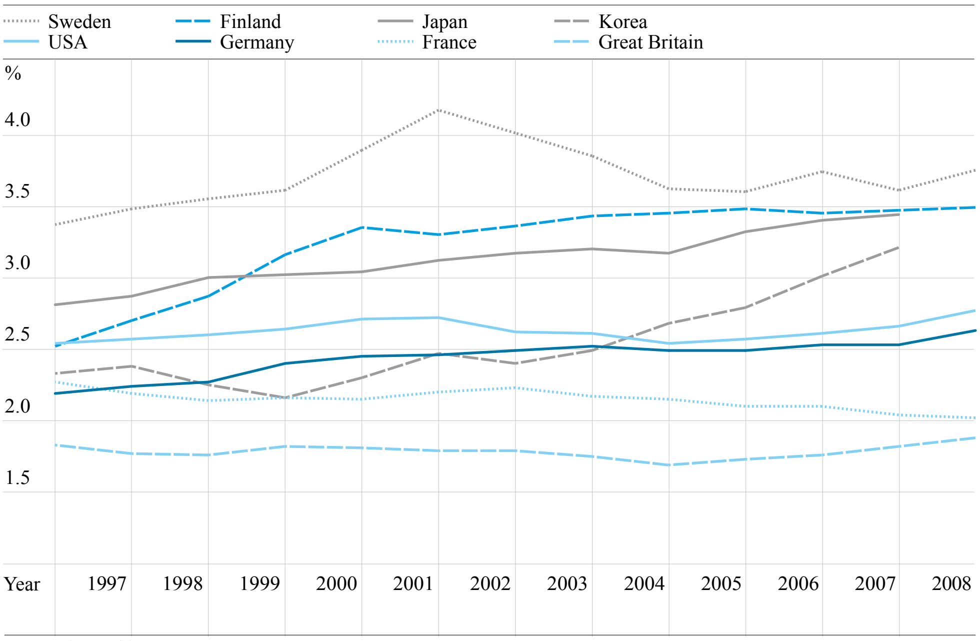
It is not possible to tell from the data which course was adopted in Germany regarding research and development during the economic and financial crisis. At the start of the crisis, the German position had been a favourable one. Currently, the plan data of German companies indicate that research and development is hardly being cut back in the crisis. However, long-term trends and international comparisons show that Germany is losing ground. Other countries, in particular in Asia, have invested much more in R&D and their economy is clearly directed towards knowledge-intensive services and cutting-edge technology. Their rapidly expanding domestic demand and well-trained workforces also make these countries attractive for direct foreign investments.

Most of the data evaluated in this section is from OECD sources (Main Science and Technology Indicators) and the R&D survey of the Stiftererband for the German science system. The data published by the OECD is gathered from 30 member countries and nine non-members, and covers central resources available for R&D, patent data, and details of foreign trade in technology-intensive industries. The Stifterverband regularly surveys some 30 000 companies in Germany regarding their R&D expenditure, their R&D personnel, sources of finance for R&D, the R&D locations, and their products.

Investigated indicators:

- Development of R&D intensity (R&D expenditure as a percentage of gross domestic product)
- R&D intensity in selected OECD countries
- Investment by the government in R&D
- Internal R&D expenditure of universities and non-university research institutions
- Public and private sector funding for R&D

C 2 – 1 R&D INTENSITY IN SELECTED OECD COUNTRIES



Data estimated in part.
Source: OECD (2009a). Calculations and estimates by NIW.

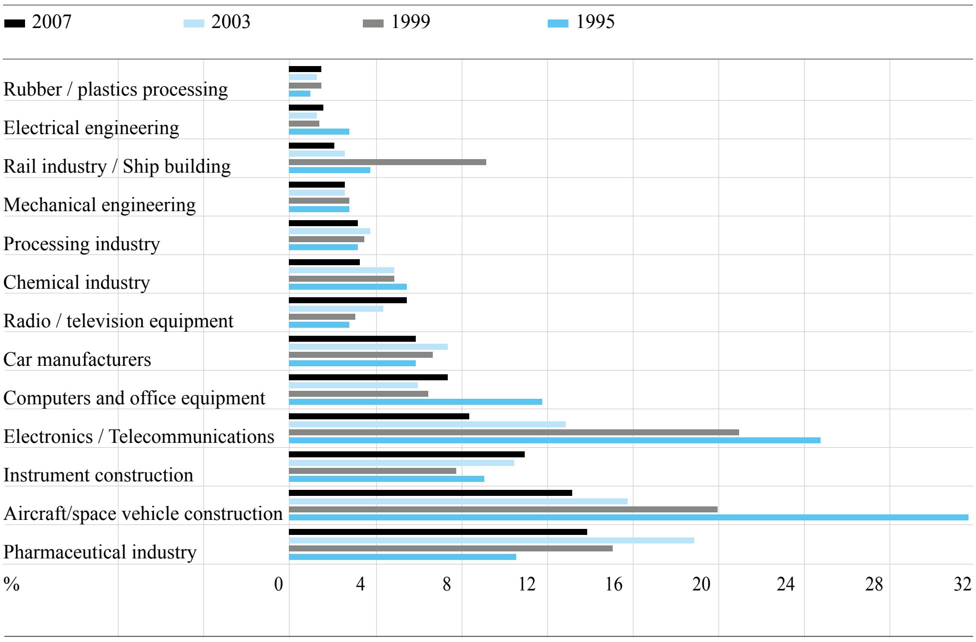
R&D intensity: Expenditure on research and development as a proportion of GDP.

Germany is no closer to the three percent target

In 2008, Germany invested 2.6 percent of its gross domestic product in research and development. Of this, the public sector funded 28 percent. In an international comparison of OECD countries, this puts Germany in a forward midfield position. Sweden was in the lead with an investment of 3.6 percent of gross domestic product in R&D, followed by Finland (3.5 percent), Japan (3.4 percent) and Korea with 3.2 percent. Italy was the trailing western industrialised countries with an R&D intensity of only 1.1 percent. France, the Netherlands and Great Britain were all well behind Germany. The OECD average was 2.3 percent, the EU average was considerably lower. The three-percent target is still a long way away.

The United States dominate the international R&D activities, and 42 percent of R&D expenditure in OECD countries was made by the USA. Germany accounted for 8.1 percent. Above all in recent years, most countries have again been investing considerably more R&D than at the start of the decade. However, western industrialised countries could not keep up with the rate of expansion of the Asian countries. In 2007, China spent US$ 102 billion on R&D, of which more than 70 percent came from the private sector. This puts China in third place among researching countries in absolute terms, although with an R&D-intensity of only 1.4 percent.

TOTAL PRIVATE SECTOR R&D EXPENDITURE RELATIVE TO TURNOVER



Source: Stifterverband-Science statistics. Federal Statistical Office, Series 4 - 4.1.1 and 4.3. Calculations by NIW.

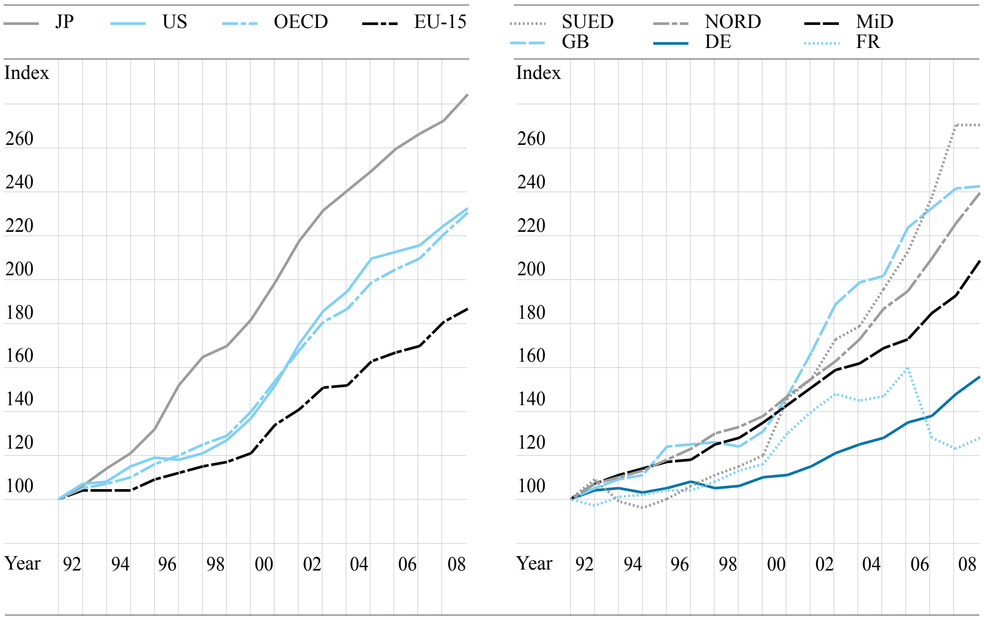
R&D-intensity: Expenditure on research and development as a proportion of turnover of a company or a branch.

The German private sector: high R&D intensity, but low R&D growth rates

In 2008, the German private sector invested 2.9 percent of gross value created in R&D. The OECD average in 2007 was 2.4 percent. Germany ranked eighth among the OECD countries. While at the start of this Millennium the growth rates of real R&D expenditures were very moderate, they began to increase again in 2003. Above all in Asia, but also in southern Europe, larger sums are being spent on R&D. Korean private sector R&D expenditure is increasing by eleven percent annually, that of the German private sector by almost three percent. Although this is based on a high level, the rate of increase is lower than the average for the EU-15 member states (3.8 percent).

R&D involvement and R&D intensity for the private sector vary considerably between industrial sectors. In cutting-edge technology segments an average of more than 13 percent of personnel are involved in R&D activities, but only some three percent in low to medium technology segments. R&D intensity is particularly high for aircraft and spacecraft, pharmaceuticals, and the IT industry. These sectors spend about 10 to 13 percent of their revenue on R&D. However, R&D expenditure is highest for the automotive industry. The R&D intensity of many sectors has changed considerably in recent years. In particular there has been a massive reduction for aircraft and spacecraft construction, but also in electronics and telecommunications. The average over all sectors has also gone down since 2003.

C 2 – 3 STATE BUDGETS FOR CIVILIAN R&D IN SELECTED WORLD REGIONS



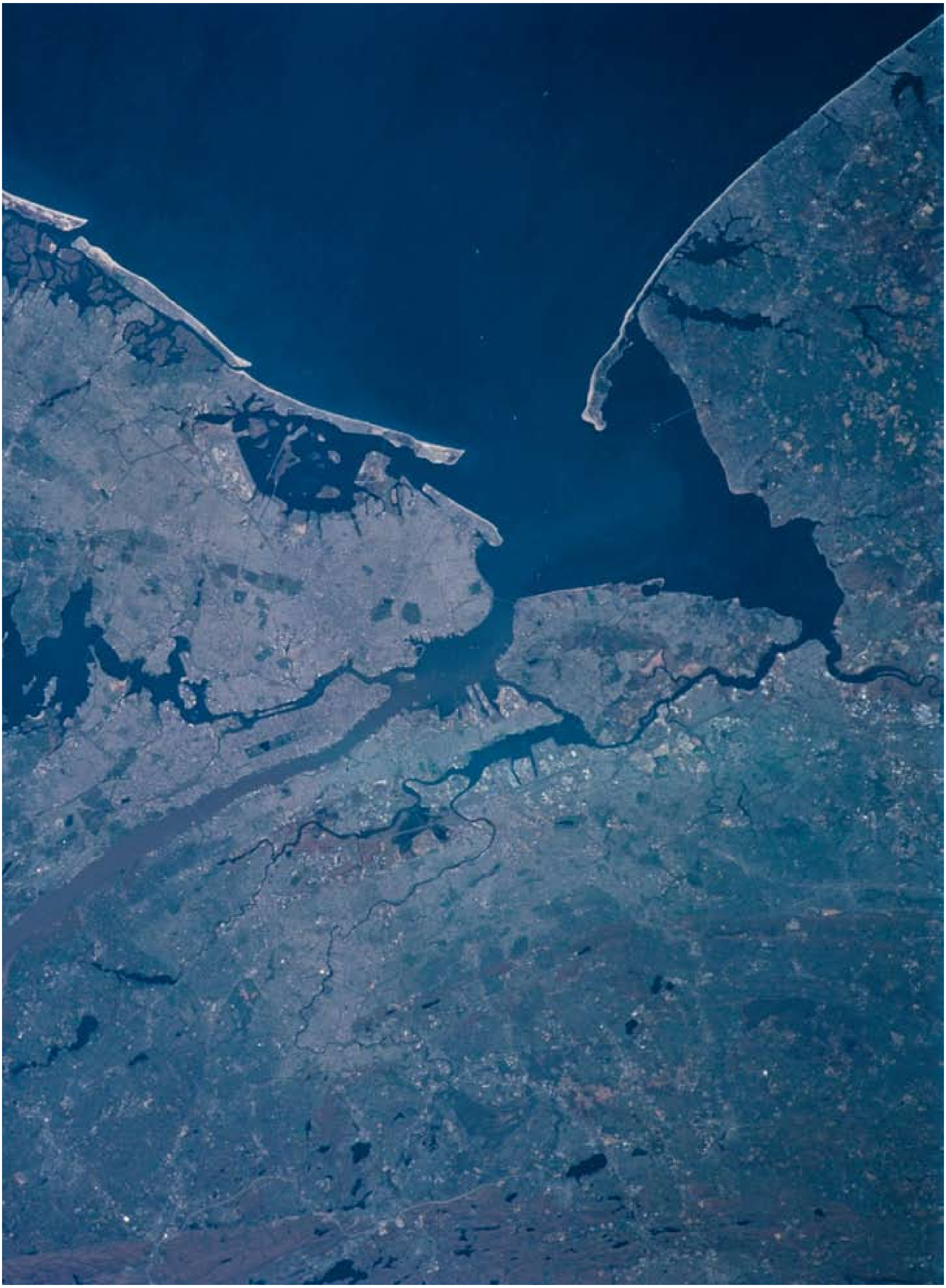
Index: 1991 = 100. Semi-log scale. Data in part estimated. NORTH: SE, FI, NO, DK, IE, IS. SOUTH: IT, PT, ES, GR.
MID: BE, NL, AT, CH.
Source: OECD (2009a). Calculations and estimates by NIW.

R&D budget: The amount allocated in the government budget to finance research and development.

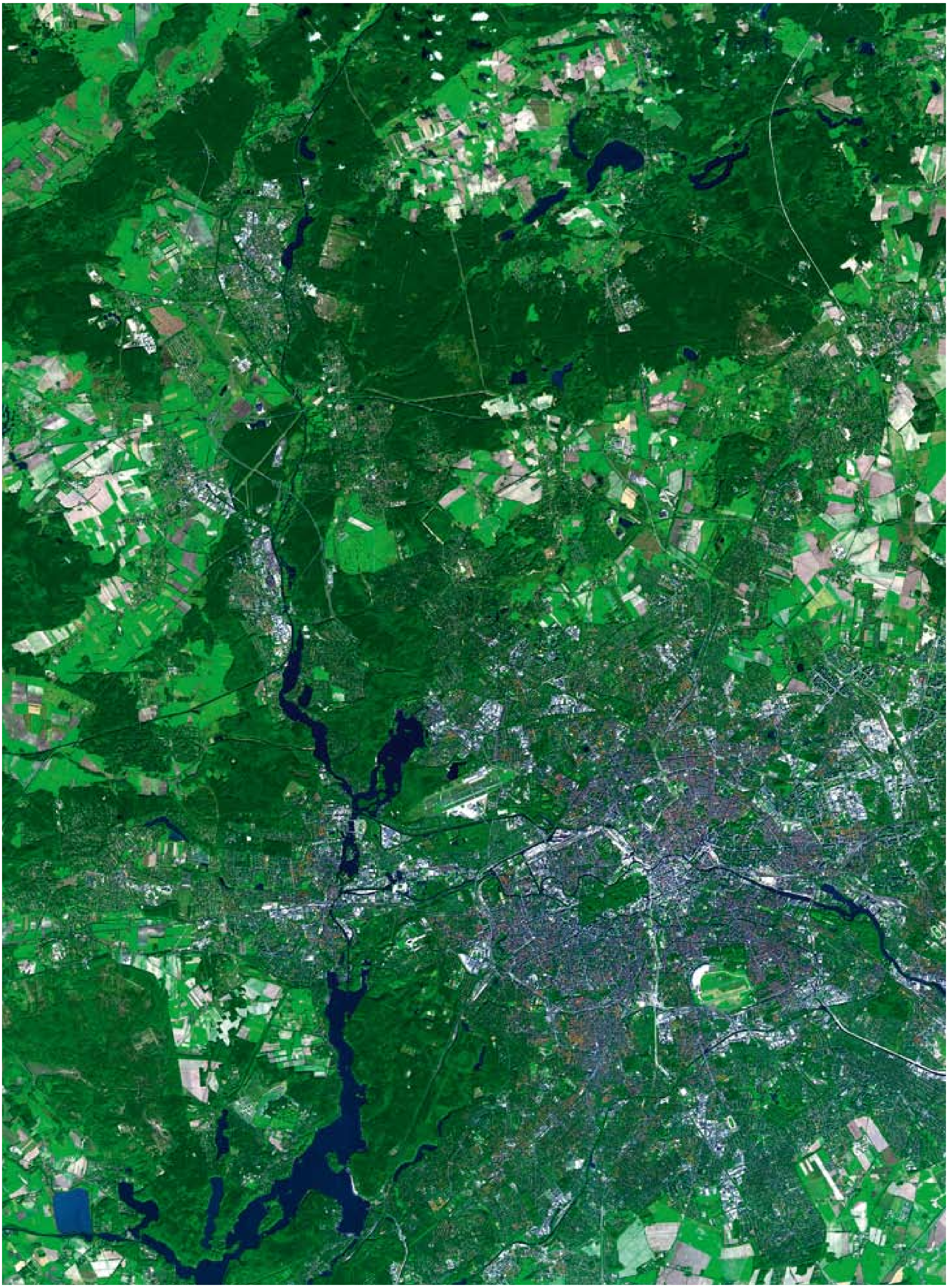
Significant increase in state investment in research and development

In Germany, the government budget for R&D has increased markedly since 2004, at an average rate of five percent per annum. Germany has therefore moved ahead of the USA and leading EU member states such as France. However, in the preceding years Germany had shown comparatively weak R&D involvement and lost ground to other industrialised countries. Germany's state R&D expenditure in the civilian sector is still high by international comparisons. It is interesting that government R&D expenditure went down in many EU member countries immediately after the announcement of the three-percent target.

In Germany, 27.7 percent of R&D activities were financed by the state in 2007. The largest part of this (42 percent) went into university research. 30 percent of R&D activities were carried out by state organisations or by universities. This was similar to the level in the USA and corresponded to the average for the OECD countries. This meant that 0.7 percent of Germany's domestic product was used by the state to finance R&D, which is an historic low. Note however that this does not take into account the flow of funds from other countries, such as R&D finance from the EU or the European Space Agency, which have considerable relevance.



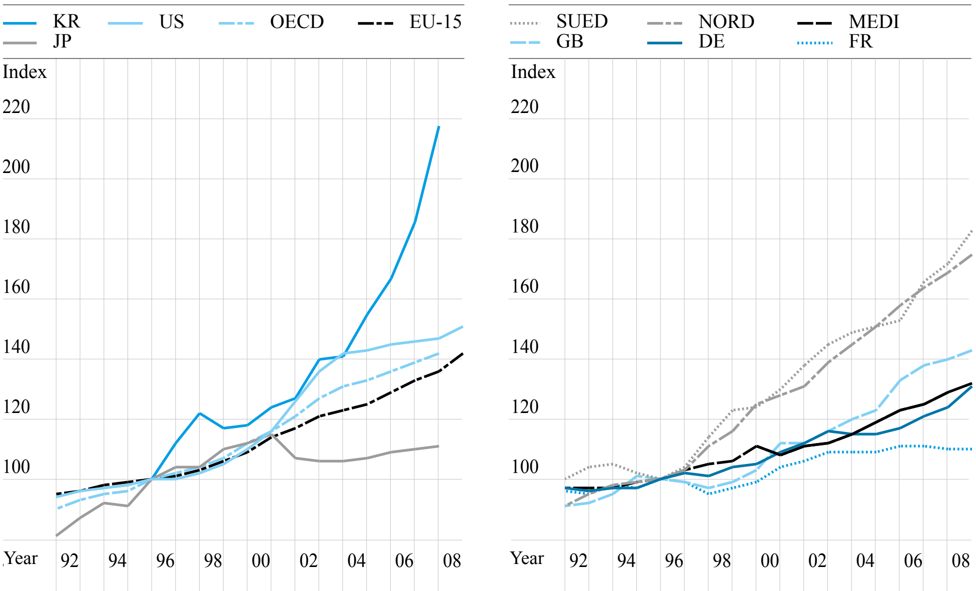
New York



Berlin

INTERNAL R&D-EXPENDITURE OF UNIVERSITIES AND NON-UNIVERSITY INSTITUTIONS* IN CONSTANT PRICES ACCORDING TO WORLD REGIONS

C 2 – 4



* Including non-profit private organisations. Index: 1995 = 100. Semi-log scale. Data in part estimated. NORTH: SE, FI, NO, DK, IE, IS. SOUTH: IT, PT, ES, GR. MID: BE, NL, AT, CH.
Source: OECD (2009a). Calculations and estimates by NIW.

Internal R&D expenditure: Financial expenditure for R&D personnel, R&D equipment, and in-house investments in R&D.

High private sector participation in German university research

In Germany, expenditure by universities and non-university research institutions on R&D has increased more rapidly since 2004 than the OECD average. However, viewed from a longer-term perspective it can be seen that the R&D expenditure has increased much more in real terms in northern European countries, but also in Great Britain and the USA.

Public sector R&D is not financed solely by the state. In the OECD countries, the private sector financed 6.6 percent of university research in 2007, and 3.9 percent of research in non-university research institutions. In Germany, the contribution by the private sector is particularly high, accounting for 14.2 percent of university research and 10.8 percent of R&D in non-university institutions. Over time, there has been an increase in demand from the German private sector for R&D contributions from the science system.

C 2 – 5 FINANCING R&D IN THE PRIVATE SECTOR ACCORDING TO ECONOMIC SECTOR, SIZE AND TECHNOLOGY CLASSES (2007)

	Private Sector	Public Sector	Other domestic	Foreign
All researching companies				
Unternehmen	**92.9**	**3.1**	**0.1**	**3.9**
Manufacturing industry	93.4	2.6	0.1	3.8
Chemical industry	96.9	0.6	0.0	2.4
Mechanical engineering	94.1	2.4	0.1	3.5
Electric eng. / Electronics	93.3	2.6	0.0	4.0
Motor vehicle construction	91.9	3.6	0.2	4.3
Other industry	94.0	2.0	0.1	4.0
Other sectors	88.0	7.4	0.3	4.2
< 100	85.9	10.1	0.3	3.8
100 to 500	91.9	4.0	0.1	4.0
500 to 1 000	93.2	4.4	0.1	2.3
> 1 000	93.4	2.5	0.1	4.0
Technology classes in industry				
Low and medium technology	94.0	2.0	0.1	4.0
High-value technology	96.2	0.7	0.1	3.0
Cutting-edge technology	88.4	6.2	0.2	5.2

in percentages.
Source: Stifterverband-Science statistics. Calculations by NIW.

State financing contribution: Proportion of total private sector R&D expenditure which derives from public sector sources.

There has been a clear drop in state support for private sector R&D

Both in the EU member states and in the OECD countries there has been a considerable drop in state support for private sector R&D over the past 30 years. It has been reduced from about 20 percent at the start of the 1980s to below 7 percent today. This trend could also be observed in Germany. In 2007, the state supported only 4.5 percent of domestic private sector R&D carried out by individual companies and joint research institutions – which is below-average in an international comparison. Many countries also provide tax incentives for R&D, which widens the gap over Germany even more, because here no such instrument exists at present. On the other hand, the figures do not include support which companies receive mony from the EU or other supra-national organisations, which cannot be quantified accurately.

State support for R&D in Germany benefits in particular the air and space industry, electrical engineering and manufacturers for data processing equipment. The sectors receiving most support also include mechanical engineering. Smaller enterprises now receive a relatively higher state contribution for R&D expenditure than large companies. In companies with fewer than 100 employees, state support covers, on average, 10.1 percent of R&D expenditure, compared with only 2.5 percent in companies with more than 1 000 employees.

Overview

The ongoing financial and economic crisis has changed the situation for private sector innovation activities, with businesses having to cope with falling demand coupled with a shortage of financial loans and liquidity. Opportunities can arise when companies find they have superfluous human resources, which they can divert to innovation projects, so that in the next upturn they will be in a position to compete with a new range of products and improved processes.

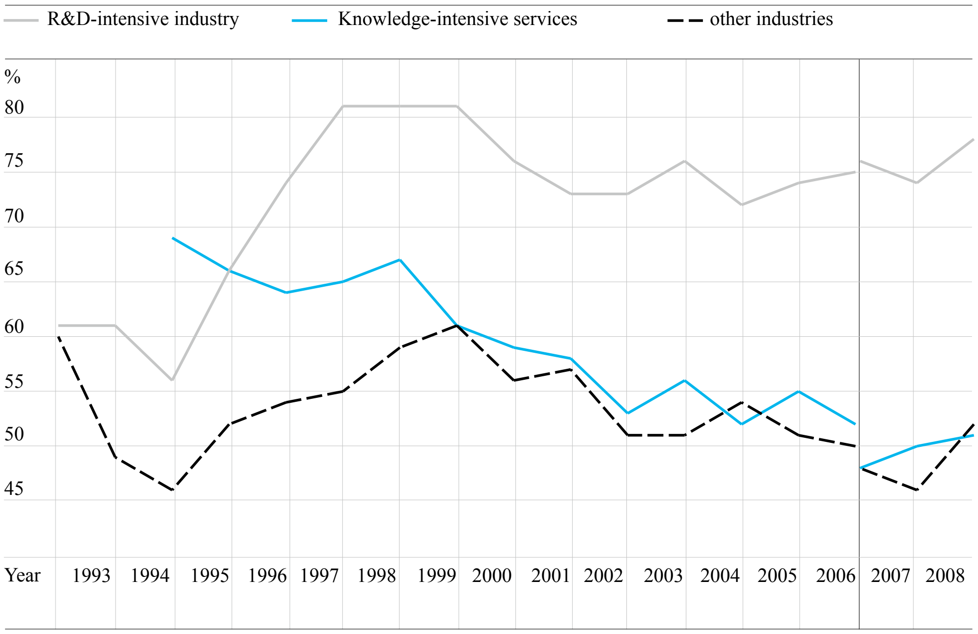
So far, no conclusive data is available to show how the German private sector has changed innovation activities as a reaction to the crisis. The innovation and R&D indicators extend to 2008, with only plan data available for 2009. However, this does allow a provisional assessment. In 2008, the economic downturn had not yet had negative consequences for the innovation activities of companies. However, the plan figures from spring and summer 2009 do indicate a marked decline in innovation expenditure for that year.

The data presented here on the innovation behaviour of the German private sector is drawn from surveys carried out annually since 1993 by the Centre for European Economic Research (ZEW), the Mannheim Innovation Panel (MIP).[181]
The MIP is a survey of the innovation activities of legally independent companies with five or more employees from the manufacturing sector and selected services sectors. It represents the German contribution to the Community Innovation Surveys (CIS) of the European Commission. The MIP survey in 2009 includes a number of methodological changes, which have affected the comparability of innovation indicators over time. All the changes were implemented retrospectively back to 2006, so that innovation indicators in accordance with the new methodology are available for three years (2006–2008). Comparisons with other European countries are based on data from the CIS survey 2007 and refer to Great Britain, Italy, Spain, Sweden, Austria, Denmark, Belgium, Finland and Norway.

Investigated indicators:

- Innovator rate in the private sector and in the knowledge-intensive services in Germany
- Companies with continuous or with occasional R&D activities in the manufacturing industry and in the knowledge-intensive services in Germany
- Innovation intensity in industry and in the knowledge-intensive services of Germany
- Proportion of revenue generated with new products in the industry and in the knowledge-intensive services of Germany
- Planned innovation expenditure in industry and in the knowledge-intensive services in Germany

C 3 – 1 INNOVATOR RATE IN THE PRIVATE SECTOR AND IN THE KNOWLEDGE-INTENSIVE SERVICES IN GERMANY



No data in 1992, and 1993 and 1995 for knowledge-intensive services, 1995 interpolated value. 2006 time series interrupted. Values for 2007 and 2008 provisional. Source: Mannheim Innovation Panel. Calculations by ZEW

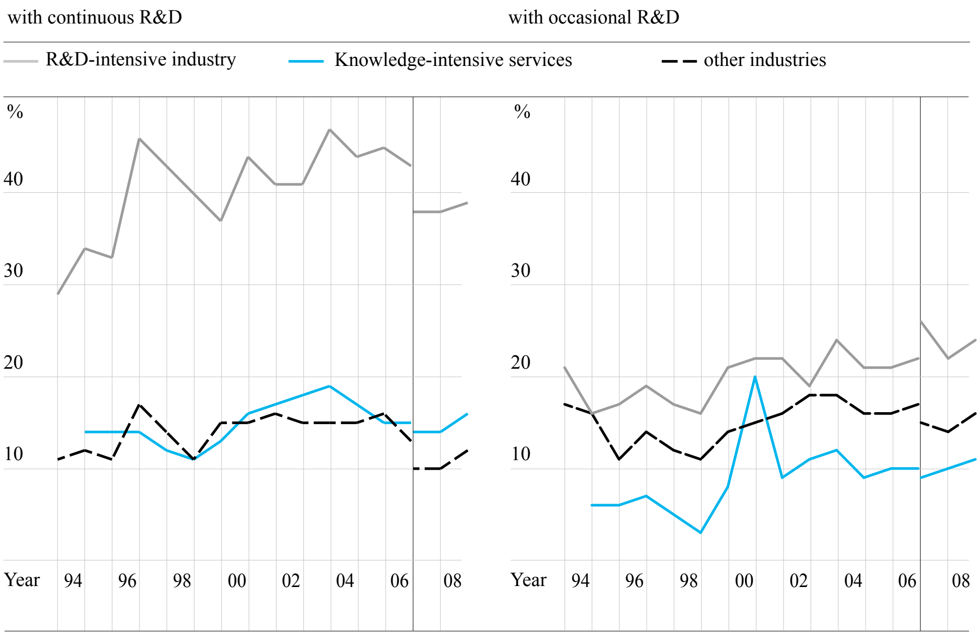
Innovator rate: Proportion of companies who have brought at least one new product or process onto the market within the previous three years.

High innovation involvement of German companies

In 2008, the looming financial and economic crisis had not yet impacted on the innovative activity of German companies. The innovator rate was higher than the previous year, both for R&D-intensive industry as well as in other industries and the knowledge-intensive services. In R&D-intensive industry it was 78 percent, which was four percentage points higher than in 2007. In the other industries the innovator rate increased by six percentage points over the same period to 52 percent. The increase was much lower in the knowledge-intensive services, where the proportion of innovators only moved from 50 percent in 2007 to 51 percent in 2008. A long-term view shows that the innovator rate in the R&D-intensive industry has remained fairly stable since the mid-1990s. In contrast, the knowledge-intensive services have shown a downward trend; this has also been the case for the other industries since the year 2000. Innovations which represent market novelties were introduced in 2008 by 32 percent of R&D-intensive industrial companies. In the other industries and in the knowledge-intensive services, 14 or 15 percent of companies introduced market novelties. In comparison with other European countries, the innovation participation of German companies in all three sectors was very high. However, smaller countries have higher values for the proportion of companies introducing market novelties.

COMPANIES WITH CONTINUOUS OR OCCASIONAL R&D ACTIVITY

C 3 – 2



Services sector values were not registered for 1995 or 1997. 2006: Break in the time series.
Source: Mannheim Innovation Panel. Calculations by ZEW

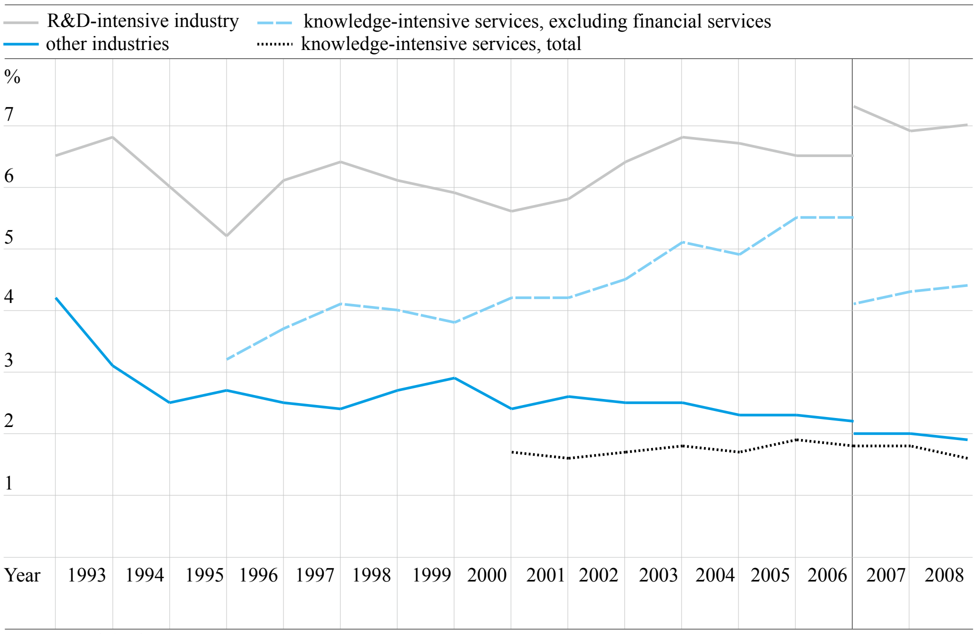
Proportion of companies with continuous or occasional R&D activity: Companies which have carried out internal R&D activities continuously or occasionally within the previous three-year period.

Increasing R&D involvement of German companies

Research and development work is usually necessary for the introduction of new products, which differ from those already on the market. It is also needed to carry out internal R&D in order to be able to respond to external stimuli for innovations, e.g. customer wishes, or new technologies or novel materials offered by suppliers. To this extent, R&D represents the "core" of innovation activities.

In the R&D-intensive industry, 39 percent of companies were carrying out continuous R&D and 24 percent occasional R&D. The R&D involvement was particularly high in the chemical industry, and also in electronics, precision and optical instruments. In the other industries, twelve percent of comparisons were carrying out continuous R&D. The proportion of companies with occasional R&D was 16 percent. In the knowledge-intensive services the situation is reversed; in this case, 16 percent of the companies carried out continuous R&D and eleven percent occasional R&D. Involvement was considerably above average in the R&D services. In all three sector groups considered here, the R&D participation increased in 2008. The German private sector shows a relatively strong R&D orientation. In the R&D intensive industry, the proportion of companies carrying out continuous R&D is higher than in any of the European comparison countries. Considering the average for all sectors, Germany also has the highest proportion of occasionally researching companies.

C 3 – 3 INNOVATION INTENSITY IN GERMAN INDUSTRY AND KNOWLEDGE-INTENSIVE SERVICES



2006: Break in the time series.
Source: Mannheim Innovation Panel. Calculations by ZEW.

Innovation intensity: Innovation expenditure of companies relative to total revenue.

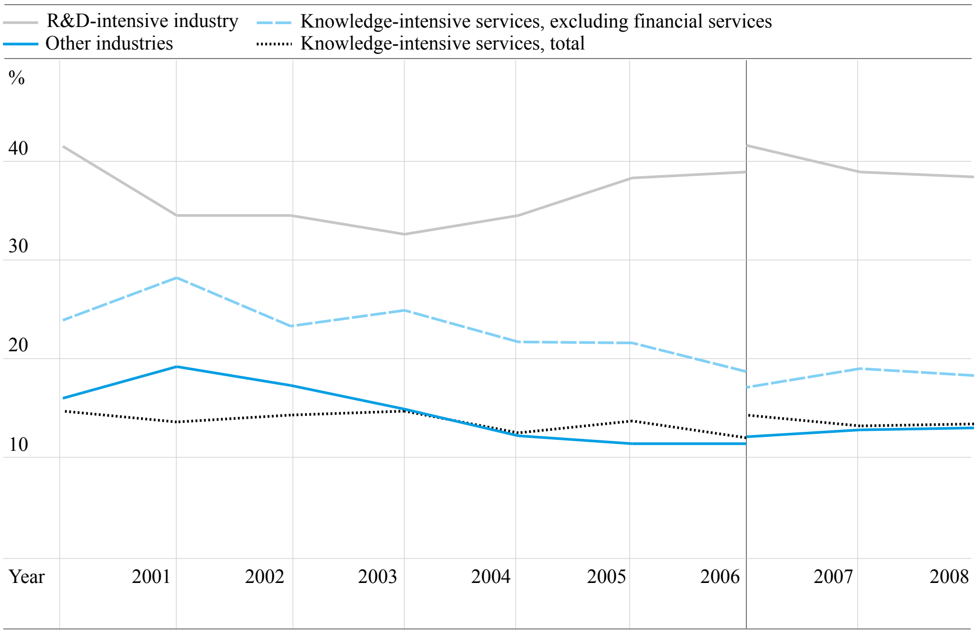
Innovation intensity in the knowledge-intensive services showing rising trend

The innovation expenditures of companies covers internal and external R&D, patents and licences, machines and equipment for innovations, product design, launching new products, and other innovation-related goods and services. In 2008, the total for R&D-intensive industry, other industries, and the knowledge-intensive services amounted to nearly EUR 117 billion.

R&D-intensive industry companies alone spent EUR 77.2 billion on innovations in 2008. This corresponds to about seven percent of the total revenues of the sector group. From 1992 to 2008, the innovation intensity in the R&D-intensive industry hardly increased at all. The relative increase in the stagnation years 2001 to 2003 is above all due to the weak revenue situation. Since then, there has been a slight downward trend in innovation intensity for the R&D-intensive industry. In the other industries, the companies' innovation expenditure in 2008 amounted to EUR 18 billion. The innovation intensity was 1.9 percent, which is much lower than the value for the R&D-intensive industry, with a continuing downward trend. The companies in the knowledge-intensive services spent EUR 21.6 billion towards innovations in 2008. This corresponds to 1.6 percent of the total revenues for this sector group. Excluding financial services, the innovation intensity in 2008 was much higher at 4.4 percent and also showed an upward trend.

PROPORTION OF REVENUE ACHIEVED WITH NEW PRODUCTS IN GERMAN INDUSTRY AND THE KNOWLEDGE-INTENSIVE SERVICES

C 3 – 4



2006 Break in the time series. Source: Mannheim Innovation Panel.
Calculations by ZEW.

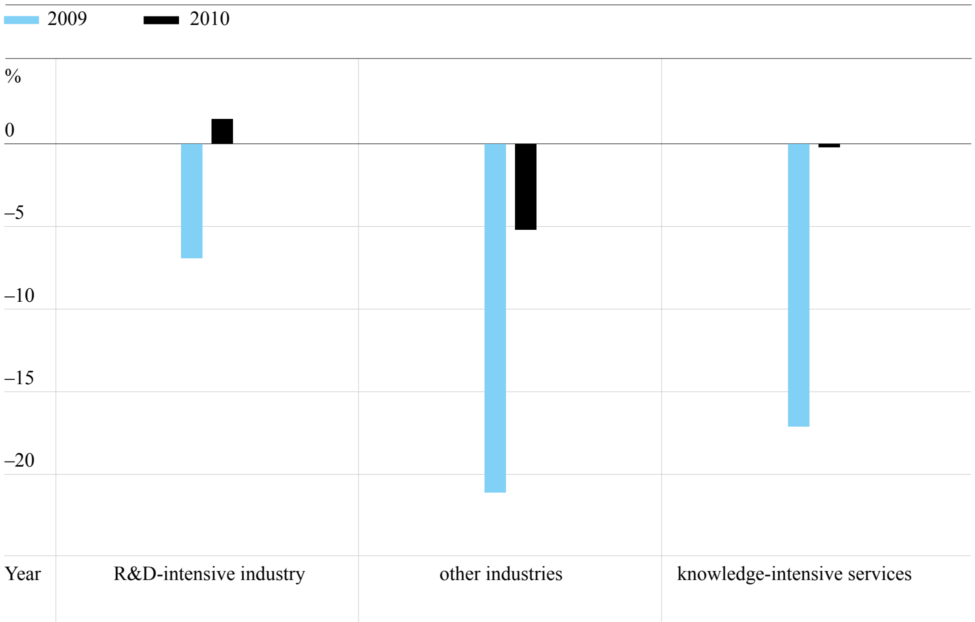
Proportion of revenue achieved with new products: Revenue from new or significantly improved products introduced in the preceding three years by the innovating companies, relative to total revenues.

Successes in sectors with high innovation intensity and short product cycles

In the R&D-intensive industry, some 38 percent of revenue in 2008 was generated with new products. In the automotive industry the proportion was 53 percent and in electronics, and precision and optical equipment it was 45 percent, both of which are well above average. Both sectors have high innovation intensity and short product cycles. In contrast, and despite higher innovation intensities, the proportion of revenue achieved with new products in the pharmaceuticals industry and the chemical industry was just under 19 percent in each case, and thus below average. In these sectors there is intensive innovation competition, combined with long product cycles and development periods.

In the other industries, 13 percent of revenue in 2008 was generated with new products. The figure was the same for the knowledge-intensive services. Without the financial sector, about 18 percent of revenue was generated with new products. Innovation success was above average in these sector groups for R&D services and computers and communications, with values of about 29 and 28 percent respectively. In a European comparison, the German private sector is well positioned in all three sector groups regarding the share of revenue generated with new products. But this is primarily due to the success with imitating innovations – comparing the share of revenue generated with market novelties, Germany is well behind.

C 3 – 5 PLANNED INNOVATION EXPENDITURE IN GERMAN INDUSTRY AND KNOWLEDGE-INTENSIVE SERVICES



Values based on company plans for spring and summer 2009.
Source: Mannheim Innovation Panel. Calculations by ZEW.

Planned innovation expenditure: Figures derived from company plans on changes to innovation expenditure compared with the previous year.

Economic crisis signals a drop in innovation expenditure in 2009

What are the effects of the severe financial and economic crisis on the innovation activities of the German private sector? As far as 2009 is concerned, the only figures available while preparing this report have concerned the plans of the individual companies. The responses given in spring and summer 2009 suggest that they were setting much less aside for innovation projects in 2009. Since 1995, there has been a consistent year-on-year increase in innovation expenditure. This trend will probably be interrupted in 2009. In the R&D-intensive industry, the plan figures indicate that the innovations- budgets will be cut back by seven percent compared with the previous year. The development seems to be particularly unfavourable for mechanical engineering, electronics, and precision and optical instruments. Innovation expenditure in the other industries and in knowledge-intensive services are expected to have declined by 21 and 17 percent, respectively. In total, the three sector groups under consideration will register a decline of eleven percent for 2009. In 2010, the innovation expenditure for the three sector groups should stabilise again according to the responses made by the companies. Innovation budgets should increase further in the R&D-intensive industry, whereas the other industries plan further cuts. In the knowledge-intensive services, innovation expenditure seems set to develop stably in general.

Overview

In a market economy, company start-ups and closures are an expression of the competition for the best solutions. With new business ideas, start-up companies expand and modernise the available product and services, so that established companies are stimulated to greater innovative efforts. In particular in the knowledge economy, i.e. in technology- and knowledge-intensive sectors, young enterprises are important motors of innovation. They promote developments in new fields of technology as new trends emerge and in the early phases of the transfer of scientific insights for the development of new products and processes. Start-up companies often occupy market niches and pick up on innovative ideas which are not appreciated by large companies. Company closures are the reverse side of the processes. They show when companies are no longer able to hold their own on the market. Their products and services are either not competitive, or are being produced by other companies, or are marketed in another, improved form.

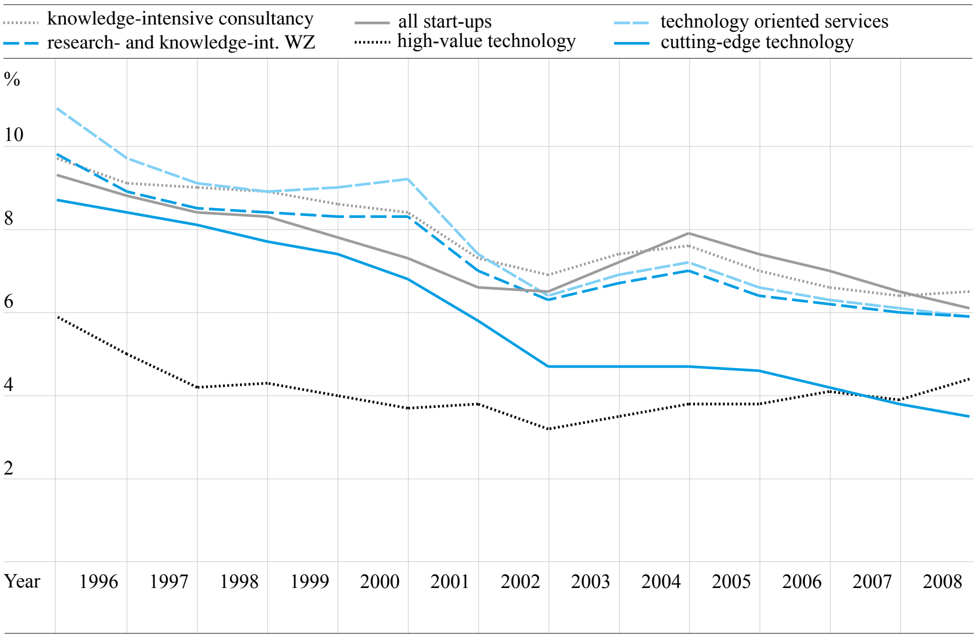
In Germany, the start-up rates are relatively low and also show a long-term downward trend. In particular, the marked fall in the rates for cutting-edge technology are a cause for concern regarding innovation dynamics. The development in high-value technology is more favourable. It is apparent that the focus of innovation activities in Germany will continue to be on high-value technology and not on cutting-edge technology.

The following results on enterprise dynamics in the knowledge economy are based on the evaluation of the Mannheim Enterprise Panel (MUP) carried out by the Centre for European Economic Research (ZEW).[182] MUP, which now also includes the ZEW Start-up Panel, is a panel dataset for companies in Germany derived in cooperation with Creditreform, the largest German business information service. The concept of companies as used by MUP refers to economically-active entities. Start-ups include only newly established companies, which are beginning a new entrepreneurial activity, which corresponds to the full-time activity of at least one person. A company is deemed to have closed when a company no longer carries out economic transactions and markets no goods.

Investigated indicators:

- Start-up rates in the knowledge economy in Germany
- Closure rates in the knowledge economy in Germany
- Net change in company structures in Germany according to company groups

C 4 – 1 START-UP RATES IN THE KNOWLEDGE ECONOMY IN GERMANY



2008 provisional values.
Source: Mannheim Enterprise Panel. Calculations by ZEW.

Start-up rate: Number of start-ups relative to total number of companies.

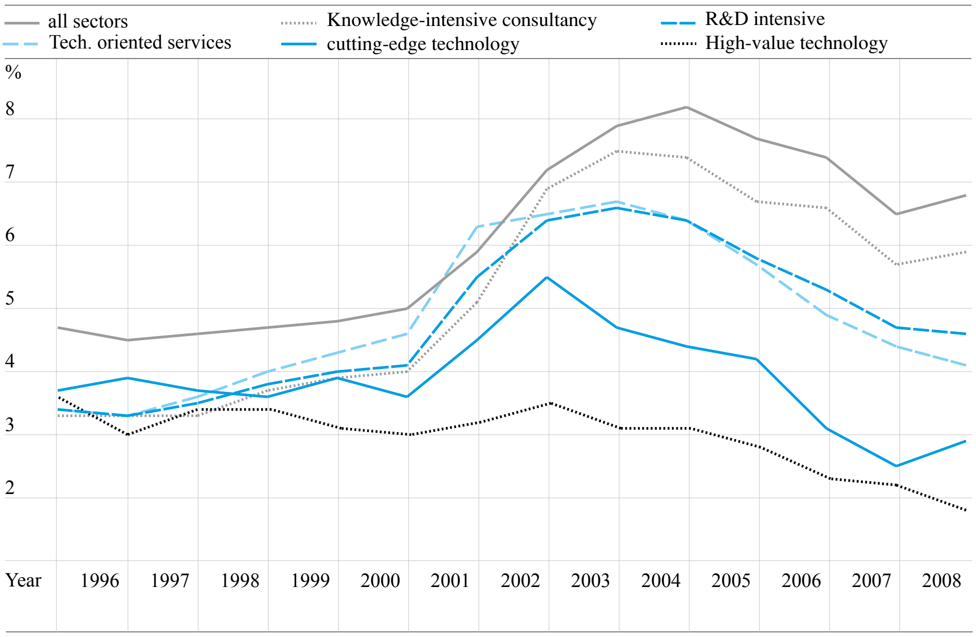
Further increase in the start-up rate in the high-value technologies

In 2008, 206 000 economically active companies were established in Germany. A seventh of the new enterprises started up in sectors of the knowledge economy (13.4 percent in the knowledge-intensive services and 1.3 percent in the R&D-intensive industry). The start-up rate, which measures the renewal of the stock of companies, was about six percent in 2008 both for the private sector as a whole and also in the knowledge economy, showing a long-term downward trend. In a European comparison, Germany is among the countries with a low start-up rate.

In the knowledge economy, knowledge-intensive consultancy had the highest start-up rate at 6.5 percent. In contrast, the R&D-intensive industry showed comparatively low start-up rates. The rate for the high-value technologies was 4.4 percent. Here, the start-up rates in recent years have been increasing, in contrast to the general trend observed in the knowledge economy. In cutting-edge technology the rate fell to 3.5 percent. The lower start-up rates in the R&D-intensive industry are the result of higher barriers to market entries, and in particular the need to finance plant and equipment and the development of products. Very high demands are also placed on the expertise and the specific market experience of the company personnel. In many market segments, young enterprises find themselves confronted with dominant large companies.

CLOSURE RATES IN THE KNOWLEDGE-ECONOMY IN GERMANY

C 4 – 2



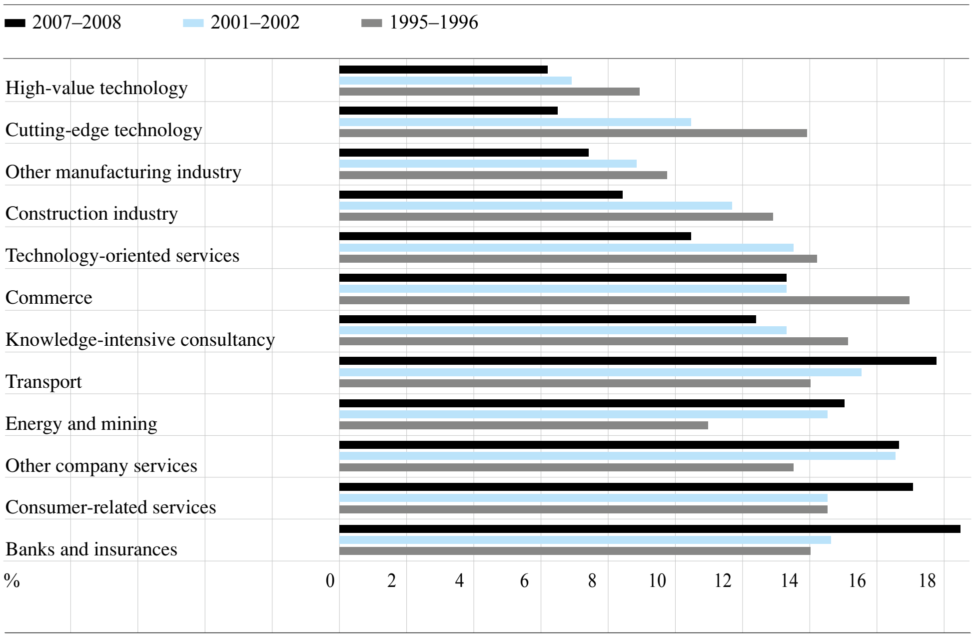
All values are provisional.
Source: Mannheim Enterprise Panel. Calculations by ZEW.

Closure rate: Number of companies closing down in a year relative to the total number of companies.

Lower closure rates in the knowledge economy

While new companies are starting up, at the same time other companies are closing down. In 2008 some 230 000 enterprises ceased operating in Germany. There were 24 000 closures in the knowledge economy. The number of closures here – as in nearly every year – was lower than the number of start ups, i.e. the total number of companies in the knowledge economy increased. This shows that there has been a shift in demand towards products and services of the knowledge economy. The closure rate in the knowledge economy in 2008 was 4.6 percent, some two percentage points lower than the rate for the economy as a whole. In a European comparison, the German closure rates are relatively low. The knowledge-intensive services show higher closure rates than the R&D-intensive industry. In 2008, 5.9 percent of knowledge-intensive consultancy companies closed down, and 4.1 percent in the technology-oriented services. In the high-value technologies and in cutting-edge technology, in contrast, the closure rates were only 1.8 and 2.9 percent, respectively, which is below the level in the mid-1990s. Enterprises benefited from the favourable economic situation in the years before the financial and economic crisis. At the same time, competition has been reduced by the decrease in the rate of new enterprises being started up over the same period.

C 4 – 3 COMPANY DYNAMICS IN GERMANY ACCORDING TO SECTOR GROUPS



Start-ups + closures – provisional two-year means.
Source: Mannheim Enterprise Panel. Calculations by ZEW.

Company dynamics: Number of start-ups plus number of company closures as a percentage of total number of companies in mid-year.

Falling innovation competition in the R&D-intensive industry

In an inter-sectoral comparison, the company dynamics shows the intensity of competition in an individual sector group and the barriers to market entries and exits. Comparisons over time reflect the effects of the economic situation and the incentives offered for new or struggling companies. In 2007–2008, an annual mean of 18 percent of banks and insurance companies either closed down or had newly started up – the highest company dynamics. Most of this fluctuation was due to insurance agents and other small service companies either starting business or closing down. Company dynamics was also relatively high in the transport sector (18 percent). The sector groups with the lowest company dynamics in 2007–2008 were high-value technology and cutting-edge technology, each with six percent.

The company dynamics in high-value technology decreased slightly between 1995–1996 and 2007–2008, and decreased significantly in both cutting-edge technology and technology-oriented services. Since there was no great change in market entry and exit barriers (e.g. minimum company size, fixed asset intensity, human resources requirements, market domination by large companies, or legal requirements), then this result indicates a fall in innovative activity by start-ups and company closures. This is worrying in the R&D-intensive industry because high innovation dynamics are an indicator for a high level of innovation competition.

Overview

A patent is a right of exclusion. For a specified period it gives the holder the right to prevent others from using the patented invention. Patents are national rights – they apply within a limited jurisdiction.

In order to obtain a patent, the invention must be described in a patent application. The invention must meet three conditions. It must be novel, it must have a certain quality (inventive step), and it must have a commercial use. As a rule, an examination is carried out by the relevant patent office to ensure that the application meets these criteria. The German Patent and Trade Mark Office (DPMA) and the European Patent Office (EPO) can award patents for Germany.

In addition to details of the invention, patents also include additional information about the inventor and applicant, a classification of the patent in terms of time and place, and also a technical classification. With such data, patents can become an important source of information for the evaluation of the technological performance of a country, a region or a company.

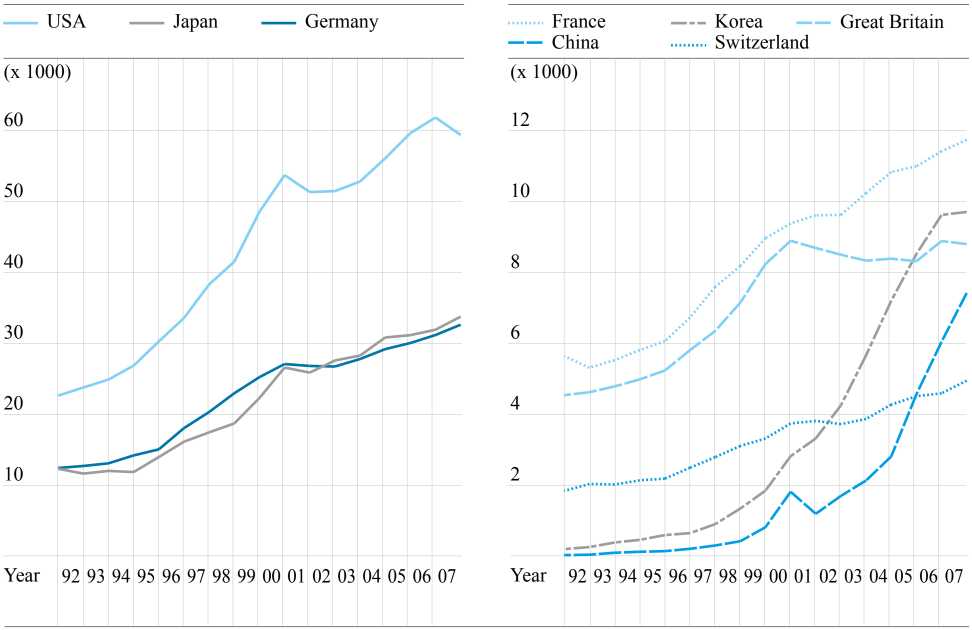
There are a series of factors, which can limit the use of patent data for R&I analyses. Firstly, not all inventions are protected by patents. Patenting involves making an invention public. But in many cases the inventor or company will decide to keep the invention secret rather than applying for a patent. Also, patent law excludes certain areas from patenting, e.g. scientific theories or mathematical methods.

The Commission of Experts for Research and Innovation mainly considers "transnational patent applications" in its analyses. These are patent applications made to the European Patent Office for European countries or which are made under the Patent Cooperation Treaty for non-European countries. A transnational patent application is made when the invention is to be implemented in various national markets. For patent statistics and the associated indicators, the use of this data offers two advantages. Firstly, the transnational patent applications are very relevant. Secondly, it is possible to make better comparison between economies on the basis of the data of the international offices (EPO and WIPO) than using national patent data.

Investigated indicators:

- Transnational patent applications in selected countries
- Number, intensity and growth of transnational patent applications
- Patent specialisation in the field of high technology
- Patent specialisation in cutting-edge technology

C 5 – 1 VARIATION OVER TIME OF NUMBERS OF TRANSNATIONAL PATENT APPLICATIONS IN SELECTED COUNTRIES



Source: Questel (EPPATENT, WOPATENT). Calculations by Fraunhofer ISI, October 2009.

The transnational patent applications cover patent families with at least one application with the WIPO[183] through the PCT[184] procedure or an application with the European Patent Office.

Increasing internationalisation of technological activities

The United States, Japan and Germany are worldwide leaders for transnational patent applications. In 1991, German and Japanese inventors applied for about the same numbers of patents. The Asia crisis in the 1990s led to a slight German advantage, but this has been lost again in the new century.

There was a noticeable decline in patent applications from the USA in 2007. The tense economic situation in 2008 had a negative effect on the decision of American inventors to also submit their patent applications with the priority year 2007 internationally. In retrospect this is a sign of the current economic crisis.

There are considerably fewer patent applications from other countries. However, since 2002 there has been an upward trend in France, Korea and China. In particular, the Chinese and Korean patent applications have shown very dynamic development. In the case of China, for example, patent applications more than tripled over a five year period. In Korea there was an increase of about 70 percent, but in France only of some 15 percent.

ABSOLUTE NUMBERS, INTENSITIES AND GROWTH RATES OF TRANSNATIONAL PATENT APPLICATIONS IN HIGH TECHNOLOGY[185] FOR 2007

C 5 – 2

	Absolute	Growth %	Intensity	Total growth[186] in %
Total	**141 500**	**191**	**–**	**186**
EU-27	50 086	167	280	161
USA	41 401	151	328	155
Japan	25 786	202	531	193
Germany	21 168	167	673	160
France	7 957	170	392	154
Korea	6 598	1 028	305	1 057
Great Britain	5 680	137	254	138
China	5 679	2 502	9	2 341
Italy	3 431	174	174	178
Switzerland	3 261	203	934	177
Canada	3 223	220	264	212
Netherlands	3 174	170	459	172
Sweden	3 000	158	832	147
Finland	1 502	152	712	152

Index: 1997 = 100.
Source: Questel (EPPATENT, WOPATENT). Calculations by Fraunhofer ISI, October 2009.

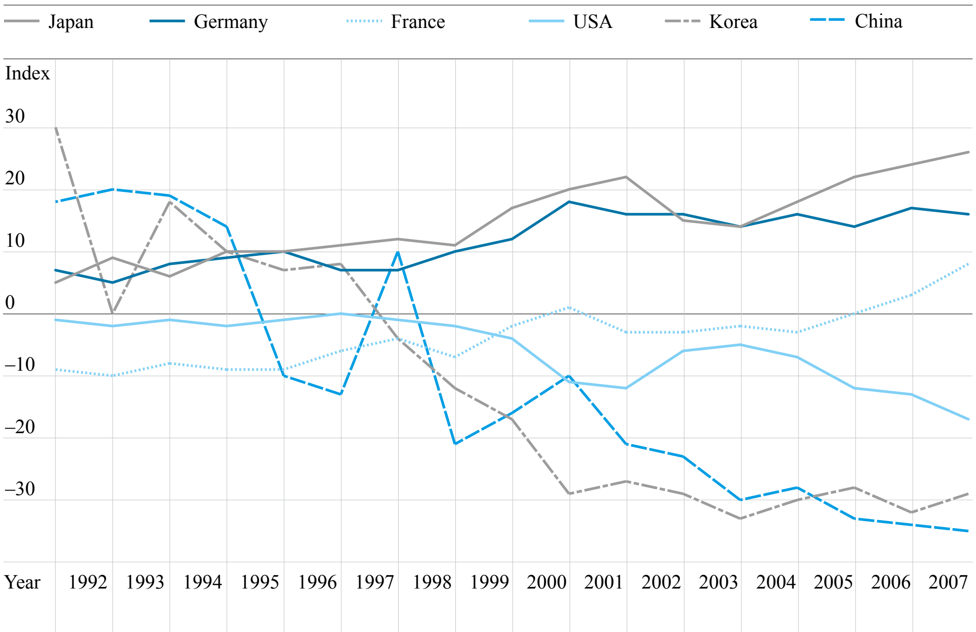
The high technology sector includes manufacturing branches which invest between 2.5 and 7 percent of revenue in research and development.

Increased involvement of the investigated countries in high technology

The USA dominates with regard to the absolute numbers of transnational patent applications in high technology, followed by Japan and Germany, with France, Great Britain, Korea and China some way behind. The number of patent applications per million employees (intensity) is an indicator of the relative innovation potential of an economy. Switzerland is in first place with an intensity value of 934, followed by Sweden and Finland. Germany lags some way behind them, but is ahead of Japan, the United States, France and the Netherlands.

The rapid development of China and South Korea is highlighted by the growth rates in high technology patents in the period 1997–2007. Of course, both countries started from a relatively low level. Chinese inventors applied for 262 high technology patents in 1997, and the South Koreans for 756 patents. These only represent a fraction of the 12 661 transnational patent applications from Germany. Nevertheless the figures do signal an expansion of the activities of Asian companies on international high technology markets. A comparison shows that the growth rates for high technology transnational patent applications are somewhat higher than the overall growth rates. Many companies register high technology patents in order to secure strategically important fields of innovation.

C 5–3 HIGH-VALUE TECHNOLOGY[187] SPECIALISATION INDICES FOR SELECTED COUNTRIES



Source: Questel (EPPATENT, WOPATENT). Calculations by Fraunhofer ISI, October 2009.

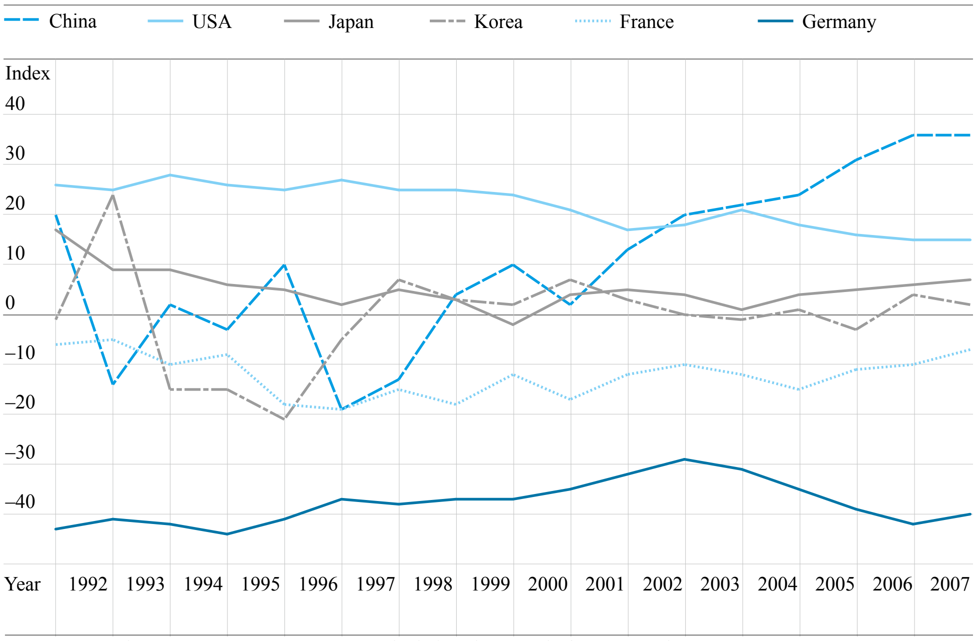
The specialisation index[188] is calculated with reference to all worldwide transnational patent applications. Positive values indicate activity in a field, which is above the global average, and negative values indicate activity which is below average.

The focus in Germany is still on high-value technologies

Japan und Germany enjoy a relative advantage in high-value technologies. Traditional German strengths such as motor vehicle construction, mechanical engineering and chemistry are reflected in above-average specialisation in this technology sector. However, the German specialisation values have remained more or less unchanged since the year 2000, whereas Japan has steadily increased its specialisation. This indicates that Japan will be focusing even more on high-value technologies in the near future. In contrast, the USA shows a definite under-specialisation in this sector. This means that Germany and the USA have complementary patent profiles. In technology sectors such as rail vehicles, motor vehicles, engines and components, or machine tools, which form an important part of the German technology portfolio, the USA is unable to establish such a clear profile. There is a clear downward trend in the specialisation profile for high-value technology in China und Korea, and both countries are definitely under-specialised here. In China there are indications of a clear shift in the patent structure towards cutting-edge technology and a decreasing focus on the field of high-value technology. However, despite the decline in specialisation in high-value technologies in Korea, the following section shows that there is only an average specialisation in cutting-edge technology.

CUTTING-EDGE TECHNOLOGY[189] SPECIALISATION INDICES FOR SELECTED COUNTRIES

C 5 – 4



Source: Questel (EPPATENT, WOPATENT). Calculations by Fraunhofer ISI, October 2009.

The specialisation index[190] is calculated with reference to all worldwide transnational patent applications. Positive values indicate activity in a field which is above the global average, and negative values indicate activity which is below average.

Under-specialisation in cutting-edge technologies remains a characteristic of the German technology profile

In comparison, patent applications for both the USA and China show above-average orientation towards cutting-edge technologies. The development is particularly dynamic for China. Since the year 2000, cutting-edge technology has become increasingly important. Japan and Korea show only average activity in this technology field, although the Japanese technology profile shows a slight upward trend in specialisation since 2003.

German companies continue to compete successfully above all in high-value technology, and in comparison with the other countries selected for this comparison, Germany shows the least focus on cutting-edge technology. The IT crisis in 2000–2001 affected in particular young German companies which were active in this market segment – they were faced with considerable financial problems as a result of the lack of venture capital. This had a negative effect on the number of patent applications.[191] However, the effect of the crisis on the German economy as a whole was less noticeable given the low level of specialisation in cutting-edge technology. The lack of a structural change towards more cutting-edge technology has contributed to the failure to achieve the three-percent target of the Lisbon Strategy.[192]

C 6 SCIENTIFIC PUBLICATIONS AND PERFORMANCE

Overview

For many years, the importance of "knowledge" has been discussed as a factor for successful economic development. A knowledge lead can often prove to be a decisive comparative advantage in fierce international competition. Developing this knowledge lead is one of the primary objectives of science. In a macroeconomic context, training qualified specialists and establishing a sound scientific base for future technological developments is among the key tasks of science.

The importance attached to "knowledge" as a production factor is indicated by the fact that it is now usual to include the scientific capability when evaluating the technological capability of a country. The focus is not on the direct economic benefit, but the longer-term orientation towards further technological developments.

However, it is difficult to measure the performance of science, because the structures and scientific backgrounds in various disciplines are very different. In most cases, scientific publications are used as an indicator of research performance, but they only reflect the formal aspect of scientific communication. The differences between disciplines can lead to misinterpretations, so that a careful methodology is necessary. Bibliometry (the analysis of scientific publications) can draw on decades of experience gained by various international research groups.

The numbers of scientific publications is only a first indicator of performance, but it says little about the quality of the contributions. In order to include qualitative aspects, it is also usual to analyse citations, which reflect the scientific impact, i.e. the perception of a publication by the scientific community. In particular when investigating citations it is essential to meet strict methodological requirements. The following section draws on the results of a study[193] of leading international journals and covers natural sciences, engineering, medicine, and life sciences. Humanities and social sciences were not included.

Investigated indicators:

- Shares of selected countries and regions in all publications in the *Science Citation Index* (SCI)
- International Alignment (IA) of selected countries and regions for SCI publications
- Journal-specific scientific regard (SR) of selected countries and regions for SCI publications

SHARES OF SELECTED COUNTRIES AND REGIONS FOR ALL SCI PUBLICATIONS C 6—1

Country/Region	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
USA	34.3	33.7	32.9	32.3	31.9	32.1	31.9	31.7	31.4	30.8	30.5	29.9	28.3
Japan	9.5	9.5	10.0	10.2	10.2	10.2	10.1	10.0	9.4	9.0	8.5	8.2	7.5
Germany	8.2	8.6	9.0	9.0	9.0	9.0	8.8	8.7	8.4	8.4	8.2	8.0	7.7
Great Britain	9.6	9.3	9.4	9.3	9.4	9.1	8.8	8.6	8.4	8.2	8.1	8.1	7.5
France	6.4	6.6	6.7	6.7	6.6	6.6	6.4	6.4	6.1	6.0	5.9	5.8	5.8
Switzerland	1.8	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	2.0	1.9
Canada	4.7	4.4	4.3	4.3	4.3	4.1	4.2	4.3	4.8	4.4	4.5	4.6	4.4
Sweden	2.1	2.1	2.1	2.1	2.0	2.1	2.1	2.0	2.6	1.9	1.8	1.8	1.7
Italy	4.2	4.2	4.3	4.4	4.4	4.6	4.7	4.8	0.9	4.7	4.7	4.9	4.8
Netherlands	2.6	2.7	2.6	2.5	2.5	2.5	2.5	2.5	2.8	2.6	2.6	2.5	2.5
Korea	–	–	–	1.7	1.9	2.1	2.3	2.6	2.8	3.0	3.1	2.9	3.3
China	–	–	–	–	–	–	5.2	5.8	3.5	7.6	8.6	9.3	9.9
EU-15	–	–	–	40.9	40.7	40.6	39.9	39.4	42.0	38.8	38.4	38.0	36.8
EU-12	–	–	–	–	–	–	3.4	3.4	3.5	3.5	3.5	3.5	4.1
EU-27	–	–	–	–	–	–	42.4	41.9	41.3	40.9	40.9	40.4	40.1
World	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Source: SCI. Research by the University of Leiden (CWTS). Calculations by Fraunhofer ISI.

The bibliometric analyses draw on the database of the Science Citation Index (SCI). The shares of countries are considered, and not absolute numbers, in order to allow for changes to the journal covered by the database.

Increased presence of Asian authors in the SCI reduces shares of major industrialised countries

Since 2001 there has been a steady decline in the share of publications from Germany, the USA, Japan, Great Britain, and France. British and Japanese scientists are affected by this trend more than German scientists. In contrast, authors from Canada, Italy and the Netherlands have at least been able to maintain their positions. The falling shares of many countries are due to the increasing significance of China, and to a lesser extent of South Korea. But India, Russia, and Brazil are also catching up.[194] Since the SCI index only covers a limited number of journals, the increase in the share of publications from such countries necessarily reduces the shares of publications from the established countries. In the 1980s, the emerging economies had a share of 7.4 percent of all SCI publications. In 2007, one in four SCI publications had at least one author from an emerging country. The examination of regions shows a gradual decrease in the share of publications from the EU-15 member countries. The publication share of the new EU member states (EU-12) is showing a slight upward trend, though from a relatively low level. The new EU member states are therefore much less dynamic than South Korea and China. The following sections show the qualitative evaluation of publications in terms of international alignment and journal specific scientific regard.

C 6 – 2 INTERNATIONAL ALIGNMENT (IA) OF SELECTED COUNTRIES AND REGIONS FOR PUBLICATIONS IN THE SCIENCE CITATION INDEX

Country / Region	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
USA	36	36	34	33	33	32	32	31	30
Japan	–14	–14	–18	–11	–11	–10	–6	–7	–6
Germany	3	5	7	6	8	9	11	13	16
Great Britain	10	12	15	15	19	19	20	21	21
France	2	0	3	4	5	3	5	7	7
Switzerland	29	30	29	28	28	27	30	31	29
Canada	11	13	11	16	14	15	15	14	16
Sweden	8	8	11	12	11	15	15	16	18
Italy	1	2	1	–1	–1	3	3	7	7
Netherlands	14	21	20	19	21	24	26	27	28
Finland	–	8	10	6	8	9	8	9	8
Korea	–	–45	–38	–38	–37	–34	–32	–30	–29
China	–	–	–	–	–56	–47	–45	–42	–37
EU-15	–	1	3	2	4	5	6	8	8
EU-12	–	–	–	–	–38	–36	–38	–36	–32
EU-27	–	–	–	–	1	2	3	4	5

Source: SCI, Research by the University of Leiden (CWTS). Calculations by Fraunhofer ISI.

The IA Index[195] shows whether the authors of a country publish in internationally visible or in less visible journals, compared with the world average. A positive IA value is above average. Self-citations are not included.

Increased international alignment of publication activity in almost all the countries investigated

The steady increase in IA values for German authors indicates an increasing international alignment. However, most of the selected countries also showed an increased IA. Here the career motives of authors have to be taken into consideration, because successful international publication activity is associated with high citation rates, and these are often regarded as an important evaluation criterion for research performance. American journals often have a dominant position internationally, and this gives American scientists an advantage, which is reflected in high IA values. Comparably high values are achieved by Switzerland and the Netherlands. The authors from these countries have fewer domestic opportunities for publication, so that they have to publish their papers internationally. The situation is problematic for authors from Asian countries. However, Japanese authors have managed to find better access to the international scientific discussion, although the IA values still only correspond to the world average. It is also noticeable that the values for the new EU member states are also very poor. In this context, the IA for EU-12 is comparable with that of China.

JOURNAL-SPECIFIC SCIENTIFIC REGARD (SR) FOR PUBLICATIONS FROM SELECTED COUNTRIES AND REGIONS

C 6 – 3

Country/Region	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
USA	10	10	11	11	11	9	9	9	10	9	9	8	7
Japan	–7	–7	–8	–7	–4	–7	–6	–7	–7	–10	–9	–10	–8
Germany	10	9	9	7	8	7	7	8	8	7	7	7	6
Great Britain	10	9	5	4	3	8	9	9	10	7	8	8	8
France	2	4	4	3	2	1	3	2	1	2	2	1	3
Switzerland	24	20	23	22	17	15	17	17	16	17	15	15	16
Canada	5	5	6	5	9	5	9	3	4	6	5	4	6
Sweden	15	12	13	14	12	15	9	8	9	11	9	8	11
Italy	–4	–4	–5	–5	–4	–3	–2	–4	0	–5	–2	–1	0
Netherlands	12	13	10	15	14	10	7	11	8	13	11	9	9
Finland	–	–	–	–	–	2	7	8	8	3	2	4	9
Korea	–	–	–	–	–	–16	–11	–11	–9	–5	–2	4	–3
China	–	–	–	–	–	–	–	–	–11	–1	1	3	4
EU-15	–	–	–	–	–	2	2	2	2	2	2	2	2
EU-12	–	–	–	–	–	–	–	–	–15	–13	–11	–12	–8
EU-27	–	–	–	–	–	–	–	–	1	1	1	1	1

Source: SCI, Research by the University of Leiden (CWTS). Calculations by Fraunhofer ISI.

The SR indicator[196] shows whether the articles of a country or region are cited on average more or less frequently than the articles in the journals in which they appear. Positive (negative) values indicate that the citation rate is above (below) average.

Qualitative improvement of Chinese publications

The SR indicator shows a relative decline in the significance of German publications. German authors are increasingly contributing to leading international journals but are still receiving less attention. Comparable SR values are calculated for the USA, Great Britain, and Canada. But because the language disadvantages are eliminated, Germany has a much better position in comparison to the English-speaking countries in terms of SR values than with straightforward citation rates. The high SR values of Switzerland and the Netherlands show that as well as retaining their shares of publications they also receive recognition for research results. The increasing SR values for South Korea and China suggest a qualitative improvement in the publications. However, the authors are publishing in lower-ranking journals (cf. IA indicator), so that in terms of quality they remain behind the international standard. Japanese authors continue to receive poor scientific regard, with a further slight downward trend in the latest figures. The authors are increasingly publishing in higher-ranking international journals and are thus finding themselves in competition with established scientists. The new EU member states currently have a poor position in the scientific community, with poor SR values plus publication in lower-profile journals (cf. IA indicator).

C 7 PRODUCTION, VALUE CREATION AND EMPLOYMENT

Overview

Successful innovations lead to the creation of additional value. By specialising in technological innovations and high quality goods and services, highly developed economies can charge prices, which make it possible for employees to earn high real incomes and for the companies to achieve growth in production and higher levels of employment. The technological capability of a country is therefore linked to the level of its R&D-intensive products and knowledge-intensive services it generates. The advantages of the highly-developed economies (high level of technological knowledge, high level of investments in R&D, highly-qualified personnel) have the greatest effect in these markets. Long-term economic development therefore requires structural change towards R&D-intensive industries and knowledge-intensive services.

In Germany, the knowledge-intensive industry has been developing much more dynamically in terms of gross value added and employment effects than the non-knowledge-intensive industry. In the services, the differences between knowledge-intensive sectors and the non-knowledge-intensive sectors is less pronounced. Overall, there is a trend towards tertiarisation.

In comparison with other OECD countries, technology and knowledge-intensive sectors of the economy in Germany account for a large proportion of the work volume of the economy as a whole and of the value added. This is also reflected in foreign trade. In 2006, Germany had the largest share of world trade for research-intensive goods as well as for all industrial goods. However, Germany's specialisation advantages in commerce with technology goods are declining over time. German companies are facing growing foreign competition on the domestic markets. This applies in particular for the automotive industry, which has been mainly responsible for the German specialisation advantages in high-value technology. Germany has traditionally not been specialised in cutting-edge technologies.

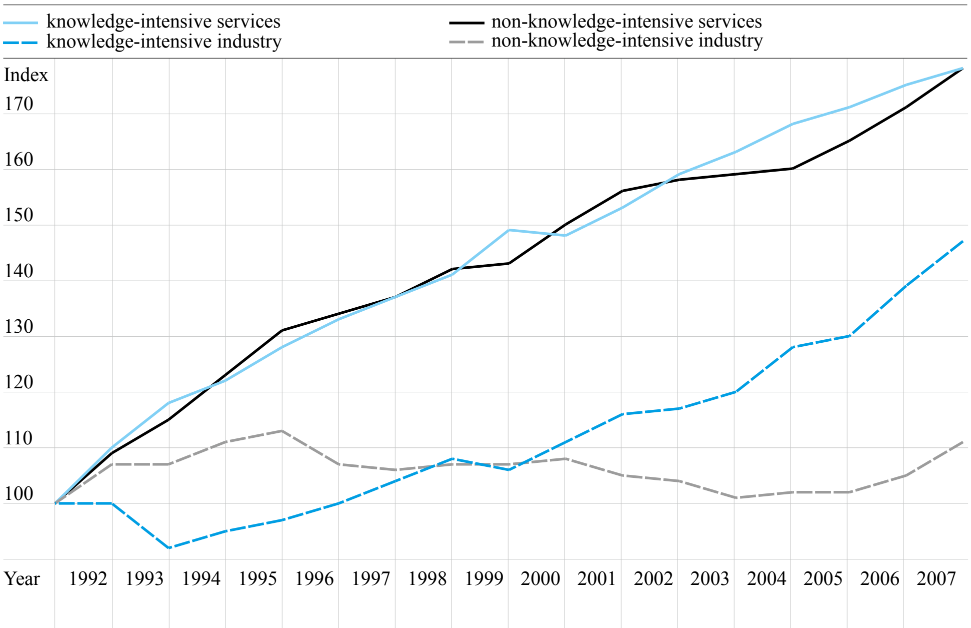
This section draws on the evaluation of data from various sources by the German Institute for Economic Research (DIW) and the Lower Saxony Institute for Economic Research (NIW).[197]

Investigated indicators:

- Development of gross value creation in various manufacturing sectors in Germany
- Employment in manufacturing sectors in Germany
- Share of R&D-intensive industries and knowledge-intensive services in labour input and value creation
- Germany's foreign trade specialisation in R&D-intensive goods
- Development of foreign trade in R&D-intensive goods for selected OECD countries

GROSS VALUE CREATION IN GERMANY'S BUSINESS ECONOMY

C 7 – 1



Index: 1991 = 100.
Source: Federal Statistical Office, Series 18 (1.4.) Calculations by NIW.

Knowledge-intensive industry accounts for 21 percent of gross value created, other industry 16 percent, knowledge-intensive services 37 percent, other services 26 percent.

Continued growth in gross value created in the services

The increasing link between industry und services is leading to a restructuring of the German economy. Since 1991, both knowledge-intensive services and non -knowledge-intensive services have been growing steadily. However, internal R&D activities and the broad application of technologies from the industrial sector have increased the technology dependence of many services.

In contrast, the growth opportunities of the manufacturing sector are limited in the long term. In general, companies in this sector are more dependent on the state of the economy than in the services sector. The effects of this dependence vary between knowledge-intensive and non-knowledge-intensive manufacturing sectors. In the course of the global recession at the start of the 1990s, the knowledge-intensive sectors suffered considerable set-backs, whereas the non-knowledge-intensive sectors (above all consumer goods) profited from the special situation existing after German unification. From 1993 onwards, the development changed. Less knowledge-intensive industrial sectors stagnated or declined, whereas knowledge-intensive sectors experienced a period, in which the growth dynamic almost paralleled that of the services sector. The last two years covered by the data have also been positive for the manufacturing sectors, which are less knowledge-intensive.

C 7 – 2 EMPLOYMENT IN THE BUSINESS SECTOR IN GERMANY

	1998	2002	2005	2008	1998–02	2002–05	2005–08	1998–08
	in 1 000				Changes in percent			
Industry	**10 241**	**9 421**	**8 554**	**8 724**	**–2.1**	**–3.2**	**0.7**	**–1.6**
Knowledge-intensive sectors	3 494	3 510	3 376	3 521	0.1	–1.3	1.4	0.1
Non-knowledge-intensive sectors	6 747	5 910	5 178	5 203	–3.3	–4.3	0.2	–2.6
Service	**12 373**	**13 418**	**13 037**	**13 983**	**2.0**	**–1.0**	**2.4**	**1.2**
Knowledge-intensive sectors	4 955	5 504	5 379	5 556	2.7	–0.8	1.1	1.2
Non-knowledge-intensive sectors	7 418	7 914	7 657	8 427	1.6	–1.1	3.2	1.3
Business sector	**22 614**	**22 839**	**21 590**	**22 707**	**0.2**	**–1.9**	**1.7**	**0.0**
Knowledge-intensive	8 449	9 015	8 755	9 077	1.6	–1.0	1.2	0.7
Non-knowledge-intensive	14 165	13 824	12 835	13 631	–0.6	–2.4	2.0	–0.4

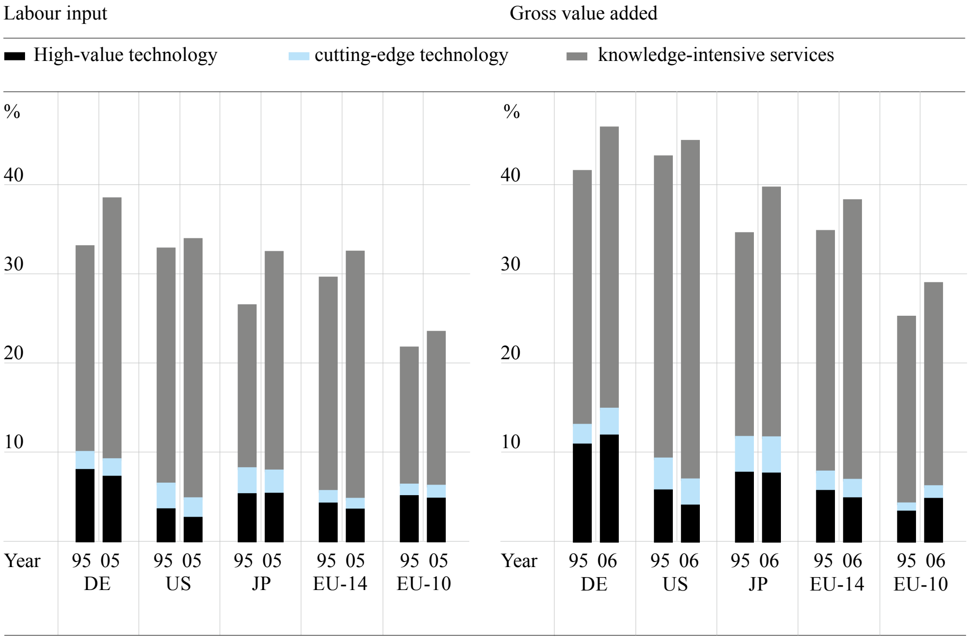
Source: Federal Agenca for Employment. Employment statistics. Calculations and estimates by NIW.

Business sector: excluding agriculture, public administration and services, education, private households, etc.

The trend towards tertiarisation in Germany continues

The growing importance of the tertiary sector is leading increasingly to a redistribution of the labour force. In the period 1998–2008, the average number of employees in the services sector increased by 1.2 percent per annum, compared with a 1.6 percent p.a. drop in the numbers employed in industry. Differentiating between levels of knowledge intensity and comparing changes over time gives a better overview of the development of employment. From 1998 to 2002, employment increased in all knowledge-intensive sectors. This contrasts with a 3.3 percent p.a. decline in the industrial sectors, which are not knowledge-intensive. The unfavourable economic situation in the period 2002–2005 impacted negatively on the business sector as a whole, while the figures for 2005 to 2008 indicate a recovery.[198] However, this has not been enough for the non-knowledge-intensive manufacturing sectors to make up fully for the losses suffered in the previous years. In the services sector, the economic recovery from 2005 to 2008 has led to an improvement in the employment situation compared with 1998. In particular the non-knowledge-intensive services benefited from the improved employment possibilities for lower-skilled personnel in this period. In the knowledge-intensive services, the increasing shortage of skilled personnel has led to a weaker expansion of employment opportunities.

LABOUR INPUT AND VALUE ADDED IN THE R&D-INTENSIVE MANUFACTURING SECTOR AND KNOWLEDGE-INTENSIVE SERVICES



The value added for 2006 was estimated using STAN values.
Source: EUKLEMS Database (3/2008). OECD STAN (2008). Calculations and estimates by DIW Berlin.

The labour input is measured in working hours and represents the macroeconomic input of a sector; the nominal value added represents the output.

Germany overtakes the USA for value added in the knowledge-intensive sectors

The comparison of the shares of labour input and value addition in the research-intensive sectors reflects the importance of R&D for employment and economic growth. From 1995 to 2005, labour input in the knowledge-intensive services increased for all the countries and regions compared. This trend reflects the increasing tertiarisation and research-orientation of the economies. At the same time there was a relative drop in the significance of research-intensive manufacturing sector. Only the new EU member countries saw an increase in labour input in cutting-edge technology. On the output side (value added) the knowledge-intensive services generally show more growth. The eastern European countries show a different development trend, and in particular the research-intensive industries have above-average growth rates. In an international comparison, Germany is in a leading position for the overall evaluation of labour input and value added in the R&D-intensive sectors. This is due above all to the large proportion of high-value technology. However, for a further positive macroeconomic development it is important to expand the knowledge-intensive services, because Germany is still not strong enough in this area.

C 7 – 4 GERMAN FOREIGN TRADE SPECIALISATION[199] FOR R&D- INTENSIVE GOODS

Year	DE	US	JP	FR	GB	DK	SE	FI	CH	EU-14
Comparison of export and import structure (RCA)										
1991	24	19	76	10	18	–23	–4	–62	20	–8
1995	25	13	64	8	11	–21	–13	–49	17	–8
2000	15	17	49	9	12	–6	–6	–27	15	–4
2006	11	23	44	12	20	–4	–3	–25	21	0
Relative share of imports in world trade (RMA)										
1991	–9	6	–39	–6	–2	–17	–3	2	–10	–2
1995	–12	7	–30	–7	2	–17	7	6	–8	–2
2000	–4	0	–20	–6	2	–23	3	3	–11	–1
2006	2	–3	–15	–6	–3	–19	–3	2	–8	–2
Relative share of exports in world trade (RXA)										
1991	15	27	38	6	16	–40	–7	–59	11	–2
1995	13	22	34	3	14	–38	3	–42	13	–2
2000	11	19	29	5	15	–29	–1	–23	10	–1
2006	13	21	29	7	17	–23	–7	–22	13	–2

Source: DIW Foreign trade data. Calculations by DIW Berlin.

EU-14 refers to EU-15 without Germany, trading with third countries.

Decline in comparative advantage of Germany in trade with R&D-intensive goods

The values of the RCA indicators confirm the leading position of Japan, the USA, Switzerland, Great Britain, Germany and France in international trade with R&D-intensive goods. For all countries, the comparative advantages of research-intensive goods (RCA-value > 10) are linked to an above-average export specialisation (high RXA-value).

However, the comparative advantage of Germany is steadily declining. This is not due to changes in export specialisation, as is clearly demonstrated by the fairly constant RXA value. Rather, the decline is due to rising imports of R&D-intensive goods from emerging economies in the medium- to low-price sector, which is reflected in the positive value for the RMA indicator in 2006. A similar development can be observed in Japan. In contrast, Finland and Denmark show marked improvement in the net position concerning R&D-intensive goods – rising RCA values. This is primarily due to the increased specialisation in the export of R&D-intensive goods. In the countries with a lower change in the net position regarding specialisation in R&D-intensive goods, such as the USA, France, Great Britain, Sweden and Switzerland, the specialisation in R&D-intensive goods has declined for exports and at the same time also declined (even more) for imports.

NET CONTRIBUTION OF R&D-INTENSIVE GOODS TO FOREIGN TRADE FOR SELECTED OECD COUNTRIES IN PER MILL

C 7 – 5

Year	DE	US	JP	FR	GB	DK	SE	FI	CH	EU-14
R&D-intensive goods										
1991	65.4	52.8	218.2	29.3	48.2	–49.8	–14.9	–140.4	55.0	–17.2
1995	70.8	32.7	196.0	24.4	31.1	–48.0	–38.8	134.0	48.2	–20.6
2000	49.6	46.1	167.0	28.9	35.8	–16.9	–19.4	–86.4	44.0	–11.3
2006	43.5	59.9	151.7	36.4	58.2	–8.5	–12.3	–74.3	65.5	0.0
Cutting-edge technology										
1991	–16.1	53.6	55.7	1.6	25.1	–15.2	–7.9	–56.3	15.8	–6.1
1995	–21.4	25.7	39.2	7.2	26.6	–7.2	–4.9	–44.6	9.3	–4.4
2000	–30.9	40.5	0.2	10.2	19.5	5.1	14.2	–1.0	8.9	–0.2
2006	–34.4	33.6	–21.9	13.0	50.8	10.0	4.7	–14.7	54.6	4.8
High-value technology										
1991	81.5	–0.8	162.5	27.7	23.2	–34.7	–7.0	–84.2	39.2	–11.1
1995	92.2	6.9	156.9	17.2	4.5	–40.8	–33.9	–89.4	38.9	–16.2
2000	80.5	5.7	166.8	18.8	16.3	–22.0	–33.6	–85.4	35.1	–11.1
2006	77.9	26.3	173.7	23.4	7.4	–18.5	–17.0	–59.6	10.8	–4.8

Source: DIW Foreign trade data. Calculations by DIW Berlin.

The net contribution to foreign trade comparative advantage (or for negative values the comparative disadvantage) of a country. The net contribution is equal to the contribution to exports minus the contribution to imports (BZX – BZM).[200]

High-value technology remains Germany's export strength

The R&D-intensive goods in Japan make by far the greatest net contribution to the foreign trade balance. Germany, Switzerland, Great Britain, the USA and France also have clear comparative advantages in foreign trade with R&D-intensive goods. However, the German position in the group of six leading nations has worsened considerably since the early 1990s. In 1991, Germany was ahead of the USA, Great Britain and Switzerland, but by 2006 it was trailing someway behind them at the end of group, just ahead of France.

Differentiation according to knowledge intensity shows that Japan and Germany have a clear dominance in high-value technology goods. However, although this technology class represents the traditional strongpoint of the German manufacturing sector, there is a negative trend in the development of the net contribution to foreign trade. For cutting-edge technology, Germany and Japan show comparative disadvantages. In contrast, USA, Switzerland, Great Britain and France have a more or less balanced technology profile with comparative advantages for both cutting-edge technology and high-value technology, although the net contribution of cutting-edge technology goods to foreign trade in Great Britain und Switzerland shows a marked increase at the end of the observation period. Denmark and Sweden also have comparative advantages for cutting-edge technology goods.

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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
BFE	Federal Research Institutions
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
CO2	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 Statistical Office of the European Communities
EU	European Union
FhG	Fraunhofer Society
GERD	Gross Domestic Expenditure on R&D
GEM	Global Entrepreneurship Monitor
HGF	Helmholtz Association
HIS	Higher Education Information System
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
MPG	Max Planck Society
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
WGL	Leibniz Association
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
CN	China
CY	Cypress
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	Iceland
IT	Italy
JP	Japan
KR	Korea
LU	Luxembourg
LT	Lithuania
LV	Latvia
MT	Malta
MX	Mexico
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
SE	Sweden
SG	Singapure
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[137]

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

WZ 2003	**Cutting-edge technology**
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

WZ 2003	**High-value technology**
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)

WZ 2003	**Knowledge-intensive services**
	Logistics
603	Transport via pipelines
611	Sea and coastal water transport
622	Non-scheduled air transport
623	Space transport
	Communications
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
	Finance and assets
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
	Technical research and consultancy
731	Research and experimental development on natural sciences and engineering
742	Architectural and engineering activities and related consultancy
743	Technical testing and analysis
	Non-technical research and consultancy
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
	Health
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

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. The results of these studies have flown into this report.

Recent studies on the German innovation system:

1-2010 Leszczensky, M.; Frietsch, R.; Gehrke, B.; Helmrich, R. (2010): Bildung und Qualifikation als Grundlage der technologischen Leistungsfähigkeit Deutschlands, Berlin.

2-2010 Legler, H.; Schasse, U.; Grenzmann, C.; Kladroba, A.; Kreuels, B. (2010): Forschungs- und Entwicklungsaktivitäten der deutschen Wirtschaft – eine strukturelle Langfristbetrachtung, Berlin.

3-2010 Gehrke, B.; Legler, H.; Schasse, U.; Grenzmann, C.; Kreuels, B. (2010): Regionale Verteilung von Innovationspotenzialen in Deutschland: Ausgewählte Indikatoren zu Forschung und Entwicklung, Sektorenstrukturen und zum Einsatz von Qualifikation in der Wirtschaft, Berlin.

4-2010 Gehrke, B.; Legler, H. (2010): Forschungs- und wissensintensive Wirtschaftszweige – Aussenhandel, Spezialisierung, Produktion, Beschäftigung und Qualifikationserfordernisse in Deutschland, Berlin.

5-2010 Belitz, H.; Clemens, M.; Gornig, M.; Schiersch, A.; Schumacher, D. (2010): Wirtschaftsstrukturen, Produktivität und Aussenhandel im internationalen Vergleich, Berlin.

6-2010 Belitz, H. (2010): Internationalisierung von Forschung und Entwicklung in Multinationalen Unternehmen, Berlin.

7-2010 Rammer, C.; Peters, B. (2010): Innovationsverhalten der Unternehmen in Deutschland 2008: Aktuelle Entwicklungen – Innovationsperspektiven – Beschäftigungsbeitrag von Innovationen, Berlin.

8-2010 Schmoch, U.; Schulze, N. (2010): Performance and structures of the German science system in an international comparison 2009 with a special feature on east Germany, Berlin.

9-2010 Frietsch, R.; Schmoch, U.; Neuhäusler, P.; Rothengatter, O. (2010a): Patent applications – Structures, trends and recent developments, Berlin.

10-2010 Rammer, C.; Metzger, G. (2010): Unternehmensdynamik in der Wissenswirtschaft in Deutschland und im internationalen Vergleich, Berlin.

11-2010 Polt, W.; Berger, M.; Boekholt, P.; Cremers, K.; Egeln, J.; Gassler, H.; Hofer, R.; Rammer, C. (2010): Das deutsche Forschungs- und Innovationssystem – ein internationaler Systemvergleich zur Rolle von Wissenschaft, Interaktionen und Governance für die technologische Leistungsfähigkeit, Berlin.

12-2010 Winter, M.; Cleuvers, B. A.; Anger, Y. (2010): Implikationen der gestuften Hochschul-Curricula auf die Innovationsfähigkeit Deutschlands. Qualitative Untersuchungen zur Umstellung der Studien-Curricula in Deutschland, Berlin.

13-2010 Alesi, B.; Schomburg, H.; Teichler, U. (2010): Humankapitalpotenziale der gestuften Hochschulabschlüsse in Deutschland: Weiteres Studium, Übergang in das Beschäftigungssystem und beruflicher Erfolg von Bachelor- und Master-Absolventen, Berlin.

14-2010 Mühlenweg, A.; Sprietsma, M.; Horstschräer, J. (2010): Humankapitalpotenziale der gestuften Hochschulabschlüsse in Deutschland – Auswertungen zu Studienbeteiligung, Studienabbrüchen, Mobilität und Eingangsselektion, Berlin.

15-2010	Frietsch, R.; Schmoch, U.; Van Looy, B.; Walsh, J. P.; Devroede, R.; Du Plessis, M.; Jung, T.; Meng, Y.; Neuhäusler, P.; Peeters, B.; Schubert, T. (2010b): Study for the value and indicator function of patents, Berlin.
16-2010	Günther, J.; Nulsch, N.; Urban-Thielicke, Wilde, K. (2010a): 20 Jahre nach dem Mauerfall: Transformation und Erneuerung des ostdeutschen Innovationssystems – Historie und Entwicklungslinien der Innovationspolitik, Berlin.
17-2010	Günther, J.; Wilde, K.; Titze, M.; Sunder, M. (2010b): 20 Jahre nach dem Mauerfall: Stärken, Schwächen und Herausforderungen des ostdeutschen Innovationssystems heute, Berlin.
18-2010	Meurer, P.; Schulze, N. (2010): Overheadkosten für Drittmittelprojekte in Hochschulen und außeruniversitären Forschungseinrichtungen, Berlin.

ENDNOTES

1 Cf. Statistical Federal Agency (2009c: 20).
2 Cf. Federal Employment Agency (2009a, and 2009b), Statistical Federal Agency (2009a, and 2009b).
3 Cf. Barabas et al. (2009: 128–132).
4 Cf. The German Council of Economic Experts (2009: Summary, p.4).
5 Cf. DIW econ (2009).
6 The results of the BCG study are available to the Expert Commission.
7 Cf. Legler and Frietsch (2007).
8 For example, on support for cutting-edge technologies and knowledge-intensive services, EFI Report 2008 (44 -57) and EFI Report 2009 (55-57); on knowledge and technology transfer, EFI Report 2009 (39-44); on increasing innovative potential EFI Report 2009 (44–52); on government support for SMEs, EFI Report 2009 (47–48); and support for sustainable technologies EFI Report 2008 (46).
9 For example EFI Report 2008 (25-26, 34); EFI Report 2009 (17, 50–51).
10 Cf. DIW econ (2009: 18–20).
11 Cf. Polt et al. (2010: 165–167).
12 Cf. Blind (2010).
13 Cf. Association of German Foundations (2009).
14 Cf. IfM Bonn (2009).
15 Cf. Legler et al. (2010: 20).
16 Cf. Ministère de l'Enseignement supérieur et de la Recherche (2009b).
17 Cf. Ministère de l'Enseignement supérieur et de la Recherche (2009a).
18 Cf. EVCA (no year), data for 2008.
19 See EFI Report (2009: 13, 51–52).
20 Funds from the Pact for Research and Innovation are received by the organisations of the Fraunhofer Society, the Max Planck Society, Helmholtz Association, Leibniz Association and the German Research Council as promoting organisation. The Federal Government and the Laender have agreed to increase the financial provisions to these organisations by at least three percent for 2010, and from 2011 to 2015 by at least five percent per annum. The organisations agree to concentrate on excellence, increased cooperation and networking beyond organisational boundaries, as well as supporting young scientists and stimulating new and unconventional approaches to research.
21 The Higher Education Pact 2020 is intended to create 275 000 additional places for students between 2011 ad 2015.
22 In the coalition agreement, the Federal Government supports so-called future accounts with a starting deposit of EUR 150 for each newborn child, with a premium if money is paid into the account through until adulthood.
23 Cf. Middendorff et al. (2009).
24 Cf. Wolf (2007: 46–47).
25 Cf. Simon et al. (2010).
26 Currently, teaching strategies at ten universities are receiving support totalling ten million euros. Funding is provided in equal parts by the Stifterverband and the federal states.
27 Cf. National Science Board (2008).
28 Cf. Kuhlmann and Holland (1995: 197–198, 227–228), Rhomberg et al. (2006: 22–24, 58, 63, 83), and European Commission – Joint Research Centre and Joanneum Research (2002: 66).
29 On the results of the study see Kuhlmann and Holland (1995).
30 Cf. Kuhlmann and Holland (1995: 201–206) and Rhomberg et al. (2006: 45–47).

31 Cf. BMWi (2004) and DeGeval (2006).

32 Gibbons et al. (1994) and Nowotny et al. (2001) refer to a Mode 2 of knowledge production gradually replacing Mode 1.

33 The expenditure on innovation by the private sector is regularly surveyed for the Mannheim Innovation Panel. Innovation expenditure not only covers R&D, but also the costs of plants and machinery, software and external knowledge, construction, product development and design, services planning, personnel training, product introduction, and other preparations for the marketing of innovations. Innovation expenditure is on average double the R&D expenditure. Cf. Rammer und Peters (2010).

34 The figure of EUR 77 billion was erroneously given in the original report in German.

35 Including in particular Japan (77.7 percent) and Korea (73.7 percent). Cf. OECD (2009a).

36 The performance capacity of innovation in the private sector is measured in term to the level and structure of R&D expenditures, growth in revenues and personnel number, patent and export levels.

37 In 2008 the number of R&D personnel in the German private sector was increased by about 11 000 (i.e. by 3.4 percent) over the previous year.

38 Cf. Stifterverband für die Deutsche Wissenschaft (2010).

39 The most recent science, technology and industry scoreboard of the OECD (2009b: 24) already shows a reduction of company R&D expenditures in 2009 for most OECD countries.

40 The elasticity of R&D expenditure with respect to GDP in Germany is well below 1. The average for OECD countries is well above 1. Some countries have values of 2 to 3.5. Cf. OECD (2009b: 27).

41 Cf. Legler (2010: 2).

42 A good example of intrasectoral structural change is the increased emphasis on electronics and IT in the automotive industry.

43 Cf. Polt et al. (2010: Section 5.3).

44 Cf. National Science Board (2008: 4–52 ff.) and Belitz et al. (2010).

45 Cf. Dunning and Lundau (2009) on the discussion of "hollowing out" as a result of increased foreign R&D activities of multinational companies.

46 Belitz et al. (2010: 4) and Gerybadze (2010). The pharmaceutical industry has considerably expanded R&D expenditure in this period. Much of this still pays for R&D in Germany, but the majority of the increase goes towards pharmaceutical research in foreign R&D laboratories.

47 Chemistry graduates faced considerable problems finding employment in the 1990s, in part due to the relocation of industrial R&D capacity to other countries.

48 The two figures do not sum up to 100 percent. Part of the R&D is financed by other countries, or foundations and similar institutions.

49 Cf. Legler (2010: 29).

50 Based on estimates for 2008 by the Federal Statistical Agency. Final figures on R&D expenditure and employees will be published later in 2010.

51 In the international analyses of OECD these components of R&D budgets are referred to as Government Intramural Expenditure on R&D (GOVERD). See OECD (2009a: 76).

52 Cf. Hohn and Schimank (1990), Grande and Häusler (1994), Knie and Simon (2009), Simon and Knie (2009).

53 Polt et al. (2010).

54 Polt et al. (2010: 43 f.).

55 Cf. BMBF (2007a), Ten guidelines of a modern departmental research at the level of the Federal Government, and BMBF (2007b), Concept of a modern departmental research.

56 Important approaches are offered by the Recommendations of the National Science Council (2007), which have not yet been implemented fully. A new paper of the Wissenschaftsrat will be discussed in May. In the coalition negotiations in October 2009, departmental research was placed on the agenda by Minister Pinkwart, NRW, for the research and innovation policies for

the new Bundestag. There is room for optimisation regarding departmental research at Federal Government and Laender levels.

57 Evaluations on the basis of only a few quantitative indicators can be problematic. The use of patent data as a measure of innovation performance is considered in Section B 5 of this report.

58 In the course of its evaluation of the strategic departmental research at the level of the Federal Government, the National Science Council (2007) also evaluated the publication output, but used a different methodology.

59 Measuring output on the basis of SCI publications may exclude other important outputs (journals not covered by the SCI system, books, conference proceedings, etc.).

60 Comparisons should take into account the differing activity profiles and performance must be measured multi-dimensionally. Cf. FÖV (2007), and Schmoch (2009).

61 An outlier value for MPG researchers in 2004 was corrected down. Numbers of MPG researchers before 2002 were probably underestimated.

62 At LMU Munich, attocube systems GmbH was set up in 2001 as a spin off from the Centre for NanoScience with the participation of Wittenstein AG (see Part A of this report). The E.ON Research Institute for Energy was set up at RWTH Aachen. TH Darmstadt has established Public Private Partnerships with Henkel (Sustech), Merck (Merck Lab), and SAP (CEC). Heidelberg University runs CaRLa together with BASF. The University of Oldenburg and NEXT Energy have established an energy research institute. For a detailed analysis of these new forms of cooperation see Koschatzky et al. (2008).

63 Polt et al. (2010: 81 f.).

64 Specific problems of innovation and knowledge transfer in the field of materials research are considered in: Bräutigam and Gerybadze (2010), Malanowski and Zweck (2010).

65 Cf. an analysis of the pros and cons of the project funding institutions in Polt et al. (2010: 155 ff.).

66 Polt et al. (2010: Part 3).

67 However, student numbers are currently at a record high. In Winter Semester 2009 / 2010 there were 2.129 million higher education students, about five percent up over the previous year. New students in 2009 were 43 percent of their peer cohort (3% up on the previous year). Cf. press release of the Federal Statistical Office, 25 November 2009. But the proportion of school-leavers choosing to go on to higher education sank steadily from 2002 onwards, with only a slight rise between 2006 and 2008. Cf. Leszczensky et al. (2010: 36). It must be hoped that this marks the start of a trend to improved fulfilment of educational potential.

68 Cf. The European Higher Education Area, Joint Declaration of the European Ministers of Education, 19 June 1999, Bologna, see www.bmbf.de/pub/bologna_deu.pdf (accessed on 28 January 2010).

69 Cf. The Bologna Process 2020 – the European Higher Education Area in the new decade. Communiqué of European ministers responsible for higher education, Leuven / Louvain-la-Neuve, 28 and 29 April 2009, see http://www.ond.vlaanderen.be/hogeronderwijs/bologna/conference/documents/leuven_louvain-la-neuve_communiqu%C3%A9_april_2009.pdf (accessed on 28 January 2010).

70 Cf. The Bologna Process, www.bmbf.de/de/3336.php (accessed on 28 January 2010).

71 National strategies for the social dimension of the Bologna Process, see www.kmk.org/fi- leadmin/pdf/Wissenschaft/BE_081010_NatBericht_TeilII_SozialeDimension_endg.pdf (accessed on 28 January 2010).

72 Cf. Mühlenweg et al. (2010: 18). There is a delay in publishing the official statistics for scientific evaluation. This means it was not possible to include data for 2008 / 2009. In addition, bachelor courses enrolments are for an academic year rather than for each semester. Due to the delay in determining final student numbers, the figures only extend to 2006.

73 In the lead are Hamburg (94.5 percent), Lower Saxony (94.4 percent), Schleswig-Holstein (92.8 percent) and Berlin (90.7 percent). The stragglers include Bavaria (55.2 percent) and Saarland (54.8 percent). Cf. Stifterverband für die Deutsche Wissenschaft (2009b).

74 Cf. Mühlenweg et al. (2010: 41). The drop-out rate is based on statistics for winter semester 2000 / 2001 to WS 2007 / 2008, but can only be calculated until 2004 due to the delay in registering students who have .

75 Rate of transfer: Proportion of those with entrance qualifications who enrol up to one year later; a sign of how attractive a course is.

76 Cf. Mühlenweg et al. (2010).

77 The Federal Statistical Agency identifies foreign students based on nationality. As a result, foreign passport holders who have been to school in Germany cannot be distinguished from those who have come to Germany to study. The statistics also do not show whether a student is taking a full course at a German university, or only studying for a shorter period.

78 It is not possible to compare changes in the numbers taking further degree courses over the past ten years, because there were no comparable courses before the introduction of the bachelor's degree which also offered a qualification after three years.

79 Cf. Alesi et al. (2010: 33 f.). On the interest of bachelor's students in obtaining a further degree, see SWOP (2009).

80 The study investigated the reforms in chemistry, mechanical engineering and sociology at three German universities. Cf. Winter et al. (2010).

81 The new courses usually have a module system. A module consists of two or more lectures which are connected in some way. The module must be completed within a certain period, and a delay may result in points being deducted. The idea is to encourage students to study in an organised and timely fashion. If the number of deducted points exceeds a certain total, this can lead to penalties or even ex-matriculation. Problems can arise if lectures and seminars are not available, or if no allowances are made for students who spend a period in a foreign country, or who also have a job.

82 Cf. Winter et al. (2010).

83 In chemistry there has been a considerable increase, in mechanical engineering a slight increase, and in sociology at present even a slight decrease. Cf. Winter et al. (2010: 433 f.).

84 Cf. Winter et al. (2010: 6).

85 55 percent of employed bachelor graduates from universities have a full-time job, compared with 69 percent of those who completed a traditional course of studies at a university. The highest figure is graduates from universities of applied sciences with a master's degree, of which 88 percent are fully employed. 68 percent of bachelor's degree graduates from universities see a close link between the subject they studied and their current occupation, in contrast to 81 percent of those with a "traditional" qualification from a university. Cf. Alesi et al. (2010: 38 ff.).

86 Graduates with a bachelor's degree in mathematics and natural sciences from universities seem to find it much more difficult at the beginning of their career than those who obtained traditional qualifications. In contrast, with university bachelor's degree graduates in computer sciences there is hardly any difference, both in comparison to those who studied traditional courses at universities as well as with bachelor's degree graduates from universities of applied sciences. Interestingly, their monthly income is also considerably higher than that of their colleagues from a university of applied sciences (EUR 3 425 compared with EUR 2 706, or 27 percent more). Cf. Alesi et al. (2010: 44 f.).

87 Chemists are often expected to have a doctorate, whereas employers are more willing to consider mechanical engineers and sociologists with a bachelor's or master's degree. Cf. Winter et al. (2010).

88 Cf. Winter et al. (2010: 280 ff.).

89 Cf. Resolution of the 327th Standing Conference of the Ministers of Education and Cultural Affairs of the Laender on 15 October 2009 for the further development of the Bologna Process.

90 Cf. Results of the 328th Plenary meting of the Standing Conference of the Ministers of Education and Cultural Affairs of the Laender on 10 December 2009.

91 Cf. Resolution of the 327th Standing Conference of the Ministers of Education and Cultural Affairs of the Laender on 15 October 2009 for the further development of the Bologna Process.
92 Cf. Hess et al. (2009).
93 Cf. Blüthmann et al. (2008), Brandstätter et al. (2006), Derboven et al. (2006), Georg (2008), Zimmermann et al. (2008).
94 Cf. Heublein et al. (2009).
95 According to a recent HIS study, more than a third of prospective students see financing their studies as a problem. Cf. Heine and Quast (2009: 21).
96 Proposals on student grants were made in late 2009 by the Centre for Higher Education Development, and by a joint initiative of the German Trade Union Confederation and the German National Association for Student Affaires. Cf. Stuckrad et al. (2009) and DGB & DSW (2009).
97 Under the coalition agreement, the Federal Government and Laender should jointly establish a national scholarship programme to support universities and universities of applied sciences who organise student scholarships of EUR 300 per month from companies and private sources. These will not be taken into consideration when determining a student grant (BAföG).
98 Cf. For the following Günther et al. (2010a).
99 R&D employment in 1989 is for the GDR, and in 1993 for the five new federal states and Berlin.
100 Cf. Mayntz (1994).
101 Cf. Mayntz (1994).
102 Cf. Hochschulkompass, www.hochschulkompass.de (accessed on 28 January 2010) and BMBF (2008).
103 Cf. Gehrke et al. (2010).
104 Cf. Federal Government (1997).
105 Cf. Günther et al. (2010a).
106 Financial scope for infrastructure improvements in the new Laender were also offered by Solidarity Agreements I and II. Between 1995 and 2019 more than EUR 251 billion will be transferred to east Germany. Solidarity Agreement II, in particular, targets infrastructure and growth stimulation. However, given the financial straits of the new Laender, a large proportion of the funds are in fact not invested but consumed. Cf. Kitterer (2002) and Ragnitz (2005).
107 Cf. Dolata (2006), and Meyer-Krahmer (2005).
108 Cf. Meyer-Krahmer (2005).
109 Cf. Braczyk et al. (1998), and Lundvall (1992).
110 Cf. Fier and Harhoff (2002).
111 Cf. Günther et al. (2010b).
112 If Berlin is included in east Germany, the comparison with west Germany is even less favourable. This is due to the serious structural problems in eastern and western areas of Berlin. The real gross domestic product of Berlin is still lower than in the mid-1990s, and per capita gross domestic product in Berlin is below the national average, which is not typical for an agglomeration of this size. In 2008, it was nearly EUR 26 000, only half the value of Hamburg and 60 percent of the value in Bremen.
113 Cf. Eickelpasch (2009).
114 Cf. Gehrke et al. (2010).
115 Cf. Gehrke et al. (2010).
116 Cf. Eickelpasch (2009), and Gehrke et al. (2010).
117 Data from the Mannheim Innovation panel for 2008. Cf. Rammer et al. (2010).
118 The IAB Establishment Panel is a representative survey of employers by the Institute for Employment Research (IAB). Every year, 16 000 companies of all sizes and sectors are asked to respond about topics related to employment and economic policies. The IAB Panel has been working since 1993in west Germany and since 1996 in east Germany, and provides longitudinal data for research on demand in the employment market.

119 Cf. Günther et al. (2010b).

120 "Part-time" R&D employees are weighted with a factor of 0.5. Non-commercial operations are excluded from the evaluation. "West–South": Baden-Württemberg, Bavaria, Hesse; "West–North": all other west German Laender, not including Berlin.

121 Cf. Franz (2008).

122 Cf. Eickelpasch (2009).

123 Cf. Schmoch and Schulze (2010).

124 Cf. Aschhoff et al. (2009).

125 Cf. Görzig et al. (2009).

126 Cf. Aschhoff et al. (2009) and Rammer et al. (2010).

127 Cf. Schmoch and Schulze (2010).

128 In 1989, 2.5 million women between 20 and 40 years lived in the GDR (15 percent of the population). In 2007, there were 1.5 million women of this age group in the same region (about 11 percent).

129 Cf. IWH (2009).

130 Cf. Statistical Federal Agency (2006).

131 Cf. Schneider (2008).

132 The GRW forms a coordination framework for the deployment of funds from the European Regional Development Fund (ERFD), see www.bmwi.de/BMWi/Navigation/Wirtschaft/ Wirtschaftspolitik/Regionalpolitik/gemeinschaftsaufgabe,did=151098.html?view=renderPrint (accessed on 28 January 2010). Many ERFD measures are co-financed by GRW.

133 Cf. Titze (2008).

134 Cf. CDU, CSU and FDP (2009).

135 In 2009, 16 percent of Germany's electrical energy requirements came from renewable sources: 6.4 percent from wind power, 4.4 percent from biomass, 3.3 from percent hydraulic power, 1.0 percent from photovoltaics and 0.9 percent from waste incineration. Cf. German Energy and Water Association (BDEW), Press release 28 December 2009, www.bdew.de/bdew.nsf/id/DE_20091228_PM_Erneuerbare_erzeugten_16_percent_des_Stroms?open (accessed on 28 January 2010).

136 The coalition agreement of CDU, CSU and FDP sets a target of a 40 percent reduction of greenhouse gas emissions in Germany by 2020 in comparison with 1990 levels. Cf. CDU, CSU and FDP (2009).

137 IC engines emit, in addition to carbon dioxide, benzene, lead compounds, carbon monoxide, hydrocarbons, nitrogen oxides, sulphur dioxide and particulate matter. With electric cars, this pollution is avoided locally in the conurbations themselves, even if the power is derived from fossil-fuelled power stations.

138 In 1955, Tokyo and New York / Newark were the only urban agglomerations worldwide with more than ten million inhabitants. 50 years later there were already 20 megacities with a total of 293 million people living in them. The United Nations (UN 2006) expect that by 2015 there will be 22 megacities with a total of 359 million residents.

139 The European Union currently has a CO_2 reduction target of 20 percent by 2020 relative to emission values for 1990. The Federal Government has set itself the goal in the coalition agreement to achieve a 40 percent reduction of greenhouse gases by 2020. Cf. CDU, CSU and FDP (2009). 18.1 percent of German CO_2 emissions in 2007 were from traffic and transport, compared with: energy sector 45.8 percent, domestic and small consumers 15.3 percent, manufacturing sector 10.7 percent, and industrial processes 9.9 percent. Cf. Federal Environment Agency (2009).

140 Battery electric vehicles (Cf. Table 6 in this report) would probably be of interest mainly for commuters at first.

141 In the medium- to long-term, fuel-cell vehicles can also play a role, but there is so far no infrastructure for the supply of hydrogen. The storage of hydrogen is also technically complicated. Some vehicle manufacturers have recently cut back their research programmes on the use of hydrogen, while other remain active. Cf. Handelsblatt, 7 December 2009, p. 1.

142 Electrochemistry is important for the development of battery technology. In Germany, it is allocated to departments of physical chemistry, or organic chemistry in the case of organic electrochemistry. In recent decades, electrochemistry has variously lost Chairs as these became vacant, with the result that research in electrochemistry is inadequately represented (Holze 2007). The reduction in scientific capacity at German universities has been noted by the National Association of the German Electrical and Electronics Industries (ZVEI), the German Bunsen Society for Physical Chemistry (DBG) and the Faculty for Mathematical and Natural Sciences of the German Higher Education System (MNFT). A joint Centre for Electrochemical Sciences (CES) has been established by Ruhr-Universität Bochum, the Max-Planck-Institut für Eisenforschung GmbH in Düsseldorf and the DOC Dortmunder Oberflächen Centrum, see www.ruhr-uni-bochum.de/ces/Zentrallabor.html (accessed on 28 January 2010).

143 Registered in the Science Citation Index (SCI).

144 Comparisons between countries on the basis of patents, publications, production or foreign trade on the basis of absolute figures are affected by factors such as country size, the geostrategic location, etc. Specialisation indices express the weight of a specific field or sector of a country in relation to a general reference, usually a global mean. Specialisation indices are dimensionless, and symmetrical around a central value of 0. Upper and lower limits can be set to eliminate the effects of outlier values. Increasing activities will only results in a higher index value if most other countries have not also increased their activities to the same extent.

145 In the BMBF-supported project "System Research Electromobility", 34 institutes of the Fraunhofer Society will be cooperating over the next two years. There are also new priority activities in the Helmholtz Association (HGF).

146 See DFG press release, 11 September 2007, http://www.dfg.de/service/presse/pres semitteilungen/2007/pressemitteilung_nr_56/ (accessed on 28 January 2010).

147 Next-generation batteries will go beyond the lithium-cobalt-graphite-polymer system. The challenge is to develop novel electrodes, electrolytes and separators. New concepts include other lithium-based systems (lithium-iron, lithium-metal oxide, lithium-silicon, etc.) or lithium-free systems such as metal-air batteries or magnesium-based systems. It is also necessary to develop double-layer capacitors for high performance and rapid response.

148 Cf. Tushman and Andersen (1986), Henderson and Clark (1989), Christensen (1997).

149 Gross value creation in the sector "Motor vehicles and components" was EUR 77 billion in 2007, compared with EUR 515 billion for the manufacturing industry as a whole (Statistisches Bundesamt 2009d).

150 RWI has calculated the employment effects from the demand for domestic motor vehicles in Germany using data for 1978, 1990, 1991 and 2000 obtained from Input-Output tables of the Federal Statistical Office (RWI 2005). The results were updated using data for 2005 and extrapolated for 2006 to 2008. (EFI has an unpublished working paper from RWI).

151 France is supporting the development of hybrid and electric vehicles in the next four years with some EUR 400 million. Purchasing subsidies will also be offered, which are linked to the CO_2 emissions of the vehicle. Similar incentives are to be introduced in Great Britain. The US government plans to invest US$ 150 billion in energy technologies over the next ten years. Further US$ 2 billion are earmarked for the further development of electric vehicles. China is promoting the development of more efficient motor technologies with EUR 1 billion. The development of ten pilot regions for more than 10 000 vehicles is to be supported in 2009 to 2011 with EUR 2 billion. Cf. Bundesregierung (2009: 14 f.).

152 According to the vehicle registration statistics, in early 2009 49.6 million vehicles were registered in Germany, of which 41.3 million were cars, see www.kba.de/cln_005/nn_125398/DE/Statistik/Fahrzeuge/Bestand/2009 b ueberblick pdf,templateId=raw,property=publicationFile.pdf/2009_b_ueberblick_pdf (accessed on 28 January 2010).

153 Cf. Innovation alliance "Lithium Ion Battery LIB 2015", www.bmbf.de/de/11828.php (accessed on 28 January 2010) and Bundesregierung (2009: 20).

154 There are more than 60 million electric scooters in China. More than 20 million are produced each year. They currently use lead batteries. Cf. Die Zeit, No. 47, 12 November 2009, p. 42.

155 The report of the Federal Trade Commission states: “[…] Questionable patents are a significant competitive concern and can harm innovation.” Cf. Federal Trade Commission (2003: 5).

156 See Hall (2002) for an overview. According to Scherer, without the patent systems, R&D expenditure of private actors would only fall slightly in most sectors, but in the pharmaceutical industry there would be a considerable decline. Cf. Scherer (2009: 171 ff.). The varying significance of patents is also regularly confirmed in company surveys, see Levin et al. (1987) for US companies. Corresponding results are also obtained in surveys of European companies, e.g. König and Licht (1995). Econometric evidence is presented by Arora et al. (2008).

157 Cf. Federal Trade Commission (2003). In the Pharmaceutical Sector Enquiry, the European Commission draws attention to the harmful effects patents can have on competition. Cf. European Commission (2009).

158 In 1982 the US Congress created the Court of Appeals for the Federal Circuit (CAFC) for patent disputes. Merges (1992) noted that judgements by the CAFC were very frequently in favour of the patent holder. Similar conclusions are reached by Henry and Turner (2006).

159 Cf. Hall and Ziedonis (2001).

160 Cf. Harhoff (2009).

161 In eBay Inc versus MercExchange, the US Supreme Court decided unanimously in 2006 that in the case of a patent infringement an injunction should not be granted automatically, but only after due consideration of various factors. The case is interpreted as weakening the position of the patent holder, because prior to eBay Inc versus MercExchange an injunction could be obtained to stop the business activities of the infringer, given the patent holder a very strong negotiating position.

162 In Bilski versus Kappos, a decision was expected in June 2010. In this case, the US Patent Office rejected a patent application for a business method. CAFC overturned an objection filed by the patent applicant. The case is important because it could redefine the sorts of inventions for which patent protection can be claimed.

163 The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement) is the most important international agreement on immaterial property rights and sets minimum standards for national legal systems.

164 This topic was dealt with in detail in 2007 in a report of the scientific advisory board at the Federal Ministry for Economy and Technology. Cf. Wissenschaftlicher Beirat (2007).

165 Whereas a priority filing at a national patent office would usually lead to one EPO patent application, it is now frequently observed a number of EPO applications are created from a priority. By means of splitting – more than 7000 cases each year at the EPO – some patent applicants attempt to delay the examination procedure in order to react to the current developments. For a detailed analysis see Guellec and van Pottelsberghe (2007) and Wissenschaftlicher Beirat (2007).

166 Cf. Shapiro (2001). A patent thicket is a network of overlapping patents, often of uncertain scope and validity. Patent thickets are found above all in so-called complex technologies, i.e. areas in which a single product is protected by a large number of patents. This affects in particular information and communications technology.

167 Cf. Wissenschaftlicher Beirat (2007: Fig. 5).

168 Cf. Harhoff (2009).

169 This does not include applications which are withdrawn before their first publication and which are thus not made public. Patent offices frequently include the number of these applications in their calculations and thus report a slightly lower rate of approval. Often patent offices do not relate their figures to application cohorts, but define the approval rate as the number of patents approved in a year divided by the number of all final decisions (approvals, rejections, withdrawn applications).

170 Cf. Friebel et al. (2006).

171 This includes a lack of supervision and the neglect of the additional efforts involved in rejecting applications. Although rejecting a patent application increases the workload by about 70 percent, it was classed the same as granting a patent in the performance evaluations until 2008. The EPO now allows its examiners more time for rejecting an application than for granting a patent. The German Patent and Trade Mark Office (DPMA) has not yet followed suit.

172 On the historical development and importance of criteria of inventive activity, cf. Beier (1985), and Asendorf et al. (2006).

173 (1972: 430 f.).“

174 Cf. Conclusions on an enhanced patent system in Europe, see www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/intm/111744.pdf (accessed on 28 January 2010).

175 The standardisation of the patent conflict procedures at CAFC in the USA had the opposite effect.

176 N.B. “in cross-sectional data”. The relationship between R&D expenditure and the number of patents of a company has changed over recent decades. Hall and Ziedonis (2001) note that the number of patents per million dollars increased from about 0.3 in 1982 to 0.6 in 1992. They attribute this in large part to an “arms race” between companies.

177 Cf. Griliches (1990).

178 Cf. Frietsch et al. (2010b).

179 Cf. Frietsch et al. (2010b).

180 Cf. Leszczensky et al. (2010).

181 Cf. Rammer and Peters (2010).

182 Cf. Rammer and Metzger (2010).

183 WIPO: World Intellectual Property Organization.

184 PCT: Patent Cooperation Treaty.

185 High technology covers goods of high-value technology involving an overall R&D expenditure between 2.5 and 7 percent of annual revenues, and goods of cutting-edge technology with an R&D intensity of more than 7 percent.

186 Growth rates for the transnational patent applications for selected countries.

187 High-value technology goods have an overall R&D expenditure between 2.5 and 7 percent of annual revenues. Examples include motor vehicle construction, mechanical engineering, “classical” electrical engineering, chemistry, and precision instruments.

188 Cf. Endnote 144.

189 Cutting-edge technology goods have an overall R&D-expenditure as an OECD average, which is more than 7 percent of annual revenues. Examples include pharmaceuticals, IT equipment, medical and measuring technology, aircraft and space vehicles.

190 Cf. Endnote 144.

191 Cf. Frommann and Dahmann (2005).

192 Cf. Frietsch et al. (2010a).

193 Cf. Schmoch and Schulze (2010).

194 The following countries were investigated: Brazil, Mexico, Korea, China, India, Poland, Czech Republic, Slovakia, Hungary, Romania, Russia, South Africa, Turkey and Israel. Cf. Schmoch and Qu (2009).

195 Cf. Endnote 144.

196 Cf. Endnote 144.

197 Cf. Belitz et al. (2010), Gehrke et al. (2010).

198 Labour market observations indicate that the manufacturing sectors and in particular export-oriented industrial sectors and the suppliers are being hit particularly hard by the current recession. Cf. Gehrke et al. 2010.

199 Cf. Endnote 144.

200 Cf. Endnote 144.

201 Cf. Legler and Frietsch (2007).

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