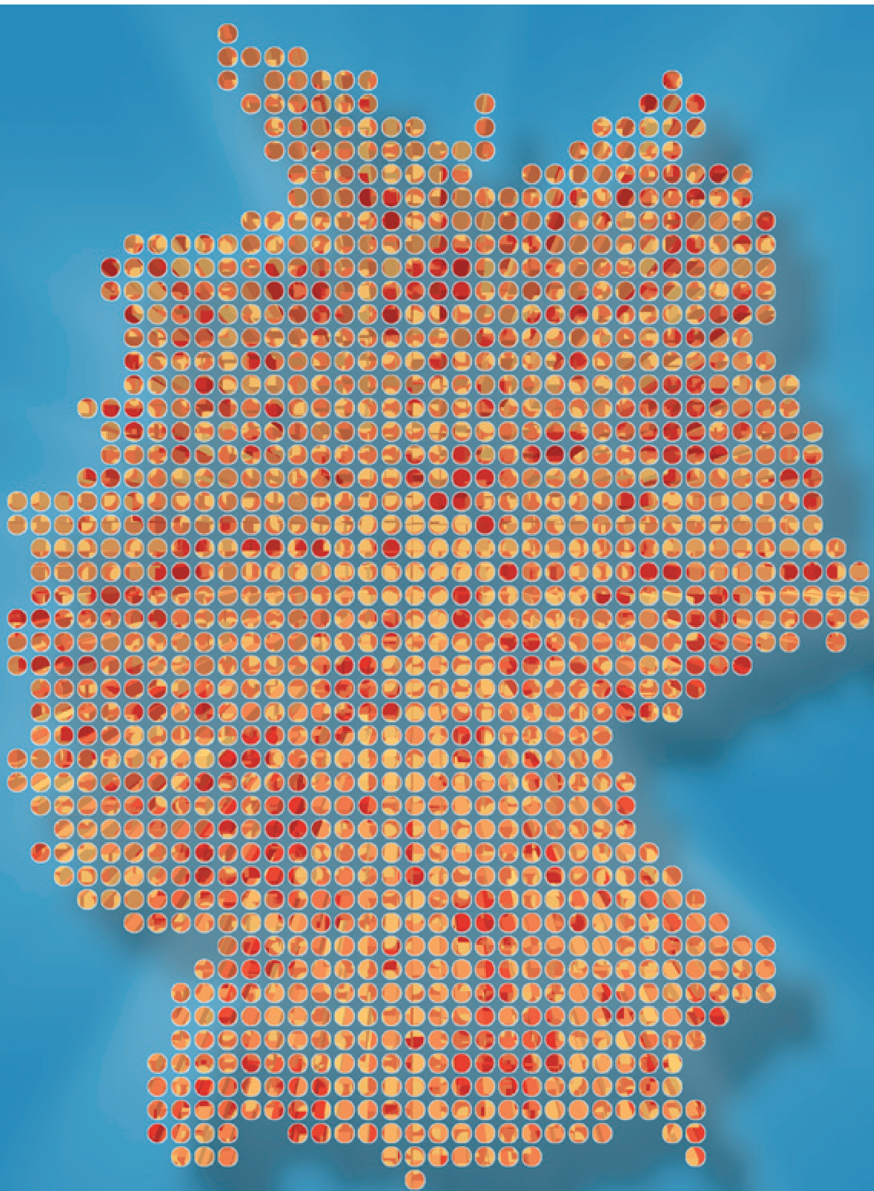
Federal Ministry
of Education
and Research

Federal Report on Research and Innovation 2010

Abstract



RESEARCH

Igniting ideas !

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Foreword

In Germany, the proportion of value-added products and services based on research is higher than in any other industrialised country. The export of technological goods makes up one fifth of our country's economic output. Hence, research and development are very important to the economic power and economic growth in Germany.

The Federal Report on Research and Innovation (Bundesbericht Forschung und Innovation, BuFI) shows that the further development of Germany as a research location has gained significant momentum in recent years. This applies to new concepts and alliances between science and industry. This also applies to our goal of significantly increasing investments in research and development in companies and by the public sector. Since 2005, central government expenditure on research has risen by 21 percent; private sector investment in research has increased by 19 percent. This puts Germany in the leading group among European countries. We have also steadily increased the number of scientific publications and patents.

The Federal Report on Research and Innovation underlines the key findings of the report on research, innovations and technological performance (Gutachten zu Forschung, Innovationen und technologischer Leistungsfähigkeit) compiled by the Expert Commission on Research and Innovation (Expertenkommission Forschung und Innovation). This report shows that our country has a powerful and internationally recognised scientific system and a high proportion of innovative enterprises.

Given the intensification of global competition for innovation, the focus is shifting. Global expenditure on research and development has doubled since 1997. Many emerging economies are catching up. The German Federal Government will, therefore, hold its current course on research and innovation. We will continue and consolidate the positive developments achieved in research and innovation. Our policies will make an important contribution to solving urgent global problems such as climate change or dwindling reserves of raw materials. And we will focus our German High-Tech Strategy 2020 programme (Hightech-Strategie 2020 für Deutschland) on these priorities. Germany is now in an excellent position to tackle these issues.

Table of contents

Introduction

This abridged version of the Federal Report on Research and Innovation 2010 provides an overview of the German research and innovation system. It contains selected texts, figures and tables from the report.

The long version contains detailed information about the activities of the German Federal Government, the governments of the federal *Länder* and their research and development organisations and institutions, and about commercial research and development activities and international partnerships. It can be ordered on the Internet or downloaded at www.bmbf.de/publikationen.

Part I presents the German Federal Government's research and innovation policy objectives and measures. It outlines current developments, further developments in Germany's High-tech Strategy, the composition of the science and education system, the internationalisation of research and innovation policy, and policy advice on science, research and innovation.

Part II contains five chapters on the structures, resources and funding programmes of the German research and innovation system.

The first chapter, **An overview of the German research and innovation system** introduces the structures of the German research and innovation system. The chapter answers three important questions: "Where is research taking place?", "Who funds research?" and "How does state research funding work?"

The second chapter, **Central government's research and innovation policies** outlines the research priorities of government research funding.

The third chapter, **Research and innovation policies of the federal *Länder*** gives an introduction to local government research priorities.

The fourth chapter, **International cooperation on research and innovation** highlights the international orientation of German research and innovation policy. It provides an overview of the internationalisation strategy and major bilateral/multilateral partnerships.

The fifth chapter presents selected **Data and facts about the German research and innovation system.** The chapter is rounded off with a selection of tables.

Part I The German Federal Government's research and innovation policy objectives and measures

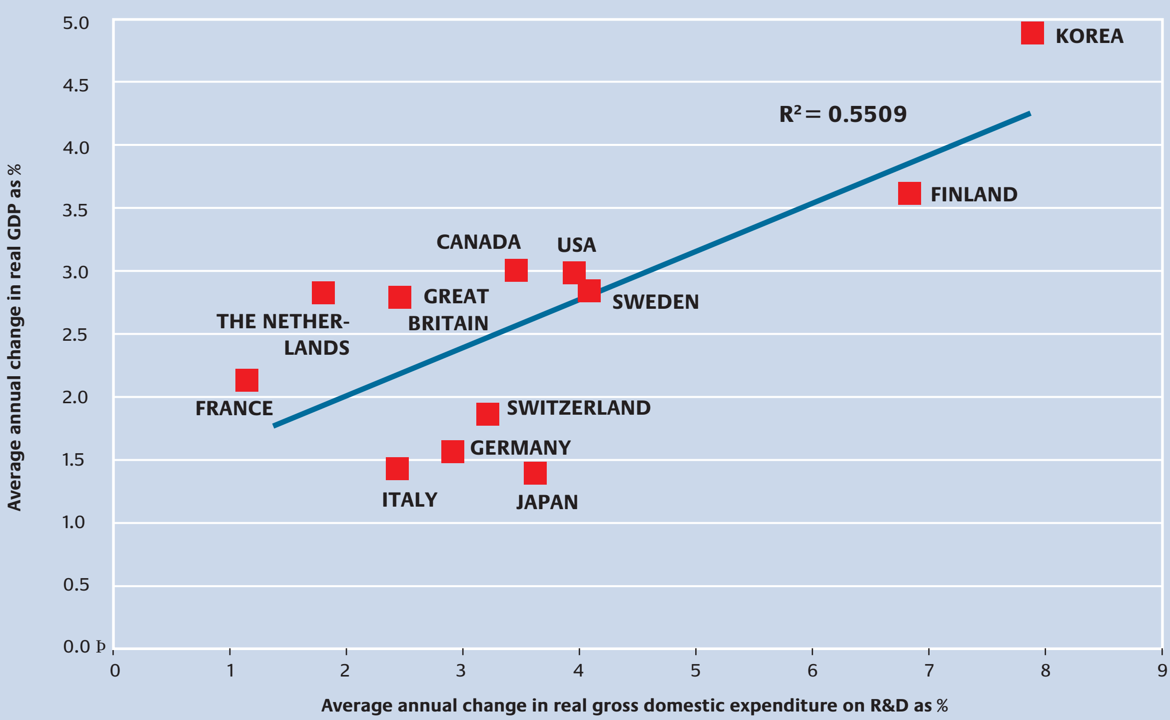
1 Recent developments in research and innovation

Innovations are ideas that become reality. The impetus for new ideas often comes from scientific and technological developments, but also from pressing challenges. At the beginning of the second decade of this century, scientific and technological progress continues to gain momentum. At the same time, there is a growing need for sustainable solutions to global problems.

While, in 1953, the global population was almost 2.7 billion, today it is almost 6.7 billion. In 2050, there will be 9.2 billion people on the planet. The largest increase is expected to be in the traditionally less developed regions of the world. Ensuring world food supply is therefore one of the key challenges of the coming decades. Global energy consumption will at least double by 2050 due to the growth in population and prosperity. If unforeseen changes to the livelihoods of millions of people are to be prevented then, according to analyses by the IPCC, global warming must not exceed two degrees Celsius. Solutions to these challenges can only be found through new ideas, inventions and their successful implementation.

Worldwide, research and innovation systems are in a process of strong growth and transformation: global expenditure on research and development (R&D) has doubled since 1997. In total, more than 5.7 million people work in research and development – compared to just below four million in 1995. Many industrial and emerging countries are increasingly investing in education, research and innovation. The contest for knowledge will further accelerate in the medium and

Fig. 1 **Relationship between R&D and economic growth in major industrial nations 1994-2008***



Basis of data: OECD; Main Science and Technology Indicators 2009/2, data from the Federal Statistical Office; NIW calculations and estimates

* The Netherlands, Switzerland, Japan and Korea: 1994-2007

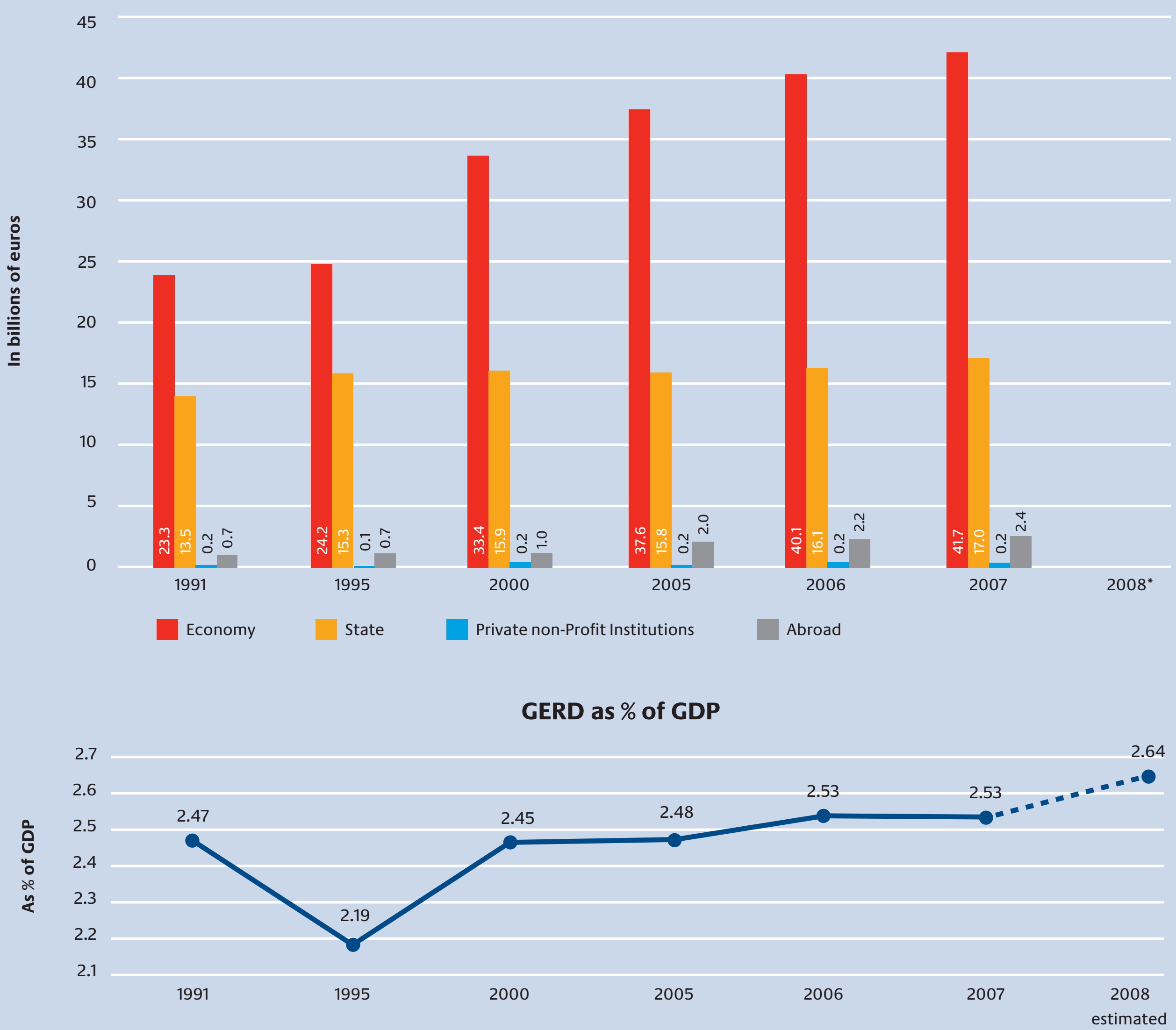
Source: Legler, H. (2010): FuE-Aktivitäten von Wirtschaft und Staat im internationalen Vergleich (International comparison of public and private sector R&D activities), Berlin long term. Competitive pressure is increasing. The struggle for talent, technologies and locations continues to intensify.

The decisive impetus for technological and economic developments no longer comes exclusively from Europe or America, but increasingly also from Asia. China has finally taken over Germany's title as the export champion of the world. Back in 2007, China moved into third place behind the USA and Japan on the list of absolute expenditure on R&D. In 2008, Japan spent a record 3.4% of its GDP on R&D. For Germany, it is a question of asserting itself in this competitive environment with the appropriate emphasis. The German economy needs new prospects for growth.

In a leading industrial nation like Germany, R&D activities in particular form an essential basis for new and sustainable growth: new, because it is based on the latest findings from R&D; and sustainable because it is derived from proactive and courageous decisions for promising products, processes and services. ■ Figure 1

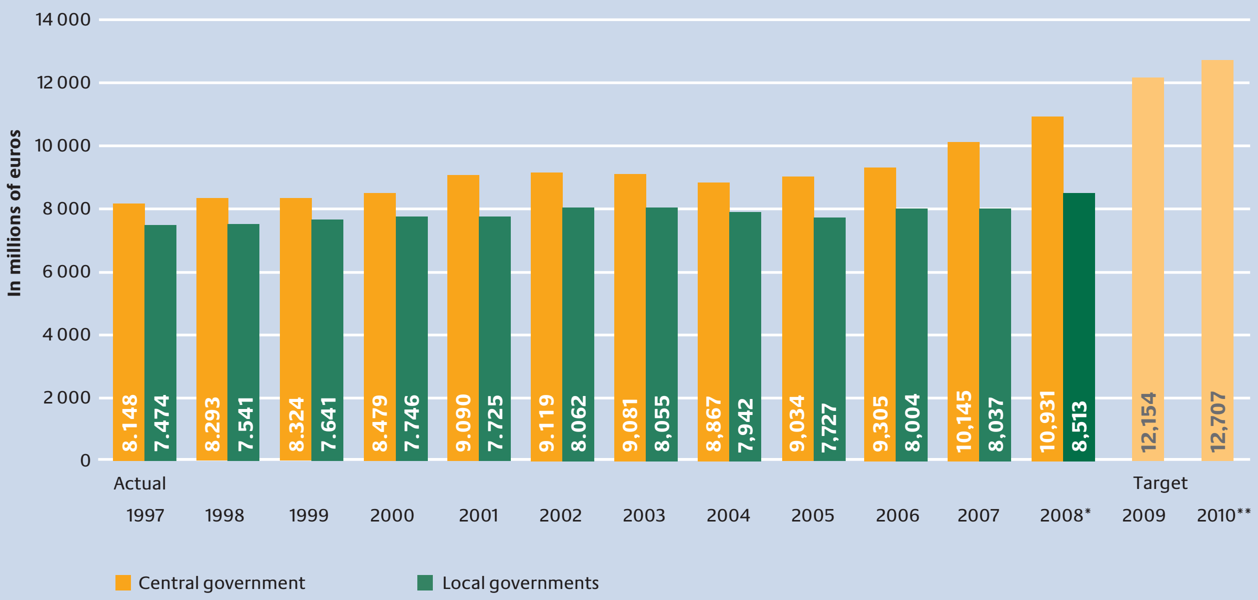
In recent years, the German Federal Government has moved research and innovation closer to the core of its growth policy. It has consistently given priority to education, research and innovation. The importance of these issues for solving global challenges and for the future of Germany as a location is anchored in the public consciousness.

Fig. 2 **Gross domestic expenditure on research and development (GERD) in the Federal Republic of Germany by funding sectors (implementation view) GERD as a percentage of the gross domestic product (GDP) over time**



* Data for 2008 was not available when going to press
Basis of data: table 1

Fig. 3 **Expenditure on research and development by central and local governments over time (financing view)**



* Estimated local government expenditure in 2008, **) Estimated central government expenditure in 2010 (excluding the economic stimulus package II)
Basis of data: tables 13 and 14

The Federal Government's research and innovation policy measures were re-initiated and bundled together to form the High-Tech Strategy. The central and local government reform initiatives – the Excellence Initiative (Exzellenzinitiative), the Higher Education Pact (Hochschulpakt) and the Joint Initiative for Research and Innovation (Pakt für Forschung und Innovation) – have strengthened the performance capability of the German science system and made Germany even more attractive as a scientific location. This High-Tech Strategy, the reform initiatives and the strategy for the internationalisation of science and research complement each other perfectly.

The following data and facts show that the chosen path is the correct one:

- In 2007, absolute expenditure on R&D in Germany was higher than in any other country in Europe. Compared internationally, only the USA, Japan and China spent more on R&D.
- According to preliminary calculations by the Federal Ministry of Education and Research (BMBF), expenditure on R&D as a percentage of GDP rose to about 2.64% in 2008. This is the highest level since German reunification and a further step towards the 3% targeted of the Lisbon Strategy.
- In absolute terms, total expenditure on R&D (government, industry and others) between 2005 and 2007 increased from 55.7 billion euros to 61.5 billion euros. This corresponds to an increase of approximately 10%. A further increase to over 65 billion euros is expected in 2008. ■ Figure 2
- Central government expenditure on R&D increased from 9 billion euros in 2005 to 10.9 billion euros in 2008, a rise of around 21%. In 2009, central government expenditure on R&D increased further to 12.1 billion euros (target), a rise to 12.7 billion euros is planned for 2010. ■ Figure 3
- Despite the uncertainty caused by the financial and economic crisis in 2008, German companies have increased internal expenditure on R&D, compared to the previous year, by 7% (to 46.1 billion euros). As a result, enterprises in Germany increased their annual R&D investments between 2005 and 2008 by around 19% (7.4 billion euros). Increases were recorded by large, small and medium-sized enterprises.[A 1]
- Never before have so many people in Germany been employed in R&D: in 2008, the number of researchers, laboratory technicians and engineers employed in industry rose to 333 000 (measured in full-time equivalents). Compared to 2005, this is an increase of almost 30 000 people.
- The proportion of research-intensive products and services providing added value is more than 45% in Germany,

1 Þ Sources see p. 72

higher than in any other industrialised country. The USA, which was ahead in 2000, has now been surpassed. [B] The German economy is excellently positioned in the global technology markets. The creativity and technological performance of those companies impressively demonstrates how new ideas can open up future markets and top international positions.
- Statistics have proven that, by the end of 2008, there was a positive innovation climate: around 31% of companies can trace their innovation behaviour back to central government's improved research and innovation policies.[C]

The sum total of all the scientific, economic and political initiatives has had considerable impact: Germany has taken significant steps forward in research, development and innovation, as confirmed by the German Council of Economic Experts[D] and the Expert Commission on Research and Innovation[E] .

It is important to build on Germany's strong position at the beginning of a new decade. The Federal Government is committed to the 10% target for education and research agreed at the Dresden Education Summit (Dresdner Bildungsgipfel) on 22 October 2008, which exceeds the target agreed as part of the Lisbon Strategy. To this end, the Federal Government is aiming at additional investments in education and research of 12 billion euros by 2013. The initial step was already taken in the 2010 budget where 750 million more euros were made available for education and research than in the previous year. Also, additional funding is being provided for R&D as part of the economic stimulus package (Konjunkturpaket) for 2009 to 2011.

Germany will continue with its structural reforms of the research and innovation system: continuing the High-Tech Strategy, making education and science more dynamic and increasing the internationalisation of science and research.

2 Developing the German High-Tech Strategy further

In the last legislative period, the German Federal Government presented the High-Tech Strategy, a comprehensive national innovation strategy, for the first time. The integrative approach of the High-Tech Strategy has received great support from science and industry, and has attracted considerable international attention. It was therefore decided in the coalition agreement to develop the High-Tech Strategy further.

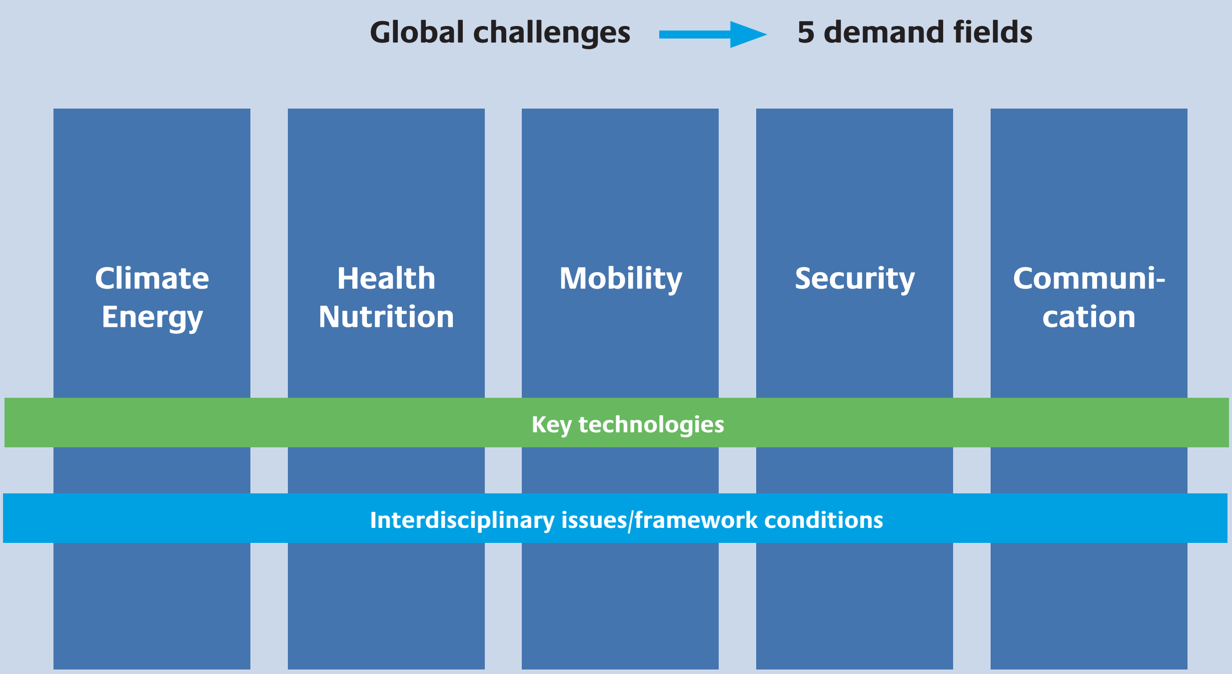
The High-Tech Strategy bundles research and innovation activities from a variety of policy fields and subject areas. Its aim is to create lead markets in Germany and to intensify co-operation between science and industry. It is important to improve the framework conditions for innovations further: Core interdisciplinary tasks, such as innovation financing, SME policy, optimising standardisation and the legal framework to protect intellectual property, and promoting young talent, must be pursued further. The promotion of important key technologies is aimed at contributions to progress in the demand fields. ■ Figure 4

At the same time, the Federal Government is generating new impetuses to mobilise human resources in science and industry and is focussing its commitment on research and innovation.

Focusing on global challenges

The High-Tech Strategy is aimed at the five major demand fields – climate/energy, health/nutrition, mobility, security and communication – and therefore at basic human needs. It will contribute towards solving the pressing global problems of our time. At the same time, it addresses the mega markets of the 21st century. ■ Infobox Germany is uniquely positioned to take advantage of its opportunities.

Fig. 4 Germany's High-Tech Strategy 2020



Source: BMBF

Infobox

The economic potential of the demand fields

Climate/Energy

- The global volume of lead markets on climate protection[1] in 2007 was almost 900 billion euros. Forecasts project a **volume** of almost 2 000 billion euros for 2020.[F]
- Climate protection as a whole is associated with positive **effects on employment**. To achieve its climate protection goals, the Federal Government is forecasting an addition-al 800 000 to 900 000 jobs by 2030.[G]
- The overall economic analysis shows that, between 2008 and 2030, **GDP** may increase by around 70 billion euros as a result of climate protection investments.[H]
- The **prospects for growth** are extremely positive: for example, the global market for environmentally friendly energy generation and storage will increase from 155 billion euros (2007) to 615 billion euros by 2020; the global market for energy efficiency will almost double by 2020 with an annual growth rate of 5% (2007: 540 billion euros).[I]

Health/Nutrition

- At the end of 2008, a total of 4.6 million people or about one in nine workers in Germany were employed in the health sector. This was around 76 000 people or 1.7% more than a year ago. Since 2000, the number of **employees** in health care has risen by 500 000 or 12.2%. In the next ten to fifteen years, up to 800 000 **additional jobs** could be created in the health sector in Germany, according to scientific estimates.[K]
- Forecasts for the coming years show there is **growth potential** in the various demand fields: in developed countries, demand for medical technology products will grow considerably faster than GDP[L] at an average of 3% to 4% per annum by 2020; from 2006 to 2020, annual growth in the European telemedicine market is expected to reach 10% or around 19 billion euros.[M]

Mobility

- In 2007, products and services that contribute to sustainable mobility represented a **global market** of 200 billion euros. By 2020, this volume will grow to 300 billion euros.[N]
- Electric vehicles, plug-in hybrid and hybrid vehicles have a **potential global market** of up to 470 billion euros (2020). There will be up to 140 000 **new jobs** (2020) in the battery, electric motor, power electronics or wiring industries. In contrast, a possible 46 000 jobs could be lost worldwide as classical mechanical components are no longer required.[O]
- High **growth rates** can be expected: e.g. a 22% annual increase in hybrid drives by 2020; telematics systems are expected to increase by 22.5% annually by 2016.[Q]
- Global civilian air traffic is expected to double over the next 15 years.[R]

Security

- The market in Germany for civilian security technologies and services for 2008 has an **overall volume** of just around 20 billion euros.[S]
- According to expert assessments for 2015, there will be a relevant **sales volume** in Germany of more than 31 billion euros. For German companies, this will mean a sales volume of over 21 billion euros or 69%. According to the Organisation for Economic Cooperation and Development (OECD), annual **global growth** rates will be around 7%.[U]
- For example, there are a number of **promising technology fields**: an average growth rate of 7.7% is forecast for the European RFID container security systems market between 2006 and 2013; growth in the European market for biometric sensor systems is expected to reach more than 60%.[V]
- In future, there will be considerable **growth potential** for products and services in the civilian security industry from emerging countries in central and eastern Europe, the Arab region and Asia. Germany is regarded as a competent partner in these countries.

Communication

- In 2008, **global turnover** in ICT grew by 4.6% to 2 347 billion euros. In 2009, the global ICT market is expected to grow by 2.9% to 2 416 billion euros.[W]
- According to recent polls, the **mood of ICT companies in Germany is buoyant despite the crisis**. For 2010, total sales in ICT are expected to match levels achieved in the previous year and, in 2011, growth is forecast at 1.6% to 142 billion euros. In 2010, information technology sales in Germany are forecast to increase by 1.4% to 64.4 billion euros.[X]
- Mobile internet and IT security are among the **most important trends** of the year. Sales of software will increase by 0.9% to 14.4 billion euros, while IT services, such as maintenance and outsourcing services ought to rise by 2.2% to 33 billion euros. For 2011, growth rates of 4.1% are expected for software and 5% for IT services and an increase of 3.8% for the German IT market as a whole.[Y]

1 The lead markets in climate protection are environmentally friendly energy generation and energy storage, energy efficiency and sustainable mobility.

Mission-oriented approach

The High-Tech Strategy will focus its research and innovation policy on clear objectives. These future projects specify the objectives of scientific, technological and social developments for a period of ten to fifteen years. They form the starting point for content guidelines and innovative strategies to achieve the necessary intermediate steps, and to realise their stated objectives.

From knowledge to product

Research results should be transformed quickly into innovations in the marketplace and in society. The German Federal Government is promoting dialogue between universities, non-university research institutes and companies, and is enhancing knowledge and technology transfer. The research results can therefore be converted more quickly into innovations in the marketplace and in society, and be made available to end users.

The BMBF will launch a new measure to validate funding. This measure is intended to better exploit the potential of academic research results in commercial ventures.

In addition, the development of a subsidy instrument is planned for the new "campus models". The objective is to get universities and non-university research institutions to cooperate with industry at one location in the medium to long term (in the form of public private partnerships). The Federal Government will continue with its successful interdisciplinary measures, such as the Leading Edge Cluster competition (Spitzencluster-Wettbewerb), Entrepreneurial Regions (Unternehmen Region), the Central Innovation Programme for SMEs (Zentrales Innovationsprogramm Mittelstand, ZIM), EXIST, High-tech Startup Fund I (High Tech-Gründerfonds I), KMU-innovativ and the Innovation alliances (Innovationsallianzen).

Key technologies

Key technologies, such as biotechnology and nanotechnology, optical technologies, microsystem, materials and production technologies, aeronautics technology, as well as information and communication technology are the drivers of innovation and form the foundation for new products, processes and services. They are essential in solving global challenges in the demand fields. Its benefits will depend critically on how successfully they can be converted into industrial applications. Key technologies' funding will therefore focus more on fields of application.

Interdisciplinary issues/framework conditions

State funding for research is only useful if the climate for innovation and innovation-friendly framework conditions are in place. The legal framework conditions are consistently reviewed to ensure they promote innovation and are adjusted if necessary. New initiatives are designed to create scope for invention and innovation.

In particular, the conditions for starting up innovative enterprises in Germany must be improved further and the financing of innovations secured. This mainly concerns a strengthening of the venture and equity capital market in Germany, and improving the start-up climate in Germany.

According to the coalition agreement, tax breaks will be introduced for R&D, acting as an additional research incentive, in particular for small and medium-sized enterprises (SME). This is intended to strengthen research and development and therefore trigger long-term growth in Germany. However, this measure is dependent on sufficient funding being found.

Guidelines and standards ensure high quality, security and sustainability of products and services. They open up markets and create equal access conditions, especially for SMEs. Consequently, the Federal Government will integrate standardisation into research funding, in order to tap into these potentials.

When awarding public contracts, the Federal Government will increasingly take innovative aspects into account. Not only do innovative solutions promote administrative profitability, they also offer effective support for companies.

Almost twenty years after reunification, the structure of the innovation system in Eastern Germany is still significantly different in some areas from the structure in Western Germany. As a result, a targeted innovation policy and funding is still required in Eastern Germany. Successful instruments are being checked for possible nationwide use.

To ensure the future capability of Germany, the Federal Government will consolidate the skills base with a strong focus on education and training.

Dialogue on innovations

Research and innovation need dialogue with society and, specifically, the working world. In particular, with socially controversial future technologies, a factual debate and civil dialogue is necessary. Interdisciplinary cooperation between research in science, humanities, law and social science plays an important role here.

Future topics

Future developments require orientational knowledge. The Foresight Process, initiated by the BMBF in September 2007, examined new thematic options for the future and new horizons for trends in research and innovation over a period of more than ten years. The German Federal Ministry of Economics and Technology (BMWi) started a new dialogue process on future technology development to tap into new, value-added potential for the German economy. In addition, the government ministries are also developing research, development and innovation strategies for their areas of responsibility.

European innovation strategy

The successful approach of the High-Tech Strategy and its priorities should be taken into account in European research and innovation policy. It is a question of designing coherent innovation policy approaches. A European innovation strategy should be based on societal demand fields and global challenges. With this objective in mind, Germany is also actively participating in the development of the 8th European Framework Programme and the upcoming programme to strengthen competitiveness.

3 Dynamising education and science

Germany is a leading location for science, research and innovation. The three central and local government reform initiatives – the Higher Education Pact, the Excellence Initiative and the Joint Initiative for Research and Innovation – have prompted optimism and dynamism. They help to shape structure and profile in German universities and research institutions. ■ Infobox

Research institutions in Germany are closely linked to each other, as the recent appraisal by the Expert Commission on Research and Innovation shows. The Expert Commission's report is at odds with the previously held theory that the "pillarisation" of Germany's research landscape is hindering innovation.

In order to strengthen the economic potential of science in Germany further, central and local government have developed a clear agenda.

Continuing the reform initiatives

Plans for the next round of selection in the Excellence Initiative began on 4 June 2009 when a resolution was passed by the heads of central and local government. Based on a scientific selection process, the joint funding decision on continuation and new applications is planned for summer 2012.

If the Higher Education Pact is granted continuation, another 275 000 university places will be made available. Future students are assured of their university places, the federal *Länder* and universities can plan for twice the number of secondary school graduates and the required numbers of professors and other teachers will be employed in good time. Continued programme funding will also give the universities a new strategic freedom.

Central and local government together will improve the quality of lessons by implementing the recommendations made by the German Council of Science and Humanities (Wissenschaftsrat) to improve the quality of study courses and lessons. The Higher Education Pact receives another string to its bow. Central government offers local governments a joint quality pact on university tuition. These measures should enable, in particular, the deployment of additional human resources, such as professors, tutors and mentors for tuition, consulting and support. They contribute to a professionalising of tuition, to the development of a new teaching and learning culture and to a strengthening of institutional responsibility for the quality of study courses and tuition at universities.

The German Federal Government is committed to a transparent, user-friendly and efficient process of university admissions. As the result of an initiative by the Federal Minister for Education and Research, an understanding was reached at the beginning of 2009 between the federal *Länder* and universities on the development and use of a new dialogue-oriented service method.

The new method – planned to start in the winter semester 2011/2012 – will support the placement of university applicants at all universities. In the process, the autonomy of the universities in selecting applicants is not limited. The Federal Ministry of Education and Research (BMBF) is providing initial funding of 15 million euros.

With the continuation of the Joint Initiative for Research and Innovation, research in Germany can rely on financial planning security: grants to the partners of the initiative will increase by 5% annually from 2011 to 2015. Research and scientific organisations can expand their competitive instruments with scientific autonomy. The focus here is on further dynamising the scientific system, enhancing the performance of its networking activities, new strategies for international cooperation, long-term partnerships between industry and science, and acquiring the best people for research.

Scientific freedom initiative

The "Scientific Freedom Act" (Wissenschaftsfreiheitsgesetz) will considerably increase the attractiveness of Germany in international competition for scientific systems and innovation locations. Through the federal budget in 2009, phase I of the initiative would target improvements to the legal framework for research institutions in terms of budgets, personnel, partnerships, construction and procurement. The Federal Government will, as agreed in the coalition agreement, continue the scientific freedom initiative (phase II). The aim is to introduce global budgets for research institutions and to create appropriate framework conditions to acquire and keep highly qualified personnel, and to improve the long-term opportunities for business investments and start-ups.

Infobox

The three central and local government reform initiatives

The Excellence Initiative

- The Excellence Initiative has not only generated the desired profile-building effect in funded universities, its scientific approach and competitive procedure has also received a great deal of international attention.
- The 39 graduate universities, 34 of which are cooperating with non-university institutions, promote up-and-coming scientists and, in some cases, work together with different faculties and across various disciplines.
- Research of the highest international level is conducted in 37 Clusters of Excellence. They generally integrate at least two areas of expertise and cooperate with regional, national and international partners from science and industry.
- Nine universities will implement the successful concepts, intending to establish themselves among the top international institutions.
- Expanding the international network as an interdisciplinary and management duty plays an important role in all future concepts.
- To date, around 4 200 scientists have been recruited, 25% of them from abroad.

The Higher Education Pact

- Central and local government are offering demand-oriented study courses, thereby ensuring the quantitative expansion of higher education.
- Recent figures from the Federal Statistical Office show that, with 423 000 new students and a new student ratio of 43.3%, there was a record number of first-year students in Germany in 2009. The MINT professions have also benefited from this record.
- Universities focussing on research have further strengthened their strategic competence thanks to the introduction of programme funding. Experience has shown that universities use their newfound opportunities in different ways. They use the additional funding, for example, to develop innovative approaches and research fields, and implement them long-term.

The Joint Initiative for Research and Innovation

- The dynamic development in non-university research institutions is being reinforced and accelerated. The non-university research institutions Helmholtz Association of German Research Centres (HGF), Max Planck Society (MPG), Fraunhofer-Gesellschaft (FhG), Gottfried Wilhelm Leibniz Scientific Association (WGL) and German Research Foundation (DFG) can be used as funding organisations for university research to secure their long-term position among the world's best.
- The initiative is accompanied by unanimously agreed research policy objectives which are described in annual monitoring reports by the initiative partners and assessed by central and local government at the Joint Science Conference (GWK).
- As well as systematically identifying future-oriented areas of research at an early stage, the other key objectives of the initiative are to promote young talent, network across organisations, internationalise the transfer of knowledge and technology and establish long-term partnerships with industry. A number of key figures have been collected by the initiative partners on this. These figures have been included in the monitoring reports as part of a qualitative synopsis.

Bologna reform process

The federal *Länder* and universities have contributed to the implementation of new academic structures with a variety of resolutions and measures. The German Accreditation Council has also reviewed its regulations on the commencement and renewed accreditation of courses, and adjusted them in terms of feasibility of study. Additional efforts are needed to further develop the Bologna Reforms. In particular, there will be a focus on supporting students and strengthening tuition.

The Federal Government is extending its funding for mobility as part of a Bologna mobility package, which makes special allowances for tiered courses (among other things, more structured programmes for stays abroad, such as joint degree programmes and bachelor's degrees with a year abroad).

Advancement through education

The basic requirements for research and innovation are, as emphasised by the Expert Commission for Research and Innovation, a high quality education system that opens up advancement opportunities for everyone, and good initial and further training opportunities.

Consequently, the heads of central and local government decided to go beyond the 3% target agreed in the Lisbon Strategy for research and development and, in the “Advancement through Education” qualification initiative for Germany, agreed on 22 October 2008 that overall social investment in education and research should be increased to 10% of GDP by 2015. The first implementation report on the central and local government's qualification initiative makes clear that one year after the qualification summit, numerous measures have been put in motion and agreed initiatives have been given a kick-start. Interim results show that further implementation steps are necessary to achieve the common objectives.

At a meeting of the heads of central and local government on 16 December 2009, it was determined that, in order to reach this goal, the central government, the local governments, industry and private bodies will have to invest at least 13 billion more euros in education in 2015. By June 2010, central and local government will compile proposals as to how this gap can be closed. The Federal Government has agreed to cover 40% of the additional cost of financing the extra 13 billion euros.

The Federal Government will continue to promote the acceptance of bachelor degrees among employers. It is a chance for tiered study structures to facilitate diverse educational biographies and to close the gap between professional experience and academic education, and thereby improve the transparency between vocational and higher education.

Another contribution to ensuring the supply of skilled personnel and to improve permeability between vocational and academic education is the "Advancement through Education: open universities" (Aufstieg durch Bildung: offene Hochschulen) competition, adopted by central and local government. It supports life-long academic and employment-based learning. The aim is to set up and expand study courses, study modules and certificates as part of scientific learning (e.g. extra-occupational study courses, BA/MA courses for the professionally qualified, dual BA/MA study courses, tailored participant-oriented offers of scientific further training). Central government will provide funding of 250 million euros for the initiative between 2010 and 2018.

The Federal Government will further expand the "Advancement Grants" (Aufstiegsstipendien) programme. The programme, which has since provided funding for around 1,000 students, also promotes transparency between vocational and higher education.

Student financing

The three elements, BAföG (Federal Training Assistance Act), student loans and scholarships will secure student financing in Germany. The Federal Government has introduced the legislative process for a 23rd Act to Amend the Federal Training Assistance Act (BaföGÄndG) to secure and develop BAföG further. This would ensure an increase in the required income rates and income allowances as well as other structural improvements.

The proportion of scholarship holders should be increased from around two to ten percent in the medium term, with the aid of a national scholarship programme funded by central and local government, and private bodies. The scholarships will be financed by private funds obtained by the universities and by public funds. If the universities obtain a sum of at least 150 euros per month per scholarship from private funds, then central and local government will top up this amount by 75 euros per scholarship respectively. The scholarship is worth 300 euros per month. Both bills were adopted by the cabinet on 21 April 2010. They should be adopted before the parliamentary summer recess, so they can come into effect in the winter semester 2010/2011.

There are also plans to adjust the existing loan packages on offer to individuals for education funding to meet their needs in the various phases of educational development, and thereby take into account the importance of predictability and feasibility in repaying individual loans.

4 Internationalising research and innovation

With the ever-increasing advancement of global integration in science and industry, international partnerships in science and research are becoming increasingly important. Excellent science has always been global. Successful applied research institutions and companies are increasingly seeking partners to help supplement their own skills and expertise and to improve their own competitiveness. Leading locations in science and innovation excel as magnets and hubs for global knowledge.

Internationalisation strategy

The Federal Government's 2008 strategy to internationalise science and research puts the framework in place for identifying outstanding knowledge, successful structures and optimal processes on an international scale, and allows them to be utilised. The focus is on four priority objectives:

1. Enhancing research cooperation with the world's best
2. Opening up international innovation potential
3. Strengthening long-term cooperation with developing countries on education, research and development
4. Taking on international responsibility and overcoming global challenges

Three interdisciplinary measures complement these objectives: presence abroad, international monitoring and advertising for Germany as a study, research and innovation location.

With its internationalisation strategy, Germany has become a global pioneer. The EU is establishing a new structure for internationalising European science and research, with significant German participation.

Bilateral and multilateral cooperation

The focus of bilateral cooperation is on long-term exchange programmes and joint research projects. New approaches have been developed from the partnership between networks and clusters, as well as from greater involvement by small and medium-sized enterprises.

The Federal Government will intensify future cooperation with developing and emerging countries on education, science and research. Based on the principles of partnership, personal responsibility and demand-orientation, it is a question of searching for solutions to common issues together. At the same time, institutional and personnel capacities will be built up in partner countries in order to establish sustainable partnerships. In a partnership with developing and emerging countries, particular emphasis will be placed on applying the research results in the partner countries.

The decisive factor is a strong political and institutional dialogue with partners on an intergovernmental and scientific level, to identify jointly appropriate and adequate cooperation approaches.

Bilateral R&D partnerships with European countries – apart from the German-French cooperation – will be increasingly embedded in a multilateral and/or European context (e.g. EUREKA or COST).

In addition to partnerships within Europe, Germany will assume more global responsibility for research policy. To this end, Germany is strengthening multilateral initiatives with various research-policy players as part of the G8 and OECD, in particular, involving major emerging countries.

European Union

Since the Treaty of Lisbon came into force on 1 December 2009, the European Commission and the Member States are duty bound to make the European Research Area (ERA) a reality. Germany is actively contributing towards this objective. In addition to national research programmes, the 7th EU Framework Programme for Research, Development and Demonstration (2007-2013) is a key instrument for the European Research Area. It is now the world's largest R&D programme with 54.4 billion euros.[1]

The European Research Area will play a key role in the Lisbon Strategy to be revised in 2010. Based on the results of a public consultation process and intense discussions with stakeholders, the European Commission put forward specific proposals for the Europe 2020 Strategy. As a result, the European Heads of State and Government decided, at a European Council (EC) meeting in March 2010, to adopt the following fundamentals for the Europe 2020 Strategy:

The new strategy will focus on knowledge and innovation, and strengthening its orientation on economic sustainability,

1 Incl. Euratom.

high employment and social inclusion. The European Council has agreed the following five key objectives[Z] :

1. The conditions for research and development should be improved – particularly with the aim of achieving a total public and private investment volume of 3% of GDP in this area; the Commission will develop an indicator for R&D and innovation intensity.
2. The level of education should be improved, in particular, with the aim of reducing school dropout rates and increasing the proportion of the population that has completed a university degree or has an equivalent qualification.
3. The aim is to achieve an employment ratio of 75% among 20 to 64 year olds.
4. Greenhouse gas emissions should be reduced by 20% compared to 1990 levels, and by 30%[2] under certain conditions; the ratio of renewable energies to overall energy consumption should be increased to 20%, and efforts should be made to increase energy efficiency by 20%.
5. Social inclusion should be promoted, in particular, by reducing poverty.

In addition, the Commission is planning seven flagship initiatives to implement these goals. Research and innovation-relevant aspects can be found primarily in the first flagship initiative "Innovation Union", but also in the "A Digital Agenda for Europe" and "Resource Efficient Europe" flagship initiatives. According to agreements made by the European Council, the Commission will continue to develop the measures that they intend to adopt at EU level through the flagship initiatives, and submit them to the Council by October 2010.

Based on its experience with the High-Tech Strategy, the Federal Government will actively participate in shaping the Europe 2020 Strategy as an overall strategy for more sustainable growth and employment. The flagship initiative "Innovation Union" should contain the following elements: ensuring sufficient resources in the budget for research and innovation, achieving the 3% target contained in the Lisbon Strategy as a key innovation policy objective, focussing on major societal challenges, understanding all policy areas holistically as part of a coherent innovation policy, vertically integrating all political levels, and accompanying the implementation process with systematic, evidence-based monitoring.

The EU is heading in the right direction with its current debate on the Europe 2020 Strategy: education, research and innovation are the key to overcoming the key challenges of tomorrow. The Federal Government is contributing here with its innovation and research policies.

2 The EU has agreed to draw up a decision aiming at a 30% reduction by 2020 compared to the 1990 level – and as a conditional offer in respect of a global and comprehensive agreement for the period after 2012 – insofar as the other industrialised nations are obligated to a comparable reduction in emissions and the developing nations make a contribution that corresponds to their responsibilities and capabilities.

5 Policy advice on science, research and innovation

Against a background of dynamism in research and innovation policy, the need for orientational knowledge is growing. The Federal Government has created a suitable platform for this with a differentiated system of policy consulting for research and innovation. The spectrum ranges from government agencies involved in R&D and academies of sciences to permanent advisory committees and the numerous scientific advisory boards. In addition, an innovation dialogue between government, industry and science is to be set up by the Federal Chancellor.

Departmental research

Politics needs scientific advice on all spheres of activity. The government's departmental research serves to prepare, support and implement policy decisions. Departmental research develops courses of action for government measures and is inextricably linked to the performance of public functions. Departmental research occurs as part of in-house research, through continual cooperation with selected research institutions and by awarding R&D projects to third parties. Scientific expertise is also included through the scientific advisory boards, monitoring, peer reviews, expert systems and partnerships with other scientific institutions.

The range of R&D activities in which federal institutions are engaged is broad. They include typical activities such as dealing with scientific issues concerned with legally assigned tasks, providing science-based services to support legal tasks, accompanying and preparatory work related to the development and updating of legal regulations and standards, the operation and maintenance of national, international and supranational expert systems and of databases, as well as all forms of science-based monitoring networks. The intensive anchoring of practical applications within institutions also benefits general science and research. In order to continue creating future framework conditions for efficient departmental research, the Federal Government has developed a concept for modern departmental research (Konzept einer modernen Ressortforschung). It is currently being implemented specifically in all departments and institutions.

Academies of sciences

The German Academy of Sciences Leopoldina - National Academy of Sciences represents German scientists with one voice in international committees (international representation) and is also involved in providing science-based advice on research and innovation to society and politics. In this area, it cooperates with the German Academy of Science and Engineering (acatech e.V.), the Berlin-Brandenburg Academy of Sciences and Humanities (BBAW) and the federal *Länder* Academies, and incorporates their expertise.

The German Academy of Science and Engineering promotes dialogue between science, industry, politics and society. It also advises and informs politics and the general public about science-based and technology-related future issues.

Consulting on research and innovation

The independent Expert Commission on Research and Innovation provides the Federal Government with scientific policy advice on issues concerning research, innovation and technology policy. It combines interdisciplinary discussions on economic and social sciences, the economics of education, engineering and natural sciences, and technology perspectives as related to innovation research.

The Industry-Science Research Alliance (Forschungsunion Wirtschaft-Wissenschaft) will monitor implementation of the High-Tech Strategy. It advises and develops initiatives for its implementation. It constantly monitors developments in the demand fields, identified barriers to and drivers of innovation, as well as relevant interdisciplinary issues. The Research Alliance formulates future research tasks and identifies areas requiring action based on these developments.

Evaluation

The transparency of research and innovation funding is increased through comprehensible priority decisions and clear documentation of research foci and their financing. This will involve the systematic evaluation of the High-Tech Strategy's further development.

Part II Structures, resources and funding measures of the German research and innovation system

1 An overview of the German research and innovation system

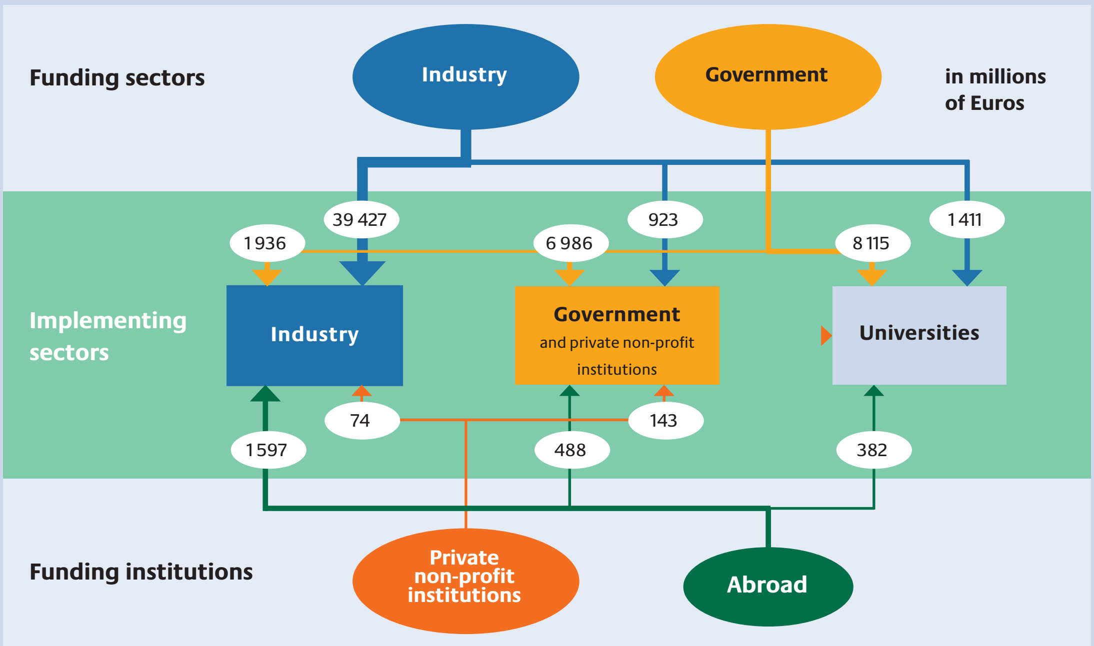
The achievement potential of German research has a long tradition and is reflected in an impressive series of prominent researchers. These include Carl Zeiss (1816-1888), Robert Koch (1843-1910), Conrad Röntgen (1845-1923), Max Planck (1858-1947), Albert Einstein (1879-1955), Otto Hahn (1879-1968) and Emmy Noether (1882-1935) and Hertha Sponer (1895-1968), to name but a few. Numerous Nobel Prizes – most recently for chemistry in 2007, for physics in 2007 and for medicine in 2008 – prove the high quality and excellence of German research. These research results gave and are giving rise to pioneering developments and new economic activities. Germany is an attractive and sought-after research location. The good R&D infrastructure and high qualification of R&D personnel in Germany is often highlighted in international surveys.

In order to maintain Germany's competitiveness, a differentiated research and innovation system, supported by several pillars, is needed. Consequently, the close integration of basic research with applied research and industrial developments is an essential condition for the ability to transform research results into innovations.

Figure 5 illustrates the complex relationships between the implementing and funding sectors.[1] ■ Figure 5

1 Private non-profit institutions: for national reporting purposes, this sector largely incorporates non-profit organisations funded by the state (e.g. HGF, MPG, FhG) and private, non-profit organisations that are financed neither by the state nor by private industry and/or do not provide services predominantly for industrial enterprises.

Fig. 5 Gross domestic expenditure on R&D by implementing and funding sectors 2007



Basis of data: table 1 – data for 2007

1.1 Where does research take place?

The German research and innovation system has a broad and differentiated structure. Research is conducted in a variety of public and private institutions. Figure 6 gives an overview of this. ■ Figure 6

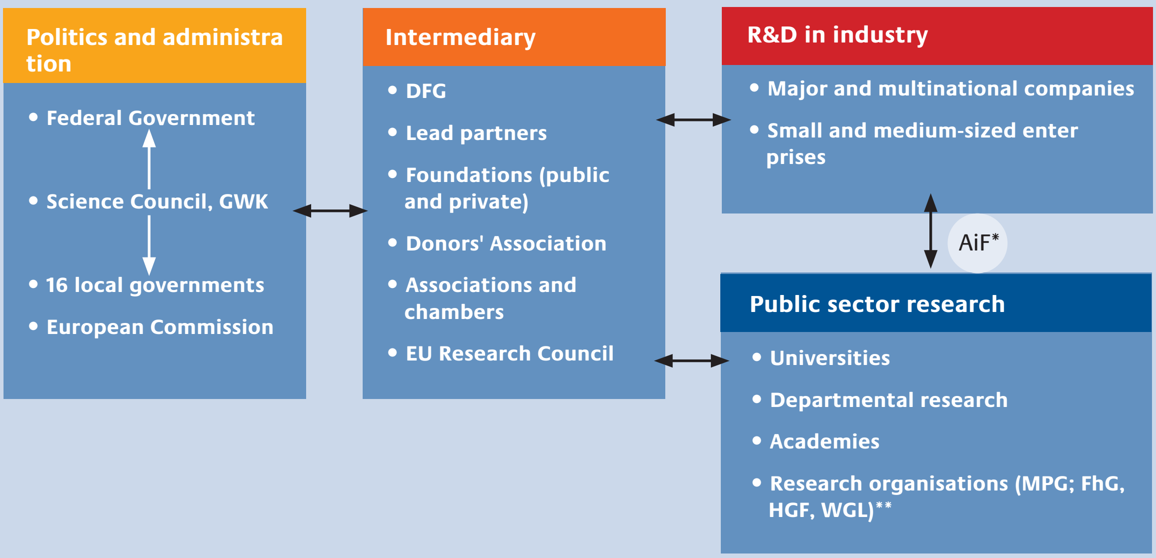
Public institutions, private non-profit institutions

Firstly, on the public side, there are the universities, colleges and universities of applied sciences. While university research is characterised by a broad subject matter and methodology, at universities of applied sciences, the focus is more on applied research. Another main task of the universities is to train young scientists.

In addition to academic research, there is a wide range of non-university research conducted at private non-profit institutions. In addition to the various academies and foundations etc., four research organisations with different profiles and focusses play a significant role. The Max Planck (MPG) institutes focus, in particular, on basic open research in innovative fields. The thematic emphasis here is on biomedicine and physicochemistry, as well as social sciences and humanities. The Fraunhofer-Gesellschaft (FhG) focuses more on applied research. Its institutes conduct research for industry, service providers and the public sector. The Helmholtz Association (HGF) comprises 16 scientific-technical and biomedical research centres that provide large appliances and the corresponding infrastructure for national and international research groups. In cooperation with university and non-university institutions, primarily the Leibniz Association, it conducts strategically oriented and programmatic top-level research in six areas: energy, earth and environment, health, key technologies, structure of matter, aeronautics and transport. At the 86 institutions of the Gottfried Wilhelm Leibniz Scientific Association (WGL), or Leibniz Association for short, the focus is on demand-oriented and interdisciplinary research. There are numerous cooperation agreements with companies, government agencies and universities.

Furthermore, there are central and local government research and development activities that serve to prepare and support policy and administrative decisions and are related to the performance of official duties. This departmental research focusses on current social, technological, economic and population health issues and develops courses of action for government measures. Departmental research is the responsibility of the individual central and local government ministries. In implementing departmental research, the respective ministries are supported by the federal agencies with R&D activities and R&D institutions, so that departmental research can be conducted in controlled and continuous cooperation.

Fig. 6 Stakeholders in the German research and innovation system



* Consortium of Industrial Research Associations
** MPG = Max-Planck Society, FhG = Fraunhofer-Gesellschaft, HGF = Helmholtz Association, WGL = Gottfried Wilhelm Leibniz Scientific Association
Source: VDI/VDE-IT

Industry

Industry is an important player in the German research landscape. More than two thirds of annual funding invested in research in Germany comes from the private sector. These funds will be spent both on the companies' own research as well as on joint projects with partners from science. The research conducted in this sector is very application-oriented in nature and is aimed directly at utilisable results. Basic research plays a minor role in this sector.

The diversity of the German research system has resulted partly from the federal structure and the size of the country. On the one hand, it provides a great deal of different research areas and, on the other, the ability to specialise. Another important factor for the success and achievement potential of German research is the willingness of different players to cooperate (e.g. by forming research alliances among non-university research institutions, universities and enterprises).

The complementary effect of private and public funding is not just the total amount of R&D funds available, but that it also leads to extensive entanglements in the financing (and implementation) of research projects. Such complementary and cooperative structures can be regarded as strong evidence of a sophisticated and diverse R&D landscape that unfolds its full potential in cooperation with the participants.

1.2 Who funds research?

The outlined sophistication and variety of the German research and innovation system are also reflected in its funding. For example, public institutions are not only financed by state funds, but also by external funds from industry. Private research, however, also receives some public funding. In addition, the Framework Research Programmes managed by the European Commission are also important for research in Germany.

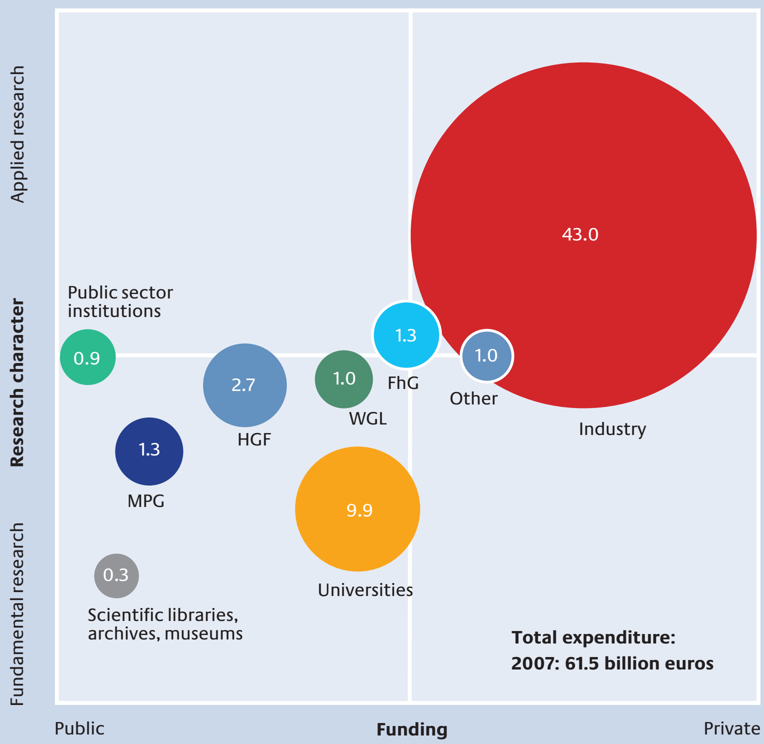
Overall, the proportion of expenditure on R&D in Germany remained at a constant 2.53% of GDP in 2007. Estimates by the BMBF for 2008 show a considerable increase in R&D expenditure to around 2.64% of GDP. In absolute terms, total expenditure (by industry and central and local government) on R&D between 2005 and 2007 increased from 55.7 billion euros per annum to 61.5 billion euros per annum, a rise of almost 10%. A further increase to over 65 billion euros is expected in 2008.

Stakeholders in German research funding

Figure 7 illustrates the character and funding of the German research landscape. ■ Figure 7

Fig. 7 The German research landscape

R&D expenditure in billions of euros (2007 data)



FhG	Fraunhofer-Gesellschaft
HGF	Hermann von Helmholtz Gemeinschaft
MPG	Max-Planck-Gesellschaft
Other	non-profit scientific institutions, predominantly funded neither by the state nor industry
WGL	Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz

Basis of data: tables 1 and 28
Source: BMBF, VDI/VDE-IT

Central and local government

The federal system in Germany gives both central and local government the opportunity to fund German research in their respective areas of responsibility, without having to enact special research funding laws.

Both central and local government act jointly in accordance with Article 91b of the Basic Law for the Federal Republic of Germany (Grundgesetz)) in funding institutions and scientific research projects of national importance. This reflects the shared responsibility of central and local government for research, which in many cases requires coordinated action meeting general government interests.

Central government's share of national expenditure on R&D increased from around 9 billion euros in 2005 to 10.9 billion euros in 2008. In 2009, central government expenditure on R&D increased further to 12.1 billion euros (target), R&D expenditure for 2010 should reach around 12.7 billion euros (excluding the economic stimulus package II). Also, additional funding is being provided for R&D as part of the economic stimulus package II for 2009 to 2011. So, for example, research may be supported in branches of industry that may not be directly related to technological or economic development, but that are in the interests of society, perhaps because they produce an impetus for applied research branches. In addition, young researchers are trained in the science system, its funding therefore becomes very important.

Industry

In 2008, internal R&D expenditure by industry totalled 46.1 billion euros in Germany (+7% compared to the previous year). Looking at the sector as a whole, there are some clear differences: around 38% of internal R&D expenditure by industry was invested in vehicle construction. Around 19% of funding for R&D was spent on electrical engineering. This was followed by the chemical industry with 14% and mechanical engineering with almost 11%.

In Germany, around two thirds of all gross domestic expenditure on research and development (R&D) is financed by industry. For 2007, the proportion of R&D activities funded by industry was 1.72% of GDP. In 2005 this amount was still 1.68% of GDP.

Industry is increasingly conducting R&D with partners from industry and science. In 2007, around one fifth of R&D expenditure went on external research projects (at other companies, universities, government research institutions etc). For comparison: in 1995, the proportion was one-tenth, in 2002 it was one sixth of R&D expenditure.

Two thirds of R&D expenditure on external companies still goes to German companies. Nearly one fifth of R&D contracts were awarded abroad, whereby companies in the chemical and pharmaceutical industries, in particular, exploited more R&D capacities abroad than domestically. About one tenth of external R&D expenditure by industry went on university institutions and university professors.

R&D funding organisations

A number of foundations in Germany have made valuable contributions to securing the quality of science and research. They supplement government funding and are an expression of the private sector's financial commitment to research. These donors are the perfect example of responsible commerce in a democratic state. In 2008, the Association of German Foundations funded a total of 1 020 start-ups from foundations.

The German Donors' Association for the Promotion of Sciences and Humanities (Stifterverband für die Deutsche Wissenschaft e.V.) is a joint initiative of the business community to promote German science and research. It supervises around 450 foundations and manages total assets of 2 billion euros. There are also other major German foundations – such as The Robert Bosch Stiftung, the Volkswagen Foundation, the Deutsche Bundesstiftung Umwelt, the Klaus Tschira Foundation, the Bertelsmann Foundation or the German Foundation for Peace Research – that fund projects and/or institutions from various fields of science. From 2001 to 2008, around 30% of foundations were set up in the areas of science, research, education and upbringing.

The twelve scholarship programmes for gifted students, financed mainly from government funds, have a special place in the German foundation landscape with their scholarship funding for undergraduate and doctoral students. The pluralism of our society is reflected in the variety of sponsors. The scholarship programmes have a responsibility to both individual talent and to our liberal, democratic society as a whole, which would not survive without a functioning elite.

European Union

The Framework Research Programmes managed by the European Commission are playing an increasingly important role in the structure of R&D funding. Besides the considerable financial importance of EU funding for the various specialist areas, the European Research Programmes also contribute significantly to the networking of science and research in Europe. In doing so, they are making an important contribution to the development of a European Research Area and focus the world's gaze on the European research landscape. The 7th Framework Research Programme, with a budget of about 54 billion euros for the period 2007 to 2013, has a substantially larger budget than the previous programme and will concentrate primarily on the continuity of content and tools. However, the European Research Council (ERC) has established a new, independent and result-driven funding structure for research, which supports a new kind of basic research (pioneering research) among European countries, and is based solely on excellence as the decisive factor in selecting projects.

In addition, COST (European Cooperation in Science and Technology) and EUREKA (initiative for greater technological cooperation in Europe) are two cooperation mechanisms that provide a framework for cooperation among research institutions and companies in Europe without any direct project funding. Driven exclusively by the interests of science and industry, these cooperation systems represent an outstanding addition to the European Framework Programme in variable geometry. The cooperation between EUREKA and the European Commission has continued successfully and is being further intensified through the Eurostars joint funding programme. Eurostars is an R&D programme under Article 169 of the EC Treaty (Article 185 TFEU), that focuses on small and medium-sized enterprises conducting research. In the period from 2008 to 2013, around 300 million euros will be available to participating countries. The European Commission will top up this amount by a further 100 million euros.

The EU education programme, Lifelong Learning, with a total volume of around 7 billion euros for the period 2007 to 2013 envisages comprehensive exchange measures and, in particular, transnational projects to improve the quality of education systems. It will also support transnational networks in university and vocational training research.

1.3 How does government research and innovation funding work?

Functioning government research and innovation funding requires several pillars. The legal foundation is established in the German Basic Law. Central and local government work together on government research funding, based on the legal framework in place. Central and local government have several instruments at their disposal to facilitate targeted research funding: project funding, institutional funding and financing departmental research.

Legal basis

The funding of research is a shared responsibility between government and society. Internationally competitive research and the constitutionally guaranteed freedom of scientists (German Basic Law, Article 5, paragraphs [3]) require the appropriate financial frameworks. The areas of funding for which central and local government are responsible are anchored in the German Basic Law.

The central constitutional provision for jointly funding science and research by central and local government is contained in Article 91b of the German Basic Law. Under this provision, central and local government may, due to agreements in cases of cross-regional importance, cooperate in the funding of:

1. Institutions (e.g. MPG, WGL, DFG, FhG, HGF) and scientific research projects not conducted by universities
2. Science and research projects at universities
3. Research buildings at universities, including large-scale equipment

Furthermore, central government also has responsibility for the funding of large-scale scientific projects (e.g. aviation, space, marine and nuclear research) and international research institutions. In addition, central and local government are responsible for performing their official duties and consulting on policy and administrative decisions (departmental research).

Interaction of central and local government

In accordance with the constitutional requirements of the Federal Republic of Germany, central and local government cooperate on institutional state research funding. In doing so, not only are research and science ministries at both central and local government level involved, so too are other departments (e.g. economy, agriculture and consumer protection, environment and health).

The Joint Science Conference (GWK) provides a forum for exchanging ideas and coordinating science and research policy. Furthermore, the GWK also serves to enhance joint cooperation on the funding of research organisations and projects of cross-regional importance (e.g. the Excellence Initiative and the Higher Education Pact).

The Science Council (WR), which is composed of scientists, public figures and central and local government representatives, also advises central and local governments on science policy and makes recommendations. The Science Council assumes a dual role as mediator between science and politics and between central and local government.

Government funding instruments

Central government funds research and development with target-oriented, short to medium-term research funding (project funding) and with medium to long-term institutional funding.

Project funding

Project funding – in particular from the Federal Ministry of Education and Research (BMBF), the Federal Ministry of Economics and Technology (BMWi), the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV), the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Federal Ministry of Health (BMG) – is implemented in the context of funding or specialist programmes, and based on an application for a temporary project.

Direct project funding refers to a specific field of research in each case. The aim is to achieve or secure a high performance level of research and development on an international scale in selected areas.

The aim of indirect project funding is to support research institutions and companies – in particular, small and medium-sized enterprises – in their R&D activities. The funding is directed not at a particular subject area, but is guaranteed for any technology project, irrespective of the particular technology field. For example, it is aimed at developing and strengthening research infrastructure, research partnerships, innovative networks and exchanges of personnel between research institutions and industry.

In addition to providing funding for individual projects, it may also finance joint projects with several equal partners.

Project funding in departmental research is primarily application-oriented and addresses current scientific issues important for the department. Project funding by central government is implemented according to legal and policy framework conditions that are determined at European and national level. At European level, the European Commission's Community framework plays a crucial role in government subsidies for research, development and innovation.

The national framework conditions are determined in the German Federal Budget Code (Bundeshaushaltsordnung) and the German Federal Budget Law (Bundeshaushaltsgesetz). The funded projects are scientifically, technically and administratively managed by lead partners, who are commissioned to advise applicants, prepare funding decisions, process the projects and monitor their success (including utilising the results).

Institutional funding

Institutional funding does not refer to individual research projects but to the investments and overall operation of research institutions funded over a longer period by central government or jointly with local government. As a result, the competence and strategic orientation of the German research landscape are secured. Important examples of this are subsidies paid out by central and local government as part of joint research funding, in accordance with Article 91b of the German Basic Law.

The flexibility of the institutions jointly funded by central and local government, in accordance with Article 91b of the German Basic Law, to reassign their priorities in terms of scope and specialist orientation, should not be hindered by the agreement procedures of public funding bodies.

Institutional funding is associated with demanding requirements and corresponding accountability. Where no specific guidelines exist for utilising results, the general requirement for activity reports on the past budgetary or financial year to be completed by the funded institution allow the utilisation of results to be monitored.

Departmental research (including contract research)

As part of federal administration, the institutional core of departmental research lies with the institutions with departmental research functions that are allocated to the portfolio of a certain federal ministry and are financed by them. These institutions conduct research work themselves and/or they award research contracts (contract research).

2 Central government's research and innovation policy

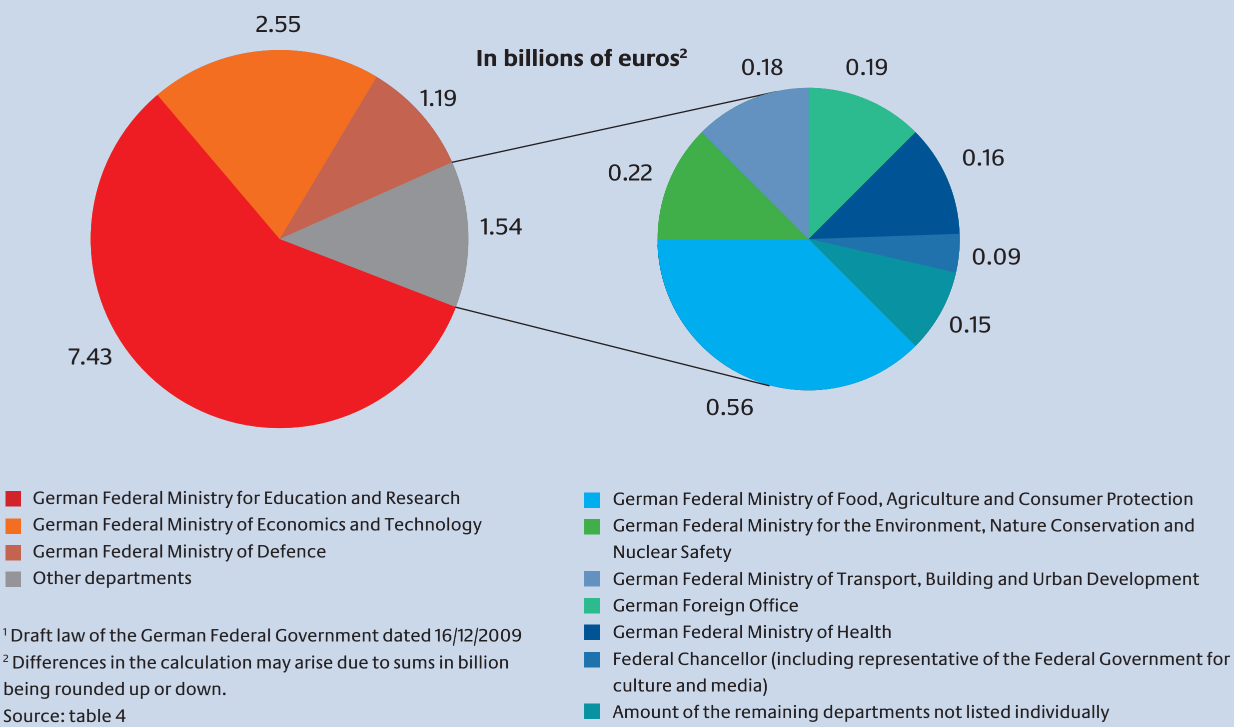
The activities of the Federal Government make up the majority of public expenditure on research, development and innovation in Germany. By its actions, the Federal Government contributes long-term to an efficient infrastructure for research and development (R&D), to training scientists, implementing research and development and therefore to generating innovations.

The "High-Tech Strategy for Germany" (HTS), adopted in August 2006, is an innovation strategy that consolidates and further develops existing scientific-technical competences. The aim of the High-Tech Strategy is to make Germany a pioneering force in solving global challenges. The various measures in the five demand fields of the High-Tech Strategy, health/nutrition, climate/energy, mobility, communication and security are complemented by supporting initiatives and programmes in key technological areas, and by taking account of interdisciplinary topics (e.g. young scientific talent).

The Federal Government's funding of research and innovation extends far beyond the activities of the High-Tech Strategy and include numerous socially important funding activities, such as research in education or the humanities. Apart from the various research areas, the Federal Government funds R&D infrastructures, interdisciplinary measures, and small and medium-sized enterprises with specially tailored measures.

The central government's research and innovation policy includes the demand field, **health and nutrition**, in the areas of *health and medical technology as well as research and development for nutrition, agriculture and consumer protection.*

Fig. 8 Expenditure of the Federal Government on science, research and development by department 2010 (target[1])



[1] Draft law of the German Federal Government dated 16/12/2009
[2] Differences in the calculation may arise due to sums in billion being rounded up or down.
Source: table 4

Measures for the demand field **climate and energy** are focussed on six funding priorities: *climate, environment, sustainability* and *energy research and energy technology* as well as *spatial planning and urban development*.

Activities relating to *vehicle and transport technologies, including maritime technologies, and relating to mobility and transport research* are listed in the **mobility** demand field.

Funding measures in the demand field of *communication* are represented by the key research priority, **information and communication technologies.**

The demand field, **security**, incorporates *civil security research* and *peace and conflict research*.

Activities in the service sector and in the areas of *biotechnology, nanotechnology and materials technology, optical technology, production systems and technologies, aerospace* and *research on improving working conditions* are listed under the demand field of **key technologies**.

Other research priorities in German research and innovation funding include *research into innovations in education, humanities, economics and social sciences.*

A powerful and dynamic science system is an important prerequisite for providing convincing answers to the pressing issues of the 21st century. To this end, both central and local government are therefore making an important contribution with the *Higher Education Pact*, the *Excellence Initiative* and the *Joint Initiative for Research and Innovation*. In addition to these issues, the **institutional infrastructures**, such as *basic financing of the funding organisations, funding of the federal institutions with R&D tasks*, **large-scale facilities** and **interdisciplinary measures**, are of great importance.

One particular focus of central government's research and innovation policy is on **innovative SMEs**, for which special research funding measures have been developed to assist small and medium-sized companies in Germany.

In 2010, central government expenditure on research and development should amount to 12.7 billion euros (target). Of central government's total expenditure, 88% goes to the BMWi, the BMVg and the BMBF collectively, the remaining 12% goes to the other departments. ■ **Figure 8**

3 Research and innovation policies of the federal *Länder*

The federal structure of the Federal Republic of Germany makes it possible for the regional capabilities, resources and infrastructure of the 16 *Länder* to be developed and utilised taking into account the individual circumstances. In addition to the activities of the Federal Republic, the 16 *Länder* implement a variety of state-specific research, technology and innovation policy funding measures. In doing so, the specific strengths of the individual regions in terms of technology, industry and innovation are addressed and existing spatial structures and characteristics taken into account. These state-specific funding measures complement the overall measures in place. As a result, the federal *Länder* can have funding measures in the same technology context, but with differences in the emphasis. These different regional research and innovation funding measures are critical to strengthening the German research and innovation system as a whole.

State expenditure varies on research and development (in the subject areas mentioned above and others). The figure left provides an overview of the regional breakdown. ■ Figure 9

Local government measures are characterised by the following key areas:

Baden-Wuerttemberg

- Securing a very well differentiated and internationally competitive higher education and research infrastructure
- Forming key priorities and profiles with a focus on scientific excellence and targeted funding for young scientists
- Strengthening knowledge and technology transfer: networking science and industry, as well as supporting start-up companies (particularly high-tech)

The Free State of Bavaria

- Financing and supporting basic research in its broadness and diversity whilst simultaneously intensifying the acquisition of third-party funding
- Creating a differentiated and efficient network between university research, non-university research and departmental research
- Fast and sustainable implementation of research results in cooperation with industry, in particular also SMEs

Berlin

- Health management
- Communication, media and cultural industries
- Mobility and transport

Brandenburg

- Research on key technologies (i.a. materials research, medical technology, microelectronics)
- Life sciences and biotechnology
- Geo, climate and climate-related research

The Free Hanseatic City of Bremen

- Globally visible, excellent maritime, polar and climate research (including maritime technology) with unique position
- High level of interdisciplinary cooperation and broad range of application fields in material sciences focussing on “intelligent materials”
- Strong focus on information and communication technologies in the field of mobile solution, in robotics (mobile autonomous systems) and logistics/e-logistics

The Free and Hanseatic City of Hamburg

- Combining growth with sustainability and sense of responsibility in long-term development strategy, the Hamburg principle: growth with foresight (Leitbild Hamburg: Wachsen mit Weitsicht), which is targeted at competence clusters from science, industry and research networks
- Own state initiatives on research funding with the state Excellence Initiative and the Hamburg science and research foundation (Wissenschafts- und Forschungsstiftung Hamburg)
- Depillarising the science system: new forms of cooperation have been created, such as the KlimaCampus Hamburg, the Centre for Free Electron Laser Science and new agreements between the University of Hamburg and the DESY Hemlholtz Centre

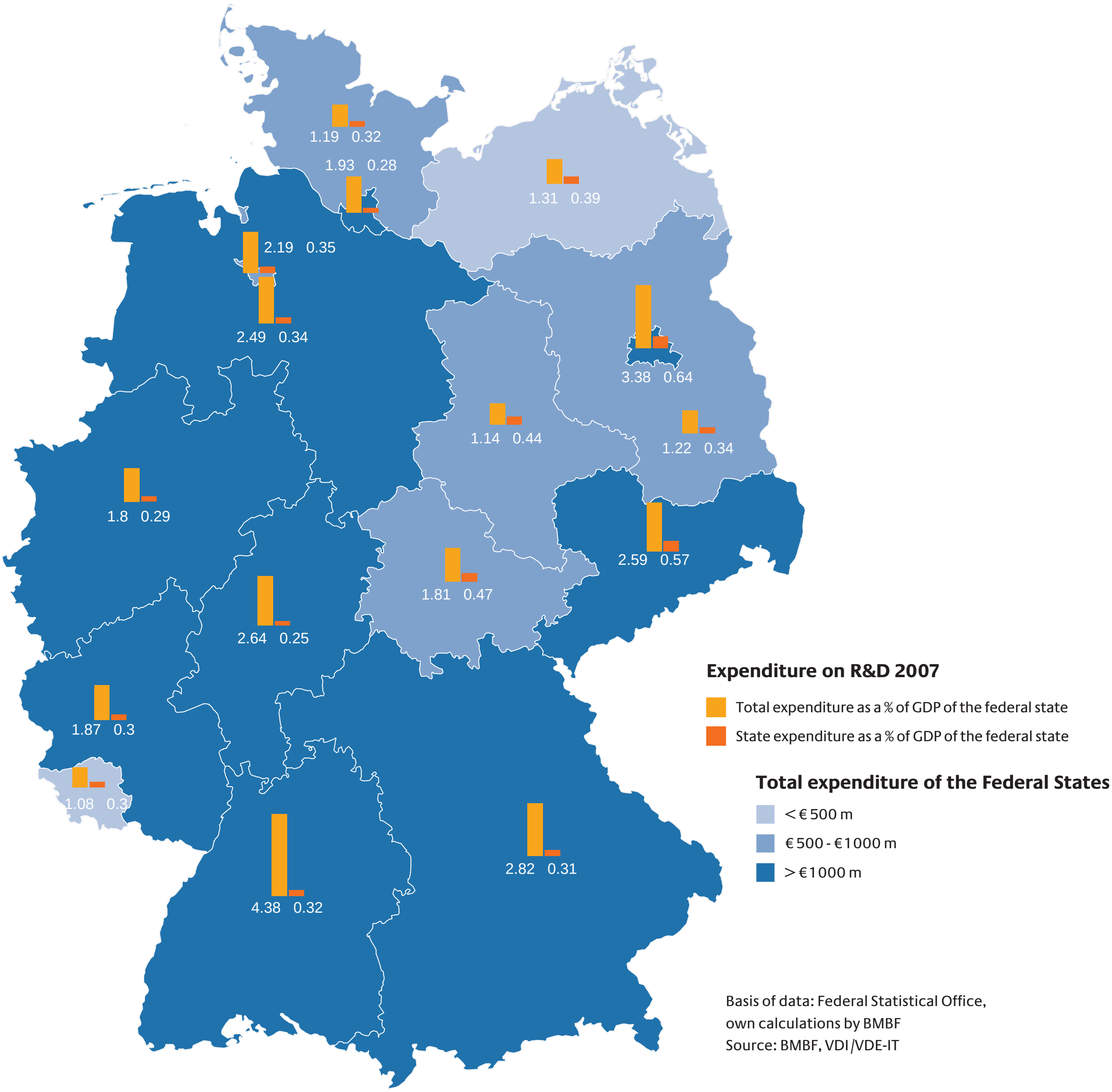
Hesse

- Life sciences and medicine: two clusters of excellence, six LOEWE key priorities and two LOEWE centres
- ICT: LOEWE centre, a graduate school and, in future, a new high-performance computer in Darmstadt and a LOEWE key priority in Kassel
- Humanities and social sciences: Giessen graduate school, cluster of excellence and a LOEWE centre in Frankfurt, as well as two LOEWE key priorities in Giessen and Darmstadt

Mecklenburg-Western Pomerania

- Plasma physics with the Wendelstein nuclear fusion experiment initiative 7X and research in the field of low temperature plasma physics in Greifswald
- Catalysis research
- Life sciences

Fig. 9 **Expenditure of the federal *Länder* on research and development in 2007**



Basis of data: Federal Statistical Office, own calculations by BMBF
Source: BMBF, VDI/VDE-IT

Lower Saxony

- Energy research focussing on renewable energies (solar, wind, biomass and geothermal energy) in close cooperation with grid integration and grid structure (decentralised energy systems)
- Life sciences in the Hanover/Brunswick/Göttingen medical triangle with core competences of neuroscience, translational research, medical technology and regenerative medicine
- Mobility of the future in close cooperation with the engineering science faculties, particularly in the fields of production technology, vehicle technology, new materials, IT and aviation

North Rhine-Westphalia

- Targeted research and technology funding focuses primarily on the key areas of energy, materials research and life sciences including medical research and medical technology
- The interdisciplinary technologies of micro, nano and biotechnology are the core drivers of innovations in numerous sectors
- Competition for highly remunerative funding and cooperation between science and industry in nationwide clusters have been crucial impetuses

Rhineland-Palatinate

- Materials sciences – ideas for the future
- Information technologies – direct knowledge and connecting people
- Biomedicine – the innovative research area on the interface of experimental medicine and biology

Saarland

- Strengthening knowledge and technology transfer through partnerships between science and industry in so-called clusters focuses primarily on the areas of nanotechnology, biotechnology, materials research, computer science (particularly software development and artificial intelligence), automotive and mechatronics, as well as medical research and medical/laboratory technology
- Innovation drivers are interdisciplinary technologies, for example between automotive, IT and energy (“car of the future”) disciplines/sectors and establishing new products and procedures in cooperation with science and industry
- Fast and continual implementation of research results in cooperation with industry, in particular also SMEs and high-tech start-ups

The Free State of Saxony

- Developing strengths in publicly funded research, in particular in the areas of biotechnologies/microtechnologies/nanotechnologies and materials sciences
- Expanding strategically important energy technologies including regenerative energies, sustainable use of fossil energy raw materials, energy efficiency
- Health research, neurosciences

Saxony-Anhalt

- Strengthening key research priorities that were created in the state Excellence Initiative in 2004, in particular in the areas of neurosciences, materials sciences and nanotechnology, biosciences, engineering sciences, educational advertising (also in respect of the anniversary of the Reformation in 2017)
- Strengthening research and development at universities of applied sciences, in particular in the areas of life sciences, regenerative raw materials, information and communication technology, chemistry and plastics
- Application-oriented research and development in the areas of automotives, photovoltaics and other areas of regenerative energies

Schleswig-Holstein

- Marine sciences including marine and coastal research, climate research and application-oriented research for the marine industry
- Life sciences, including medical research, biotech research and medical technology in basic and application-oriented research
- Nano and surface research are the new sustainable fields of research that are currently being expanded significantly

Thuringia

- Optics, photonics and photonic technologies, their application in laser physics and medical technology
- Macrotechnologies and nanotechnologies, and their application in organic and inorganic areas in connection with the development of innovative materials
- Dynamics of complex biological systems (studying global material cycles, biomedicine and biotechnology, gerontology)

4 International cooperation on research and innovation

Science and research make an important contribution to overcoming major global challenges. In view of the ever more rapidly progressing international cooperation in many areas of society, international collaboration in science and research is becoming increasingly important. The objectives of the German Federal Government in research and innovation policy, in conjunction with the European intention of becoming the most competitive knowledge-based macroeconomy worldwide, require that we avail ourselves of the opportunities of growing internationalisation to a greater extent. The Federal Government has reacted to these challenges with its strategy to internationalise science and research. In conjunction with the *High-Tech Strategy, the Joint Initiative for Research and Innovation* and the *Excellence Initiative,* the internationalisation strategy is a key element of German research policy.

Bilateral cooperation with important partner countries around the world is the focus of international research partnerships for Germany. This reveals German research policy particularly clearly and applies in particular to countries with strong development dynamics and important future markets, it is also strategically important with regard to attractive scientific and technology resources. Bilateral cooperation generally occurs as part of *Scientific and Technological Cooperation (Wissenschaftlich-Technologische Zusammenarbeit, WTZ)*, which prioritises long-term exchange programmes and joint research projects. New approaches have been developed from the partnership between networks and clusters, as well as from greater involvement of small and medium-sized enterprises (SME) in technological cooperations.

At a European level, Germany is actively involved in establishing the European Research Area (ERA). For example, the BMBF supports the excellence and efficiency efforts in European research and innovation. In addition to national research programmes, the 7th EU Framework Programme for Research, Development and Demonstration (Framework Research Programme) is now the largest programme in this area worldwide. To enable them to make full use of the opportunities of this programme, a wide range of advisory services is available to German applicants. The German Federal Government contributes to the Framework Research Programme in the network of National Contact Points (NCPs). European intergovernmental initiatives such as EUREKA and COST also offer an open framework for research and development in applied sciences. European research organisations such as CERN form the institutional basis for research in Europe.

Germany aims to take on greater responsibility for research policy to contribute to overcoming global challenges such as climate change, scarcity of energy resources and the spread of infectious diseases. This requires multilateral initiatives by the various parties involved in research policy and inclusion of the major emerging countries. As part of G8 and OECD, BMBF pursues the objective of improving multilateral cooperation and management of research policy.

4.1 The strategy to internationalise science and research

In conjunction with the *High-Tech Strategy,* the *Joint Initiative for Research and Innovation,* the *Higher Education Pact* and the *Excellence Initiative,* the German Federal Government's strategy for internationalising science and research is a key element of its research and development policy (R&D policy). Under the leadership of BMBF and in coordination with the federal *Länder* and the fields of science and industry, these strategies and initiatives complement one another and combine to increase the effectiveness of the measures taken. The implementation of the internationalisation strategy is the responsibility of all parties in the research landscape, as internationalisation is a key strategic element of their new mea-sures. An initial interim report to the Cabinet on the implementation status of the strategy was drafted in July 2009.

The conditions for successful implementation of the internationalisation strategy are good. Germany has become more attractive on a global scale as a result of continuous increases in subsidies for research and development. The expansion of international alliances within the BMBF programme-specific funding areas is also successful: BMBF's expenditure on international activities almost doubled between 2006 (185 million euros) and 2009 (target: 360 million euros). Contributions to international organisations and European research institutions also increased slightly in the same period (from 237 million euros in 2006 to 247 million euros in 2009). As part of its *Connecting Worlds of Knowledge initiative*, the Foreign Office (AA) increased its expenditure for international science exchanges from 190 million euros to 233 million euros in 2009. In the Federal Ministry for Economic Cooperation and Development (BMZ), the *departmental research strategy (BMZ research strategy)* will continue the development-policy related fundamental orientation of the internationalisation strategy. The expansion of internationalisation is also an important area for action as part of the *Joint Initiative for Research and Innovation*. In return for the increase in annual expenditure of at least 5% per annum until 2010, the research organisations (Fraunhofer-Gesellschaft FhG, Helmholtz Association HGF, Max-Planck Society MPG, Leibniz Scientific Association WGL and the German Research Foundation DFG as a research funding organisation) undertook to increase the quality, efficiency and competitiveness of their respective R&D activities. The Joint Initiative for Research and Innovation allowed the German science organisations to increase their international activities signific.

Enhancing research cooperation with the world's best

German researchers are to cooperate more closely with the most innovative scientists. At the same time, Germany is to become the first port of call for the best researchers and students from around the world. The research residence permit created to implement the EU Researcher Directive has already reduced the bureaucracy involved in obtaining residence and employment permits significantly. As of 1 January 2009, access to the labour market for family members has also been simplified to increase Germany's attractiveness further. Academic exchange organisations, such as the German Academic Exchange Service (DAAD) and the Alexander von Humboldt Foundation have expanded their subsidy services with funds from the AA, BMBF and BMZ: mobility and internationalisation of the German research landscape remain basic foundations of the cooperation with excellent institutes and researchers. The Alexander von Humboldt Professorship – at 5 million euros the best-endowed international research award in Germany – and the continuation of the Sofja Kovalevskaja Award, support excellent academics working abroad in bringing their research and teaching work to German universities. The presence of German universities abroad is growing via the establishment of new institutes and the expansion of the DAAD German Universities Abroad programme. Also, centres of excellence in research and teaching are being set up abroad with the collaboration of German universities, the first of which will be in four locations in Chile, Columbia, Russia and Thailand.

Opening up international innovation potentials

Companies, research institutes and universities are supported in opening up international innovation potentials to better position themselves in global competition. This includes in particular promoting internationalisation of clusters and networks, as well as innovative small and medium-sized enterprises. For this purpose, an interdisciplinary working group with representatives of BMBF, the Federal Ministry of Economics and Technology (BMWi) and the industrial associations was set up in 2008 to develop a framework concept for suitable measures to support the internationalisation of German innovation clusters. As a result, BMBF supported a competition for establishing contact between German economic and scientific networks and foreign networks and clusters, which will support twelve German networks in establishing cooperation projects with partner clusters in six target countries by the beginning of 2010.

The BMBF *Leading Edge Cluster competition* launched in 2007 supports high-performance clusters on their way to joining the international leaders. Among other things, the selected clusters are to increase their attractiveness via international cooperation. The BMWi *Kompetenznetze Deutschland – networking for innovation initiative* – unites over 100 of the best innovation clusters from nine innovative areas and supports the development of clusters that are also renowned outside Germany. Since May 2009, BMWi has also supported the establishment of international technological cooperation projects of medium-sized enterprises with partners from economically and technically significant countries outside the EU by arranging cooperation events in the respective target countries.

Strengthening long-term cooperation with developing countries on education, research and development

The internationalisation strategy will add a new quality to the cooperation with developing countries in education, science and research by building on the key areas of vocational training, tertiary education, science and research. At the same time, cooperation will develop capacities in the developing countries. This allows German educational, scientific and research institutes to network with partners in developing countries, which will provide a solid basis for solving important global challenges together. The choice of instruments and cooperation areas focuses on the needs of the partners in the respective countries and regions. Coordination and integration of the activities of the various players in Germany and the partner countries, and involving them in multilateral processes are particularly important for this.

Taking on international responsibility and overcoming global challenges

Germany wants to contribute to solving the global climate, resource, health, security and migration challenges with its research and innovation. In this way, the Federal Government not only wants to back up its scientific policy, but also its foreign and development policy goals. In addition to direct scientific solutions to problems, the research policy and administrative framework conditions are to be improved for increased international collaboration on these global challenges. International responsibility for overcoming global challenges scientifically supports the implementation of legitimate German interests: Germany is also affected by global risks (climate change, epidemics, scarce resources), but relevant research subjects (biodiversity, mineral deposits) are in other countries – global application of research results offers major export opportunities for the German economy.

In the years to come, BMBF intends to improve the framework conditions of multilateral research cooperation and use Europe to assert its interests on a global scale. Within the framework of G8 and G20, the German Federal Government initiates and supports cooperation in research and technology. After the Lisbon Treaty came into effect, BMBF decided to use the European level for these political approaches to a greater extent. On taking over the presidency of the Strategic Forum for International Cooperation (SFIC), Germany has shown that international R&D cooperation on global challenges must by increasingly coordinated at a European level in addition to a strong national basis. In close cooperation with BMWi, BMBF is continuing its work in the OECD science committee and other research policy committees of the Organisation for Economic Cooperation and Development. The Global Science Forum (GSF) draws up recommendations on fundamental goals for international research, including research infrastructure with the participation of German government and scientific representatives.

4.2 Interdisciplinary measures

Presence abroad

The government's scientific advisors play a key role in communications between Germany and the respective partner countries, and in reporting from them. In order to guarantee and improve a united image of all institutions abroad involved in science, research and innovation, AA, BMBF, the presidents of the research and exchange organisations and the German Chamber of Industry and Commerce (DIHK) agreed to establish German Houses of Science and Innovation (DWIH). DWIH are planned for Moscow, New Delhi, New York, Sao Paulo and Tokyo.

International monitoring

The objective of international monitoring is to provide the German research landscape with relevant national and international information and analyses for international R&D cooperation. This is intended to allow the opportunities of international cooperations to be used more easily and effectively, both to improve academic excellence and develop markets for German research-intensive companies.

Advertising Germany as a destination for studying, research and innovation

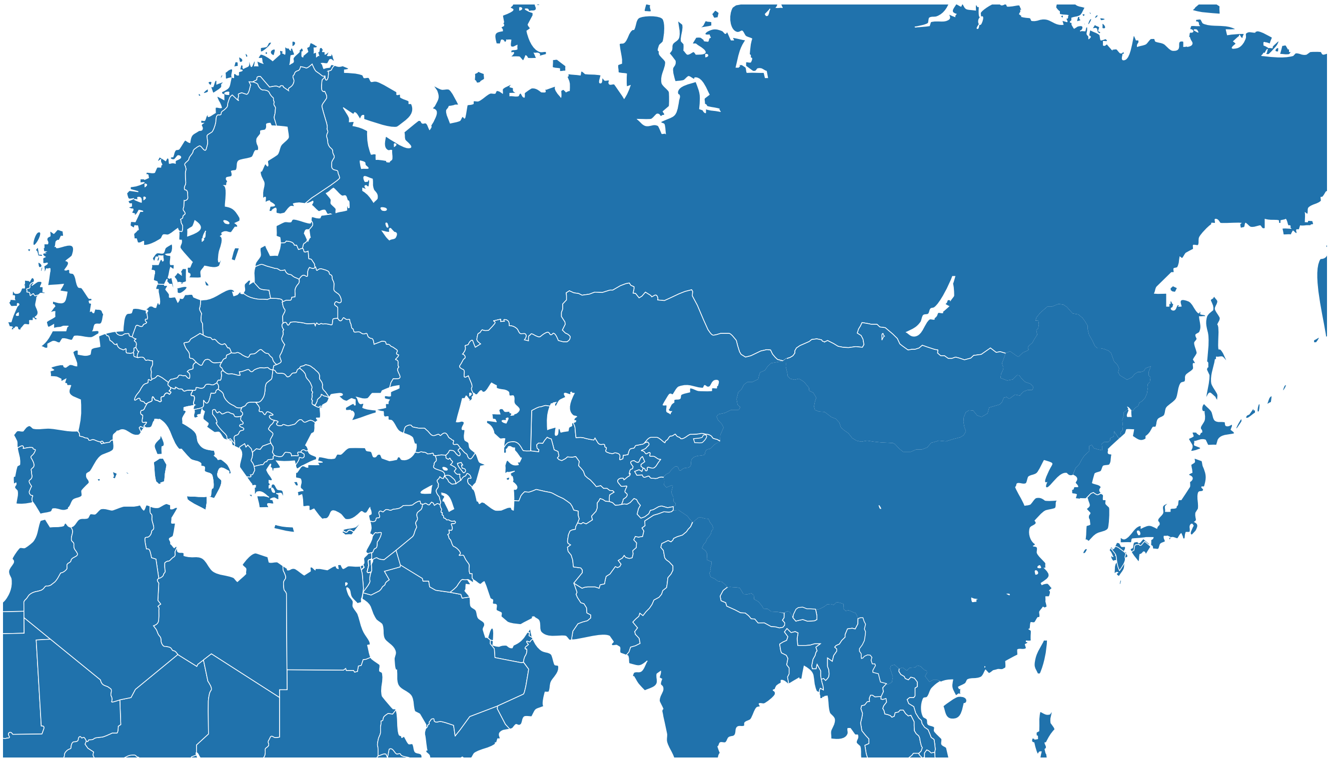
The fields of science, research and innovation have advertised abroad under the brand *Research in Germany – Land of Ideas* since 2006. The new *Study in Germany* campaign will establish a second foundation for destination marketing, targeted specifically at foreign students. In order to increase the effectiveness of the measures, campaigns focusing on specific subjects and countries will be implemented, each for a period of approximately one and a half years. The subject-specific approach will be non-country-specific and the country-specific approach will be non-subject-specific. The www.resesearch-in-germany.de Internet portal will offer foreign target markets in science and research a central information resource on Germany as a research destination.

4.3 Bilateral cooperation

Cooperation with European countries

Cooperation with European countries is crucial for Germany. Bilateral cooperation largely occurs within a multilateral framework. Coordination processes and the creation of synergies between projects and partners enhance the cooperation and strengthen partnership relationships. Joint initiatives and the identification of areas of mutual interest boost the development of European strategy and also actively build the European Research Area. Key cooperation objectives include coordination of joint measures for the establishment and expansion of international research alliances and putting in place framework conditions that support the players in their strategic orientation in international competition. These activities are aimed at implementing the internationalisation strategy of the German Federal Government in Europe, cooperating in research with the best in the world and utilising international innovation potential.

The *International Cooperation in Education and Research – Central, Eastern and South Eastern Region programme*, with which BMBF supports establishing projects in national and European funding programmes, also pursues this goal. Together with five countries from central and eastern Europe, Poland, the Czech Republic, Hungary, Romania and Bulgaria, Germany entered into a dialogue on sustainability research in 2007, which was strengthened as part of the BMBF Sustainability Forum in 2008.



Cooperation with the Community of Independent States

Cooperation with the countries in the Community of Independent States (CIS) – the former Soviet Union – plays an important role in the implementation of the German Federal Government's internationalisation strategy. It is based on traditional scientific strengths which, at least in some countries, involves the strategic expansion of scientific potential, growing market potential close to the EU and the strategic importance of the region in solving global problems, in particular with regard to climate change and guaranteeing the supply of energy. It builds on the traditionally close relationships between scientific organisations, universities and innovative companies from Germany and the partner countries. Moreover, the cooperation will also be driven by the close partnership between the EU and this region as part of the European Neighbourhood concept, the Europe's new Eastern Partnership, the Central Asia strategy and the special relationships of the EU to Russia and the Ukraine.

The key legal basis for the cooperation is the WTZ government agreement with the former Soviet Union, which entered into force in 1987 and whose continued validity is largely accepted by the legal successors. After independence of the successor states, a new basis for cooperation was created with the individual countries by making joint declarations (e.g. Ukraine in 1993, Belarus in 1996, Uzbekistan in 1998, and Russia in 2009).

Cooperation with the Asia-Pacific region

From a political, scientific and economic point of view, the Asia-Pacific region is becoming one of the leading regions in the world, and growing increasingly important in particular for the implementation of international cooperation aspects of the *High-Tech Strategy*. After Europe and North America, this region is the most important knowledge producer in the world. Judging by the number of co-publications, Japan remains by far the country with which German researchers cooperate most intensively, followed by Australia and China. However, countries like South Korea, Singapore and New Zealand are also important partners. The BMBF can look back on many years of successful cooperation with countries such as China, India, Vietnam, Indonesia, New Zealand and Australia, but its concept also involves actively keeping up with the radical changes in the Asia-Pacific region in recent years, for example via cooperations with Singapore the up-and-coming hotbed of research.

Cooperation with USA and Canada

Scientific and technological cooperation with the North American industrial countries of USA and Canada plays an important role. Research institutes in these countries are still the leaders in global knowledge production. Cooperation with partners from the USA includes all areas of science and research and entails a variety of initiatives and several thousand funded exchanges of scientists and students to the partner country every year. Also, there is a traditionally intensive ex-

change of information in a wide range of joint or complementary research projects.

In recent years, Canada has made significant new investments in research and development. Since then, the equipment of research institutes has greatly improved and the funding organisations or strategic funding programmes have recorded notable growth. This makes Canada an interesting and important partner in the cooperation in education and research.

Cooperation with Central and South America

The traditional affinity of Germany with the countries of Latin America in culture, politics and economics makes the region an important cooperation partner. In March 2009, German Minister Schavan travelled to Chile, Brazil and Columbia. The purpose of this trip was to intensify the cooperation in research and education, and, as emphasised repeatedly by Chancellor Merkel during her tour to Latin America in May 2008, to enhance the strategic cooperation in the areas of education and research.

Cooperation with the Mediterranean region and Africa

The scientific and research cooperation with the Mediterranean region and Africa is becoming increasingly important in light of the upcoming global challenges. This is an important target region for the actions by the internationalisation strategy of *strengthening long-term cooperation with developing countries on education and research*. Bilateral cooperation is embedded in developing scientific and research strategies in a multilateral framework, in particular those of the European Union, in the implementation of which Germany is actively involved. In future, both the cooperations at a bilateral level as well as cooperations at a regional and multilateral level are to be strengthened. Bilateral cooperation with countries in the Mediterranean region focuses on Turkey, Israel, Jordan and Egypt. South Africa is the most important cooperation partner in the countries in Sub-Saharan Africa.

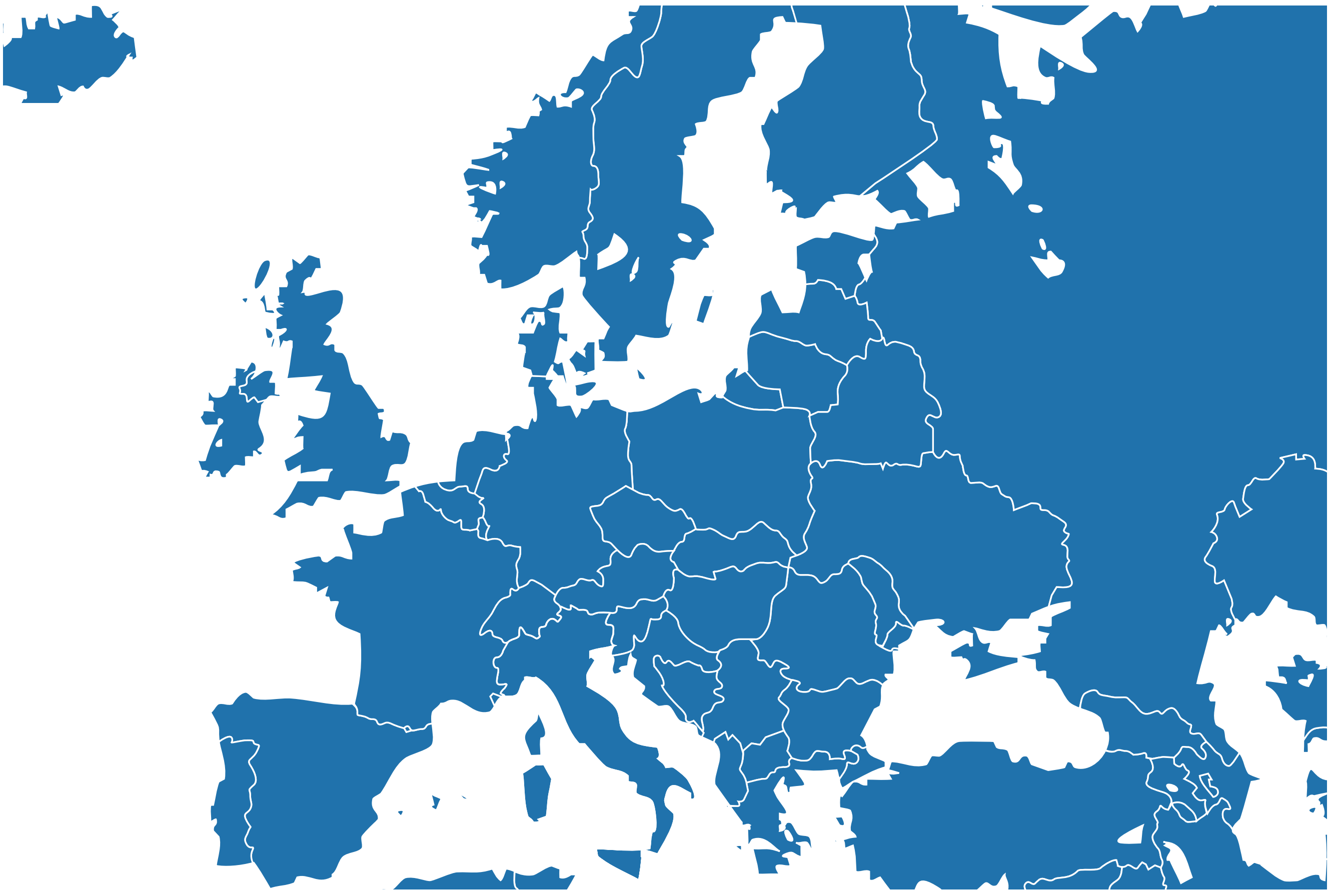
4.4 European cooperation

The Lisbon Treaty entered into force on 1 December 2009. With this agreement, the European Union established the goal of enhancing its scientific and technological foundations by creating a European Research Area where researchers are free to move from country to country and where scientific findings and technologies can be exchanged freely. Other goals include promoting the development of competitiveness of the European Union including that of its industry, and supporting all research measures considered necessary, based on other chapters of the agreements (see Article 179 of the Treaty on the Functioning of the European Union, TFEU). In order to reach these goals, the European Union runs programmes for research, technological development and demonstration (Framework Research Programmes) (see Article 180 TFEU).

The target definition in the Lisbon Treaty is broader than before. One new feature is the power of the Union to specify measures required to implement the European Research Area in addition to the campaigns planned in the Framework Research Programme (see Article 182 paragraph 5 TFEU). Thus, the Union's scope of action is expanded with a separate basis for competence with regard to the European Research Area.

In light of this, the coalition agreement between the German parties CDU, CSU and FDP concluded on 26 October 2009 for the 17th legislative period incorporates the goal for Germany to actively establish the European Research Area and support an enhancement of the role of the Member States.

The 7th EU Framework Research Programme (FRP)[1], with a total budget of approx 54 billion euros for the period from 2007 to 2013, is the world's largest research funding programme. Its outstanding feature is a high degree of continuity compared with the 6th FRP, both with regard to the funding areas and the instruments. This is in the interests of applicants, participating persons and institutions that can rely on proven research funding structures. At the same time, the 7th FRP includes new areas of funding such as fundamental research, which is now funded by the European Research Council. Thus, the 7th FRP covers the entire value chain from fundamental research to innovation.



1 See Decision No 1982/2006/EC of the European Parliament and of the Council of 18 December 2006 concerning the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007-2013); Download (plus legal foundations of the specific programmes): http://cordis.europa.eu/fp7/find-doc_en.html

5 Data and facts about the German research and innovation system

5.1 Selected data on the German research and innovation system

The selected data on the German research and innovation system refers to three subject areas: the resources for research and development (funds, personnel), the output from the research and development process (publications, patents) and the actual innovation via economic utilisation of research and development results[1] . In some areas, additional data was added to make interrelations clearer.

1 The diagram shows the intersection of the Research and Development and Utilisation areas. This should show how, in reality, both processes overlap and why it is not always clear whether a specific sub-step (e.g. prototype construction) is part of research and development or part of utilisation.

INFOBOX

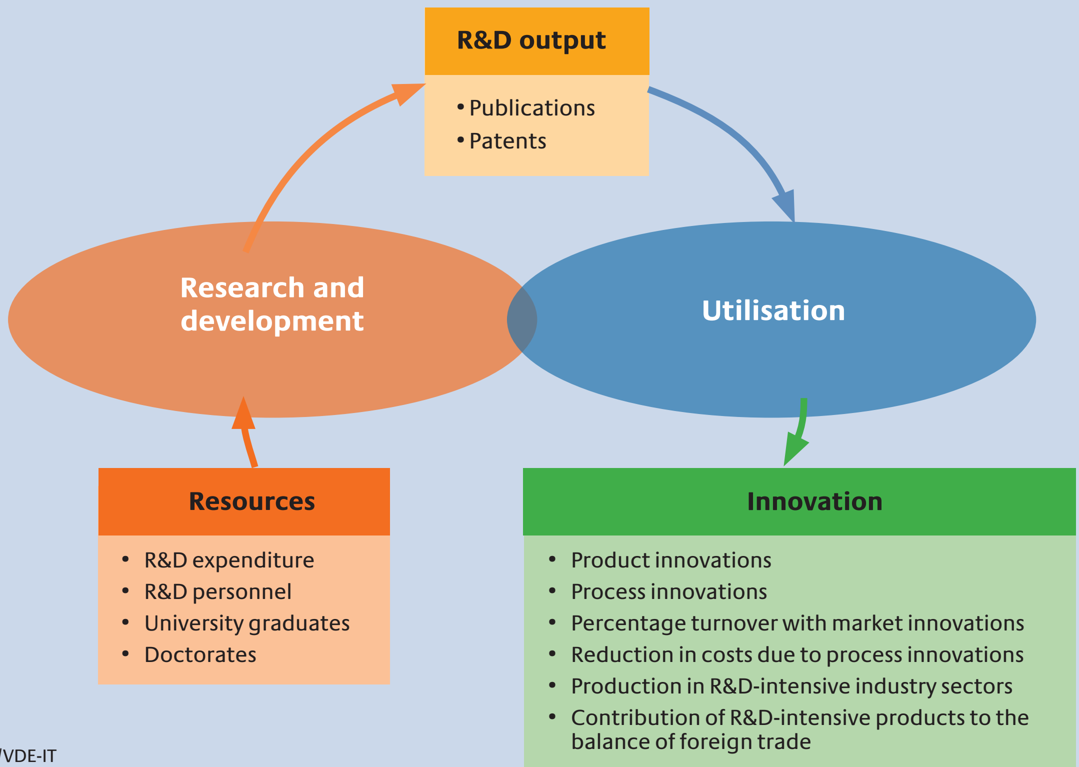
Availability of data

This chapter generally uses data from 2007. In addition to this, some data and estimates for 2008 are listed in individual cases.

The results of R&D processes are outputs such as scientific findings, discoveries or technological inventions.

This R&D output can be applied, whereby the (private) economic utilisation for new products or production processes will be the focus of consideration. Utilisation in political, social or cultural contexts is also possible.

Fig. 10 Selected indicators of the German research and innovation system



Source: VDI/VDE-IT

Resources[2] are required for research and development, such as funding or personnel for R&D institutions at universities, research institutes or private sector R&D centres. An important source of this personnel are graduates of technical and scientific courses or doctoral students in these subjects.

The R&D output[3] can be described more precisely in the case of scientific findings and discoveries via the number of scientific publications, and in the case of technical discoveries via the number of patents registered or granted.

The indicators for innovation[4] – that is the utilisation of R&D output by the economy and society – includes the percentage of companies that have made product, process or other innovations in a specific period (e.g. product innovators, process innovators). The success of innovations is revealed in the case of product innovations in the percentage of turnover earned with new products. If successful, process innovations lead to reduced costs in the production process or improvements in quality. ■ **Figure 10**

5.1.1 Resources

Financial resources

Fundamental information on expenditure on science, research and development

Particularly important indicators of R&D resources include the funds spent for R&D. Three main approaches must be distinguished: scientific expenditure, R&D expenditure and gross domestic expenditure for research and development (Bruttoinlandsausgaben für Forschung und Entwicklung, BAFE)[5].

Scientific expenditure incorporates the expenditure for R&D, the expenditure for scientific education and teaching, and other related scientific activities, for example scientific and technical information services, data collection for general purposes or studies on the feasibility of technical projects. The total scientific expenditure of the Federal Republic of Germany in 2007 amounted to 78.2 billion euros, and has increased by 21% since 2000.

In 2007, the private sector accounted for 56% of scientific expenditure. Government funding, including non-profit scientific organisations, accounted for 44%. The state governments[6] have accounted for approximately 60% of scientific expenditure of the public sector budgets since the mid-nineties. At almost 20 billion euros, it reached 58% in 2007. Central government accounted for 36% in the same year (approx. 12 billion euros). 87% of scientific expenditure of local governments was used for the universities, while 80% of scientific expenditure of central government went to the non-university research institutes.

By contrast to scientific expenditure, R&D expenditure does not include expenditure for academic teaching and training and other scientific activities, for example scientific and technical information services. R&D expenditure is restricted to funding systematic, creative work to build on existing knowledge, including knowledge of mankind, culture and society, and using this knowledge with the objective of finding new applications.

In 2007, domestic bodies, that is, local authorities, private non-profit institutions and the private sector spent approximately 62.2 billion euros, or approximately one fifth more than in 2001. In 2007, the private sector provided 70%, or approximately 43.8 billion euros. → **Table 2**

The approaches to date refer to the R&D expenditure financed by state-internal bodies, which also includes the funds sent abroad for research purposes. By contrast to the financing and resident concept, the gross domestic expenditure for research and development (GERD) only contains the funds spent domestically on the implementation of research and development. According to the resident concept, this also includes R&D expenditure in Germany that was funded from foreign sources, for example by the EU or companies with headquarters abroad. The gross domestic expenditure for research and development is an important indicator, in particular for international comparison of R&D efforts, as double counting is avoided in this concept. For this reason, this indicator will be used for all of the following international comparisons. The important 3% goal of the Lisbon strategy[7] also refers to the target gross domestic expenditure on research and development value of 3% of the gross domestic product in 2010.

In absolute terms, the gross domestic expenditure (by industry and central and local government) on R&D between 2005 and 2007 increased from 55.7 billion euros per annum to 61.5 billion euros per annum, a rise of almost 10%. A further increase to over 65 billion euros is expected in 2008.

When considering funding of research and development, the increasing importance of the private sector is becoming clear. In 2007, the private sector in Germany funded over two thirds of the gross domestic expenditure on research and de-

2 In international literature, these resources are also called input factors.

3 In international literature, these R&D returns are also known as throughput factors, as they refer neither to input nor output, but to intermediate results.

4 In international literature, these innovation indicators are also called output factors.

5 Internationally, the English term Gross Domestic Expenditure on Research and Development (GERD) is used.

6 The data of the federal *Länder* is based on the basic funding concept, where the direct revenues of the federal *Länder* from scientific institutions, in particular the daily hospital rates, are deducted from the net expenditure for science in order to exclude the influence of expenditure for healthcare at university hospitals.

7 This target is part of the Lisbon Strategy passed by the heads of state and government in Lisbon at a special summit in March 2000. This strategy aims to achieve lasting economic growth with more and better qualified jobs and greater social cohesion.

velopment, or approx. 41.8 billion euros. This refers to all financial expenditure by the private sector, regardless of where the R&D work was performed: in the private sector itself or in government, non-profit or public institutions such as universities. This figure is extremely high compared with the rest of the world and is considered a key feature of the German research and innovation system. →**Table 1**

In this context, the percentage of gross domestic expenditure on research and development of the gross domestic product (GDP) is a particularly important indicator. Overall, according to the preliminary calculations, the percentage of gross domestic expenditure on R&D in Germany increased to an estimated 2.64% of the gross domestic product in 2008. Even if that is not yet at the Lisbon target level, it indicates significant progress over time: this is the highest value this decade – in 2001, the expenditure was at 2.46% – and the highest value since reunification; the previous maximum level of 2.52% was reached in 2003. Compared with the situation in the mid-nineties, the increase is particularly significant.[8] →**Table 1**

Over time, the R&D expenditure of the private sector developed extremely dynamically again from 2005 to 2008 – after a period of stagnation in the middle of the decade. Broken down by industry, vehicle construction, electrical engineering, including data processing devices and optics and the chemical industry stand out in the level of their R&D expenditure.

Gross domestic expenditure for R&D is spread unevenly over the individual industries (sectors) that perform research and development. The private sector funded 70% of the overall gross domestic expenditure for R&D in 2007. This figure refers to the total of all expenditure for R&D performed in the private sector provided by the domestic economy itself, the national government, private non-profit institutions and from abroad.

With regard to implementing sectors, the majority of the R&D funding available was provided by the private sector in 2007, at 43 billion euros, while only a comparatively small amount was provided by the government and from abroad. The public sector (including private non-profit institutions) used approximately 8.5 billion euros and the universities 9.9 billion euros. Both sectors were primarily financed by the national government.

As the 3% goal of the Lisbon Strategy refers to European research and innovation policy, a comparison of Germany with the other EU countries and overall European values is particularly interesting. Of the 27 EU countries, Germany is in fifth place for the percentage of GDP accounted for by GERD. Only Sweden and Finland meet the three percent criterion – however, they exceed it significantly by over half a percent. Denmark and Austria have similar values to Germany. All other countries are significantly lower – by at least half a percent age point. ■ **Figure 11**

In a global comparison of OECD nations, Germany was in the top group of countries with GERD percentages greater than 2.5% in 2008, with an (estimated) value of 2.64%, Israel (4.86%, 2008), Sweden (3.75%, 2008), Finland (3.50%, 2008), Japan (3.44%, 2007), South Korea (3.21%, 2007), Switzerland (2.90%, 2004[9]) and the USA (2.77%, 2008) surpassed this level.

Bringing up the rear with GERD percentages below 1.5% were eastern and south European countries (e.g. Romania and Greece) and Latin American countries (Mexico and Argentina). Israel's first place figure is over double the average of the OECD member states of 2.28% (2007).→**Table 7**

The development of this indicator in selected OECD countries over time reveals varying dynamics. The European leaders, Sweden and Finland, are stagnant at a high level; in Sweden a multi-year downturn prevailed from 2001 to 2005.

By contrast, the eastern Asian countries of Japan and in particular South Korea are marked by significant growth. Since the middle of the decade, South Korea has increased its lead over Germany and even the USA. The intensity of R&D in France is waning. In recent times, the values of Great Britain have begun to rise from a low level. The USA and Germany have demonstrated positive trends in the past few years. ■ **Figure 12**

German Federal Government expenditure on research and development

The R&D expenditure of the German Federal Government increased from 9 billion euros in 2005 to 10.9 billion euros in 2008. In 2009, central government expenditure on R&D increased further to 12.1 billion euros (target), a rise to 12.7 billion euros is planned for 2010.

88% of central government's total expenditure goes to the BMWi, the BMVg and the BMBF collectively, the remaining 12% goes to the other departments. →**Table 4**

The diagram showing R&D expenditure broken down into funding areas and funding priorities is based on the central government's R&D performance plan system. The expenditure is broken down according to research subjects, regardless of the department that funded it.[10]

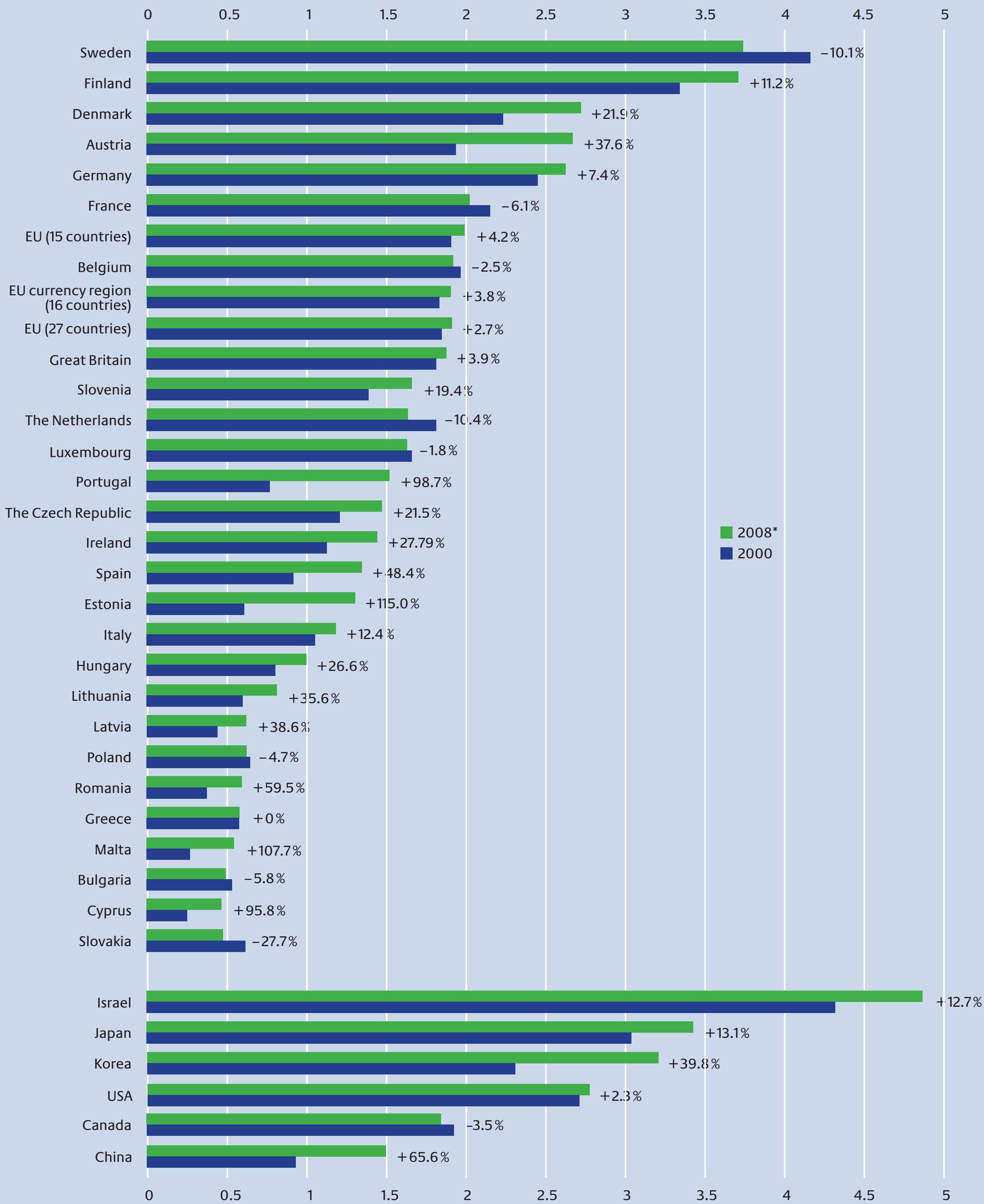
The German Federal Government has fundamentally updated the procedures for coordinating national research and development activities, and drawn up a new R&D performance plan system. The details of central government research priorities in Part II B are structured according to this new system.

8 See also the 2010 Annual Economic Report by the German Federal Ministry of Economics and Technology (BMWi)

9 No more recent data was available when going to press.

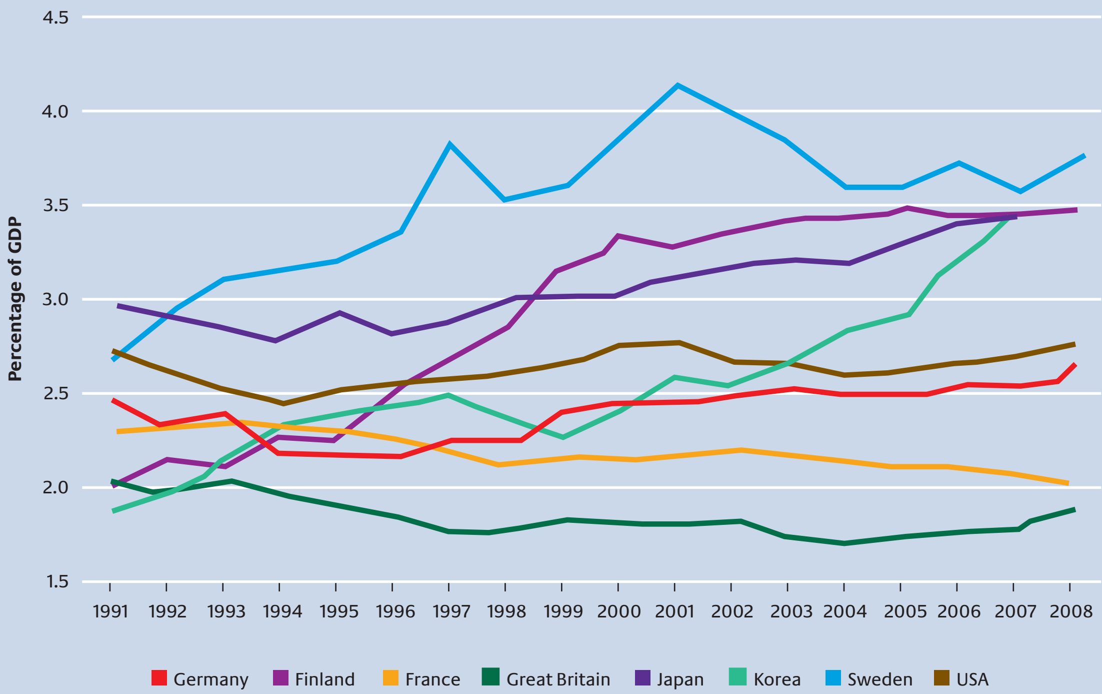
10 For BMBF and in part for BMWi, BMU and BMELV, allocation is made at a project level, while the other departments focus on the budget unit level. The funds for institutional financial aid, including the expenditure of the Federal Government scientific institutions, are allocated to one or more funding areas or key topics in accordance with their tasks, and are also broken down by research subjects. The procedure for the basic funding of the MPG, DFG and FhG, as well as the funds for university construction and university-related special programmes, which each form a separate major funding area and are grouped in one funding area, differs.

Fig. 11 **Gross domestic expenditure on research and development as a percentage of gross domestic product in selected countries, 2000 and 2008**



* Deviations due to data availability: instead of 2000, 2001 is used for Greece and Sweden, 2002 is used for Malta; instead of 2008, 2007 is used for China, Greece, Japan and Korea
Basis of data: table 18, Eurostat and OECD

Fig. 12 **Gross domestic expenditure on research and development as a percentage of gross domestic product in selected countries, 1991-2008**



Basis of data: OECD; Main Science and Innovation Indicators 2009/2 Source: BMBF

The IT technical implementation of the coordination of the German Federal Government R&D activities has not yet been fully programmed. Therefore, the statistical data on central government expenditure on science, research and development cannot yet be presented broken down according to research areas and research priorities. They are therefore structured according to the old performance plan system. The same applies to the corresponding expenditure of the German Federal Ministry of Education and Research (BMBF).[11]

Central government R&D expenditure can be divided into civilian and military research. While civilian research is broken down further to funding areas and funding priorities, defence research and technology is a separate funding area regardless of its research topics. Civilian research reached 89% of overall central government R&D expenditure in 2008; this amount has remained largely stable in recent years. For 2010, the percentage of civilian research is expected to increase to 91%.

At 23%, the funding area of management organisation, university construction and primarily university related special programmes account for the majority of central government R&D expenditure in 2008 (actual value). The percentage planned for 2010 is similarly high at 22%. The majority of this consists of funds for basic financing for DFG at 7.7% (target 2010[12] : 7.0%).

This is followed by the fields of *aerospace research and aerospace technology* (2008: 8.1%; target 2010: 7.7%), *large-scale equipment for fundamental research* (2008: 7%; target 2010: 7%), *innovation and improved framework conditions* (2008: 5.6%; target 2010: 6.5%) and *health and medicine* (2008: 5.6%; target 2010: 6.3%). →**Table 5**

Approximately 58% of central government R&D expenditure goes to the BMBF. This is dominated by the following funding areas: management organisations, university construction and primarily university-related special programmes (2008: 39.8%; target 2010: 37.6%), large-scale equipment for fundamental research (2008 and target 2010: 12%), health and medicine (2008: 7.6%; target 2010: 8.5%), information technology including multimedia and production technology (2008: 7.6%; target 2010: 8.1%), environmentally friendly, sustainable development (2008: 6.9%; target 2010: 5.2%) and biotechnology (2008 and target 2010: 5.4%).

When breaking this data down by funding types, project funding, institutional research, university-related funding and international contributions in particular must be distinguished. Project funding includes both project-specific funding and expenditure for commissions as part of the departmental and defence research. The overall percentage of

11 The tables converted to the new performance plan system are expected to be published on the BMBF homepage in September 2010.

12 Status: Draft law of the German Federal Government dated 16/12/2009

institutional funding in central government R&D expenditure in 2008 (actual) was 44% (target 2010: 43%), and the project funding percentage[13] was 45% (target 2010: 49%).

The breakdown of central government expenditure on R&D by recipient groups gives an overview of the distribution of funding to the individual sectors – central government and municipal authority institutions, non-profit organisations and private-sector companies.[14]

In 2008 (actual), non-profit organisations (including DFG, MPG, FhG and HGF) received the majority of central government expenditure on R&D, amounting to 54%. The second-placed recipient group were private sector groups and companies at 20%. The percentage of central government R&D expenditure received by local authorities was 17%, of which 7% was accounted for by central government and 10% by local governments and communities. →Table 6

Central government R&D expenditure on the private sector amounted to 2,152 million euros in 2008. Of this:

- 485 million euros (23%) went to the German Federal Ministry of Education and Research,
- 727 million euros (34%) went to the German Federal Ministry of Defence
- 775 million euros (36%) went to the German Federal Ministry of Economics and Technology,
- 165 million euros (8%) to the other departments.→Table 6

Central government funding of small and medium-sized enterprises[15] for research and innovation amounted to over one billion euros in 2009 (approx. 850 million euros in 2008) – excluding the economic stimulus package II. Of this, 646 million euros (2008: 562 million euros) went to technology-open programmes of the BMWi for SMEs, of which approximately half went directly to SMEs. Within the specialised BMWi and BMBF programmes, 371 million euros was paid to SMEs (2008: 297 million euros). In 2009, the other departments (excluding the BMVg) funded SMEs in this area with a further 50 million euros (2008: 39 million euros). Thus, SMEs are not only funded disproportionately to their percentage of the R&D expenditure of the private sector, the funds also increased significantly disproportionately by approximately two thirds compared to 2005.

The economic breakdown of the actual central government expenditure on science, research and development to private sector groups and companies reveals that around 64% of the expenditure went to the manufacturing industry in 2008. The most significant sub-groups are companies in the vehicle construction industry and manufacturers of office equipment, data-processing equipment and devices, electrical engineering and mechanical engineering. After several years of increases, the percentage of the manufacturing industry decreased in 2008, both absolutely and in relation to the overall expenditure.

Approximately a quarter (26%; 2.5 billion euros) of the domestic R&D funded by central government went to the Eastern German *Länder*, including Berlin, in 2008. This percentage has remained stable in recent years.

Of central government expenditure on science, research and development in 2008, totalling 10.9 billion euros, 91% remained in Germany. The majority of the funds sent abroad amounting to 1,001 million euros went on contributions to international scientific organisations and intergovernmental research institutions (approx. 901 million euros). →Table 6

Federal *Länder* expenditure on science, research and development

The expenditure of the federal *Länder* on science, research and development benefits the universities in particular, both in the form of basic funding for research and teaching, and as external funding via the state's contribution to financing the German Research Association (DFG) and funding for graduate students. In addition to this, the joint central and local government research funding also plays a major role, that is the funding of the Max-Planck Society, Fraunhofer-Gesellschaft, Helmholtz Association, Leibniz Association and academy programme institutes. Also, local government expenditure on science and research is paid to state and community institutions with responsibilities in science and research, as well as in the private sector, which receives public funding as part of funding measures for research, technology and innovation.

Federal *Länder* and communities spent 19.9 billion euros on science, research and development in 2007. This figure has remained largely stable compared with previous years. Eastern German *Länder* (including Berlin) received 23.1% of the total scientific local government expenditure in 2007.

The majority of the scientific expenditure, or, to be more precise, of the basic funding for science, from the federal *Länder* and communities in 2007 was paid to universities including university hospitals (86%), with 14% going to science and research outside the universities. The percentage of expenditure on the universities thus remained virtually constant compared with previous years.

Local government expenditure on research and development (excluding communities) amounted to approximately 8.5 billion euros in 2008 (estimated), compared to around 8 billion euros in the previous year.[16]

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13 Including departmental research

14 Financing includes both institutional funding and the other types of funding. Funds passed on to third parties for research by institutions are not incorporated, i.e. the initial recipient principle is always applied.

15 Different definitions are usually used to distinguish this from SMEs. The German Federal Government has used a specific national definition for its statistics for many years. It is based on the criteria of the EU definition, but sets further limits, with a turnover of 100 million euros (EU: 50 million euros) and 50% ownership of other large-scale companies (EU: 25%). This definition is more appropriate to the German situation with many medium-sized companies.

16 See also the 2010 Annual Economic Report by the German Federal Ministry of Economics and Technology (BMWi)

In 2007, the federal *Länder* contributed 12.9% of the total public and private R&D expenditure in Germany (62.2 billion euros), compared with 14.5% in 2003. The federal *Länder* accounted for approximately 44% of the total central and local government expenditure. This trend is slightly downward – at the turn of the last decade, the corresponding figure was approximately 48%. →Table 2

In 2007, the federal *Länder* of North Rhine-Westphalia (18.7% of the local government expenditure), Bavaria (16.7%) and Baden-Wuerttemberg (14.1%) were the largest contributors to local government expenditure. The highest growth compared to 2006 was recorded in Bremen (10.7%) and Baden-Wuerttemberg (9.7%). The greatest decreases were in Mecklenburg-Western Pomerania (-26.0%) and Saxony-Anhalt (-17.2%).

Joint central and local government research funding

Together, central and local governments spent approximately 18.2 billion euros on research and development in 2007. Thus, the country funded 29.2% of all R&D expenditure as part of the joint research funding in Germany. Approximately one third (32%) of this national R&D expenditure went on institutional funding, which is paid as part of the joint central and local government research funding. →Table 2

The funds provided by the central and local governments were primarily used for basic financing (institutional funding) of the scientific and research organisations Max-Planck Society (MPG), Helmholtz Association of German Research Centres (HGF), Gottfried Wilhelm Leibniz Scientific Association (WGL), Fraunhofer-Gesellschaft (FhG) and German Research Association (DFG). In total, joint research funding for these institutions in 2008 amounted to 6.5 billion euros, and the target value for 2009 is 6.8 billion euros. Of this total expenditure, approximately two thirds are provided by central government, whereby the funding shares of central and local governments differ, depending on the institution.

University resources

In addition to the private sector and non-university institutions, the universities are the third main area where research and development is performed. The close link between research and teaching is a special feature of universities, which makes precise studies of these two responsibilities difficult.[17]

17 The R&D expenditure by universities is calculated using R&D coefficients based on the overall expenditure of the universities. Further factors include the number of students, the examinations taken and the working hour budget of the personnel. According to the criteria for R&D statistics passed as part of the OECD, the university sector does not include the affiliated institutes, which have close and multifaceted connections to the respective universities, but are legally autonomous institutions.

In 2007, the expenditure of the universities for education and research amounted to 22.4 billion euros. From 2000 to 2007, the total increase was 18.1%. In 2007, universities accounted for 16.1% of the R&D performed in Germany. →Table 1

The expenditure by universities on R&D in 2007 amounted to approximately 9.9 billion euros. This corresponds to 44% of the overall expenditure of the universities on education and research. The increase in R&D expenditure by universities between 2000 and 2007 amounted to 21.6%, which means that the rate of increase in the R&D expenditure is significantly higher than the rate of increase in overall expenditure of the universities on education and research.

The R&D expenditure of universities is largely provided by central and local governments (82% in 2007). The percentage of all R&D expenditure accounted for by external funding at universities has increased significantly. In 2007, this was 43% (equal to 4.3 billion euros) compared to 36% (3.1 billion euros) in 2001. Thus, the external funding increased by almost 38.7% in this period.

Human resources

R&D personnel

In addition to the R&D expenditure, R&D personnel is the most important indicator of resources in the area of research and development in a country or in a sector of the research landscape.[18] ■ Figure 13

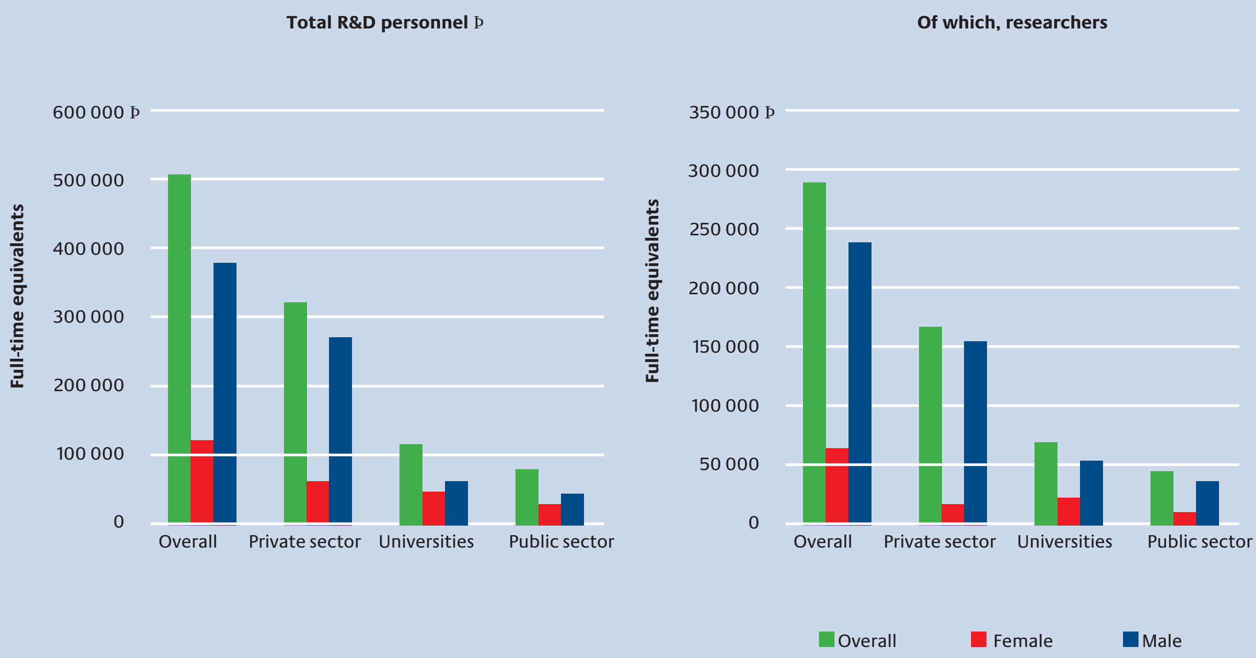
In 2007, a total of 506,000 full-time equivalents were employed in Research and Development in Germany. This represents an increase of 4.5% compared to 2000.→Table 9

Not all staff members employed in the R&D area perform direct research work. The abovementioned figures also contain groups of persons who perform technical (e.g. machine operation) or other (e.g. secretarial services) supporting tasks for these actual research activities. The percentage of scientific R&D personnel – researchers – of the overall R&D personnel in 2007 was 57%.[19] After a slight increase at the beginning of the decade, this percentage has remained virtually constant since 2004. →Table 9

18 Þ One advantage of using R&D personnel over R&D expenditure as an indicator is that inflationary effects do not have an effect when comparing different periods, or purchasing power differences in international comparisons. In order to rule out the effects of part-time employment contracts, R&D personnel is specified in full-time equivalents. This form of counting also takes into account that, in particular, research and education are regularly performed by one and the same person at universities. The research percentage is calculated using R&D coefficients based on a process agreed by the Federal Ministry of Education and Research, the Conference of Cultural Ministers, the Federal Statistical Office and the Science Council.

19 The percentage of scientific R&D personnel is estimated based on the formal qualifications (university degrees). Qualifications are not the main criterion for classification of R&D personnel according to their type of employment. However, it can generally be assumed that researchers are also academics.

Fig. 13 R&D personnel by gender, broken down by sector and personnel groups, 2007



Source: table 31

Women are underrepresented among R&D personnel. Of the approximately 506 000 employees in R&D in 2007, 133 000 or 26% were female. The participation rate of women among R&D personnel has thus increased slightly since 1995 (24%). There are significant differences between the sectors. While the percentage of women at universities in 2007 was around 41%, and accounted for 38% of the overall R&D personnel at non-university research institutes, or, to use OECD nomenclature, the public sector, they only made up 18% of the private sector.

Among the highly qualified employees, the difference between the sectors is also clear. In this category, female researchers are also rarest in the private sector, where they make up just 12% of personnel. At the universities (31%) and in the public sector (28%), the percentage of women among the highly qualified research personnel was over twice as high. Of the approximately 291 000 researchers in Germany, around 55 000 are female, which is equivalent to 19 percent. Overall, the percentage of women has increased significantly from 16% to 19% since 2003. This increase was clearest, from 24% to 31% at the universities, and somewhat lower, from 25% to 28% in the public sector, while the percentage of women in the private sector hardly changed (increase from 11% to 12%). This increase proves the success of the policy of the German Federal Government to improve equal opportunities at universities and research institutions.

Within the university sector, significant differences can be observed in the percentage of female researchers in individual scientific fields. Medicine at 51% and agricultural science at 41% were the fields with the highest female percentage of highly qualified research personnel in 2007. In the humanities and social sciences, they accounted for 34% and 24% in the natural sciences. In the engineering sciences, men continue to dominate, as 17% of researchers in this field are female. However, it is notable that at universities in all areas of science, the percentage of female highly qualified research personnel has increased continuously since 1995.

The non-university research institutions stated that, on average during 2007, 38% of their R&D personnel were women. This figure has increased slightly since 2000 (35%). The percentage of females among the highly qualified researchers increased particularly significantly from 22% (2000) to 28% (2007).

Up-and-coming researchers: university qualifications and doctorates

University graduates are a key future resource for R&D. This area has developed positively in recent years. The number of graduates increased from 198 000 in 2005 to a record level of 254 000 in 2008. Almost 20% of an age group completed their education with a university qualification in 2005. In 2008, this figure was over 25%. The percentage of university graduates of the respective age group thus increased proportionally more than the absolute number of university graduates. ■ **Figure 14**

For technological development and utilisation of future markets it is particularly important to ensure sufficient new personnel for mathematics, information technology, science and technology (commonly abbreviated to MINT in German).

From 2005 to 2008, the number of graduates in engineering increased by around one quarter or approximately 8,000 students after a phase of stagnation. The percentage of the age group also increased around one quarter.

Of the graduates in mathematics and science, the increase in absolute figures was even more impressive, with over 12 000 or around 40%, which continues the positive trend of previous years at a higher level. The increase relative to the age group was also around 40%.

It is also of note that the number of graduates in mathematics and science, which had always been lower than the figures for engineering (e.g. by more than 10 000 in 2003), drew level with engineering in 2007 and was even slightly higher in 2008.

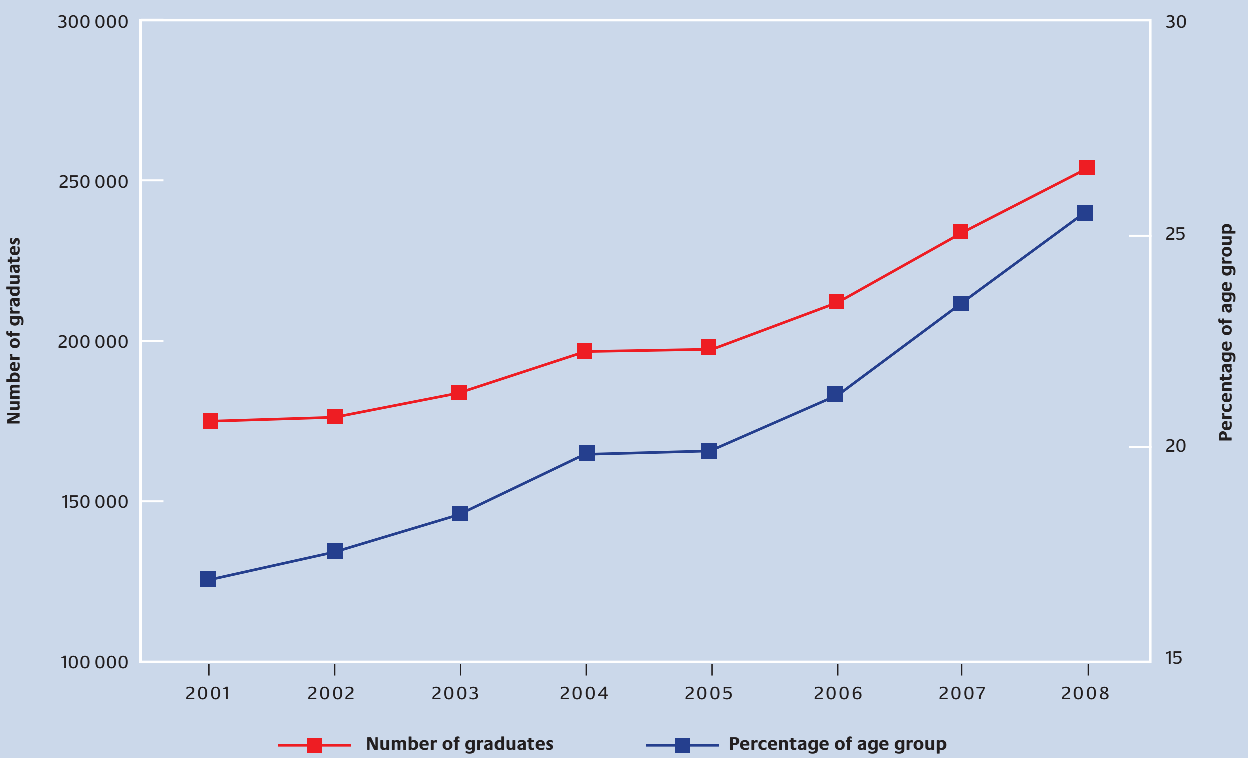
These positive developments of the MINT graduates are extremely pleasing, not only with regard to the demand of the German research and innovation system for qualified personnel. In addition to this, it must also be taken into account that, in particular, engineering courses are considered typical advancement routes for students whose parents are not academics. The number of foreign students in science and engineering courses is also extremely high.[20]

Doctoral studies are relevant for particularly highly-qualified staff for R&D activities. Moreover, the number of doctorates can also serve as a general indicator for R&D activities.

The development since 2000 has been uneven. After a constant decline from 2000 to 2003 by a total of approximately 10% or around 2 600 students, the numbers of doctorate qualifications increased markedly to a decade high of almost 26 000 doctorates in 2005, to decrease to below 24 000 doctorates by 2007. The most recent figures from 2008 again show an upward tendency to figures of over 25 000 doctorates; however, they did not quite reach the peak values of 2005 and 2000. Like the numbers of graduates, the doctorates in the MINT area will also be considered separately. After a decrease from 2000 to 2004, the number of doctorates in mathematics and science has increased constantly since 2006. The ratio – the percentage of doctorates in mathematics and sciences of all doctorates of the respective years – is relatively constant at a very high level: almost 30% of all doctorates are in these subjects. In engineering, the development is marked by a greater degree of constan-

20 See Leszczensky/Frietsch/Gehrke/Helmrich, Studien zum deutschen Innovationssystem (studies on the German innovation system) No. 1-2010

Fig. 14 Number of university graduates and percentage of age group, 2001-2008



Basis of data: table 52

cy, both with regard to the absolute figures and the percentage of all doctorates. The most recent figures reveal a certain positive tendency (increase by around 13% in absolute figures from 2007 to 2008). Overall, it is noteworthy that the MINT subjects account for almost 40% of all doctorates. This highlights the particular relevance of this group of subjects for research.[21]

5.1.2 R&D output

Successful research and development work leads to scientific findings or technological inventions. Scientific findings are reflected in scientific publications, and technological inventions are reflected in patents.[22]

Patents are an indicator of the technological performance of a country in a narrower sense; by contrast, publications measure the scientific performance. With regard to the increasing importance of knowledge as a production factor, publications are recognised as an indicator of scientific performance in innovation policy contexts. It must be taken into account that there are significant differences in the publication activities between the academic disciplines. Moreover, the absolute publication data does not provide information on the recognition of the publication in the research community. Additional citation data must be considered.

Scientific performance: Publications

The number of scientific publications (per million citizens) has increased continuously in recent years in Germany. Between 2000 and 2008, this increase was approximately 20%. One of the leading positions in the triad comparison (Europe, North America, East Asia) in terms of scientific publications is held by the USA. [23] Germany has caught up to the USA in the report period to a degree: in 2000, the number of German publications was around 92% of the publications by American researchers, and reached approximately 97% in 2008. The lead over Japan also increased significantly in this interval (from around 143% to around 168% of the respective Japanese figures). ■ **Figure 15**

Compared with the European average, Germany's leadership position – in particular due to the greater average growth in publication figures in the EU 27 region – decreased somewhat (from around 130% to around 126% of the respective European figures).

The percentages of countries of all international publications revealed a decrease in the values of the classical industrial nations – including Germany – due to a greater participation in publication by eastern Asian countries, such as South Korea and China.[24] For example, the German percentage of publications recorded in the Science Citation Index (SCI)[25] decreased by 14.5% from 2000 to 2008. The figures for the USA (-11.1%), France (-11.5%), Great Britain (-19.9%) and Japan (-25.7%) are similar. By contrast, China (+91.1%) and South Korea (+73.4%) have grown rapidly.

This data provides a rough overview of the scientific performance of individual countries based on the absolute numbers of publications. Citation indices are used for more in-depth analyses, which consider the citations in the year of publication of the corresponding publication and the two subsequent years. Further indicators also take the citations of articles from a specific country into account compared with other articles published in the same journal (journal-specific consideration) or the positive or negative disproportional representation of articles from a specific country in internationally renowned journals (international focus).

Technological performance: Patents

Patents are often used as indicators of technological performance. Even if data on this is readily available, interpreting it with regard to R&D output in the national economy is not without its problems. For example, there are industries in which inventions are never or rarely patented for reasons of confidentiality, for example.

Inventions that are registered in Europe or with the World Intellectual Property Organization (WIPO)[26] are referred to as global market-relevant or transnational patents. For the export-oriented German economy, such patents are particularly important, because they protect the invention, even beyond the borders of the domestic market. This indicator has grown strongly at a high absolute level in Germany. The growth in the number of patents per million citizens was around 20% between 2001 and 2007. In the same period, Germany increased its lead over the EU-27 average slightly (from approximately 243% to approximately 251% of the respective European values).

21 It must also be taken into account that in certain scientific disciplines, doctorates are required for many jobs.

22 Publications and patents can be referred to as the output of the R&D processes. With regard to the overall innovation process (see Figure 24), these publications and patents can be viewed more as intermediate results, which in turn are a prerequisite (input) for the utilisation of the findings and inventions in business and society. This is why they are also referred to as throughput indicators.

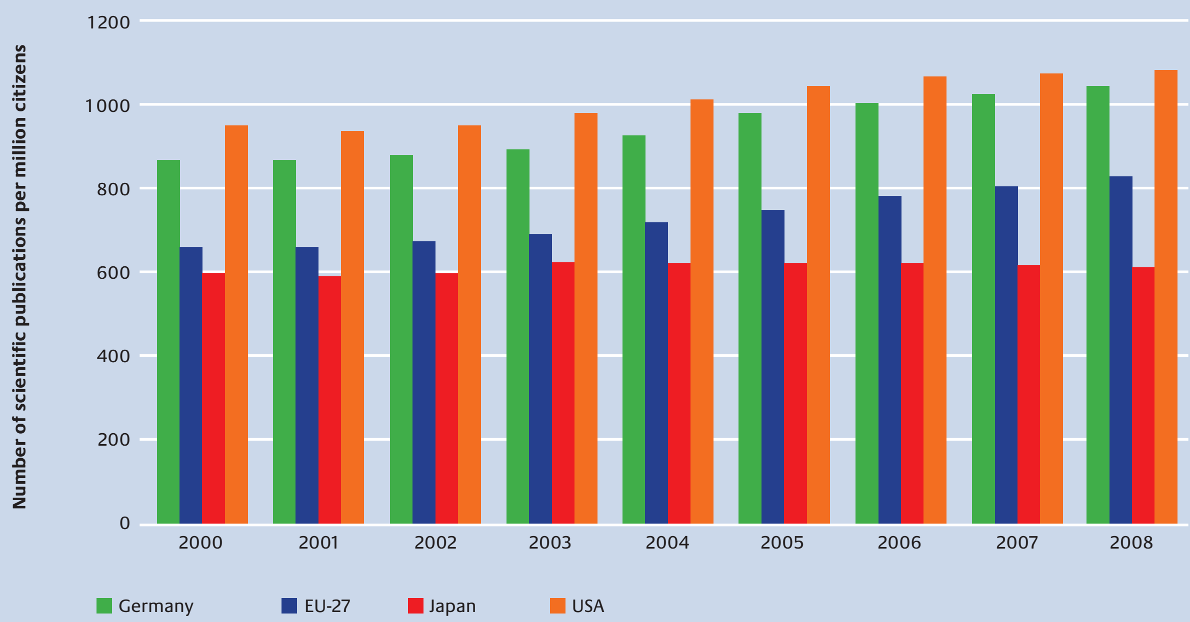
23 The OECD country with the highest publication figures is Switzerland (OECD Technology and Industry Outlook, 2008). With regard to the USA, it should be noted that researchers whose native language is English have a significant advantage in international publications.

24 See Schmoch/Schulze: Performance and Structures of the German Science System in an International Comparison 2009 with a Special Feature on East Germany. Studien zum deutschen Innovationssystem (Studies on the German innovation system) No. 8-2010

25 For a list of the journals recorded in SCI, see http://scientific.thomson.com/cgi-bin/jrnlst/jloptions.cgi?PC=K

26 Global organisation for intellectual property, a specialised agency of the United Nations.

Fig. 15 **Publications: Germany, EU 27, Japan and USA, 2000-2008 Þ**



Basis of data: table 44

Compared with the USA, Germany records approximately twice as many transnational patents per million citizens, with a slightly increasing tendency from 2001 to 2007. Compared with Japan, the patent intensity is approximately 50% higher, with a slightly declining tendency. ■ **Figure 16**

However, it must be taken into account that the situation is different if other standard patent indicators are used. This applies in particular to triad patents: patents which are also registered in the other two regions of the Europe/North America/eastern Asia triad in addition to the domestic country. In this indicator, for example, the Japanese figures are significantly higher than the German figures, compared with the figures for global-market relevant patents specified here. This will become clear in Chapter 2 on international indicator systems.

If we break this down by patents in different technology areas, a typical constellation for Germany is revealed: in the high-value technologies[27] (e.g. automobile, mechanical engineering), Germany is very strongly represented with patents. However, in the top technologies[28] (e.g. computers/electronics or pharmaceuticals/biotechnology), it is below the global average.[29]

5.1.3 Innovation

Innovation participation, innovator ratios

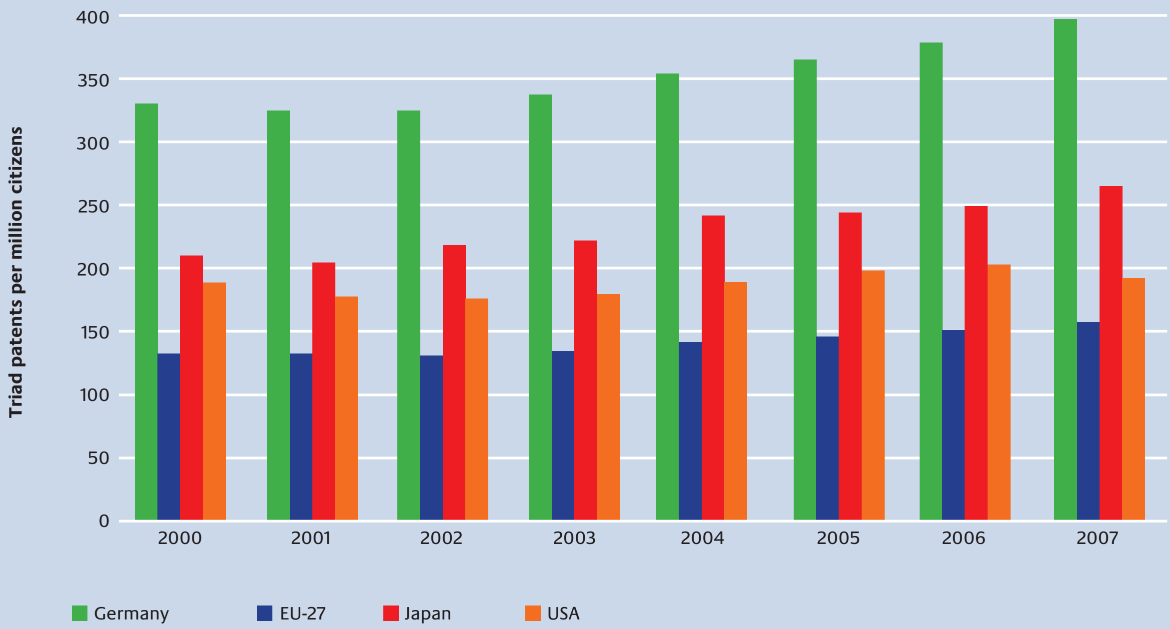
R&D output – publications and, in particular, patents – can be utilised by commercial organisations (companies). This means that the actual innovation follows the invention (the technical-scientific invention). In the manufacturing industry, including mining, 58% of the companies were innovators in 2008; these are companies which introduced at least one innovation within the preceding three-year period. This innovation need only be new from the point of view of the company itself – and can therefore already have been introduced

27 High-value technological goods are R&D-intensive goods with manufacturing processes for which an annual average of between 2.5 percent and 7 percent of the turnover is used for research and development.

28 High-value technological goods are R&D-intensive goods with manufacturing processes for which on annual average of between 2.5 percent and 7 percent of the turnover is used for research and development.

29 See Frietsch/Schmoch/Neuhäusler/Rothengatter: Patent Applications – Structures, Trends and Recent Developments. Studien zum deutschen Innovationssystem (Studies on the German innovation system) No. 9-2010

Fig. 16 **Global-market relevant patents: Germany, EU 27, Japan and USA, 2000-2007**



Basis of data: table 45

by another company. The corresponding innovator ratios for knowledge-intensive company-related services were around 51% and around 33% for the other company-related services.

Product and process innovations are the main types of innovation.[30] Product innovations can be broken down further into range or company innovations – products which are new for the company in this form, but may already be offered by other companies (in a similar form) – and market innovation, in other words products not available on the market yet in this form. Range innovations include market innovations and copycat innovations.

In addition to the fact that companies bring out product or process innovations to a certain extent, the success of these innovations is particularly important.

For product innovations, the success of the innovation can be measured in percentage turnover earned with new products, with range or market innovations.

Cost reductions and quality improvements achieved via the new processes are indicators for the success of process innovations.

Product innovators

Figure 17 shows the percentage of companies which have introduced at least one product innovation in the period in question; the innovations can be either market innovations or product copies (copycat innovations). In this and the following figures, please note the following: between 2005 and 2006, there is a disruption in the time sequence as a result of changes in the survey methods or the definition of the population.[31] ■ **Figure 17**

The most intensive innovation activity takes place in the manufacturing industry (incl. mining) with product innovator ratios of 40% to 50%, followed by knowledge-intensive company-related services (around 40%) and other company-related services (20% to 30%). After uneven and declining development in early years, the most recent figures comparing 2008 to 2007 reveal a positive trend for all sectors (increase of around two percent respectively). In 2008, 13% of companies in the German economy introduced market innovations, or the same number as in previous years.

30 See Rammer/Aschhoff/Doherr/Köhler/Peters/Schubert/Schwiebacher on the individual indicators and their definitions: Indikatorenbericht zur Innovationserhebung 2009 (Indicator report on the 2009 innovation survey). ZEW publication, January 2010

31 See Rammer/Peters: Innovationsverhalten der Unternehmen in Deutschland 2008 (Innovation activity of companies in Germany in 2008). Studien zum deutschen Innovationssystem (Studies on the German innovation system) No. 7-2010.

Fig. 17 **Product and process innovators, 2001-2008**

Basis of data: tables 42 and 43 Þ

Process innovators

Like the product innovator ratios, Figure 18 also shows the percentage of companies that introduced at least one process innovation in the period in question.

In terms of intensity of the innovation activity in process innovations, the manufacturing industry (incl. mining) sectors and the knowledge-intensive company-related services with process innovation ratios between 30% and 40% distinguish themselves positively from the other company-related services (around 20%). However, the progression of values over time is uneven: in 2008 (manufacturing industry and other company-related services) or 2007 (knowledge-related company-related services), a certain tendency to increased innovation activity can be detected, compared to the previous years. ■ **Figure 18**

Innovation success

Percentage turnover with market innovations

The percentage turnover made with products new to the company and with market innovations is an ideal indicator for product innovation success. The latter indicator is the more discriminating, as only "real" innovations, not copycat innovations, are taken into account. These innovations are in a much closer relationship to R&D than mere imitative innovations.

The percentage turnover with products new to the companies was around 27% in mining and the manufacturing industry in 2008. In the knowledge-intensive company-related services sector (around 13%) and other company-related services sector (around 7%), the figures were far lower; the figures are typical for the individual industry sectors and largely stable conditions over time. For the overall economy, the percentage turnover with new products was approximately 17%: thus, in 2008, one sixth of the overall turnover of the German economy was based on new products.[32]

The percentage turnover with market innovations is far lower as this is the more discriminating of the two indicators. In 2008, the corresponding figure for the mining sector and manufacturing industry was 5.2%, 2.5% for knowledge-intensive company-related services and 1.1% for other company-related services.

The figure shows the development of the percentage turnover with market innovations indicator over time. For the manufacturing industry (incl. mining) and the other company-related services, the trend is a moderate decline, with the other company-related service becoming more stable in recent years.

32 See Indikatorenbericht zur Innovationserhebung 2009 (Indicator report on the 2009 innovation survey), see footnote 24

Fig. 18 **Innovation success: percentage of turnover earned with market innovations and cost reduction share via process innovation, 2001-2008**

Basis of data: tables 42 and 43

The indicator progression in the knowledge-intensive company-related services is extremely conspicuous. In addition to banking and insurance, this sub-sector includes IT and telecommunications services in particular. The percentage turnover with market innovations dropped sharply by around three quarters of the indicator value between 2004 and 2006.[33] The trend has been positive since 2006 (increased by 25% of the indicator from 2006 to 2008), but at a significantly lower level than before 2004.

It should be noted that the period from approximately 1997 to 2002 was a historically atypical situation. During this period, the propagation of new information and communication technologies (Internet boom, dotcom hype) made many new types of product innovation possible, both for hardware providers and in particular for the providers of software and telecommunication services at issue here. The clear subsequent decrease could be interpreted as a return to normality. The moderately increasing values of the last three years attest to this.

Also, the increasing internationalisation of this industry may have lead to product innovations that were considered new in regional markets but were revealed to be imitations in international market environments, as they had already been introduced by others on non-domestic markets.[34]

Reduction in costs due to process innovations

The percentage reduction in costs due to process innovations is an indicator for the cost effects of these innovations. This reduction refers to the unit or process costs in the year in question, saved as a result of the process innovation introduced in the preceding three-year period.[35] In the knowledge-intensive company-related services, a significant decline from 2001 to 2004 was partially compensated in 2005. The development from 2006 to 2008 revealed a moderate decrease. In order to

33 This statement does not change qualitatively if the values are corrected for the change in the survey method; see Rammer/Peters, Studien zum deutschen Innovationssystem (Studies on the German innovation system) No. 7-2010.

34 See Rammer/Peters: Innovationsverhalten der Unternehmen in Deutschland 2008 (Innovation activity of companies in Germany in 2008). Studien zum deutschen Innovationssystem (Studies on the German innovation system) No. 7-2010.

35 Another success indicator for process innovations is an increase in turnover due to process innovation achieved by quality improvements. This is not discussed here, as there are no time sequences comparable to the other indicators for this indicator. This indicator is mentioned for the first time in the ZEW indicator report on the 2005 innovation survey.
See Aschhoff/Doherr/Ebersberger/Peters/Rammer/Schmidt: Indikatorenbericht zur Innovationserhebung 2005 (Indicator report on the 2005 innovation survey). ZEW publication, March 2006.

interpret this data, we refer to the special situation around the year 2000 already mentioned when discussing the turnover percentage with market innovations. The development of the other company-related services was uneven. The most recent figures (2006 to 2008) reveal a rising trend.

Production and foreign trade in R&D-intensive areas

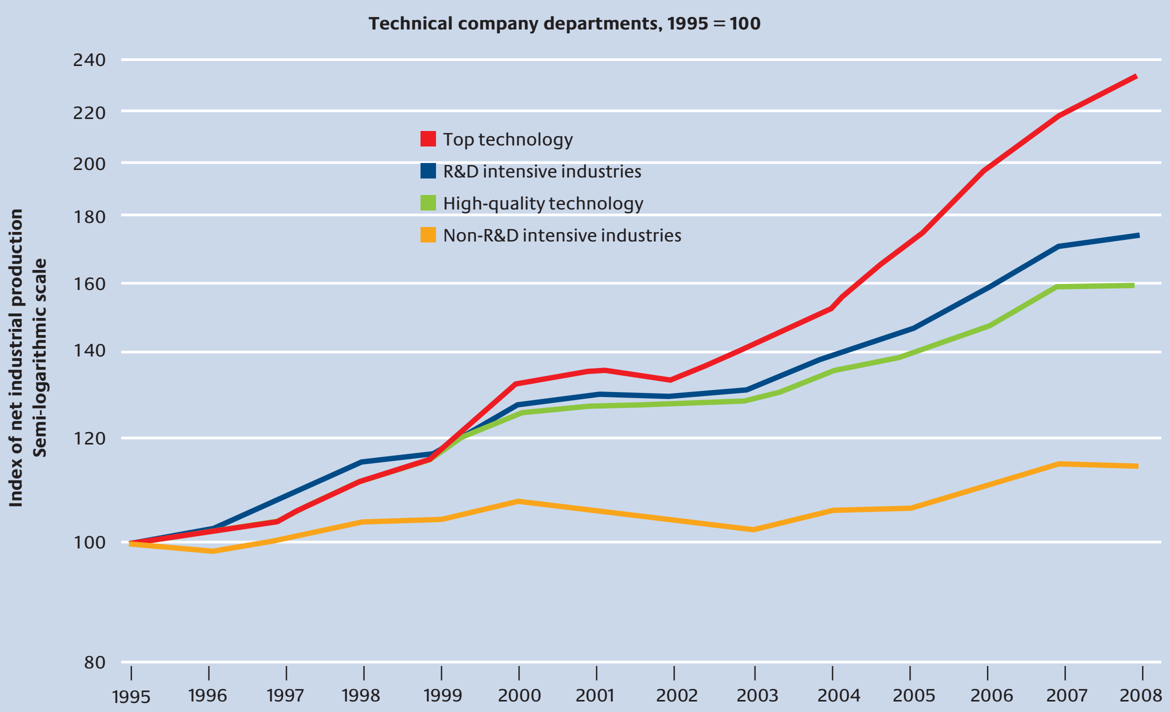
In addition to the success indicators described above, percentage turnover with market innovations and cost reduction due to process innovation, data for the production of R&D-intensive goods or the production in R&D intensive sectors and on the balance of foreign trade can also provide information on innovation success for such products.[36]

36 See Gehrke/Legler: Forschungs- und wissensintensive Wirtschaftszweige-, Außenhandel, Spezialisierung, Produktion, Beschäftigung und Qualifikationserfordernisse in Deutschland (Research and knowledge-intensive sectors, foreign trade, specialisation, production, employment and qualification requirements), Studien zum deutschen Innovationssystem (Studies on the German innovation system) No. 4-2010.

Figure 19 shows the development of production of R&D intensive goods in Germany over time. A particularly significant increase to far more than double the level in 2008 compared with 1995 is noteworthy in the particularly R&D-intensive top level technologies. The comparatively somewhat less R&D-intensive high-quality technologies and in particular the non-R&D intensive industries have a significantly lower growth dynamic. ■ Figure 19

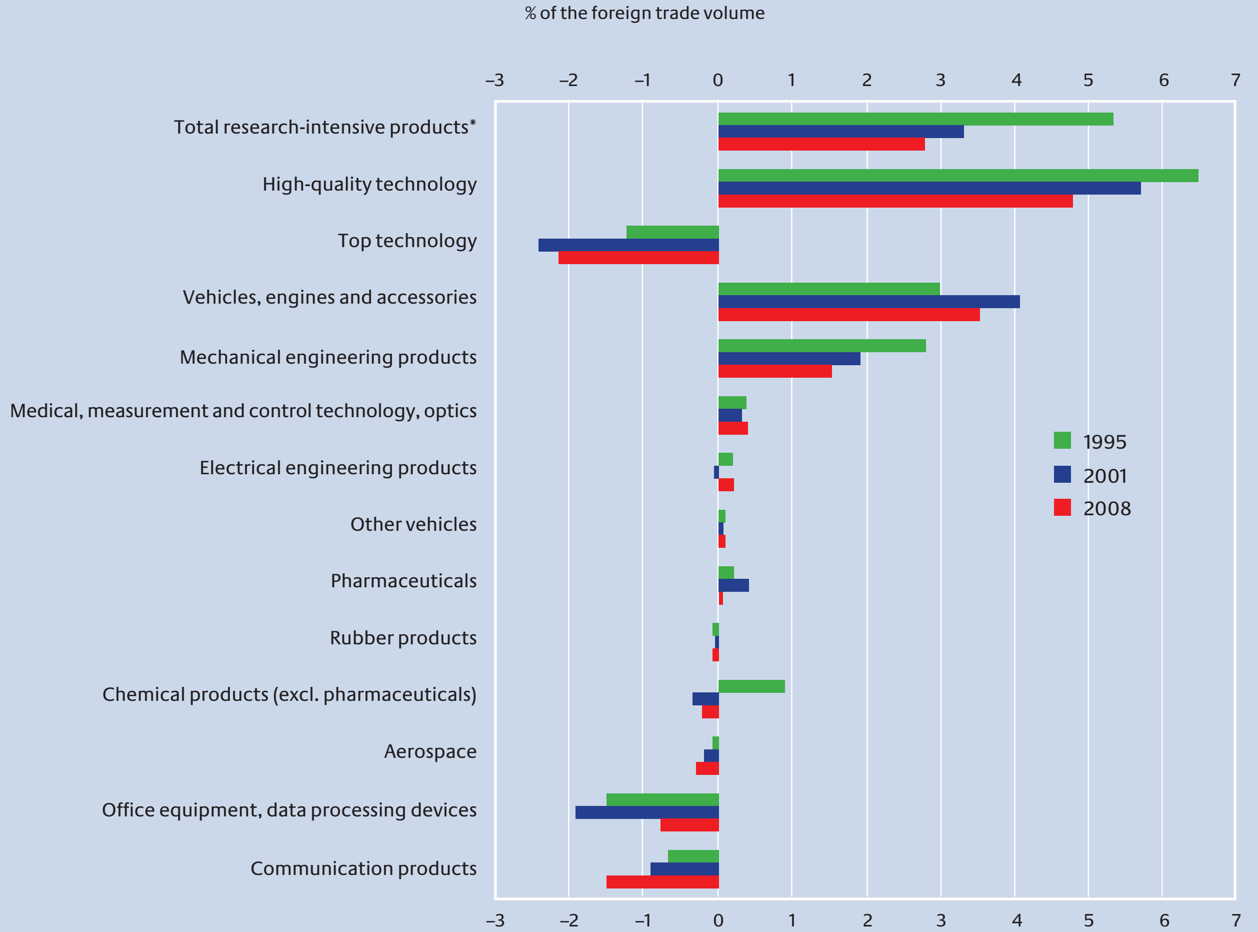
This data on the production of R&D-intensive industries raises the question as to the contribution R&D-intensive goods made by the German balance of trade. Figure 20 shows such data. Positive figures indicate a positive contribution of the corresponding group of products to the balance of foreign trade. The opposite is true for negative values – these goods contribute negatively to the balance of foreign trade. Overall, R&D-intensive products make a positive contribution to the balance of foreign trade, in other words this indicates that this area is one of Germany's export strengths. However, this positive contribution has decreased since 1995. Furthermore, the positive contribution to the balance of foreign trade is largely made by high-quality technology; particularly R&D-intensive top technologies even make negative contributions to the balance of foreign trade. ■ Figure 20

Fig. 19 Production in R&D-intensive industry sectors in Germany, 1995-2008



Index of net industrial production semi-logarithmic scale. Source: Gehrke/ Leger: Forschungs- und wissensintensive Wirtschaftszweige-, Außenhandel, Spezialisierung, Produktion, Beschäftigung und Qualifikationserfordernisse in Deutschland (Research and knowledge-intensive sectors, foreign trade, specialisation, production, employment and qualification requirements), Studien zum deutschen Innovationssystem (Studies on the German innovation system) No. 4-2010. Basis of data: Federal Statistical Office – NIW calculations

Fig. 20 **Contribution of R&D-intensive products to Germany's balance of foreign trade, 1995, 2001 and 2008**



Positive value: The sector contributes to a positive balance of foreign trade. The value indicates the relative foreign trade surplus in the product group in question as a percentage of the total foreign trade volume in manufacturing industries.

* 1995 and 2001 incl. non-attributable complete production facilities etc.

Source: Gehrke/ Leger: Forschungs- und wissensintensive Wirtschaftszweige-, Außenhandel, Spezialisierung, Produktion, Beschäftigung und Qualifikationserfordernisse in Deutschland (Research and knowledge-intensive sectors, foreign trade, specialisation, production, employment and qualification requirements), Studien zum deutschen Innovationssystem (Studies on the German innovation system) No. 4-2010.

Basis of data: OECD, ITCS – International Trade By Commodity Statistics, Rev. 3 /various years); Federal Statistical Office; calculations and estimates of the NIW

5.2 Selected tables

The preceding sections contained diagrams and text that gave a quick overview of the status and development of the German research and innovation system. The following section contains a comprehensive collection of tables that gives readers with special interests access to detailed data on the German research and innovation system.

Definitions

The sources of the data tables are the German Federal Ministry for Education and Research, the Federal Statistical Office, the German Donors' Association for the Promotion of Sciences and Humanities, and the Organisation for Economic Cooperation and Development (OECD). Information from the German Federal Bank, the Centre for European Economic Research (ZEW), the Lower Saxony Institute for Economic Research (Niedersächsisches Institut für Wirtschaftsforschung, NIW) and the Statistical Office of the European Commission (Eurostat) is also used.

The following definitions of the main terms used are based on national agreements or, where indicated accordingly, on the R&D manual (Frascati Manual) passed by the OECD, which defines the terms and methods for statistical evaluation of research and development. The corresponding OECD innovation manual (Oslo Manual) is also relevant for innovations. Further definitions are given in the text itself.

Expenditure

Scientific expenditure

Expenditure on research and development (R&D), expenditure on academic teaching and education and other related scientific and technological activities. The latter includes for example scientific or technological information services, data collection for general purposes, feasibility studies for technological projects (however, feasibility studies for research projects are part of R&D), developing bases for decision-making aids for politics and the private sector.

R&D expenditure

Research and development (R&D) is the systematic creative work that builds on existing knowledge, including knowledge of mankind, culture and society, and that uses this knowledge with the objective of finding new applications (see Frascati Manual 2002, Art. 63). Expenditure in relation to this work is expenditure on research and development.

Net expenditure

Expenditure adjusted for payments within the same level of the public sector, less payments from other public sectors. It indicates the expenditure financed from internal revenue sources of the respective entity or group of entities (cost unit principle).

Gross domestic R&D expenditure

All funds used to implement research and development within a country, regardless of the source of funding; this therefore also includes overseas funding and funding from international organisations for research work performed in the company. Conversely, this does not include funding for R&D performed by international organisations with domestic locations abroad, or funding sent abroad (see Frascati Manual 2002, Art. 423).

Internal R&D expenditure or R&D spending

All funds used for research and development nationally or within a specific sector of a national economy or within another sub-area (reporting unit), regardless of the source of funding. This does not include R&D funding paid to international organisations or abroad (see Frascati Manual 2002, Art. 358f.).

External R&D expenditure or R&D spending

Expenditure on research and development made abroad, in international organisations or outside a specific sector or another sub-area of a national economy (report unit) (see Frascati Manual 2002, Art. 408).

Overall R&D expenditure or spending

Overall expenditure or spending includes internal and external expenditure or spending on R&D by a country, a sector or another sub-area of a national economy (report unit).

Nationally funded R&D expenditure

All R&D expenditure funded by central and local governments, regardless of the sector in which the research and development is performed.

Private sector expenditure on R&D

Expenditure of companies and institutions on joint industrial research and joint experimental research (IfG).

Self-financed private sector expenditure

Internal R&D expenditure financed by the private sector.

Breakdown by sector

Commercial (private sector)

Private and government companies, institutions for joint industrial research and joint experimental research, and private non-profit institutions largely funded by the private sector or which primarily provide services for companies (see Frascati Manual 2002, Arts. 163-183).

Universities (university sector)

All universities, technical colleges, universities of applied science and other tertiary institutions, regardless of their sources of funding or legal status. This also includes research institutes, experimental facilities and hospitals (see Frascati Manual 2002, Arts. 206-228).

Government (government sector without universities)

For national reporting, a close distinction is assumed, that is on the funding side, only the funds in the budgets of the local authorities (central and local governments) and on the implementation side, only the institutions of central and local government and communities are considered. For international reporting, the government sector also includes the private non-profit organisations that are largely funded by the government (e.g. HGF, MPG, FhG). On the funding side, the independent revenues of these organisations are also attributed to the government sector (see Frascati Manual 2002, Arts 184-193).

Private non-profit sector (PNP sector)

For national reporting, this sector includes non-profit organisations funded primarily by the national government (e.g. HGF, MPG, FhG), and private non-profit organisations that are neither funded primarily by the national government nor funded primarily by the private sector, or that do not principally provide services to private sector companies.
Conversely, for international reporting, this sector only includes private non-profit organisations that are neither funded primarily by the national government nor primarily by the private sector (see Frascati Manual 2002, Arts. 194-205).

Abroad

On the funding side, funding from abroad, the European Union (EU) and international research and development organisations within the Federal Republic of Germany are documented, while on the implementation side, the funds paid abroad, to the EU or international organisations – even if they are located in Germany – by the Federal Republic of Germany are documented (see Frascati Manual 2002, Arts. 229-235).

Personnel working in research and development (R&D personnel)

All personnel working directly in R&D regardless of their position. This includes researchers, technical and similar personnel, other personnel (see Frascati Manual 2002, Arts. 294ff).

Researchers

Scientists or engineers who design or create new findings, products, processes, methods and systems – generally university graduates (see Frascati Manual 2002, Art. 301).

Technical or similar personnel

Personnel with technical training or corresponding training for non-technical areas who work directly in R&D, generally under the supervision of a researcher – generally graduates of technical secondary schools (see Frascati Manual 2002, Art. 306).

Other personnel

Personnel whose work is directly linked to the performance of R&D, that is clerical, secretarial and administrative staff, technical staff, unskilled and semi-skilled assistants (see Frascati Manual 2002, Art. 309).

Full-time equivalent

Calculation unit for full-time employment of an employee in a given period. This unit serves to convert the working hours of employees only partially involved in R&D (including part-time employees) to the working hours of a person employed full time in R&D (see Frascati Manual 2002, Arts. 331ff).

Innovations

Innovations

Innovations are new or markedly improved products or services introduced on the market (product innovations) or new or improved processes that are introduced (process innovations) (see Oslo Manual 1997, Art. 129). The percentage cost reduction is the percentage of costs saved by implementing the process innovations.

Innovation expenditure

More than expenditure for R&D; also incorporates licence fees, investments and advanced training for the implementation of R&D results, and so on.

Regional terms

Results for Germany as a whole

Documentation of results for the Federal Republic of Germany based on its territorial status since 3 October 1990: Germany.

Documentation of results for regions

Documentation of results for the Federal Republic of Germany, including West Berlin, based on the territorial status until 3 October 1990: Former territory of Federal Republic of Germany.
Documentation of results broken down by Eastern and Western German *Länder* from 3 October 1990: Eastern German *Länder* and Berlin[1] (Eastern German *Länder* include Brandenburg, Mecklenburg-Western Pomerania, Saxony, Saxony-Anhalt and Thuringia), Western German *Länder* excluding Berlin[2].

Legend

0 = less than one half in the last decimal place used, but more than zero
- = not available
. = survey not performed, not yet completed or no longer possible
X = not reported for reasons of confidentiality, but contained in the overall total

Note

Rounding differences may occur both in the tables and in the figures and cannot be ruled out.

1 Formerly: New federal *Länder* and East Berlin

2 Formerly: Old federal *Länder* and West Berlin

Index of tables

(Number in brackets is the table number in the long version of the Federal Report on Research and Innovation 2010)

Table 1 Gross domestic expenditure on R&D (GERD) of the Federal Republic of Germany, by performing sectors [1]

Millions of €				
Performing sector [2]		2003	2005	2007
Business enterprise sector [3]				
	financed by			
	Business enterprise sector	34 805	35 585	39 427
	Government sector	2 325	1 723	1 936
	Private non-profit sector	23	66	74
	Abroad	876	1 278	1 597
Total		**38 029**	**38 651**	**43 034**
Government and private non-profit sector [4]				
	financed by			
	Business enterprise sector	175	777	923
	Government sector	6 829	6 524	6 986
	Private non-profit sector	153	98	143
	Abroad	151	469	488
Total		**7 307**	**7 867**	**8 540**
Higher education sector [5]				
	financed by			
	Business enterprise sector	1 159	1 304	1 411
	Government sector	7 842	7 575	8 115
	Private non-profit sector	–	-	-
	Abroad	201	342	382
Total		**9 202**	**9 221**	**9 908**
Gross domestic expenditure on R&D				
	financed by			
	Business enterprise sector	36 139	37 666	41 761
	Government sector	16 996	15 821	17 036
	Private non-profit sector	176	164	217
	Abroad	1 228	2 089	2 468
Total		**54 539**	**55 739**	**61 482**
GERD in % of GDP [6]		2.52	2.48	2.53

1) Data from surveys of the relevant performing sectors. Until 1990, the former Federal Republic of Germany; as of 1991, all of Germany. Due to revision of the calculation method, figures as of 1991 are only partially comparable to data from earlier publications.
2) Figures for even years are estimates. The estimated figures are based on values converted from deutschmarks (DM) into euros (€) and rounded off.
3) Companies and institutions for cooperative industrial research; intramural R&D expenditures (OECD concept) of business enterprises; until 1990, including non-apportionable government funding; as of 1992, government R&D funding for business enterprises pursuant to figures of funding institutions – Federal Government and *Länder*. The funding-source data of the Stifterverband Wissenschaftsstatistik (subsidiary of the Association of German Academic Foundations), which have been obtained from R&D-performing reporting units, differ from these since the performing reporting units are not always able to identify the original funding source clearly.
4) Non-university institutions. Government: federal, *Länder* and municipal (research) institutions; Federal Government institutions as of 1981; *Länder* institutions as of 1985, only with their R&D shares. As of 1992, modified survey procedure; in 1995, the reporting scope was expanded; in 2004, partially revised; in 2005, modified calculation method.
5) Figures for 2006 revised, 2007 funding provisional.
6) As of 1991, the calculations of gross domestic product revised (revision 2005).

Source: Stifterverband Wissenschaftsstatistik, Federal Statistical Office and calculations of the Federal Ministry of Education and Research

Table 2 R&D expenditure of the Federal Republic of Germany and funding thereof [1]

Year	Financed by				Total R&D expenditure [5]
	Territorial authorities [2]		Business enterprises [3]	Private non profit institutions [4]	
	Millions of €	In % of the overall government budget [5]	Millions of €		Millions of €
1981	8 981	3.2	11 154	78	20 213
1983	9 475	3.2	13 011	86	22 572
1985	10 587	3.4	15 896	68	26 551
1987	11 114	3.3	18 831	122	30 067
1989	11 864	3.3	21 064	166	33 094
1991	14 821	3.2	23 935	196	38 952
1993	15 491	2.7	23 973	122	39 586
1995	15 735	2.6	24 733	104	40 572
1997	15 608	2.6	27 036	141	42 785
1999	15 965	2.7	32 411	205	48 581
2001	16 814	2.8	35 095	222	52 131
2003	17 136	2.8	38 060	176	55 372
2004	16 791	2.7	38 394	208	55 393
2005	16 761	2.7	39 569	164	56 494
2006	17 310	2.7	42 281	211	59 802
2007	18 173	2.8	43 768	217	62 158

1) Data from surveys for the relevant domestic funding sectors. Until 1990, the former Federal Republic of Germany; as of 1991, all of Germany. Discrepancies from the figures in Table 1 result from use of different surveys (Table 2: survey of financing sectors; Table 1: survey of performing sectors).
2) Central and local government. Funding for Federal research institutions as of 1981; funding for *Länder* research institutions as of 1983, but only R&D shares. Figures revised in comparison to figures from earlier publications as of 1991.
3) Data from surveys of the Stifterverband Wissenschaftsstatistik; from 1981 to 1989, figures include data for the R&D staff cost subsidy programme (German Federation of Industrial Cooperative Research Associations (AiF)), with an estimate for 1989, and adjusted to eliminate double counting. Figures for industry-funded R&D expenditures refer to intramural R&D expenditures and to funds that other sectors (e.g. universities, other countries) received from business enterprises. Due to revision of the calculation method, figures as of 1991 are not comparable to data from earlier publications.
4) Financed from own funds. Some figures are estimates.
5) Net expenditure without social insurance. As of 1998, does not include hospitals and university clinics with commercial accounting procedures.
Source: Federal Statistical Office and Stifterverband Wissenschaftsstatistik

Table 3 Regional distribution of the R&D expenditure of the Federal Republic of Germany as a whole [1]

Federal Land	Performing of R&D: Total R&D expenditure 2003 Millions of €	2003 in %	2005 Millions of €	2005 in %	2007 Millions of €	2007 in %
Baden-Wuerttemberg	12 322	22.6	13 702	24.6	15 676	25.5
Bavaria	11 348	20.8	11 458	20.6	12 212	19.9
Berlin	3 107	5.7	3 028	5.4	2 865	4.7
Brandenburg	550	1.0	572	1.0	651	1.1
Bremen	641	1.2	538	1.0	586	1.0
Hamburg	1 435	2.6	1 552	2.8	1 665	2.7
Hesse	5 107	9.4	5 204	9.4	5 682	9.3
Mecklenburg-Western Pomerania	395	0.7	450	0.8	456	0.7
Lower Saxony	5 240	9.6	4 298	7.7	5 152	8.4
North Rhine-Westphalia	8 460	15.5	8 742	15.7	9 471	15.4
Rhineland-Palatinate	1 678	3.1	1 675	3.0	1 952	3.2
Saarland	277	0.5	289	0.5	328	0.5
Saxony	1 841	3.4	1 992	3.6	2 406	3.9
Saxony-Anhalt	531	1.0	550	1.0	588	1.0
Schleswig-Holstein	732	1.3	777	1.4	851	1.4
Thuringia	798	1.5	805	1.4	880	1.4
Total for all *Länder* [2]	54 462		55 631	100.0	61 420	100.0
Of which: Eastern German *Länder* and Berlin	7 222	13.3	7 397	13.3	7 844	12.8
German institutions based abroad	56		57		62	
Total	**54 539**		**55 739**		**61 482**	

1) Estimated in part. Intramural R&D expenditures for 2006 of the business enterprise sector in accordance with regional breakdown for 2005.
2) Including higher education funds that cannot be broken down (2005: €51 million).
Source: Federal Statistical Office, Stifterverband Wissenschaftsstatistik and Federal Ministry of Education and Research

Table 4 Federal Government expenditure on science, research and development, by government department

Government departments	ACTUAL 2008 Total	ACTUAL 2008 Of which, R&D	TARGET[1] 2009 Total	TARGET[1] 2009 Of which, R&D	TARGET[1] 2010 Total	TARGET[1] 2010 Of which, R&D
Millions of €						
Federal Chancellor and Federal Chancellery [2,3]	316.6	98.6	307.3	86.9	315.1	88.2
Federal Foreign Office	219.5	155.0	259.5	190.4	261.8	192.8
Federal Ministry of the Interior [4]	71.8	55.1	86.3	64.0	67.5	46.3
Federal Ministry of Justice	2.5	2.5	2.7	2.7	2.7	2.7
Federal Ministry of Finance	2.3	2.3	4.3	4.3	2.3	2.3
Federal Ministry of Economics and Technology [5]	2 297.1	2 127.5	2 625.4	2 443.0	2 735.9	2 545.5
Federal Ministry of Food, Agriculture and Consumer Protection	389.8	345.7	519.3	448.7	639.2	562.9
Federal Ministry of Labour and Social Affairs	64.6	31.2	73.3	36.1	77.4	37.4
Federal Ministry of Transport, Building and Urban Affairs [6]	275.3	149.8	325.3	197.2	311.4	178.7
Federal Ministry of Defence	1 400.0	1 247.1	1 372.8	1 218.1	1 337.1	1 185.4
Federal Ministry of Health [3]	243.2	111.7	280.9	138.7	315.2	159.1
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety	342.5	193.4	397.3	216.7	408.2	221.3
Federal Ministry for Family Affairs, Senior Citizens, Women and Youth	22.4	22.4	22.7	22.7	24.3	24.3
Federal Ministry for Economic Cooperation and Development	31.7	29.2	36.2	33.5	36.2	33.5
Federal Ministry of Education and Research [7]	7 501.9	6 359.9	8 253.8	7 051.0	8 844.7	7 426.9
General Fiscal Administration [8]	-	-	-	-	-	-
Total expenditure	**13 181.2**	**10 931.3**	**14 567.0**	**12 153.9**	**15 378.8**	**12 707.1**

1) Not including funds from the "Investment and redemption fund" (Investitions- und Tilgungsfonds ITF) - (economic stimulus package - Konjunkturpaket II). Distribution among funding areas/priorities partly estimated. Target 2010: draft law of the German Federal Government dated 16/12/2009.
2) Including expenditures of the Federal Government's Commissioner for Cultural and Media Affairs.
3) For purposes of comparison, expenditures for R&D projects in the new *Länder* have been retroactively assigned from the Federal Government's Commissioner for Cultural and Media Affairs to the Federal Ministry of the Interior.
4) For purposes of comparison, expenditures for R&D projects in the new *Länder* have been retroactively assigned from the Federal Ministry of Transport, Building and Urban Affairs to the Federal Ministry of the Interior.
5) The 2010 government draft includes €16 million for R&D measures in other government departments.
6) For purposes of comparison, expenditures for R&D projects in the new *Länder* have been retroactively assigned from the Federal Government's Commissioner for Cultural and Media Affairs and from the Federal Ministry of Transport, Building and Urban Affairs to the Federal Ministry of the Interior.
7) The 2010 government draft includes €35 million for R&D measures in other government departments. Planned expenditure including the share of the total expenditure reduction for science, R&D (2009: €147.4 million, 2010: €143.2 million).
8) Including payments for universities, and for projects at industry-sector research institutions, in connection with German reunification (1991 and 1995).
Source: Federal Ministry of Education and Research

Table 5 1/4 Federal Government expenditure on science, research and development, by funding area and funding priorities[1]

Funding area	Funding priority	Millions of € ACTUAL 2007 Total	2007 Of which, R&D	2008 Total	2008 Of which, R&D
A	**Research funding organisations; university construction and mainly university-related special programmes**	**3 073.1**	**2 225.6**	**3 466.6**	**2 557.3**
A1	Basic funding MPG	522.2	522.2	646.2	646.2
A2	Basic funding DFG	815.6	815.6	840.0	840.0
A3	Basic funding FhG	383.6	383.6	395.9	395.9
A5	Expansion and construction of universities[3]	1 098.3	286.0	1 085.8	279.1
A6	Mainly university-related special programmes	135.4	100.2	241.5	138.9
A7	Funding of top-class universities	118.0	118.0	257.2	257.2
B	**Large-scale equipment for basic research**	**754.3**	**754.3**	**762.8**	**762.8**
C	**Marine and polar research; marine technology**	**221.4**	**198.9**	**222.8**	**201.3**
C1	Marine and polar research	191.5	179.9	192.6	181.0
C2	Marine technology	30.0	19.0	30.2	20.3
D	**Space research and space technology**	**849.5**	**849.5**	**886.4**	**886.4**
D1	National funding of space research and space technology	269.7	269.7	292.1	292.1
D2	European Space Agency (ESA)	579.8	579.8	594.3	594.3
E	**Energy research and energy technology**	**769.1**	**468.2**	**845.2**	**517.5**
E1.E2	Coal and other fossil fuels / Renewable energy and energy conservation	254.8	254.8	295.7	295.7
E3	Nuclear energy research (excluding decommissioning of nuclear facilities)	169.5	87.8	186.0	94.7
E4	Decommissioning of nuclear facilities; risk sharing	223.3	4.1	244.0	7.7
E5	Nuclear fusion research	121.5	121.5	119.4	119.4
F	**Sustainable development**	**694.9**	**553.0**	**725.8**	**580.5**
F1	Socio-ecological research; regional sustainability	285.8	214.2	287.9	213.8
F2	Sustainable production; cleaner environmental technology	235.0	168.1	239.4	170.8
F7	Global change (including peace-building research)	174.1	170.7	198.6	196.0
G	**Research and development in the health sector**	**696.1**	**542.1**	**768.2**	**608.0**
H	**Research and development to improve working conditions**	**79.3**	**45.1**	**85.4**	**52.0**
I	**Information technology (including multimedia and production engineering)**	**527.4**	**506.5**	**548.7**	**527.6**
I1	Computer science	131.0	131.0	138.9	138.9
I2	Basic information technologies	169.1	169.1	182.3	182.3
I3	Application of microsystems (including application of microelectronics; microperipherals)	91.8	91.8	93.1	93.1
I4	Production engineering	64.0	64.0	62.0	62.0
I5	Multimedia	71.5	50.5	72.3	51.2

1) The German Federal Government has fundamentally updated the procedures for coordinating national research and development activities, and drawn up a new R&D performance plan system. The IT technical implementation of the coordination of the German Federal Government R&D activities has not yet been fully programmed. Therefore, the statistical data on central government expenditure on science, research and development cannot yet be presented broken down according to research areas and research priorities. They are therefore structured according to the old performance plan system. The tables converted to the new performance plan system are expected to be published on the BMBF homepage in September 2010.
3) Including the German Federal Armed Forces universities and the Federal University of Applied Administrative Sciences.
Source: Federal Ministry of Education and Research

Table 5 2/4 Federal Government expenditure on science, research and development, by funding area and funding priorities[1]

Funding area / Funding priority		Millions of € ACTUAL 2007 Total	2007 Of which, R&D	2008 Total	2008 Of which, R&D
K	**Biotechnology**	**312.5**	**312.5**	**340.6**	**340.6**
L	**Materials research; physical and chemical technologies**	**410.3**	**370.2**	**422.6**	**379.1**
L1	Materials research; materials for emerging technologies	197.1	178.4	197.7	175.6
L2	Physical and chemical technologies	213.2	191.8	224.9	203.5
M	**Aeronautical research and hypersonic technology**	**145.1**	**145.1**	**172.3**	**172.3**
N	**Research and technology for mobility and transport**	**155.5**	**99.4**	**184.0**	**121.0**
O	**Geosciences and raw material supplies**	**38.6**	**22.3**	**42.6**	**25.3**
O1	Geosciences (especially deep drillings)	36.2	21.3	40.2	24.3
O2	Raw material supplies	2.4	1.0	2.4	1.0
P	**Regional planning and urban development; building research**	**55.1**	**55.1**	**56.1**	**55.6**
P1	Regional planning; urban development. housing	23.5	23.5	29.6	29.4
P2	Building research and technology; research and technology for preserving the architectural heritage	31.6	31.6	26.5	26.3
Q	**Research and development in the food sector**	**85.1**	**46.0**	**102.6**	**58.6**
R	**Research and development in agriculture, forestry and fishery**	**267.3**	**263.9**	**303.9**	**303.9**
S	**Educational research**	**137.4**	**109.7**	**149.4**	**116.1**
S1	Vocational training research	77.3	62.8	80.2	65.3
S2	Other educational research	60.1	46.9	69.3	50.8
T	**Innovation and improved basic conditions**	**584.9**	**539.8**	**654.6**	**609.1**
T1,T3	Indirect funding of R&D personnel in the business enterprise sector; participation in technology companies' innovation risks	176.0	176.0	186.3	186.3
T2	Improving the transfer of technology and knowledge/funding of innovation networks and research cooperation	342.0	342.0	399.2	399.2
T4	Technical and economic infrastructure	59.3	14.2	61.5	16.0
T5	Other funding measures	7.6	7.6	7.7	7.7
V	**Humanities; economic and social sciences**	**556.5**	**355.5**	**612.1**	**384.1**
W	**Other activities not assigned to other areas**	**587.9**	**461.7**	**595.1**	**460.0**
W1	Structural/innovative (generic) measures	127.9	122.5	150.7	144.7
W2	Other generic activities	460.1	339.3	444.4	315.3
W3	Total expenditure reduction (share for science, R&D)[4]	-	-	-	-
A-W	**Total of civil funding areas**	**11 001.3**	**8 924.4**	**11 947.9**	**9 719.2**
X	**Defence research and technology**	**1 243.2**	**1 221.1**	**1 233.3**	**1 212.1**
Total expenditure[5]		**12 244.5**	**10 145.5**	**13 181.2**	**10 931.3**

1) The German Federal Government has fundamentally updated the procedures for coordinating national research and development activities, and drawn up a new R&D performance plan system. The IT technical implementation of the coordination of the German Federal Government R&D activities has not yet been fully programmed. Therefore, the statistical data on central government expenditure on science, research and development cannot yet be presented broken down according to research areas and research priorities. They are therefore structured according to the old performance plan system. The tables converted to the new performance plan system are expected to be published on the BMBF homepage in September 2010.
4) Distribution of the total BMBF expenditure reduction among funding areas/priorities is only possible for the ACTUAL data.
5) Minor discrepancies with regard to earlier publications are due to retroactive revision of the allocation to funding areas/priorities.
Source: Federal Ministry of Education and Research

Table 5 3/4 Federal Government expenditure on science, research and development, by funding area and funding priorities[1]

Funding area Funding priority		Millions of € TARGET[2] 2009 Total	2009 Of which, R&D	2010 Total	2010 Of which, R&D
A	**Research funding organisations; university construction and mainly university-related special programmes**	**3 758.5**	**2 768.3**	**3 861.6**	**2.818.3**
A1	Basic funding MPG	616.1	616.1	616.0	616.0
A2	Basic funding DFG	865.2	865.2	891.2	891.2
A3	Basic funding FhG	472.6	472.6	419.8	419.8
A5	Expansion and construction of universities[3]	1 136.0	322.4	1 130.4	321.5
A6	Mainly university-related special programmes	383.5	206.9	508.8	274.5
A7	Funding of top-class universities	285.0	285.0	295.4	295.4
B	**Large-scale equipment for basic research**	**847.8**	**847.8**	**885.4**	**885.4**
C	**Marine and polar research; marine technology**	**239.6**	**213.1**	**257.0**	**230.0**
C1	Marine and polar research	200.1	185.6	215.0	200.0
C2	Marine technology	39.4	27.5	42.0	30.0
D	**Space research and space technology**	**971.9**	**971.9**	**974.6**	**974.6**
D1	National funding of space research and space technology	363.6	363.6	362.7	362.7
D2	European Space Agency (ESA)	608.3	608.3	612.0	612.0
E	**Energy research and energy technology**	**989.3**	**678.4**	**1030.7**	**691.0**
E1.E2	Coal and other fossil fuels / Renewable energy and energy conservation	393.5	393.5	403.0	403.0
E3	Nuclear energy research (excluding decommissioning of nuclear facilities)	226.2	108.8	233.2	110.4
E4	Decommissioning of nuclear facilities; risk sharing	227.1	33.6	251.6	34.6
E5	Nuclear fusion research	142.5	142.5	143.0	143.0
F	**Sustainable development**	**678.7**	**519.2**	**715.2**	**552.2**
F1	Socio-ecological research; regional sustainability	230.2	149.3	249.7	167.1
F2	Sustainable production; cleaner environmental technology	306.3	231.5	312.8	236.1
F7	Global change (including peace-building research)	142.2	138.4	152.7	148.9
G	**Research and development in the health sector**	**914.9**	**745.0**	**988.2**	**803.8**
H	**Research and development to improve working conditions**	**100.1**	**62.9**	**103.6**	**63.6**
I	**Information technology (including multimedia and production engineering)**	**621.9**	**599.5**	**680.3**	**655.9**
I1	Computer science	161.6	161.6	173.0	173.0
I2	Basic information technologies	201.5	201.5	207.1	207.1
I3	Application of microsystems (including application of microelectronics; microperipherals)	111.2	111.2	132.3	132.3
I4	Production engineering	72.0	72.0	72.0	72.0
I5	Multimedia	75.6	53.2	96.0	71.6

1) The German Federal Government has fundamentally updated the procedures for coordinating national research and development activities, and drawn up a new R&D performance plan system. The IT technical implementation of the coordination of the German Federal Government R&D activities has not yet been fully programmed. Therefore, the statistical data on central government expenditure on science, research and development cannot yet be presented broken down according to research areas and research priorities. They are therefore structured according to the old performance plan system. The tables converted to the new performance plan system are expected to be published on the BMBF homepage in September 2010.
2) Not including funds from the "Investment and redemption fund" (Investitions- und Tilgungsfonds ITF) - (economic stimulus package - Konjunkturpaket II). Distribution among funding areas/priorities partly estimated. Target 2010: draft law of the German Federal Government dated 16/12/2009.
3) Including the German Federal Armed Forces universities and the Federal University of Applied Administrative Sciences.
Source: Federal Ministry of Education and Research

Table 5 4/4 Federal Government expenditure on science, research and development, by funding area and funding priorities[1]

Funding area Funding priority		Millions of € TARGET[2] 2009 Total	2009 Of which, R&D	2010 Total	2010 Of which, R&D
K	**Biotechnology**	**381.3**	**381.3**	**400.6**	**400.6**
L	**Materials research; physical and chemical technologies**	**423.6**	**382.3**	**460.0**	**417.7**
L1	Materials research; materials for emerging technologies	210.0	190.4	233.1	213.1
L2	Physical and chemical technologies	213.6	191.9	227.0	204.6
M	**Aeronautical research and hypersonic technology**	**205.5**	**205.5**	**237.2**	**237.2**
N	**Research and technology for mobility and transport**	**244.5**	**180.7**	**251.2**	**182.9**
O	**Geosciences and raw material supplies**	**99.3**	**80.4**	**88.1**	**68.9**
O1	Geosciences (especially deep drillings)	96.2	79.2	84.9	67.7
O2	Raw material supplies	3.0	1.2	3.1	1.3
P	**Regional planning and urban development; building research**	**64.5**	**63.8**	**47.6**	**46.9**
P1	Regional planning; urban development; housing	26.2	25.8	20.9	20.5
P2	Building research and technology; research and technology for preserving the architectual heritage; road building research	38.3	38.0	26.8	26.4
Q	**Research and development in the food sector**	**111.2**	**63.3**	**124.2**	**71.7**
R	**Research and development in agriculture, forestry and fishery**	**412.0**	**389.3**	**516.5**	**492.8**
S	**Educational research**	**177.0**	**127.6**	**279.8**	**149.6**
S1	Vocational training research	82.3	63.9	101.8	50.8
S2	Other educational research	94.6	63.7	178.0	98.8
T	**Innovation and improved basic conditions**	**830.6**	**784.1**	**873.5**	**824.7**
T1,T3	Indirect funding of R&D personnel in the business enterprise sector; participation in technology companies' innovation risks	187.3	187.3	212.4	212.4
T2	Improving the transfer of technology and knowledge/funding of innovation networks and research cooperation	500.2	500.2	506.9	506.9
T4	Technical and economic infrastructure	142.7	96.3	154.0	105.2
T5	Other funding measures	0.3	0.3	0.3	0.3
V	**Humanities; economic and social sciences**	**659.9**	**429.6**	**672.3**	**435.4**
W	**Other activities not assigned to other areas**	**631.1**	**477.0**	**758.8**	**552.8**
W1	Structural/innovative (generic) measures	198.3	191.5	225.3	204.3
W2	Other generic activities	580.2	432.8	676.7	491.8
W3	Total expenditure reduction (share for science, R&D)[4]	-147.4	-147.4	-143.2	-143.2
A-W	**Total of civil funding areas**	**13 363.0**	**10 970.8**	**14 206.6**	**11 555.9**
X	**Defence research and technology**	**1 204.0**	**1 183.1**	**1 172.2**	**1 151.2**
Total expenditure[5]		**14 567.0**	**12 153.9**	**15 378.8**	**12 707.1**

1) The German Federal Government has fundamentally updated the procedures for coordinating national research and development activities, and drawn up a new R&D performance plan system. The IT technical implementation of the coordination of the German Federal Government R&D activities has not yet been fully programmed. Therefore, the statistical data on central government expenditure on science, research and development cannot yet be presented broken down according to research areas and research priorities. They are therefore structured according to the old performance plan system. The tables converted to the new performance plan system are expected to be published on the BMBF homepage in September 2010.
2) Not including funds from the "Investment and redemption fund" (Investitions- und Tilgungsfonds ITF) - (economic stimulus package - Konjunkturpaket II). Distribution among funding areas/priorities partly estimated. Target 2010: draft law of the German Federal Government dated 16/12/2009.
4) Distribution of the total BMBF expenditure reduction among funding areas/priorities is only possible for the ACTUAL data.
5) Minor discrepancies with regard to earlier publications are due to retroactive revision of the allocation to funding areas/priorities.
Source: Federal Ministry of Education and Research

Table 6 Federal Government expenditure on science, research and development, by recipient group

Recipient group		ACTUAL 2007 Total	2007 Of which, R&D	2008 Total	2008 Of which, R&D
Millions of €					
1.	**Territorial authorities**	**3 384.9**	**1 758.6**	**3 612.3**	**1 856.4**
1.1	Federal Government	1 574.1	691.4	1 686.6	744.6
1.1.1	Federal Government-owned research institutions	1 318.5	637.7	1 407.5	683.6
1.1.2	Other institutions of Federal administration [1]	255.5	53.7	279.1	60.9
1.2	*Länder* and communities	1 810.8	1 067.1	1 925.8	1 111.8
1.2.1	Research institutions of the *Länder*	74.5	70.6	65.7	61.8
1.2.2	Universities and university hospitals [2]	1 668.1	930.6	1 798.5	991.8
1.2.3	Other institutions of the *Länder*	36.3	34.7	35.4	32.9
1.2.4	Communities, local authority and special-purpose associations	31.9	31.3	26.2	25.3
2.	**Private non-profit organisations**	**5 734.8**	**5 323.4**	**6 348.9**	**5 922.0**
2.1	Research funding organisations (e g MPG. FhG. DFG) [3]	2 635.2	2 532.6	3 021.2	2 912.7
2.2	Hermann von Helmholtz Association of National Research Centres (HGF)	2 100.1	1 944.3	2 183.5	2 021.9
2.3	Other non-profit science organisations	920.7	779.3	1 071.3	926.3
2.4	Other non-profit organisations	78.8	67.2	73.0	61.2
3.	**Business enterprise** [4]	**2 142.2**	**2 108.8**	**2 190.8**	**2 151.5**
3.1	Business enterprises	1 616.6	1 595.2	1 459.0	1 433.8
3.2	Services if rendered by companies and the professions	525.5	513.6	731.8	717.7
4.	**Abroad**	**981.0**	**953.1**	**1 029.0**	**1 001.4**
4.1	Payments to business enterprises abroad	81.2	81.2	99.9	99.9
4.2	Contributions to international organisations and other payments to recipients abroad	899.8	871.9	929.1	901.5
5.	**Cross-group positions**	1.6	1.5	0.0	0.0
Total expenditure [5]		**12 244.5**	**10 145.4**	**13 181.2**	**10 931.3**
	For information:				
	Business enterprises [4]	2 142.2	2 108.8	2 190.8	2 151.5
	Of which:				
	Federal Ministry of Economics	689.2	682.3	782.7	775.3
	Federal Ministry of Defence	865.0	865.0	726.9	726.9
	Federal Ministry of Education and Research	459.8	433.4	515.3	484.6

1) Including German Federal Armed Forces universities. Discrepancies in R&D expenditures with regard to earlier publications are due to retroactive revision of the R&D coefficient for the BMBF's expenditure on university expansion and construction.
2) Not including basic funding for DFG and funding for collaborative research centres.
3) Including basic funding for DFG and funding for collaborative research centres.
4) Including funding to promote contract research; differentiation in keeping with the classification of economic activities; not including funding for business enterprises abroad.
5) Minor discrepancies with regard to earlier publications are due to subsequent data collection and/or retroactive revision of the allocation to recipient groups.
Source: Federal Ministry of Education and Research

Table 7 1/2 Gross domestic expenditure on research and development in selected OECD countries, by funding and performing sectors

Country	Year [1]	R&D expenditure		Financed by			Performed by			
		Millions of US $ [2]	Share of GDP in %	Business enterprise sector	Govern-ment sector	Other domestic sources and abroad	Business enterprise sector	Govern-ment sector	Higher education sector [3]	PNP sector [4]
				Share in %						
Germany	2005	64 298.8	2.49	67.6	28.4	4.1	69.3	14.1	16.5	.
	2006	68 476.0	2.53	68.2	27.7	4.2	70.0	13.9	16.1	.
	2007	71 789.0	2.53	67.9	27.7	4.4	70.0	13.9	16.1	.
Finland	2005	5 601.2	3.48	66.9	25.7	7.5	70.8	9.6	19.0	0.6
	2006	5 918.7	3.45	66.6	25.1	8.3	71.3	9.4	18.7	0.6
	2007	6 376.8	3.47	68.2	24.1	7.7	72.3	8.5	18.7	0.6
France	2005	39 235.7	2.10	51.9	38.6	9.4	62.1	17.8	18.8	1.3
	2006	41 156.4	2.10	52.3	38.5	9.2	63.1	16.5	19.2	1.2
	2007	42 487.0	2.04	52.1	38.3	9.6	63.3	15.8	19.8	1.2
United Kingdom and Northern Ireland	2005	34 080.7	1.73	42.1	32.7	25.2	61.4	10.6	25.7	2.3
	2006	36 304.6	1.76	45.2	31.9	22.9	61.7	10.0	26.1	2.2
	2007	39 341.8	1.82	46.7	30.2	23.2	63.4	8.8	25.6	2.2
Italy	2005	17 999.0	1.09	39.7	50.7	9.7	50.4	17.3	30.2	2.1
	2006	19 678.1	1.13	40.4	47.0	12.7	48.8	17.2	30.3	3.7
	2007	21 397.2	1.18	42.0	44.3	13.7	51.9	14.5	30.1	3.5

1) Some figures are provisional, estimated or only partially comparable with figures from previous years (cf. original edition of "Main Science and Technology Indicators 2009/2").
2) Nominal expenditures, converted into US$ purchasing-power parities.
3) Including general funding for university research.
4) PNP: Private non-profit sector.
7) Not including investment expenditure; only central government expenditure included in the public sector.
Source: OECD (Main Science and Technology Indicators 2009/2) and calculations of the Federal Ministry of Education and Research

Table 7 2/2 Gross domestic expenditure on research and development in selected OECD countries, by funding and performing sectors

Country	Year [1]	R&D expenditure		Financed by			Performed by			
		Millions of US $ [2]	Share of GDP in %	Business enterprise sector	Govern-ment sector	Other domestic sources and abroad	Business enterprise sector	Govern-ment sector	Higher education sector [3]	PNP sector [4]
				Share in %						
Sweden [5]	2005	10 509.9	3.60	63.9	24.4	11.7	72.7	5.0	22.0	0.3
	2006	11 700.9	3.74				74.7	4.5	20.6	0.2
	2007	12 080.9	3.61	64.0	22.2	13.8	73.7	4.8	21.3	0.2
Japan [6]	2005	128 694.6	3.32	76.1	16.8	7.2	76.5	8.3	13.4	1.9
	2006	138 930.1	3.40	77.1	16.2	6.8	77.2	8.3	12.7	1.9
	2007	147 800.8	3.44	77.7	15.6	6.6	77.9	7.8	12.6	1.8
Canada	2005	23 174.8	2.05	49.1	31.6	19.2	56.1	9.7	33.8	0.4
	2006	23 732.9	1.97	49.5	31.4	19.2	56.0	9.9	33.7	0.4
	2007	24 116.2	1.90	47.8	32.9	19.3	54.5	10.0	34.9	0.6
United States [7]	2005	322 914.0	2.57	64.4	30.2	5.4	70.0	11.9	14.0	4.0
	2006	347 692.0	2.61	65.4	29.3	5.4	71.2	11.4	13.5	3.9
	2007	373 093.0	2.66	66.2	28.3	5.5	72.2	10.9	13.1	3.8

1) Some figures are provisional, estimated or only partially comparable with figures from previous years (cf. original edition of "Main Science and Technology Indicators 2009/2").
2) Nominal expenditures, converted into US$ purchasing-power parities.
3) Including general funding for university research.
4) PNP: Private non-profit sector.
5) 2003, 2004: total R&D expenditures and GDP share underestimated; performing shares of the university sector overestimated.
6) Funding shares of the public sector and other domestic sources have been adjusted in line with OECD standards.
7) Not including investment expenditure; only central government expenditure included in the public sector.
Source: OECD (Main Science and Technology Indicators 2009/2) and calculations of the Federal Ministry of Education and Research

Table 8 1/2 Employees, turnover and internal R&D expenditure of companies by industry sectors and employee size category [1]

Industry sector [2] Employee size category		2007					
				Internal R&D expenditure			
		Employees [3]	Turnover [3]	Total	Per employee	Share of turnover	For information: total in the Eastern German *Länder* and Berlin
		Thousand	€ m	€ m	€ '000	in %	€ m
A, B	Agriculture, hunting and forestry; fishing	4	731	94	23.50	12.9	17
C	Mining and quarrying	45	23 084	27	0.60	0.1	x
D	Manufacturing	3 232	1 023 675	37 942	11.70	3.7	2 443
DA	Manufacture of food products and beverages; manufacture of tobacco products	118	68 234	317	2.70	0.5	15
DB	Manufacture of textiles and apparel	35	6 096	127	3.60	2.1	x
DC	Manufacture of leather and leather products	2	671	5	2.50	0.7	x
DD	Manufacture of wood and wood products excluding furniture	14	3 046	20	1.40	0.7	x
DE	Manufacture of pulp, paper and paper products; publishing and printing	43	12 054	179	4.20	1.5	x
DF	Manufacture of coke, refined petroleum products and nuclear fuel	10	39 136	93	9.30	0.2	x
DG	Manufacture of chemicals and chemical products	353	135 507	6 456	18.30	4.8	395
DH	Manufacture of rubber and plastic products	149	32 946	868	5.80	2.6	26
DI	Manufacture of glass, ceramics and non-metallic mineral products	73	14 122	250	3.40	1.8	22
DJ	Manufacture of basic metals; manufacture of fabricated metal products	326	94 059	941	2.90	1.0	85
DK	Manufacture of machinery and equipment	597	132 842	4 733	7.90	3.6	331
DL	Manufacture of office machinery and computers, electrical machinery, precision and optical instruments	629	146 892	8 142	12.90	5.5	1 270
DM	Manufacture of transport equipment	838	329 845	15 606	18.60	4.7	217
DN	Manufacture of furniture, jewellery and musical instruments; recycling	44	8 224	205	4.70	2.5	20
E	Electricity, gas and water supply	141	109 627	118	0.80	0.1	7

1) Not including institutions for cooperative industrial research and experimental development.
2) Classification of industry sectors, 2003 edition.
3) Employees and turnover of companies with internal and external R&D expenditure.
Source: Stifterverband Wissenschaftsstatistik

Table 8 2/2 Employees, turnover and internal R&D expenditure of companies by industry sectors and employee size category [1]

Industry sector [2] / Employee size category			2007					
					Internal R&D expenditure			
			Employ-ees [3]	**Turnover** [3]	**Total**	Per em-ployee	Share of turn-over	For informa-tion: total in the Eastern German *Länder* and Berlin
			Thousand	**€ m**	**€ m**	**€ '000**	in %	**€ m**
F	Construction		64	12 833	58	0.90	0.5	16
I	Transport and communication		261	64 070	249	1.00	0.4	□
K	Real estate, renting and business activ-ities		219	32 627	3 887	17.70	11.9	751
O	Other community, social and personal service activities		2	239	16	8.00	6.7	10
G,H,J,L-N	Remaining categories		81	95 134	368	4.50	0.4	7
Total			**4 050**	**1 362 021**	**42 759**	**10.60**	**3.1**	**3 306**
Companies with employees								
less than	100		212	33 192	2 135	10.10	6.4	736
100	to	249	307	65 616	2 187	7.10	3.3	382
250	to	499	340	82 178	2 253	6.60	2.7	255
		sub-total	859	180 986	6 575	7.70	3.6	1 373
500	to	999	359	98 491	2 694	7.50	2.7	203
1 000	to	1 999	433	119 366	3 850	8.90	3.2	150
2 000	to	4 999	522	184 885	5 806	11.10	3.1	615
5 000	to	9 999	338	193 127	4 183	12.40	2.2	12
10 000	and over		1 540	585 166	19 652	12.80	3.4	952
		sub-total	3 192	1 181 035	36 185	11.30	3.1	1 932
Total			**4 050**	**1 362 021**	**42 759**	**10.60**	**3.1**	**3 306**

1) Not including institutions for cooperative industrial research and experimental development.
2) Classification of industry sectors, 2003 edition.
3) Employees and turnover of companies with internal and external R&D expenditure.
Source: Stifterverband Wissenschaftsstatistik

Table 9 R&D personnel by occupation and sector of employment

Sector (OECD differentiation)	Year	Full-time equivalents			
		Total	Of which:		
			Researchers	Technicians	Others
1. Business enterprise sector [1]	**2003**	**298 072**	161 980	70 056	66 035
	2005	**304 502**	166 874	76 256	61 372
	2007	**321 853**	174 309	83 565	63 985
2. Government sector [3,5]	**2003**	**73 867**	38 719	8 525	26 623
	2005	**76 254**	39 911	8 420	27 923
	2007	**80 644**	43 561	11 751	25 332
3. Higher education sector [2]	**2003**	**100 593**	68 243	11 375	20 976
	2005	**94 522**	65 363	9 902	19 258
	2007	**103 953**	72 985	11 836	19 132
4. Total	**2003**	**472 532**	268 942	89 956	113 634
	2005	**475 278**	272 148	94 578	108 553
	2007	**506 450**	290 855	107 152	108 449
of which: Eastern German *Länder* and Berlin					
1. Business enterprise sector [1]	**2003**	**30 463**	18 346	6 294	5 822
	2005	**29 525**	17 393	.	.
	2007	**31 510**	18 195	7 826	5 491
2. Government sector [3,5]	**2003**	**21 943**	12 805	1 722	7 416
	2005	**21 970**	12 012	2 018	7 940
	2007	**23 955**	13 950	2 823	7 182
3. Higher education sector [2]	**2003**	**22 504**	15 532	2 249	4 723
	2005	**22 441**	15 579	1 896	4 966
	2007	**23 184**	16 636	2 203	4 345
4. Total	**2003**	**74 911**	46 683	10 265	17 961
	2005	**73 936**	44 984	.	.
	2007	**78 651**	48 781	12 852	17 018

1) Figures for even years are estimates.
2) Figures for the higher education sector refer to full-time staff of private and state universities (ACTUAL), calculated in accordance with the procedure agreed on by the Conference of Ministers of Education and Cultural Affairs (KMK), the Science Council, the Federal Ministry of Education and Research (BMBF) and the Federal Statistical Office.
3) Government institutions and private non-profit science organisations financed primarily by the government. In contrast to earlier publications, the PNP sector has been included in the public sector.
5) As of 2003, breakdown by technicians and other staff modified for methodical reasons. Hence, figures since 2003 are only partially comparable with previous years.

Source: Stifterverband Wissenschaftsstatistik and Federal Statistical Office

Table 10 R&D personnel in EU countries and selected OECD countries, by occupation and sector of employment

Country	Year[1]	Full-time equivalents				Of which, active in the		
		Researchers	Technicians and other staff	Total R&D personnel		Business enterprise sector	Higher education sector	Government and PNP[2] sector
		Number			per 1000 labour force	Share in %		
Germany	**2005**	272 148	203 130	**475 278**	11.6	64.1	19.9	16.0
	2006	279 822	208 113	**487 935**	11.8	64.0	20.0	16.0
	2007	290 853	215 597	**506 450**	12.2	63.6	20.5	15.9
Finland	**2005**	39 582	17 889	**57 471**	21.8	55.9	30.4	13.8
	2006	40 411	17846	**58 257**	21.8	56.6	29.8	13.6
	2007	39 000	17 243	**56 243**	20.9	56.8	29.3	13.9
France	**2005**	202 507	147 175	**349 681**	12.8	55.8	28.2	16.0
	2006	210 591	155 223	**365 814**	12.9	56.8	27.6	15.6
	2007	215 755	156 571	**372 326**	13.1	57.3	27.5	15.2
United Kingdom and Northern Ireland	**2005**	248 599	76 318	**324 917**	10.8	44.8	47.0	8.2
	2006	254 009	80 795	**334 804**	11.0	44.7	47.2	8.1
	2007	254 599	94 761	**349 360**	11.4	46.6	46.2	7.2
Italy	**2005**	82 489	92 759	**175 248**	7.2	40.4	38.2	21.4
	2006	88 430	103 573	**192 002**	7.8	41.7	35.3	23.0
	2007	93 000	115 376	**208 376**	8.4	45.0	34.1	20.9
Sweden	**2005**	55 090	22 614	**77 704**	16.8	72.2	22.8	5.0
	2006	55 729	22 986	**78 715**	16.9	73.2	21.8	5.0
	2007	47 775	29 052	**76 827**	15.9	72.8	22.8	4.3
Japan	**2005**	704 949	216 224	**921 173**	13.9	66.2	25.4	8.4
	2006	709 691	225 491	**935 182**	14.1	66.2	25.5	8.3
	2007	709 974	227 891	**937 865**	14.1	66.1	25.7	8.2
Canada	**2005**	136 759	81 853	218 612	12.6	65.0	26.1	8.9
	2006	139 011	85 095	224 106	12.7	65.4	25.6	9.0
	2007	.	.	.	.	.	.	.
United States	**2005**	1 387 882	.	.	.	.	.	.
	2006	1 425 550	.	.	.	.	.	.
	2007	.	.	.	.	.	.	.

1) Some figures are provisional, estimated or only partially comparable with figures from previous years (cf. original edition of "Main Science and Technology Indicators 2009/1").
2) PNP: Private non-profit sector.
3) 1995 R&D staff figures overestimated (use of personnel data instead of full-time equivalents).
Source: OECD (Main Science and Technology Indicators 2009/1) and calculations of the Federal Ministry of Education and Research

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